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Abstract:

This deliverable reports the work done in the framework of Task 4.1 - Analysis of grid infrastructure conditions and pilot site formal analysis. The purpose of this deliverable is to provide the formal analysis of the requirements and GRIDFLEX Use Cases (UCs) to be demonstrated at four demo sites (Albena, Luče, Ravne na Koroškem, Xanthi) considering the technical and operational constraints and regulatory, market and social conditions. This includes a complete detailed analysis of each demo site according to identified conditions in order for the UCs to be implemented without limitations, barriers and obstacles. The possible demo site issues that may affect the implementation are highlighted and explained.

Keywords:

GRIDFLEX, UCs, Grid Infrastructure, Flexibility, Constraint, Pilot, Demonstration

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Executive Summary

This deliverable reports the work done in the framework of Task 4.1 - Analysis of grid infrastructure conditions and pilot site formal analysis. This document provides the formal analysis of the GRIDFLEX requirements and use cases (UCs) to be demonstrated at four demo sites (Albena, Luče, Ravne na Koroškem and Xanthi), considering the technical and operational constraints and regulatory, market and social conditions. The analysis conducted in this report, includes a complete detailed analysis of each demo site according to predefined UCs pre-conditions of implementation so that UCs could be implemented without limitations, barriers and obstacles. Based on that, the mapping of GRIDFLEX UCs and requirements with the pilot site's conditions was realized in order to elaborate in detail and provide a picture of the possibilities of realization of GRIDFLEX UCs. Testing GRIDFLEX UCs in real conditions, which is a task starting in 2021, will additionally require the consideration of end-users needs and constraints during demonstration activities in order to ensure the seamless and smooth integration of the new technologies in the operation of the electricity grid. The implementation of the defined GRIDFLEX UCs will thus largely relate to the deployment of smart grid technologies and solutions, which will be demonstrated at the pilot sites taking into account existing and new infrastructure, and end-users' needs.

The analysis of all pilot site's grid infrastructure was performed by collecting technical information using questionnaires. Three different questionnaires related to different technical information of the pilot site's grid infrastructure were used.

The first questionnaire (see Figure 7) refers to information related to pilot site assets. In this questionnaire, the pilot site partners provided detailed information regarding the installed assets at their pilot site. Provided information includes: types of asset, asset's capacities, communication and management protocols, and information on whether there is historical data of the asset or not.

The second questionnaire (see Figure 8) refers to installed assets, but the pilot site partners had to provide more detailed information on each asset’s measurements. More detailed information was meant to define the measurement parameters for each asset (e.g. voltage, current, active power, reactive power, etc.), available measurement intervals and frequency of data measurement.

The third questionnaire refers (see Figure 9) to information on external services data. This questionnaire gathered the details on whether the pilot site partners could provide information on historical and real-time weather forecast data. This data was identified as one of the preconditions for implementing two UCs (UCs 2.8, and 2.14).

After gathering the technical details of each pilot site, this information was combined with pre-defined and recognized preconditions for the implementation of GRIDFLEX UCs taken from document D2.2 – Use case and requirements definition – in order to perform an assessment of the grid infrastructure of all pilot sites individually. After evaluating the pilot sites and comparing the collected technical information on the grid infrastructure with the necessary preconditions for implementing GRIDFLEX UCs, it was concluded that all pilot sites are ready for testing UCs and meet all the requirements for integration, implementation and realisation.

During the collection of information on grid infrastructure for each pilot site individually, only two limitations were identified, which at this point do not represent constraints for implementation:

1. Due to the travel restrictions caused by COVID 19, the team conducting the assessment could not personally get introduced to the grid infrastructure of pilot sites. So, according to the information provided by pilot site partners, the team evaluated pilot sites grid conditions and made final conclusion for each pilot site remotely.

2. Due to the COVID-19 pandemic, they were delays in performing technical works at the pilot sites and in the delivery due to disrupted supply chains for equipment installed. Partners were urged to provide the updated information regarding the grid infrastructure once a month.

For the X-FLEX project purposes, each pilot site had to integrate new assets and new devices into its network. The integration of new assets and devices required a lot of time and technical work on each pilot site's grid infrastructure. Due to COVID-19, technical works were either suspended or delayed. Thanks to the excellent cooperation of all pilot site partners who participated in T4.1, this assessment was completed without reduced scope and all pilot sites were validated as ready for implementation of planned UCs.

Index

1 INTRODUCTION 10
1.1 Purpose of the document 10
1.2 Scope of the document 10
1.3 Structure of the document 10
2 METHODOLOGY 11
2.1 Use Case overview 11
2.1.1 Introduction 11
2.1.2 Methodology used for formal analysis of pilot site grid infrastructure 11
2.1.3 Different types of collected data 11
2.1.4 A short overview of GRIDFLEX UCs 12
2.1.5 Use cases mapping per pilot site 14
2.1.5.1 Albena pilot site 14
2.1.5.2 Luče pilot site 14
2.1.5.3 Ravne na Koroškem pilot site 15
2.1.5.4 Xanthi pilot site 16
3 PILOT SITE ANALYSIS 17
3.1 Albena pilot site 17
3.1.1 Grid conditions of the pilot site 17
3.1.2 Requirements and Use Cases to be demonstrated at the pilot site 20
3.2 Luče pilot site 22
3.2.1 Grid conditions of the pilot site 22
3.2.2 Requirements and Use Cases to be demonstrated at the pilot site 24
3.3 Ravne na Koroškem pilot site 27
3.3.1 Grid conditions of the pilot site 27
3.3.2 Requirements and Use Cases to be demonstrated at the pilot site 28
3.4 Xanthi pilot site 29
3.4.1 Grid conditions of pilot site 31

3.4.2 Requirements and Use Cases to be demonstrated at the pilot site 33
3.5 Pilot site socio-economic constraints and mitigations 36
4 CONCLUSION 37
5 ACRONYMS 38
6 ANNEX A 40
7 ANNEX B 41

List of Figures

Figure 1: The five activities for successfully conducting T4.1 11

Figure 2: Albena grid topology 17

Figure 3: Luče pilot site topology 22

Figure 4: 42 MV line Xanthi 29

Figure 5: 39X MV line Xanthi 30

Figure 6: 33X MV line Xanthi 31

Figure 7: Questionnaire regarding assets information 40

Figure 8: Questionnaire regarding assets measurement 40

Figure 9: Questionnaire regarding external services 40

List of Tables

Table 1: The list of GRIDFLEX UCs 13

Table 2: Demonstrated UCs in Albena pilot site 14

Table 3: Demonstrated UCs in Luče pilot site 15

Table 4: Demonstrated UCs in Ravne na Koroškem 16

Table 5: Demonstrated UCs in Xanthi (HEDNO) pilot site 16

Table 6: PV Systems in Albena pilot site 17

Table 7: Solar thermal collector in Albena pilot site 18

Table 8: Battery systems in Albena pilot site 18

Table 9: Power to Heat – Electrical boiler system in Albena pilot site 19

Table 10: Power meters in Albena pilot site 20

Table 11: Mapping Albena pilot site conditions with UCs requirements 20

Table 12: Albena pilot site final comments regarding UCs implementation 21

Table 13: PV systems in Luče pilot site 22

Table 14: Battery system in Luče pilot site 23
Table 15: EV charging system in Luče pilot site 24
Table 16: Mapping Luče pilot site conditions with UCs requirements 24
Table 17: Luče pilot site final comments regarding UCs implementation 25
Table 18: CHP systems in Ravne na Koroškem pilot site 27
Table 19: Power to Heat – Electrode boiler system in Ravne na Koroškem pilot site 27
Table 20: Mapping Ravne na Koroškem pilot site conditions with UCs requirements 28
Table 21: Ravne na Koroškem final comments regarding UCs implementation 28
Table 22: List of PV assets operated by HEDNO 31
Table 23: List of HEDNO MV lines 32
Table 24: HEDNO substations 32
Table 25: Mapping Xanthi pilot site conditions with UCs requirements 33
Table 26: Xanthi final comments regarding UCs implementation 34

1 INTRODUCTION

1.1 Purpose of the document

This document is the first report under Work Package 4 (WP4) "Advanced automatic control and observability of the flexible grid - GRIDFLEX tool" and provides formal analysis of the grid infrastructure and conditions of the pilot sites in detail. It elaborates the requirements for the GRIDFLEX UCs to be demonstrated at each demo site in the context of proposed scenarios, considering technical and operational constraints and regulatory, market and social conditions. Since the ultimate goal is the successful implementation and realization of UCs, it is necessary to assess the pilot sites based on their current technical capabilities and conditions they meet in order to develop technical UCs solutions without any obstacles in further project progress. This deliverable aims to provide a clear insight into the met grid infrastructure conditions and help in further work on the implementation of GRIDFLEX UCs.

1.2 Scope of the document

This document is the result of the cooperation of the partners within the task T4.1. This task aims to examine the requirements for implementing the GRIDFLEX UCs defined in document D2.2 with the pilot site network infrastructure's current capabilities to implement them successfully. All implementation requirements necessitate certain preconditions that pilot sites must meet. The defined UCs are related to integrating technologies and solutions of smart grids, which will be demonstrated at pilot sites, based on the European Smart Grid Architecture Model (SGAM) framework. Moreover, these UCs are defined taking into account end-users' needs and the necessary electricity infrastructure. Based on that, the mapping of GRIDFLEX UCs requirements with the pilot site's conditions was realized in order to elaborate in detail and provide a picture of the possibilities of realization of UCs. Testing UCs in real conditions requires the integration and serious consideration of end-users needs and constraints in the process, in order to ensure the seamless and smooth integration of the new technologies in the operation of the electricity grid.

1.3 Structure of the document

This deliverable begins with an introduction in Section 1, presenting purpose, scope and structure of this document. Section 2 presents the methodology used to gather information including data sets and infrastructure characteristics as well as the mapping out of GRIDFLEX UCs in X-FLEX project to corresponding pilot sites. This is followed in Section 3 by detailed pilot sites analysis, for each of the 4 X-FLEX demo sites – Albena, Luče, Ravne na Koroškem and Xanthi - presenting grid conditions and requirements for UCs in order to be demonstrated at these pilot sites, focusing on GRIDFLEX tool requirements and pathways to obtain required data to perform design algorithms including notified gaps. Section 4 presents conclusions upon conducted analysis. Section 5 provides acronyms used in the project. In Section 6 are represented two Annexes (Annex A and Annex B). Annex A contains the three different types of the questionnaire used for collecting information from pilot site partners. Annex B includes an interview to pilot site partners conducted by the BPE team.

