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# DEMOCRAT

## Deliverable D3.5 – Report with the Technical Specification of the Communications System

Activity: Technical Specification of the Solution and Its Components

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| Editor: | Filipe Pereira |
| Dissemination level: (Confidentiality) | Public |
| Suggested readers: | DEMOCRAT Team |
| Version: | 0.2 |
| Total number of pages: | 13 |
| Keywords: | Communications, Microgrid |


DEMOCRAT ABSTRACT

The DEMOCRAT project aims at demonstrating an integrated and innovative micro-grid concept applied to LV and MV networks, as a suitable solution for efficiently managing their distributed energy resources (DER), working simultaneously as a flexible asset of the distribution networks.



DEMOCRAT is a project co-funded by:

COMPETE 2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

# Document

| | | |
|---|---|---|
| **Name** | Deliverable D3.5 – Report with the Technical Specification of the Communications System | |
| **Document No.** | AS18005792 | |
| **Revision and Date** | 0.2 | 2018-06-30 |
| **Project** | DEMOCRAT | |
| **Made by** | Filipe Pereira | |
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| **Approved by** | Ivan Sousa | |
| **Total Pages** | 13 | |

## Language Requirements (for non-native English speakers)

In order to fully understand the content of this document, it is therefore recommended that the reader possesses a language proficiency equivalent to B1 level, according to European Language Levels

## Disclosure

# Revisions

| Rev. | Date | Comments | Author |
|---|---|---|---|
| 0.1 | 2018-06-10 | Document release | Filipe Pereira |
| 0.2 | 2018-06-30 | Final Version | Filipe Campos |
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# Executive Summary

This deliverable presents to the user a high-level overview of the communication flows between all the systems and devices present on the microgrid solution developed within DEMOCRAT project scope. The outcomes of this task will provide the integration architectures, including data models to be exchanged among systems necessary for the implementation of the all the foreseen functionalities of the microgrid management system. This technical specification has been performed in such a way an integrated management of the network is leveraged.

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# Glossary

| | |
|---|---|
| BESS | Battery Energy Storage System |
| DER | Distributed Energy Resources |
| DMS | Distribution Management System |
| DR | Demand Response |
| DSO | Distribution System Operator |
| ESCOs | Energy Services Companies |
| EV | Electric Vehicle |
| HV | High Voltage |
| LV | Low Voltage |
| MV | Medium Voltage |
| SCADA | Supervisory Control and Data Acquisition |

# 1. Introduction

DEMOCRAT – DEMOnstrator of a miCro grid integRAting sTorage – is a demonstration project resulting from an integration process of a set of individual solutions and technologies developed by Efacec Energia within the scope of Smart Grids, jointly with its Storage and Inverters solutions, allowing the development of a turnkey micro-grid solution for wide-scale application for electrical power systems. More than a solution that enables the on-grid and off-grid grid operation, DEMOCRAT extends these functionalities by endowing the micro-grid with advanced management capabilities, in such a way it works as a flexible asset of distribution networks by aggregating and coordinating their Distributed Energy Resources (DER), such as charging stations infrastructures for Electric Vehicles (VE). DEMOCRAT enables, among others, the increasing of the networks capacity to host new DER, to increase the penetration levels of renewable energy in the energy mix and the improvement of the quality of service and energy, while deferring investments in network infrastructures.

This deliverable, D3.5, belongs to the Activity 3 – Technical Specification of the solution and its components -, as depicted in Figure 1.

