DSO INTERACTING WITH HETEROGENEOUS DER IN DISTRIBUTION GRID

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ABSTRACT

On one hand, DER companies are facing a need for productivity improvement along the whole activity chain from investment to maintenance healing towards standardization of equipment and control systems while on the other hand , the French DSO needs a wider monitoring and control ability of DER resources whose connection to MV networks is bursting : DSO related needs that are definitely at the beginning of what will be continuously evolving with Smart grids in the coming years ; only standards could cope with this pace. The conjunction of standardization needs gave ERDF, the French DSO and MAIA EOLIS an opportunity to get deeply involved in a practical implementation of IEC 61850 standard improve drastically the monitoring and control interface between wind power plants and distribution networks dispatching and IT systems.

In this frame, ERDF, MAIA EOLIS and EDF R&D experiment since 2015 a communication infrastructure based on Web service technology and IEC 61850 data model. Data exchanges between wind power plant monitoring and control system and ERDF ITs systems shall include I/O statuses, measurements, weather data, maintenance scheduling, active and reactive load scheduling programs and remote controls (set points, O/C commands, On/Off controls and automatisms etc.). This paper presents the project as a whole, the participating companies' motivation, details the technical issues (infrastructure, data model technology, cyber security issues, etc.) and stresses the standardization awaited outcomes.

INTRODUCTION

In the purpose of reducing the reliance on oil caused by economic and environmental issues and of reacting against the increasing demand for electrical energy, the world witnesses a growth of decentralized electric power production.

The growth of decentralized electric power production or distributed energy resource (DER) was encouraged by the development of new technologies of small power production, by the deregulation of the energy market, the increase of environmental constraints, and the Network Codes.

Nowadays, Distribution System Operators (DSO) are seeking for solutions to maintain a reliable energy power distribution considering the electrotechnical impact generated from the intermittent and random energy production of DER (Wind power plant as an example).

EDF R&D, ERDF and MAIA EOLIS experiment a solution to address the need of monitoring and controlling the DER system with a real time information exchange and in a standardized and cybersecured framework.

DER STAKEHOLDERS CHALLENGES

DSO's challenges (ERDF)

DSO are and will continue to be the most impacted by DER. The need of greater efficiency and reliability of the power system let the automation of the distribution system a major requirement.

Distribution system automation implies new remote control functions, modified distribution configurations, the increase of intelligent protection systems and a significant use of improved telecommunication and information technologies [1].

The French commission of energy regulation (CRE) set a decree demanding producer under certain conditions to install the DER interface to provide DSOs informations and data about their energy production and to shut-down their DER in emergency cases.

The DSOs are responsible for the safety and efficiency of the distribution system. The actual DER recommended for producers does not meet all the DSO's needs:

Actual situation	DSO needs
The need for new functions such as scheduling couldn't be assured by the actual protocol IEC 60870 5-104. This protocol between DER and the control center does not fit all services of communication covered by the IEC 61850	Acting on the energy production (scheduling, regulation of active and / or reactive power…)
Primary generation of DER system does not allays allow real time exchange information and dynamic data collect from the DER.	Having a real time and bidirectional work flow
Implemented DER systems does not allow regulation of the predefined instructions	Dynamic reactive power and voltage regulation functions
The existing DER systems communicate with many protocols: MODBUS,	Interoperability and interchangeability

PROFINET, OPC….	

Producer's challenges (MAIA EOLIS)

Producers, like MAIA EOLIS are one of the DER operators in France. They are responsible for turning the DER systems on and off during normal operations, based on their need or use.

The DER operators may be a person pushing a button on the DER device, or an automated controller/ synchronizer with a built-in scheduler.

From a DER operator's point of view, the DER interface could not only increase information exchange with DSO, in order to improve the efficiency of DER's operation and maintenance in the short term, but also raise the DER penetration in the long term thanks to a reliable power grid.

