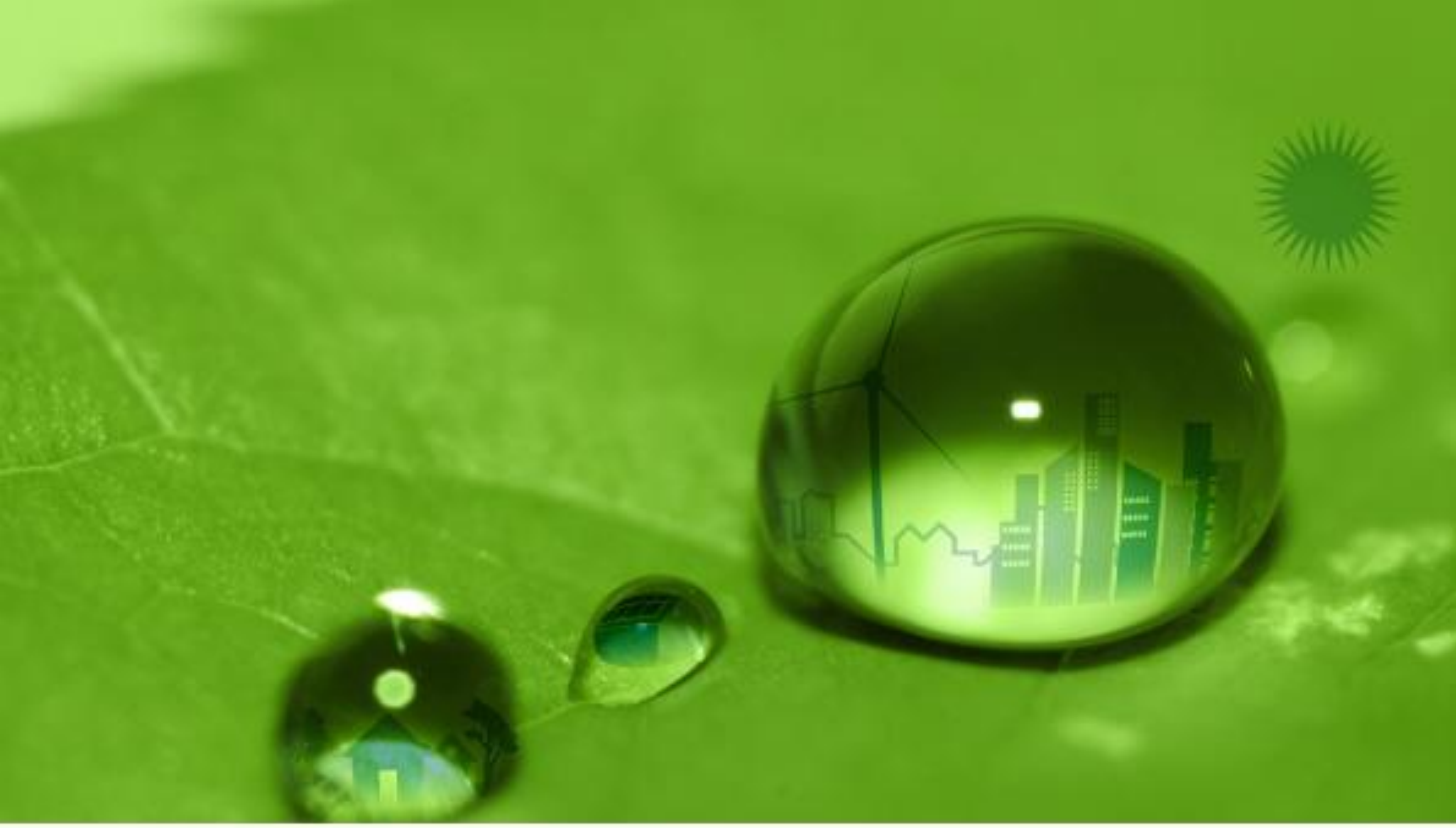

INNOVATION FOR ENERGY NETWORKS

Technical Spotlight DEMO6-S6

Spotlight on BPL communication implemented in DEMO6

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1. Introduction

1.1 Definitions

In the DEMO6 project, we have deployed **Broadband over Power Line (BPL)** communication between the centralized system and the equipment installed on the field. This technology uses the distribution network to carry data with high speed (> 10Mbits/s).

