



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

Work Package 3

NA3 - Organisation and Management of Trans-national Access User Projects

Deliverable D-NA3.1

General rules for the ERIGrid trans-national access

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Abbreviations

<i>AC</i>	Alternating Current
<i>AMI</i>	Advanced Metering Infrastructure
<i>API</i>	Application Programming Interface
<i>CEN</i>	Comité Européen de Normalisation (European Committee for Standardization)
<i>CENELEC</i>	Comité Européen de Normalisation Électrotechnique (European Committee for Electrotechnical Standardization)
<i>CHAdemo</i>	CHArge de MOve (EV charging protocol)
<i>CHIL</i>	Controller Hardware-in-the-Loop
<i>CHP</i>	Combined Heat and Power
<i>CIGRÉ</i>	Conseil International des Grands Réseaux Electriques (Council on Large Electric Systems)
<i>CIM</i>	Common Information Model
<i>COSEM</i>	Companion Specification for Energy Metering
<i>CPU</i>	Central Processing Unit
<i>DAQ</i>	Data Acquisition
<i>DC</i>	Direct Current
<i>DG</i>	Distributed Generation
<i>DER</i>	Distributed Energy Resource
<i>DLMS</i>	Device Language Message Specification
<i>DSO</i>	Distribution System Operator
<i>DVR</i>	Dynamic Voltage Restorer
<i>EC</i>	European Commission
<i>EEGI</i>	European Electricity Grid Initiative
<i>EERA</i>	European Energy Research Alliance
<i>EMF</i>	Electro-magnetic Field
<i>ES</i>	Energy Saving
<i>ETSI</i>	European Telecommunications Standards Institute
<i>EU</i>	European Union
<i>EV</i>	Electric Vehicle
<i>EVSE</i>	Electric Vehicle Supply Equipment
<i>FACTS</i>	Flexible AC Transmission System
<i>FPGA</i>	Field Programmable Gate Array
<i>FRT</i>	Fault-Ride-Through
<i>GIS</i>	Geographic Information System
<i>GOOSE</i>	Generic Object Oriented Substation Events
<i>GPRS</i>	General Packet Radio Service
<i>GPS</i>	Global Positioning System
<i>HIL</i>	Hardware-in-the-Loop
<i>HV</i>	High Voltage

<i>HVDC</i>	High-Voltage Direct Current
<i>IA</i>	Integrating Activity
<i>ICT</i>	Information and Communications Technology
<i>IEC</i>	International Electrotechnical Commission
<i>IED</i>	Intelligent Electronic Device
<i>IEEE</i>	Institute of Electrical and Electronics Engineers
<i>ISGAN</i>	International Smart Grid Action Network
<i>IT</i>	Information Technology
<i>I/O</i>	Input/Output
<i>LAN</i>	Local Area Network
<i>LV</i>	Low Voltage
<i>LVRT</i>	Low-Voltage Ride Through
<i>MG</i>	Motor-Generator
<i>MPPT</i>	Maximum Power Point Tracker
<i>MV</i>	Medium Voltage
<i>NA</i>	Networking Activity
<i>NTP</i>	National Technology Platform
<i>OLTC</i>	On-Load Tap Changer
<i>PC</i>	Personal Computer
<i>PHIL</i>	Power Hardware-in-the-Loop
<i>PMU</i>	Phasor Measurement Unit
<i>PLC</i>	Power Line Communication
<i>PLC</i>	Programmable Logic Controller
<i>PQ</i>	Power Quality
<i>PV</i>	Photovoltaic
<i>RCP</i>	Rapid Control Prototyping
<i>RES</i>	Renewable Energy Sources
<i>RI</i>	Research Infrastructure
<i>RIA</i>	Research and Innovation Actions
<i>RP</i>	Responsible Person
<i>RPM</i>	Revolutions per minute
<i>RT</i>	Real Time
<i>RTD</i>	Research and Technical (or Technological) Development
<i>RTS</i>	Real-Time (Digital) Simulator
<i>RTU</i>	Remote Terminal Unit
<i>RUE</i>	Rational Use of Energy
<i>R&D</i>	Research and Development
<i>SCADA</i>	Supervisory Control And Data Acquisition
<i>SGAM</i>	Smart Grid Architecture Model

<i>SIRFN</i>	Smart Grid International Research Facility Network
<i>SME</i>	Small and Medium-sized Enterprise
<i>STATCOM</i>	Static Synchronous Compensator
<i>TA</i>	Trans-national Access
<i>TSO</i>	Transmission System Operator
<i>UPS</i>	Uninterruptible Power Supply
<i>USP</i>	User Selection Panel
<i>VPP</i>	Virtual Power Plant
<i>V2G</i>	Vehicle-to-Grid

Executive Summary

The core of the ERIGrid project is the trans-national access to integrated research infrastructure, operated at 21 distributed installations, located in 11 countries. The ERIGrid trans-national access activity, placed at the disposal of (mainly) the European research community, includes “free of charge” access to these infrastructures, technological and scientific support and funding to cover travel and accommodation during stays.

This document specifies the general rules of the ERIGrid trans-national access scheme, describing the entire access procedure, the public calls, proposal evaluation and selection and hosting of researcher groups at the facilities on offer. Moreover, the document indicates the basic provisions for the dissemination of the results of implemented user projects. The descriptions of the offered research infrastructures, along with the corresponding trans-national access conditions, are provided as well.

1 Introduction

The ERIGrid project tries to mitigate the lack of validation schemes for Smart Grids configurations, based on a holistic and cyber-physical approach. The ERIGrid Pan-European Research Infrastructure (RI), which integrates 18 research institutions, supports the technology development and the roll out of Smart Grid solutions by the joint development of testing methods and validation procedures.

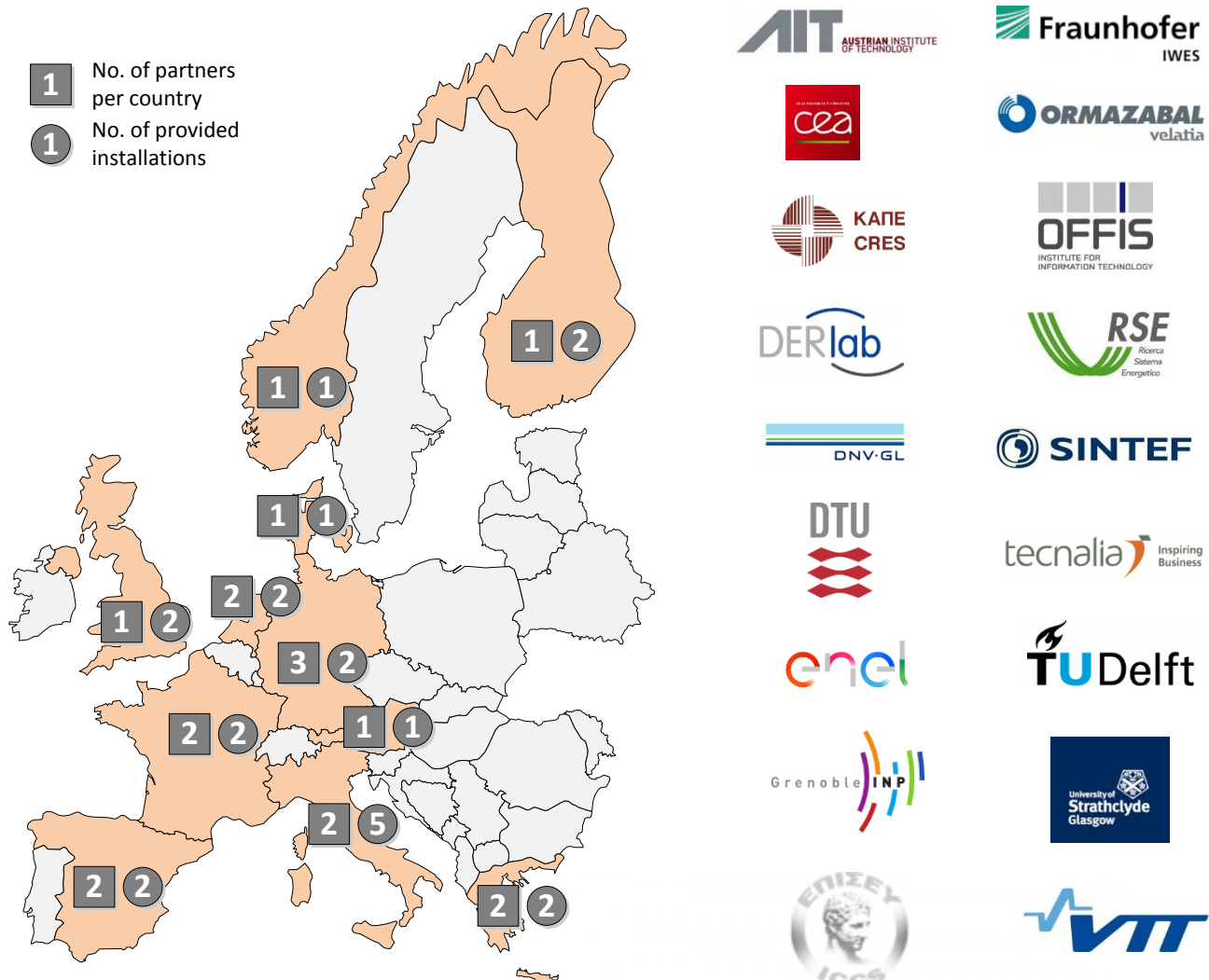


Figure 1: Overview of the ERIGrid consortium members and provided installations

The ERIGrid RI operates through an integrated approach of 21 distributed installations, located in 11 countries. ERIGrid aims at placing the RI at disposal of the European research community, including industrial organisations, in a 4-year access programme supported by the European Commission (H2020).

ERIGrid offers to eligible external users “free of charge” Trans-national Access (TA) to its research infrastructures along with logistical, technological and scientific support. The TA scheme includes also free travel and lodging for the stays¹.

1.1 Purpose of the Document

The objective of this document is to become the basic guide for those Users Groups who are thinking of using the ERIGrid TA and benefiting from this opportunity supported by the European Com-

¹ For some international users there could be limitations. See section 2 for details.

mission (H2020). An updated version of the document might be necessary during the execution phase of the TA as further aspects are brought to light by potential applicants and granted users.

1.2 Scope of the Document

The document has been prepared following a didactic approach that covers the eligibility of the users and the end-to-end procedure to be followed in the ERIGrid TA programme: from the call announcement to the mandatory dissemination of the user project results.

This guide provides also the descriptions of the RI offered by ERIGrid and the concrete TA conditions applicable to the individual installations. As part of the streamlined process, two templates are also included: a first one for the user project proposal and second one for the declaration of TA expenses by the User Group.

Even though some basic contractual indications are contained as a reference in this document, the actual contract template is out of scope for this deliverable and will be included in the complementary deliverable (D-NA3.2).

1.3 Structure of the Document

The document has two main chapters: Section 2 on the eligibility conditions to be fulfilled by the users of the TA programme, and Section 3 on the step-by-step access procedure. Since the reimbursement of the TA expenses is a critical point for the users, Section 4 provides the basic treatment of this issue.

For the sake of clarity, the comprehensive descriptions of the RI and the helpful templates are presented within the annexes of this document.

2 Eligibility of the User Groups

TA is provided to selected “users” and “user groups” (teams of one or more researchers led by a User Group Leader). The selection will be done through the evaluation of the received user project proposals by an independent review panel of experts from different domains that are involved in smart grids (power systems, ICT, cyber-security, etc.).

Funding is for “trans-national access” i.e. within another country that is not the country of origin of the user. The User Group Leader and the majority of the User Group members should work in an institution/SME² located in a different country to the country where the infrastructure/installation (i.e., Smart Grid laboratory in the context of ERIGrid) is located. For multi-site projects this rule applies to all sites to be accessed.

The ERIGrid TA is open to researchers that are primarily from organizations (this includes SMEs and larger industries) located in an EU Member State.

Limited access is also available to applicants from non-EU countries (“third countries”): the limitation is not on the number of User Groups from these countries but on the amount of access that can be provided by ERIGrid: access for user groups with a majority of users working in third countries is limited to 20% of the total amount of units of access provided under the grant. Third countries include H2020 Associated Countries³ (Albania, Bosnia & Herzegovina, Faroe Islands, Former Yugoslav Republic of Macedonia, Georgia, Iceland, Israel, Moldova, Montenegro, Norway, Serbia, Switzerland – partial association⁴, Tunisia, Turkey, and Ukraine), and other developing countries⁵.

Industrialised countries from non-EU or associated countries can apply for TA but travel and subsistence expenses will be covered subject to budget availability, especially in the later stages of the project. The general H2020 conditions for International Cooperation⁶ and H2020 rules apply for formal eligibility.

Only User Groups that agree to disseminate the results that they have generated under the project are eligible to benefit from access to the infrastructure free of charge, except for SMEs and industrial users, for which special confidentiality provisions may be needed. Young scientists at the start of their careers and female researchers will be positively considered.

The duration of the stay at a RI will normally be 1-4 weeks but in some cases longer stays of up to 3 months may also be justified.

² Small and Medium-sized Enterprise

³ http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/3cp/h2020-hi-list-ac_en.pdf

⁴ http://ec.europa.eu/research/participants/data/ref/h2020/other/hi/h2020-hi-swiss-part_en.pdf

⁵ http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-a-countries-rules_en.pdf

⁶ http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/international-cooperation_en.htm

3 Trans-national Access (TA) Procedure

This section describes the steps of the entire procedure, detailing how the trans-national access in ERIGrid will be implemented through successive public calls. It provides the criteria for the assessment and selection of proposals by the User Selection Panel (USP) and settles the general rules for the development of the selected user projects and the dissemination of the results. In addition, it defines the general contractual conditions pertaining to the researcher stay at the infrastructures. Further elaboration and specifics will be detailed using a contract.

The general timeline is shown in the next figure below. As a reference, the duration of the call and the associated user stays will last for around 8 months, with the following main time periods:

- The Call will remain open for 3 months.
- The received proposals will be evaluated within one month after the closing date of each call.
- The stay period depends on the user project: 1-4 weeks typically and limited to a maximum of 3 months if well justified.
- Finally, the User Group has a month to carry out the mandatory reporting of the project.

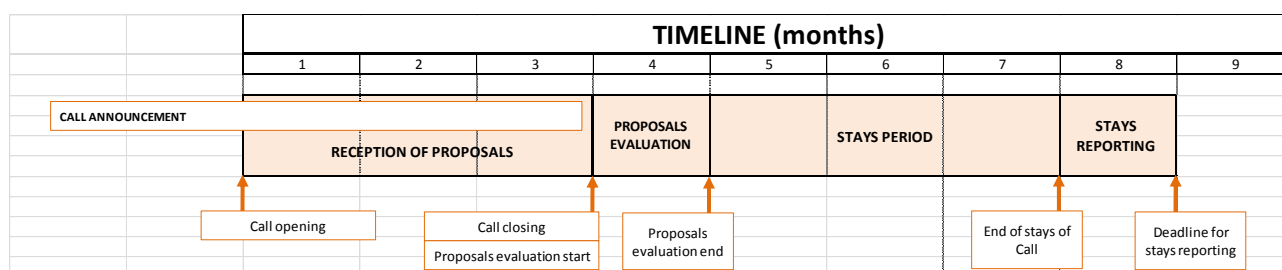


Figure 2: Call reference timeline

3.1 STEP 1: Publications of the Call for Proposals

Every 6 months a Call for Proposals will be launched by ERIGrid for TA to conduct experiments at the Research Infrastructures listed in Appendix 1.

The dissemination of the trans-national access calls will be done through the ERIGrid website (www.erigrid.eu, where a dedicated TA section has been created), social networks, advertisement through different channels (posters, flyers, press releases, ERIGrid partners' web pages, etc.), publications at conferences, workshops and journals, and direct contact with potential users.

3.1.1 Topics targeted by the Calls

The Calls for Proposals will be targeted to research and development of Smart Grid concepts and configurations and to testing and validation methods and tools following a holistic approach.

Future electrical networks will integrate higher shares of fluctuating renewable energy, distributed energy resources at all voltage levels, active prosumers, electrical vehicles, demand side management programmes, etc. Besides the power system components, like the grid infrastructure, storage, generation, consumption, etc., it also comprises ICT, cyber-security, markets, regulation, etc. Any project proposal covering these broad and complex themes, will fall into the ERIGrid TA scope and may be eligible.

In this context, those proposals contributing to the improvement of the services provided by the infrastructures, the harmonisation and optimization of methodologies, and the reinforcement of the partnership with industry will receive a special consideration.

The experimental research on the selected research topics must be implemented in one (or several) of the offered research infrastructures listed in Appendix 1, therefore technical feasibility will be checked in advance by the corresponding research infrastructures based on the available equipment/facility and offered services.

3.2 STEP 2: Submission of the User Proposals

In response to the Calls, User Groups will submit their project proposals to ERIGrid. The submission will be done electronically (using the ERIGrid TA email address, the on-line tool or the on-line application form) before the Call deadline. Proposal documents must be completed using the proposal template (Appendix 2), available on the ERIGrid website.

The User Group preparing the proposal will indicate the preferred infrastructures (one, two or three options are allowed) where the experimental research will be carried out. These preferences will be considered, to the extent possible, during the evaluation process.

Normally (it is not mandatory but recommended for a successful proposal), before submission of the application form, the User Group will contact the preferred infrastructure/s to check the preliminary availability of the facilities and feasibility of the experiments, and to clarify the research objectives and access conditions.

3.3 STEP 3: Evaluation of the User Proposals

The selection of researchers or research teams will be carried out through an independent peer-review evaluation of their research projects.

The evaluation of the user project proposals will be done in two phases: (1) pre-screening, and (2) full evaluation. The entire evaluation process is expected to be completed within one month after the deadline for the submission of proposals.

3.3.1 Pre-Screening

The pre-screening is the first assessment of the technical, economic, and organizational feasibility of the received proposal done by the three RI selected (preferred) by the User Group. Technical problems, risks, and related cost will be considered. No further evaluation criteria will be employed at this stage.

The pre-screening process will start as soon as a proposal is received, even before the Call is closed. In this phase, the selected infrastructures may suggest/request modifications to the proposal in order to ensure feasibility and pass the pre-screening (in any case, the improved proposal resulting from this interaction must be submitted by the User Group before the Call deadline).

If the proposal is not feasible at any of the three selected infrastructures, the ERIGrid TA Manager will circulate it to the rest of the RIs so they can assess it for feasibility at their own RI. The proposal will be assigned to one of the research infrastructures, not initially selected by the User Group, but able to implement the user project. If more than one RI can develop the project, the User Group will be contacted to choose. If in the end, the proposal (even modified or adapted) cannot be implemented at any RI, it will be rejected.

The aim of pre-screening is to filter out and avoid the unnecessary work by the User Selection Panel in evaluating and approving a proposal that cannot be implemented due to technical or economical infeasibility at the selected infrastructures (or even in any ERIGrid infrastructure).

The pre-screening is expected to run smoothly if preliminary contact has been established between the proposing User Group and the selected infrastructures.

On conclusion the pre-screening phase, each feasible proposal will be linked to a research infrastructure, where the project can be carried out. At this point, the proposal is ready for the full evaluation phase.

3.3.2 Full Evaluation

All received proposals that pass the pre-screening will be subsequently fully evaluated. This will be performed by the USP. The USP is a group consisting of experts from within and outside ERIGrid partner organisations with diverse profiles (academia, industry) and covering the different domains of the Smart Grid area (power systems, ICT, etc.). The concrete experts for the evaluation of each proposal will be appointed by the ERIGrid TA Manager and the ERIGrid Project Coordinator depending on the proposal topic and the availability of the USP members. The ERIGrid TA Manager and the ERIGrid Project Coordinator will not participate in the proposal evaluation but shall guarantee the compliance of the proposal with the eligibility rules of the trans-national access.

Each USP member evaluating a proposal will assign the following score:

- A for Excellent (16-20)
- B for Good (11-15)
- C for Fair (6-10)
- D for Poor (0-5)

Evaluation Criteria

The criteria for the assessment of the proposals successfully pre-screened (i.e. technically feasible) are the following:

- a) **Scientific/Technical merit** (score: 0-5): scientific and technical relevance, originality and innovation, methodology.
- b) **Improve know-how and capacity of the Research Infrastructure** (score: 0-5): improvement of know-how within the Research Infrastructures, enhancement of RI technologies and methods, alignment with ERIGrid scenarios/use cases/test cases, synergies with other projects and cooperation with other infrastructures.
- c) **Compliance with EU policies and priorities** (score: 0-5): compliance with European RTD policies and priorities, social impact, impact on EU industry (e.g., standardization and competitiveness), sustainable growth interest, new users, young researchers, female researchers.
- d) **General quality of the proposal** (score: 0-5): completeness and organization of the proposal, clear definition of the objectives and expected results, relevance of the proposed dissemination actions, justified requested amount of access.

Also in this phase, the USP may provide comments and suggest modifications to improve the proposal and make it ready for resubmission to future calls.

3.4 STEP 4: Selection of the Proposal and Notification to the User Group

All the proposals will be ranked based on the scores assigned by the USP. D-scored proposals will be normally rejected. Proposals resubmitted, that may have been unsuccessful in previous calls, will be evaluated as new ones.

The User Group of each proposal will be formally notified of the evaluation result by the ERIGrid TA Manager at the end of the evaluation period (one month after the Call deadline). This result will be accompanied with a short Review Report with comments and possibly suggestions for improvement.

If due to technical/economic/organizational feasibility or laboratory availability none of the RIs selected by the User Group can be allocated, a different RI may be offered. If this is the case, the User Groups can (1) withdraw the proposal, (2) update and resubmit the proposal as a new one in one of the next calls, (3) remain with the assigned score for the next Call, when it will be ranked in a new list with the new proposals, or (4) accept the alternative RI suggested by the TA Manager. Normally this situation will be communicated to the User Group and clarified during the pre-screening phase.

3.5 STEP 5: Access to the Research Infrastructure

When a proposal is accepted, a focussed interaction between the proposing User Group and the host infrastructure starts. The estimated access period indicated in the proposal must be confirmed and agreed between the User Group and the host RI. Normally, the access period must be allocated to a date within the next 3 months, following the agreement of the technical details for executing the experiments and fulfilment of administrative issues.

3.5.1 Signature of the Contract

Before the commencement of the project, a contract must be signed between the hosting research infrastructure and the User Group. The basic template contract will be provided for use in all ERIGrid TA projects as a reference model, but extensions or specific modifications may be introduced by each research infrastructure for the project, as necessary. This contract model will make up the deliverable D-NA3.2; the essential information is outlined in Annex 4.

The Contract will have a Technical Annex that describes the test programme to be performed during the access period in the RI. This annex must be coherent with the proposal (even though some adjustments in practice are allowed). Significant modifications of the technical content or the access conditions (e.g., number of access days) with respect to the planned ones in the proposal should be checked with the ERIGrid TA Manager for approval.

3.5.2 Assistance to the User Group

Each RI must nominate a Responsible Person (RP) for each accepted User Project (linked to a proposal). The RP is in charge of supervising the experimental activity at the installation (including the safety matters), and supporting the User Group in all technical, administrative and logistic needs. The RP is also the reference person for reporting to ERIGrid on the state of the activity running at the RI.

3.5.3 Notification of the Use of the RI

At the end of the stay at the RI, the User Group must declare the use of the installations by signing a specific form (attached to the Contract) and indicating the total number of “access days” (days of real use of the installation) and the total number of “stay days” (which includes the access days in the laboratory but normally also the days working in the office of the host, weekend days if applicable, etc.) of each member of the User Group.

3.6 STEP 6: Dissemination and Publication of the Project Results

The ERIGrid access opportunity has some dissemination commitments, specified in the access Contract. Firstly, with the aim of improving the TA quality, two questionnaires must be filled: the first one for collecting the user feedback on the access and the stay at the infrastructure, and a second one regarding the host experience to be filled by the host infrastructure. Secondly, an extended abstract of the user project must be prepared by the User Group to be published as a “Project Fact Sheet”. Further to this, a detailed Technical Report is also mandatory, describing the objectives and experiments, and comprising the obtained results and conclusions. In case the Tech-

nical Report contains confidential information (for example, for some industrial users), special provisions will be taken by ERIGrid and the European Commission: the Technical Report will not be made publicly available (it will be distributed just to the hosting research infrastructure, the ERIGrid project coordinator, and the European Commission).

The three mandatory dissemination documents (questionnaire, extended abstract and technical report) must be prepared by the User Group and submitted to the ERIGrid TA Manager within one month after the end of the stay.

In addition, the User Group is obliged to give detailed information to the ERIGrid TA Manager about future reports, papers, conference presentations, etc., preferably open (otherwise it must be justified), as soon as they are published in order to provide evidence of the soundness of the scientific work performed at the RI under this opportunity. Whenever possible ERIGrid would like to receive any publication made as a result of this research to publish them in the website (provided that the full rights of the researchers are not affected and the copyright conditions are not violated: for example, pre-print or post-print copies could be acceptable for non-open access publications).

Finally, a workshop on user projects will be organised by ERIGrid as a forum for sharing user experiences and lessons learnt. User Groups will have the opportunity to disseminate their investigations, present their project results, and extend their contact network.

