TESTS OF INNOVATIVE FAULT DETECTORS FOR THE FRENCH DISTRIBUTION NETWORK

Loïc JOSEPH-AUGUSTE
EDF R&D – France
loic.joseph-auguste@edf.fr

Gilles MALARANGE
EDF R&D – France
gilles.malarange@edf.fr

Thierry PELINSKI
EDF R&D – France
thierry.pelinski@edf.fr

Didier COLIN
ERDF – France
didier.colin@erdf.fr

Dominique KLAJA
ERDF – France
dominique.klaja@erdf.fr

ABSTRACT

The objective of this paper is to present tests carried out for the project VENTEEA – a smart grid demonstration project led by the French DSO ERDF. The article will provide a specific focus on tests of innovative MV fault detectors in the experimental test facility Concept Grid, recently commissioned by EDF R&D in the South of Paris.

The tests conducted on Concept Grid enabled :

- *to check the fault detectors installation on an overhead line : connection to conductors, communication with the remote terminal unit installed at the bottom of the pole,*
- *to validate the behaviour under various conditions :*
  - *fault type : short circuits, ground faults, permanent faults, restriking faults,*
  - *fault location : upstream or downstream the detector,*
  - *variation of network parameters : neutral grounding through resistance or Petersen coil, different capacitive network impedances, variation of the Petersen coil unbalance, different ground fault resistances.*

Concept Grid tests enabled to create about fifty faults in a short period of time (one week). In comparison, a maximum of two faults would be expected in the real network over a period of one year.

The tests performed in 2014 enabled to evaluate the behaviour of fault detectors from two manufacturers (about fifty faults were carried out on each).

INTRODUCTION

VENTEEA is a smart grid field demonstration aiming to facilitate the integration of renewable energy sources. In this framework, innovative equipments are to be experienced under real operational conditions in rural MV distribution network areas with a high rate of wind power generation.

Among these innovative equipments, new generations of fault detectors (usually installed on MV grids for fault localisation) are tested. They are enabling a better network monitoring and control and thus an optimised network management.

The fault detector enables to localize the fault section of a feeder on the medium voltage network, through lighting signals, further to a permanent fault.

Furthermore, it records all the fault occurrences (self-extinguishing, fugitive, semi permanent) in an internal meter in order to facilitate the maintenance decisions of the grid.

In order to speed-up the correct design of these new fault detectors and reduce the risks during the VENTEEA field roll-out, it was decided to run prior experimental validation on the real network of Concept Grid.

VENTEEA

The VENTEEA project is a 3-year field demonstration effort among the top initiatives of the French smart grid R&D portfolio. Its goal is to facilitate the integration of Renewable Energy Sources (RES) in the MV distribution systems of the future. For this purpose, a distribution grid with high penetration of RES was selected to test industrial pilots of new technologies and control approaches including primary substation digital management package, real-time network state estimation, Volt Var Control (VVC) schemes and a Distributed Energy Storage System (DESS).

CONCEPT GRID

Concept Grid (see figure 1) is an experimental flexible test platform whose architecture and components have been designed so as to represent a real smart distribution network in order to anticipate and support the evolution of current electrical systems towards smart grids. This set of facilities operates a low and medium voltage network and enables a wide range of experiments. Its special design is halfway between lab tests and experiments in the field. Concept Grid makes it possible to conduct, in complete safety, complex testing campaigns that would be impossible to perform on a real network.

The Concept grid distribution network includes 3 km of MV network (20 kV) supplying 7 km of LV network. Concept Grid has also banks composed of resistors, inductors and capacitors (RLC, see figure 3) on the MV grid able to simulate up to 120 km of additional MV cables by means of four feeders under normal or disturbed conditions so-called « RLC SAFE » feeders and « RLC FAULT » feeder.

