DERlab

European Network of Excellence of DER Laboratories and Pre-Standardisation

2nd Activity Report 2008 to 2010

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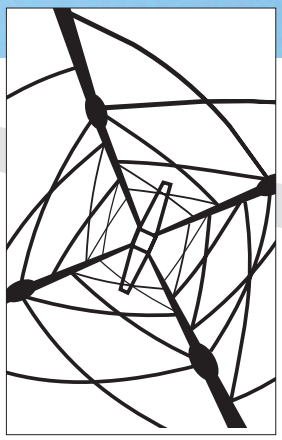
Our Vision

To be the reference lab in Europe for the sustainable integration of Distributed Energy Resources into power systems.

Our Mission

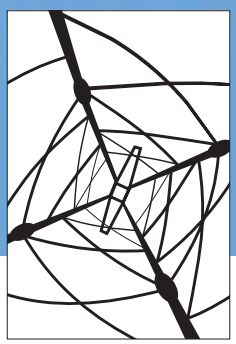
Perform tests, pre-competitive and pre-normative research, as well as training activities, supporting the transition towards more decentralized power generation.



Preface

In the European Network of Excellence DERlab, supported by the European Commission, the research institutes from eleven countries have jointly been developing common requirements and quality criteria for the interconnection and operation of distributed energy resources (DER) since the end of 2005.

This second report of DERlab presents the work and the activities between November 2008 and August 2010. During this period DERlab has, for example, taken actively part in ongoing standardization processes in Europe around interconnections of DER, worked on a testing method for standards on photovoltaic inverters and organized its first seminar for PhD students and young researchers.



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Introduction

In March 2007, the European Union agreed on an energy policy that aims to tackle climate change and, at the same time, increase the EU's energy security and competitiveness. As part of this approach, the EU's leaders set a series of demanding climate and energy targets to be met by 2020, better known as the 20-20-20 targets. One of these targets was to reach 20 % of EU energy consumption using Renewable Energy Sources (RES).

Meanwhile, many European countries built wind parks on the coastlines and installed photovoltaic modules on the roofs of houses. Other Distributed Energy Resources (DER's) such as biogas, hydro power, combined heat and power (CHP) or fuel cells were also developed and their installations supported, based on resources, knowledge and objectives of each European country.

Connecting this increasing number of smaller power generators in the electrical network, however, presents a challenge. The European grid was originally designed to provide end users with centrally produced electricity. With these smaller power generators connected to the grid, power can also flow the other way – from the users to the grid. In order to maintain the reliability and security of the energy supply, both new technologies and standards are needed.

Later in 2007, the European standard EN 50438 *Requirements for the connection of micro-generators in parallel with public low-voltage distribution grid* was released. This was a major step forward in integrating the DER to the common grid. However, many national exceptions still remain. More harmonized protection settings, in particular, would help to ensure the security of the energy supply.

To reach the 20-20-20 target requires not only active communication with all the stakeholders who develop and plan DER in different countries but also strong scientific research for testing the new concepts and ideas of the electricity supply, distribution and storage. DERlab is a network of eleven high-class laboratories from eleven EU member states providing a platform for common research and knowledge transfer around Distributed Energy Resources and their interconnections.

DERlab


UK | University of Manchester
D | IWES
DK | RISØ DTU
PL | TU Łódź
NL | KEMA
A | AIT
DERlab
F | CEA INES
BG | TU Sofia
E | LABEIN
I | RSE
EL | NTUA CRES

Network of Excellence

DERlab
Network of Excellence – project partners

Fraunhofer IWES
Kassel, D, (coordinator)

Austrian Institute of Technology (AIT)
Vienna, A

Commissariat à l´ Energie Atomique, Institut National de l'Energie Solaire (CEA INES)
Le Bourget du lac, F

Institute of Communication and Computer Systems – National Technical University of Athens (ICCS NTUA)
Athens, EL

Kema Nederland B.V
Arnhem, NL

Labein-Tecnalia
Derio - Bizkaia, E

Ricerca sul Sistema Energetico RSE S.p.A
Milan, I

Risø National Laboratory, Technical University of Denmark
Roskilde, DK

Technical University of Łódź, Institute of Electrical Power Engineering
Łódź, PL

Technical University of Sofia, Research and Development Sector (R&DS TU Sofia)
Sofia, BG

The University of Manchester
Manchester, UK

European Distributed Energy Resources Laboratories (DERlab) e.V.
Kassel, D

DERlab is a network of laboratories, who work in the area of new distributed energy technologies and their integration into the future distribution network. All laboratories have their own focus – from different power devices through to testing DER interconnections. Together the partners have comprehensive understanding of future electricity networks.