3.6.1 Conditions of EU Horizon 2020 Support for TA Concerning Publication

The ERIGrid project reports to the European Commission will contain the names, home institutions and description of the work of the users. The ERIGrid website will publish a list of projects naming the researchers' organizations, research project titles and short descriptions, and the facilities used. Users must also note that the European Commission has the right to publish the list of users.

Publications (including presentations) which result from TA in ERIGrid shall display the EU emblem and contain the acknowledgement:

"This <insert here the type of research/result> has been <performed/achieved> using the ERIGrid Research Infrastructure and is part of a project that has received funding from the European Union's Horizon 2020 Research and Innovation Programme under the Grant Agreement No. 654113. The support of the European Research Infrastructure ERIGrid and its partner <name> is very much appreciated".

Publications must be in English (at least the first one associated to the access).

4 Reimbursement of the Access Expenses

The trans-national access offered by ERIGrid covers the User Group's expenses for travel and subsistence according to the H2020 rules and the host RI conditions (see Appendix 1).

Reasonable travel expenses (low-cost company, economy class and public transportation, whenever possible) will be reimbursed with the presentation of the corresponding invoices/receipts. For the daily subsistence expenses (accommodation in conventional – not luxury – hotels or equivalent lodging, and meals in regular restaurants), two possibilities (or a combination) are allowed depending on the host infrastructure conditions:

- *“Payment by invoice”*: the User Group will get the refund of the subsistence costs after the stay, when declaring the incurred expenses and presenting the invoices/receipts (same mechanism than the reimbursement of the travel expenses); normally, the host infrastructure indicates a reference maximum amount per person for the daily subsistence fee as an indication for the users.
- *“Daily allowance”*: each user receives a per-day pocket money for each day of stay according to the host infrastructure conditions to pay for all the daily subsistence expenses.

For the declaration of the expenses the User Group can use the template included in Appendix 3 (which can be downloaded from the ERIGrid website) and must send it to the host infrastructure for approval and refund.

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5.2 Annex 1: RI Descriptions and TA Conditions

This Annex contains the descriptions of the RI included in the TA programme offered by ERIGrid. In addition to the description of the facilities, the TA conditions prescribed by each infrastructure are specified. This information can be also downloaded from the TA section of the ERIGrid website (www.erigrid.eu).

AIT Austrian Institute of Technology



1. Research Infrastructure

Name of Infrastructure/Installation	Smart Electricity Systems and Technologies Laboratory (SmartEST)
Location	AIT – Vienna, Austria
Web Site	www.ait.ac.at

2. Description of the Research Infrastructure

The AIT SmartEST, located in Vienna, Austria, provides a multifunctional research, validation, and testing infrastructure allowing the testing of single devices as well as analysis of the interactions among multiple power system components – especially Distributed Energy Resource (DER)-based inverter systems – and the power grid under realistic, nearly real-world situations. The laboratory includes three configurable three-phase low-voltage grids; a high-bandwidth, programmable power grid simulator; several Photovoltaic (PV) array simulators; and an environmental test chamber for emulating various environmental conditions. This permits the validation and testing of DER-based inverter systems at full power under extreme temperature and humidity conditions and the investigation of their interactions under various power grid conditions. The facility is capable of testing inverters, storage units, grid controllers, and Combined Heat and Power (CHP) units as well as charging stations/supply equipment for electric vehicles in the power range from a few kVA up to 1 MVA.



Figure 3: AIT SmartEST facility

In addition, AIT SmartEST allows the real-time simulation of complex power grids and components as well as the coupling of this virtual environment with the laboratory grids. This kind of Hardware-in-the-Loop (HIL) setup lets researchers integrate real power system components into a virtual grid environment and test them as they interact with the grid under realistic conditions.



Figure 4: AIT SmartEST research and testing facility for smart grid systems and components

Besides the HIL-based integration of power system components, Information and Communication Technology (ICT)/automation approaches, concepts, and developments can be integrated into the whole setup, allowing a comprehensive analysis of smart grid-related topics. The combination of a state-of-the-art testing infrastructure with HIL-based simulations (i.e., of the power system and ICT/automation infrastructure) provides cutting-edge testing capabilities for component manufacturers and network operators.



Figure 5: HIL and smart metering capabilities of SmartEST

Designed as a pure low-voltage research and testing environment, all AC buses are rated for operation at voltages of up to 480 V (line to line). The laboratory itself is supplied from the local 20 kV medium-voltage power grid via two independent medium- and low-voltage (MV/LV) transformers. The test facility has been used for comprehensive performance testing of DER equipment as well as qualification testing to national and international grid codes and standards based on the exten-

sive range of accreditations held by AIT. Research on procedures for advanced interoperability testing of single as well as multiple DER units under different grid control schemes supports the integration of DERs into a future smart grid through standardized communication and coordination among generators, consumers, and storage units.

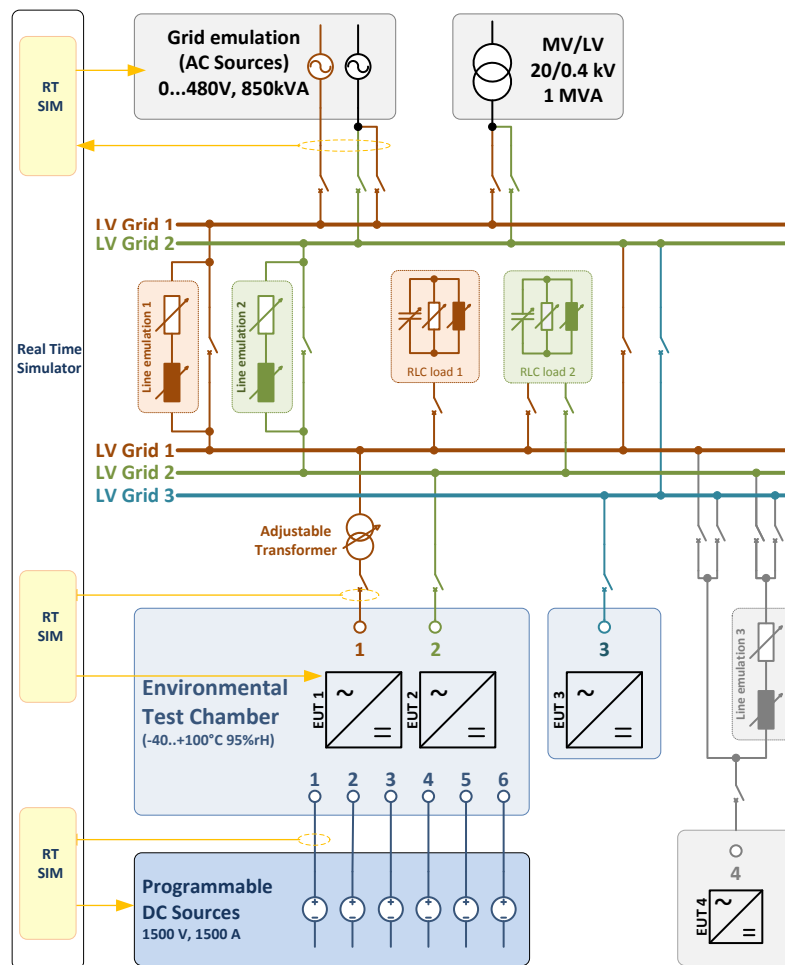


Figure 6: Schematic overview of the SmartEST lab

The following components are available in the SmartEST lab and provided for ERIGrid:

Electrical setup and components

- Grid simulation (3 independent laboratory grids; 2 independent high bandwidth grid simulators – 0-480 V, 800 kVA; 3-phase balance or unbalanced operation; LVRT/FRT testing possibilities)
- Line impedance emulation (adjustable line impedances for various LV network topologies: meshed, radial or ring network configuration)
- Adjustable loads for active and reactive power (freely adjustable RLC loads up to 1 MW, 1 MVar – capacitive and inductive behaviour; individual control possibilities)
- Environmental simulation (test chamber for performance and accelerated lifetime testing)
- DC sources (5 independent dynamic PV array simulators: 1500 V, 1500 A, 960 kVA)
- DAQ and measurement (multiple high precision power analysers with high acquisition rate; simultaneous sampling of asynchronous multi-domain data input)

Simulation tools and components

- Multicore Opal-RT Real-Time Simulator (i.e., eMegaSim)
- Typhoon HIL Real-Time HIL Simulator

- Mathworks xPC-Target Simulator
- Power-HIL and Controller-HIL experiments at full power in a closed control loop
- General simulation tools: Matlab/Simulink, SimPowerSystems, PSpice/Cadence
- Network simulation tools: DigSILENT PowerFactory, PSAT
- Communication network simulator: OMNeT++
- Powerful simulation cluster for complex and large-scale system simulations

ICT/automation tools and components

- SCADA and automations system (highly customizable laboratory automation system, remote control possibilities of laboratory components, visualization and monitoring)
- Distributed control approaches: IEC 61499/4DIAC
- Communication methods: IEC 61850, Modbus/SunSpec, OPC/OPC-UA, Industrial Ethernet (Ethernet POWERLINK, Modbus/TCP, etc.)
- Planning methods, interoperability and compatibility, integration: IEC 61970/61968 (CIM)
- Network information system
- Cyber-security assessment methods and tools for Smart Grid systems and components
- Smart metering testing facility

Data Analytics

The AIT SmartEST lab also includes a Data Analytics Lab with a 24 node / 48 CPU / 288 core parallel cluster infrastructure, including 3TB RAM and 100TB distributed storage systems. The scalable network file system is based on GlusterFS, a large distributed storage solution for data analytics and other bandwidth intensive tasks. Interconnection is provided via fast high bandwidth networks, based on Infiniband technology. The cluster's host systems support open virtualization to enable highly flexible processing of parallel applications, making it highly suited to data analytics activities. Various open source stacks for MapReduce (e.g. Hadoop Ecosystem) based data exploration provide high configurability. A Teradata/ASTER commercial database is currently used in conjunction with MapReduce functions that can be realised via open source means (e.g., Python/R/Java), is used for performing MapReduce analytics in research projects with grid data. The high performance Data Analytic workstations flexibly offer tool support for various applications (e.g. anaconda/R/eclipse/Python) also with ease of access to and working on the various data bases.

3. Services Offered by the Research Infrastructure

In the AIT SmartEST lab the following services are offered (but not limited to):

Smart grid system and DER-oriented expertise and validation/testing activities

- Integration of DER, standards, national requirements in EU and USA
- Power Quality (PQ) lab test and field monitoring: impact of DER components including storage on PQ (e.g., harmonics, flicker), impact of PQ disturbances on Distributed Generation (DG) components (e.g., voltage sags, over-voltages)
- Safety of DER components (research and testing): PV inverters (e.g., DC current, Loss of Main protection) and PV modules
- Quality and performance of DER components including storage and systems: inverters performance (e.g. efficiency, MPPT efficiency, de-rating), quality and performance control of PV-modules, performance assessment of PV systems, online monitoring, mutual interference of multiple DERs in distributed power system
- Qualification testing and conformity assessment of PV and battery inverters and protection devices according to diverse national standards and recommendations
- Energy storage system validation
- Electric vehicle supply equipment/charging system validation

Smart grid simulation/HIL-based and automation application development/testing activities

- Experimental real-time simulation platform for advanced Power-HIL and Controller-HIL analysis
- Distributed/coordinated/central voltage control approaches with many distributed generators across a section of network
- Validation of energy management systems and distribution SCADA
- Standard-based controller implementation (e.g., IEC 61850/61499, SunSpec)
- Interoperability and communication testing

Data Analytics Activities

- Data extraction, loading and transformation into appropriate data structures
- Data filtering and mining for events and anomalies
- Descriptive and predictive data analytics, including clustering, prediction and machine learning based model training
- High performance parallel data processing based on MapReduce
- Time series analysis, event detection
- Forecasting and model prediction
- Visualization, Reporting and interactive exploration techniques
- Network data and measurement data analysis for e.g. asymmetry, voltage band reserves, topology extraction
- Communication data analysis, for pattern detection (e.g. topology)
- Customer data analysis
- Data fusion with other data sources (e.g. GIS, SAP)

4. Brief Description of the Organization Managing the Research Infrastructure

The AIT Austrian Institute of Technology GmbH is an Austrian research institute with a European format and focuses on the key infrastructure issues of the future. The company, employing about 1.260 scientists and research engineers, takes a leading position in the Austrian research and innovation system and a corresponding key role in Europe.

In the field of electricity networks and distributed energy resources AIT's main expertise is in low and high voltage technology, power quality, safety and reliability analysis. Furthermore, AIT provides an excellent national and international network. It is represented in several technology platforms, namely the National Technology Platform Smart Grids Austria (NTP), the European Technology Platform for Electricity Networks of the Future as well as in DERlab e.V. It is also involved in the European Electricity Grid Initiative (EEGI), the EERA Joint Programmes on Smart Grids and PV and several Implementing Agreements of the International Energy Agency (ISGAN, IEA-PVPS).

5. Trans-national Access Conditions Offered by AIT

All the offered experimental systems included in the AIT SmartEST are in the same building in Vienna, Austria.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of AIT. For **the rest of applications** and after ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of AIT's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to AIT's infrastructure, the access being offered

includes supervision and help of AIT's staff:

- As a complement to the pre-access contacts between the user group and AIT, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- AIT's researchers will support the realisation and follow-up of the experiments.
- AIT's researchers will support the results interpretation, data processing and analysis, and test report preparation.





In principle, a typical stay of 2-4 weeks is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group (usually 2-3 persons) can use the infrastructure for the defined time.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to AIT SmartEST by plane/trains, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in SmartEST, AIT will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to AIT in order to get the refund. Logistical expenses must be made by the user: travels will be made in economy class and conventional hotels (not luxury) or equivalent accommodation will be used.

6. Contact Details for Research Infrastructure

Smart Electricity Systems and Technologies Laboratory (SmartEST) – AIT			
Address: Giefinggasse 2, 1210 Vienna, Austria			
Website: www.ait.ac.at			
<i>For lab management/technical issues (DER, storage, etc.):</i>		<i>For lab technical issues (DER, HIL, etc.):</i>	
Roland Bründlinger Phone: +43 664 8157954 E-mail: roland.bruendlinger@ait.ac.at		Georg Lauss Phone: +43 664 8157939 E-mail: georg.lauss@ait.ac.at	
<i>For TA management/organization issues:</i>		<i>For lab technical issues (ICT/automation):</i>	
Cyndi Moyo Phone: +43 664 88225012 E-mail: cyndi.moyo@ait.ac.at		Thomas Strasser Phone: +43 664 2351934 E-mail: thomas.strasser@ait.ac.at	

COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES

Institut National de l'Energie Solaire



1. Research Infrastructure

Name of Infrastructure/Installation	PRISMES Hardware-in-the-loop simulator and multi microgrid test platform
Location	CEA-INES, Le Bourget-du-Lac, France
Web Site	www.ines-solaire.org

2. Description of the Research Infrastructure

The heart of the infrastructure is the Hardware-in-the-Loop (HIL) simulator which allows the simulation of any complex grid situation and which transforms a specific grid points into reality with the use of 45kVA three-phase power amplifier. This can be used to test specific components and the different control and management strategies. The hardware in the loop simulator is integrated in the multi microgrid platform PRISMES, which covers the complete campus of INES. Single phase and three phase grids are available at the platform, which are completely independent allowing running different projects in parallel.



Figure 7: CEA Ines (Le Bourget-du-Lac, France)

PRISMES consists of a low voltage (400V AC) micro-grid, including several generators with different technologies (renewable and conventional), controllable loads, electrical vehicles and storage systems. PRISMES can provide electricity to the main grid and is supervised by a SCADA system.

For the activities in ERIGrid, the necessary components will be selected and connected to the hardware in the loop simulator using the PRISMES platform. It is previewed to link this infrastruc-

ture to the PREDIS platform of G2ELAB which is a one hour drive away from INES. Available devices which can be connected to this PRISMES platform are among others:

- About 100 kWp photovoltaic modules which are divided into more than ten freely configurable different PV systems with single phase and three phase inverters
- A set of two 12 kWp PV fields simulators



Figure 8: Facilities at CEA Ines

- 45 kVA conventional fuel generator
- Several electrochemical storage systems like a Redox flow battery (10kW/100kWh), high-temperature NaNiCl₂ storage (140 kWh / 90 kW), li-ion storage (25kWh/25kW)
- Battery simulator 250 kVA



Figure 9: Facilities at CEA Ines

- Solar Mobility charging station with 20kWp PV generator and more than twelve electric vehicle charging terminals, two of them with an associated stationary storage system.
- Electric load simulator (125kVA)



Figure 10: Facilities at CEA Ines

3. Services Offered by the Research Infrastructure

The hardware in the loop simulator combined with the multi microgrid platform, provides a complete range of Rapid Control Prototyping (RCP) solutions to quickly develop, iterate and test control strategies for:

- PV and storage power plant connected to grid
- Storages (batteries, flywheel, etc.) connected to grid
- Ancillary services (voltage control, frequency control, stability control ...)
- Microgrid operation, control and protection

4. Brief Description of the Organization Managing the Research Infrastructure

INES is the reference centre in France, and one of the first in Europe, dedicated to research, innovation and training on solar energy. Set up with the support of the Savoie Departmental Council and Rhône-Alpes Regional Council, it hosts teams from the CEA and the University of Savoie, and is supported by the CNRS and the CSTB. INES currently employs 400 staff, a figure that will rise to 500 engineers and scientists, on a 22,000-m² site equipped with state-of-the-art facilities.

KEY FIGURES:

- 22,000-m² of laboratories, offices and training rooms
- 800 professionals trained each year
- 400 researchers and technicians
- 200 industrial partners
- 85 patents pending per year
- 15 laboratories

5. Trans-national Access Conditions Offered by CEA-INES

All the offered experimental systems included in the PRISME platform are in the CEA-Ines centre in Le Bourget-du-lac, near Chambéry, France.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of CEA-Ines. For **the rest of applications** and after ad-hoc training, the user group will be granted access to the related facilities for the duration of the stay (with the support of CEA-Ines researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to PRISMES infrastructure, the access being offered includes supervision and help of CEA-Ines staff:

- As a complement to the pre-access contacts between the user group and CEA-Ines, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- CEA-Ines researchers will support the realisation and follow-up of the experiments.
- CEA-Ines researchers will support the results interpretation, data processing and analysis, and test report preparation
- Assurance covering the visiting period may be demanded by the local administrators.

In principle, a typical stay of 1 month is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group can use the infrastructure for the defined time.




Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to PRISMES/CEA-Ines by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in PRISMES, ERIGrid will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to CEA-Ines in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy 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 local canteen free to the user.

6. Contact Details for Research Infrastructure

Institut National de l'Énergie Solaire, CEA INES Address: Technopôle Savoie technolac, 50 Avenue du Lac Léman, 73370 Le Bourget-du-Lac Website: www.ines-solaire.org			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Quoc Tuan TRAN Tel.: +33 4 79 79 22 31 E-mail: quoctuan.tran@cea.fr Research Director Scientific Manager		Hervé Buttin Tel.: +33 (0)4-79-79-29-60 E-mail: Herve.buttin@cea.fr PRISMES zone Manager	
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Centre for Renewable Energy Sources and Saving (CRES)



1. Research Infrastructure

Name of Infrastructure/Installation	Distributed Generation Laboratory (DG-Lab)
Location	CRES - Pikermi, Attiki, Greece
Web Site	www.cres.gr

2. Description of the Research Infrastructure

The department of PVs and Distributed Generation of CRES is involved in applied research, mainly regarding power/energy balance issues at distribution system level. In the frame of the department's research activities, there has been developed the Distributed Generation Laboratory, which consists of two main facilities: the Hybrid system/Microgrid test site and the PV systems laboratory. Each of the two facilities consists of the following laboratories:

Experimental Microgrid: The Hybrid Power Plant and Microgrid laboratory is designed for studies on the performance of stand-alone and interconnected microgrids, but it can also serve as an emulator of autonomous weak grids, such as the power systems of islands. The microgrid's backbone is a low voltage, 3-phase network to which all DER components are connected. The interconnections of the cables allow, among others, the ad hoc introduction of lumped parameters such as resistors and inductances which emulate the characteristics of distribution lines. The system is designed with a capability of hosting devices up to 20kW. The communication and control of the system is primarily obtained via Interbus. Apart from that, the microgrid incorporates some extra acquisition and supervisory control components, such as a power quality meter for monitoring active/reactive power, voltage and frequency at the mains. The communication of this latter with the central control console is obtained via Modbus protocol. Furthermore, there is one set of battery inverters which makes use of proprietary RS485 protocol for data and commands exchange. The visualisation of supervision, monitoring and control of the microgrid is obtained by an application built in LabVIEW. The test site is appropriate for connecting DER units to evaluate their performance in a microgrid environment, but control components such as load controllers, energy management systems and distributed generation unit controllers can also be applied in order to implement demand side and energy management optimisation. Storage components are also available for use, including electrochemical (batteries) and chemical (Hydrogen) storage. The system is divided into three major layers: the power components, the control system and the communication interface.

The power components of the microgrid include two PV panels (PV1 at 1.1 and PV2 at 4.4 kWp capacity) both of which are interconnected via single-phase PV inverters (1.1 and 2.5kWp respectively). It is worth noting that PV2 is placed on a single-axis tracking system. In addition to the PVs the system is equipped with two battery banks, 400Ah/96V and 690Ah/60V respectively. Both banks utilise lead-acid batteries (OPzS). The energy conversion for the batteries is obtained via

three single phase inverters which can be used in combination with one bank as a 3-phase system or as three separate single-phase systems. The battery inverters are capable of providing P/f and Q/V droop control while operating in grid-connected or islanded mode. In the latter case, which regards the operation of islanded power systems, a 3-phase diesel generator 400 Vac, 50 Hz, 12.5 kVA can be deployed for the electrification of the microgrid with extra power. Alternatively, the microgrid is (mainly) operated in interconnection to the LV distribution grid.

The already existing system of generators is expandable by incorporating the equipment of the adjacent laboratory, namely the RES & Hydrogen Technologies Integration Laboratory, of CRES. Thus, in the DER portfolio there can be included a set of hydrogen technology units, namely a 5-kW PEM fuel cell and one electrolyser capable of producing 0.5Nm³/hr which functions as a load to the system. Apart from that, the other consumers of the microgrid are a 13 kW resistor load bank, one capacitive load (2.5kVAr) and one reverse osmosis desalination unit (3.5 kW).



Figure 11: Overview of microgrid's main components of DG-Lab at CRES (Pikermi, Greece)

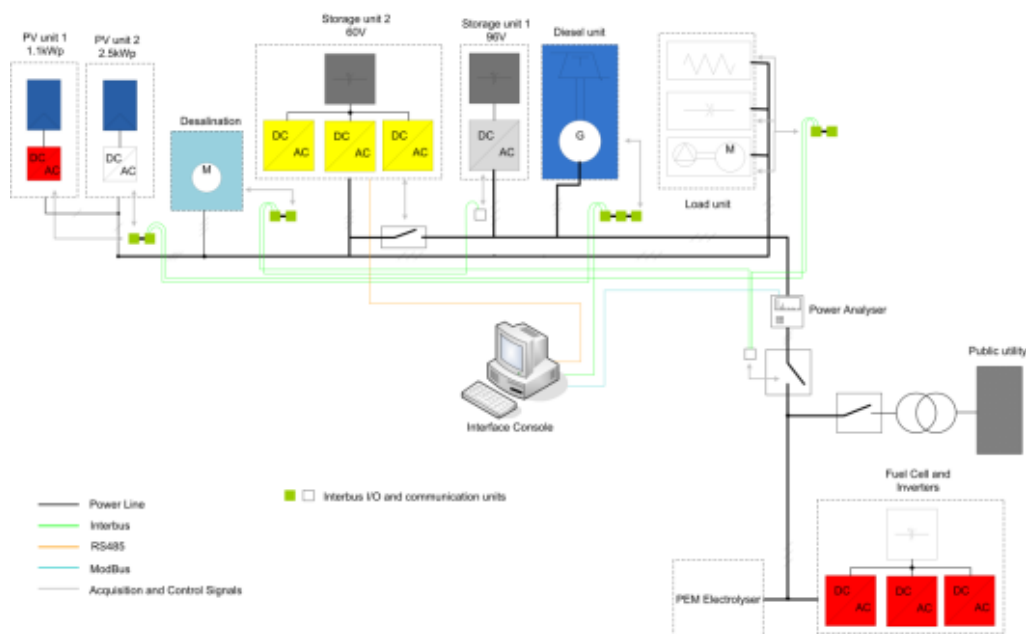


Figure 12: Overview of microgrid's main configuration of DG-Lab

The main communication and control layer of the microgrid is based on Interbus which is equipped with distributed analogue and digital I/O modules. The latter modules communicate via RS485, thus transferring data to the interface console and control signals to all controllable devices. All signals are acquired by a central PC which hosts the Interbus controller and an interface application developed in LabVIEW that provides the following capabilities:

- Easy and flexible access to all the devices. This contains the control of operation of each device. All the controls are fully automated which means that through the interface the operator can perform any desired experiment.
- Data acquisition monitoring and storage to files for further processing.
- Ability to operate remotely through web publishing tool and OPC servers.
- The modular construction of the interface as well as the multiple features provided by the platform makes modifications when necessary very easy.

