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Federal Department of the Environment, Transport, Energy and Communications DETEC

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Energy Research and Cleantech Division

REEL Demo – Romande Energie ELectric network in local balance Demonstrator

Deliverable: 1a Asset monitoring study (topology, voltages, currents and flows) at 50 fps

Demo site: Rolle

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1. Description of deliverable and goal

1.1. Executive summary

In the electrical grid of the city of Rolle, the Distribution System Operator (DSO) Romande Energie installed Zaphiro's grid monitoring system called "SynchroGuard monitoring". This system monitors the power flows in the grid by measuring voltages and current flows at different points in the grid by means of unique hardware devices called SynchroSense. The goal of this monitoring system is to analyze the data collected from SynchroSense devices and provide to Romande Energie an accurate view of the grid behavior in real-time.

1.2. Research question

DSOs need to upgrade the level of monitoring and automation of their grids in order to cope with the unpredictability of DERs (Distributed Energy Resources, such as renewables, electric vehicles and batteries),as well as with the stringent power-quality requirements imposed by regulatory authorities. For example, phenomena like overloads and overvoltages are becoming more frequent due to increasing power generation, and augment the stress on grid components, thus threatening grid efficiency and reliability. Additionally, regulators require DSOs to improve the quality of power supply by decreasing the number and duration of power outages caused by faults. To address these challenges, control of DERs and fault location are a paramount, but both first need a grid monitoring infrastructure that provides real-time.

1.3. Novelty of the proposed solutions compared to the state-of-art

The novelty is the use of a peculiar type of measurement called synchrophasor in distribution grids. Synchrophasors are time-synchronized and high-resolution (up to 50 measurements per second, more than 100 times faster than currently used measurements) measurements of voltage and current signals. It is the first time that these measurements are used in distribution grids to enable unique benefits, such as the most accurate fault location and the fastest and optimal control of DERs. This is not

achievable with standard devices that are unsynchronized and with a slow measurement rate of seconds/minutes.

1.4. Description

Power grid description: Figure 1 is the single line diagram of feeders 51 (light blue lines) and 60 (red lines) departing from the primary substation Rolle. They can be connected to each other or to other feeders, but they are normally operated in a radial configuration.

In Figure 1 we numbered lines and buses in each feeder:

- Feeders 51 is composed of 22 distribution lines and 23 buses (20 substations plus the primary substation plus 2 zero-injection buses[1] due to two opened lines).
- Feeders 60 is composed of 16 distribution lines and 17 buses (16 substations plus 1 zero-injection bus due to an opened lines).

In Figure 1 we also show the locations of the measurements taken by the SynchroSense devices:

- Voltage measurements are shown in red as a V inside a circle. They are always placed on a line departure, not on the busbar of the MV-LV substation.
- Line current measurements are depicted by "s/r id#.#" in blue beside the line departure:
    - s/r identifies the sending-end or receiving-end of the line.
    - id#.# is the SynchroSense identification number. The 1st number is the SynchroSense id and the 2nd number is the SynchroSense channel.

  For example, "s id 11.2" at Bus 5 Jolimont, means that the currents on the sending-end of the line Jolimont–Pré-de-la-Cure are measured by the channel 2 of SynchroSense 11.
- Transformer current measurements are depicted by "T id#.#" in green beside the substation. Note that some substations are equipped with a SynchroSense, but the transformer currents are not monitored.

The substations where no SynchroSense is present are:

[1] A zero-injection bus (ZIB) is a grid node where no power is absorbed or injected. It can be due to a bifurcation of a distribution line or because a line is opened at one side.

- Feeder 51: Schenk, Rte de Lausanne, and C.S.I.
- Feeder 60: Rosey, and Dôme des Arts.

The lines opened at one side are:

- Feeder 51: line 12 Lac–Village (opened at Village) and line 15 Vernes–Prèlaz (opened at Prèlaz).
- Feeder 60: line 15 Centre–Rte-de-la-Prairie (opened at Rte-de-la-Prairie).

