TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	*WAHPS*
Title	Wide Area Harmonic Propagation Study
ERIGrid Reference	***05.017-2018***
TA Call No.	**5**

HOST RESEARCH INFRASTRUCTURE			
Name	PNDC		
Country	UK		
Start date	**30/09/2019**	**Nº of Access days**	**6**
End date	**08/10/2019**	**Nº of Stay days**	**9**

USER GROUP	
Name (Leader)	Stanislav Babaev
Organization (Leader)	Eindhoven University of Technology
Country (Leader)	Netherlands
Name	
Organization	
Country	
Name	
Organization	
Country	
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Organization	
Country	

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

The scope of the project is to study the phenomenon of harmonic distortion propagation through distribution networks. The core of the research is employing a multi-point distributed measurement system synchronized to a precision clock with high accuracy. This measurement configuration enables the evaluation of the power network response at different nodes to time-varying harmonic current injections.

The proposed set-up includes voltage and current measurements at both medium and low-voltage levels. Several MV/LV substations are involved in the experiment. The harmonic impact of a solar power inverter and an electrical vehicle charger is assessed in this work. Additionally, a synthetic harmonic current was generated as a reference injection.

The objectives of the research comprises the investigation of the phenomena of harmonic interaction between background voltage harmonic distortion and harmonic current injections of the non-linear sources under study. Furthermore, with provision of experimental measurements the diversity of harmonic phase angles and the degree of harmonic cancellation between non-linear loads are evaluated. Thus, special attention is given to the signal processing of recorded waveforms and retaining phase angles for every harmonic order.

To quantify the harmonic impact of certain loads, their spectrum is evaluated as a function of applied background voltage magnitudes and angles.

Furthermore, additional conclusions are derived based on the influence of network impedance and short-circuit powers on voltage distortion levels. The former involves network topology changes and varying powers of resistive loads at low-voltage levels.

The research project advances the knowledge in the field of power quality and introduces new approaches and measurement techniques for the assessment of harmonic distortion and their impact on the wider network. Additionally, the results of the research are expected to further facilitate integration of devices with global synchronization of samples and their utilization for power quality assessment.

The results and considerations of this study can be used for network design, analysis of the connection requirements for installations and assessment of the emission limits as well as planning of mitigation activities.

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

The main achievements are as follows:

Achievement 1: Assessment of the harmonic profile of non-linear source by measuring its full harmonic fingerprint.
The relationship between harmonic current injections of power-electronic loads and voltage background distortion applied to its terminals is evaluated by sweeping voltage magnitudes and angles and recording the current response of the load. As a matter of fact, the harmonic behavior of the device differs from the one provided by the manufacturer (tested under perfect sinusoidal conditions). The actual THD_i values are in most cases higher than expected. The proposed measurement procedure allows not only to estimate an impact of certain harmonic loads on the distribution network but also can be used as an input to measurement-based modelling process.

Achievement 2: Quantifying the summation of time-varying harmonics and correlating it with harmonic voltage distortion levels.
The advantage of the accurate synchronized waveform recording is in its capability to capture harmonic components at various points in the grid while preserving the phase angle relation. This fact delivers an opportunity for accounting on the diversities of phase angles between different harmonic sources and quantifying the levels of cancellation. Given the dynamic nature of harmonics it is also possible to correlate changes in harmonic voltage distortion at different locations based on harmonic current injections extracted from synchronized data. Having fingerprint input from the previous stage and considering harmonic interaction a conclusion about the impact of the particular source can be drawn.

Moreover, as the performed experiments involved some share of linear loads, the synchronized voltage and currents waveforms allowed to differentiate the sources of the harmonics and linear loads influenced by reduced voltage quality.

Achievement 3: Evaluation of the impact of system impedance on voltage harmonic distortion.
The results of the experiment indicate that network topology changes at MV levels and operation of the substantial fraction of resistive loads connected to the LV network do influence harmonic voltages at various points of the distribution network and these altered voltages in turn affect harmonic currents in the power grid. The conclusion is drawn that while performing harmonic studies a thorough consideration must be given to the uncertainties associated with impedances of power system components.

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

Journal publication in MDPI Energies or in the Special Issue ‘Phasor Measurement Units Algorithms, Challenges and Perspectives’ in MDPI applied sciences.

Additionaly, this work will comprise a chapter in the Doctoral dissertation of Stanislav Babaev.