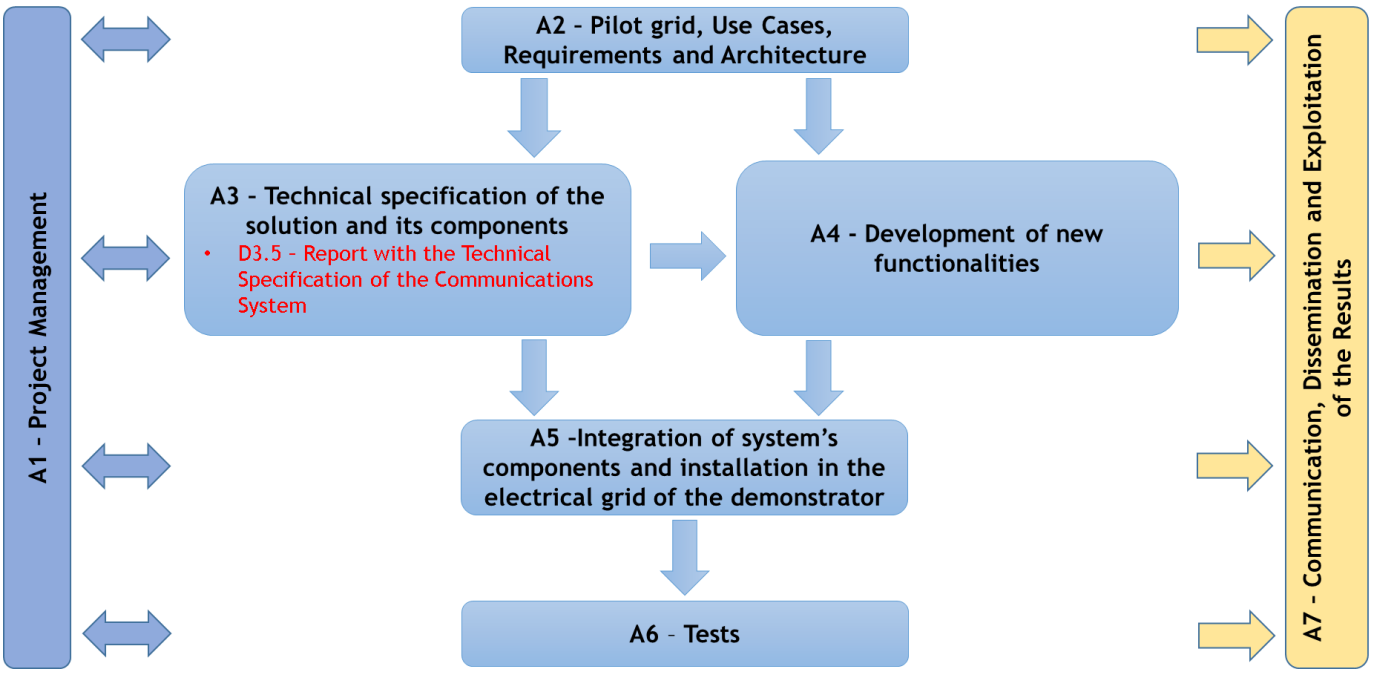


**Figure 1 - Position of the deliverable D2.3 within DEMOCRAT activities structure.**

The purpose of this document is to provide an overview of all the integration architectures between the different systems and components present on microgrid solution, which are mainly spread across three main layers: i) external systems ii) backend systems on the cloud where all the microgrid management is performed and iii) field systems consisting of all devices that are used to not only perform local controls but equally provide data to the upper level systems. With this document it will be possible to proceed with the system's implementation, and thus, leading to its real demonstration. This document specifically targets the communication flows between each of the involved parties, devices and systems.

# 2. Communication System Overview

This chapter comprises an overview of the main communication systems and respective architecture to be deployed on the microgrid solution developed within DEMOCRAT scope.

The functional communication architecture to be microgrid solution is summarized in **Error! Reference source not found.**. This architecture is divided into three layers:

- External Data Source Layer constituted by:
    - Third-party servers that will provide inputs to the microgrid operation which may be related with market conditions (e.g. energy market prices) or technical information provided by corporative systems from electric utilities, namely Distribution System Operator (DSO) or Demand Response (DR) interactions. For demonstration purposes the energy services simulator platform will be used. Weather Forecast provider that will be used as input for the functions available in the microgrid management system
- Back-end Layer (e.g. running on cloud) constituted by the:
    - Microgrid Management System that will be responsible for the overall high-level microgrid management and operation including treatment of the information gathered from the fields and determination of control actions to be carried out by the controllable devices.
- Local equipment Layer: encompasses all the devices installed on the field which may be divided into three categories:
    - Controllable devices: devices than can receive controls in order to change their operation point – energy storage systems and EV charging stations
    - Active devices: devices that despite not being controllable, their behaviour impacts the operation state of the controllable devices, such as generation resources.
    - Monitoring (passive) devices: used to monitor the network's operation conditions and the operation point of all the assets present on the field.