One of the main focuses of the DERlab network is to support the standardization work in Europe on Distributed Energy Resources (DER) interconnections by also preparing its own initiatives. For example, in 2008 and 2009 DERlab experts developed and tested the standards on photovoltaic inverters in its round-robin tests in nine partner laboratories. The findings were delivered to relevant standardization committees. DERlab laboratories offer also other kinds of technical testing services.

DERlab is a practical platform for knowledge dissemination. DERlab organizes several events each year for special technical topics – and the events are open for participants also from industry, decision-making bodies and other research institutes. Besides workshops, DERlab also offers training courses and seminars on DER.

DERlab is the European project "European Network of Excellence of DER laboratories and Pre-Standardization". In 2008, the project partners founded the association "European Distributed Energy Resources Laboratories (DERlab) e. V." and sealed their co-operation for the future. Thus DERlab will continue to use its laboratory facilities and the know-how of its highly-skilled staff with the aim of becoming the recognized leading European laboratory in the field of integration of Distributed Energy Resources.

DERlab:

- supports the development of European and international standards
- offers testing services around DER technologies and their interconnections
- organizes training courses, seminars and workshops on relevant DER topics
- provides a platform for common research and knowledge transfer and
- targets to be the distributed world-class DER laboratory of Europe

Testing Services

The DERlab laboratory network comprises a great variety of technical capabilities in terms of power ranges, generation and storage technologies and network assets. DERlab offers services that support producers of components, planners as well as operators of plants and supply networks with regard to questions concerning the transition process towards networks that are based on distributed generation and renewable energy. The focus of the laboratories ranges from pure academic to commercial, and from testing of small residential single phase inverters to powerful devices of up to several MVA.

The laboratories and their technical infrastructure complement each other and a common DERlab approach is fostered by the exchange of test results and personnel, in a frame of round-robin testing, for example.

Micro grid testing laboratory of Labein

Power range

DERlab laboratories offer test facilities over a broad range of rated power, enabling tests for small scale inverters below the kW range, medium scale in the 100 kW range until several MW connected to either LV or MV networks.

Interconnection and grid code compliance testing

DERlab laboratories offer testing of interconnection requirements and compliance with grid codes according to a great variety of national, European and International standards. Among these are the following:

- EN50438
- TS 50549
- EN 61000-4-11/EN 61000-6-
- EN 61000-3-2
- EN 61000-3-12
- RD 1663/2000
- RD 436/2004
- IEEE 1547
- UL 1741
- German (BDEW) Medium Voltage and Low Voltage Grid Codes
- VDE 0126-1-1,
- ÖVE/ÖNORM E 8001-4-712,
- UK ER G83/1-1 and
- C10/11.

Besides testing services, DERlab offers consultation with regard to grid code requirements.

Testing of electromagnetic compatibility (EMC)

DERlab laboratories offer EMC tests concerning conducted and radiated emissions on inverters, and also offer immunity tests.

Interoperability and communication testing

DERlab offers several laboratory platforms able to test interoperability between generating units. These include testing the communication interfaces according to international standards (for example IEC 61850-7-420).

Environmental and reliability testing

DERlab laboratories include facilities for stress testing of inverters, for example climatic chambers and salt fog tests.

Inverter testing facilities

Inverters are devices that form an important link in the chain between energy generation from renewable energy sources and the point of consumption. This chapter presents how inverters are tested in DERlab laboratories all around Europe, in different individual laboratories.