Nowadays, Distribution System becomes more and more saturated by DERs. For reliability reasons, before giving a connection permission, DSO compares the sum of DER's nominal powers of one connection point with its facilities installed, for example the nominal power of its MV transformer. However, more connection availability could be released by introducing a new dynamic DER interface, which gives benefits to DSO and producer from dynamic data exchanges for:

- The information of the local power consumption, which makes more production possible [2], and,
- The measured values of every DER's production. The difference between the current power value and the nominal value of one DER can release temporarily production room for other DERs connected to the same point.

Besides, the producers could benefit from new functions of the evolved DER system like

- The built-in capability to shut down or not turn on if it is unsafe for the device to operate;
- Extra bonus income if the frequency regulation is operational;
- The selling of reactive power production or consumption, if the voltage regulation is implemented to help DSO;
- Improvement of hybrid source generation efficiency thanks to forecast data and maintenance schedule exchange;
- Production optimization according to a dynamic electricity price in the future

THE EDF, ERDF AND MAIA EOLIS EXPERIMENT

The experimentation since 2015 between EDF R&D, ERDF and MAIA EOLIS aims to develop an advanced solution for the DER system that meets the relevant need of the DER stakeholders in an automated electric power distribution.

The evolved DER System will benefit from the last technology of system engineering in order to easily implement the specifications embedded in regular objects like **regulators of reactive energy**, **regulator of voltage**, **systems of forecasting**…

The experiment aims to experience, identify the technical issues and develop an advanced version of the DER system: eDER (evolved DER).

This eDER should:

- Be evolutive and able to implement new functions like a forecasting system helping in demand-response real time regulation,
- Communicate with a protocol that exchanges different type of informations: system automation, market, system management…

Main subjects of the experiment

The experiment handles the following subjects:

- Defining a new infrastructure for the eDER,
- Testing different communication protocol between the DER system and DSO,
- Defining a secure framework to exchange informations,
- Standardizing the new infrastructure and protocols,

Perimeter of the experiment

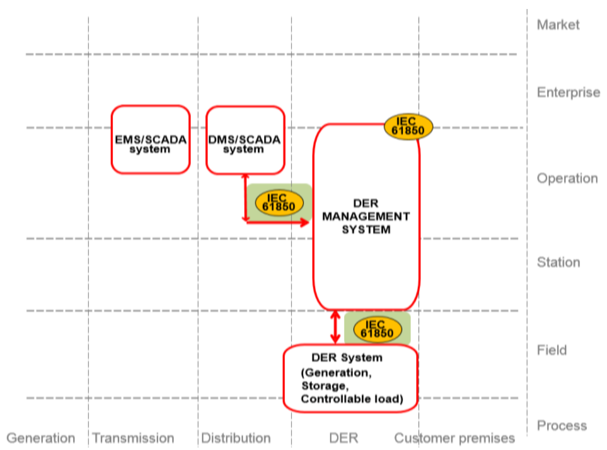

Figure 1
Scope of the experiment (IEC 61850 7-420) [3]

TECHNICAL ISSUES

To define the advanced version of the DER system, EDF R&D, ERDF and MAIA EOLIS overcame some technical issues: **infrastructure, data model exchange, cybersecurity and standardization.**

New System infrastructure

The new eDER's infrastructure consists in three modules, pictured in figure 3.

The eDER allows to control power plant (PV, Wind power…) at the same time by both the DSO's control center and the producer.

The communication DSO / eDER / producer is ruled by only one data model based on the IEC 61850.

The eDER's infrastructure fulfills the heterogeneous protocol deployed on the field.

Interface [M0-M1]: Communication between DSO's control center and eDER's system control (WAN : Wide Area Network) (figure 3)

The **IEC 60870 5-104** protocol is used in actual communication status between the French DSO (ERDF) and the DER system.

This protocol has been mapped to the **IEC 61850 80-1** in order to be able to collect data under the unified IEC 61850 data model.
The use of this protocol is experimented in the SmartGrid demonstrator VENTEEA [4] which aims to improve:

- Grid efficiency,
- Integration of large wind generation in MV distribution networks,
- Optimizing real time communication

The demonstrator's participants are BORALEX with their Wind Power Plant and ERDF as DSO.

