Smart_Rural_Grid

"Smart ICT-enabled Rural Grid innovating resilient electricity distribution infrastructures, services and business models"

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Executive summary

This document is an iterated version of deliverable D2.4 titled “Data and values specifications, managing procedures, v1” submitted during M6. The iteration process tracks modifications and changes made to the original version of semantic model for integrating smart rural grid control room with IDPR considering the outcomes of platform integration and pilot evaluation reports from WP 6 and 7 respectively.

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Abbreviations and Acronyms

Acronym	Description
D	Deliverable
EMS	Energy Management System
IEC	International Electrotechnical Commission
IDPR	Intelligent Distributed Power Router
RTU	Remote Terminal Unit
WP	Work package
LC	Local Control
TC	Transformer Centre as secondary substation
BMS	Battery Management System
LEMS	Local Energy Management System
SRG	Smart Rural Grid
T	Task
MV	Medium Voltage
LV	Low Voltage
SCADA	Supervisory Control and Data Acquisition
CVM	Electrical Network Analyser
WAN	Wide Area Network
PAN	Personal Area Network
PLC	Power Line Communications
TCP	Transmission Control Protocol
IP	Internet Protocol
WiMAX	Worldwide Interoperability for Microwave Access
I/O	Input/Output

1 Introduction

This document is a deliverable report under Task T2.4 “Integration in control centre room” for WP2 in the FP7 Smart Rural Grid (SRG) project. The aim of this report is to document the modifications and iterations to the semantic model for control room integration of Intelligent distribution power router (IDPR) outlined in deliverable report D2.4 prepared during M6 of the project. This report tracks the changes to the parent document considering the outcomes of platform integration and pilot evaluation from WPs 6 and 7 respectively since M6. Hence, it is suggested that this document be used together with the parent document for reference purposes. Additionally, the following deliverable reports are used as reference documents for better understanding:

1. D6.3 System Field Trials Readiness Assessment Report
2. D7.2 Pilot Preliminary Evaluation

The overall goal of task T2.4 is to determine parameters needed to manage and operate control room centre and to specify processes for managing data, values and events. Deliverable report 2.4 has specified the managing procedures with respect to control room display design, use cases for control room, communication interfaces and protocols for control room operation and finally, control room integration. In this report, the various iterations and changes to the above-mentioned managing procedures developed since M6 have been tracked and documented.

2 Control room display design

Control room display plays a significantly important role in visualizing data, values and events. Guidelines for control room display design are largely relevant for managing procedures and specifications related to data and events. Hence, the control room display design proposed in the original document based on state-of-the-art design principles such as information rich design and dull screen principle remains unchanged.

3 Use cases for the control room

Four use cases were originally proposed in D2.4 for four types of control room operations in SRG. The use cases are listed as follows:

1. (Re)connecting with the SRG
2. Monitoring and operating the grid
3. Setting operation parameters
4. Planning isolated mode

The four modes of control room operations are listed as follows:

1. Operation in connected grid mode
2. Operation in planned isolated mode
3. Operation in isolated mode – external grid failure
4. Partial grid operation in isolated mode – internal electric failure.

The use cases along with the operating modes for SRG are depicted in Figure 1.