1.2 Tags & metadata (Technical Glossary)

Type of solution						
■ Equipment / Hardware / Firmware	☐ Information system	☐ Process				
Manufacturer(s) implied (for equipment or hardware)						
GE Grid Solutions (previously mentioned as Alstom Grid)						
Work Stream considered						
■ Active Demand	■ DER integration	■ Storage	☐ Islanding	☐ MV Innovation	■ LV Innovation	
Location / Topology (with regards to distribution grid)						
■ HV/MV Substation	☐ MV	■ MV/LV SS	■ LV	■ DER	■ Meter	☐ Downstream meter
☐ Other Centralized system (calculations, information system)	☐ Other Decentralized system	☐ Other :				
Thematic(s)						
☐ Grid Monitoring / state estimation	■ Active demand / DSM	■ DER Integration / increased grid capacity				
☐ Islanding	☐ Anti Islanding protection	☐ Automatic Failure Detection	■ Remote Grid Operations			
☐ Automatic Failure Management / Grid recovery	☐ Automatic Grid topology reconfiguration	☐ Other :				
Use Case(s)						
DEMO 6	☐ Islanding	■ Peak demand reduction	■ Integrate massive PV production on LV network	☐ Encourage resident to adopt smarter habits according to network state		
Key figures ▪ **2 MV** feeders with BPL communication **(7 km and 5 km)** ▪ Raw speed over **10 Mbits/s** ▪ **30** IP equipments connected to the BPL network						

2. Objective and technical requirements

In DEMO6, the use of a secure communication tool between the **Network Energy Manager (NEM)** and the other equipment installed on the public distribution grid (storage systems, solar transformer, smart meters, etc.) is necessary to:

- send **load plans** to storage systems and ensure they are monitored 24/7
- send **voltage set points** to the on-load tap-changing transformer
- transmit the data measured by meters at the **primary substation** and at **secondary substations**
- transmit measurements recorded by *Alptec* quality measurements devices
- remotely control batteries and their converters (monitoring, remote alarms, etc.)

To meet this need, the real-time communication architecture has been adopted:

1. A **secure ADSL connection** to ensure the exchange of information between the ERDF environment that hosts the **NEM** and the Carros primary substation
2. **Broadband Power Line (BPL)** communication between the **primary substation** and all the equipment installed on the Carros public distribution grid, using the MV and LV grids to transmit data.

3. Development and implementation

3.1 Architecture

The IT architecture is partly decentralized in Carros, with a **Master Control Unit (MCU)** connecting the **primary substation** to the **NEM**, and several Field Control Units (**FCU**s) located near the grid batteries and solar transformer to serve as local “smart systems”. The **MCU** and **FCU**s naturally communicate via **BPL**.