2 METHODOLOGY

2.1 Use Case overview

2.1.1 Introduction

To successfully perform a formal analysis of the grid infrastructure and GRIDFLEX UCs for each pilot site individually, the Blueprint Energy Team (BPE) team together in coordination and cooperation with partners working on WP3 (SERVIFLEX) and WP5 (MARKETFLEX) developed a questionnaire (see Annex A) in order to gather the required information for the UCs analysis from the pilot site partners. This questionnaire, together with interview (see Annex B) has been used for preparation of this report.

2.1.2 Methodology used for formal analysis of pilot site grid infrastructure

In order to accomplish T4.1, five main activities have been defined to conduct a successful analysis of UCs requirements with pilot site characteristics and capabilities (see Figure 1).

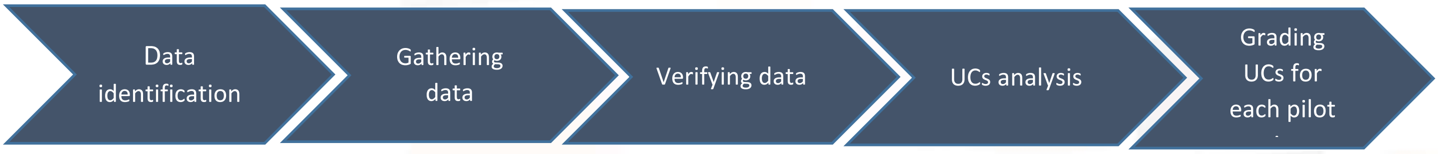

Figure 1: The five activities for successfully conducting T4.1

The questionnaire was created as an Excel spreadsheet that contains fields related to the necessary information regarding the grid infrastructure of pilot sites. The data collected from the partners were related to installed assets, asset measurements, electrical data, historical data, communication protocol and real-time network monitoring. The data collection activity lasted about a month, after which the BPE team organized a virtual meeting with all partners to, once again, confirm the accuracy of the data they had previously provided. After completing the data collection activity, the BPE team started organizing and classifying the collected data to bring all data to the same level. As the last activity, the BPE team evaluated the UCs for each pilot site individually according to the previously prepared data. As a guideline for collecting all UC's requirements, the BPE team used the document D2.2–Use Case and requirements definition, which describes and clearly defines all GRIDFLEX UCs and necessary requirements for their implementation. The deliverable D2.2 clearly shows what preconditions for the implementation of each UC must be met. The evaluation of UCs was performed by matching the main preconditions with the collected information from the pilot site partners. Following this procedure, the final comments on the possibility of UCs implementation for each pilot site were made.

2.1.3 Different types of collected data

Since most of the GRIDFLEX UCs will be implemented in almost all pilot sites, all pilot site partners provided certain technical data regarding their grid infrastructure in order to assess the conditions for GRIDFLEX UCs implementation.

The following bullets describe the different types of collected data and to which extent they are necessary:

- **PILOT SITE ASSETS DATA**

  Technical data refers to all installed assets (such as photovoltaic (PV), battery storage system, boiler station, Combined Heat and Power (CHP), etc.) in pilot site locations. This data includes their capacities, their measurements in a proper time interval, and measurement parameters such as voltage, current, energy input/output, active/reactive power, Alternating Current (AC)/Direct Current (DC), etc.

- **REAL-TIME INTERFACE**

  This data refers to the controllable switches and electrical measurements (current, voltage, power, energy) which are available in real-time thanks to a connection (if it exists) with GRIDFLEX. It starts from Supervisory Control and Data Acquisition (SCADA)[1], as the highest point of integration and goes down to Remote Terminal Unit (RTU) (or similar purpose device), or even to Intelligent Electronic Device (IED) - (meter, relay, etc.) - if no higher level device is available. It is expected for GRIDFLEX to use an interface for the local SCADA system, wherever it exists, and to look for interfaces to RTUs or IEDs only in case where no SCADA is available. For every connection point, type or product name should be defined and protocol of data exchange. If there is no protocol available, then the physical connection should be listed (i.e., Ethernet, or RS-232, or even on the signal level, 4-20 milliampere (mA)). The definition of real-time interfaces does not mean that GRIDFLEX should use all interfaces, but just to have in mind what activities should be performed prior to the installation of GRIDFLEX to get the possibility to control, or just monitor, the asset: pilot site could need to install new RTUs to provide an interface to GRIDFLEX.

- **HISTORICAL DATA**

  Similarly, to real-time data, access to historical data should be defined for all systems, i.e. their source, the query protocol and information on how to read the data. The source could be a database, or plain Extensible Markup Language (XML) or Excel (XLS) file. GRIDFLEX could decide either to have an interface to the source or use import procedure for it.

- **EXTERNAL SERVICES DATA**

  This data refers to any available data regarding weather forecast data/real-time data. In case the pilot site has this data available, the access and query protocol to import it into GRIDFLEX will be noted.

2.1.4 A short overview of GRIDFLEX UCs

GRIDFLEX is the X-FLEX tool for grid operators to shift supply and demand peaks, to prevent problems in the grid, such as congestion (voltage and current issues) and to avoid power quality problems with the increasing share of intermittent Renewable Energy Sources (RES), given special attention to the risks due to the impact of extreme weather events (EWEs) - e.g., EWE module will focus on extreme winds. The tool will use flexibility as an alternative to network reinforcement when it is more cost-efficient than traditional reinforcement of the network. To locally manage the network load and voltages, grid operators should have access to flexibility for their own use, increase network capacity, integrate storage capacity in a congested area, activate additional local demand, or even reduce injectable power by renewables at the local level.

The main functionalities of the tool are:

1 **Advanced system security, monitoring, and control of the electricity grid**:

  - Estimation of network state through real-time monitoring systems
  - Congestion detection and management
  - Anticipation of problems and incidents of the network based on the forecast of the network status
  - Network reconfiguration and restoration capabilities

[1] For Slovenian pilot sites an Internet of Things (IoT) platform (via TANGO API) will be the highest point of integration to the other X-FLEX tools or partners.

2 **Distribution System Operator (DSO) scheduling control**
   - Distributed Renewable Energy Sources (DRES) and demand forecast
   - Peak curtailment for adaptation to the loss of generation capacity or proactively for-profit maximization by avoiding the use of expensive energy sources during peak hours
- **DSO-Aggregator/DSO and DSO/Transmission System Operation (TSO) coordination schemas to provide ancillary services that optimize the activation of flexibility and network operation**
- **Consumers/prosumers management and other advanced services**
   - End-user fraud detection
   - Notification of unexpected events
   - Grid incidents detection and maintenance planning
   - SLAM integration (advanced smart meter coming from NOBEL GRID project)
   - Network resilience under extreme weather events

The process of UCs identification and definition has been performed using an analytical approach, starting from the project objectives and the GRIDFLEX tool to be developed, considering the needs of the end-users and of the energy infrastructure in the presence of high penetration of RES and flexibility sources and under the impact of extreme weather events. Considering the status of each one of the four demonstration sites (Albena, Luče, Ravne na Koroškem, Xanthi), their needs and goals, a correspondence has been carried out between the demos and the UCs. Moreover, the UCs have been associated with the respective functional and data requirements by their authors, and the operational requirements have been corresponded with the respective pilot sites. The list of the identified GRIDFLEX UCs is shown in the Table below (see Table 1) as per Deliverable 2.2.

Table 1: The list of GRIDFLEX UCs

GRIDFLEX UCs
Use Case 2.1: Network real-time monitoring
Use Case 2.2: Network planning
Use Case 2.3: Network reconfiguration
Use Case 2.4: RES scheduling control
Use Case 2.5: State estimation
Use Case 2.6: Grid incidents detection and maintenance
Use Case 2.7: Real time congestion detection and management
Use Case 2.8: Advanced forecasting tools
Use Case 2.9: Congestion forecast (LV/MV power flow)
Use Case 2.10: Real-time demand side management
Use Case 2.11: Anticipation of problems and incidents using DMS planning
Use Case 2.12: Automatic end-user notification
Use Case 2.13: End user fraud detection
Use Case 2.14: Increase system resilience in extreme weather events
Use Case 2.15: DSO-DSO / microgrid operator / aggregator cooperation schemes
Use Case 2.16: TSO - DSO cooperation schemes

2.1.5 Use cases mapping per pilot site

2.1.5.1 Albena pilot site

The Albena pilot site aims to implement 9 UCs (see Table 2) supported by GRIDFLEX tool, in order to improve its microgrid. The implementation of these 9 UCs aims to increase the reliability of the energy monitoring and grid resilience, by unifying and adding more monitoring points along with failure policy and alerting and prepare the microgrid for further on-site RES expansion. Power-to-heat (P2H) optimization is also planned in the boiler installations at hotels, where the management of domestic hot water for guests is the primary source of flexibility. The demonstration pilot will implement flexibility management and forecasting and will create flexibility market mechanisms with the provision of a model for financial incentives to flexibility owners as a motivation for future flexibility efforts and collaborations and a proper cooperation scheme between the TSO and DSO/microgrid operator (UC2.16)

Key issues to be tackled with GRIDFLEX tool:

- **Advanced monitoring and control of the microgrid**

  Albena aims to implement a holistic grid supervision system which would increase system resilience by having a greater observability and control of the grid network.

- **Ancillary services provision from micro-grid to the TSO targeting extreme weather conditions**

  Albena will explore possibilities to utilize the boiler installations as Demand Side Response (DSR) during heat waves (extreme weather conditions).

- **Ancillary services collaboration between microgrid and TSO targeting congestion (voltage and current issues) and avoiding power quality problems with the increasing share of intermittent RES**

  Similarly, the pilot will explore possibilities to utilize the biomass power plant and the batteries in case of transmission grid congestions. Respectively, the aim is to decrease power output from fossil fuels.

Table 2: Demonstrated UCs in Albena pilot site

ALBENA GRIDFLEX UCs
Use Case 2.1: Network real-time monitoring
Use Case 2.4: RES scheduling control
Use Case 2.5: State estimation
Use Case 2.7: Real-time congestion detection and management
Use Case 2.8: Advanced forecasting tools
Use Case 2.9: Congestion forecast (LV/MV power flow)
Use Case 2.10: Real-time demand side management
Use Case 2.12: Automatic end-user notification
Use Case 2.16: TSO – DSO cooperation schemes

2.1.5.2 Luče pilot site

In Luče pilot site, the X-FLEX project is planning to address specific issues by providing flexibility from DER (community battery, home batteries, PV, Electric Vehicle (EV) charging units) to enable further RES penetration in the Low Voltage (LV) network. The provided flexibility would help limit the use of standard methods for strengthening the network (installation of additional cables) and contribute for ancillary services to the DSO - and potentially to the TSO, with the tools and methods developed in X-FLEX. Luče pilot site aims to demonstrate cooperation among key actors (Local Energy Community/Aggregator – DSO) and improve the network operation, optimise costs and operational reliability inside the area operated by the DSO.