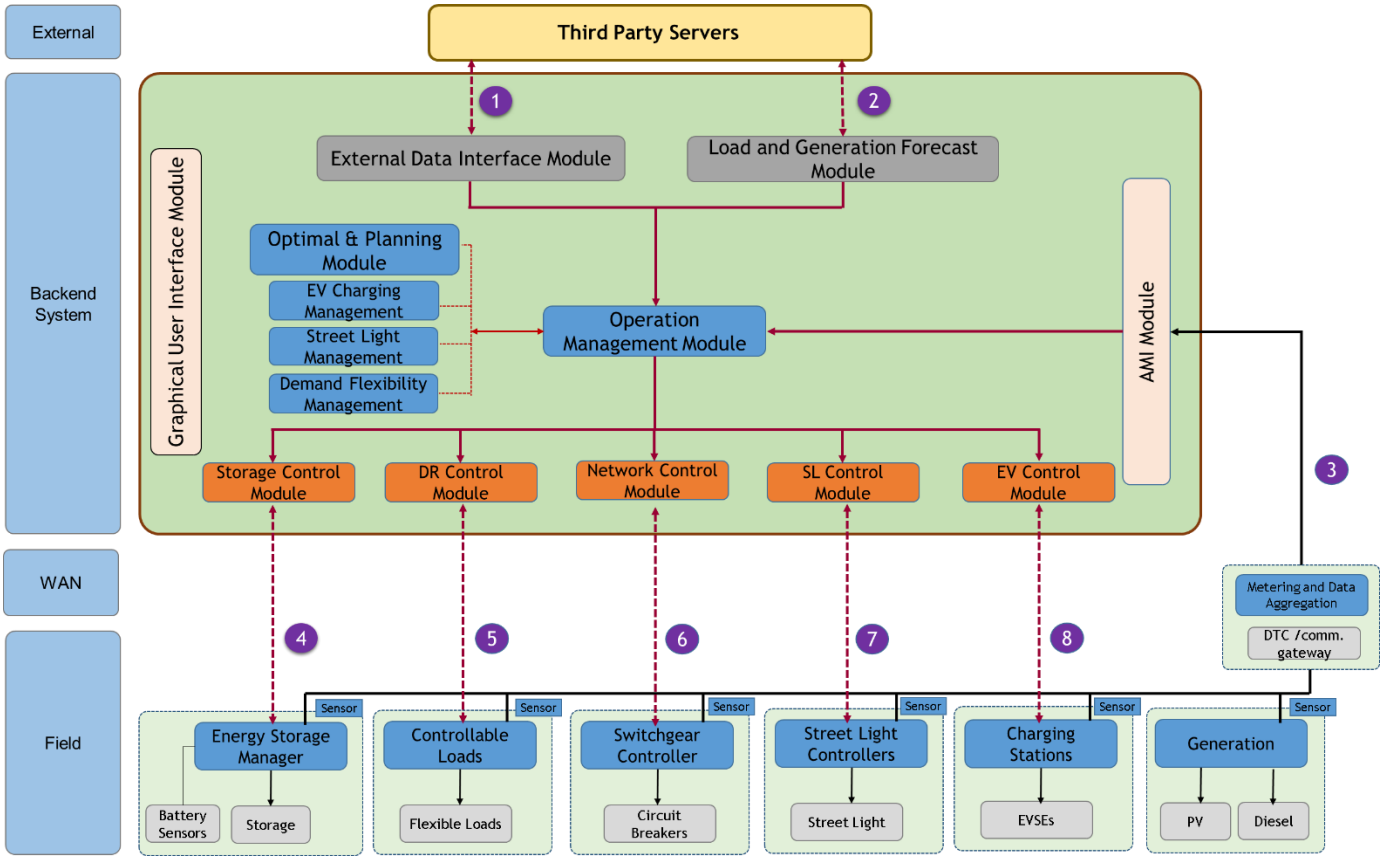


**Figure 2 - Communication Architecture of DEMOCRAT solution.**

The communication flows represented on the Figure 2 and respective technology are thoroughly described below.

