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

TRANSNATIONAL ACCESS PROVISION

RESEARCH INFRASTRUCTURE DESCRIPTION AND
TRANSNATIONAL ACCESS CONDITIONS

DNV·GL
Strategic Research & Innovation

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1 Research Infrastructure

Name of Infrastructure/Installation	**Flex Power Grid Laboratory (FPGL)**
Location	DNV·GL – Arnhem, the Netherlands
Web Site	*www.FlexPowerGridLab.com*

2 Description of the Research Infrastructure

The Flex Power Grid Lab (FPGL) in Arnhem, the Netherlands takes a unique position in the world because of its voltage capability (24kV,3Φ;50kV,1Φ), power range (1MVA) and bandwidth (2.4kHz). It builds on its long term experience of component research and testing in order to set the standard for future system validation research and testing.

The Flex Power Grid Laboratory infrastructure is particularly well suited for research on, or testing of utility-interactive devices intended for low-voltage or medium-voltage distribution grids, such as power electronics converters, combined-heat & power (CHP) systems and storage systems. It features freely programmable, high-power AC and DC sources capable of realistically emulating a grid connection, a PV system, a storage system or a combination thereof. This enables extensive research and testing capabilities on aspects such as *grid compliance* – including fault-ride-through (FRT), interface protection and power quality (PQ) – functionality, component performance and component reliability.

Furthermore, the infrastructure incorporates real-time simulation capabilities to extend the research capabilities into the domain of *Power Cybernetics*[1] as part of power system validation.

A fully equipped measuring system is provided in the safety of the command-room. Moreover, the command room overlooks the laboratory floor on which the research objects are clearly visible but guarantees the user's safety at all times.

One particular feature of this infrastructure that deserves special attention is its ability to influence the power quality of the AC distribution grid within the facility (AC grid simulator) to which the research equipment can be connected. It is possible to superimpose an arbitrary contribution of harmonic voltages on the grid voltage to simulate a badly polluted grid, or a badly polluted load (in reverse power flow direction). Dynamic network phenomena such as voltage and frequency variations can be realized with the ability to include voltage dips, phase jumps and rapid voltage changes, see Figure 1. The AC grid simulator is also capable of coping with unbalanced loads/sources and still provides the capability to superimpose harmonic voltages and instigate dynamic network phenomena for the purpose of interaction verification (equipment with grid under dynamic conditions) as well as component immunity and susceptibility analysis.