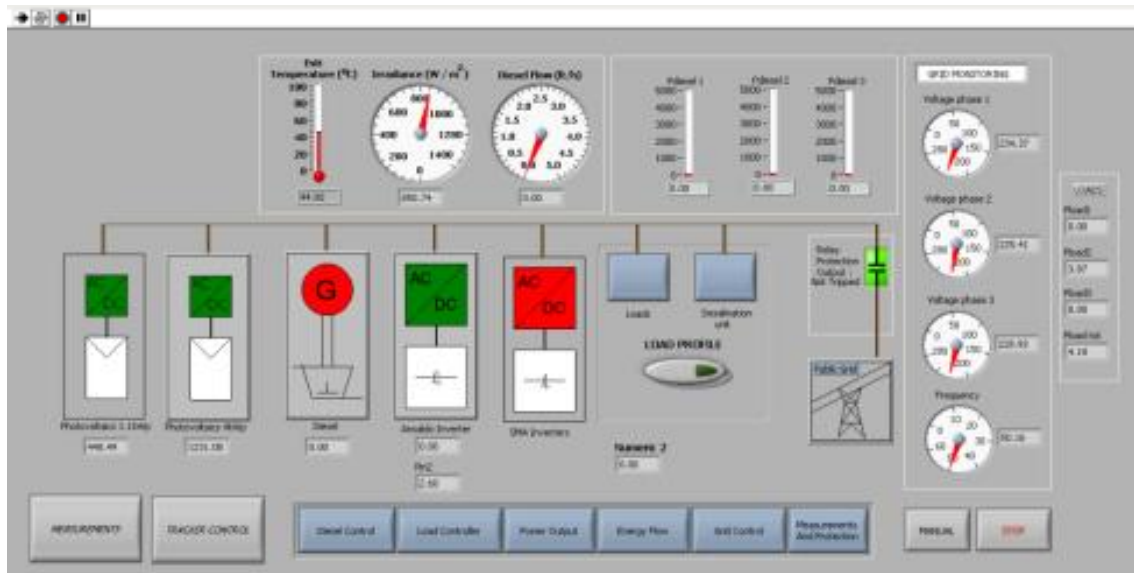


Figure 13: Snapshot of the main screen of the supervisory control application in DG-Lab

PV Systems Laboratory: It is divided into three laboratories each specialised on one type of components of a PV system, namely PV testing lab, Power Electronics lab and Battery testing lab.

- The PV Testing laboratory is equipped with the following main hardware, intended for the characterisation of PV cells, modules or arrays:
 - One class “A” solar simulator featuring a Xenon flash lamp and a computerised control and data acquisition system, for the acquisition of IV curve of PV cells/modules.
 - One field IV curve tracer for the outdoors IV curve acquisition of PV modules or arrays for PV power up to 100kW.
 - One environmental chamber of useful volume of 5m³, with capability of temperature control in the range from -40°C to 85°C, for the implementation of thermal cycling tests on PV modules.
 - One long-term outdoor testing of PV modules.



Figure 14: Long-term test of PV modules in DG-Lab

- The power electronics laboratory is concerned with the testing of inverters used in PV systems, and evaluation of their suitability as DER equipment. The power electronics laboratory is equipped with the following hardware:
 - One PV array simulator consisting of two programmable DC power sources reaching up to 400V and 25A.
 - One load bank of 100 kVA total consumption.
 - One 12kVA programmable AC power source rated used in order to simulate a low voltage power grid operation
 - One power-meter for the power measurement of DC and AC circuits as well as one power quality meter for the measurement of electrical power quality of inverters, such as harmonics and transients.



Figure 15: Programmable grid simulator and load-bank control in DG-Lab

- The battery testing laboratory focuses on the characterisation of batteries operating under specified conditions, referring to battery testing according to international standards (such as capacity or endurance tests) and the development of guidelines for the improvement of battery usage depending on the application. The main hardware of the lab is:
 - A set of programmable charge/discharge power converters capable of performing tests according to programmed control parameters. These units range from low voltage and current up to 300 VDC and current capacities up to 300A.
 - One high-rate discharge tester for 12V batteries testing with a max. discharge current of 1500A.
 - One environmental chamber providing temperature control between -20°C and +45°C during battery tests. The chamber's volume is 1m³.
 - One temperature controlled water bath for the immersion of batteries and control of their temperature during tests. The temperature range for control is between ambient and 40°C.



Figure 16: Battery testers in DG-Lab

3. Services Offered by the Research Infrastructure



Figure 17: DG-Lab facilities

The services that the DG-Lab can provide with regard to all the above mentioned facilities are listed below:

- Performance evaluation and characterisation of distribution grid components, i.e. load controllers, inverters, control algorithms, power quality issues.
- Investigation of microgrid operation scenarios including islanded or grid-connected operation and Demand Side Management strategies, energy and cost optimisation studies.
- Evaluation of control architectures, i.e., central, distributed, decentralised control schemes.
- Characterisation of PV cells, modules, panels etc. in terms of I-V curves and conformance with relevant standards.
- Characterisation of PV inverters performance in terms of efficiency and protection and conformance with relevant standards.
- Characterisation of battery cells and conformance with relevant standards.

4. Brief Description of the Organization Managing the Research Infrastructure

The Centre for Renewable Energy Sources and Saving (CRES) is the Greek organization for Renewable Energy Sources (RES), Rational Use of Energy (RUE) and Energy Saving (ES). CRES has been appointed as the national co-ordination centre in its area of activity. CRES was founded in September 1987 by Presidential Decree 375/87. It is a public entity, supervised by the Ministry of Environment and Energy and has financial and administrative independence. Its main goal is the research and promotion of RES/RUE/ES applications at a national and international level, as well as the support of related activities, taking into consideration the principles of sustainable development. The Centre is managed by a seven-member Administrative Council, which includes representatives from the General Secretariat of Research and Technology (Ministry of Education and Religious Affairs, Culture and Sports), the Public Power Corporation and the Hellenic Federation of Enterprises. CRES has a scientific staff of more than 120 highly qualified and experienced multi-disciplinary scientists and engineers. Its organisational structure comprises of the following units:

- Division of Renewable Energy Sources
- Division of Energy Efficiency
- Division of Energy Policy and Planning
- Division of Development Programmes
- Division of Financial and Administrative Services

Since 1992, CRES is located on its wholly owned premises in Pikermi, Attica, where in addition to over 2000 square meters of main office space; it has experimental outdoor installations, specialised laboratories for energy technologies, a mechanical shop, conference rooms, a library and maintains a strong computing infrastructure. CRES has installed a demonstration Wind Park in the area of Agia Marina in Lavrio, Attica. The Wind Park is connected to the distribution network and has an installed capacity of 3MW. In the facility of the Wind Park, CRES operates the Park of Energy Awareness (PENA), a new demonstration site for Renewable Energy Sources. In PENA everyone has the opportunity to observe real small scale RES plants in operation, while the young visitors can learn about environmental friendly technologies through innovative educational tools.

The Department of PVs and Distributed Generation of CRES is part of the Division of Renewable Energy Sources (RES-D). RES-D employs 40 scientists and engineers, focusing its activities on the design, support and execution of European and national RTD programs for the development of economically viable and environmentally friendly RES/RUE/ES technologies. The Department of PVs and DG cooperates systematically with organisations for the promotion of PV technology and Distributed Generation, such as EPIA and actively participates in European initiatives, e.g. the Electricity Networks of the Future (Smart Grids) and the European Technology Platforms for Photovoltaics (PV-TRAC), etc.

5. Trans-national Access Conditions Offered by CRES

All the offered experimental systems included in the DG-Lab are in the same area, in nearby buildings in Pikermi, near Athens, Greece.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of CRES. For **the rest of applications** and after ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of CRES's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection etc.) and the support and advice on accommodation and transportation to CRES's infrastructure, the access being offered includes supervision and help of CRES's staff:

- As a complement to the pre-access contacts between the user group and CRES, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- CRES's researchers will support the realisation and follow-up of the experiments.
- CRES's researchers will support the results interpretation, data processing and analysis, and test report preparation

In principle, a typical stay of 2-3 weeks is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group (typically 1-2 persons) can use the infrastructure for the defined time.

Reimbursement of Expenses:



User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to DG-Lab (CRES) by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in DG-Lab, CRES will refund the stay expenses when the stay is finished with two options:

- By issuing an invoice to CRES with the sum total of the expenses if the home organisation temporarily covers the stay expenses of the visitor or
- The visitor must declare the incurred expenses and present the invoices/receipts to CRES in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy 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 150 €/person must be considered per day.

6. Contact Details for Research Infrastructure

Distributed Generation Laboratory (DG-Lab) - CRES Address: 19 th km Marathonos ave., 19009, Pikermi-Athens, Greece Website: www.cres.gr			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Stathis Tselepis Tel.: +30 210 6603370 E-mail: stselep@cres.gr		Evangelos Rikos Tel.: +30 210 6603368 E-mail: vrikos@cres.gr	

DNV-GL

Strategic Research & Innovation



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,3 Φ ;50kV,1 Φ), 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.



Figure 18: FPGL at DNV GL (Arnhem, the Netherlands)

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*⁷ 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 19. 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.

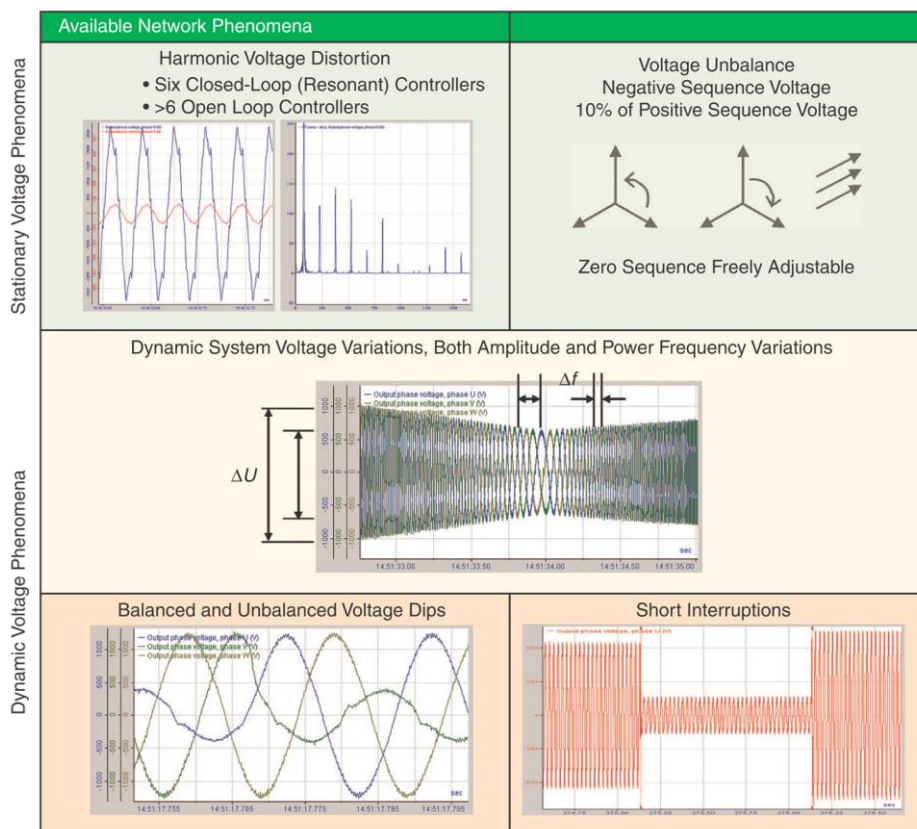


Figure 19: Different AC power quality phenomena available at the FPGL infrastructure

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

⁷ Reference: DNV·GL's position paper on *Power Cybernetics – The future of validation*; 2016 (available on request).

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 provides the capability to superimpose harmonic voltages and instigate dynamic network phenomena onto it.

Finally, the laboratory is equipped with resistive (0.5MW), inductive (1MVA_r) and capacitive (1MVA_r) 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 19, etc.), also as (part of) grid compliance initiatives⁸.
- 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.

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.

⁸ Although DNVGL is accredited for performing grid compliance certification to a number of (inter)national standards, no certification is available within ERIGrid TNA activities.

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. Trans-national 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 TA 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 Arnhem 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	

Technical University of Denmark



1. Research Infrastructure

Name of Infrastructure/Installation	SYSLAB and ICL
Location	Technical University of Denmark, Kgs. Lyngby, Denmark
Web Site	www.dtu.dk , www.powerlab.dk

2. Description of the Research Infrastructure

SYSLAB

SYSLAB is an experimental facility at DTU Risø campus, designed as a testbed for advanced control and communication concepts for power grids. The facility has been extended several times since its inception in 2005; the current setup extends across multiple sites on Risø campus within an area of about one square kilometre. A 400V, 3-phase grid with a total of 16 busbars and 119 automated coupling points serves as the electrical backbone of the facility and allows a large variety of different grid topologies to be set up by means of a central crossbar switch. When all cables are in use, a maximum feeder length of up to 3km can be achieved. The grid can be connected to the campus distribution grid through one of several interconnection points, operated in island mode or be split up into multiple independent subgrids.

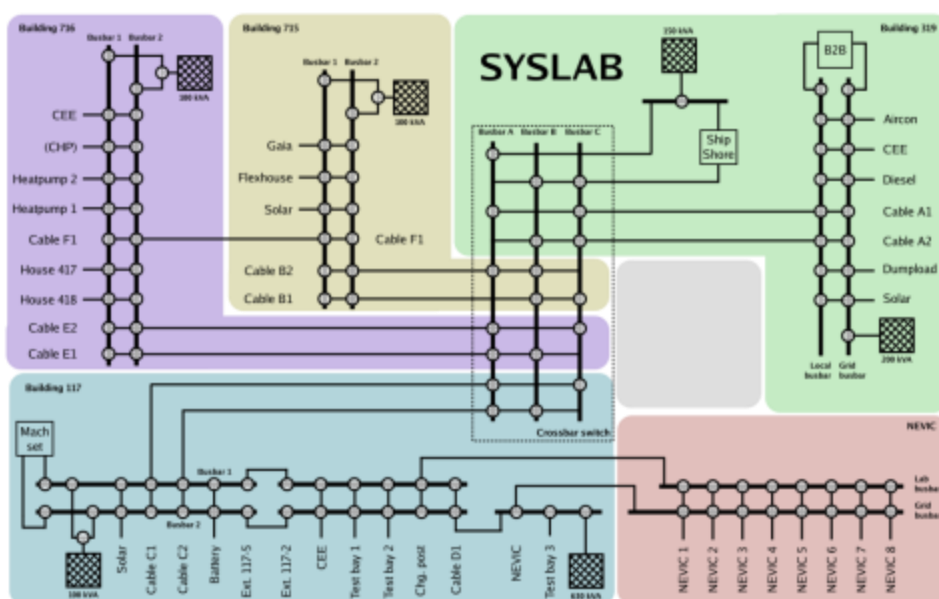


Figure 20: Layout of the electrical grid in SYSLAB

A large variety of DER units can be connected at different points of the grid. These include two wind turbines, three PV installations, a conventional (combustion engine) generator, three buildings

with controllable heating, vanadium redox-flow and lithium-ion batteries for storage, electric vehicle charging posts and various other types of controllable loads. Unit sizes range between 10 and 100 kVA. A back-to-back converter allows controlled power exchange between SYSLAB and the campus grid and can be used for equipment simulation or PHIL tests.



Figure 21: Overview of the SYSLAB facility on Risø campus

All equipment on the grid is automated and remote-controllable. Each unit is supervised locally by a dedicated computing node which acts as a communication gateway. The node computers run a custom, Java-based software platform on top of a standard Linux installation which provides communication between nodes, facilitates the deployment of local controllers and logs unit data. The nodes are almost identical, and the layout of the communication network does not put any of them at the center of the network. This results in great flexibility with respect to control architectures; standard master-slave control concepts can be tested as well as less traditional approaches such as controllers based on peer-to-peer communication or multi-layered hybrid control systems.

Various software interfaces exist for the interaction with the laboratory infrastructure; besides the native Java API many SCADA functions can be accessed through Matlab. Integration with most other programming languages such as C or Python is possible via the web services and XMLRPC APIs.

SYSLAB is currently being expanded with a small **district heating network** in order to study the interaction between energy carriers. A custom-built “heat substation” allows the flexible intercon-

nection and transfer of energy between a number of heat sources, heat consumers and a storage tank. In the current setup, a heat pump and an electrical booster heater allow energy to be transferred from the electrical network of SYSLAB to the heat network.

The **Flexhouses** are three highly automated buildings which are integrated into SYSLAB. Flexhouse I is a former office pavilion, while Flexhouses II and III were originally built as single-family homes before being retrofitted for research use. Their primary purpose is to facilitate research on the integration of buildings into the control of energy systems. Flexhouse I is electrically heated and cooled, with individual electrical radiators and split airconditioning systems in each room. The other two buildings have water-borne central heating systems which are fed from the SYSLAB district heating switchboard.

All buildings are equipped with a multitude of sensors, including room temperature, light intensity, presence/motion, window and door contacts. Each building has a variety of controllable energy consumers - appliances, space heating and cooling and hot tap water.

A custom-made building automation platform allows the deployment of building controllers written in Java or Python which are able to interact with the building as well as process remote-control signals from SYSLAB, e.g. for demand response applications.

Intelligent Control Lab (ICL)

The **ICL** is a laboratory for research, development and test of new advanced principles for intelligent supervision and control of smart grids. It consists of:

- A full-scale ABB Network Manager SCADA system which is linked to the SCADA system operated by the local DSO on the island of Bornholm and allows monitoring of the entire Bornholm grid on a large monitor wall in a realistic control room setup
- A 10-rack real-time digital simulator (RTDS) able to simulate power systems of up to 480 buses. The RTDS can be used for Hardware-in-the-Loop (HIL) tests and can be connected to a linear high power amplifier in order to conduct Power Hardware-in-the-loop (PHIL) experiments.
- A PMU extension to the RTDS with GTNET PMU cards (46 channels) for research and development on wide area monitoring and control.
- A PMU lab with a PMU test platform, consisting of a Doble amplifier and PMUs from several manufacturers.
- An IBM Blade Center for hosting and executing optimization and control software.

Potential applications of the ICL include proof-of-concept tests of intelligent control and operator training, HIL and PHIL testing, wide area monitoring and control topics, relay testing and protection coordination using IEC 61850 and PMU testing according to IEEE C37.118.1.

3. Services Offered by the Research Infrastructure

SYSLAB has been used in the past for a variety of applications, including:

- Development and proof-of-concept testing of novel control concepts for smart grids
- Component characterization and testing
- Validation of simulation tools
- Electrical vehicle interoperability testing
- Testing of real-time prediction algorithms
- Development of demand response algorithms
- Testing of communication performance at the protocol level
- Proof-of-concept testing of data models for smart grid communication
- Island grid and microgrid studies

Potential applications of the **ICL** include:

- Proof-of-concept tests of intelligent control algorithms
- Operator training
- HIL and PHIL testing against the RTDS
- Wide area monitoring and control related research
- Relay testing and protection coordination using IEC 61850
- PMU testing according to IEEE C37.118.1.

4. Brief Description of the Organization Managing the Research Infrastructure

The Center for Electric Power and Energy (CEE) is a center for research, innovation and education at the Technical University of Denmark (DTU), department of Electrical Engineering. CEE covers a broad range of electric technologies including production, transmission, distribution and consumption of electricity as well the interactions with other energy carrier systems such as district heating. CEE aims at enabling a more intelligent, flexible and automated electric power system that can accommodate the future expansion of renewable energy production and the long term vision of a fossil-free society. CEE holds competences within electric components, electric power systems, automation of complex power systems, electricity markets, end-user interaction and intelligent energy systems.

The Energy Systems Operation and Management (ESOM) group is a research group within CEE and performs research covering the development and analysis of new solutions for the management and operation of future distributed power systems with a high share of renewable energy and distributed energy resources. The investigation of future system architectures, centralized as well as decentralized, is part of the research area, with the goal to provide optimal and seamless interaction of all system elements and subsystems. This includes e.g. agent-based solutions and aggregation. The solutions cover novel ICT implementations combined with innovative market-based designs and new grid management methods and important aspect is interoperability of communication and services. ESOM research efforts also cover innovative monitoring, operation and control which enable for example management of grid bottleneck, islanding solutions and microgrids. The research has important interfaces with many of the other groups including research within markets and energy resources, services and control.

PowerLabDK is an experimental platform for electric power and energy laboratory administered by CEE. PowerLabDK supports development, test, training and demonstration of technologies that will contribute to the development of a reliable, cost efficient and sustainable energy system based on renewable energy sources. PowerLabDK is a national GreenLab under the Danish Energy Agency.

The facilities contain flexible test laboratories, large-scale experimental facilities and a complete full-scale power distribution system on the Island of Bornholm which serves as a data source and platform for full-scale and real-life experiments. The PowerLabDK facilities welcome engineers and researchers from industry and academia as well as innovative students. The two PowerLabDK facilities available for the TA programme in ERIGrid are SYSLAB and the Intelligent Control Lab.

5. Trans-national Access Conditions offered by DTU

The offered experimental facilities are located in Denmark, SYSLAB in Roskilde, DTU Risø Campus and Intelligent Control Lab in Kgs. Lyngby, DTU Lyngby Campus.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of DTU. For **the rest of applications** and after ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of DTU's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked

prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to DTU's infrastructure, the access being offered includes supervision and help of DTU's staff:

- As a complement to the pre-access contacts between the user group and DTU, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician install the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and configuration of the experimental conditions.
- DTU's researchers will support the realisation and follow-up of the experiments.
- DTU's researchers will support the results interpretation, data processing and analysis, and test report preparation

In principle, a typical stay of 2 weeks is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group (usually 2 persons) can use the infrastructure for the defined time.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to DTU by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place at SYSLAB and ICL (DTU) will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to DTU in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy class and conventional hotels (not luxury) or equivalent accommodation will be used.

6. Contact Details for Research Infrastructure

SYSLAB & ICL at DTU Address: (SYSLAB) Frederiksborgvej 399, DK-4000 Roskilde, Denmark (ICL) Elektrovej 325, DK-2800 Kgs. Lyngby, Denmark Website: http://www.powerlab.dk/Facilities			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Kai Heussen Tel.: +45 61 39 62 63 E-mail: kh@elektro.dtu.dk		Oliver Gehrke Tel.: +45 51647471 E-mail: olge@elektro.dtu.dk	

Laboratoire de Génie Électrique de Grenoble



1. Research Infrastructure

Name of Infrastructure/Installation	PREDIS Real-Time PHIL simulation platform
Location	G2Elab, Grenoble, France
Web Site	www.g2elab.grenoble-inp.fr

2. Description of the Research Infrastructure

The G2ELab (i.e., GRENOBLE INP) owns two real-time (RT) multiprocessors digital simulators, in the framework of the PREDIS centre. They are a new generation of RT simulators, allowing applications from different physical domains like aerial or surface transports, fluids, mechanical and electrical systems using Matlab-Simulink® environment. Such simulators are able to carry out Hardware-In-the-Loop (HIL) as well as Power-Hardware-In-the-Loop (PHIL) applications. In such simulations, a part of the simulated system is achieved numerically in the heart of the simulator, whereas the other part is integrated in the open (or closed) loop through power amplifiers, in the form of physical components (or emulated numerically by calculators). The different components and the heart of the simulator can be linked by the communication system, which uses different communication protocols (TCP/IP, Ethernet, FireWire, Infiniband, etc.). It allows the remote operation of real-time systems via local networks or Internet. Moreover, a RT smart grid demonstrator is under development in the framework of a national research project. It will include a digital simulation of a distribution grid (MV/LV), some programmable loads and programmable sources to emulate this equipment, smart meters, amplifiers, a SCADA system (Supervisory Control And Data Acquisition) including optimal energy management ADA functions, and a communication network using IEC 61850.

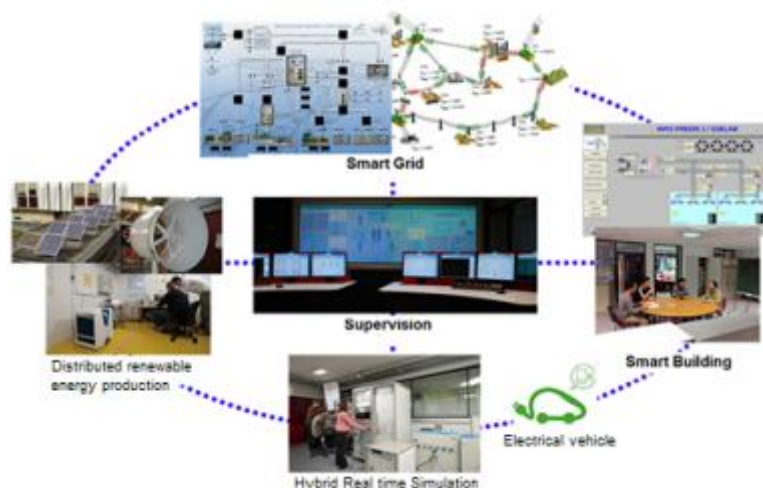


Figure 22: G2Elab facilities (Grenoble, France)

In addition, integrated in the PREDIS centre, there are five special platforms to reinforce the capabilities in the specific fields of research:

- **Supervision Platform (SCADA):** This is the vital organ of the PREDIS center, which allows the development and deployment of central supervision of all other platforms.