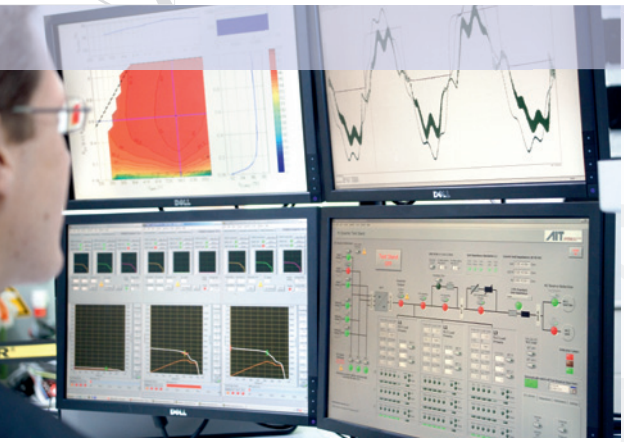
The following portfolio focuses merely on inverter testing, and it is not a complete description of any single laboratory in DERlab. For further information about the laboratories and services, please contact us.

Photovoltaic module outdoor tests

In 2009, DERlab developed a formalized-method for testing photovoltaic modules at outdoor conditions (see page 14).

Testing Services

Inverter Testing Facilities



Analysis of the test results of photovoltaic inverters at AIT

Austrian Institute of Technology (AIT), Austria

The AIT laboratories offer a comprehensive portfolio to test and analyze DER components and systems, focusing on power electronic converters for photovoltaic installations and high power/high current devices up to MW range. The laboratory infrastructure and a wide range of accreditations enable clients to perform standardized compliance tests as well as customized analyses on power system equipment and components for renewable energy installations. In addition, the broad know-how in the field of numerical simulation of electricity grids, power system components, as well as the multi-domain analysis of electrical phenomena as, for example, switching arcs complements the laboratory-focused research and development services.

Measuring the meteorological PV testing conditions on the roof of the CRES laboratory

Centre for Renewable Energy Sources (CRES), Greece

In Athens, the testing facilities of CRES include laboratories and equipment able to cover research activities and services in the field of photovoltaics and distributed generation. These consist of a PV testing laboratory, a power electronics laboratory including PV array and grid simulator, load bank and measuring instruments for inverter testing, a battery testing laboratory, and an experimental micro grid including PVs, battery storage, diesel generator, grid interconnection and monitoring and control system SCADA used for research in the field of micro grids, smart grids and distributed resources.

PV inverter testing facility at RSE

RSE, Italy

The DER test facility at RSE consists of a low voltage micro grid, connected to the medium voltage grid by means of a 800 kVA transformer. This facility has several generators with different technology (renewable and conventional), controllable loads and storage systems, and can provide electricity to the main grid with a maximum power of 350 kW. All the DERs are connected to the micro grid by means of a configuration and interconnection board that allows the micro grid operator to change the interconnections of DERs. In this way it is possible to obtain different grid topologies and to extend feeders up to one kilometer. The interconnection board and all the DERs are provided with electrical measurement equipment having a high-speed data acquisition system.

Institut National d'Energie Solaire (INES), France

The laboratory facilities at INES allow testing and validating of DER systems and especially electrochemical storage technologies and their management strategies in connection to the electrical grid. INES has also a modular platform for the test and evaluation of DER systems up to 100 kW. The platform can be used for evaluation and development of system components, overall systems, including the aspects related to the grid connection. The inverter test facility at INES is used for static and dynamic efficiency measurements, maximum power point tracking (MPPT) efficiency measurements, and provides test possibilities for all prevalent DER interconnection tests.

Battery testing facility at INES

Fraunhofer IWES, Germany

Fraunhofer IWES offers standard and customized tests and measurements to qualify system components and products. The laboratory equipment is accredited to test inverters and photovoltaic components: the performance of off-grid inverters and battery charge controllers in hybrid systems can be tested with different loads and generators. In the accredited EMC testing laboratory, all necessary emission and immunity tests can be carried out. IWES has extended facilities for testing grid code compliance and is accredited for interconnection testing according to the new German BDEW medium voltage and low voltage grid codes.