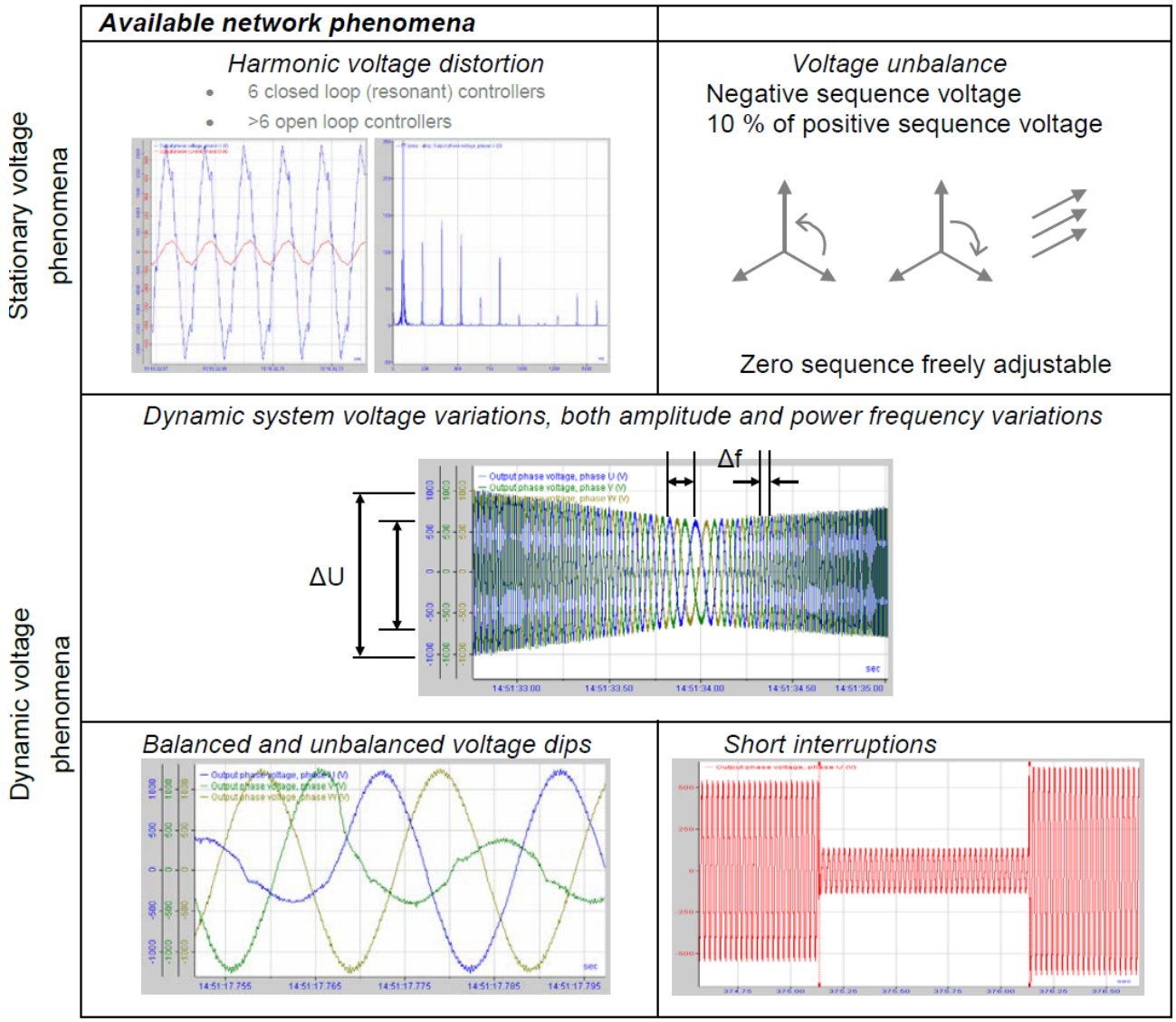

Figure 1 Different AC power quality phenomena that are available at the infrastructure

[1] Reference: DNV·GL's position paper on *Power Cybernetics – The future of validation*; 2016. Available on request.

In essence there are two distinct operation modes available:

1) First is the basic static operation mode with a fixed fundamental frequency (DC up to 75Hz), in which it is possible to superimpose a wide variety of harmonic distortions on top of the base frequency to simulate a badly polluted grid, or a badly polluted load (in reverse power flow direction). These amplitudes of the fundamental frequency, as well as that of the harmonics (voltage amplitude and angle of each individual harmonic individually controllable), can be varied online and are closed-loop controlled to a large extent.

2) Secondly, there is the dynamic mode of operation. In this operation mode all kinds of other grid phenomena can be produced, e.g. voltage and frequency variations with the ability to include voltage dips, phase jumps and rapid voltage changes. The programmed grid is also capable of coping with unbalanced loads/sources and still provide the capability to superimpose harmonic voltages and instigate dynamic network phenomena onto it.

Finally, the laboratory is equipped with resistive (0.5MW), inductive (1MVAr) and capacitive (1MVAr) loads that are adjustable in a large range; and a connection to the utility grid with off-load tap changer (400V...4kV) to provide maximum flexibility for any research of testing endeavour.

3 Services offered by the Research Infrastructure

The facility allows researchers to gain “hands-on” experience on the interaction of utility-interactive equipment, such as power electronics converters and its controls, with a distribution system and thereby fosters practical innovation in equipment technology within the power system industry.

Within the scope of the ERIGrid – Trans National Access activities, the FPGL research infrastructure offers the following services (for inspirational purposes, actual services can differ):

- Analysis, measurement and testing of **(large scale) utility-interactive, power electronics equipment** (inverters, battery storage systems, UPS systems, Vehicle2Grid and EV charging applications, active (harmonic) filters, STATCOMs, etc.) behaviour, in the development and deployment of **advanced inverter functions, ancillary services, synthetic inertia, grid stability**, etc.
- Development, optimization, measurement and testing of (**large-scale) smart grid operation and control algorithms** based on distributed embedded control in power electronics equipment, for example.
- Individual **conformance testing of utility-interactive power electronics equipment** and evaluation of the **performance of devices within a distribution system** under different static and dynamic electrical conditions (efficiency, power quality (see Figure 1), etc.), also as (part of) grid compliance initiatives[2].
- Analysis of **system stability** (large and small signal) in grids with a high penetration of power electronics equipment and/or controllers.
- **Model validation** of utility-interactive equipment and/or controllers within distribution grid applications.