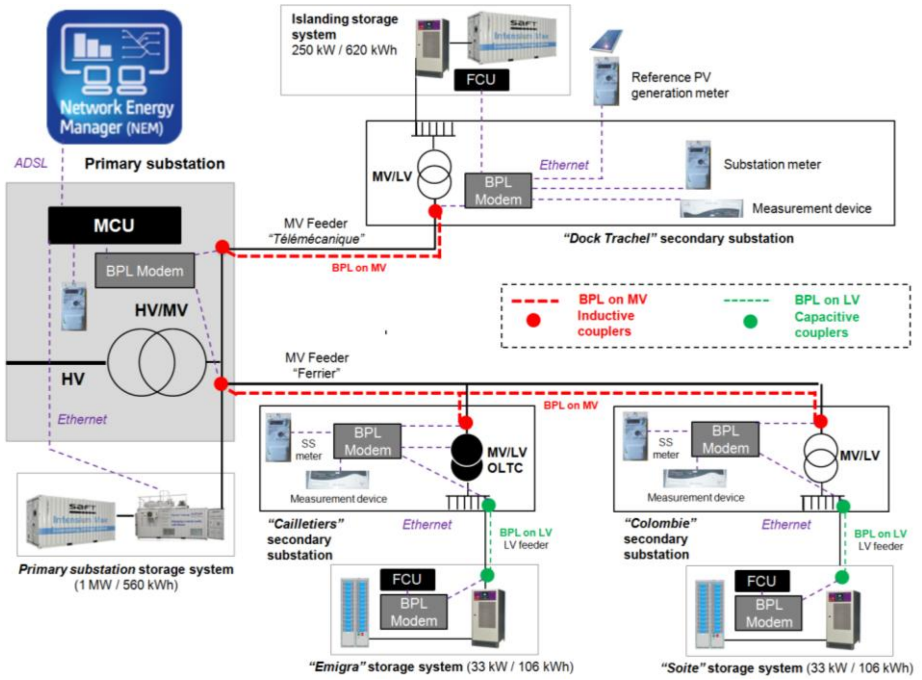

Figure 1 - Overall BPL communication architecture

3.2 Deployment

In DEMO6, BPL solution has been installed by ERDF technicians. The equipments were provided by GE. Commissioning has been realised jointly by ERDF and GE.

The following diagram shows the locations of **BPL modems** at one of the two outgoing MV feeders equipped.