PV inverter under test at IWES

KEMA, Netherlands

The Flex Power Grid Lab (FPGL) in Arnhem is built around a fully programmable four-quadrant power electronics converter that can either create a grid with a customizable power quality level or represent a custom load. The laboratory has been designed to enable for example the circulation of power from the programmable source, through the device under test, back to the feeding grid. Additionally, various passive loads are available in the lab for easy connection. A fully equipped measuring system is provided in the safety of the command-room, which overlooks the laboratory floor where the device under test is clearly visible. The facility allows to gain hands-on knowledge on the device under test and its interaction with the energy system and thus facilitates innovation in the power system industry.

An outlook of Flex Power Grid Lab at KEMA

Testing Services

Inverter Testing Facilities

Micro grid testing laboratory of Labein

Labein, Spain

At the LABEIN-Tecnalia there is a micro grid testing laboratory which can be used for testing interconnection requirements of DER units. The installation is able to provide the basic set-up for testing the grid connection requirements according to several standards and the codes of several electrical companies. This is complemented by a fully equipped EMC laboratory for assessing the specific EMC requirements.

Measurement equipment for inverter testing at NTUA

NTUA-ICCS, Greece

The Microgrids Laboratory, being part of the Electric Power Systems Laboratory of the National Technical University of Athens, consists of a test and measuring laboratory, a simulation laboratory and a micro grid laboratory. The interconnection testing of DER units can be measured by using an AC Grid simulator, PVs and the PV characteristic curve simulator. Tests can be performed for example on harmonic current measurement, PV leakage current, DC current injection and on anti-islanding protection for inverter testing and the overview of the testing procedure is done via a local SCADA system.

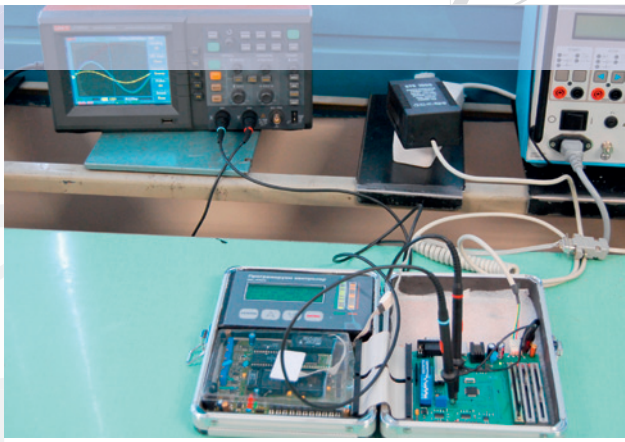
Switching panel of the micro grid testing facility at TU Łódź.

Technical University of Łódź, Poland

The laboratory of Distributed Generation at the Institute of Electrical Power Engineering Technical University of Łódź serves to test the integration of distributed generation with the distribution power networks. All devices are connected to the network via a laboratory switching panel. The laboratory network is built based on a model of the distribution medium voltage/low voltage network with a nominal power of 70 kVA. Using the crossing panel one can build multiple variants of the low voltage network arrangement. An additional device installed in the crossing panel can perform one, two or three phase short-circuits for a specified duration causing different voltage dips and enabling testing the device immunity, for example. Different operating conditions for distribution energy sources in steady states and transients that can occur in real low voltage networks can be realized and the operation of the grid and the devices connected can be measured by an advanced monitoring system.

Technical University of Sofia, Bulgaria

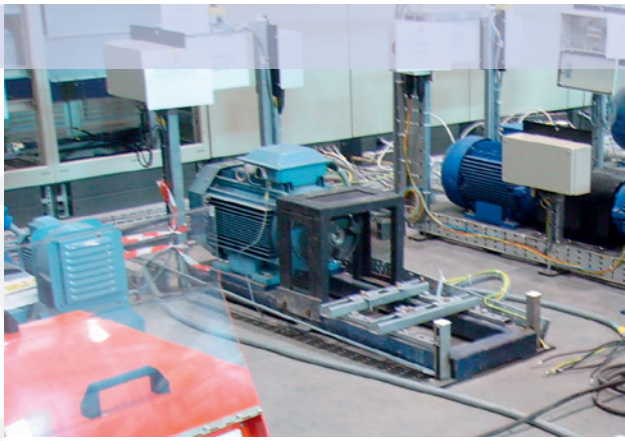
At the Technical University of Sofia there is a system that includes a physical model of a synchronous generator driven by a DC motor. The control is realized through three mutually connected counters at frequency, tension and power factor. Visualization and registration of all parameters are carried out. The interconnection synchronization of a generator with the electrical network is realized for three regimes – constant angle of overtaking, constant time of overtaking and combined method with prediction of phase angle between generator tension and network tension.