Figure 23: G2Elab facilities (Grenoble, France)

Different industrial SCADA are deployed and studied:

- SCADA PCVue: fully developed by the engineers of G2Elab and ENSE3 for supervising the reduced size electrical grid at PREDIS.
- SCADA Lynx: Developed by ATOS ORIGIN
- SCADA Zenon: Developed by COPA-DATA
- SCADA ADACS: specialized for nuclear center.
- SCADA E-Terra: Developed by ALSTOM and used in the project SUPERGRID.
- **Platform of decentralized energy production (PDE):** This platform regroups multiple means of production, connectable to different reduced grids. It allows the study and control of real energy production, including renewable sources.



Figure 24: G2Elab facilities (Grenoble, France)

- **Platform of reconfigurable electrical grid:** This platform regroups several real instrumented and flexible electrical grids with a reduced size of 30kVA. It allows the study on different structure of future smart grid. The reconfigurable distribution and industrial grids use the production means and loads of PDE platform and is supervised by the SCADA platform.



Figure 25: G2Elab facilities (Grenoble, France)

- Platform of real time simulation and PHIL:** This platform offers the tools for electrical system design, optimization and control. It allows users to actualize researches on all kind of emulated grids with interaction with real components. This modular platform is suitable for different research thematic, from electrical vehicle to renewable energy resources.



Figure 26: G2Elab facilities (Grenoble, France)

- Platform of smart building:** The platform is dedicated to the research on smart energy management and auto-consumption. It consists of a demonstrating building with associated measures and instrumentation. The real time management strategy takes into account comfort data, consumption and production and other factors.



Figure 27: G2Elab facilities (Grenoble, France)

3. Services Offered by the Research Infrastructure

The PREDIS platform enables to test coupled ICT and electrical infrastructures, through a flexible combination of prototypes, emulation and simulation, including real-time simulation with PHIL facilities. We can list some examples of R&D services:

- HIL applications:
 - Test of power systems protection relays, and
 - Validation of controllers for different kind of equipment (FACTS, wind/hydro turbine, PV, etc.).
- PHIL applications:
 - Smart Grid (RT simulation of distribution network with ICT network IEC 61850, SCADA, ADA functions, DG emulators, DSM emulators with smart meters, etc.),
 - Wind generator emulation,
 - Shunt and series FACTS systems like STATCOM and DVR (Dynamic Voltage Restorer),
 - Residential micro-network with dispersed generation, and
 - Test of industrial converters for photovoltaic generation Systems.

All user projects will be realized according to the procedures developed in NA5.

4. Brief Description of the Organization Managing the Research Infrastructure

Ideally located in the heart of the French Alps, Grenoble Institute of Technology is one of Europe's leading technology universities. It offers a range of engineering, masters and doctoral courses both in French and in English, driven by world-class research in 38 laboratories, and 6 technology platforms, developed in partnership with other institutions.

Grenoble Institute of Technology's mission is to empower new generations of engineers to respond to global challenges in the fields of energy, the digital world, micro- and nanotechnologies, the environment, as industries of the future. For 120 years, Grenoble Institute of Technology has been instrumental in developing innovative solutions with industrial partners to support continuous technological advances and economic growth. With its solid combination of teaching, research and business promotion, Grenoble Institute of Technology plays a key role in making Grenoble one of the most attractive scientific and industrial locations worldwide.

International cooperation has always been a priority for Grenoble Institute of Technology, developing programs alongside renowned technology universities in Europe, North and South America and Asia. The Institute is proud to host research and teaching fellows and students from right across the world, and to encourage its students and staff to travel abroad to work in partner universities or do internships in foreign companies.

5. Trans-national Access Conditions offered by G2Elab/Grenoble-INP

All the offered experimental systems included in the PREDIS centre are in the Green-ER building in Grenoble, France.

Access to PREDIS centre is granted under agreed authorization of both G2Elab and Grenoble-INP.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of G2Elab. For **the rest of applications** and after ad-hoc training, the user group will be granted access to the related facilities for the duration of the stay (with the support of G2Elab researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Adminis-

trative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to G2ELab infrastructure, the access being offered includes supervision and help of G2Elab staff:

- As a complement to the pre-access contacts between the user group and G2Elab, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- The preparatory works (before granting access and in the process) are counted towards the units of access. G2Elab researchers will support the realisation and follow-up of the experiments.
- G2Elab researchers will support the results interpretation, data processing and analysis, and test report preparation
- Assurance covering the visiting period may be demanded by the local administrators.

In principle, a typical stay of 1 month is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group can use the infrastructure for the defined time. The user group will have access to an office, computer and telephone.



Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to PRE-DIS-G2Elab by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in PREDIS, ERIGrid will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to G2Elab in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy 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 local canteen free to the user.

6. Contact Details for Research Infrastructure

Laboratoire de Génie Electrique de Grenoble, G2Elab Address: 21 avenue de Martyrs, 38031 Grenoble CEDEX, France Website: www.g2elab.grenoble-inp.fr			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Yvon Besanger Tel.: +33 4 76 82 64 41 E-mail: Yvon.Besanger@g2elab.grenoble-inp.fr		Van Hoa Nguyen Tel.: +33 4 76 82 71 87 E-mail: Van-hoa.nguyen@grenoble-inp.fr	

ICCS-NTUA



**SMART
RUE**
SmartGrids Research Unit ECE NTUA

1. Research Infrastructure

Name of Infrastructure/Installation	ICCS – NTUA – EESL (ELECTRIC ENERGY SYSTEMS LABORATORY)
Location	9, Iroon Polytechniou Str., 157 73 Zografou Campus, Athens, Greece
Web Site	www.iccs.gr/en , www.smartrue.gr

2. Description of the Research Infrastructure

The **EESL (ELECTRIC ENERGY SYSTEMS LABORATORY)** comprises the following equipment:

- **Low Voltage Microgrid:** A main component of the laboratory is the single phase microgrid that includes a PV generator, a small Wind Turbine, battery energy storage, controllable loads and a controlled interconnection to the local LV grid. The battery unit, the PV generator and the Wind Turbine are connected to the AC grid via fast-acting DC/AC power converters. The converters are suitably controlled to permit the operation of the system either interconnected to the LV network (grid-tied), or in stand-alone (island) mode, with a seamless transfer from the one mode to the other. Part of the laboratory's infrastructure is the 3-phase microgrid with main elements 3 single-phase battery inverters and micro-sources connected in each phase.
- **Multi-Microgrids Cluster:** The three ICCS-NTUA Microgrids form a Multi-Microgrid cluster (through Electrical and Internet connection) in order to investigate the development and verification of different control strategies and the impact of wide deployment of Microgrids at the distribution level.
- **Multi-Agent System for Microgrid Operation:** Multi-agent technology has been implemented for the control of the distributed sources and the loads of the LV microgrid. The system is developed in the Java based platform called Jade and communicates with the DER/DGs via industrial communication protocols such as OPC. Furthermore the laboratory is equipped with 10 load controllers. These are embedded systems with Java Virtual Machine, multiple analogue & digital I/O as well TCP/IP connectivity. This system can be used to test in the laboratory or in a real test field various algorithms for distributed control of Microgrids and DG/RES. Some of the functionalities that can be tested are: market participation of the Loads or the DG/RES, formulation of a VPP, ancillary services provision, black start operation, islanded operation, multi-Microgrid operation and emergency load shedding.
- **Laboratory SCADA:** The laboratory SCADA is implemented using a PLC (Programmable Logic Controller) system with LabVIEW/CoDeSys software. It provides measurements on the AC and DC side of the inverters, environmental measurements (irradiation, wind speed etc.), control of the DGs and load profile programming.

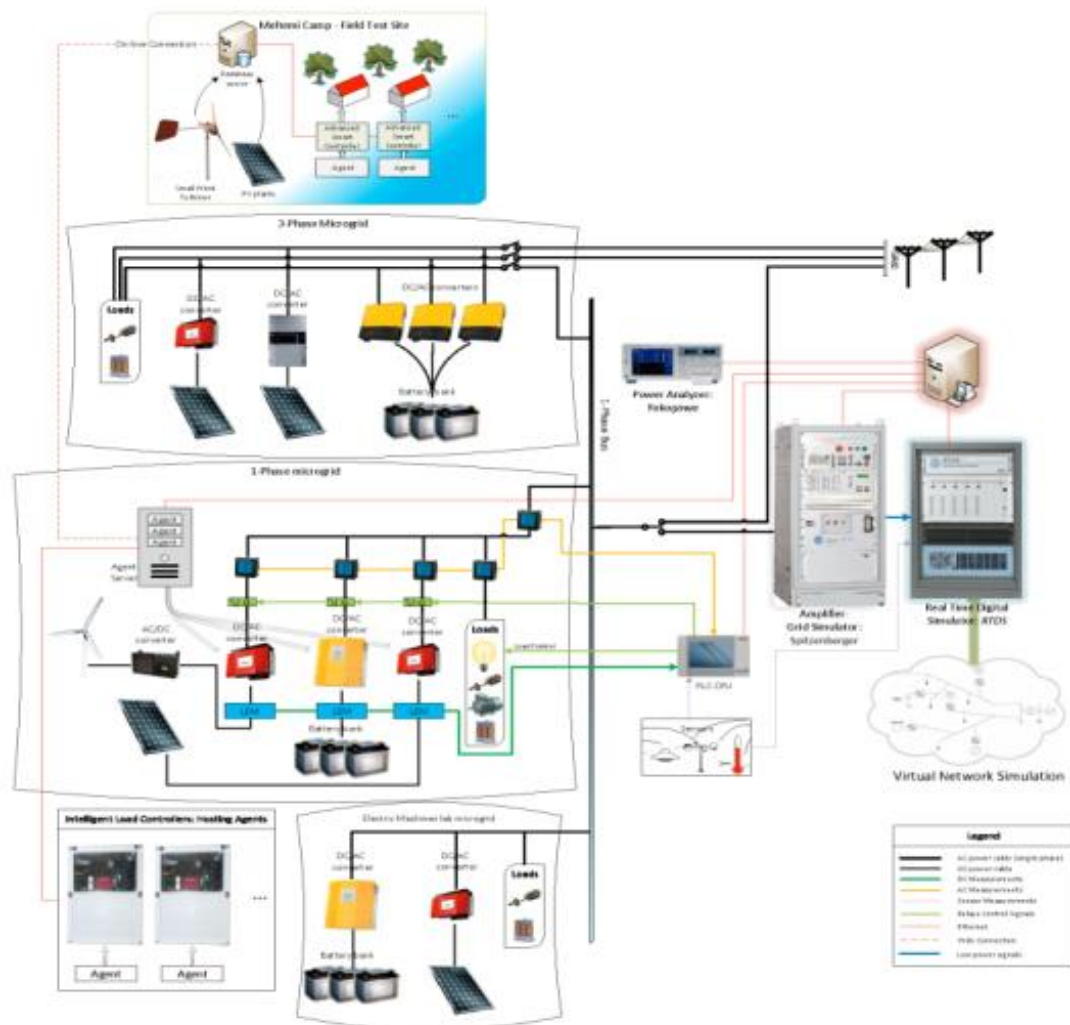


Figure 28: EESL Laboratory at ICCS-NTUA (Athens, Greece)



Figure 29: EESL Laboratory at ICCS-NTUA

- Power Hardware-in-the-Loop (PHIL) simulation environment:** The PHIL facility developed at ICCS-NTUA provides an efficient environment for studying interactions between hardware DER power devices and various simulated networks. A rack of the commercially available Real Time Digital Simulator RTDS[®] is operated. A Switched-Mode Amplifier by Triphase and a linear amplifier by Spitzenberger & Spies (PAS 5000) are used as Power Interfaces between the RTDS and physical equipment to perform PHIL simulation. The Triphase power electronic converter platform allows the user to design in Matlab/Simulink the control algorithms. PHIL experiments are performed, where hardware equipment (loads, PV inverters, etc.) are connected to simulated distribution networks. An irradiation sensor and an anemometer, provide input to simulated models in the RTDS in order to achieve realistic conditions.
- Controller Hardware in the Loop (CHIL) simulation environment:** In the context of its involvement with microgrids and dispersed generation, the research group is active in the development and study of advanced control algorithms for power electronic converters (DC/DC, DC/AC, AC/DC/AC, etc.). Based on the real-time simulator (RTDS) and a controller provided by Triphase, it is possible to thoroughly test control algorithms of power converters in an environment that reveals "hidden" weaknesses and faults in the design of these algorithms. Specifically, the design of the control algorithm is performed in the controller of Triphase while the power electronics are simulated in the RTDS. The communication between the two systems is achieved through analogue and digital signals.

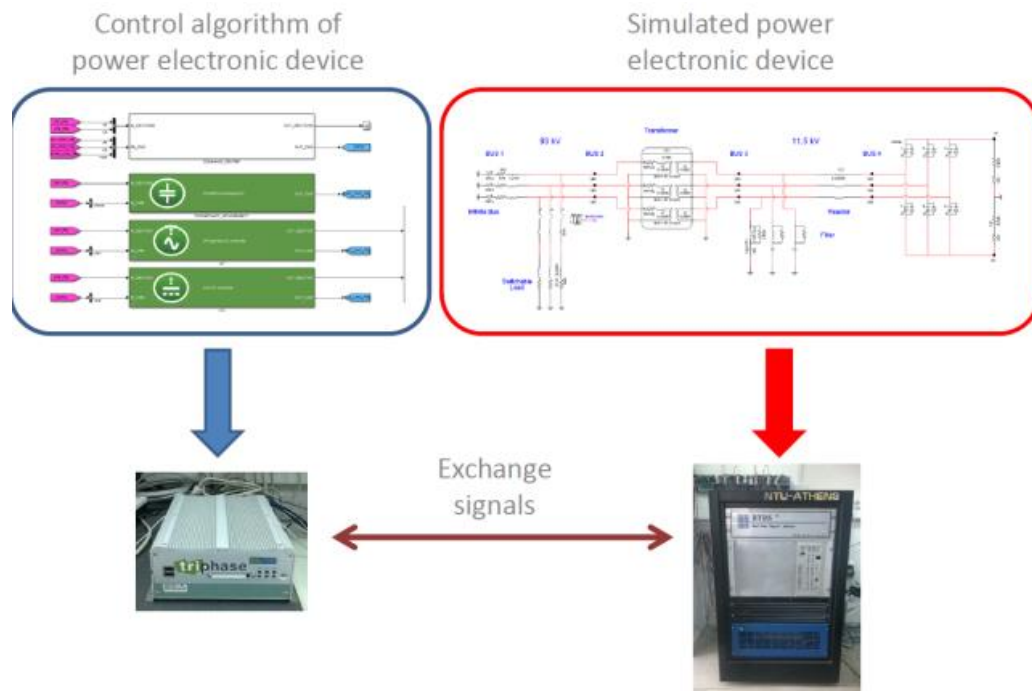


Figure 30: EESL Laboratory at ICCS-NTUA

- Adaptive Protection System in Distribution Grids with DER Penetration in a HIL environment:** In order to study new protection problems arising, a laboratory adaptive protection system has been developed at ICCS-NTUA. The electrical networks are designed and studied in the real-time digital simulator (RTDS). Through analogue and digital signals the RTDS is connected to external devices, such as the industrial protection relay SEL-311B. The relay is programmed to protect a feeder of the electrical network and receive voltage and current signals from the RTDS. It also controls the status of the simulated breaker in the RTDS while its condition is fed back to the relay. All relays have overcurrent elements with 2-6 setting groups that are used for the adaptive protection implementation.

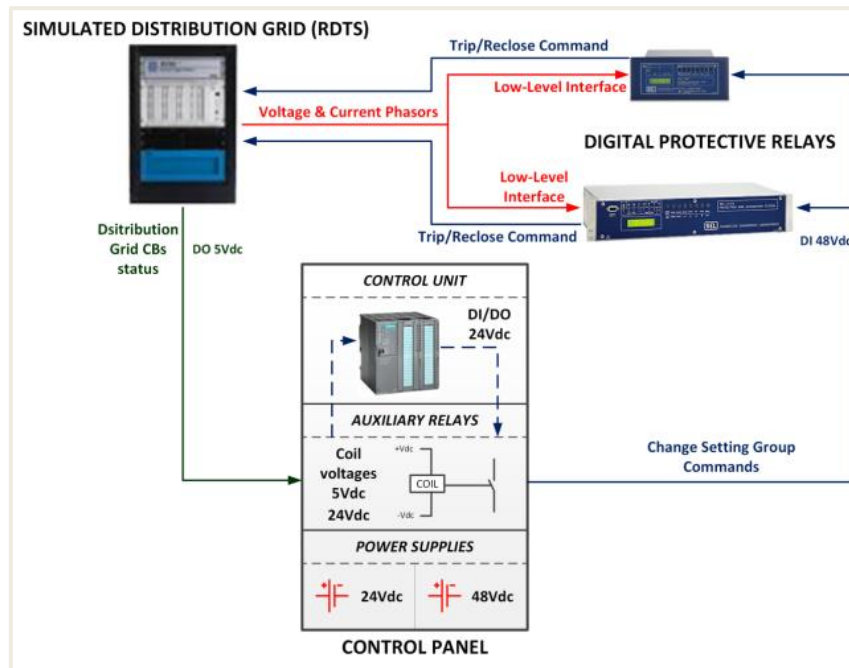


Figure 31: EESL Laboratory at ICCS-NTUA

- PV Inverter testing according to standards:** The laboratory operates the necessary equipment to perform tests on photovoltaic inverters according to standards. A PV Simulator by Regatron (3x TopCon Quadro Programmable DC Power Supply) features fully controllable and customizable voltage-current characteristics (V-I), and a Linear Amplifier/Grid Simulator by Spitzenberger & Spies (PAS 5000 – 4 Quadrant Linear Amplifier 5kVA) applies voltage (dips, introduction of harmonics etc.) and frequency variations on the inverter. In this way a testing environment is created for the testing of both the direct current (DC) and alternating current (AC) side of the inverter. By appropriately controlling the two simulators, the necessary conditions specified by the standards for PV inverter tests are represented. The tests that can be carried out in the laboratory are:
 - Static and Dynamic Maximum Power Point Tracking (MPPT) (EN 50530)
 - EMC tests (IEC 61000-3-2, Harmonic measurements 0-100KHz, etc.)
 - Connection requirements (VDE-AR-N 4105)
 - Fault ride through (VDE 0126-1-1)
 - Anti-islanding Requirements (In progress)

The electrical quantities (voltage, current, power, etc.) during the tests can be measured accurately and analysed with the use of a Yokogawa WT3000 Power Analyzer.

- Flexible Power Electronics Configuration for Coupling RES & Storage:** At EESL the simulation of distribution network under future scenarios is thoroughly analysed. An integral part of this process is the Triphase's Distributed Power Modules that realize a scalable, flexible and open platform for rapid prototyping of power conversion and power system applications. The setup consists of a 15 kVA bidirectional active frontend (DC/AC), and a 15 kW bidirectional DC/DC converter consisting of 3 channels. The Power Modules are fully reconfigurable and open. Researchers have access to all data and can change all the software (based on Matlab/Simulink) from the highest level (e.g. coordination and control of power flows between the storage and the grid) down to the lowest level (e.g., PWM control). Currently the module is operated as a 3ph inverter to interface a battery storage system or as a 1ph-3-leg back to back converter (AC/DC/AC) for power amplification. All converters are connected to a single DC bus which is accessible to external DC sources (e.g., DC simulator). The open, reconfigurable and fully reprogrammable structure of the Power Modules can readily be adapted to new research areas.

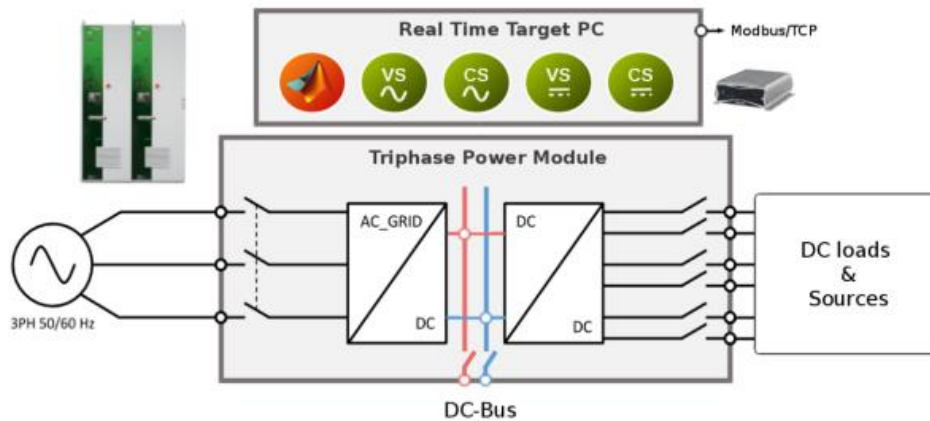


Figure 32: EESL Laboratory at ICCS-NTUA

- Axial flux generator bench testing facilities:** The bench testing rig allows for the testing of axial flux generators of power up to 9kW and maximum diameter of up to 1m. With the use of a 60 HP DC motor, a DC bi-directional drive and a tachogenerator, the axial flux generators can be driven at different and constant revolutions per minute (RPM). Different loads can be applied to the generators such as a grid-tie inverter for grid connection or a 12/24/48V battery bank for battery charging modes, along with a diversion load controller and resistive load. In addition, a three phase ohmic load of maximum power 3.3kW can be connected directly to the generator. The experimental setup mentioned allows for a complete analysis of the generator's behavior under different situations.
- Residential Wind and Hydro Turbines construction:** The study and simulation of residential wind and hydro turbines for rural electrification applications follows local manufacturing which enables the user with the ability of local maintenance and immediate repairs of possible failures. In the workshop, small wind and hydro turbines are constructed from scratch. Up until now, residential wind turbines for battery charging and grid connection have been manufactured, with rotor diameters of up to 4.3 meters and a pico-hydro system of 500W.
- Meltemi Test Site:** ICCS-NTUA has access to the Meltemi site where a number of Distributed Generators (DGs) are installed, including a 40kVA diesel generator, 4.5 kW photovoltaic panels and small residential wind turbines that can partially support the Meltemi camping load in islanded Microgrid operation. The MAGIC (Multi-Agent Intelligent Control) system installed in a number of households allows the DGs and the loads to negotiate in order to decide next sequence of actions. This system is a Java based software that implements intelligent agents. The test site also allows for outdoor measurements of the power and energy production of household small wind turbines for grid connected and battery charging applications. The facilities of the test site are in accordance to the IEC international standard IEC 61400-12-1. With the use of the standard one can plot the power curve, the system's power coefficient C_p and also predict the annual energy production of the turbine for different mean wind speeds.
- E mobility lab facilities:** The lab facilities which can be exploited for e-mobility applications are:
 - An **EV (Electric Vehicle) emulator** supporting the interoperability testing of the EV related protocols (IEC61851) is developed. It can be connected to an EVSE (Electric Vehicle Supply Equipment), as the device under testing, in order to validate its compliance with the standards.
 - An **EVSE emulator** allowing the charging of a real or emulated EV in respect to IEC61851. The EVSE can also communicate with external stakeholders, i.e. the EVSEO, implementing the OCPP 1.5 protocol. Apart from the EVSE emulator, a commercial EV charging station (ETREL wallbox- 32A) is also available with smart charging capabilities.
 - An **EVSEO (Electric Vehicle Supply Equipment Operator)** adopting the OCPP 1.5 protocol for the communication with custom-made or commercial EVSE.

- **A custom-made energy management system with user interface** offering several services to e-mobility stakeholders such as searching for EVSE location, electricity price information, EVSE availability, booking capabilities. The interaction between the EV user interface and the EVSEO is realized via Rest-Based Web Service technology.