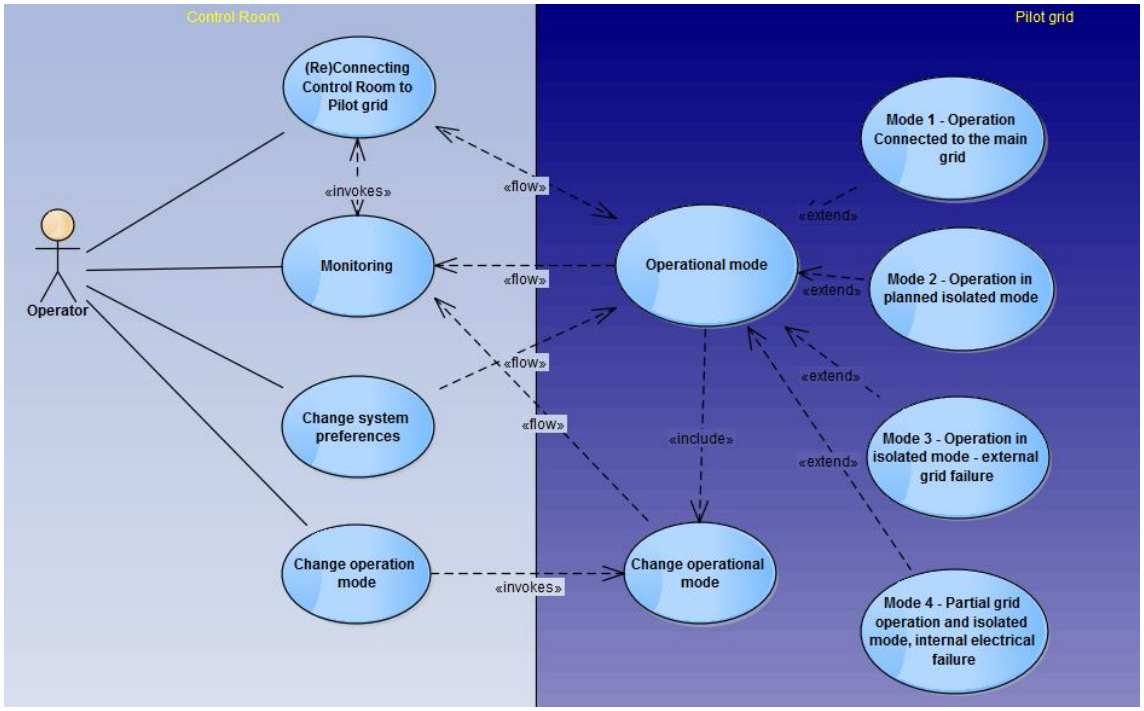

Figure 1: Overview of the use cases and operation modes for the SRG control room

While the use cases defined in D2.4 remain the same, there have been some changes to the outlined operation modes after pilot evaluations and platform integration results. The changes to above-mentioned operation modes are as follows:

1. Operation in connected grid mode – no changes
2. Operation in planned isolated mode – a similar mode of operation is in place
3. Operation in unplanned isolated modes – due to both external grid failure and internal failure have not been tested yet due to difficulties with isolation. These modes may not be achievable.

4 Control room integration

The iterations to D2.4 with respect to the SRG control room integration with IDPR has been classified into four subsections.

4.1 System Architecture

The revised SRG system architecture for EYPESA pilot as depicted in D6.3 is shown in the figure below.