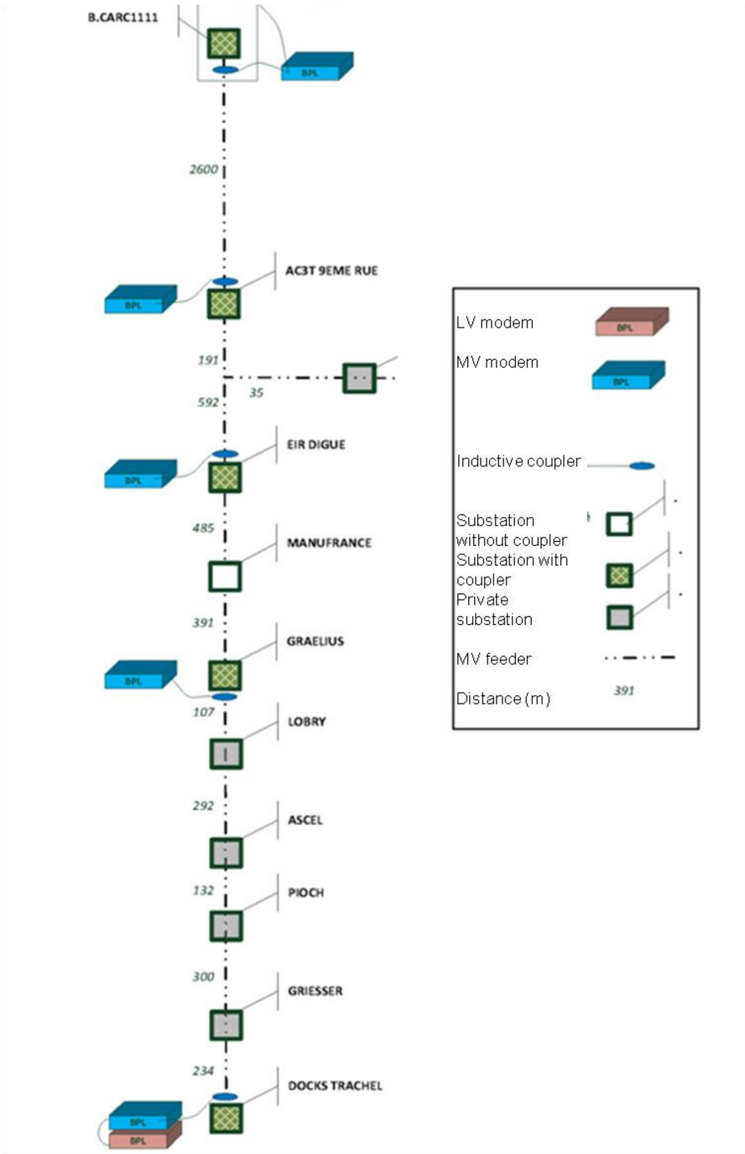

Figure 2 - BPL modem setup at the "Telemecanique "outgoing MV feeder

To exchange information, the **BPL coordinator** located at the primary substation sends data to the different local smart systems (**FCU**s). **BPL repeaters** are installed at the MV/LV substations to repeat and amplify the signal in order to reach the destination **FCU**. It should be noted that the distance between two **modems** varies and depends on the topology of the MV or LV section(s) traveled (see §7.2).

At each substation, the **BPL** system is made up of two parts:

- An **inductive coupler** installed on one of the MV phases
- A **BPL modem** that acts as an signal relay and transmitter/receiver

Figure 3 - Inductive coupler on the MV grid and BPL modem at an MV/LV substation

3.3 Lab tests

After this infrastructure was validated by ERDF's smart grid teams and passed the Linky PLC compatibility tests run by EDF R&D in October 2013, it was decided to implement the **BPL** solution at the two outgoing MV feeders where all the project's equipments were concentrated.

3.4 Main functions

BPL infrastructure allows communication between the network energy managers and devices installed on the distribution grid. ☞**See §2 and §4.2**

4. Technical results

4.1 Distances traveled

The **BPL** signal travels **around 5 k**m over each of the two outgoing MV feeders, offering a **wide variety of configurations**, with sections that may be long (up to 3 km) or short, recent or older and elevated or underground.

4.2 List of connected equipment

The following equipment on the MV/LV grid is connected to the power distributor's tools via BPL communication with the **MCU**:

- **SME meters** installed at MV/LV substations and one at a PV generator
- Three **Alptec measuring devices** located at three MV/LV substations which measure a substantial amount of electrical data (U, I, f) every three seconds
- A **video surveillance camera** to check broadband
- The four Saft grid batteries
- All the **Power Converter Systems** (GE and SOCOMEC) associated with the batteries
- The **OLTC transformer**
- The **FCU**s
- A monitoring PC
- An ERDF quality metrics tool

4.3 Bandwidth

All modem to modem raw bandwidth is above **10 Mbps**. The actual net **bandwidth** measured across the entire MV+LV grid is around **1 Mbps**, which is more than sufficient for the project's requirements."

4.4 Frequencies used

The **BPL communication infrastructure** exchanges data within a frequency range of 2 to 12 MHz. The NMS box monitoring the **BPL** network and installed at the **primary substation** allows us to monitor all the MV and LV segments. It specifically allows us to know the real time speed on each segment and the carrier frequencies with a high signal to noise ratio.

4.5 Latencies

Average latencies are quite good – between 100 ms and 200 ms – and packet loss is low. However, there may be occasional latency spikes with values reaching one to two seconds.

5. Cost benefit analysis

As mentioned earlier on this document, the major advantage on **BPL** technology is an effortless and fast installation using existing power infrastructure as medium for communications. That results in a remarkably low CAPEX when compared to other technologies, such as fiber and radios links that require extensive civil works to lay down cables, rising towers and so on. These works state an important deployment cost.

On the operational side, the OPEX can be also advantageous as it is a private network, avoiding carrier or third-parties leasing contract fees found on GSM and leased lines services rentals. The full network ownership increases operational autonomy and faster responsiveness for maintenance in critical networks.

6. Conclusion and key messages

There are several advantages to using **BPL**:

1. It is **easy to install** and can be adapted to **any type of environment** (underground or elevated cables)
2. It offers **very high bandwidth** (several megabits per second over several kilometers)
3. It offers **secure communication** by virtue of the medium used (MV cables in particular)

On the other hand, the range of data transmitted via **BPL** for DEMO6 is limited to around **3 km of MV line and 250 m of LV line**. We also observed that **BPL** signal quality was sensitive to harmonics generated by the **primary substation's** battery.