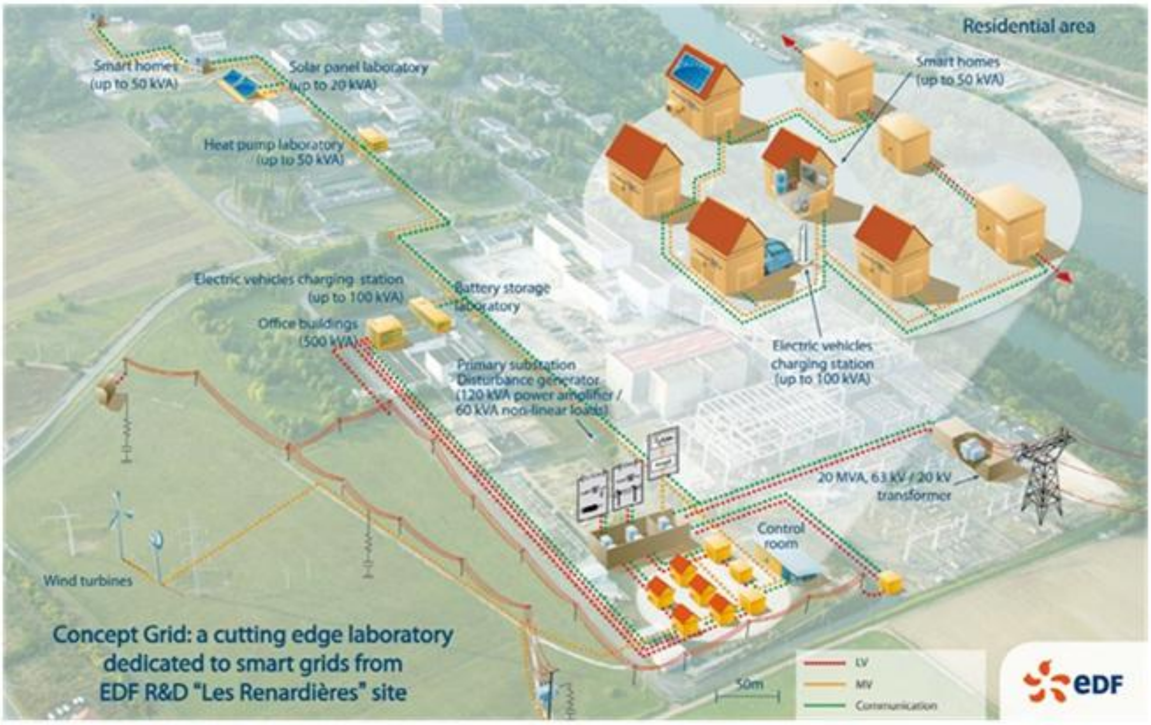

Figure 1. Concept Grid

TESTS ON CONCEPT GRID

Innovative fault detectors

The innovative fault detector system, tested in the experimental test facility Concept Grid, is composed of three measurement sensors (one per phase) installed on the MV overhead line and a processing unit located at the bottom of the pole (see figure 2).

The sensors are autonomous so that they do not require any external power supply. They are self powered via the MV overhead line induction and have the main functions of :

- measuring current and voltage signals,
- transmitting, via radio link, the measurements to the processing unit just after a sudden current and/or voltage change.

When a fault appears on the network, the processing unit analyses the recording sent by each sensor, integrates a processing logic and confirms the fault occurrence, based on current and/or voltage measurements, its type, and its location (upstream or downstream the detector).

These sensors have to be fixed on the powered MV overhead line. They can be installed with insulating stick with a hook.

Figure 2. Fault detector system location : sensors on the MV overhead line and processing unit on the ground

Tests procedure

The tests carried out on the fault detectors are mainly functional tests.

The test objective was to create faults on the MV overhead line located upstream and downstream the fault detector under tests by means of a mobile circuit breaker (see figure 4).

The tests have been carried out according to the following sequences :

Location 1 : fault downstream the detector

- sequence 1 : single phase permanent fault with neutral grounding through resistance,
- sequence 2 : single phase permanent fault with neutral grounding through Petersen coil.

Location 2 : fault upstream the detector

- sequence 1 : single phase permanent fault with neutral grounding through resistance,
- sequence 2 : single phase permanent fault with neutral grounding through Petersen coil.

Each sequence included a test series in order to test different network configurations during a fault.

Different parameters have been modified during the tests :

- the capacitive current value of the MV network can be modified by switching “on” or switching “off” the « RLC SAFE » feeders and « RLC FAULT » feeder. These modifications are controlled from the Concept Grid control room with three possible capacitive current values : 40 A, 90 A and 154 A,

Figure 3. RLC banks area

- the resistance in series with the fault can be adjusted between 0 and 360 Ω in steps of 36 Ω. The change of the resistance value requires a technician intervention for cabling the desired configuration,
- the auto reclose cycle can be activated or not.
- the Pertesen coil unbalance can be also modified.

Figure 4. Mobile circuit breaker

Measurements

The following measurements were carried out :

- measurement of three MV phases current in the « RLC FAULT » area with current transformers.
- measurement of the residual current in the « RLC FAULT » area with a current transformer.
- measurement of three MV phases voltage in the « RLC FAULT » area with voltage transformers.

The measurement and the recording of MV phase current, residual current and MV voltage in the « RLC FAULT » area have been made by a power analyzer. The signal sampling frequency was 10 kHz.