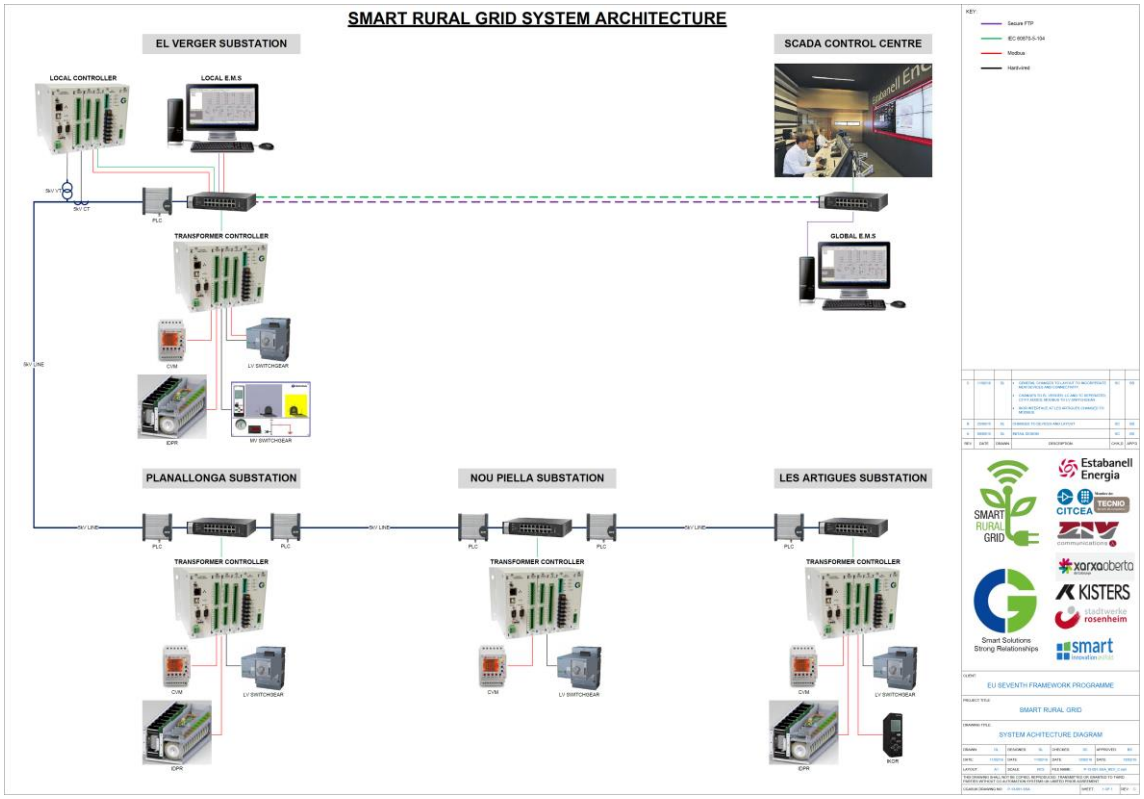

Figure 2: Revised SRG system architecture for EYPESA pilot

With respect to D2.4, the system architecture mostly remains the same except for the introduction of an additional transformer controller remote terminal unit (RTU-TC). The

RTU-TC interfaces between the local energy management system (LEMS)/ Local controller RTU (RTU-LC) and field devices such as IDPR, low voltage (LV) and medium voltage (MV) switches, electrical network analyser (CVM), etc. Throughout D2.4, the sequence diagrams for measurement, events, commands, IDPR control room integration, control room operation mode change, etc. and the data movement sequence between components in the pilot grid, consider one common RTU without showing the split between RTU-LC and RTU-TC. However, the flow of data, commands and information between the field devices and RTU-LC/LEMS/SCADA remains the same.

4.2 IDPR management

The IDPR as a passive component senses the following parameters: load active power – 3 phases, load reactive power – 3 phases, grid active power – 3 phases, grid reactive power – 3 phases, rated apparent power scale factor, grid phase voltage – 3 phases, grid frequency, battery voltage and current. When the IDPR acts as an active component in certain control room operation modes, IDPR monitors the active and reactive power, voltage and frequency. In isolated operation modes, IDPR controls the frequency, voltage and harmonics of the grid. The parameters required for both passive and active IDPR operation has been listed in D2.4. An expanded list of all IDPR parameters can be found in the following table from D7.2.