Key issues to be tackled with GRIDFLEX tool:

- **Distribution grid cooperation module**

  This module enables the DSO and Aggregator to optimally use the flexible energy sources present in the local grid. DSO proposes the limitations based on the operating state of the grid, and the Aggregator engages the flexible sources to optimize the grid support or the economic profit from market participation (e.g., wholesale or ancillary services market) or other existing or innovative market mechanisms proposed in X-FLEX.

- **Increasing the carrying capacity of RES in the distribution grid of the local energy community**

  - by optimal EV charging control strategy[2]
  - by the optimization of the present flexibilities (5 house batteries, a community battery)
  - by implementing the distribution grid cooperation module

The Luče pilot site will demonstrate GRIDFLEX tool, testing 11 UCs (see Table 3) with the main aim of enabling further penetration of RES (without standard measures to strengthen the grid), providing ancillary services for DSO and exploring possibilities to provide ancillary services to the TSO with the use of flexibility from controllable units. GRIDFLEX tool will foster the Local Energy Community/Aggregator - DSO cooperation (Petrol and Elektro Celje). The harmonization and optimization of the flexible energy technologies will also improve the resilience to extreme weather events.

Table 3: Demonstrated UCs in Luče pilot site

LUČE GRIDFLEX UCs
Use Case 2.1: Network real-time monitoring
Use Case 2.2: Network planning
Use Case 2.4: RES scheduling control
Use Case 2.5: State estimation
Use Case 2.7: Real-time congestion detection and management
Use Case 2.8: Advanced forecasting tools
Use Case 2.9: Congestion forecast (LV/MV power flow)
Use Case 2.10: Real-time demand side management
Use Case 2.12: Automatic end-user notification
Use Case 2.14: Increase system resilience in extreme weather events
Use Case 2.15: DSO-DSO / microgrid operator / aggregator cooperation schemes

2.1.5.3 Ravne na Koroškem pilot site

In Ravne na Koroškem, Petrol, as a main electricity grid operator of the industrial zone, is planning to provide flexibility on electricity grid by using synergies with the heat production and heat network operation with RES power-to-heat (P2H) technology. The pilot site will demonstrate 2 GRIDFLEX UCs (see Table 4) with the main aim of providing flexibility and ancillary services for the TSO and to optimize the combined operation of CHP units and the electrode boiler (RES P2H), resulting in improved efficiency and reliability of heat production. This way Petrol aims to optimize the engagement of flexible devices, improve the reliability of electricity and heat supply, demonstrate cooperation among key actors (TSO – DSO/Aggregator cooperation scheme), and improve the network operation costs and reliability inside its DSO area. In Ravne na Koroškem, Petrol has a

[2] EV charging control strategies (UC 1.3) will be demonstrated in Luče in limited form (demonstrating increase of carrying in RES capacity is questionable).

role of DSO and Aggregator. However, Petrol offers system services to TSO as an aggregator (due to the legal framework in Slovenia).

Table 4: Demonstrated UCs in Ravne na Koroškem

RAVNE NA KOROŠKEM GRIDLEX UCs
Use Case 2.1: Network real-time monitoring
Use Case 2.16: TSO – DSO/Aggregator cooperation schemes[3]

2.1.5.4 Xanthi pilot site

Xanthi pilot site aims to increase the network resilience against extreme weather conditions and increase the coordination between the available infrastructure through advanced monitor and control techniques such as RES/Demand forecasting, reconfiguration management, state estimation, etc. The GRIDFLEX tool can contribute to improve the operation of the system through proper management of the renewable energy resources and the network topology. Coordination of the available infrastructure will result in significant improvements in terms of power losses reduction and voltage stabilization.
Key issues to be tackled with GRIDFLEX tool:

- **Demand Side Management (DSM) functionalities for minimizing impact of extreme weather events**

  The impact of extreme weather events in Xanthi's distribution network will be reduced by applying the developed functionalities of the GRIDFLEX tool (e.g., advanced forecasting, automated restoration of the grid, network reconfiguration, resilience monitoring, advanced protection schemes, state estimation, etc.).

- **Scheduling of Distributed Energy Resources (DERs) for coordinated energy management of distribution networks**

  Coordination of the available devices will result in significant improvements in terms of power losses reduction and voltage stabilization. Appropriate strategies such as network reconfiguration could contribute to the improvement in power quality indexes.

Xanthi (HEDNO)[4] pilot site will demonstrate the GRIDFLEX tool and its capability of increasing system resilience, especially in extreme weather events. In this context, 14 GRIDFLEX UCs (see Table 5) will be tested and implemented at Xanthi (HEDNO) pilot site. Moreover, the GRIDFLEX UCs and its functionalities in the HEDNO network will contribute to a significant reduction of power losses and voltage stabilization through proper management of RES production and automation devices that are already installed in the grid.

Table 5: Demonstrated UCs in Xanthi (HEDNO) pilot site

XANTHI (HEDNO) UCs
Use Case 2.1: Network real-time monitoring
Use Case 2.2: Network planning
Use Case 2.3: Network reconfiguration
Use Case 2.4: RES scheduling control
Use Case 2.5: State estimation
Use Case 2.6: Grid incidents detection and maintenance
Use Case 2.7: Real-time congestion detection and management

[3] In Ravne, Petrol has a role of DSO and Aggregator. However, Petrol offers system services to TSO as an aggregator (due to legal framework in Slovenia)

[4] Sunlight System does not participate in the testing of GRIDFLEX UCs.

Use Case 2.8: Advanced forecasting tools
Use Case 2.9: Congestion forecast (LV/MV power flow)
Use Case 2.11: Anticipation of problems and incidents using DMS planning
Use Case 2.12: Automatic end-user notification
Use Case 2.13: End user fraud detection
Use Case 2.14: Increase system resilience in extreme weather events
Use Case 2.15: DSO-DSO / microgrid operator / aggregator cooperation schemes

3 PILOT SITE ANALYSIS

3.1 Albena pilot site

The Figure below (see Figure 2) represents Albena pilot site topology diagram provided by the Albena team.

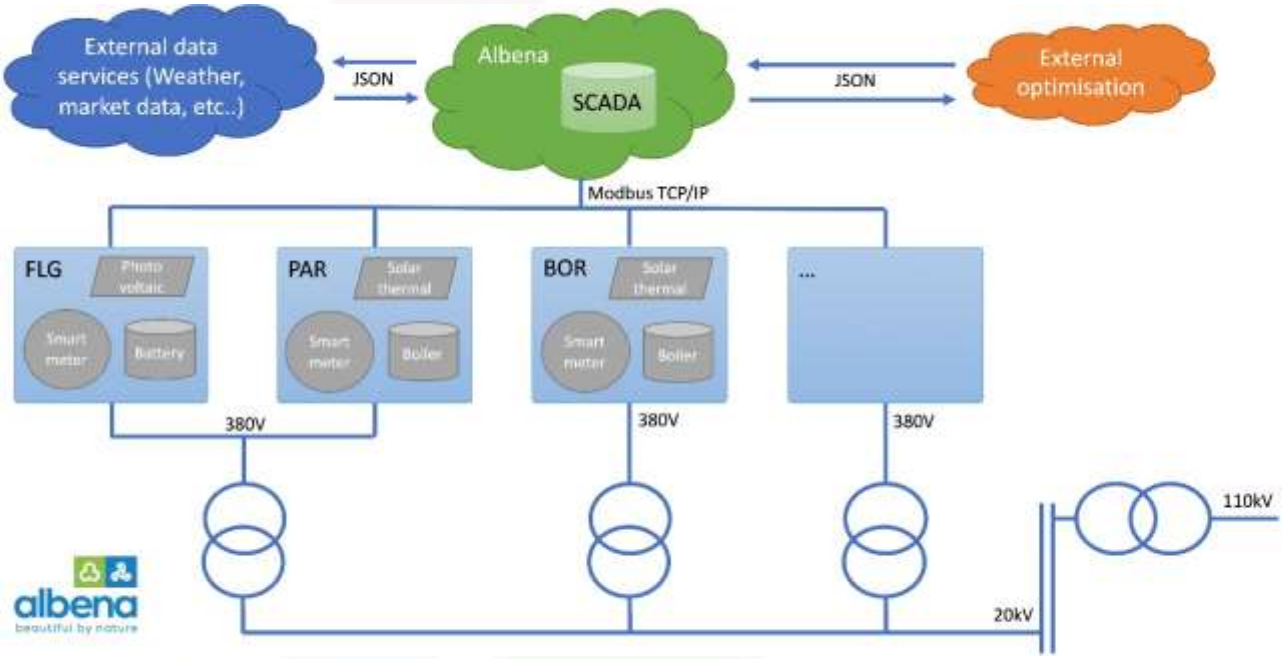

Figure 2: Albena grid topology

3.1.1 Grid conditions of the pilot site

Generation System

For the X-FLEX project purpose, the installed PV systems and solar thermal collector will be used for the Albena pilot site's demonstration activities. In the Tables below (see Table 6 and Table 7) technical information about the installed PV system and solar thermal collectors are outlined:

Table 6: PV Systems in Albena pilot site

PV SYSTEM	
System Information	Manufacturer: Yingli Solar Number of panels: 100 Nominal Power: 27 kW
Inverter type	Manufacturer: SMA Model: Sunny Tripower 25000TL-30 Number of inverters: 1

	Nominal Power: 27 kW
Inverter with integrated battery	No
Communication Protocol	ModBus RS485 / SCADA StruxureWare Power Monitoring
Control parameters	(N/A)
Measurement Parameters	Active Power, Energy Feed-in
Available measurement interval	Since August 2018
Frequency of data measurement	15 min, potentially 20 sec with SCADA upgrade

Table 7: Solar thermal collector in Albena pilot site

SOLAR THERMAL COLLECTOR	
Solar Collector System Information	Manufacturer: Sunsystem Model: SELECT PK 2,7
Communication protocol	ModBus RS485 Custom Modbus table interface / SCADA StruxureWare Power Monitoring
Measurement Parameters	Heat exchanger temperatures (inlet and outlet of both circles), current water debit, total water volume/debited in both boiler circle and solar circle, also thermal power and thermal energy in both boiler circle and solar circle.
Control Parameters	Water pumps start/stop control in boiler circle
Frequency of data measurement	15 min, potentially 20 sec with SCADA upgrade