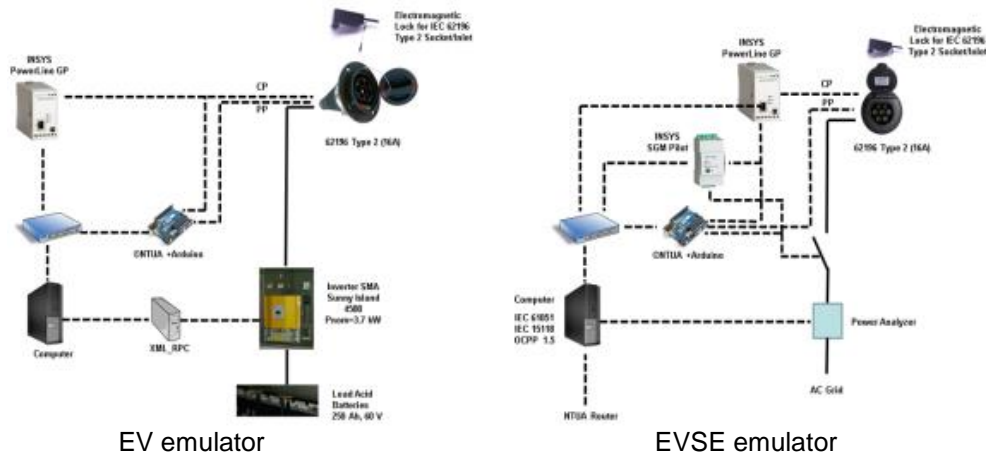


Figure 33: EESL Laboratory at ICCS-NTUA

3. Services Offered by the Research Infrastructure

The main services offered by the above facilities are:

- Performance of Power Hardware-in-Loop testing of DER devices integrated with the RTDS simulator. MIMO PHIL tests can also be performed using the two power amplifiers of the lab.
- CHIL applications with the RTDS simulator and an external Triphase Target PC which allows the design of the control algorithm in Matlab/Simulink and it's testing in real time.
- Testing both local and remote by Multi Agent System (MAS) technology and performance of optimizations.
- Fast testing of developed control algorithms (Matlab/Simulink) in flexible hardware power electronic converters (DC/DC, DC/AC, AC/DC/AC) provided by Triphase
- Power curve measurement of Small Wind Turbines
- Small wind turbine generator testing
- Testing and validation of DG components within the Microgrids operation
- Testing commercial or custom made e-mobility products for their compliance with EV standards/protocols (IEC61581, OCPP)
- Developing and testing EV smart management algorithms in lab environment (microgrids)
- Testing and validating EV integration within simulated distribution network in the RTDS
- PV inverter testing according to standards
- Testing of protection schemes with the RTDS
- Steady state and dynamic simulations of power systems with high RES penetration: using various in-house and commercial packages.

4. Brief Description of the Organization Managing the Research Infrastructure

The Institute of Communication and Computer Systems (ICCS) is a private law body associated with the Department of Electrical and Computer Engineering of the National Technical University of Athens (NTUA). ICCS has been established in 1989 by the Ministry of Education in order to carry research and development activities in the fields of telecommunication systems and computer systems and their applications in a variety of applications, such as electric power systems, software and hardware engineering, control systems and biomedical engineering. R&D staff of ICCS-NTUA consists of

40 members of staff of NTUA, 20 additional senior researchers and 120 research students.

Smart RUE is one of the Research Groups of ICCS. It belongs to the Electric Energy Systems Laboratory (EESL) of the School of Electrical and Computer Engineering of the National Technical University of Athens. It was founded by Professor Nikos Hatziaargyriou and operates under his supervision. It is composed of Professors, post-doctoral scientists, postgraduate students and highly specialized researchers and collaborators. It is technically and administratively supported by the personnel of EESL.

The main activities of Smart RUE focus in research and technology development in the area of Smart Grids. The main Smart RUE activities deal with planning and operation of modern power systems characterized by high penetration of renewable energy sources, distributed generation and flexible loads. For the efficient solution of related problems advanced control and ICT technologies are employed.

Smart RUE has coordinated and participated in a large number of European and national R&D projects and studies. It has organized several international Conferences, Seminars and workshops and it has published numerous papers in international journals and conference proceedings. Its members are active in several EU and international organizations. It maintains excellent connections with many Universities, Research Centres, Utilities and Power Industries active in the area of Smart Grids both at national and international level.

5. Trans-national Access Conditions Offered by ICCS-NTUA

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of ICCS-NTUA. For **the rest of applications** and after ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of ICCS-NTUA's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to ICCS-NTUA infrastructure, the access being offered includes supervision and help of ICCS-NTUA staff:

- As a complement to the pre-access contacts between the user group and ICCS-NTUA, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- ICCS-NTUA's researchers will support the realisation and follow-up of the experiments.
- ICCS-NTUA's researchers will support the results interpretation, data processing and analysis, and test report preparation.



Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to Athens by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in ICCS-NTUA, ICCS-NTUA will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to ICCS-NTUA in order to get the refund.

Reasonable expenses must be made by the user: travels will be made in economy 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 60 €/person must be considered per day, excluding the hotel cost (i.e. for meals, coffee etc.). The tickets for the transportation to and from NTUA (metro, bus) will be also reimbursed.

6. Contact Details for Research Infrastructure

Electric Energy Systems Laboratory (EESL) – ICCS-NTUA			
Address: 9, Iroon Polytechniou Str., 157 73 Zografou Campus, Athens, Greece			
Website: http://www.smartrue.gr/			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Nikos Hatziargyriou Email: nh@power.ece.ntua.gr		Panos Kotsampopoulos Email: kotsa@power.ece.ntua.gr Telephone: +30 2107721499	

Fraunhofer IWES Kassel



1. Research Infrastructure

Name of Infrastructure/Installation	Test Center for Smart Grids and Electromobility (IWES-SysTec)
Location	Fraunhofer IWES, Kassel, Germany
Web Site	www.energiesystemtechnik.iwes.fraunhofer.de

2. Description of the Research Infrastructure

In the IWES-SysTec test centre for smart grids and electromobility, Fraunhofer IWES is developing and testing new equipment and operation strategies for smart low and medium voltage grids. In addition, investigations regarding grid integration and grid connection of electric vehicles and their power generated from renewable energy sources as well as photovoltaic systems, wind energy plants, storage and hybrid systems are carried out under realistic conditions here. A large open-air ground of approx. 80,000 m² offers sufficient space and very good conditions for solar and wind energy. Furthermore, the open-air ground provides configurable distribution grid sectors (low and medium voltage).



Figure 34: The main building of IWES-SysTec with the labs SysTec PNI and SysTec TPE

In the eastern area of the premises there is a hall presently with two laboratory divisions: one of the labs, which is entitled “**SysTec PNI**” includes a testing area for low and medium voltage converters or distribution grid equipment. There it is possible to develop and test the electrical properties and in particular the ancillary services of distributed generators in the power range up to 6 MVA. A mobile test container able to be used to measure the fault-ride-through of generation plants has been integrated into the laboratory. The second lab “**SysTec TPE**” is equipped with facilities to test grid integration of electric vehicles and power storage, such as hardware simulators for batteries, bidirectional charging controllers, charging columns and a three-phase grid simulator with 270 kVA rated capacity.

SysTec PNI: Lab for Network Integration

The PNI is part of the Fraunhofer IWES SysTec test center for smart grids and electro-mobility. Currently devices connected to the low voltage grid with rated power up to 1.25 MVA and those

with connection to medium voltage networks up to 6 MVA may be tested. For the testing of the static and dynamic response of generators and network assets different test setups are available.

- **Control room:** The test sequence as well as the control of the test facility is controlled from a central control room. As part of the control the relevant electrical data, in particular power quality data, can be acquired, recorded and analyzed centrally. Matlab® / Simulink® applications may be integrated into the control.

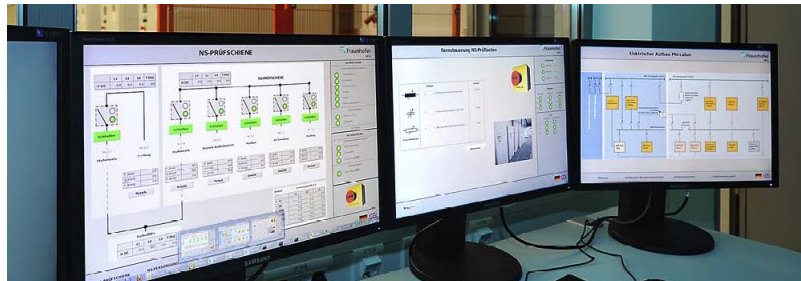


Figure 35: View into the control room of the Lab SysTec PNI

- **Low voltage test bay:** For investigations of devices connected to low voltage networks a tap transformer (1.25 MVA) with a wide, finely adjustable voltage range from 254 VAC to 690 VAC as well as an electronic AC grid simulator (100 – 900 VAC, 45 – 65 Hz, max. 1 MVA) is available. For investigations of generators with inverters, e.g. photovoltaic inverters, fast controllable DC sources (14 units, with max. 3000 ADC @ 1000 VDC) can be utilized. Programmable loads with 3 x 200 kW resistive load, 3 x 200 kvar inductive load and 3 x 200 kvar capacitive load, which may be adjusted in 1 kW and 1 kvar steps respectively, are available as well. The low voltage test bus bar is divided into 2 bus bar sections to allow an easy investigation of line regulators, e.g. voltage stabilizers. To research interactions between different components operating on the same grid part configurable low voltage networks can be connected to the test bus bar.



Figure 36: Inside view into the Lab "SysTec PNI"

- **Medium voltage test bay:** By utilizing digital test signal generators the secondary control technique (protection relays and controls) of generating units and network assets can be tested. For testing the transient behaviour a mobile test container (LVRT test facility) is available, which is integrated into the central lab control as well. Since the test setup is inside a container, even on-site measurements and tests of complete power plants are possible. In this case the test facility is connected to the medium voltage network between the equipment under test and the network connection point of the grid operator. It produces voltage dips on the medium voltage side of the equipment under test without disturbing the public power grid. With the LVRT test facility 3-phase as well as 2-phase faults can be generated.

3. Services Offered by the Research Infrastructure

Within IWES-SysTec Fraunhofer IWES offers the following services to research and industrial partners:

- Examination of distributed generators (PV inverter, CHP units, diesel gen-sets etc.) in accordance with different grid connection guidelines (low voltage, medium voltage).
- Field and laboratory tests of hybrid systems, small wind power plants and individual smart grid components as well as tests with hardware emulations under defined operating profiles.
- Real time distribution grid simulations to test control centres and the grid integration of distributed generators, electric vehicles and power storage (hardware-in-the-loop).
- Investigation of operating performance strategies for individual plants and hybrid systems (e.g. photovoltaic, storage facilities, heat pumps, combined heat and power).
- Metrological examination of performance (tripping characteristic) of protection devices.
- Measurements of power quality and analyses of performance.



Figure 37: MV Equipment under test:
Power transformer with OLTC

4. Brief Description of the Organization Managing the Research Infrastructure

The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society. With a workforce of over 24,000, the Fraunhofer-Gesellschaft is Europe's biggest organization for applied research, and currently operates a total of 67 institutes and research units. The research activities of the Fraunhofer Institute for Wind Energy and Energy System Technology IWES cover wind energy and the integration of renewable energies into energy supply structures. Fraunhofer IWES was established in 2009 as a merger of the former Fraunhofer Center for Wind Energy and Maritime Engineering CWMT in Bremerhaven and the Institute for Solar Energy Technology ISET in Kassel.

The TA will be conducted at Fraunhofer IWES Kassel within the R&D Division Systems Engineering and Distribution Grids, which has a long term experience in the systems technology for the utilization of renewable energies such as solar energy and wind energy as well as for other electricity generators, storage systems, and electrical vehicles. Converters and other equipment are being developed which support the new requirements of smart grids. The laboratory equipment of the Division Systems Engineering and Distribution Grids allows carrying out tests not only of smart grid equipment but also of complete sections of smart LV/MV-distribution networks using new ICT technologies.

5. Trans-national Access Conditions Offered by Fraunhofer IWES

All the offered experimental systems included in IWES-SysTec are in the same location in Rothwesten, near to Kassel, Germany.

For **safety reasons** the users are not expected to operate the lab infrastructures by themselves; even when safety instructions will be provided, experiments and tests will be carried out together with the staff of Fraunhofer IWES. The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, etc.) and the help and advice on accommodation and transportation to Fraunhofer IWES's infrastructures, the access being offered includes supervision and support of Fraunhofer IWES's staff:

- As a complement to the pre-access contacts between the user group and Fraunhofer IWES, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- Fraunhofer IWES's researchers will support the realisation and follow-up of the experiments.
- Fraunhofer IWES's researchers will support the results interpretation, data processing and analysis.

In principle, a typical stay of 2 work weeks is foreseen for a single user group, but this period could be extended depending on the concrete user project. The user group (usually 2 persons) can use the infrastructure for the defined time.



Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to IWES-SysTec (Fraunhofer IWES) by plane, accommodation, daily subsistence, and daily transportation during the stay. Fraunhofer IWES will reimburse each User with a daily grant following the "Bundesreisekostengesetz" as a lump sum covering all expenses for subsistence during the stay at the facility.

For the user projects taking place in IWES-SysTec, Fraunhofer IWES will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to Fraunhofer IWES in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy 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 94 €/ person must be considered per day. Lunch will be provided by Fraunhofer IWES free to the user.

6. Contact Details for Research Infrastructure

Test Center for Smart Grids and Electromobility (IWES-SysTec) – Fraunhofer IWES			
Address: Königstor 59– 34119 Kassel, Germany			
Website:			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Dr. Thomas Degner Tel.: +49 561 7294-232 E-mail: Thomas.Degner@iwes.fraunhofer.de		Dr. Gunter Arnold Tel.: +49 561 7294-231 E-mail: Gunter.Arnold@iwes.fraunhofer.de	

ORMAZABAL Corporate Technology



1. Research Infrastructure

Name of Infrastructure/Installation	Demonstration & Experimentation Unit (UDEX)
Location	ORMAZABAL Corporate Technology, Amorebieta, Spain
Web Site	http://www.ormazabal.com/en/about-us/our-own-technology/technological-innovation-center

2. Description of the Research Infrastructure

Demonstration and Experimentation Unit (UDEX), consists of an Experimental Grid designed as a platform to research, develop and verify equipment and systems in a real grid in a non-risk environment: 3500 m² real-time experimentation network with over 15 km of underground cable and 450 m of overhead line.

This configurable autonomous grid permits the reproduction of normal conditions and anomalous situations to produce real medium voltage operating conditions independent from the grid and at different power frequencies.

The main purpose of the UDEX is to facilitate access to a smart grid network having a high degree of flexibility, independent of the utility network, for the development and testing of new technologies. It is able to reproduce real conditions of existing worldwide grid topologies at different voltage levels and at different power frequencies. The UDEX management system (UMS) controls the operation of the infrastructure to run according to a certain strategy, physically connects/disconnects the elements, and changes the network topology, by means of fully automated operation. The facility allows the research and development of the connection, integration and validation of new technologies, assessment of the impact on the network, and the investigation of operation of the complete network.

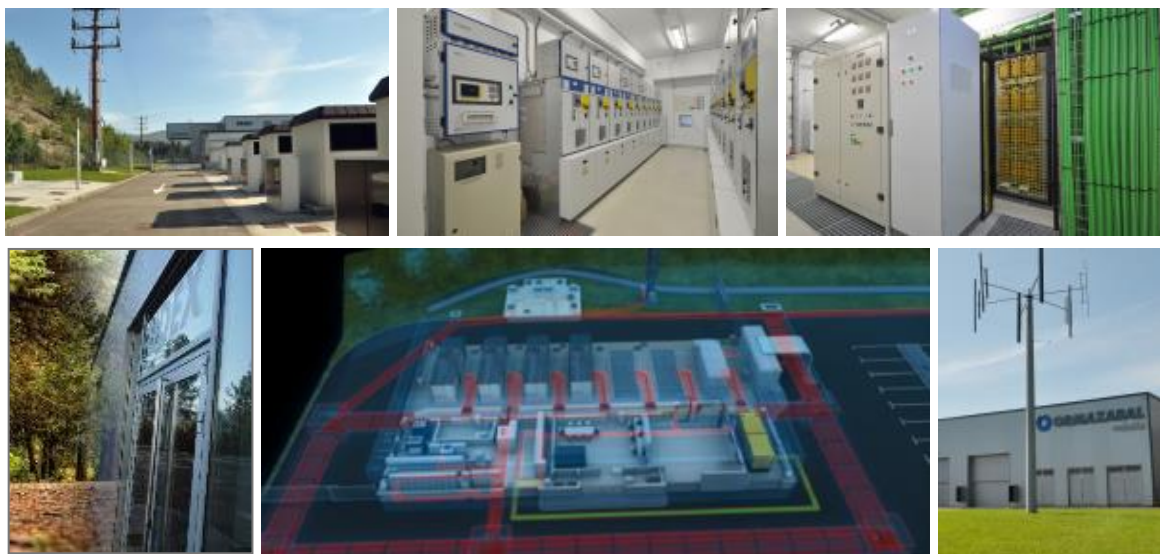


Figure 38: UDEX at ORMAZABAL Corporate Technology

In addition, in the UDEX there are five special test cases with singular capabilities in the specific fields of voltage regulation, MV network compatibility, network diagnosis, powerline communications, and smart metering:

- **Regulation of network voltages to maintain quality of supply affected by integration of renewables and/or significant intermittent loads:** Functional validation of MV/LV voltage regulating systems (e.g. on-load automatic tap changer) in real MV network environment, with different MV Network Configurations and voltage levels - including Neutral configuration, Power Frequency (50-60Hz) MV Network Voltage Level (0-36kV)-.
- **Validation of correct functioning of IED systems in a real network in the face of transient overvoltages / overcurrents occurring during typical switching operations in the MV network:** Functional validation of IED's in real network environment tested with different MV Network Operations, especially during and after transients occurring during network switching. Neutral configuration, Power Frequency (50-60Hz), MV Network Voltage Level (0-36kV) can be controllable parameters.
- **Asset management of network and its components through online technologies:** Functional validation of network diagnostic equipment and systems, from simple detection devices to complete monitoring systems, in real MV network environment. Especially focused on validation of systems to do all or some of the following: Detection, analysis, identification, localization and evaluation of defects arising from PD sources and the communication of this data to supervision interface. Network and neutral configuration, Power Frequency (50-60Hz), MV Network Voltage Level (0-36kV), Measurement Bandwidth, defect type and location being controllable parameters to perform the assessment of the system.
- **Testing of functional compatibility of combined sensors with MV & PLC signal measurements in the Medium Voltage Networks:** Simultaneous Compliance of Precision & communications performance of combined sensors, using a real distribution network with different components under test (Combined sensors, RTU, PLC modems, measurement cables, MV Network Configurations). Network and neutral configuration, Power Frequency (50-60Hz), MV Network Voltage Level (0-36kV), and Communications Bandwidth can be controllable parameters.
- **Testing of functional narrowband powerline communications in distribution networks:** Compliance with communications performance requirements, using a real distribution network with different components under test (PLC modems/Data concentrators, Meters, Network Configurations, MV/LV Transformers, Switchgears, Sniffers). Network and neutral configuration, Power Frequency (50-60Hz), MV Network Voltage Level (0-36kV), and Communications Bandwidth can be controllable parameters. This system allows also to change the length and type of the LV lines and network topology, the number and type of meters, in such a way that not only individual meters can be tested but also entire meter systems and the interoperability performance.



Figure 39: UDEX at ORMAZABAL Corporate Technology

3. Services Offered by the Research Infrastructure

Important tool for the research, development and evaluation of new technologies for the future grid and for anticipating problems, which may appear under the most realistic conditions.

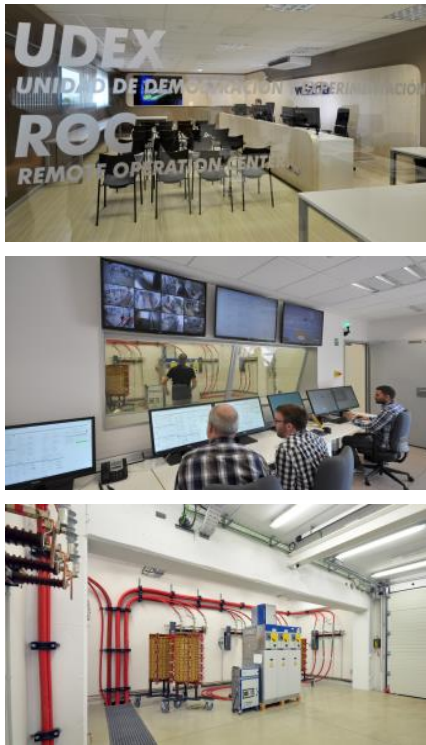


Figure 40: UDEX at ORMAZABAL Corporate Technology

UDEX's concept consists of a highly configurable distribution network independent from the grid which allows the development and testing of new technologies, products & services in a safe and controlled environment, positioning Ormazabal at the high-end of world-class R&D capabilities, providing the following services (but not limited to):

- Electrical protections and network automation
- Network diagnostic systems
- Power Line Communications (PLC)
- AMI (Advanced Metering Infrastructures)
- Active demand management
- Integration of dist. & renewable generation in the grid
- Bidirectional power flow
- Dynamic configuration of the distribution network
- Electric vehicle integration in the distribution network
- Integration of energy storage systems
- Power electronics
- Power quality and efficiency
- Impact on the safety (EMF, step and touch voltages, short circuit behaviour)

4. Brief Description of the Organization Managing the Research Infrastructure

From the time Ormazabal was founded in 1967, we have been aware of the strategic importance of research applied to own technological development, and in this way offer quality products and services to the customers and consolidate the leading position in the world's technology sector.

The Research and Technology Center, managed by Ormazabal Corporate Technology (OCT), represents an important leap in the company's track record; a project that has long been desired and aspires to become a technical reference at an international level, in the field of electrical power distribution networks.

The Research and Technology Center becomes an essential element in R&D projects, with the purpose of acquiring and improving existing technologies and researching new ones.

Ormazabal facilities offer their services to the technological scientific sector for performing research testing and for developing and type testing products the electrical sector.

Ormazabal is very active in national and international recognized electrical product and services for the distribution networks relevant for ERIGrid, contributing to the development of common visions, roadmaps and strategies for the energy sector and having an excellent perspective and vision of the future challenges. This networking structure is complemented by a large experience in national and international research projects based on the research and technology development capabilities of OCT. In addition to the UDEX infrastructure offered in ERIGrid, OCT has a high power laboratory, a high voltage laboratory and a low voltage laboratory for equipment testing, being an accredited laboratory according to EN ISO/IEC 17025 for many testing activities.

5. Trans-national Access Conditions Offered by OCT

All the offered experimental systems included in the UDEX are located in the research and technology centre of ORMAZABAL Corporate Technology in Boroa (Amorebieta-Etxano), near Bilbao, Spain.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of OCT. For **the rest of applications** and after ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of OCT's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications. In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to OCT's infrastructure, the access being offered includes supervision and help of OCT's staff:

- As a complement to the pre-access contacts between the user group and OCT, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the user's requests, and programming of the experimental conditions.
- OCT's researchers will support the realisation and follow-up of the experiments.
- OCT's researchers will support the results interpretation, data processing and analysis, and test report preparation

In principle, a typical stay of 1 month is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group (usually 2 persons) can use the infrastructure for the defined time.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to UDEX (OCT) by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in UDEX, OCT will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to OCT in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy 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.

6. Contact Details for Research Infrastructure

ORMAZABAL Corporate Technology (OCT)			
Address: Parque Empresarial Boroa · parcela 24. 48340 Amorebieta-Etxano. Bizkaia (Spain)			
Website: http://www.ormazabal.com/en/about-us/our-own-technology/technological-innovation-center			
<i>For Management/Administration Issues:</i>		<i>For Technical Issues:</i>	
Iñaki Orue Tel.: +34 629 460 137 E-mail: ios@ormazabal.com		Nabil Akroud Tel.: +34 94 630 51 30 E-mail: nak@ormazabal.com	

OFFIS – Institute for Information Technology



1. Research Infrastructure

Name of Infrastructure/Installation	Smart Energy Simulation and Automation Laboratory (SESA-Lab)
Location	OFFIS – Oldenburg, Germany
Web Site	www.offis.de/en

2. Description of the Research Infrastructure

The core of the automation lab is a real-time simulator (eMEGAsim) from OPAL-RT that allows for the execution of highly detailed, dynamic power grid- and network component models on dedicated FPGA-based signal processors. With this the dynamic/transient behaviour of an electric AC system can be resolved with an accuracy of up to 10 μ s (max. 100 kHz). The power grid simulator provides analogue interfaces that forward the AC signals of the grid. With this setup the HIL operation of real devices and components is possible.



Figure 41: Real-time simulator at OFFIS

In addition to that, the lab consists of additional embedded (FPGA-based) platforms that are directly connected to the eMEGAsim (analogue and digital I/O) and can be used for various purposes, such as real-time platforms, which can execute device- and component models on MATLAB/Simulink basis in real-time (similar to the power grid simulator), or as standard industry components that are able to implement standard-compliant controllers or even complex agent-based control strategies. The systems with the highest performance are additionally operated as substation platforms in order to realize control- and protection systems.

A special feature of the SESA-Lab installation is the topology free allocation and combination of inputs and outputs. That means access and visibility can be controlled in a rule-based manner for

the Ethernet- and EtherCAT-based component-to-component communication. Furthermore, the analogue inputs and outputs of the real-time platforms can be virtually interconnected. This allows a flexible connection of the dynamic component models with different nodes of the real-time simulation without significant manual changeovers. The virtual and topology free connection even enables the parallel operation of independent simulations/experiments in standard-compliant power system automation environments.

Another part of the lab is a virtualization server that can provide virtual machines for mosaik-based (open source power/ICT simulation coordinator) simulations (lower-resolution parts of the analysed scenario that run conjointly in parallel with the hardware-based real-time simulation), development environments, or licensing servers for possible runtime environments. The external interface allows connections to research infrastructures provided by the University of Oldenburg, e.g., the HERO cluster (High-End Computing Resource Oldenburg) that can be used for significantly more extensive complex mosaik-based simulation scenarios that are co-simulated and synchronized with the hardware-based component simulations of the SESA-Lab. However, the interface foremost provides the possibility to integrate infrastructures from external research- and cooperation partners into the SESA-Lab. This is of special interest for the functional integration of testing equipment for power electronics and components located at external universities and institutes – which is comfortably to handle with mosaik.