Modbus Mapping																			
Modbus Address (HEX)	**Data Model**	**Bit**																**Access**	**Unit**	**Range**	**Format**
	Input Registers	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15				
1		IDPR Software Revision																R	---	0…32767	INT16
2		IDPR Serial Number																R	---	0…32767	INT16
3		IDPR rated power (Parameter)																R	0.01kW	0…5000	INT16
4		Rated AC side current (Parameter)																R	0.1A	0…4000	INT16
5		Rated AC side Voltage (Parameter)																R	V	0…1000	INT16
6		Rated AC side frequency (Parameter)																R	0.01Hz	0…10000	INT16
7		Maximum AC Voltage (Parameter)																R	V	0…1000	INT16
8		Minimum AC Voltage (Parameter)																R	V	0…1000	INT16
9		Maximum AC frequency (Parameter)																R	0.01Hz	0…10000	INT16
A		Minimum AC frequency (Parameter)																R	0.01Hz	0…10000	INT16
B		Rated DC side current (Parameter)																R	0.1A	0…4000	INT16
C		Rated DC side Voltage (Parameter)																R	V	0…1000	INT16
D		Maximum DC Voltage (Parameter)																R	V	0…1000	INT16
E		Minimum DC Voltage (Parameter)																R	V	0…1000	INT16
F		Input_Reserved0 (aditional parameters)																R	Reserved		
…		…																R			
18		Input_Reserved9 (aditional parameters)																R			
19		Rated apparent power scale factor																R	0.01pu	0…100	INT16
1A		DC bus Voltage 1																R	V	0…1000	INT16
1B		DC bus Voltage 2																R	V	0…1000	INT16
1C		Air temperature																R	0.01·ºC	-5000…20000	INT16
1D		Maximum IDPR power module temperature																R	0.01·ºC	-5000…20000	INT16
1E		IDPR power module temperature CCSPC1_C1																R	0.01·ºC	-5000…20000	INT16
1F		IDPR power module temperature CCSPC1_C2																R	0.01·ºC	-5000…20000	INT16
20		IDPR power module temperature CCSPC2_C1																R	0.01·ºC	-5000…20000	INT16
21		IDPR power module temperature CCSPC2_C2																R	0.01·ºC	-5000…20000	INT16
22		IDPR power module temperature CCSPC3_C1																R	0.01·ºC	-5000…20000	INT16
23		IDPR power module temperature CCSPC3_C2																R	0.01·ºC	-5000…20000	INT16
24		Input_Reserved10 (aditional parameters)																R	Reserved		
25		Input_Reserved11 (aditional parameters)																R			
26		IDPR Active Power, Phase A																R	0.01kW	-5000…5000	INT16
27		IDPR Reactive Power, Phase A																R	0.01kvar	-5000…5000	INT16
28		IDPR Active Power, Phase B																R	0.01kW	-5000…5000	INT16
29		IDPR Reactive Power, Phase B																R	0.01kvar	-5000…5000	INT16
2A		IDPR Active Power, Phase C																R	0.01kW	-5000…5000	INT16
2B		IDPR Reactive Power, Phase C																R	0.01kvar	-5000…5000	INT16
2C		LOAD Active Power, Phase A																R	0.01kW	-5000…5000	INT16
2D		LOAD Reactive Power, Phase A																R	0.01kvar	-5000…5000	INT16
2E		LOAD Active Power, Phase B																R	0.01kW	-5000…5000	INT16
2F		LOAD Reactive Power, Phase B																R	0.01kvar	-5000…5000	INT16
30		LOAD Active Power, Phase C																R	0.01kW	-5000…5000	INT16
31		LOAD Reactive Power, Phase C																R	0.01kvar	-5000…5000	INT16
32		GRID Active Power, Phase A																R	0.01kW	-5000…5000	INT16
33		GRID Reactive Power, Phase A																R	0.01kvar	-5000…5000	INT16
34		GRID Active Power, Phase B																R	0.01kW	-5000…5000	INT16
35		GRID Reactive Power, Phase B																R	0.01kvar	-5000…5000	INT16
36		GRID Active Power, Phase C																R	0.01kW	-5000…5000	INT16
37		GRID Reactive Power, Phase C																R	0.01kvar	-5000…5000	INT16
38		BAT Power																R	0.01kW	-5000…5000	INT16
39		PCC RMS Voltage, Phase A																R	V	0…1000	INT16
3A		PCC RMS Voltage, Phase B																R	V	0…1000	INT16
3B		PCC RMS Voltage, Phase C																R	V	0…1000	INT16
3C		PCC Frequency																R	0.01Hz	0…10000	INT16
3D		Voltage, Battery																R	V	0…1000	INT16
3E		Current, Battery																R	0.1A	-4000…4000	INT16
3F		SOC, Battery																R	% bat capacity	0…100	INT16
40		IDPR STATE																R		0…128	INT16
41		IDPR SUBSTATE																R		0…128	INT16
42		IDPR Total Active energy (MSB)																R	10·kWh	0…2147483647	INT32
43		IDPR Total Active energy (LSB)																R			
44		LOAD Total Active energy (MSB)																R	10·kWh	0…2147483647	INT32
45		LOAD Total Active energy (LSB)																R			
46		Total Operating Time Hours																R	hours	0…32767	INT16
47		Total Operating Time Minutes																R	min	0…60	INT16
48		Last Statistics Reset Date Year																R	year-2000	0…99	INT16
49		Last Statistics Reset Date Month																R	month	1…12	INT16
4A		Last Statistics Reset Date Day																R	day	1…31	INT16
4B		Last Statistics Reset Date Hour																R	hours	0…23	INT16
4C		Last Statistics Reset Date Minute																R	min	0…59	INT16
4D		Event memory number (Indicates last important event)																R		0…25	INT16
4E		MEMORY DATA 0																R		0…32767	INT16
…		…																R		0…32767	INT16
6D		MEMORY DATA 31																R		0…32767	INT16
6E		Input_Reserved12																R	Reserved		
…		…																R			
13E		Input_Reserved220																R			