Storage System

During X-FLEX project, two different storage technology types (battery storage and electrical boiler system) will be used for the UCs demonstration activities in the Albena pilot site. For the demonstration of P2H technology, in total 8 boiler systems are placed in the demo site, with multiple boilers per system and different capacity. In the Tables below (see Table 8 and Table 9), technical information about battery and electrical boiler systems are outlined:

Table 8: Battery systems in Albena pilot site

BATTERY SYSTEM	
Energy storage system information	Manufacturer / Model: Samsung/TESVolt Storage Energy: 201 kWh Usable Energy: 130 kWh (SOH: 66%) Type of electrode / Technology: Lithium Ion
Battery inverter(s) type and topology	Manufacturer: SMA Model: SunnyTriPowerStorage 60 STPS60 Number of Inverters: 3 Capacity for charge: 180 kW

	Capacity of discharge: 180 kW
Communication Protocol	ModBus RS485 Custom Modbus table interface / SCADA StruxureWare Power Monitoring
Measurement Parameters	SOC, DOD, Max Charge Current, Max Discharge Current, Real Energy Input, Real Energy Output, Voltage, Power, Current, Temperature
Control Parameters	Battery charge power and discharge power
Available measurement interval	Since October 2019
Frequency of data measurement	15 min, potentially 20 sec with SCADA upgrade

Table 9: Power to Heat – Electrical boiler system in Albena pilot site

Power to Heat – Electrical Boiler System	
Nominal Power	A list of water heater boilers connected to the SCADA system and will be considered in the project: **System ID** — **Power Capacity** System 1 – 8 Boilers — 96 kW System 2 – 10 Boilers — 120 kW System 3 – 7 Boilers — 84 kW System 4 – 7 Boilers — 84 kW System 5 – 10 Boilers — 120 kW System 6 – 8 Boilers — 96 kW System 7 – 12 Boilers — 282 kW System 8 – 8 Boilers — 188 kW **Total** — **1070 kW**
Boiler Parameters	**MaxChargePower** - the water heater's total real power in kW. Note: this can vary if some of the heaters burn out and thus become defective during regular operation. M**axNegativePower** - This is the calculated maximum discharge power of each boiler, which is static and can be computed once - this is based on the boiler capacity and the max expected hot water debit.
Communication protocol	ModBus RS485 Custom Modbus table interface / SCADA StruxureWare Power Monitoring
Measurement Parameters	CurrentRealPower, CurrentApparentPower, CurrentReactivePower, cosPhi, Voltage, CurrentThermalSOC - current state of charge in kWh (thermal), boiler current temperature, boiler min and max allowed temperature, boiler volume **Extra parameters:** temp inlet/outlet, water debit (litres), water flow (litres per second).
Available measurement parameter	Since June 2018
Control Parameters	Status ON /OFF per each boiler within a boiler station
Frequency of data Measurement	15 min, potentially 20 sec with SCADA upgrade

Measuring and monitoring

For the purpose of power meters measuring and monitoring the Albena grid, in total, 161 power meters measurement points are placed in the demo site. In the Table below (see Table 10) technical information about power meters is outlined:

Table 10: Power meters in Albena pilot site

POWER METERS	
System Information	Manufacturer: Schneider electric Device short names: PM3255, PM5100, PM700 Number of meters: 161
Communication Protocol	SCADA StruxureWare Power Monitoring
Measurement Parameters	Voltage, current, Energy input and output
Available measurement interval	Since June 2018
Frequency of data measurement	15 min, potentially 20 sec with SCADA upgrade

3.1.2 Requirements and Use Cases to be demonstrated at the pilot site

This section shows the mapping of all requirements for successful implementation of UCs with GRIDFLEX UCs that will be implemented on the Albena pilot site. GRIDFLEX requirements are already analysed in D2.2 but in this case (for purpose of formal pilot site analysis in D4.1) requirements refer to the technical preconditions of GRIDFLEX UCs that pilot site must meet in order to GRIDFLEX UCs be successfully implemented. Marks such as (Yes) and (No) strictly emphasize whether certain requirements are necessary at the pilot site or not. The mark (Yes) indicates that the condition is met, while the mark (No) indicates that this condition is not necessary for the implementation of UC (see Table 11).

During the analysis of Albena's grid infrastructure, it was concluded that the Albena pilot site meets all the necessary requirements for the implementation of the appropriate GRIDFLEX UC. But it is very important to note that, for the implementation of UC 2.9, UC 2.10, UC 2.12 and UC 2.16, in addition to the necessary technical preconditions of the grid infrastructure according to document D2.2, the tools GRIDFLEX, SERVIFLEX and MARKETFLEX must already be successfully applied at the pilot site.

Table 11: Mapping Albena pilot site conditions with UCs requirements

ALBENA REQUIREMENTS (technical preconditions of GRIDFLEX UCs defined in D2.2 that pilot site must meet in order to GRIDFLEX UCs be realized)									
Requirements/UCS	2.1	2.4	2.5	2.7	2.8	2.9	2.10.	2.12	2.16
Real-time monitoring (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assets installed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Automatic record of data (Yes/no)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Electrical data (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Historical data (Yes/No)	No	Yes	Yes	No	Yes	Yes	No	No	Yes
Grid topology (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather forecast data (Yes/No)[5]	No	No	No	No	Yes	No	No	No	No

[5] For UCs 2.12 and 2.16, weather forecast data is not a direct requirement for implementation. UCs 2.12 and 2.16 are (or can be) triggered by problems in the grid that are forecasted, and those forecasts do rely on past weather data and weather forecasts. So, at least indirectly, weather forecast data is involved.

Sociodemographic data (Yes/No)	No	No	No	No	No	No	No	No	No

In the Table below (see Table 12), the final comments with preconditions that must be met before GRIDFLEX UCs implementation are outlined. During the grid infrastructure analysis, no limitations for UCs implementation were recognized.

Table 12: Albena pilot site final comments regarding UCs implementation

UCS	Final comments
Use Case 2.1: Network and real time-monitoring	Albena meets all technical preconditions for the realization of this UC.
Use Case 2.4: RES scheduling control	Albena meets all technical preconditions for the realization of this UC.
Use Case 2.5: State estimation	Albena meets all technical preconditions for the realization of this UC.
Use Case 2.7: Real-time congestion detection and management	Albena meets all technical preconditions for the realization of this UC.
Use Case 2.8: Advanced forecasting tools	Albena meets all technical preconditions for the realization of this UC.
Use Case 2.9: Congestion forecast (LV/MW power flow)	Albena meets all technical necessary information and conditions for the implementation of preconditions for this UC. **Preconditions must be met**: Implementation of GRIDFLEX forecasting module is working as expected and GRIDFLEX has access to the details of the topology (namely, U limits per node and I limit per branch).
Use Case 2.10: Real-time demand side management	Albena meets all technical necessary information and conditions for the implementation of preconditions for this UC. **Precondition must be met**: SERVIFLEX could offer DSM mechanism that can be activated by sending the appropriate requests to MARKETFLEX through the X-FLEX Platform and GRIDFLEX provides the grid operator with a Graphical User Interface (GUI) that allows triggering these SERVIFLEX mechanisms automatically or manually for specific events.
Use Case 2.12: Automatic end-user fraud notification	Albena meets all technical necessary information and conditions for the implementation of preconditions for this UC. **Preconditions must be meet**: Ability of GRIDFLEX to recognize the type of event and inform the end-user about the event through some communication networks.

Use Case 2.16: TSO-DSO cooperation schemes	Albena meets all technical necessary information and conditions for the implementation of preconditions for this UC. **Preconditions must be meet**: Preliminary analysis of potential coordinated procedures between actors involved, communication channel (X-FLEX Platform) is available between actors and tools involved and actors are integrated in the market via MARKETFLEX.

3.2 Luče pilot site

The Figure below (see Figure 3) represents Luče pilot site LV topology diagram provided by the Elektro Celje team. In this Figure, metering points are highlighted with red colour, the substation is highlighted with blue colour, cable connectors are highlighted with green and distribution cabinets are highlighted with purple colour.

Figure 3: Luče pilot site topology

3.2.1 Grid conditions of the pilot site

Generation System

For the X-FLEX project purpose, the installed PV systems will be used for the Luče pilot site's demonstration activities. In the Table below (see Table 13), technical information about the installed PV system is outlined:

Table 13: PV systems in Luče pilot site

<table>
<tr><th colspan="2">PV SYSTEM</th></tr>
<tr><td>System Information</td><td>The list of PV systems considered in the project:
<table>
<tr><th>PV System</th><th>Nominal Power</th></tr>
<tr><td>PV#1</td><td>12.9 kW</td></tr>
<tr><td>PV#2</td><td>11 kW</td></tr>
<tr><td>PV#3</td><td>10.8 kW</td></tr>
<tr><td>PV#4</td><td>10.8 kW</td></tr>
<tr><td>PV#5</td><td>10.8 kW</td></tr>
<tr><td>PV#6</td><td>12.9 kW</td></tr>
<tr><td>PV#7</td><td>10.8 kW</td></tr>
<tr><td>PV#8</td><td>11 kW</td></tr>
<tr><td>PV#9</td><td>10.8 kW</td></tr>
<tr><td>Total</td><td>101.8 kW</td></tr>
</table></td></tr>
<tr><td>Inverter Type</td><td>Manufacturer: SolarEdge
Model: SE15K-RW000BNN4
Number of inverters: 9
Nominal Power: 15 kVA</td></tr>
<tr><td>Communication Protocol</td><td>Modbus</td></tr>
<tr><td>Measurement Parameters</td><td>Energy, Real power, Apparent power, Reactive power, Current, Voltage LN, Voltage Line to Neutral, Voltage Line to Line, Grid frequency, Power Factor, DC Voltage, DC Current, DC Power</td></tr>
<tr><td>Available measurement interval</td><td>Since 22.11.2019, except PV#2</td></tr>
<tr><td>Control parameters</td><td>Max production setpoint</td></tr>
<tr><td>Frequency of data measurement</td><td>1 min. (Voltage)
1 min. (Power)
1 day (Energy)</td></tr>
</table>

Storage system

During X-FLEX project, battery system and newly installed EV charging stations will be used for Luče pilot site's demonstration activities. In the Tables below (see Table 14 and Table 15), technical information about installed PV and EV charging system are outlined:

Table 14: Battery system in Luče pilot site

BATTERY SYSTEM	
Energy storage system information	Manufacturer / Model: Qinous ESS QCompact L Storage Energy: 333 kWh Type of Technology: Lithium Ion
Battery inverter(s) type and topology	Manufacturer: Qinuos Model: ESS QCompact L Number of Inverters: 1

