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

TRANSNATIONAL ACCESS PROVISION

RESEARCH INFRASTRUCTURE DESCRIPTION AND
TRANSNATIONAL ACCESS CONDITIONS

Centre for Renewable Energy Sources and Saving (CRES)

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Project Duration:	**54 month**

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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:

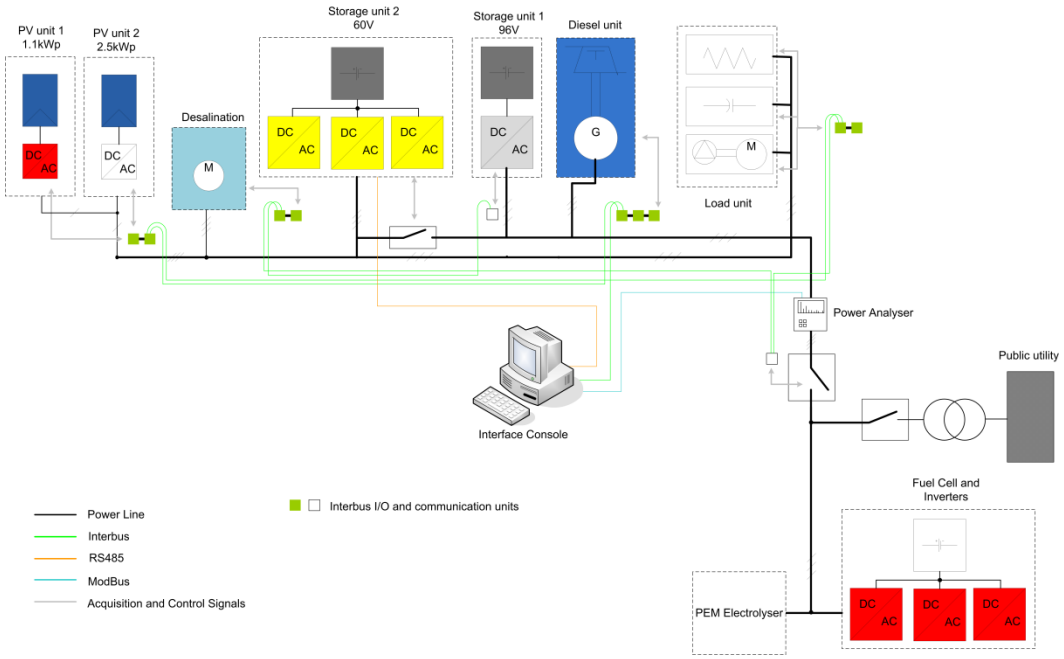
Experimental Microgrid:The Hybrid Power Plant and Microgrid laboratory is designed for studies on the performance of stand-alone and interconnected microgrids, but it can also serve as an emulator of autonomous weak grids, such as the power systems of islands. The microgrid's backbone is a low voltage, 3-phase network to which all DER components are connected. The interconnection of the cables allow, among others, the ad hoc introduction of lumped parameters such a 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. Futhermore, 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 inteconnected 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 inculed a set of hydrogen technology units, namely a 5-kW PEM fuel cell and one electrolyser capable of producing 0.5Nm^3/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 (3.5kW).

Overview of microgrid's main components

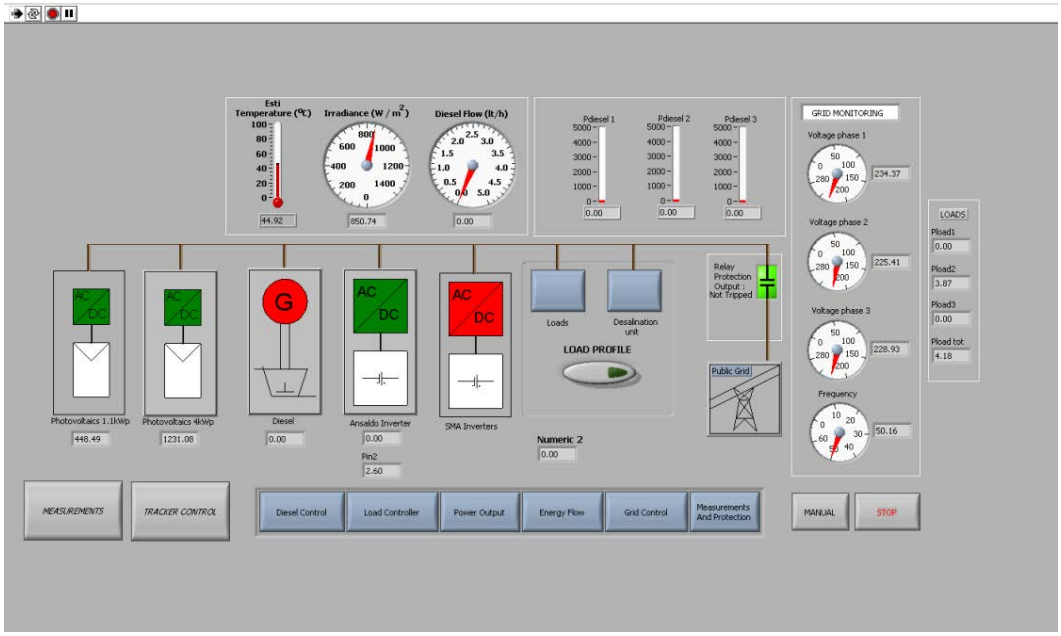


Overview of microgrid's main configuration

The main communication and control layer of the microgrid is based on Interbus which is equiped with distributed analog 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 developled 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.



Snapshot of the main screen of the supervisory control application

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 5m^3, with capability of temperature control in the range from -40^{o}C to 85^{o}C, for the implementation of thermal cycling tests on PV modules.
  - One long-term outdoor testing of PV modules.


Long-term test of PV modules

- 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.

Programmable Grid simulator and load-bank control

- 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 maximum discharge current of 1500A.
    - One environmental chamber providing temperature control between -20^{o}C and +45^{o}C during battery tests. The chamber's volume is 1m^{3}.
    - 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^{o}C.

Battery testers

3 Services offered by the Research Infrastructure

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 organisation 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 multidisciplinary 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 (RESD). RESD 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 Transnational 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. 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 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 Transnational Access 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.

Logical 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

<table>
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