[2] Although DNVGL is accredited for performing grid compliance certification to a number of (inter)national standards, no certification is available within ERIGrid TNA activities.

4 Brief description of the organization managing the Research Infrastructure

DNV GL
Driven by its purpose of safeguarding life, property and the environment, DNV GL enables organisations to advance the safety and sustainability of their business. DNV GL provides classification and technical assurance along with software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Combining leading technical and operational expertise, risk methodology and in-depth industry knowledge, DNV GL empowers its customers' decisions and actions with trust and confidence. The company continuously invests in research and collaborative innovation to provide customers and society with operational and technological foresight. DNV GL, whose origins go back to 1864, operates globally in more than 100 countries with its 16,000 professionals dedicated to helping their customers make the world safer, smarter and greener.

In the Energy industry
DNV GL delivers world-renowned testing and advisory services to the energy value chain including renewables and energy efficiency. Our expertise spans onshore and offshore wind power, solar, conventional generation, transmission and distribution, smart grids, and sustainable energy use, as well as energy markets and regulations. Our 3,000 energy experts support clients around the globe in delivering a safe, reliable, efficient, and sustainable energy supply.

DNV GL Strategic Research & Innovation
The objective of strategic research is through new knowledge and services to enable long term innovation and business growth in support of the overall strategy of DNV GL. Such research is carried out in selected areas that are believed to be of particular significance for DNV GL in the future.

5 Transnational Access conditions offered by DNV·GL

All ERIGrid trans-national access activities are performed in a professional environment with highly qualified personnel, available for scientific discussions on the preparation and proceedings of the research and test activities. DNV·GL's experience with commercial testing allows users to benefit from DNV·GL's knowledge about the latest industry requirements on testing. The commercial laboratory environment provides all the required logistical support for the preparation and execution of the mutually agreed upon experiments.

The research infrastructure will only be used accordance with a mutually agreed test plan, which is based on the agreed ERIGrid user project. Furthermore, as the facility is a medium-voltage, high-power facility, local legislation as well as company policy dictate that the research infrastructure be operated by qualified DNV·GL personal *only*. DNVGL staff will be available to assist in any preparatory activities (preparation of test circuit, measurement set up, etc.), measurement data and result interpretation (if applicable) and other project related aspects on-site.

The safety of all those present at the research facility is our top concern. Safety instructions will therefore be provided for all visitors on arrival. All visitors will need to wear appropriate protective gear (safety shoes and safety hats, for example) during all activities at the research facility, which they are expected to provide themselves. This with the exception of safety hats, which are available at the research facility itself.

The access to the laboratory infrastructure will be mutually agreed upon and booked prior to the stay, according to the availability of the required DNV·GL staff and equipment. All the administration required for the access (contract, non-disclosure agreement, etc.) will comply with the both the DNV·GL terms and conditions for the execution of projects in its laboratories as well as the commonly agreed ERIGrid terms and conditions.

The duration of stay at the research infrastructure is typically 1 week for a single user group, but this period can be extended depending on the terms and conditions of the agreed user project.
The user group (typically 2 persons) can use the infrastructure for the agreed time as per the approved user project.

Reimbursement of expenses:

User expenses for the Transnational Access are paid by ERIGrid (EU H2020 Programme). This includes travels to FPGL (DNV·GL) by public transport (plane, train, bus, metro, etc.), accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in FPGL, DNV·GL will refund the expenses incurred during the stay after the stay has finished: the user must declare the incurred expenses and present the associated invoices/receipts to DNV·GL within 1 month after the stay has finished, in order to get the cost reimbursed.

Logistical expenses must be made by the user: air and rail travel will be made in economy/second class and conventional hotels (not luxury) or equivalent accommodation will be used. As an indication (it is not a daily allowance), a maximum subsistence fee of 160 €/person must be considered per day. Lunch will be provided at DNV·GL's canteen at no cost to the user.

6 Contact details for Research Infrastructure

Flex Power Grid Laboratory (FPGL) - DNV·GL Address: Business Park Arnhems Buiten, Building R11, Utrechtseweg 310, 6812AR Arnhem, the Netherlands Website: *www.dnvgl.com/energy*	
Erik de Jong Tel.: +31 26 356 2794 E-mail: *Erik.deJong@dnvgl.com*