European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out

TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	**MGCS-LTV**
Title	Microgrid Control System Laboratory Testing and Validation
ERIGrid Reference	05.024-2018
TA Call No.	5

HOST RESEARCH INFRASTRUCTURE			
Name	TECNALIA (Smart Grid Technologies Laboratory)		
Country	Spain		
Start date	03/05/2019	**Nº of Access days**	17
End date	03/06/2019	**Nº of Stay days**	32

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1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)

Background and Relevance:

Over the last years the role of microgrids has been increasing steadily and they will play a more important role in future power grids with the aim to provide a more resilient electricity supply.

The microgrid control system is the core element for dispatching energy between generators, energy storage systems and loads in the microgrid. It controls also the transition between grid-connected and islanded mode and vice versa. Testing the microgrid control system is crucial for safe and reliable operation of microgrids, hence the IEEE-SA published the IEEE 2030.8-2018 – *Standard for the Testing of Microgrid Controllers* in August 2018.

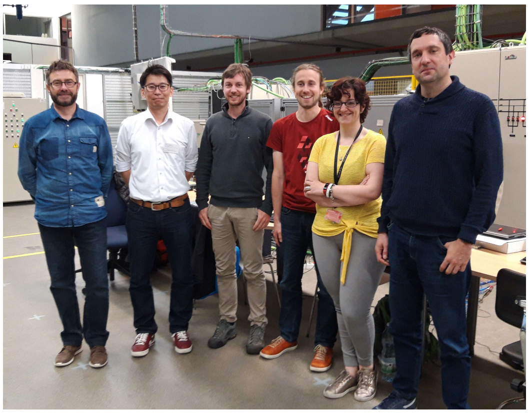

Figure 1: Team photo

From left to right: Emilio Rodriguez (TECNALIA), Jun Hashimoto (FREA, guest), Christian Messner (AIT), Christian Seitl (AIT), Julia Merino, Joseba Jimeno (TECNALIA)

Objective and Approach:

The work aims to present experiences and lessons learnt by laboratory tests following the IEEE2030.8-2018 test procedures. It addresses also the validation of usability and applicability of the standard by testing a microgrid controller at the microgrid test bed in the *Smart Grid Technologies Laboratory (SGTL)* of TECNALIA, Spain.

The standard defines five main test scenarios for the microgrid controller (cf. Table 1) and the test engineer must create test specifications for each scenario based of *initial conditions,* as generation and load-power and *initiating events* as islanding and reconnection requests.

Table 1: Test portfolio of IEEE2030.8

Dispatch function tests	*Transition/dispatch tests*
Dispatch functions define the set-point of DERs and controllable loads in grid connected and islanded modes • Steady State, grid connected scenarios • Steady state, islanded scenarios	Transition functions define the controller operation in transition from grid connected to islanded mode and reconnection • Planned islanding test • Unplanned islanding test • Reconnection test

Consequently, the first step within this Transnational Access (TA) was to create a variety of possible test specifications, followed by step-by-step testing procedures in order to perform laboratory experiments. This was done using the *Holistic Test Specification templates* which were developed within the ERIGrid project.

The standard recommends mainly the use of the settling time as a performance metric and the verification if voltages and currents are within the operational range of the equipment. Additional metrics and tolerance bands for the validation of the control strategies must be defined by the owner, the operator of the microgrid or the test engineer. In grid-connected mode the microgrid must operate in conformance with national grid-connection rules.

The test setup is shown in Figure 2. As generation units two 40 kW inverters (INV1 and INV2), which can operate in grid forming and grid following mode are used. The electricity demand is emulated with a 40 kW three phase load. At the point of interconnection (POI) to the main grid a breaker and synchro-relay is used. The synchro relay verifies the phase angle- and frequency difference between microgrid and main grid before reconnection. The measurement points for voltages and currents are also illustrated in the figure. The currents are measured at the generation units and at the POI. The voltage is measured at the microgrid side and utility grid side. The power is calculated for each measurement point.

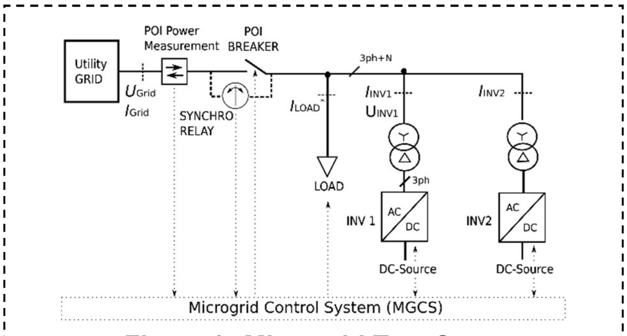

Figure 2: Microgrid Test Setup

2. MAIN ACHIEVEMENTS (results, conclusions, lessons learned)

Overall more than twenty test specifications were written, but not every test which is specified in the standard could be performed in the given lab setup. Either the test itself made no sense for the given MGCS, or we skipped them for reasons of time when no significant gain of new insights was expected. Finally, fourteen experiments were conducted, each with one or more single tests.