The SESA-Lab relies on integrated standard-compliant information- and process chains based on the IEC Common Information Model (CIM; IEC 61970/61968), IEC 61850, and the OPC Unified Architecture (UA). This covers the whole process starting in the (planned) control centre down to the controllers and various field devices.

A control centre simulation has been added to the SESA-Lab environment realizing a transparent SCADA-based viewpoint and operation of the co-simulated (both hard- and software, remote and on-site facilities/components) system, as well as the protocol families covered by the IEC 60870, the industry standard for telecontrol and power system control. Extensions will mainly address two things: firstly, communication simulation in order to realistically influence message transfer times and communication reliability, and secondly, further up-scaling the existing infrastructure.

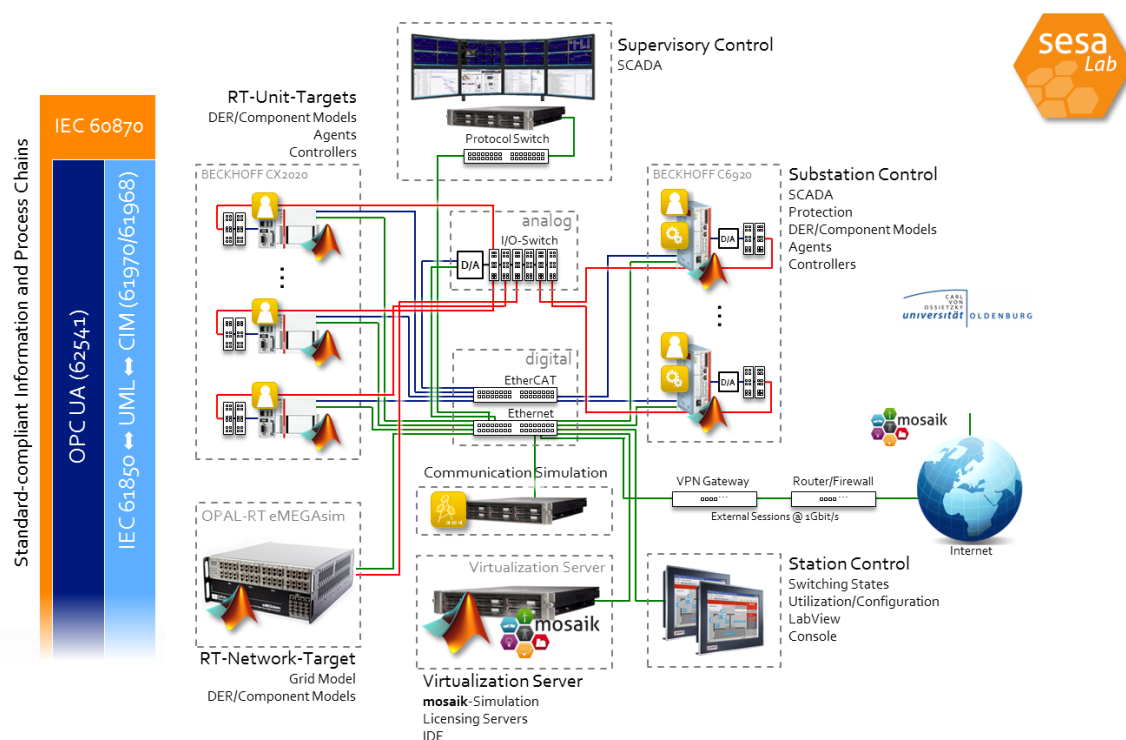


Figure 42: SESA-Lab at OFFIS

3. Services offered by the Research Infrastructure

- Prototyping for Smart Grid control concepts
 - Black / White / Grey Box testing
 - Centralized and decentralized control approaches (e.g., Multi-Agent Systems)
 - Standard compliant communication and control from devices up to SCADA systems
- Large scale Smart Grid simulations
 - Holistic system approach (design of experiment based statistical experiments)
 - Coupling heterogeneous simulations
 - Integrating frequency and time domains
 - Parallel simulation of scenarios (up to 100.000 simulator instances per scenario)
 - Transparent SCADA viewpoint and control of the conjointly (heterogeneous) simulated system

4. Brief Description of the Organization Managing the Research Infrastructure

The OFFIS – Institute for Information Technology is associated institute of the Carl von Ossietzky University of Oldenburg in Germany and federally base-funded by the state of Lower Saxony. It is primarily dedicated to technology transfer of computer science knowledge into enterprises and organisations and has a total turnover of more than 13 million €. Approximately 230 researchers work in the three application areas Energy, Healthcare, and Transportation.

The ERIGrid project is executed by the Energy division, which dedicates its research to a variety of aspects regarding the future smart grid and deals with topics like interoperability, standard-compliant IT integration of distributed producers and consumers, large and flexible distributed software architectures for business contexts within the energy domain, simulation, and intelligent data management.



Figure 43: OFFIS premises (Oldenburg, Germany)

5. Trans-national Access Conditions Offered by OFFIS

All the offered experimental systems included in the SESA-Lab are in the same building in OFFIS.

User groups from one up to four persons are welcome for a typical stay from 2-4 weeks. This period could be extended or remote access provided after the stay depending on the individual user project. The scheduling of the experiments depends on the usage of the lab and has to be agreed on before the stay. Furthermore, a user agreement must be signed before the stay. Support and advice on accommodation and transportation to OFFIS will be offered by OFFIS staff.

During the stay, an office space will be provided for the user group and access to the related facilities will be given. A training and introduction to the lab facilities will be given shortly after arrival. An introduction to Mosaik can be given as well. For using hardware in the lab the support by staff is necessary. Supervision and help by the staff will be provided throughout the whole stay.

OFFIS's researchers will support the realisation and follow-up of the experiments and will support the results interpretation, data processing and analysis, and test report preparation.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to SESA-Lab (OFFIS) by train or plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in SESA-Lab, OFFIS will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to OFFIS in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy class and conventional hotels (not luxury) or equivalent accommodation will be used. Lunch cannot be provided at OFFIS's canteen free to the user.

6. Contact Details for Research Infrastructure

Smart Energy Simulation and Automation Laboratory (SESA-Lab) – OFFIS Address: Escherweg 2, 26121 Oldenburg, Germany Website: http://www.offis.de/en			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Lars Fischer Tel.: +49 441 9722 422 E-mail: lars.fischer@offis.de		Martin Büscher Tel.: +49 441 9722 740 E-mail: martin.buescher@offis.de	

Ricerca sul Sistema Energetico – RSE



1. Research Infrastructure

Name of Infrastructure/Installation	Distributed Energy Resources Test Facility (RSE DER-TF)
Location	Ricerca sul Sistema Energetico – RSE S.p.A.
Web Site	www.rse-web.it

2. Description of the Research Infrastructure

RSE DER-TF (Distributed Energy Resources Test Facility) is a real low voltage microgrid that interconnects different generators, storage systems and loads to develop studies and experimentations on DERs and Smart Grid solutions.

The Facility extends over an area of about 20000 m², is interconnected to the MV Grid by means of a 800 kVA dedicated transformer (23 kV/400 V) and has an overall capacity of 350 kW (active power) and 300 kVAr (reactive power).

Different types of DER generators are connected as PV Fields, Wind Generator, Diesel Generator and natural gas CHPs (Internal Combustion Engines). The facility has an overall storage capability of about 230 kWh based on different storage technologies as Lithium, Flow (Redox), High temperature Nickel-Sodium and Lead (VLRA) batteries interconnected to the grid with dedicated converters. Resistive, Inductive and Capacitive Loads (overall capability of about 90 kW, 70 kVAr inductive and 150 kVAr capacitive are connected to the grid in order to simulate different typologies of actual users loads).

The microgrid is configurable (locally or remotely) at the interconnection board in order to obtain different grid topologies: radial grids and also meshed configurations. There's also the opportunity to extend feeders till one kilometre. The microgrid is able to operate grid connected or in islanded mode thanks to specific droop control algorithms implemented in some converters.

The interconnection board (main bars and all feeders) and all the DERs are provided with electrical measure equipment, set up to collect and analyse the experimental data derived from the field test.

A Supervision and Control system has been developed in order to monitor and control all installed resources.

Different Energy Management and control functions have been implemented and can be used in order to fulfil with the requested objective (economic optimisation, renewable resources balancing, self-consumption, voltage control, state estimator). Resources control can be performed manually or in a full automated mode according to the different Microgrid control functions. New Management and control functions (also from third parties) can be easily integrated to DER Test Facility Control System. Communication has been developed mainly based on LAN Ethernet. Archive functions as data storage and retrieval are integrated in SCADA.

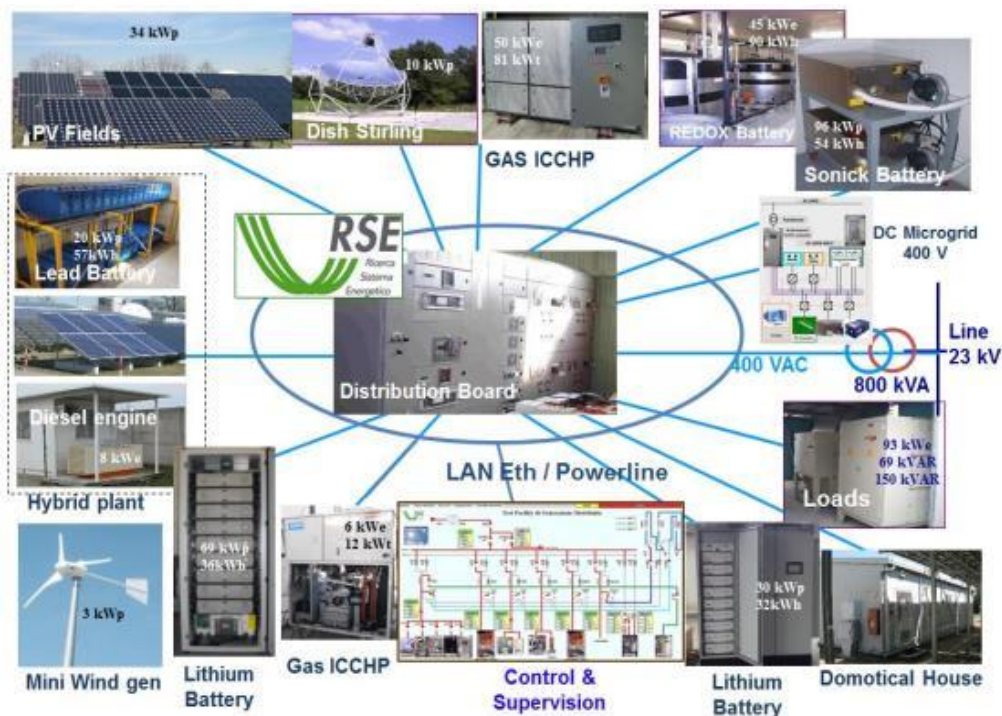


Figure 44: DER-TF at RSE (Milano, Italy)

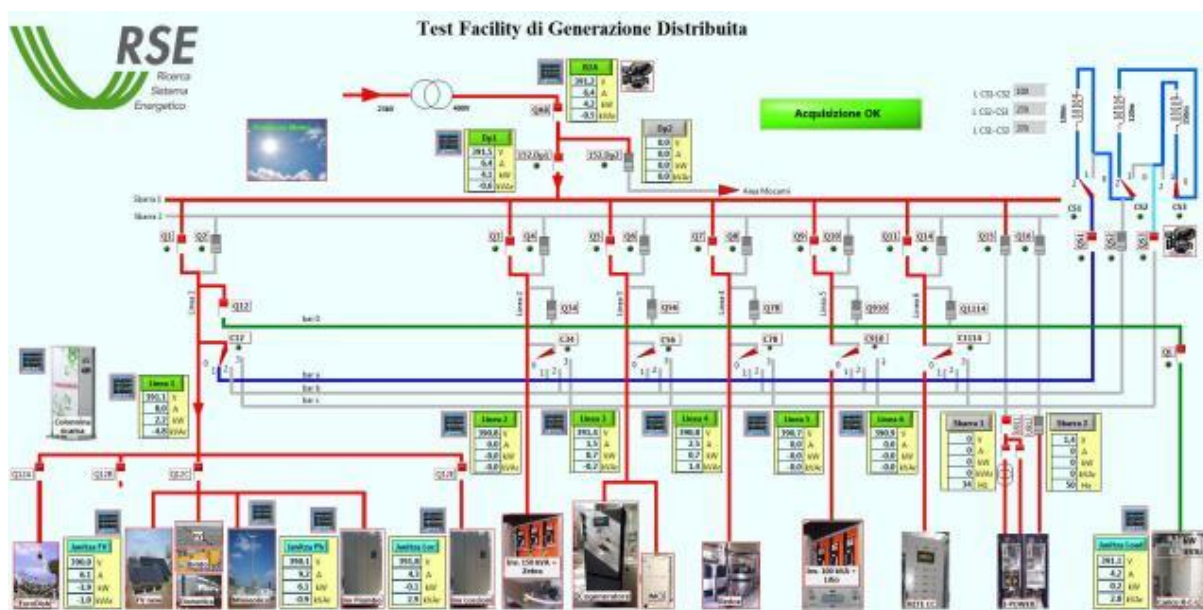


Figure 45: DER-TF diagram

In addition, integrated to the AC microgrid, there are components and facilities that can extend the infrastructure testing capabilities as:

- **Low Voltage DC Microgrid** (380 V, 100 kW_e) capable to operate in islanding mode or interconnected to the AC grid. The DC microgrid operates at nominal voltage of 380VDC with bi-directional interface inverter (100 kW_e), two Zebra batteries (each 30kWp, 16kWh), two supercapacitors banks (each 30 kWp, 8 seconds), a PV emulator (30kW_e), a DC fully controllable resistive load (30kW) connected to DC BUS by DC/DC converters and a DC programmable load (30kW) directly connected to DC grid. The grid can operate in islanded mode or connected to the main AC grid (DER Test Facility).

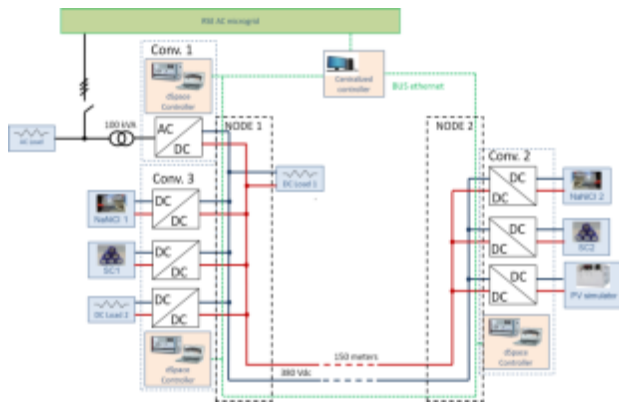


Figure 46: LV DC Microgrid at DER-TF

- **Face to face converter:** a bi-directional converter (200kWE) able to generate a second independent net at variable voltage and frequency to test components behaviour at different grid conditions. The supplied system consists of two back to back inverters. One inverter is connected to the grid and supplies power to a DC bus. The other inverter converts the DC bus power to a three phase variable frequency, variable voltage output. The power supplied by the voltage source is up to 200kW at a power factor of >0.8 . The face to face converter can be used as a **Grid Simulator** in order to test components and grid sections at different voltage and frequency.
- **“Domotic house”:** this test facility is a 60 m² building representing a common residential flat with living room, kitchen, bedroom, and bathroom. This facility makes possible to carry out several tests on different energy management strategies but also simulates the user presence thanks to an appropriate sub-system which operates each single domestic appliance as it may do a real family living in a house. The independent data acquisition & monitoring system allows to evaluate the actual results of the different energy strategies.
- **EV Charging station:** A multistandard fast charging station compatible with all CHAdeMO, CCS and Type 2 AC vehicles currently on the road is connected to the Smart Grid. This charger is the ideal choice to serve all these electric vehicles. Typical charging times range between 15 and 30 minutes.



Figure 47: Face-to-Face converter at DER-TF



Figure 48: Domotic house at DER-TF



Figure 49: EV charging station at DER-TF

- **SW Interface:** the DER-TF SCADA is written in LabVIEW and can be interfaced with other any software for both measurements acquisition and device control. The available protocols for data access are the following:
 - NI LabVIEW DataSocket protocol
 - OPC DA protocol
 - MODBUS TCP protocol



Figure 50: SW Interface at DER-TF

3. Services Offered by the Research Infrastructure

In the Distributed Energy Resources Test Facility of RSE, the architecture and management system of the microgrid and the specific features of the described infrastructure provide the following services (but not limited to):

- Development, optimization and testing of **smart grid operation and control algorithms**.
- **On grid and off grid** (islanded) AC microgrid testing
- **DC microgrid** testing (including management and control algorithms)
- Characterisation and testing of **Generators and Storage** systems
- Innovative **instrumentation and component** testing
- **AC/DC converters** testing grid connected and in **islanding** operation
- **Mgt. of EV charging station:** testing of charging control and management algorithms
- **Domotical House management:** testing of management and control strategies

4. Brief Description of the Organization Managing the Research Infrastructure

RSE (Ricerca sul Sistema Energetico) SpA (www.rse-web.it) is a Non-profit Research Organization established to take over funded research activities of national and international. About 350 technicians and researchers – and their main laboratories – carry out strategic research in the electricity and energy sector, with strong emphasis on experimental applications. The mission is to perform public interest R&D programs to address the national energy, environmental and economic goals, with an open view to the EU research initiatives. RSE SpA is currently 100% owned by GSE, “Gestore Servizi Energetici” SpA, a public company entirely owned by the Italian Government.

Competencies: On the basis of three-year Implementing Agreements for the research activities on the electric system with the Ministry of the Economic Development (MiSE), RSE SpA is mainly financed through a public fund related to the national electric system. RSE is currently cooperating in more than 60 international research projects and coordinates as leading partner more than 150 main research centres and companies in the energy field in Europe. RSE is moreover actively involved in supporting the Ministry of Economic Development with the aim of implementing the EU SET-Plan.

RSE is active in several international network and technology platforms as the European Industrial Initiatives on Electricity Grids (EEGI, GRID+ coordinator) and Wind Energy (EEWI), the Joint Programme of the European Energy Research Alliance (EERA) on Smart Grids (as JP Coordinator) and Storage, and Implementing Agreements of the International Energy Agency (ISGAN Chairman and ISGAN/SIRFN member). It is also active in the CEN-CENELEC-ETSI Smart Grid Coordination Group and in several IEC and CIGRÉ working groups. RSE has a noticeable experience in research and experiments on Smart Grids, DER characterization and integration in distribution networks. Among the others, RSE has coordinated the I3 project DERri, under the EC Research Infrastructures programme.

The RSE DER-TF (managed and operated by the Power Generation Technologies and Materials Department) is an infrastructure available for all RSE researchers in order to develop and test Smart Grid and Microgrid concepts including management and control optimization, advanced

power system architectures, DER and storages integration, electric mobility. In addition RSE DER-TF is used by several industries (in the aim of cooperation agreements) in order to develop and test with RSE new components and smart grid management and control functions.

5. Trans-national Access Conditions Offered by RSE

All the offered experimental systems included in the RSE DER-TF are located in the RSE premises in Milan, Italy – Via Rubattino, 54.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be operatively carried out by the staff of RSE closely supporting the external team of users. For **the rest of applications**, and previous ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of RSE's researchers and laboratory technicians when necessary). RSE may decide, for organizational or safety reasons, to limit the access in particular circumstances.

The stay of the users will be regulated by a specific User Team Contract, signed in advance by the Team reference person that will contain in detail of the access conditions agreed for the specific project. A template of the contract model will be provided by RSE to the Team of Users long before the stay at the infrastructure.

The **scheduling of the experiments** will be agreed and scheduled prior to the stay according to the organization planning of RSE and the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) and related procedures will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to RSE's infrastructure, the access being offered includes supervision and help of RSE's staff:

- **Introductory actions:** An RSE Senior Engineer will be dedicated to the Team of Users, being the reference for all aspects related to their stay in RSE. As a complement to the pre-access contacts between the user group and RSE, the stay will start with an introductory meeting with the dedicated senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- **Preparatory work:** A laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests and compatibly with the organization and requirements of the testing infrastructure, and programming of the experimental conditions.
- **Testing implementation:** RSE's researchers will support the realisation and follow-up of the experiments and supervise the execution of the tests.
- **Post-testing support:** RSE's researchers will support the results interpretation, data processing and analysis, and test report preparation.

In principle, a typical stay of 2 weeks is foreseen for a single users group. However, depending on the specific project and on its implementation, an extension of the stay period, or a break of the stay in following phases, whenever convenient, may be agreed before or during the execution of the project.

The user group (usually 2 persons) can use the infrastructure limitedly to the agreed time. The users will be requested to declare their use of the infrastructure by signing in an RSE form at the end of their stay basing on the final balance.

Reimbursement of Expenses:

User's live expenses for the TA are paid by ERIGrid (EU H2020 Programme). RSE will:

- a) Provide for the lunches of the User, during the working days in RSE's canteen
- b) Reimburse travel expenditures of each User (one only return ticket per User, unless differently agreed for the specific project). RSE requests the User to provide preventive indication of the travel expenses to be incurred and to condition the reimbursement to its preventive approval; travels will be made in economy class.
- c) Reimburse each User with a daily grant of 150 Euros/day as a lump sum covering all expenses for lodging and subsistence during the whole period of stay at the Facility (including working days and holidays).

RSE will basically reimburse the users expenses (as indicated in the previous points b) and c) at the end of the stay basing on the final balance: The user must declare the incurred expenses by signing RSE forms and submit invoices/receipts to RSE in order to get the reimbursement.

6. Contact Details for Research Infrastructure

Distributed Energy Resources Test Facility (DER-TF) - RSE Address: RSE SpA -Via Rubattino 54 – 20134 –Milan (Italy) Website: www.rse-web.it			
<i>For Management/Organization and Technical Issues:</i>			
Maurizio Verga Tel.: +39.2. 3992. 4765 E-mail: maurizio.verga@rse-web.it		Carlo Sandroni Tel.: +39.2. 3992. 5869 E-mail: carlo.sandroni@rse-web.it	

SINTEF Energy Research



1. Research Infrastructure

Name of Infrastructure/Installation	National Smart Grid Laboratory (NSGL)
Location	SINTEF Energy Research - Trondheim, Norway
Web Site	https://www.sintef.no/en/sintef-energy/

2. Description of the Research Infrastructure

The **National Smart Grid Laboratory (NSGL)** is located in Trondheim at the campus of the Norwegian University of Science and Technology (NTNU) and jointly operated by SINTEF and NTNU. The laboratory has been recently refurbished and is under upgrade with state of the art solutions/technologies. The laboratory mainly consists of three platforms: the smart network testing facility, the smart house demonstration and the distributed energy storage infrastructure.

Smart network testing facility: The core of the National Smart Grid Laboratory is the smart network testing facility. The facility can provide a flexible and reconfigurable electrical layout for conducting experiments at low voltage levels (e.g. 400 V AC or 800 V DC). The electrical system can be configured to represent a distribution or transmission grid with high penetration of renewable units including storage units and power electronics converters.

The laboratory is equipped to perform real time simulations of electrical systems and their controls. Three OPAL-RT units are available for parallel simulation. This enables the possibility of testing control algorithms or schemes with rapid prototyping techniques. More advanced features are the Hardware in the loop (HIL) and the Power Hardware in the loop (P-HIL) based on the OPAL-RT platform and a high bandwidth, six-leg configurable power converter (200 kW) acting as a power interface.

The following components are available in the laboratory:

- Over 250 m2 of laboratory space and possibility of running multiple experiments in parallel
- OPAL-RT units with cumulatively 10 cores activated
- 200 kW high-bandwidth power converter operating as a grid emulator (5 kHz large signal bandwidth and 20 kHz small signal bandwidth)
- Several 20 kW and 60 kW two level converter units
- 50 kW generator-motor based on induction machine
- 20 kW synchronous generator with a synchronization panel as in small hydro plants
- A network equivalent for distribution grids with configurable line impedance and resistance

The network facility is suitable for a range of purposes like:

- Testing equipment and concepts for continuous stand-alone operation as a microgrid in remote/isolated areas (i.e. new grids to be started in developing countries, islands, remote settlements etc.).
- Testing connection of independent (household) microgrids as a bottom-up approach for establishing a local, expandable power system for developing regions without an existing transmission network.
- Testing advanced Smart Grid technology for short-term management and islanded (microgrid) operation in future smart distributions systems.



Figure 51: Smart network testing facility at SINTEF (Trondheim, Norway)

Smart house demonstration: The smart house replicates a domestic environment with real appliances but under controlled conditions. The Smart House laboratory can be used to demonstrate and visualise new concepts for active load control, to test and supervise human behaviour and to test new technological solutions. They will be highly relevant for smart grids (e.g. smart meters, sensors, communication systems, interfaces and protocols, display systems, control systems, smart appliances, small scale DG, small-scale distributed energy storage, charging of electric vehicles, decision support systems).