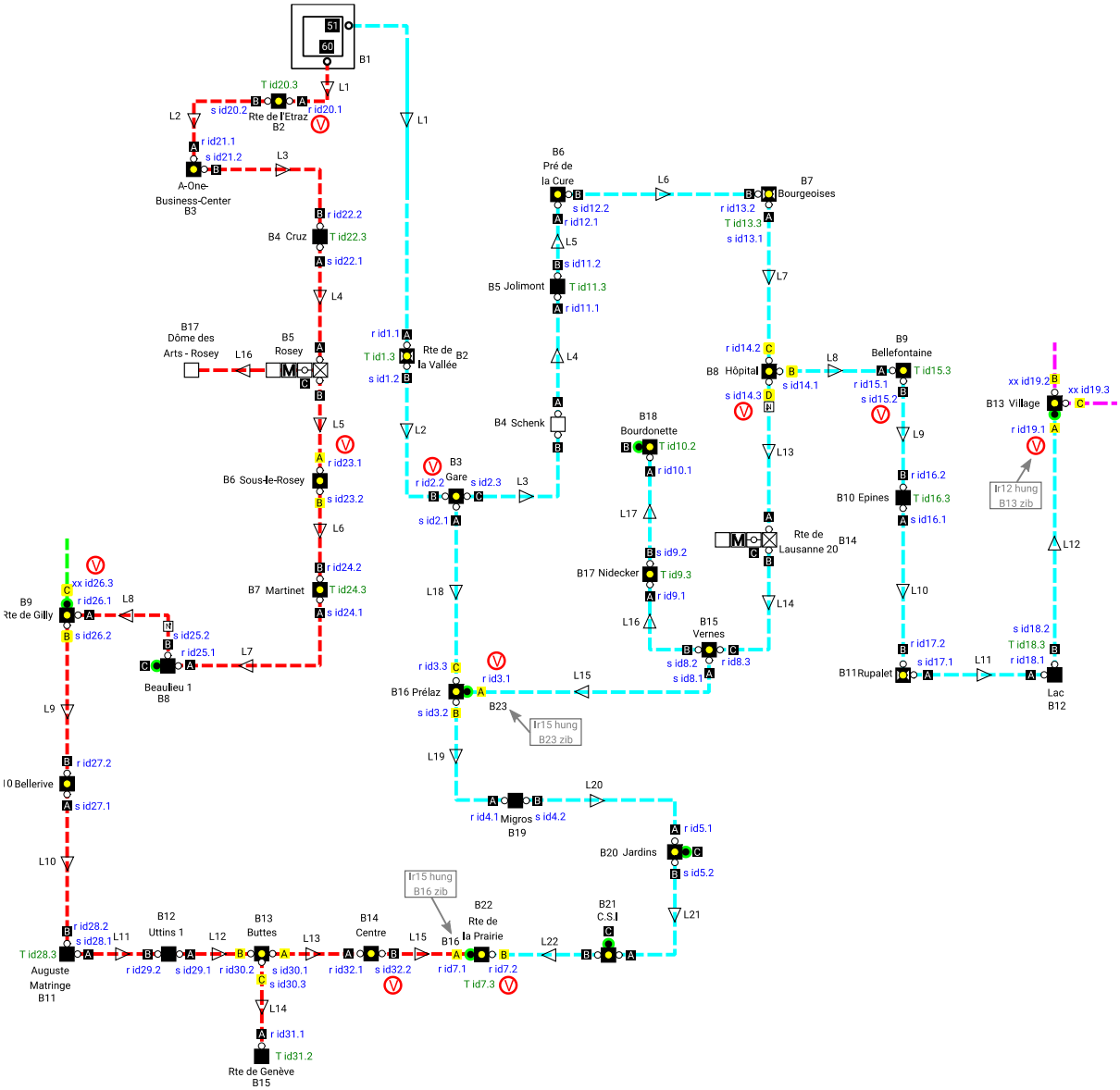

Figure 1 – Single line diagram of feeders 51 (light blue lines) and 60 (red lines) departing from the primary substation Rolle.

2. Achievement of deliverable:

2.1. Date

[22-10-2019]

2.2. Demonstration of the deliverable

Installation of SynchroSense devices

Figure 2 shows one of the installations of Zaphiro's measurement unit (SynchroSense) in an electrical substations of Romande Energie. Specifically, Figure 2a show the current sensors to take the current signals and Figure 2b shows the SynchroSense unit that acquires the signals from the current sensors and send the information to the central server. The central server collects the data from multiple SynchroSense devices and uses data-processing tools to understand the grid behavior. The main tool is called state estimation and is described here below.

(a)  (b) 

Figure 2 – Installation of Zaphiro's measurement unit (SynchroSense) in one of the electrical substations of Romande Energie. (a) current sensors; (b) SynchroSense unit.

Real-time grid monitoring via State Estimation

The main tool used to monitor the electrical grid is called State Estimation, which is a statistical procedure that uses the available measurements and the grid model (topology and grid parameters, i.e. line resistance, reactance and capacitances) to calculate the most likely state of the grid, namely voltages, currents and power flows at all buses/lines. To assess whether State Estimation is working properly in the real field, the estimates should match with the measurements, because this means that the measurements and grid topology/parameters are coherent with each other.