Simulation equipment at Technical University of Sofia laboratory for testing of interconnection requirements

UKDG, United Kingdom

The test setup in the Narec (National Renewable Energy Centre) laboratory in Blyth, United Kingdom, subjects a new design of induction machine to various fault conditions. Prototype generator testing has been undertaken with machines of up to 30 kW. These machines are scaled down versions of the final design, testing the principals of operation. One machine is used to simulate a grid connection and another to simulate a 'fault ride through' profile. A resistor bank provides the load and two sets of inductor banks control the level of fault current.



Fault-ride-through simulator in the Narec laboratory

Testing Services

Photovoltaic Module Outdoor Tests

Module manufacturers sell their products all over the world. And yet, due to the lack of unified standards, a location-specific, direct product comparison has not been possible. DERlab has developed a formalized method for the long-term testing of solar modules.

The quality standard is based on standardized test procedures and data formats as well as evaluation services and uniform reports. The long-term measurements of solar modules are harmonized over the whole of Europe. Not only is the location-specific yield measured, but also the influence of ambient conditions on the module output. In field tests, running in parallel, the researchers measure the solar modules under real conditions at the most diverse European locations.

This service was presented to module manufacturers for the first time at the world's largest solar energy conference EU PVSEC (European Photovoltaic Solar Energy Conference & Exhibition) in September 2009 in Hamburg, Germany.

PV module testing facility in Kassel, Germany

Training Services

DERlab offers training services on the topics the partners work closely with. Latest training course for industry was held on quality issues in contemporary and future power networks and the topic of the seminar for PhD students and young researchers was DER integration into power systems.

PhD and young researchers seminar in Athens

The purpose of the DERlab PhD seminars is to create a series of seminars in the field of DER integration into power systems as a starting point for common research and staff exchange. The first DERlab PhD seminar was a two-day event, organized in Athens by NTUA, in November 2009 providing new researchers with the opportunity to meet, interact and exchange knowledge.

Within these two days 24 researchers from 8 European countries had the opportunity to attend 19 presentations. The topics concerned DER integration into power systems.

As the event was very successful, the second DERlab PhD and young researchers seminar is scheduled for November 2010.

Training on DER for industry in Manchester

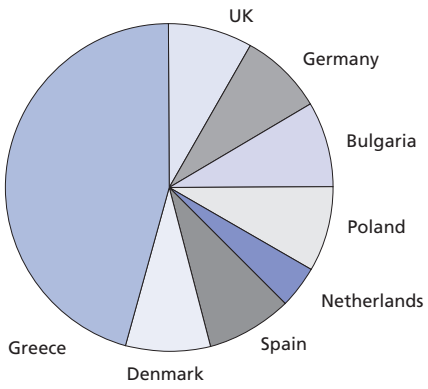
In January 2010 the University of Manchester held a training course organized jointly by DERlab and the partnership organization of universities and enterprises in the electric energy systems EES-UETP. The topic of the training course was "Power Quality Issues in Contemporary and Future Power Networks" and it was led by the Professor Jovica V. Milanovic from the University of Manchester.

The course was intended for technical staff, engineers and managers from electrical power utilities, independent generating companies, electricity regulators, industry, manufacturing and consulting companies and educational and research institutions which deal with the quality of electricity supply and distributed generation. The objective of the course was to provide a solid understanding of the major power quality issues facing customers and operators of modern electrical power systems with substantial penetration of distributed generation.

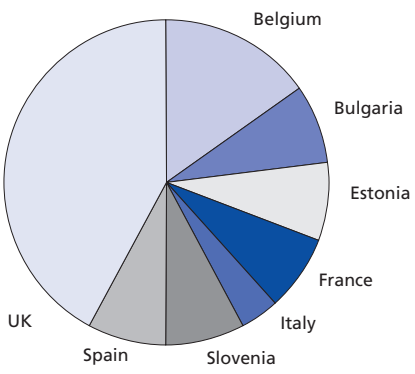
Lectures came from industry and universities including Math Bollen, the Manager Power Quality and Distributed Generation from STRI AB, Sweden and the Professor Zbigniew Hanzelka from the AGH-University of Science and Technology in Krakow, Poland.