EV charging and distributed energy storage infrastructure: The main elements of the lab are:

- A test system for energy storage systems ("battery tester")
- Energy storage batteries and supercapacitors
- Distributed electricity production with PV
- Emulated systems
- A physical façade integrated system
- A novel, complete system for smart energy storage developed by a commercial actor
- A climate chamber



Figure 52: EV charging infrastructure at SINTEF

Laboratory concept:

<i>Real time simulated power systems and controls (RTSPC)</i>	<i>200 kVA power supply interface Integrating RTSPC and PPSC</i>	<i>Physical power systems and controls (PPSC)</i>	<i>Smart home / smart Building</i>	<i>Control centre (s)</i>
			<i>Energy storage PV, EV</i>	
<i>Measurements infrastructure</i>				
<i>Communication infrastructure</i>				
<i>Data access (remote real time access, database access)</i>				

Figure 53: NSGL concept at SINTEF

3. Services Offered by the Research Infrastructure

The National Smart Grid laboratory supports:



Figure 54: NSGL equipment at SINTEF

- Smart transmission grids
- HVDC grids
- Smart active distribution grids
- Micro grids
- Integration of Smart grids, smart houses and smart industries
- Integration of renewables (large scale, DG)
- Smart Grid and home automation
- Smart electricity use
- Electrification of transport
- Energy storage in Smart Grids
- Energy conversion in Smart Grids
- Power system stability in Smart Grids
- Monitoring, control & automation in Smart Grids
- Communication technologies for Smart grids
- Information security and privacy in Smart grids
- Reliability challenges in Smart Grids – dependencies of Power Grid and ICT
- Smart grid software
- Big data management & analytics in Smart Grids

4. Brief Description of the Organization Managing the Research Infrastructure

SINTEF Energy Research has completed and participated in many national and trans-national projects dealing with research related to energy systems. This involves e.g. market studies, energy system modelling and simulation as well as the small and large-scale integration of renewable energy systems into the grid. The department is also responsible for research and development of several market simulation and hydrothermal scheduling models that are used by almost all of the Scandinavian market players, TSOs and the Norwegian regulator. A special part of this is the work with smart grids, channelled in the group of Active Grids. The group has a long experience with power quality and reliability measurement and management, end-user characterisation, and active use of new communication technology and innovative market solutions.

SINTEF Energy Research is developing solutions and systems in the fields of power production, conversion, transmission and distribution, and the efficient end use of energy. A substantial part of the institutes R&D and demo activities are within the electrical power engineering domain. By January 2014, SINTEF Energy Research had a staff of approx. 240 persons. In cooperation with Norwegian University of Science and Technology (NTNU), we have 7000 m2 of modern laboratories available for research, development and education. In 2012, the Company participated in 25 EU projects and coordinated three of them. In addition, we actively participate in a number of the EU's technology platforms, which design the strategies related to our various disciplinary areas.

The main tasks of SINTEF Energy Research within ERIGrid includes holistic system integration, implementation and demonstration of use cases/scenarios. Also, provisioning of the National Smart Grid Laboratory for Trans-national Access (TA).

5. Trans-national Access Conditions Offered by SINTEF

The National Smart Grid Laboratory is located at Sem Sælands vei 11, Trondheim, Norway.

For safety reasons, for critical applications, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of SINTEF. For the rest of applications and after ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of SINTEF's researchers and laboratory technicians when necessary). The scheduling of the experiments will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (internet connection, canteen, etc.) and the support and advice on accommodation and transportation to SINTEF's infrastructure, the access being offered includes supervision and help of SINTEF's staff:

- As a complement to the pre-access contacts between the user group and SINTEF, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) based on the users requests, and programming of the experimental conditions.
- The guest researcher will be placed within the building of SINTEF Energy Research and gets access to the lab facilities.
- SINTEF's researchers will support the realisation and follow-up of the experiments.
- SINTEF's researchers will support the results interpretation, data processing and analysis, and test report preparation

In principle, a typical stay of 1 month is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group (usually 2 persons) can use the infrastructure for the defined time.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to NSGL (SINTEF Energy Research) by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in NSGL, SINTEF will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to SINTEF in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy 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.

6. Contact Details for Research Infrastructure

National Smart Grid Laboratory (NSGL) – SINTEF Energy Research Address: SINTEF - Sem Sælands vei 11, 7034, Trondheim, Norway Website: https://www.sintef.no/en/sintef-energy/	
For Management/Organization Issues:	For Technical issues:

<p>Boye A. Høverstad</p> <p>Tel.: +4795154202</p> <p>E-mail: boy.e.a.hoverstad@sintef.no</p>		<p>Kjell Ljøkelsoy</p> <p>Tel.: +4790194173</p> <p>E-mail: Kjell.Ljokelsoy@sintef.no</p>	
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TECNALIA Research & Innovation



1. Research Infrastructure

Name of Infrastructure/Installation	Smart Grid Technologies Laboratory (SGTL)
Location	TECNALIA - Derio, Bilbao, Spain
Web Site	www.tecnalia.com

2. Description of the Research Infrastructure

The core of the **Smart Grid Technologies Laboratory (SGTL)** is a low voltage three-phase microgrid formed by different generation and storage devices and several loads, with a manageable power of around 200 kVA. Main elements of the microgrid are: generators (PV, diesel, wind turbine, etc.), network simulators, storage devices (flywheel, battery banks, ultracapacitor-based UPS, etc.), loads (resistive, inductive, capacitive, electronic loads), and power converters; a microgrid management system controls the operation of the infrastructure to run according to certain strategy, physically connects/disconnects the elements, and changes the microgrid topology, by means of a switching cabinet. The facility allows the research and development on the connection, integration and validation of DER technologies, assessment of the impact on the network, and the investigation on operation and control strategies of the entire microgrid.



Figure 55: Microgrid of the Smart Grid Technologies Laboratory at TECNALIA (Derio, Spain)

In addition, integrated in the microgrid there are three special platforms to reinforce the capabilities in the specific fields of high power electronics, electrical vehicle, and smart metering:

- **High power multilevel converter for tests (THOR):** medium voltage neutral-point-clamped converter with a modular design. Each individual converter module has a nominal power of 1.25 MW. Up to 4 modules can be parallel connected to achieve a nominal power of 5 MW. It has a programmable output with a range in AC up to 3300 VAC (20 to 70 Hz) and in DC: up to 5000 V. THOR has been designed promoting the flexibility, thus facilitating the use of this drive in different functionalities such as fully programmable voltage source, grid emulator or current source.
- **Electrical Vehicle platform (EV-ON):** system for algorithms development and simulation of electric vehicles connected to the electricity network. The system is formed by a bi-directional inverter, a grid analyzer, a smart meter, battery storage and PLC/GPRS communications.

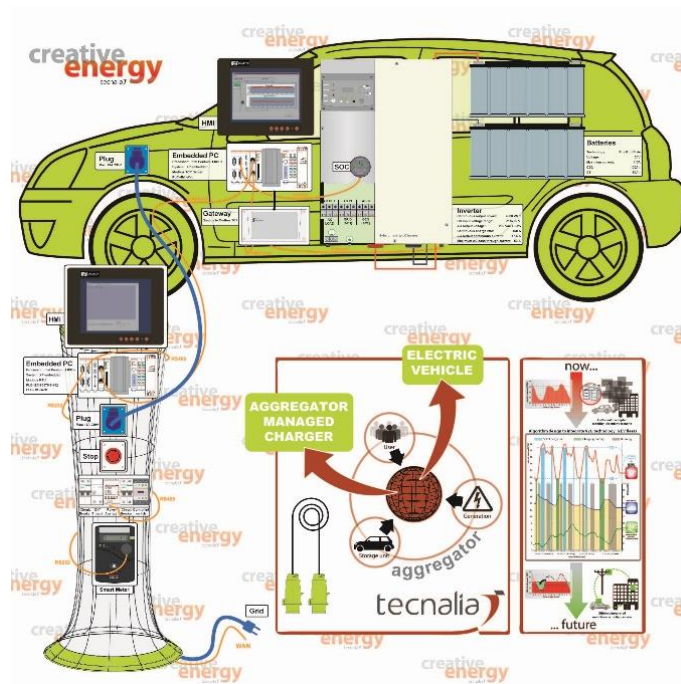


Figure 56: Electrical Vehicle platform at TECNALIA

- Smart Metering communication platform:** system for research and certification of smart metering communication protocols especially focused on power line communication (PLC) technologies. The entire communication stack is covered, from low layers (like PRIME) to application layers and data model (like DLMS/COSEM). A fully configurable installation reproduces the last mile of distribution network, from the secondary transformer to the meter cabinets. This system allows to change the length and type of the electrical lines, the network topology, the number and type of meters, the network loads, and the network noise and attenuation, in such a way that not only individual meters can be tested (so-called “conformance”) but also entire meter systems (so-called “performance”).



Figure 57: Smart Metering communication platform at TECNALIA

3. Services Offered by the Research Infrastructure

In the Smart Grid Technologies Laboratory of TECNALIA, the architecture and management system of the microgrid and the singular features of the mentioned platforms provide the following services (but not limited to):



Figure 58: Experimental set-up in the LV microgrid of TECNALIA

- Development, optimization and testing of **smart grid operation and control algorithms**.
- Analysis of **grid connected inverters**, behaviour in **islanding** situation and potential for **contribution to grid stability**.
- Management of electric vehicles connected to the grid: design and implementation of algorithms to manage the battery according to price signals and user criteria; **charging optimization and V2G strategies** in complex network scenarios associated to massive deployment.
- Individual **conformance testing of smart meters** and evaluation of the **performance of entire smart meter systems** under different network configurations (different length and type of the electrical lines, network topology, number and type of meters, network loads, network noise and attenuation).
- Implementation of algorithms to fit a **DC source** in order to behave like a renewable resource.
- Characterization and testing of **AC/AC or DC/AC converters**, active filters, STATCOMs, energy storage systems, etc.

4. Brief Description of the Organization Managing the Research Infrastructure

TECNALIA Research & Innovation is the first privately funded Applied Research and Technological Development Centre in Spain and one of the leading ones in Europe, with a staff of 1400 experts (including 200 Doctors). TECNALIA's offer includes different activities: technological services, testing and certification, R&D&I projects, transfer of industrial property, business promotion, business diversification, innovation management and foreign support. TECNALIA covers a broad range of sectors, and it is organized in 6 Business Divisions: Sustainable Construction, Energy and Environment, Industry and Transport, ICT-European Software Institute, Health, and Technological Services.

The Smart Grids Area (in the Energy and Environment Division) is focused on advanced power system architectures, integration of distributed energy resources (DER) in the network, demand side management, electric mobility, communications for smart grids and smart metering applications.

TECNALIA is very active in national and international platforms and networks relevant for ERIGrid, (EERA, ISGAN-SIRFN, EUREC, FUTURED, etc.), contributing to the development of common visions, roadmaps and strategies for the energy sector and having an excellent perspective and vision of the future challenges. This networking structure is complemented by a large experience in national and international research projects on decentralised energy and smart grids. In addition to the SGTL infrastructure offered in ERIGrid, TECNALIA has a high power laboratory, a high voltage laboratory and a low voltage laboratory for equipment testing, being an accredited laboratory according to EN ISO/IEC 17025 for many testing activities.

5. Trans-national Access Conditions Offered by TECNALIA

All the offered experimental systems included in the SGTL are in the same building in Derio, near Bilbao, Spain.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of TECNALIA. For **the rest of applications** and after ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of TECNALIA's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will

be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to TECNALIA's infrastructure, the access being offered includes supervision and help of TECNALIA's staff:

- As a complement to the pre-access contacts between the user group and TECNALIA, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- TECNALIA's researchers will support the realisation and follow-up of the experiments.
- TECNALIA's researchers will support the results interpretation, data processing and analysis, and test report preparation

In principle, a typical stay of 1 month is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group (usually 2 persons) can use the infrastructure for the defined time.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to SGTL (TECNALIA) by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in SGTL, TECNALIA will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to TECNALIA in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy 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 TECNALIA's canteen free to the user.

6. Contact Details for Research Infrastructure

Smart Grid Technologies Laboratory (SGTL) - TECNALIA			
Address: Parque Tecnológico de Bizkaia. C/ Geldo, Edificio 700 – 48160 Derio, Spain			
Website: www.tecnalia.com			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Emilio Rodríguez Tel.: +34 667 119788 E-mail: jemilio.rodriquez@tecnalia.com		Julia Merino Tel.: +34 664 116639 E-mail: julia.merino@tecnalia.com	

DELFT UNIVERSITY OF TECHNOLOGY



1. Research Infrastructure

Name of Infrastructure/Installation	Real Time Digital Simulator Lab (RTDS)
Location	TU Delft- Delft, The Netherlands
Web Site	http://www.tudelft.nl/en/

2. Description of the Research Infrastructure

The RTDS installation at TU Delft consists of 8 racks with 10 PB5 and 36 3PC cards, capable of simulating grids in 2 μ s and 50 μ s step size. Additionally the racks have analogue/digital I/O, remote I/O, two GTNetx2, and one GTSync card. The RTDS Simulator allows to test protection and controls in real time, where an hour in the real world equals an hour in the simulator. Utilizing modular custom computing hardware and software, simulations performed encompass results from DC up to electromagnetic transients. Inherently, these results include information regarding the system load flow and transient stability, as well as that of harmonics and faster disturbances.



Figure 59: Real Time Digital Simulator Laboratory at TUDelft (Delft, The Netherlands)

3. Services Offered by the Research Infrastructure

The major applications of the RTDS include:

- Equipment can be thoroughly test-driven and customized.
- New power system network designs or upgrades can be evaluated and accurately tested.
- Black box real-world equipment (e.g. closed-source controllers) can be tested and integrated in larger test scenarios without having a model.

- Interoperability of multi-vendor installation can be validated.
- Models and real implementations (products) of components can be compared.
- Closed-loop testing of protective relays and control systems.
- Studying general AC system operation including behavior of generation and transmission systems.
- Investigating dynamic power system equipment interaction.
- Studying interaction between integrated AC/DC systems.
- Integration and operation of distributed generation and renewables.
- Investigation and testing of SMART Grid initiatives including wide area protection and control.
- Testing of control system of converter based equipment.

4. Brief Description of the Organization Managing the Research Infrastructure

Technische Universiteit Delft (TU Delft) is the largest and oldest Dutch public technological university, located in Delft, Netherlands. It has eight faculties and numerous research institutes. It hosts over 19,000 students (undergraduate and postgraduate), more than 3,300 scientists, and more than 2,200 support and management staff.

The RTDS facility is within the **Intelligent Electrical Power Grid (IEPG)** group of the **Electrical Sustainable Energy (ESE)** department.

The field of the Intelligent Electrical Power Grids research program covers the generation, transmission and distribution of electrical energy, and a characteristic is the system-oriented approach. Our research program covers the three different time scales for which power systems are usually studied: transient, dynamic and steady state behaviour of power systems. The area of this research program is concerned with the technical, economical and societal performance of the electricity supply system. Theoretical and technological limits of current and future power systems and components are investigated taking into account the changing operating environment, e.g. the large-scale introduction of renewable and distributed energy sources and the application of new and sustainable technologies.

5. Trans-national Access Conditions Offered by TU Delft

The conditions of the TA offered by TU Delft are:

- Half of the rack must stay free for our other projects.
- Maximum 6 people are allowed.
- Guests have to sign a hospitality declaration for the stay at TU Delft.

Reimbursement of expenses:

Travel expenses for TA are paid by the EU H2020 project ERIGrid. Dedicated project budget is reserved for the hosting institution to cover travel and staying expenses for TA guests. Travel and stay is expected to be based on the most economical options.




6. Contact Details for Research Infrastructure

Real Time Digital Simulator Laboratory

Address: TU Delft, EEMCS Building, Intelligent Power Electrical Grids

Room LB 03.260, Mekelweg 4, 2628CD Delft, The Netherlands

Website: www.tudelft.nl/en/

<i>Contact Persons:</i>			
Peter Palensky Tel.: +31 15 27 88341 E-mail: P.Palensky@tudelft.nl		Arjen van der Meer Tel.: +31 15 27 88007 E-mail: A.A.vanderMeer@tudelft.nl	
Rishabh Bhandia Tel.: +31 15 27 83223 E-mail: R. Bhandia@tudelft.nl			

Distribution Network and Protection (D-NAP) Laboratory

University of Strathclyde



1. Research Infrastructure

Name of Infrastructure/Installation	Distribution Network and Protection (D-NAP) Laboratory
Location	Glasgow, United Kingdom
Web Site	https://www.strath.ac.uk/research/subjects/electroniclectricalengineering/instituteforenergyampenvironment/advancedelectricalsystems/

2. Description of the Research Infrastructure

Housed in a £90 M state of the art research and knowledge exchange environment, the laboratory contains a reconfigurable 400 V three-phase AC power network with multiple controllable voltage supplies and loads with flexible control systems and interfaces. The laboratory has power hardware-in-the-loop (PHIL) and controller hardware-in-the-loop (CHIL) capabilities. The network and devices are used to test and demonstrate smart grid technologies within a controlled environment, and under steady-state and abnormal conditions. Typical areas of research include: distributed control, future power systems with high penetrations of converters, control and communications integration, islanded (and auto-islanding) power systems, and dynamic power systems (e.g., marine/emergency).

There are four modes of operation of this facility: power hardware in the loop simulation; pre-set scenario playback; direct grid connection; and islanded system operation. The laboratory network is designed such that it can be split into three separate power islands under independent control, or connected together as an interconnected system. This provides a high degree of flexibility enabling many different land-based or marine scenarios to be demonstrated.





Figure 60: D-NAP Laboratory at the University of Strathclyde (Glasgow, United Kingdom)

The power network facilities are complemented with extensive real-time power system simulation capabilities enabling augmentation of the hardware network with simulated systems, which thereby representing large power networks. Simulated systems can be linked with real substation equipment – such as measurement devices, protection relays, and communications routers – to authentically and systematically validate prototype smart grid solutions. Specific technologies underpinning the infrastructure include: real-time communications emulation, precision time-synchronisation, phasor measurement units (PMUs), and state-of-the-art protocols for data communications.

The laboratory infrastructure has been mapped into the Smart Grid Architecture Model (SGAM) for facilitating the integration of devices and use cases under test. This allows for fast prototype development and minimises possible incompatibilities or integration issues.

In order to achieve accelerated testing, the RI is underpinned by the following main systems:

Power Converters and Controllable Loads

A 90 kVA back-to-back, fully-controllable converter is one of the main assets of the laboratory. It allows the performance of experiments grid-connected or islanded from the grid thereby creating an island of >90 kVA. Two other power converter units of 15 kVA and 10 kVA are available that can be controlled as emulated loads or as different types of generators; these devices could also be used to form smaller islanded systems. A 50 kVA and 2 x 12.5 kVA controllable loads are also available. Induction machines, which can be operated as motors or generators, provide inertia and controllable torque. This provides a controllable and repeatable environment for systems tests, to deploy and validate new microgrid control algorithms.



Figure 61: Power converters and controllable loads at D-NAP Lab

Two-rack RTDS system

The Real-Time Digital Simulator (RTDS) allows large power networks to be simulated at a resolution of 50 μ s or smaller. The laboratory has an up to date two-rack RTDS with a range of I/O capabilities including hard-wired analogue and digital I/O, DNP3, PMU, and IEC 61850 Sampled Values and GOOSE communications. A number of grid and marine system models have been created for validating on- and off-shore networks, renewable generation, and network automation. Such infrastructure has been used to test protection and control schemes under a large number of scenarios and to inform standard settings.



Figure 62: RTDS system at D-NAP Lab

Distributed High Accuracy, Fast Data Acquisition System

High accuracy instantaneous LV voltage and current measurements can be collected at a rate of up to 10 kHz using a distributed data acquisition system. The sampling uses an absolute time reference with resolution of <100 ns. The system is modular, so additional measurement points and processing nodes can be added where required. Furthermore, the platform can also be used to deploy control functions where control functionality can be distributed at the measurement nodes. For example, multiple PMUs or IEC 61850 IEDs – supporting standardised communications protocols – can be readily deployed for monitoring and control.

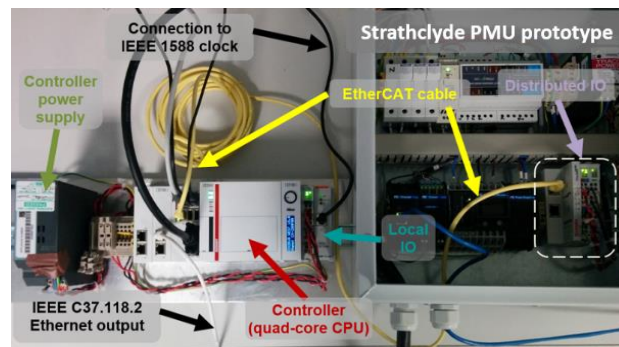


Figure 63: Acquisition system at D-NAP Laboratory

RTS and RTX Units

Two real-time simulators from Applied Dynamics International allow smart grid scenarios to be enacted within the laboratory, with capability for real-time data monitoring and control. The two real-time units can be used in conjunction with RTDS for high fidelity multi-rate co-simulations.



Figure 64: RTS and RTX units at D-NAP Laboratory

Communications Validation and Emulation

The laboratory has the capability to mimic modern utility communications network infrastructure using four Nokia (formerly Alcatel-Lucent) 7705 IP/MPLS routers, including tele-protection and Ethernet interface cards. The use of custom embedded platforms and ns3 servers allows extended communications networks to be emulated in real-time.



Figure 65: Communication emulation equipment at D-NAP Laboratory

The RI is supported by a number of neighbouring facilities including a DC Power System Laboratory, a Demand-Side Management Laboratory, HV Test Cells, and an Electrical and Mechanical Workshop.

3. Services Offered by the Research Infrastructure

The dynamic power system laboratory offers a flexible environment to test new components or algorithms on an LV network with a variable frequency and voltage supply. Devices can be attached to the network at a number of points and with voltage and current measurements taken back to a central real-time control platform. Some example services include:

Demonstration and Proof of Concept of New Solutions for Distributed Power System Control

The laboratory is well equipped to not only demonstrate novel distributed solutions for power system (for example, demand side aggregator with highly distributed portfolio providing frequency balancing ancillary service) but to rigorously test and evaluate these novel solutions. Therefore, novel prototypes can be de-risked before their adoption and deployment in industry. The various modes of operation of the laboratory provide the flexibility to represent a wide variety of smart grid configurations and scenarios.

Hardware in the Loop Testing of Control, Protection, and Automation Equipment

Using hardware in the loop testing, all primary power system equipment and assets are simulated, in real-time. It is possible to simulate arbitrary electrical networks and all the extremes of operation, including stable conditions and many different fault scenarios, such as systematically testing a range of different fault locations. However, the simulation is linked to the real commercial hardware devices under test, such as protection relays, PMUs, and communications equipment. The response of the hardware can be monitored and thereby validated. In this way, new schemes can be validated, adaptive features thoroughly tested, and new settings or operating guides resolved.

Novel Inverter Control Testing

The three-phase programmable back-to-back converters allow novel inverter controls to be tested and validated in realistic conditions. For example, a 10 kW programmable DC power supply can be used to emulate a solar PV array as the input to an inverter. The inverter under test can then be subjected to different load and fault conditions while measuring its outputs, including harmonics.

As part of a technological university and a strong research centre, the RI benefits from the close proximity to a large number of expert researchers in electrical technologies, modelling, simulation, and experimental validation.

4. Brief Description of the Organization Managing the Research Infrastructure

The Institute for Energy and Environment (InstEE) represents one of Europe's largest power systems and energy technology university research groups. Comprising 32 members of academic staff, over 200 research staff and students, and 18 technical and administrative colleagues, the Institute has four main research groups: Advanced Electrical Systems, High Voltage Technology, Power Electronics Drives and Energy Conversion, Wind Energy and Control. This is complemented by the Power Networks Demonstration Centre (PNDC) which hosts a fully operational HV and LV demonstration network and dedicated team of research, technical and support staff. PNDC accelerates grid-ready validation at a larger scale and higher voltage level than is possible than at the D-NAP facility.



Figure 66: D-NAP facility

The D-NAP Dynamic Power Systems Laboratory is based in the state-of-the-art Technology and Innovation Centre (TIC) within the University of Strathclyde. This facility, opened in July 2015, houses much of Strathclyde's industry-facing research work. There are 45 bespoke, state of the art laboratories across key research themes of energy, health, manufacturing, and future cities – which support innovation and research demonstration. The TIC also has extensive conferencing and meeting facilities.

5. Trans-national Access conditions offered by Dynamic Power Systems Laboratory – University of Strathclyde

Induction and Safety:

Induction material is available for allowing access to the building and laboratory facilities.

For **safety reasons**, any **work involving live equipment**, is not to be operated by the users themselves; experimental tests will be carried out by Strathclyde technical and research staff. Access to simulators, or other preparatory work not involving live equipment, will be granted, provided necessary reservations have been made in advance by the users by using Strathclyde's online equipment reservation platform. The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

The access being offered includes supervision and help of Strathclyde staff:







- As a complement to the pre-access contacts between the user group and Strathclyde, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users' requests, and programming of the experimental conditions.
- Strathclyde researchers will support the realisation and follow-up of the experiments.