Table 1: IDPR parameters measured in the pilots

From platform integration and pilot results, the following list of actions are suggested as improvements for future projects involving IDPR:

• A plug and play device (easy installation)

• A flexible device that is interchangeably connected in 230 V or 400 V LV networks (easier installation)

• A flexible device that is interchangeably connected for any phase sequence operation (easier installation)

• DSO communications protocols integrates like IEC 60870-5-104 Transmission Protocols

• A device which is interchangeably managed remotely through a SCADA in control centre or locally via a console (web or touch display)

• Redefine the auxiliary batteries capacity according to the real consumption of IDPR, telecommunications and switchgear devices.

• Comply with RF standards (fire standards)

• Comply with EMC standards

• Reserve a space for the overvoltage protections

• Increase the mechanical robustness

• Include a synchronism unit in order to reconnect to external grid (during islanded operation)

• Define the environmental conditions for operating

• Internal DC devices without polarity

• Industrial PC adjusted to the IDPR requirements (less powerful)

4.3 Communication signals, interfaces and protocols

The following table depicts the changes to communication interfaces and communication protocols originally suggested in D2.4 and the ones that have been implemented at the pilot sites.

A complete list of changes to IDPR, CVM and RTU-TC and -LC signals has been documented and made available separately with detailed modifications to LC-LEMS Modbus addressing and LEMS-SCADA IEC addressing.

	Communication between devices	Communications interface proposed in D2.4	Communications interface implemented	Communications protocol proposed in D2.4	Communications protocol implemented
1	EyPESA's Center control and RTU-LC	WAN and PAN (Private Area Network: WiMAX, PLC, Ethernet)	Private Area network, PLC and Ethernet, XOC radio link	IEC 60870-5-104 EyPESA profile (TBD)	IEC 60870-5-104 EyPESA profile
2	RTU-LC and Local EMS	PAN (Ethernet)	Ethernet, XML	Modbus TCP/IP	Modbus TCP/IP
3	RTU-LC and RTU-TC	PAN (WiMAX, PLC, Ethernet)	PLC and WiMAX for Planallonga, Nou Piella and Les Artigues substations and Ethernet for Verger substaion	TCP/IP	IEC 60870-5-104
4	RTU-TC and IDPR / smart-fuses/sensors/switches	PAN (Ethernet)	Ethernet	Modbus TCP/IP	Modbus RS485
5	IDPR and BMS	PAN (RS-485)	RS485	TBD	RS 485

Table 2: Comparison between communication interfaces and protocols proposed in D2.4 and pilot implementation

4.4 Pilot Implementation

At the EYPESA pilot sites, Les Artigues substation is equipped with an electrical switching element: the EKOR MV cell control and monitoring unit. Additionally, it must be noted that the Nou Piella substation is not equipped with IDPR due to the nature of its small interconnection. Accordingly, the absence of IDPR at the Nou Piella substation reduces the size of the RTU-TC and CVM Modbus data map.

At the Poesling substation in SWRO pilot site, in order to increase the hosting capacity of the grid, without breaking the voltage criteria in the grid, some technical modifications to the grid have been recommended in D7.2. These include installing an additional voltage controllable transformer, building a parallel cable to Z11 and building a cable from the transformer station to P10.

5 Summary

Deliverable D2.4 was finalized during M6 of the project and while most of the managing procedures have remained the same, some have undergone changes. This report represents an iterated version of D2.4 and tracks the changes in the subsequent months from M6. Considering the platform integration results and pilot preliminary evaluation from WPs 6 and 7, the following major changes have been documented:

1. Modified control room operation modes – operation in unplanned isolated modes have not yet been tested
2. Revised system architecture for EYPESA pilot with the introduction of an additional RTU-TC unit
3. Expanded list of IDPR measurement parameters in both active and passive modes
4. Modifications to communication signals, interfaces and protocols between LEMS, SCADA and field devices such as IDPR, RTU-LC, RTU-TC, etc.
5. Changes to pilot implementation with respect to addition of new field devices.