As you can see from *Figure 3*, the estimates of voltages, currents and power flows are very close to the measurements, thus demonstrating that State Estimation is working properly. This is an indication that the measurements taken by SynchroSense devices are accurate and the grid topology/parameter provided by Romande Energie are correct.

Note in *Figure 3* we showed only the results for feeder 51, because the outcome for feeder 60 is the same.

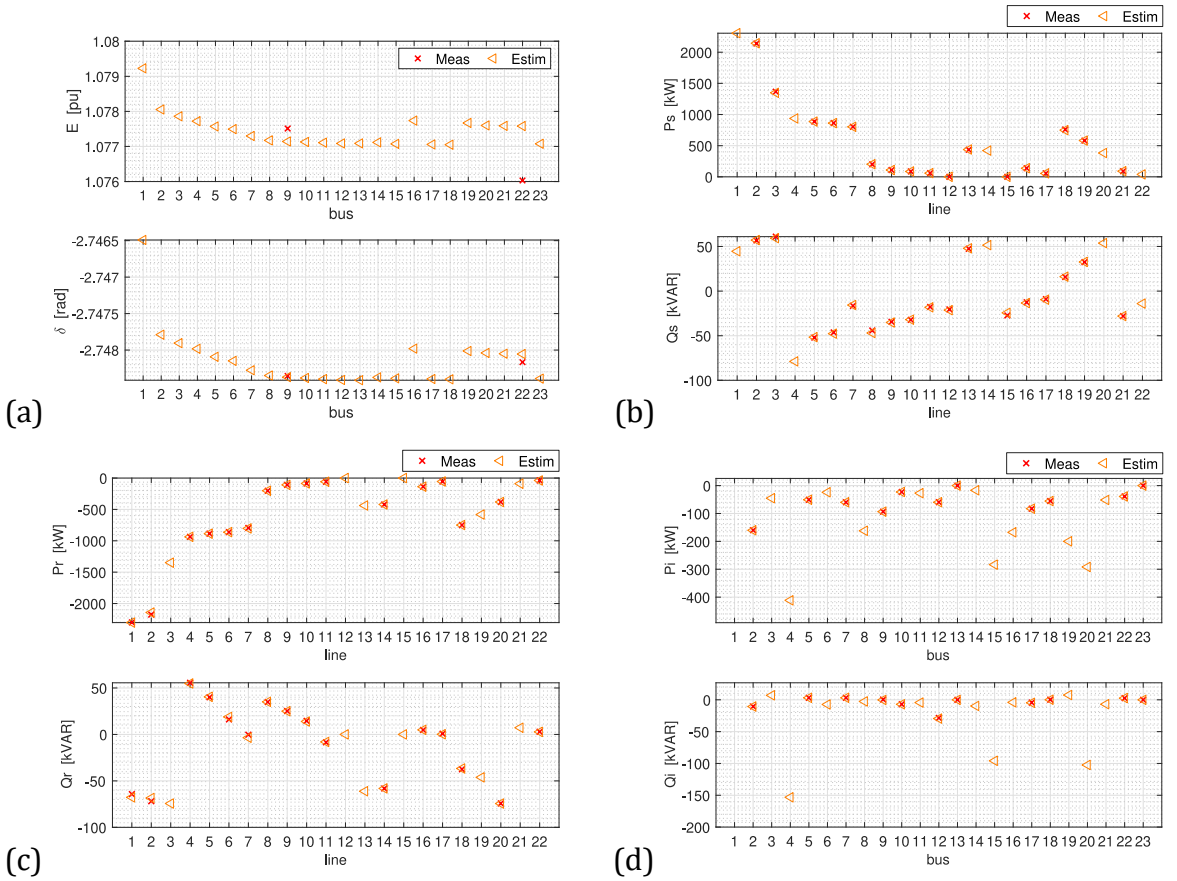

Figure 3 – Measurements vs. Estimates in Feeder 51. (a) Voltage magnitude and voltage phase-angle at all buses; (b) Active and reactive power at the sending-end of all lines; (c)

Active and reactive power at the receiving-end of all lines; (d) Active and reactive power absorbed by the transformers in all the buses/substations.

3. Impact

In the next stage of the demonstrator, this monitoring system will provide the data to other grid management functions that allow to increase grid efficiency and reliability, such as fault location and control of DERs (Distributed Energy Resources, namely generators, batteries, etc.).