	Capacity of charge: 150 kVA Capacity of discharge: 150 kVA
Communication Protocol	IP Based from Tango Platform (REST based WS)
Measurement Parameters	Active power output (A+), Reactive power output (R+), Active power output (A-), Reactive power output (R-), Voltage, Current
Available measurement interval	Since 11.2.2020
Control Parameters	Battery operation mode, charge and discharge setpoint
Frequency of data measurement	1 min

Table 15: EV charging system in Luče pilot site

EV CHARGING SYSTEM	
Energy storage system information	Manufacturer / Model: Etrel Type of Technology: Etrel Inch Pro Max. Charging power: 22 kW
Communication Protocol	Modbus
Measurement Parameters	Connector status, L-N voltage (L1), L-N voltage (L2), L-N voltage (L3), Current (L1), Current (L2), Current (L3), Active power (L1), Active power (L2), Active power (L3), Active power (total), Power factor, Total imported active energy in running session, Running session duration, Running session departure time
Available measurement interval	(N/A)
Control Parameters	Setpoint for charging power, Stop Charging, Pause Charging
Frequency of data measurement	1 min

3.2.2 Requirements and Use Cases to be demonstrated at the pilot site

During the Luče grid infrastructure analysis, it was concluded that the Luče pilot site meets all the necessary requirements for the implementation of the appropriate GRIDFLEX UCs. It is very important to note that for the implementation of UC 2.9, UC 2.10, UC 2.12 and UC 2.15, in addition to the necessary technical preconditions of the grid infrastructure, according to the document D2.2, the tools GRIDFLEX, SERVIFLEX and MARKETFLEX must already be successfully deployed at the pilot site. Also, for the UC 2.4, UC 2.7 and UC 2.15, it needs to be highlighted that implementation and real testing of these UCs are limited by existing contractual relationships between individual actors who operate at this pilot site.

Table 16: Mapping Luče pilot site conditions with UCs requirements

LUČE REQUIREMENTS (technical preconditions of GRIDFLEX UCs defined in D2.2 that pilot site must meet in order to GRIDFLEX UCs be realized)											
Requirements/UCS	2.1	2.2	2.4	2.5	2.7	2.8	2.9	2.10	2.12	2.14	2.15
Real-time monitoring (Yes/No)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assets installed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Automatic record of data (Yes/no)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Electrical data (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Historical data (Yes/No)	No	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes
Grid topology (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather forecast (Yes/No)[6]	No	No	No	No	No	Yes	No	No	No	Yes	No
Sociodemographic data (Yes/No)	No	Yes	No	No	No	No	No	No	No	No	No

In the Table below (see Table 17), the final comments with preconditions that must be met before GRIDFLEX UCs implementation are outlined. During grid infrastructure analysis, limitations for UCs implementation are recognized and described.

Table 17: Luče pilot site final comments regarding UCs implementation

UCS	Final comments
Use Case 2.1: Network real-time monitoring	Luče meets all technical preconditions for the realization of this UC. **Limitations:** Luče pilot site is limited only to simple LV network topology, and this UC could be only tested with assets connected on LV.
Use Case 2.2: Network planning	Luče meets all technical preconditions for the realization of this UC. **Limitations:** Luče pilot site is limited only to simple LV network topology, and this UC could be only tested with assets connected on LV.
Use Case 2.4: RES scheduling control	Luče meets all technical preconditions for the realization of this UC. **Limitations:** Implementation and real testing of this UC is limited to existing Petrol's management tools and by existing contractual relationships between individual actors (end users, Petrol and Elektro Celje).
Use Case 2.5: State estimation	Luče meets all technical preconditions for the realization of this UC.
Use Case 2.7: Real-time congestion detection and management	Luče meets all technical preconditions for the realization of this UC. **Limitations:** Implementation and real testing of this UC is limited to existing Petrol's management tools and by existing contractual relationships between individual actors (Petrol and Elektro Celje).
Use Case 2.8: Advanced forecasting tools	Luče meets all technical preconditions for the realization of this UC.
Use Case 2.9: Congestion forecast (LV/MW power flow)	Luče meets all necessary technical information and conditions for the implementation of this UC. **Preconditions must be met:**

[6] For 2.15, weather forecast data is not a direct requirement for implementation. UC 2.15 is (or can be) triggered by problems in the grid that are forecasted, and those forecasts do rely on past weather data and weather forecasts. So, at least indirectly, weather forecast data is involved.

	Implementation of GRIDFLEX forecasting module is working as expected and GRIDFLEX has access to the details of the topology (namely, U limits per node and I limit per branch). **Limitations:** Luče pilot site is limited only to simple LV network topology and this UC could be only tested with assets connected to LV.
Use Case 2.10: Real-time demand side management	Luče meets all necessary technical information and conditions for the implementation of precondition for this UC. **Preconditions must be met:** SERVIFLEX could offer DSM mechanism that can be activated by sending the appropriate requests to MARKETFLEX through the X-FLEX Platform and GRIDFLEX provides the grid operator with a GUI that allows triggering these SERVIFLEX mechanisms automatically or manually for specific events. **Limitations:** Implementation and real testing of this UC is limited to existing Petrol's management tools and by existing contractual relationships between individual actors (Petrol and Elektro Celje).
Use Case 2.12: Automatic end-user notification	Luče meets all necessary technical information and conditions for the implementation of precondition for this UC. **Preconditions must be met**: GRIDFLEX tool, and that is generating a message when an event is detected, the ability of GRIDFLEX to recognize the type of event and inform the end-user about the event through some communication networks
Use Case 2.14: Increase system resilience in extreme weather events	Luče meets all necessary technical information and conditions for the implementation of precondition for this UC. **Limitations:** Luče pilot site is limited only to simple LV network topology and this UC could be only tested with assets connected to LV.
Use Case 2.15: DSO-DSO / Microgrid operator / aggregator cooperation schemes	Luče meets all necessary technical information and conditions for the implementation of precondition for this UC. **Preconditions must be met**: Preliminary analysis of potential coordinated procedures (action(s) to be taken) between actors involved, communication channel (X-FLEX Platform) is available between actors and tools involved, and actors are integrated in the market via MARKETFLEX. **Limitations:** Implementation and real testing of this UC are limited to existing Petrol's management tools and by existing contractual relationships between individual actors (end-users, Petrol and Elektro Celje).

3.3 Ravne na Koroškem pilot site

3.3.1 Grid conditions of the pilot site

For the purpose of P2H optimization, in the Ravne na Koroškem pilot site, two CHP systems and one electric boiler system will be used. According to the latest updated information from pilot site activities, the electrode boiler was successfully installed and tested. The completed pilot site operational is expected on March 21st. In the Tables below (see Table 18 and Table 19), technical information about installed CHP systems and electrode boiler system are outlined:

Table 18: CHP systems in Ravne na Koroškem pilot site

<table>
<tr><th colspan="2">CHP SYSTEM</th></tr>
<tr><td>System Information</td><td>The list of all CHP systems installed at Ravne na Koroškem
<table>
<tr><th>CHP System[7][8]</th><th>Nominal Power</th></tr>
<tr><td>CHP#1</td><td>2.7 MWheat/MWel</td></tr>
<tr><td>CHP#2</td><td>2.7 MWheat/MWel</td></tr>
<tr><td>CHP#3</td><td>2.7MWheat/MWel</td></tr>
<tr><td>CHP#4</td><td>2.7 MWheat/MWel</td></tr>
<tr><td>Total</td><td>10.8 MWheat/MWel</td></tr>
</table></td></tr>
<tr><td>Communication Protocol</td><td>IP Based from Tango Platform (REST based WS)</td></tr>
<tr><td>Measurement Parameters</td><td>Active Elec power, Heat production, Natural gas consumption</td></tr>
<tr><td>Available measurement interval</td><td>Since July 2019</td></tr>
<tr><td>Control Parameters</td><td>Production Setpoint</td></tr>
<tr><td>Frequency of data measurement</td><td>5 min</td></tr>
</table>

Table 19: Power to Heat – Electrode boiler system in Ravne na Koroškem pilot site

POWER TO HEAT – ELECTRODE BOILER SYSTEM	
System Information	Manufacturer: Parat, Norway Type: high voltage electrode hot water boiler Capacity: 6 MW Power supply: 5 kV / 50 Hz
Tank Dimensions	D (mm) 2.100 - H (mm) 4.500 Transport weight: 6.500 kg Operation weight: 8.500 kg Test weight: 13.800 kg
Boiler Parameters	**MaxChargePower** (as per D3.1)- the water heater's total real power in 6 MW. Note: this can vary if some of the heaters burn out and thus become defective during regular operation.

[7] Technical details such as max MWheat power for each CHP system will be taken into account as part of GRIDFLEX design in WP4.

[8] The 2 units are in operation during the winter season. Other 2 units are on standby and are primarily used for ancillary services to the TSO.

	MaxNegativePower - This is the calculated maximum discharge power of each boiler, which is static and can be computed once - this is based on the boiler capacity and the max expected hot water debit.
Communication Protocol	IP Based from Tango Platform (REST based WS)
Measurement Parameters	CurrentRealPower, Voltage, CurrentThermalSOC - current state of charge/ capacity of stored heat in heat storage in kWh (thermal), heat production
Available measurement interval	(N/A)
Control Parameters	Production setpoint
Frequency of data measurement	5 min

3.3.2 Requirements and Use Cases to be demonstrated at the pilot site

During the Ravne na Koroškem grid infrastructure analysis, it was concluded that Ravne na Koroškem meets all the necessary requirements for the implementation of the appropriate GRIDFLEX UCs. But it is very important to note that for the implementation of UC 2.16, in addition to the necessary technical preconditions of the grid infrastructure, the tools GRIDFLEX, SERVIFLEX and MARKETFLEX must already be successfully applied at the pilot site, according to the document D2.2. Also, it is highlighted in the UC 2.16, that the implementation and real testing of this UC is limited by existing contractual relationships between individual actors who operate at this pilot site (Petrol and TSO).

Table 20: Mapping Ravne na Koroškem pilot site conditions with UCs requirements

RAVNE NA KOROŠKEM REQUIREMENTS (technical preconditions of GRIDFLEX UCs defined in D2.2 that pilot site must meet in order to GRIDFLEX UCs be realized)		
Requirements/UCS	2.1	2.16
Real-time monitoring (Yes/No)	Yes	Yes
Assets installed	Yes	Yes
Automatic record of data (Yes/no)	Yes	Yes
Electrical data (Yes/No)	Yes	Yes
Historical data (Yes/No)	No	Yes
Grid topology (Yes/No)	Yes	Yes
Weather forecast data (Yes/No)	No	No
Sociodemographic data (Yes/No)	No	No

In the Table below (see Table 21), the final comments with preconditions that must be met before GRIDFLEX UCs implementation are outlined. During grid infrastructure analysis, limitations for UCs implementation were recognized and described.