## 2.1 Communications between Third-Party Servers and Microgrid Management System

The microgrid management system is able to receive information from external systems to adjust the operation of the grid accordingly. For this purpose, can be identified two main communications:

1. Information sent from Energy Services Companies (ESCOs) namely from energy retailers or energy services companies, with market information. Within market information can be considered energy tariffs, or other inputs related with the energy prices. In addition, this information flow can also be used to receive demand response information, such as events. For this purpose, the protocol OpenADR 2.0b that provides a standard interface between different stakeholders present on electrical power systems for energy management purposes.

2. Data regarding the weather forecast conditions for the locations where there are renewable energy generation units installed and for the locations where the demand forecast is required. The weather forecast data may comprise among others information about temperature, solar irradiance and clouds. For accessing this information, it will be used web services.

   Table 1 shows an example of the data that will be sent by weather forecast provider.

**Table 1 - Day-ahead temperature forecast (illustrative)**

| Date | Hour | Temperature (ºC) |
|---|---|---|
| 14/07/2018 | 0 | 17,3 |
| 14/07/2018 | 1 | 16,8 |
| (...) | (...) | (...) |
| 14/07/2018 | 23 | 18,4 |

## 2.2 Communications between Field Layer and Microgrid Management System

This section details the main communication flows between the field and the microgrid management system:

3. Real-time measurements from devices such as Distribution Transformers Controllers (DTC), smart meters, smart sensors and other Intelligent Electronic Devices (IEDS), which includes measurements of several electrical quantities such as voltage, active power and reactive currents. These devices are also responsible for sending alarms and events about the network operation. The data collection can be performed under different modes: Real-time measurements of critical electric variables: voltage, active and reactive power, current and voltage, MV/LV power transformer; Data from non-real time measurements that are typically associated to the monitoring of energy consumptions/generation for pre-defined integration periods. This information is sent by the devices with measuring capabilities to the DTC which will then be responsible for delivering this information to the microgrid management system. This channel can also be used to send control signals to the devices installed on the field. The protocol used for building the AMI relies on several communication technologies such as GPRS, Lora and Modbus depending on the location of the assets and its characteristics.

4. Information to be exchanged between the microgrid management system and the energy storage manager. Within this information can be mentioned the planned output power for the storage system for a few hours ahead or command signals for the real time operation. For this communication channel will be used the protocol EC 60870-5-104. Below is detailed the main information to be exchanged between these two systems:

**Table 2 - Configuration data of the Energy Storage System**

| Variable | Designation |
|---|---|
| Uid | Unique identifier of the Storage System |
| NominalCapacity | Energy Capacity Battery |
| NomimalChargePower | Max Instantaneous Charging Power |
| NomimalDisChargePower | Max Instantaneous Discharging Power |
| MaxTemperature | Max admissible temperature |
| MinTemperature | Min admissible temperature |
| Max Number Cycles | Lifecycle of Storage system |
| SOC Limits | Max and Min Soc of Storage System |

**Table 3 - Runtime data.**

| Category | Variable | Description |
|---|---|---|
| Metering | SOC | Current SOC of Battery System |
| | Frequency | Voltage wave frequency |
| | IR | Current on Phase R |
| | IS | Current on Phase R |
| | IT | Current on Phase R |
| | VRS | Voltage between Phase R and S |
| | VST | Voltage between Phase S and T |
| | VTR | Voltage between Phase T and R |
| | pf | Power Factor |
| | S | Apparent Power |
| | P | Active Power |
| | Q | Reactive Power |
| | SoH | State of Health of the battery system |
| | Cycles | Current Number of Cycles |
| Events/Alarms | HighGridVoltageAlarm | Voltage above threshold |
| | LowGridVoltageAlarm | Voltage below threshold |
| | HighFrequencyAlarm | Frequency above threshold |
| | LowFrequencyAlarm | Frequency below threshold |
| Commands | Setpoint_ActivPow | SetPoints for storage control - active power |
| | Setpoint_ReactPow | SetPoints for storage control - reactive power |
| | TurnOnCommand | Trigger Storage Mode On Service |
| | TurnOffFullStopCommand | Trigger Storage Mode Off Service |
| | TurnOffPartialStopCommand | Trigger Storage Mode On Partial off-Service |
| | IslandedModeCommand | Trigger Islanded Mode |

5. Information to be exchanged with systems that are in charge of controlling flexible loads, such as when a set point for increasing or decreasing the load is sent. Can also be used to send data regarding the forecasted operation conditions for the following hours/day-ahead.