The IEC 61850 8-2 standard based on XMPP webservices technology: (Extensible Messaging and Presence Protocol) is in progress in IEC standardization [5].
This new standard is dedicated for Smartgrid applications and adapted to the communication between DER and network operators such as DSO or TSO.
The XMPP protocol has the following advantages:

- Open source protocol
- Cybersecurity functions
- Large used in NICT (new informations and communication technologies)
- Multi domain communication

If the experiment confirmed the interest in IEC 61850 8-2 protocol, ERDF will apply it in its industrial strategy based on IEC standardization protocol when deploying its next system automation generation connected to its control center.

Interface [M1-M2]: Communication Inside the eDER (LAN: Local Area Network) (figure 3)
This interface allows to connect module 1 and 2 supplied potentially by different manufacturers which are in conformity with IEC 61850 8-1.
IEC 61850 8-1 part (SCSM [6]) defines the MMS profile retained for the Local Area Networks and particularly for substations (HV, MV and LV).
The module 2 embeds IEC 61131 [7] codes of automatisms: voltage, reactive power, scheduling, forecasting…

Interface [M2-M3]: Communication inside the eDER (figure 3)
Today, in the market, there are heterogeneous communication solutions for the DER which are not adapted to foster interoperability: WIRE (I/O), OPC, MODBUS, PROFINET etc.

The [M2-M3] interface meets the legacy infrastructure :
The module 3 can be seen as an interface with the process: measurement, I/O, inverters etc. This module can be adapted to the actual solutions with a full IEC 61850 system.

[M2-M3] is the only interface of the DER which is not yet fully standardized into IEC 61850. When it will be the case, module 2 and 3 can be an all-In-one system based on IEC 61850.

Data model exchange

Some of the data model exchanges:

Information	Service	IEC 61850 reference
Unavailability of the generators	Report	DER1/LPHD1.PhyHealth.stVal
The producer is connected to the grid	Report	DER1/DGEN1.GnOpSt.stVal
Network power disconnection under emergency case	Operate	DER1/DRCC1.EmgStop

Cybersecurity issues

Cybersecurity has been implemented in the experiment in order to secure communication between DSO and the producers.
This implementation includes some parts of IEC 62351 [8]:

- Encryption with SSL/TLS,
- End-to-end security: with encryption. OTR was selected by the experiment even if there is no protocol yet defined by IEC,
- Certificate-based authentication

The cybersecurity framework established in the experiment is pictured bellow:

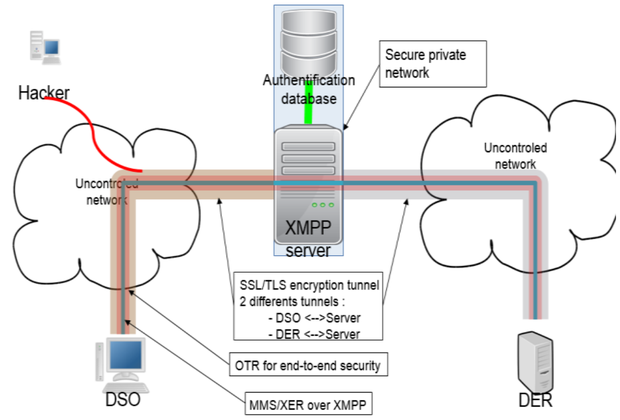

Figure 2: cybersecurity framework

Standardization objectives

One of the experiment goals is to have a standardized formats and templates to exchange data between different equipment and system connected to the distribution energy network. Modelling the eDER under IEC-61850 standards enabled its interoperability with the existing equipment in the market.

The eDER using new standardized technology allows to set up the participation of DER on demand-response markets to address technical issues of the distribution power system.

In the new Smart Grid, Micro Grid and Smart Cities paradigm, XMPP technology mapped with a semantic given by the IEC 61850 facilitates additional information sharing and configuration between different actors or systems (DSO, TSO, producer control center, maintenance center, market, TSO).
Transmitting more information in a multi-domain environment implies to make in place a safety conditions against cyber-attacks and vulnerabilities, IEC 62351 series and IEC 61850 8-2 offer a reliable standardized solution to secure the interface between DER and DSO.

