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

TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	HILT AS-DRES
Title	**H**ardware-**i**n-the-**L**oop **T**esting of **A**ncillary **S**ervices of **D**istributed **R**enewable **E**nergy **S**ources
ERIGrid Reference	05.011-2018
TA Call No.	**5**

HOST RESEARCH INFRASTRUCTURE			
Name	**Delft University of Technology**		
Country	**The Netherlands**		
Start date	**18/11/2019**	**Nº of Access days**	**25**
End date	**20/12/2019**	**Nº of Stay days**	**33**

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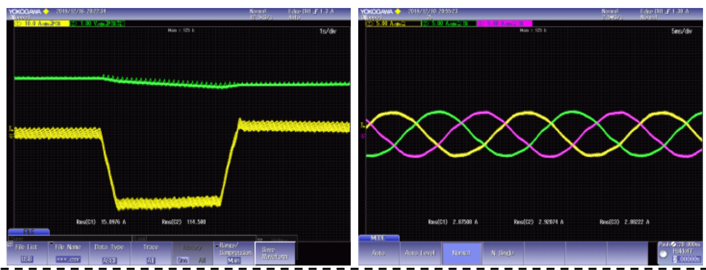
1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)

The traditional electrical power system has been designed to operate with central, dispatchable conventional power plants with synchronous generation (SG). These SG along with other control assets (transformer tap changers, capacitors, reactors, phase shifting transformers, etc.) provide the required Ancillary Services (AS) for stability and security of power grid. However, with the irruption of massive distributed renewable energy sources (DRESs), displacing the traditional SG, this situation is no longer valid being necessary the contribution of DRES to support the grid stability and security. As a matter of fact, it is expected that this technological change increases the relative AS costs from 5% in 2015 to 25% in 2020 [1]. This fact may represent an excellent opportunity for DRES owners which may consider to invest on new technologies enabling their participation in future AS markets. In spite of many AS are proposed in the specialized literature, this proposal focuses exclusively on the provision of Virtual Inertia (VI) and High-Frequency Power Smoothing (HFPS) which are directly related to the minimization of grid frequency variations. On the one hand, VI tries to emulate the behaviour of traditional SG just after a frequency excursion. On the other hand, HFPS tries to smooth the output power of the DRES due to the uncontrollable nature of the energy resource to mitigate frequency variations. For doing so, it is necessary to effectively control the injected active power to the grid being necessary to incorporate energy storage in the traditional DRES interfaces. Therefore, the objective of this proposal is to test in a Power Hardware-in-the-Loop (PHIL) environment a new DRES interface incorporating in its DC bus the required Fast Energy Storage System (FESS) for providing VI and HFPS.

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



The objective is to validate the correct performance of the prototype developed in Sevilla in different scenarios and conditions, using the equipment available on TUDelft laboratories. All tests are validated in four steps, corresponding to different AC voltages, 50V, 100V, 150V and 230V:

1. Test and validation of the hardware, connection to the grid, and grounding.
2. Grid emulator as an AC voltage source, prototype as a STATCOM.
3. Cinergia as a primary resource (current source), prototype as a STATCOM to the grid.
4. Cinergia as a primary resource (current source), prototype as a STATCOM to the grid emulator working as an AC voltage source.
5. Grid emulator as an AC voltage source, prototype as a grid-feeder AC-DC-DC converter with energy storage.
6. Cinergia as a primary resource (current source), prototype as a grid-feeder AC-DC-DC converter with energy storage, connected to the grid.
7. Cinergia as a primary resource (current source), prototype as a grid-feeder AC-DC-DC converter with energy storage, connected to the grid emulator working as an AC voltage source.
8. Same previous configuration, controlling the voltage of the supercapacitor, and injecting reactive power.

9. Same previous configuration, injecting pulses of active power.
10. Same previous configuration, providing inertia in simulated frequency drop events.
11. Same previous configuration, providing power smoothing service.

In each case waveform quality is recorded in AC side, in addition to a power injection log. In DC side voltage and current of the ultracapacitor is recorded in order to verify the dynamic of the system as well as the correct performance of the new additional control layer included in each test.

The results show that it is possible to provide inertia until reach the maximum power rating of the hardware. Active and reactive power is completely decoupled. The attached images shows an example of a inertia response of 3 kW (Lefts image: yellow, ultracapacitor current; green, ultracapacitor voltage), and an example of a steady state of reactive currents injected to the grid emulater.

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