6. Request for an automatic action at the distribution cabinet level or at the secondary substation level - opening a switch to undertake maintenance on a part of the network downstream from the cabinet; topology change by acting on switches, opening and closing a normally open switch or to isolate the microgrid from the main grid. For this communication channel will be used the protocol EC 60870-5-104.

7. Chanel used to exchange information regarding the streel light operation. Depending on the type of control and equipment deployed, the communication architecture can vary, as depicted in Figure 3. On the secondary substation are typically the devices that serve as communications interface, enabling to establish a bidirectional communication channel to the exchange of information between the microgrid management system and the street light equipment. with the upper levels. Typically, in first stage the street light management module exchanges information with the Distribution Transformer Controller (DTC) – Efacec GSmart. Then the GSmart sends this information to the communications gateway containing the target equipment address and the respective control action. The communication gateway is then responsible for conveying the controls to the equipment in the

respective communication technology, such as LoRa or GPRS communications and on the right data model of each device. This way it is possible to combine in the same network a multitude of different types of devices with different features.

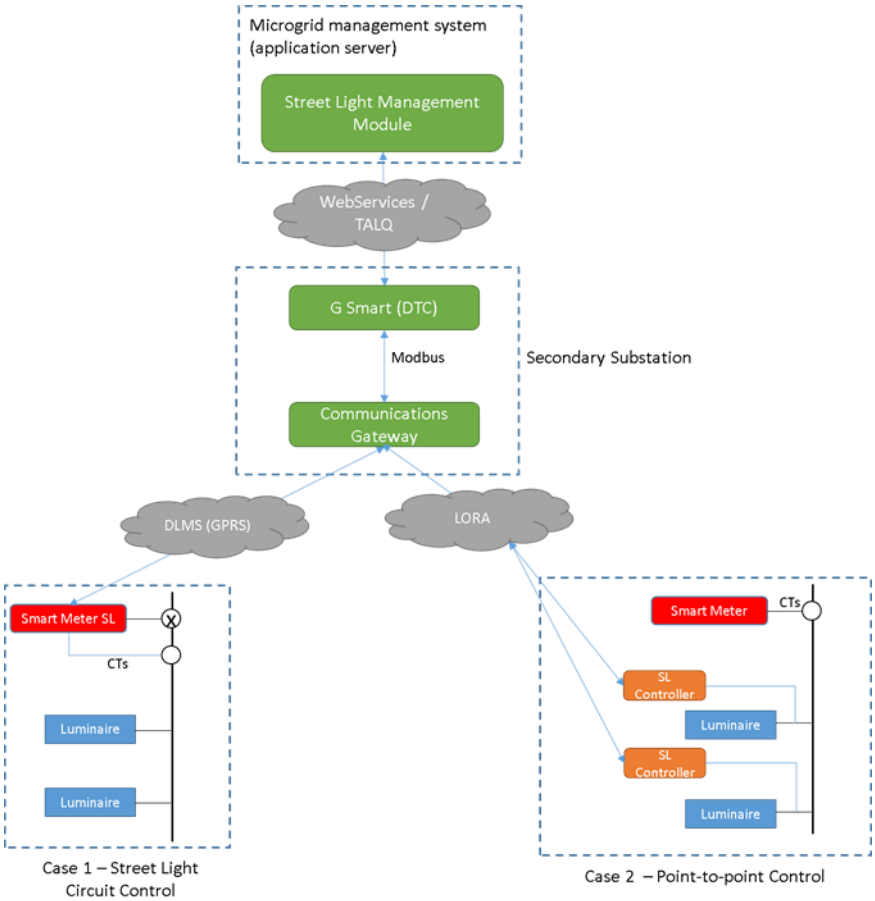


**Figure 3 - Detail of the communication architecture for Street Light control.**

8. Used to intercommunicate the microgrid management system and the charging stations. The communications are carried out using the standard protocol OCPP. This channel is particularly important to send command signals for the charging stations, as EV charging profiles for instance, so that the operation of the microgrid is not compromised.