The course was attended by 26 delegates from 8 European countries. It is worth noticing that almost three-quarters of the participants came from industry and the rest from academic institutions. Each attendee was awarded a certificate of attendance after completion of the course.

The next training coursefor industry in November 2010 in Manchester with the title "Advanced Protection of Future Networks with High Penetration of Distributed Generation (DG) Sources".



Participants in Athens



Participants in Manchester

Workshops

Specialists in the scientific community and also the industry around distributed energy technologies have the possibility to share information, discuss, identify relevant problems and propose solutions together in DERlab workshops. The workshops are intended for the dissemination of knowledge but often focus on a certain technical issue around distributed energy resources.

Workshops 2008

In 2008 DERlab organized a series of workshops which took place in Germany and also in Nice, France, within the 3rd DER integration conference. These discussions lead to the publication of the International "White Book on the Grid Integration of the Static Converters" by DERlab. The White Book aims at describing medium to long-term harmonization needs for the behavior and technical interfaces of grid connected static converters. The White Book is available in the web pages of DERlab.

Workshops 2009

In 2009 DERlab held a series of workshops that concentrated on the pre-standardization work of DERlab, concerning interconnection requirements for DER. This series was kicked off in Rome in March 2009, where a joint DERlab – CENELEC TC8X WG3 workshop was held. The second event took place in Salzburg, Austria in May 2009 and focused on technical issues like fault ride through and contribution to voltage control, which are seen as the key issues for DER integration in a scenario where the grid is highly penetrated with DER.

The third workshop in this series was held in September in conjunction with the European Conference on Power Quality and Utilisation (EPQU) in Łódź, Poland, and addressed testing and certification of DER units. The topic of the workshop was the interconnection requirements of DER in parallel with public low-voltage distribution networks. The focus was laid on the connection requirements for generators connected to the low voltage network as well as the contribution to the network operation with reactive power and voltage control. These two issues are still subjects under discussions in various countries. Additional issues such as testing, certification and commissioning have been also addressed.

The workshop was led by one of the DERlab members, the Institute of Electrical Power Engineering Technical University of Łódź, who has been organizing the EPQU conference since its beginning. In 2009 the conference gained an important supportive partner – the Institute of Electrical and Electronics Engineers (IEEE).

White Book on the grid interface of grid-connected storage systems

In 2009, DERlab's idea of the "White Book on the Grid Interface of Grid-connected Storage Systems" was presented in workshops combined with the CIRED conference in Prague in June and the IRES conference in Berlin in November. In both workshops there were around 20 participants from research institutes, universities and companies all around Europe, half of which came from outside DERlab.

The aim of the White Book is to define common European requirements for the grid-connected storage systems of the future. It deals with grid issues specific the use of grid-connected storage systems, not with storage technologies themselves. In this approach, a grid-connected storage system is defined as a bi-directional device, connected to the grid (permanently or temporarily), controllable and able to communicate.

The boundary conditions have been agreed at 35 kV (i.e. the storage is connected to the distribution network), with 10 MVA maximum power, in line with IEEE 1547. In the White Book the characterization of categories with represen-

DERlab workshop in Kassel, Germany

Laboratory visit of DERlab team to Spain

tative cycle patterns will be proposed as well as the test procedures for measurement. The work will be done by the DERlab members CEA/INES, RISOE-DTU, KEMA, ICCS/NTUA and CRES.

The White Book is meant as a roadmap towards guidelines and new standards for grid-connected storage systems. This approach will be continued in the frame of the FP7 DERri project, and applied in the partners' laboratories to different types of storage.

Workshops 2010

In April 2010, DERlab organized a workshop in Glasgow, at the University of Strathclyde. The topic was power system services, having a focus on the ancillary services provided by an individual DER unit.