Table 21: Ravne na Koroškem final comments regarding UCs implementation

UCs	**Final comments**

Use Case 2.1: Network real-time monitoring	Ravne na Koroškem meets all technical preconditions for the realization of this UC.
Use Case 2.16: TSO-DSO aggregator cooperation schemes	Ravne na Koroškem meets all necessary technical information and conditions for the implementation of preconditions for this UC. **Preconditions must be met:** Preliminary analysis of potential coordinated procedures between actors involved, communication channel (X-FLEX Platform) is available between actors and tools involved and actors are integrated in the market via MARKETFLEX. **Limitations:** Implementation and real testing are limited to existing Petrol's management tools and by existing contractual relationships between individual actors (Petrol and TSO). The TSO's qualification process for ancillary services for electrode boiler in Ravne na Koroškem completed.

3.4 Xanthi pilot site

In the Figure below (see Figure 4), 42 MV single line diagram is represented as provided by the HEDNO team

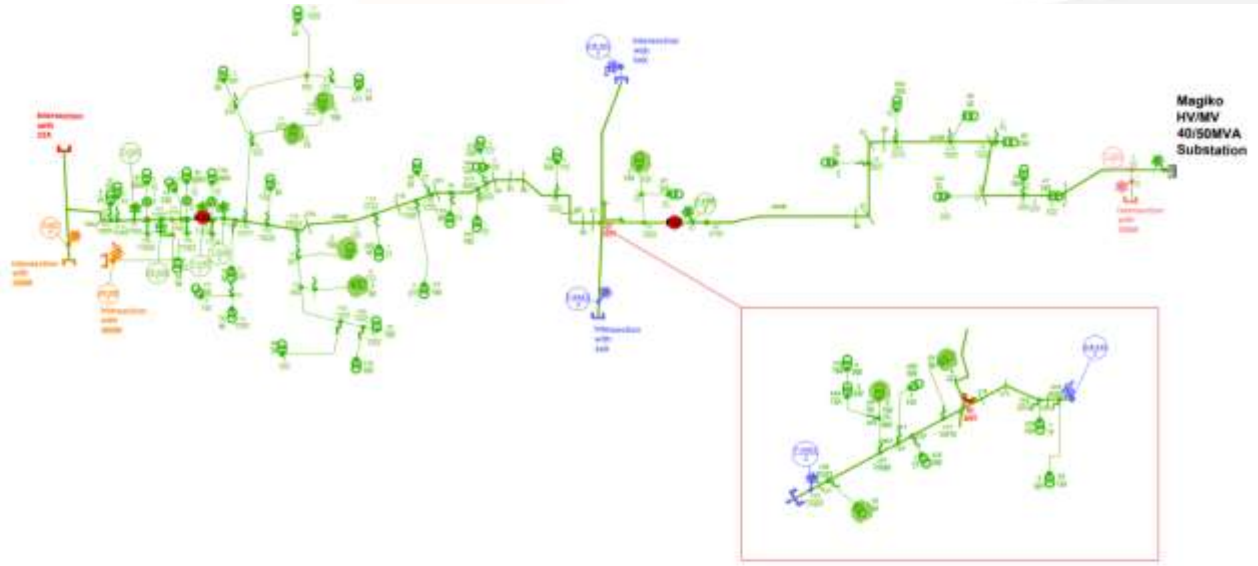

Figure 4: 42 MV line Xanthi

In the Figure below (see Figure 5), 39X MV single line diagram is represented as provided by the HEDNO team

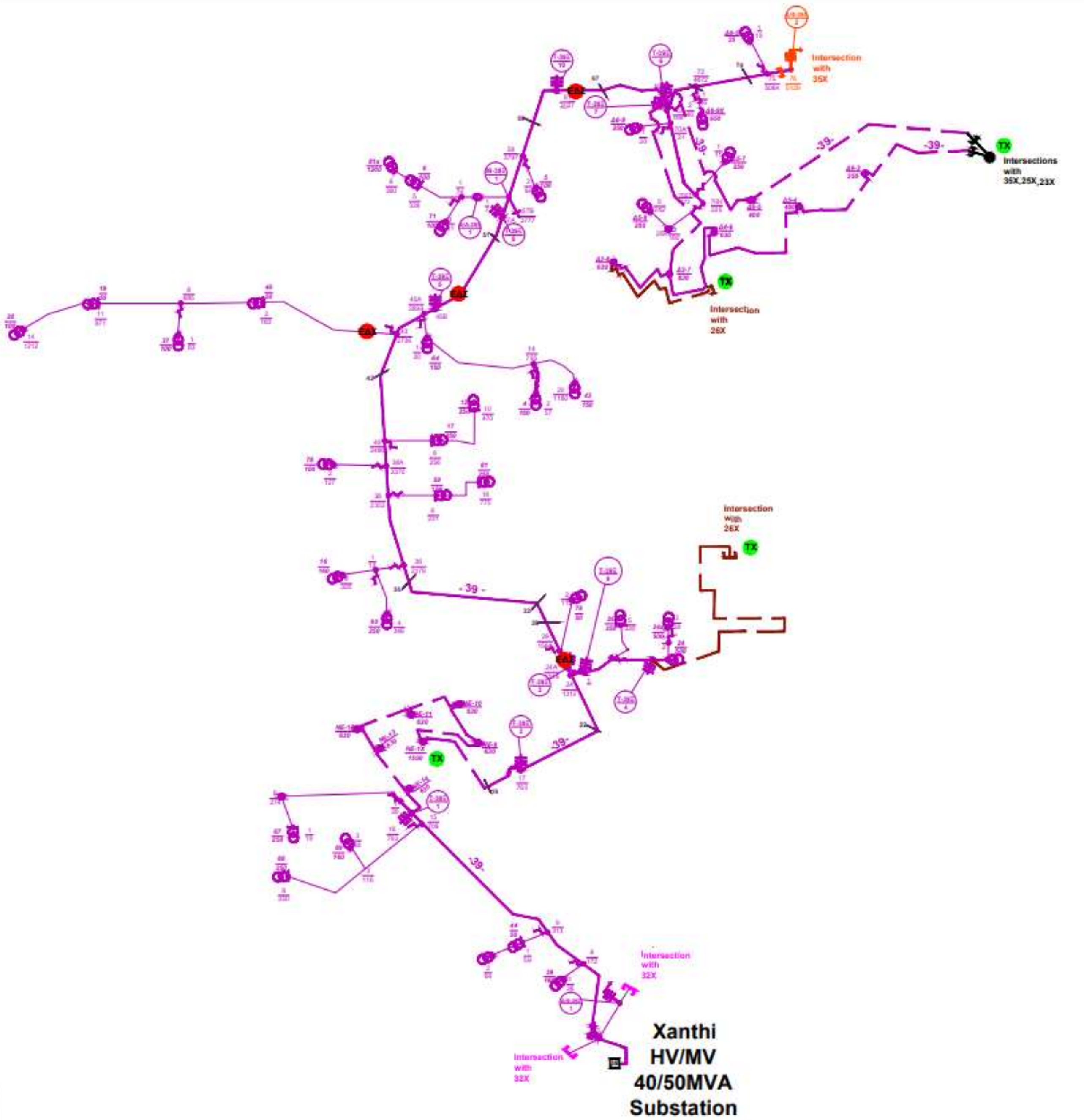

Figure 5: 39X MV line Xanthi

In the Figure below (see Figure 6), 33X MV single line diagram is represented as provided by the HEDNO team

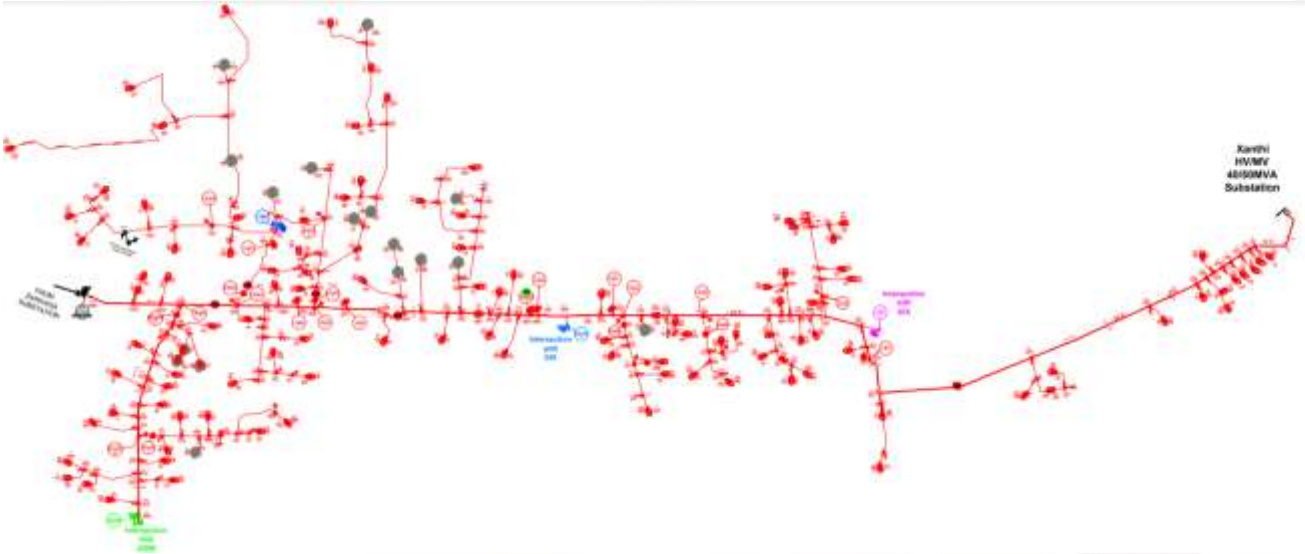

Figure 6: 33X MV line Xanthi

3.4.1 Grid conditions of pilot site

Generation system

For the testing of GRIDFLEX tool and GRIDFLEX UCs, only assets operated by HEDNO will be used for the demonstration activities. In the Table below (see Table 22), technical information of assets is outlined:

Table 22: List of PV assets operated by HEDNO

PV SYSTEM OEPRATED BY HEDNO		
System Information	A list of PV systems operated by HEDNO:	
	PV System	**Rated Power**
	PV 1 (LV) (at MV line 33X)	20 kW
	PV 2 (ΦBE-69) (LV) (at MV line 33X)	100 kW
	PV 3 (ΦBE-13) (LV) (at MV line 33X)	100 kW
	PV 4 (ΦBA-11) (LV) (at MV line 33X)	100 kW
	PV 5(ΦBE-34) (LV) (at MV line 33X)	100 kW
	PV 6 (ΦB-4X) (MV) (at MV line 33X)	150 kW
	PV 7 (ΦBMT-9) (MV) (at MV line 33X)	1000 kW
	PV 8 (ΦBE-56) (LV) (at MV line 42M)	67 kW
	PV 9 (ΦBE-56) (at MV line 42M)	100 kW
	PV 10 (ΦBE-32) (LV) (at MV line 42M)	100 kW
	PV 11 (ΦBE-18) (LV) (at MV line 42M)	100 kW
	PV 12 (ΦBE-39) (LV) (at MV line 42M)	100 kW
	PV 13 (ΦBE-40) (LV) (at MV line 42M)	100 kW
	PV 14 (ΦBE-41) (LV) (at MV line 42M)	100 kW
	PV 15 (ΦBΓ-35) (LV) (at MV line 42M)	100 kW
	PV 16 (ΦBE-87) (MV) (at MV line 42M)	100 kW
	PV 17 (ΦBE-2) (MV) (at MV line 42M)	150 kW

	PV 18 (MV) (at MV line 42M) — 500 kW PV 19 (ΦΒΓ-43) (MV) (at MV line 42M) — 500 kW Biomass 1 (MV at line 33x) — 250 kW
Inverter type	Number of inverters: 19 Manufacturer, Model, Nominal Power: (N/A) – not available during this initial analysis, will be addressed during design of GRIDFLEX tools in the next phase of the project
Communication Protocol	Device Language Message Specification (DLMS)/Companion Specification for Energy Metering (COSEM) (Electronic meters for telemetering purposes through IED)
Measurement Parameters	AC voltage, AC current, energy (reactive) consumption, energy (active) consumption/production
Available measurement interval	Provision of historical data of 1 year
Frequency of data measurement	15 min

Distribution system

Table 23: List of HEDNO MV lines

HEDNO MV LINE	
System Information	A list of MV lines operated by HEDNO: **MV line** — **Rated Power** MV line 1 (39X) — ~16 MVA installed power at the line MV line 2 (33X) — ~21 MVA installed power at the line MV line 3 (42M) — ~17 MVA installed power at the line
Communication Protocol	IEC 61850 (RTU and SCADA)
Measurement Parameters	Voltage (1 line), Current (1 phase), Apparent power
Available measurement interval	Provision of historical data of 1 year Only for MV line 42M, there will be not available historical data, since the metering equipment was very recently installed. Metering data will be collected from this point approximately from April 2021
Frequency of data measurement	30 min

MV/LV substations with telecontrollable switch

Table 24: HEDNO substations

HEDNO SUBSTATIONS	
System Information	A list of HEDNO (MV/LV) substations with telecontrollable switches: **Substations** — **Rated power** MV/LV substation NE-1X (at MV line 39X) — 1500 kVA

	MV/LV substation Δ3-7 (at MV line 39X)	630 kVA
Communication Protocol	IEC 61850, (RTU and SCADA) Telecontrollable switch	

3.4.2 Requirements and Use Cases to be demonstrated at the pilot site

During the Xanthi grid infrastructure analysis, it was concluded that Xanthi (HEDNO) pilot site meets all the necessary technical requirements for the implementation of the appropriate GRIDFLEX UCs, but there are some issues that must be clarified before UCs implementation. It is necessary to note that, for the testing of GRIDFLEX UCs, only assets operated by HEDNO will be used. According to document D2.2, the implementation of some UCs - in this case, UC2.9, UC 2.12, UC 2.11 and UC 2.15 - a successful implementation of GRIDFLEX, SERVIFLEX and MARKETFLEX tools is required first. In the Table below (see Table 25), the mapping between UCs requirements and UCs is outlined.

Table 25: Mapping Xanthi pilot site conditions with UCs requirements

XANTHI REQUIREMENTS (technical preconditions of GRIDFLEX UCs defined in D2.2 that pilot site must meet in order to GRIDFLEX UCs be realized)														
Requirements/UCS	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.11	2.12	2.13	2.14	2.15
Real-time monitoring (Yes/No)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assets installed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Automatic record of data (Yes/no)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Electrical data (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Historical data (Yes/No)	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes
Grid topology (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Weather forecast data (Yes/No)[9][10]	No	No	No	No	No	No	No	Yes	No	No	No	No	Yes	No
Sociodemographic data (Yes/No)	No	Yes	No	No	No	No	No	No	No	No	No	Yes	No	No

In the Table below (see Table 26) the final comments with preconditions that must be met before GRIDFLEX UCs implementation are outlined. During the grid infrastructure analysis, only a limitation for UC 2.15 was recognized.

[9] HEDNO receives only warnings of extreme weather events and not a periodical weather forecast

[10] External service providers will provide meteorological data (historical and forecasts) for Xanthi pilot site for UCs 2.8 and 2.14.

Table 26: Xanthi final comments regarding UCs implementation

UCS	Final comments
Use Case 2.1: Network real-time monitoring	Xanthi (HEDNO) pilot site meets all technical preconditions for the realization of this UC. **Note:** For this UC, as one of the technical preconditions is the installation of SLAM devices**.** At the time of writing, the installation of SLAM devices at Xanthi pilot site has not started yet. During further work in the X-FLEX project, HEDNO plans to install around 40 SLAM devices in the first phase. HEDNO team is currently working on the finalization of SLAM agreement with ETRA.
Use Case 2.2: Network planning	Xanthi (HEDNO) pilot site meets all technical preconditions for the realization of this UC.
Use Case 2.3: Network reconfiguration	Xanthi (HEDNO) pilot site meets all technical preconditions for the realization of this UC.
Use Case 2.4: RES scheduling control	Xanthi (HEDNO) pilot site meets all technical preconditions for the realization of this UC.
Use Case 2.5: State estimation	Xanthi (HEDNO) pilot site meets all technical preconditions for the realization of this UC.
Use Case 2.6: Grid incidents detection and maintenance	Xanthi (HEDNO) pilot site meets all technical preconditions for the realization of this UC.
Use Case 2.7: Real-time congestion detection and management	Xanthi (HEDNO) pilot site meets all technical preconditions for the realization of this UC. **Preconditions must be met:** Implementation of GRIDFLEX state estimation module is working as expected, and the module can contribute to the detection of congestion in the network.
Use Case 2.8: Advanced forecasting tools	Xanthi (HEDNO) pilot site meets all technical preconditions for the realization of this UC.
Use Case 2.9: Congestion forecast (LV/MV power flow)	Xanthi (HEDNO) meets all necessary technical information and conditions for the implementation of preconditions for this UC. **Preconditions must be met:** Implementation of GRIDFLEX forecasting module is working as expected, and GRIDFLEX has access to the details of the topology (namely, U limits per node and I limit per branch).
	Xanthi (HEDNO) meets all necessary technical information and conditions for the implementation of preconditions for this UC. **Preconditions must be met:**

Use Case 2.11: Anticipation of problems and incidents using DSM planning	Implementation of GRIDFLEX forecasting module is working as expected. MARKETFLEX and SERVIFELX are fully operational. Forecast of flexibility availability for grid operator owned assets and forecast of flexibility availability from MARKETFLEX.
Use Case 2.12: Automatic end-user notification	Xanthi (HEDNO) meets all necessary technical information and conditions for the implementation of precondition for this UC. **Preconditions must be meet:** Ability of GRIDFLEX to recognize the type of event and inform the end-user about the event through some communication networks.
Use Case 2.13: End user fraud detection	Xanthi (HEDNO) meets all technical preconditions for the realization of this UC.
Use Case 2.14: Increase system resilience in extreme weather events	Xanthi (HEDNO) meets all technical preconditions for the realization of this UC.
Use Case 2.15: DSO/DSO / microgrid operator / aggregator cooperation schemes	Xanthi (HEDNO) meets all necessary technical information and conditions for the implementation of precondition for this UC. **Preconditions must be met:** Preliminary analysis of potential coordinated procedures (action(s) to be taken) between actors involved, communication channel (X-FLEX Platform) is available between actors and tools involved, and actors are not integrated in the market via MARKETFLEX. **Limitations:** Since the MARKETFLEX tool's implementation is not foreseen at Xanthi pilot site[11], for now, it is known only that the MARKETFLEX will be used to identify the offer-request pairs that match and send the corresponding messages to fulfil them, following an approach similar as in Social Equity, but HEDNO will not test it as a market operation tool.

[11] So far, it was agreed that MARKETFLEX will be implemented but only basic functions of the tool will be used for DSM purposes

3.5 Pilot site socio-economic constraints and mitigations

While there are different attempts in the field to promote the integration of DERs in energy markets, there are still major issues that block the mass penetration of DERs in flexible market schemas, such as lack of interoperability in energy markets. The provision of flexibility services is a rather new concept and thus different rules apply per country or flexibility product and these are relevant for the development of all X-FLEX tools.

Although other work packages address the issue of socio-economic constraints in more in-depth analysis – for example D7.1–Pilot sites detailed project plan, as well as deliverables of WP8 (D8.2 – Business model analysis and economic impact assessment and D8.3 – Technical environmental and socio impact assessment), some noted risks and constraints can still be indicated here.

The issue of ongoing pandemic of COVID-19 has affected social and economic aspects of all industries and their supply chains, energy industry included. Therefore, the partners and particularly pilot site owners continue to closely monitor the situation and re-plan activities, to try to stick with the originally planned deadlines or notify everyone involved in case of delays. There is active collaboration with all the vendors regarding delays or rescheduling of equipment deliveries.

Also, regarding the obtaining of necessary permits (land use agreements, environmental permits, construction permit…), pilot site owners are actively cooperating with all relevant stakeholders to foresee barriers in time and find alternative solutions if needed.

Regarding social acceptance it has already been acknowledged for example in Greece that the key to successful implementation relies on ability to engage citizens in order to accept their participation in the project by allowing the deployment of SLAM meters inside their electrical installations. A similar point can be noted for Luče, regarding community or end user's engagement process. The goal of the community engagement process in Luče is to encourage the deployment of RES and storage technologies. On one hand partners will ensure supporting the investment of the local citizens in order to maximize the local benefits to their community and their energy system and on the other hand, trying to engage as many end users as possible to become the flexibility providers with their flexible assets.

Finally, in Bulgaria determining the fair price of flexibility still poses a challenge to be resolved. Connecting developed X-FLEX systems and modules to the Independent Bulgarian Energy Exchange (IBEX) market systems to allow for testing and prototyping flexibility transactions and performing system connection and data exchange between Albena AD and ESO EAD is closely monitored and actively being dealt with by all engaged Bulgarian partners.