Moreover, the disturbance recording has been recovered from the MV protection. The signal sampling frequency was 1 kHz.

The simplified electric diagram of Concept Grid is illustrated on the next page (see figure 5) and indicates the measurement point locations on the grid.

Case study

This case corresponds to a fault scenario so-called "upstream fault". It does mean that the fault is located upstream the detector.
The detector measures the currents from the underground network located at the line end (see figure 5).

Fault parameters for the case studied are as follows :

- the neutral grounding is made trough Peterson coil.
- the resistance in series with the fault is equal 0.
- the « RLC SAFE » feeders are not connected to the grid, and any capacitive current is added upstream the network.
- the total capacitive current value is 42 A including 35.6 A downstream the fault detector (« RLC FAULT » area).
- the Peterson coil balance is set at 42 A.

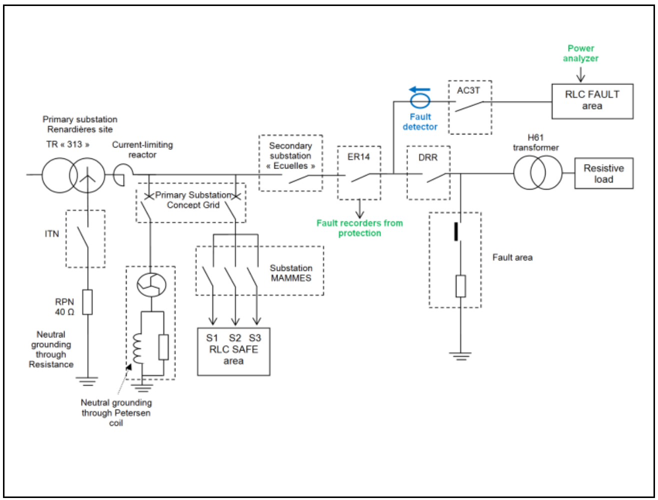

Figure 5. Concept grid network diagram implemented

Below is the measurement corresponding to the recording on the figure 6 :

U1	404.5	V
U2	19.7	kV
U3	20.1	kV
I1	916	mA
I2	20.5	A
I3	20.8	A
I residual (1st peak)	-49	A
U residual (1st peak)	46	kV
I residual RMS	35.6	A
U residual RMS	34.5	kV

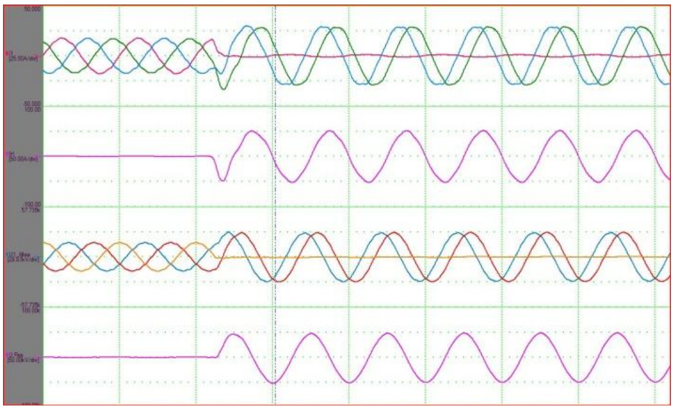

Figure 6. Fault recording

CONCLUSIONS

The tests conducted on the experimental platform Concept Grid enabled :

- to check the fault detectors installation on MV overhead line,
- to put into service the fault detector system (communication tests between each sensor and the remote terminal unit installed at the bottom of the pole),
- to validate the behaviour under real various electromagnetic and climatic environment conditions (humidity),
- to test functional performances of the fault detector with different fault parameters.

Concept Grid tests enabled to create about fifty faults in a short period of time (one week). In comparison, a maximum of two faults would be expected in the real network over a period of one year.

The tests performed in 2014 enabled to evaluate the behaviour of fault detectors from two manufacturers (about fifty faults were carried out on each).

The tests enabled manufacturers, with recording data, to proceed with necessary adjustments of the system in order to optimize the fault detector functionalities.

After the tests, the fault detector will be installed on the VENTEEA grid.

In conclusion, the testing has demonstrated the interest of Concept grid on the following aspects :

- equipment installation on a real representative network before its definitive installation on the grid allowing to improve the product implementation,
- speed-up feedback in relation with fault network, and de-risk field installation,
- flexible tool allowing to adjust network parameters to customer's needs,
- the use of the Concept Grid facility leading to interesting test results enabling manufacturers to improve their product.