Exemplary, the results of a “reconnection to the main grid”-test is shown in Figure 3. After the reconnection signal is sent, the secondary control of the MGCS updates the droop control curves, leading to a change in the power distribution of the inverters and an increased frequency.

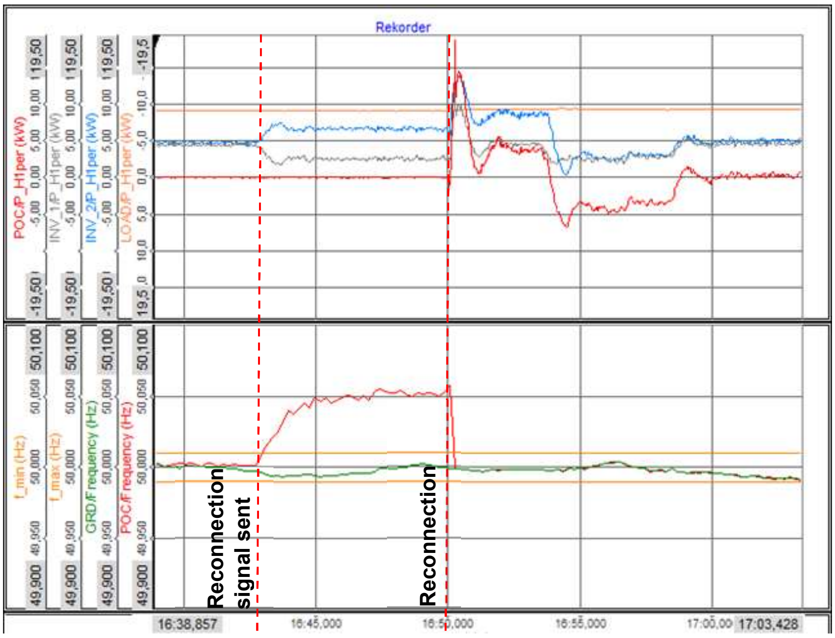

Figure 3: Reconnection to the main grid

This accelerates the occurrence of the reconnection condition: matching of phase angle between main and microgrid. When this is the case, the synchro relay allows reconnection and the breaker at the POI closes. After the reconnection one can see the time constants of the primary control of the inverter which react to the frequency change (less than 2 s) and the one of the secondary controls to achieve a defined power flow at the point of connection (approx. 10 s).

The IEEE 2030.8 standard aims to reveal weaknesses of the microgrid control system. It requires the test engineer to define specific test scenarios for individual microgrid configurations. Therefore, it is written more as a guideline with the focus on field installations, than a standard with step-by step test procedures. In future versions of the standard, it would be useful to have examples of test specifications for typical microgrid configurations and control systems to reduce the overall testing effort and to increase reproducibility of the results. Tests in steady state islanding mode required to extend the settling time definition of the standard and to use the frequency instead of power at the POI as observed variable. Improvements can also be done by introducing pass-fail criteria and failure classification e.g. minor and major failures.

Within this TA more than twenty test scenarios for the five main IEEE-2030.8 test cases were defined and corresponding laboratory tests performed. The tests showed that the standard is useful to reveal failures and possible improvements of the performance and functionality of microgrid control systems. For the case of the tested microgrid, potential improvements are related to the lack of anti-islanding capabilities in case of a grid outage and unexpected behaviour after trip events of the generation units. As the tested microgrid is used only as an experimental platform, no contractual requirements with different parties are foreseen. For a real field installation improvement with concerns to national grid-connection rules (anti-islanding, power quality, Q(U) control in grid-connected mode) would be necessary.

A drawback of the current standardization state is the fact that, the IEEE standard is not applicable for vendors of microgrid controllers to certify their product against the standard for generic arbitrary microgrids in a generic test lab. It is not possible to compare a MGCS product A with product B, as no standardized microgrid configuration exists. This is seen necessary for a performance comparison of different microgrid controllers. An introduction of a simple and uniform microgrid configuration, especially for a Controller Hardware-in-the-loop implementations, seem to be a promising future approach for producing comparable results of the performance of microgrid control systems.

3. PLANNED DISSEMINATION OF RESULTS (journals, conferences, others)

The results of the project were/will be presented at:

- PVSEC 2019: *"Testing of microgrid control systems according to IEEE 2030.8 – Experiences and learnings from laboratory tests"*
- CIGRE SEERC Conference 2020: *"Analysis of the applicability of the IEEE 2030.8 standard for testing a microgrid control system"*