Advantages	Disadvantages
▪ High speed even over long sections ▪ Stable communication ▪ IP protocol ▪ Inherently more secure than wireless solutions ▪ Easy to install ▪ Lays the foundation for other potential uses such as remote substation monitoring or Voice over IP for on-site technicians	▪ Occasionally high latency (400 ms) ▪ Sensitive to disturbances on the grid (e.g. 1-MW battery, change in MV grid operating structure) ▪ No pre-existing way of modeling performance ▪ Distance less than 250 m over LV lines

7. Appendix

7.1 To go further

Document	Topic
dD6.7 - Assessment of the developed tools for the demonstrator	Technical results (§2.4 and 3.6)
dD6.9.3 – Final assessment of the demonstrator	Key messages

7.2 Glossary

Term	Definition
ADSL	Asymmetric digital subscriber line (ADSL) is a type of digital subscriber line (DSL) technology, a data communications technology that enables faster data transmission over copper telephone lines than a conventional voiceband modem can provide.
BPL	Power-line communication (PLC) is a communication protocol that uses electrical wiring to simultaneously carry both data, and Alternating Current (AC) electric power transmission or electric power distribution. A wide range of power-line communication technologies are needed for different applications, ranging from home automation to Internet access which is often called broadband over power lines (BPL).
BPL modem	Equipment with BPL chipset, Ethernet connection and connected to the capacitive or inductive coupler.
Capacitive coupler	Coupler installed on low voltage network and directly connected to the cable to transmit BPL signal over 3 phases.
Distributed Energy Resource Management System (DERMS)	decision support system dedicated to active DER integration and control, providing facilitation services between the network operators, the commercial aggregators (suppliers , others) and the distributed flexibility resource devices
Field Control Unit (FCU)	Local controller which communicates with the MCU and the distributed network resources. It has as main functionalities: resources data collection and upload to the MCU; resources supervision and control (both manually or through NEM's

	program reception). It also has the capacity to locally store information and to work autonomously if the connection with the MCU is lost
Inductive coupler	Coupler installed on medium voltage network transmitting and receivind BPL signal by induction over 1 phase.
Master Control Unit (MCU)	Main controller which communicates with the NEM and the distributed network resources. It has as main functionalities: metered data and resources data collection and upload to the NEM; resources supervision and control (both manually or through NEM's program reception). It also has the capacity to locally store information and to work autonomously if the connection with the NEM is lost
Network Energy Manager (NEM)	instance of DERMS for the NICE GRID project as main control component, hosted in DSO Information System and ensuring forecast import, distribution system analysis, validation of operator requests, management of transaction mechanism with DER aggregators, publication of reservation/activation orders, reporting and web portal for network operator dispatchers
OLTC transformer	A tap changer is a connection point selection mechanism along a power transformer winding that allows a variable number of turns to be selected in discrete steps. A transformer with a variable turns ratio is produced, enabling stepped voltage regulation of the output. The tap selection may be made via an automatic or manual tap changer mechanism.
Power Converter System (PCS)	Bidirectional converters from AC to DC and DC to AC, used to connect batteries (DC) with the distribution grid (AC), and used to charge/discharge it.
Primary Substation	Transformer substation from high voltage (400, 225, 90 and 63 kV) to medium voltage (20 kV) supplying some industrial customers and secondary substations. Carros main primary substation consists in two 20 MW transformers
Repeater	To transmit the data over a long MV feeder, the BPL signal has to be repeated every 1 or 2 kms.
Secondary Substation	Transformer substation from medium voltage (20 kV) to low voltage (400V) supplying end customers feeders. Transformer size range from 50 to 1000 kVA whereas supplied customers is very variable (up to 300 residential customers).
SME meter	SME meter is the smart meter for customer with a subscribed power greater than 36 kVA