4 CONCLUSION

To successfully perform a formal analysis of the grid infrastructure and UCs for each pilot site individually, as foundations analysis for development of GRIDFLEX tool on pilot sites, this report has also been coordinated with partners working on WP3 (development of SERVIFLEX tool) and WP5 (MARKETFLEX tool) – see Annex A. A questionnaire has been developed in order to gather the required information for the UCs analysis from the pilot site partners. This questionnaire, together with interviews, has been used for preparation of this report.

Smart technologies and appliances existing in pilot sites will enable flexibility users and procurers (TSOs, DSOs, balance responsible parties or aggregators) to develop grid and retail products and services tailored to the needs of the flexibility service providers respecting unique specifics of existing technology and coordination between involved stakeholders.

For the X-FLEX project's purposes, each pilot site had to integrate new assets and new devices into its network. The integration of new assets and devices required a lot of time and technical work on each pilot site's grid infrastructure. Due to the COVID-19 pandemic, they were delays in performing technical works at the pilot sites and in the delivery due to disrupted supply chains for equipment installed. Thanks to the excellent cooperation of all pilot site partners who participated in T4.1 who provided monthly updates on grid infrastructure and pilot site development, this assessment was completed without reduced scope and all pilot sites were validated as ready for implementation of planned UCs:

- The Albena pilot site aims to test 9 GRIDFLEX UCs.
- Luče pilot site aims to test 11 GRIDFLEX UCs.
- Ravne na Koroškem pilot site aims to test only 2 GRIDFLEX UCs.
- Xanthi pilot site aims to test 13 GRIDFLEX UCs.

The main identified remaining challenges for pilot sites can be summarised as follows:

- Communication and integration with the existing systems – main challenge is to ensure the implementation of the most appropriate communication protocols that are compatible with the existing infrastructure on one hand and enable advanced Demand Response algorithms, as well as the integration of newly installed assets (home EV chargers) into existing infrastructure (include EV chargers in already installed Home Energy Management System (HEMS)) on the other hand.
- Interaction with SCADA system in a way that would ensure the undisturbed and safe operation of the network (i.e., actions on the network and data reception) – as well as connectivity of all sub locations (for example, in pilot site Luče). As some locations do not have internet access or Global System for Mobile Communication (GSM) signal, possible solutions are being investigated.
- Adapting various existing local infrastructure at Albena Resort to perform monitoring and increase the fleet of controllable loads.

The analysis conducted in this deliverable should sufficiently serve as an input into defining and describing the use cases and requirements in the context of the development of GRIDFLEX tool as part of X-FLEX integrated ecosystem. Detailed overview of preconditions that should be met for GRIDFLEX tool are presented. These preconditions range from message generation when an event is detected, to adequate deployment of other X-FLEX tools to enable proper communication and, for instance, actually implement DSM actions or flexibility requests. Once these preconditions have been met, the formal analysis performed in task T4.1 has confirmed that the demonstration of the GRIDFLEX tool, together with the other X-FLEX tools should be successful, and that all desired impacts have a guarantee to be met towards the end of the project.

5 ACRONYMS

Acronyms List	
AC	Alternating Current
BPE	Blueprint Energy Solutions
CHP	Combined Heat and Power
COSEM	Companion Specification for Energy Metering
DC	Direct Current
DER	Distributed Energy Resources
DLMS	Device Language Message Specification
DMS	Distribution Management System
DRES	Distributed Renewable Energy Sources
DSM	Demand-Side Management
DSO	Distribution System Operator
DSR	Demand Side Response
EV	Electric Vehicle
EWEs	Extreme Weather Events
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
HEMS	Home Energy Management Systems
HV	High Voltage
H2020	Horizon 2020
IBEX	Independent Bulgarian Energy Exchange
ICCS	Institute of Communication and Computer System
IED	Intelligent Electronic Device
IoT	Internet of Things
IP	Internet Protocol
IPR	Intellectual Property Rights
LV	Low Voltage
MV	Medium Voltage
PV	Photovoltaic
P2H	Power-to-Heat
RTU	Remote Terminal Unit
RES	Renewable Energy Sources
REST	Representational State Transfer

SCADA	Supervisory Control and Data Acquisition
SGAM	Smart Grid Architecture Model
SLAM	Smart meters resulting from the H2020 NOBEL GRID project
TSO	Transmission System Operator
UC	Use Case
WS	Web Service
XLS	Microsoft Excel file format
XML	Extensible Markup Language

6 ANNEX A

The inserted images below (see Figure 7, Figure 8 and Figure 9) represent the screenshots of three different questionnaires that have been used to gather pilot sites technical information. Each of these questionnaires is described in detail in the executive summary.

					GRIDFLEX			
SMART GRID ASSETS					REAL-TIME INTERFACE FOR SWITCH			ELECTRICAL DATA
Pilot site	Asset type	Rated power, capacity / Description	Metered? (YES/NO)	Historical data available?	Source (SCADA; RTU; IED; OTHER)	Type/Product	Protocol	Source (DB, XLS, PAPER)

Figure 7: Questionnaire regarding assets information

LIST OF MEASUREMENT FROM ASSETS					REAL-TIME INTERFACE			HISTORICAL DATA		
Pilot site	Asset type	Parameter measured	Available measurement	Frequency of the measurement	Source (SCADA; RTU; IED)	Type/Product	Protocol	Source (DB, XML, XLS...)	Type/Product	Protocol

Figure 8: Questionnaire regarding assets measurement

EXTERNAL SERVICES						REAL-TIME INTERFACE			HISTORICAL DATA		
Pilot site	External data	Source	Parameters available	Available measurement interval	Frequency of the measurement	Source (SCADA; RTU; IED)	Type/Product	Protocol	Source (DB, XML, XLS...)	Type/Product	Protocol

Figure 9: Questionnaire regarding external services

7 ANNEX B

An interview between the BPE team and the pilot site partners conducted, after the information was collected, is shown below. The purpose of the meeting was to coordinate the questionnaire and align the different data in order to bring the data to the same level as well as to discuss the idea of further work on Task 4.1.

INTERVIEW WITH PILOT SITE PARTNERS
(Coordination of T4.1 questionnaires)

Organizator: Blueprint Energy Solutions (BPE)
Pilot site Partners: Hedno, Sulight, Petrol, Elektro Celje, Albena, ESO,
Participants: Boris Njavro (BPE), Stamatia Gkiala (HEDNO), Elektro Celje team, Petrol team, Albena team
Date: 31.07.2020
Duration: 40 min

1 XANTHI PILOT SITE (HEDNO AND SUNLIGHT)

Conversation between BPE and HEDNO team

Boris (BPE): *"Please could you explain LV line 1 and LV line 2 and LV Line 3 and substation. Please could you explain the information hidden behind these assets and the information about installed power?"*
Stamatia (HEDNO): *"So far, we have uploaded several versions of the questionnaire, but this is not LV line. This is the MV line, and it was a mistake from our side. We did not see it. So, we have MV line 1, MV line 2, MV line 3 included in the demo. We have data obtained from SCADA for the two first lines, but for the third line, we do not have any data, but we will have at some point during the project because meter equipment will be installed there. The information regarding installed power is corrected."*
Boris (BPE): *"Installed power is the power of the MV, MV/LV voltage substation, or the consumers' power?"*
Stamatia (HEDNO): *"This is related with the MV/LV substations with telecontrollable switches. On the other hand, the rated power of each of the three lines is the sum of the rated (installed) power of all the MV/LV substations of this line."*
Boris (BPE): *"In the questionnaire, you said you have MV/LV substation 1500 kVA. Please can you tell me how many of them you have? Because of installed power, I mean that there are several MV/LV substations. You put only installed power of one."*
Stamatia (HEDNO): *"There are only two telecontrollable substations that can be considered as smart assets and that's why only them have been included."*
Boris (BPE): ***"****Tell me more about PV."*
Stamatia (BPE): ***"****All PVs are connected to the three MV lines of the demo, but not only on the MV level. As you can see in the table, we have PVs on MV and LV level"*

Conversation between BPE and Sunlight team

Boris (BPE): *"What is the reason for the missing GRIDFLEX part in the questionnaire?"*
Sunlight team: *"Microgrid will be involved in the SERVIFLEX, that's why data are missing. We have sensors for each device the sensors are communicating with industrial PC. All collected data are sent to the PC server, except one inverter (main inverter), which communicates directly to the Modbus."*

2 SLOVENIA PILOT SITES (ELEKTRO CELJE AND PETROL)

Conversation between BPE and Elektro Celje team

Boris (BPE): *"For Real-Time, we can access it from API. What about electrical data meaning the technical part of the assets topology? Can also you provide these data in some digital format for GRIDFLEX?"*
Elektro Celje team: *"We cannot provide data for Ravne na Koroškem pilot site. We could provide only for Luče. For Ravne na Koroškem, we cannot see the data. Ravne na Koroškem has its distribution system. Petrol is the distributor of Ravne na Koroškem."*
Boris (BPE): *"Can you take from Ravne na Koroškem the electrical assets data and send us the information."*
Boris (BPE): *"For the Luče pilot site, do you have shared files that you can provide for the GRIDFLEX to import electrical data?"*
Elektro Celje team: *"Yes, we have. We have already sent to the University of Ljubljana and Petrol this kind of data. We can send it to anyone else who required this data."*

Conversation between BPE and Petrol team

Boris (BPE): "*Regarding the Tango platform, can you also, in any case provide the possibility for GRIDFLEX to control directly on the object and assets, or this must go through the tango platform."*
Petrol team: *"It must go through the tango platform."*

3 ALBENA PILOT SITE (ALBENA AND ESO)

Conversation between BPE and ALBENA team

Boris (BPE): *"Please could you give more information about cables length and type? You said that you have DBs and XLS, but you need to do some measurements."*
Albena team: *"This is the not final version of the uploaded document. We have uploaded version V0.3. We can do this, but it would take a lot of resources and costs, so before going in that direction. We would like to find out what it would be needed for this task and the scope you need in terms of information for that particular case. The network is fast, and it would take a lot of resources."*
Albena team: *"Do you need a cable length for some kind of simulations or calculation? It should be enough. Do you also need the diameters and type of materials?"*
Boris (BPE): *"The several grid flex use cases actually dealing with the calculations of the parameters, voltages, planning, and we need it."*
Albena team: *"This could be a problem because our network is quite big. For example, the MV grid is 45km, and the LV is like 100km".*
Boris (BPE): "*We need only for loads that will be part of GRIDFLEX"*
Albena team: *"We can do for the load, which will be configured in the grid flex. We can do it."*