- Strathclyde researchers will support the results interpretation, data processing and analysis, and test report preparation.
- It is expected that the work undertaken at the RI is disseminated. Previous collaborative visits to the RI have resulted in reputable journal and conference publications.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to Strathclyde by plane (economy), accommodation, daily subsistence, and daily transportation during the stay.

6. Contact Details for Research Infrastructure

Dynamic Power Systems Laboratory – University of Strathclyde Address: 99 George Street, Glasgow, G1 1RD, United Kingdom Website: https://www.strath.ac.uk/research/subjects/electricelectricalengineering/instituteenergyenvironment/advancedelectricalsystems/			
<i>For Management/Organization Issues:</i>			
Graeme Burt Tel.: +44 (0)1415482990 E-mail: graeme.burt@strath.ac.uk		Andrew Roscoe Tel.: +44 (0)1415482715 E-mail: andrew.j.roscoe@strath.ac.uk	
<i>For Technical Issues:</i>			
Steven Blair Tel.: +44 (0)1414447279 E-mail: steven.m.blair@strath.ac.uk Expertise: Power system protection, measurements, time synchronisation, and communications		Efren Guillo-Sansano Tel.: +44 (0)1414447280 E-mail: efren.guillo-sansano@strath.ac.uk Expertise: Converter control, power quality, PHIL and CHIL.	
Mazheruddin Syed Tel.: +44 (0)1414447279 E-mail: mazheruddin.syed@strath.ac.uk Expertise: Demand side management, distributed control, PHIL, and CHIL.		Abdullah Emhemed Tel.: +44 (0)1414447274 E-mail: abdullah.emhemed@strath.ac.uk Expertise: LVDC, DC protection, grid modelling, and wind power systems	

Power Networks Demonstration Centre



1. Research Infrastructure

Name of Infrastructure/Installation	Power Networks Demonstration Centre (PNDC)
Location	Glasgow, United Kingdom
Web Site	http://pndc.co.uk/

2. Description of the Research Infrastructure

The demonstration network provides a flexible arrangement of the primary and secondary equipment that is required to represent typical rural, urban and suburban networks in the UK (11 kV and 400 V). The network can be supplied either directly from the grid or using a 5 MVA motor-generator set to allow both voltage and frequency variances to be evaluated.

The network itself is built using a mixture of cables and overhead sections. Variable lumped impedance equivalents are used to provide a more dispersed network – within the footprint available. A primary substation replica allows for voltage control via on-load tap changers and automated ring main units; these are used throughout the network. The network has fibre-optic communications throughout, as well as easily accessible connection points to allow quick changeover between communications systems.

The capability to apply resistive balanced and unbalanced faults at both voltage levels is also present.



*Figure 67: PNDC facility
(Glasgow, United Kingdom)*



Figure 68: PNDC equipment

In addition to the standard operator instructions through the SCADA system, references for the grid interface controls can be supplied from recorded profiles through a real-time digital simulation platform. This allows for the examination of the wider impacts of operational strategies and technologies beyond the section of network physically constructed. There is also a high-speed measurement and data-logging system installed in parallel to the SCADA in order to provide better granularity and further understanding of system behaviour.

In order to achieve accelerated testing, the RI is underpinned by the following main systems:

5MVA Motor-Generator Set and 600kVA Controllable Load Banks

Power to the test network can be typically supplied from a 5MVA motor-generator (MG) set. This allows for voltage and frequency control of the network independent of the public grid supply. The MG set can be controlled either through SCADA or through an interface with the centre's RTDS. 600kVA, 0.8pf lag worth of load is dispersed throughout the network and is controllable to obtain the desired load profile over a period of time.

6-rack RTDS system

The centre has an up to date 6-rack RTDS with a range of I/O capabilities including hard-wired analogue and digital I/O, DNP3 and IEC 61850 SV & GOOSE communications.

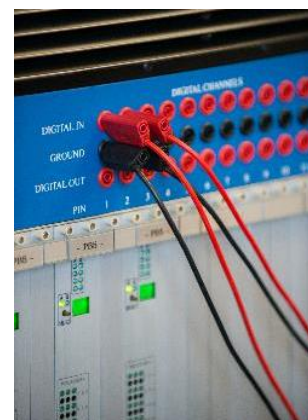


Figure 69: PNDC equipment

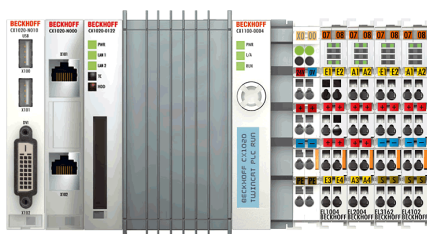


Figure 70: Fast data acquisition system at PNDC

Distributed High Accuracy, Fast Data Acquisition System

High accuracy instantaneous MV and LV voltage and current measurements can be collected at rate of up to 10kHz (samples are synchronised globally) using a distributed data acquisition system. The system is modular, so additional measurement nodes can be added where required. Furthermore, the platform can also be used to deploy control functions where control commands can be distributed at the measurement nodes.

MV and LV Fault Throwers

Phase to phase and earth resistive MV faults and solid LV faults can be applied to the test network at different locations. These allow the characterisation of the fault response of devices under test. This capability addresses the issue of having to wait for real faults to occur during a field trial of a piece of equipment connected to a real network.

3. Services Offered by the Research Infrastructure

Grid Integration, Characterisation & Functional Testing of Smart Grid Components & Systems

Rigorous functional and performance testing of systems and components connected to MV or LV can be achieved. These undergo a test regime that is agreed beforehand with the user. The test network offers flexibility in the test conditions in terms of currents, voltages, frequency and network topology. SCADA integration can also be achieved over a wide range of industry standard communication protocols.

Hardware in the Loop Testing of Control, Protection, and Automation Equipment

Equipment that is not network ready can be tested using the RTDS in a Hardware-in-the-Loop configuration. The RTDS can also be interfaced to a system under test that is partially connected to the test network. The RTDS offers a rich library of power system and control components.

Inverters Characterisation and Testing

This utilises 10kW programmable DC power supplies with solar array simulation. The inverters can

then be subjected to different load and fault conditions while measuring their outputs including harmonics.

Testing of sensors

MV and LV sensors can be subjected to realistic operating conditions, both steady state and transient. Outputs of the sensors can be integrated through the PNDC SCADA infrastructure and/or the distributed data acquisition system.



Figure 71: PNDC facility (Glasgow, United Kingdom)

4. Brief Description of the Organization Managing the Research Infrastructure

The Institute for Energy and Environment (InstEE) represents one of Europe's largest power systems and energy technology university research groups, comprising 32 members of academic staff, over 200 research staff and students, and 18 technical and administrative colleagues. The PNDC complements the InstEE D-NAP Dynamic Power Systems Laboratory. The PNDC focuses on mid-TRL testing and innovation projects in partnership with industry.

5. Trans-national Access Conditions Offered by PNDC

Induction and Safety:

The users will be inducted to the facility and a risk assessment of the work is expected to be in place at least two weeks prior to the commencement of work.

For **safety reasons**, any **work involving live equipment**, is not to be operated by the users themselves; experimental tests will be carried out by PNDC technical and research staff. Access to simulators, or other preparatory work not involving live equipment, will be granted, provided necessary reservations have been made in advance by the users by consulting with the PNDC project lead. The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

The access being offered includes supervision and help of PNDC staff:



- As a complement to the pre-access contacts between the user group and PNDC, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users' requests, and programming of the experimental conditions.

- PNDC researchers will support the realisation and follow-up of the experiments.
- PNDC researchers will support the results interpretation, data processing and analysis, and test report preparation.
- It is expected that the work undertaken at the RI is disseminated. Previous collaborative visits to the RI have resulted in reputable journal and conference publications.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to PNDC by plane (economy), accommodation, daily subsistence, and daily transportation during the stay.

6. Contact Details for Research Infrastructure

Power Networks Demonstration Centre (PNDC) – University of Strathclyde Address: 62 Napier Road, Wardpark, Cumbernauld, G68 0EF, United Kingdom Website: http://pndc.co.uk/			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Federico Coffele Tel.: +44 1236617162 E-mail: federico.coffele@strath.ac.uk		Ibrahim Abdulhadi Tel.: +44 1236617176 E-mail: him.f.abdulhadi@strath.ac.uk	

Multipower Laboratory

VTT Technical Research Centre of Finland



1. Research Infrastructure

Name of Infrastructure/Installation	Multipower Laboratory (<i>MP-Espoo</i>)
Location	VTT – Espoo, Finland
Web Site	www.vtt.fi

2. Description of the Research Infrastructure

Multipower Laboratory (*MP-Espoo*) is a national empirical research environment where new technical solutions and products for distributed energy system can be tested in a multifunctional environment. There are several independent testing facilities connected together so that the environment may cover production, control and loading concepts as well as energy storages of different sizes and technologies. Mutipower laboratory facilities have a strong interconnection with fuel testing and development. The environment consists of diesel generators but also PV units, controllable converter drive and controllable loads. Laboratory is equipped with local control system fully implemented with IEC61850 enabling measurements, external connections and controls. Energy storages, especially batteries can be tested widely under different circumstances. The laboratory is also equipped with GPS system enabling synchronization of remote units and related research.



Figure 72: VTT Multipower Laboratory (Espoo, Finland)

There are some specific operation areas that may be interesting for user groups:

- **IEC61850 – related testing:** The laboratory is equipped with latest IEDs from ABB, including a substation automation system based on ABB COM600 substation computer. This combination offers an environment where for instance protection or control solutions based on IEC61850 and for instance GOOSE messaging can be tested. The laboratory is also equipped with GPS

system, enabling time synchronization and for instance wide area monitoring/protection type applications.

- **Communication testing:** The laboratory is currently developed to enable testing with 5G communication. The area on which the laboratory is located is among first 5G pilots. VTT is closely involved in the 5G development and looking to integrate MultiPower laboratory in 5G pilot area.

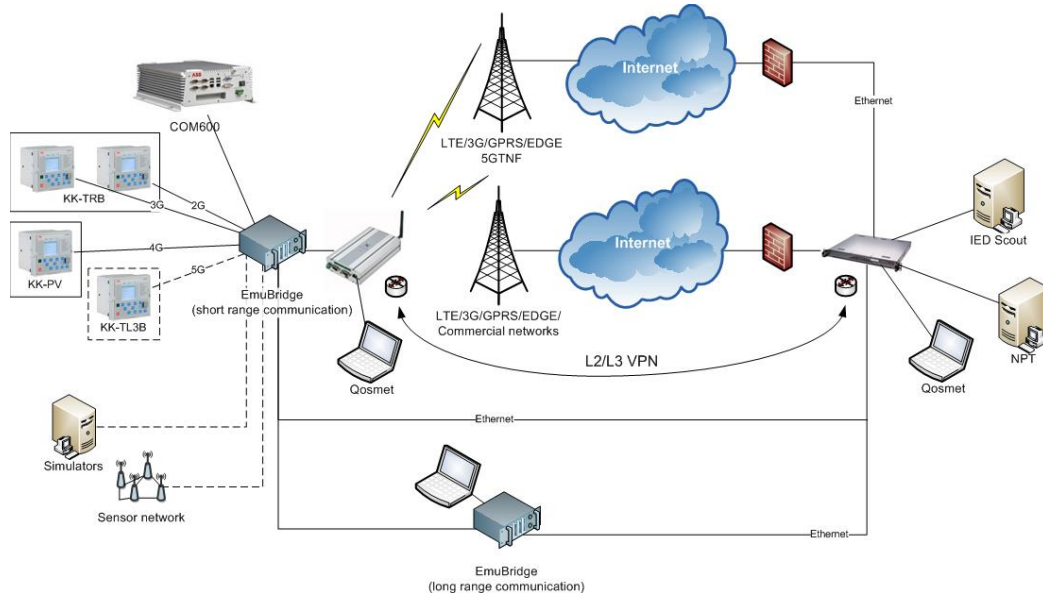


Figure 73: Communication testing architecture at Multipower Laboratory

- **Battery testing:** the laboratory offers good possibilities for testing batteries, ranging from cell level to complete systems. There are climate chambers which can be used. Lifetime testing can be done with flexible testing arrangement. For EV battery purposes, recorded drive cycles can be used to perform tests emulating real driving conditions.

3. Services Offered by the Research Infrastructure

MultiPower offers testing possibilities which cover development, operational acceptance and common tests for the DG products and systems. The platform is flexible and can be adapted for various purposes. Typical testing assignments and possibilities consider:

- DER generation units, fuel optimisation, network interconnection issues with protection and inverter systems
- ICT applications for DER systems, as well as operational optimization
- IEC61850-based distribution automation and devices
- Different malfunctions and faults can be freely realized in the network, and behaviour of the generation, protection and control systems can be identified in actual environment
- Possibility of emulating wind generator with converter drive
- Testing of EV battery packs, modules and cells

4. Brief Description of the Organization Managing the Research Infrastructure

VTT Technical Research Centre of Finland is a non-profit government organisation established by law and operating under the auspices of the Finnish Ministry of Employment and the Economy. VTT is a multi-technological research organisation providing high-end technology solutions and innovation services. VTT has a staff of 2600. Through its international scientific and technology networks, VTT can produce information, upgrade technology knowledge, and create business intel-

ligence and value added for its stakeholders. VTT's activities are focused on three areas: Knowledge intensive products and services, Smart industry and energy systems and Solutions for natural resources and environment. VTT has 70 years of experience in addressing the needs of industry and the knowledge-based society. In the past 20 years, VTT has participated in more than 1000 European R&D Framework Programme projects, within various thematic programmes. VTT has been granted ISO 9001:2000 certificate and ISO 14001 environmental certificate.

Research area "Smart Energy and System Integration" conducts wide research on future energy systems and their integration. We apply a holistic view on different energy carriers and integrate strongly ICT and communication aspect with power system research. VTT is closely involved in international co-operation networks (for instance EERA, DERlab, IEA ISGAN) as well as European research projects (for instance ELECTRA, SmartNet, STORY). VTT also participates in multiple national research programs on the area of smart grids.

5. Trans-national Access Conditions Offered by VTT

The experimental system described is located at Espoo, Finland.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of VTT. For **the rest of applications** and after ad-hoc training, the user group will have access to the related facilities for the duration of the stay (with the support of VTT's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, working space, etc.) and the support and advice on accommodation and transportation to VTT's infrastructure, the access being offered includes supervision and help of VTT's staff:

- As a complement to the pre-access contacts between the user group and VTT, the stay will start with an introductory meeting for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.
- Preparatory work: VTT's staff will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- VTT's researchers will support the realisation and follow-up of the experiments.
- VTT's researchers will support the results interpretation and data processing and analysis

In principle, a typical stay of 2-4 weeks is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group can use the infrastructure for the defined time.

Access to VTT premises requires a personal security clearance procedure, conducted before arrival by local authorities. Without the clearance the users are not allowed to move alone at VTT's premises nor given any access rights.

Reimbursement of Expenses:

User expenses for the TA are paid by ERIGrid (EU H2020 Programme). This includes travels to Espoo by plane, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects, VTT will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to VTT in order to get the refund.

Logistical expenses must be made by the user: travels will be made in economy class and conventional hotels or equivalent accommodation will be used. These costs (travel, accommodation) will be covered and additionally a daily allowance of 40 €/day can be reimbursed, following the Finnish practices.

All reimbursement practices must be checked and agreed on between the user and VTT prior to making any reservations for travelling.

VTT will primarily reimburse the costs to organization (company, university, etc.). Please note that reimbursement of daily allowances to individual person can lead to taxation depending on practices.

6. Contact Details for Research Infrastructure

VTT Technical Research Centre of Finland Address: Vuorimiehentie 3, 02150 Espoo, Finland Website: www.vtt.fi			
<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Kari Mäki Tel.: +358 40 142 9785 E-mail: kari.maki@vtt.fi		Riku Pasonen Tel.: + 358 40 574 8105 E-mail: riku.pasonen@vtt.fi	

Oulu Smart Grid Laboratory

VTT Technical Research Centre of Finland



1. Research Infrastructure

Name of Infrastructure/Installation	Oulu Smart Grid Laboratory (SG-Oulu)
Location	VTT – Oulu, Finland
Web Site	www.vtt.fi

2. Description of the Research Infrastructure

VTT has new Smart Grid laboratory for customer-level research (**Oulu Smart Grid laboratory – SG-Oulu**). This facility consists of PV panels and inverter equipment, wind power unit, storages and EV with charging post. At the same, the laboratory is built as a home environment where household devices can be monitored and controlled intelligently.

Key technical features include:

- Wind mill 5,5 kW installed on top of roof
- Solar energy 7.2 kW
- Mini inverter and two rotating solar panels (250 W, 240)
- Inverter 400V ~3 phase 15 kW
- Energy storage 58 kWh
- EV (Peugeot ION) and charging posts (2) with remote control
- Controllable domestic loads

The laboratory has flexible controllability possibilities:

- Network and consumption control
- HTML5 & CSS3 based control interface
- Programmable user interface for monitoring, control and decision making
- System details from power source, consumption, energy storage etc.
- Decision making tools for selling/buying energy and managing energy consumption
- Dual power network (24V/240V) for internal use (specially for illumination with LED technology)

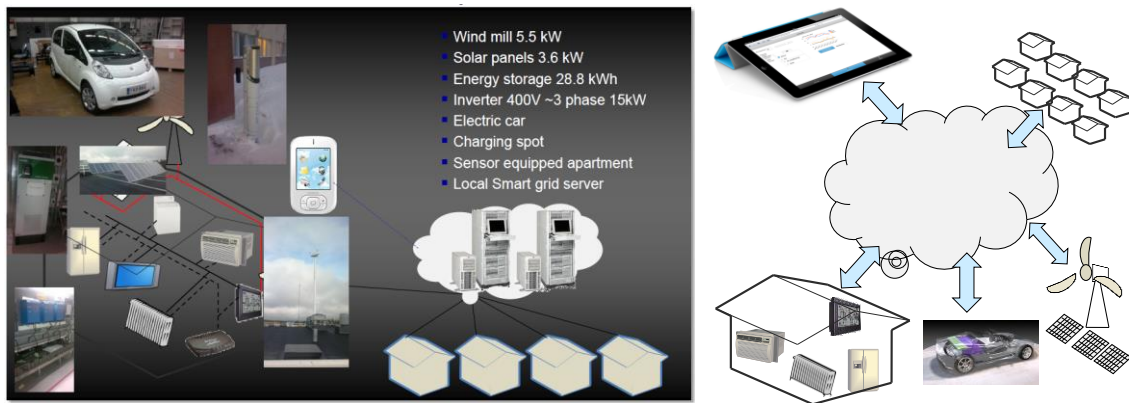


Figure 74: Oulu Smart Grid Laboratory (Oulu, Finland)

3. Services Offered by the Research Infrastructure

Smart Grid lab offers development and testing possibilities for local micro grid systems, load control and use of energy storages. The operation platform enables development of new control systems but also user interfaces. Typical possibilities include:

- Control of EV charging post and V2G integration
- Decision making and intelligence at customer level – optimization on different basis
- Active load control and demand response systems
- Development of PV, wind and storage related control strategies

4. Brief Description of the Organization Managing the Research Infrastructure

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related facilities for the duration of the stay (with the support of VTT's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

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6. Contact Details for Research Infrastructure

VTT Technical Research Centre of Finland

Address: Vuorimiehentie 3, 02150 Espoo, Finland

Website: www.vtt.fi

<i>For Management/Organization Issues:</i>		<i>For Technical issues:</i>	
Kari Mäki Tel.: +358 40 142 9785 E-mail: kari.maki@vtt.fi		Riku Pasonen Tel.: + 358 40 574 8105 E-mail: riku.pasonen@vtt.fi	

5.3 Annex 2: User project Proposal Template

ERIGRID Trans-national Access Application Form

TA Call No.	
Date of Submission	

Proposal resubmitted: ☐ Yes
☐ No

Preferred host Research Infrastructures	1 st option:
	2 nd option:
	3 rd option:
Proposed starting date for the access	
Expected access duration (in weeks)	

USER PROJECT PROPOSAL	
User Project Acronym	
User Project Title	
Main scientific/technical field	
Keywords (5 max., free text)	

LEADER OF THE PROPOSING USER GROUP	
Name	
Phone	
E-mail address	
Phone	
Nationality	
Gender	
Age	
Organization name	
Organization address	
Organization website	
Position in Organization	
Activity type and legal status of Organization ¹	

MEMBERS OF THE PROPOSING USER GROUP (repeat for all Users)	
Name	
Phone	
E-mail address	
Nationality	
Gender	
Age	
Organization name	
Organization address	
Organization website	
Position in Organization	
Activity type and legal status of Organization ¹	

SUMMARY OF PROPOSED RESEARCH (about 1/2 page)

[Prepare a ½ page summary describing the relevance, scope and objectives of the proposed work, and the expected outcomes.]

STATE-OF-THE-ART (about 1 ½ page)

[Describe in brief (about 1½ page) the current knowledge on the subject, citing recent relevant references. Identify any knowledge gaps and their relevance.]

References

[List relevant references.]

DETAILED DESCRIPTION OF PROPOSED PROJECT: OBJECTIVES, EXPECTED OUTCOMES, FUNDAMENTAL SCIENTIFIC/TECHNICAL VALUE (2-3 pages)

[Provide a detailed description of the objectives of the proposed activity, the way these objectives will be fulfilled through the proposed work, as well as indications on the expected outcomes and the fundamental scientific and technical value and interest of the proposal. Specify the activities to be undertaken, the type of TA infrastructure needed, the foreseen test setup, number of tests, possible test sequence, and parameters to be measured and controlled. Describe any special requirements for equipment, standards, safety measures, etc. Point out any shortcomings, uncertainties and risks for the fulfillment of the project objectives, as well as the means to mitigate relevant risks.]

ORIGINALITY, INNOVATION AND IMPACT OF PROPOSED RESEARCH (1-2 pages)

[Demonstrate the originality and innovation of the proposed work and the impact the expected results will have on current and future research or practice, public safety, European standardization, competitiveness, integration and cohesion and on sustainable growth.]

SYNERGY WITH ONGOING RESEARCH (about ½ page)

[Provide information on any concurrent research project with the same or similar subject with the one proposed. Describe the synergy (if any) that will be sought between the existing and the proposed project. Explain the degree of alignment with the ERIGrid approach, scope and objectives]

PROPOSED HOST RESEARCH INFRASTRUCTURE/INSTALLATION – JUSTIFICATION (about 1 page)

[Specify the type of TA infrastructure/installation needed for the research (e.g. microgrid, PHIL platform, etc.), which must be coherent with the preferred options indicated in the first page of this proposal; justifications should be provided on the grounds of the test set-up, testing method, equipment, past experience in relevant subject, etc. Explain whether the proposing User Group intends to deliver to the premises of the TA Infrastructure parts or components to be tested at the User Group's expense and responsibility, or to cover the whole or part of the construction/adaptation cost of the specimens to be tested.]

DISSEMINATION – EXPLOITATION OF RESULTS (about ½ page)

[In addition to the mandatory reporting for the access described in the “ERIGrid TA Procedure and General Rules” document, indicate other means through which the results to be obtained from the proposed project will be diffused and made broadly known.]

TIME SCHEDULE (about ½ page)

[Provide an indicative time-schedule for the proposed work and a target starting date.]

DESCRIPTION OF THE PROPOSING TEAM (as long as needed)

[Give a short description of each member (organization and persons) of the proposing team including projects, publications, technical experience and capabilities and role in the proposed project.]

¹ Choose from:

- Higher education institution
- Public research organization
- Private not-for-profit research organization
- Small or medium size private enterprise
- Large private enterprise
- Other (please specify)

5.4 Annex 3: Template for the Declaration of TA Expenses by the User

When the stay is completed, the TA User Group can use the following template for declaring the incurred expenses during the access. The sheet must be signed by the User Group members and the bank account details provided to get the refund. This declaration must be accompanied with a copy of the corresponding invoices and tickets (scanned file) and sent to the host infrastructure for approval and refund.



5.5 Annex 4: Essential Information to be Included in the Access Contract

A Contract for the access to the Research Infrastructure between the proposing User Group and the host Research Infrastructure must be signed by both Parties before starting the stay. The final balance of “access days” and “stay days” of the User Group members will be stated in the Addendum-A to the Contract and signed by both Parties after the end of the access. A template of the Contract will be available containing the basic following information (the host infrastructure can include additional clauses in the final version to cover additional specific aspects of the stay):

1. Identification of the Contractors: Research Infrastructure legal name, name and institution of the Leader of the User Group.
2. Identification of the representatives of the Research Infrastructure for the execution of the Contract.
3. Identification of the members of the User Group.
4. Reference to the ERIGrid project and EU funding.
5. Definitions (whenever necessary).
6. Access provisions: total number of expected “access days” per installation/infrastructure, and total number of expected “stay days” per user (member of the User Group).
7. Travel and subsistence reimbursement conditions.
8. Safety provisions.
9. Reporting and dissemination commitments: documents to be prepared, formats and templates, time plan.
10. Liability conditions.
11. Confidentiality obligations.
12. Intellectual Property Rights issues.
13. Signatures.
14. Addendum-A.