CONCLUSION

The first results of this experiment confirm the value of the semantic carried out by the standard IEC 61850 (unified data model).

The modelling under IEC-61850 enables faster and sustainable integration of new functions such as the voltage or reactive power regulation, forecasting, scheduling etc...

Network operators as producers can draw benefits in designing their next generation of system automation such as eDER interface with:

- An overall vision of the power network with objects connected to the control or maintenance center,
- 3 pillars standards mentioned before IEC 61850, IEC 62351 and IEC 61131,

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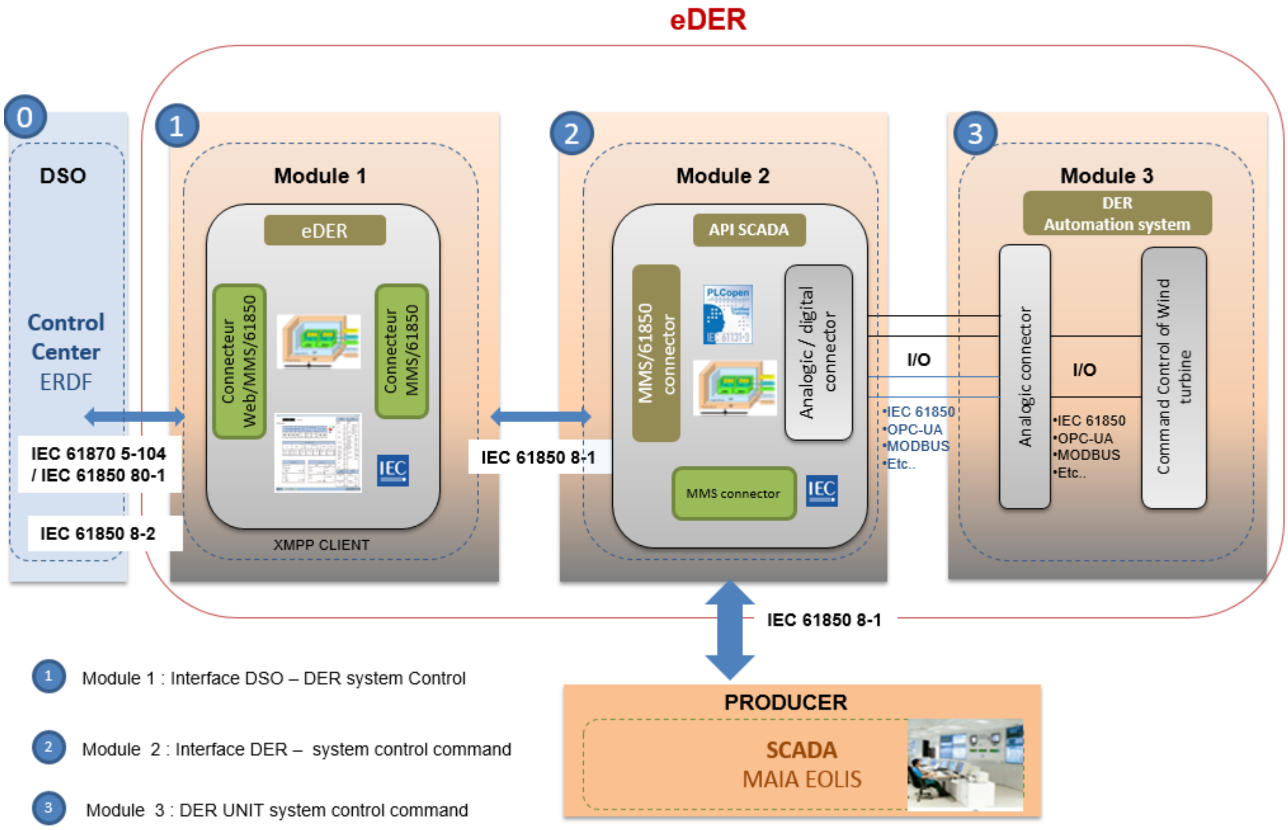

Figure 3 : eDER infrastructure