This workshop is followed-up in October 2010 within the SmartGrids and E-Mobility Conference in Brussels, where DERlab is organizing a workshop on the development of testing procedures for power system services. The topic is the same, the power system services, but here the focus is on the services that are provided as an aggregated response when more DER units are integrated in the power system.

In the DER integration conference in Albuquerque, United States, in December 2010 DERlab supports a workshop dealing with DER communication and smart grids.

Vanadium battery from the AC side (left) and DC (right) at CEA INES laboratory in France

Background: Grid interfaces of grid-connected storage systems

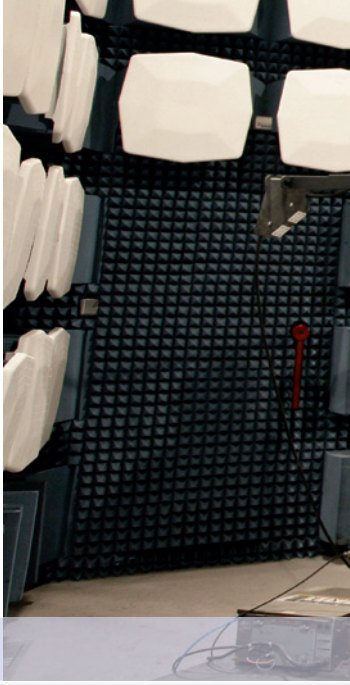
The increasing integration of decentralized energy resources in the electricity networks, and especially of intermittent renewable energies, results in an increased awareness that storage systems are needed to help the network accept these additional constraints, while maintaining satisfactory quality and safety of electricity supply. In this context, the possible applications of storage have already been listed in several studies, and a number of demonstration projects are ongoing. However, there is no general consensus on how to specify and how to objectively select the most suitable storage technology for a given application. In each project, a new test procedure is used, and results of these different tests are very difficult to compare.

Even if small grid-connected storage systems are not yet installed in very large numbers, there is already a strong need for a common understanding on selection methods. This is not a straightforward issue, as storage systems are the only grid-connected devices capable of acting both as a load and as a power supply, and their power and energy characteristics fluctuate quickly. In addition, their electrical characteristics may change during charging or discharging operation.

The common European descriptions and requirements of storage systems for the different categories of grid applications will help at every step of the design and operation of these systems: specification, cost of ownership calculation, comparison and selection of the best compromise for a given application, measurement and monitoring. It will also enable an optimized integration of storage systems into the grid and encourage innovation, by allowing quicker comparison between two manufacturers or two product generations.

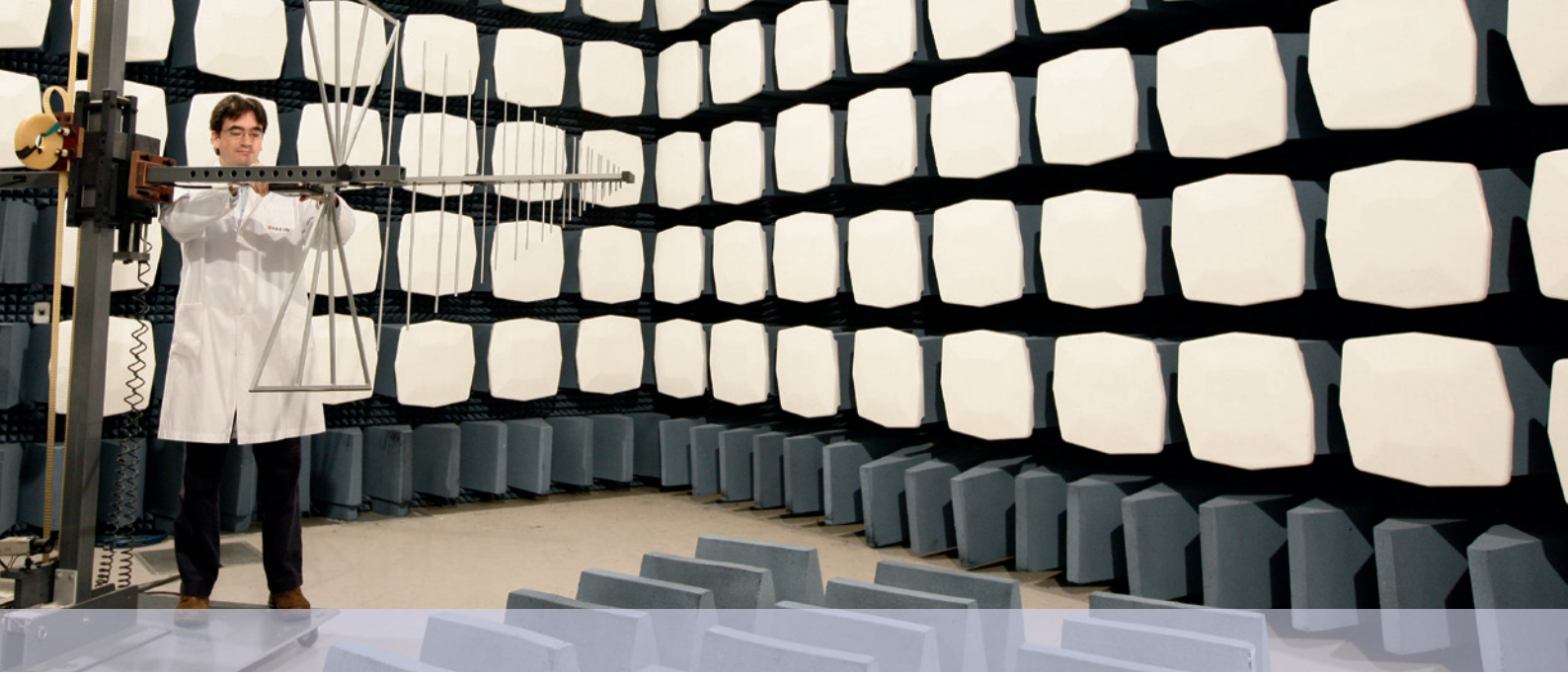
There are many various applications, and several types of markets are opening up, having close correlation to local regulations and incentives. The storage systems represent a very interesting but difficult issue: there are many prototypes but few commercial products with rated characteristics.

Pre-standardization



The lack of harmonized interconnection standards has been identified as one of the most critical obstacles for the wide deployment of DER and for the change towards active electricity networks. DERlab supports the development of European and international standards by providing technical information and input to the standardization bodies.

	DERlab members are respresented in following international standardisation committees:
IEC-TC 8	System Aspects for Electrical Energy
IEC-TC 13	Equipment for Electrical Energy Measurement and Load Control
IEC-TC 14	Power Transformers
IEC-TC 21	Secondary Cells and Batteries
IEC-TC 82	Solar Photovoltaic Energy Systems
IEC-TC 88	Wind Turbine Systems
IEC-TC 57	Power systems management and associated information exchange
IEC-TC 105	Fuel Cell Technologies
IEC-TC 99	System Engineering and Erection of Electrical Power Installation in Systems with Nominal Voltages above 1 kV A.C. and 1.5 kV D.C.
CENELEC-TC 8X	System Aspects of Electrical Energy Supply
CENELEC-TC 82	Solar Photovoltaic Energy Systems
CENELEC-TC 210	Electromagnetic Compatibility (EMC)
CENELEC-BTTF 83-2	Wind Turbine Issues



Work on the DER interconnection requirements

In the field of the interconnection of DER with the electricity grids, DERlab experts are deeply involved in two projects pursued by Working Group 3 of the standardization body CENELEC/TC8X concerning the connection of generators to distribution networks.

DERlab participates in the revision of European standard EN 50438:2007 "Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks" by bringing together the expertise and vision of the different partners. DERlab compiled a document with comments and contributions in March 2010 which summarizes its. This document was circulated to the National Committees by CENELEC.

From the beginning, DERlab experts have been actively involved also in the improvement of the draft technical specification document prTS 50549, "Requirements for the Connection of Generators above 16 A per Phase to the LV Distribution System or to the MV Distribution System" which is intended to become the main harmonized technical specification for the connection of larger DER to the European electricity grids.

As part of this work, DERlab organized a series of workshops (in Rome, Italy, in Salzburg, Austria and in Łódź, Poland within the EPQU conference) in 2009 to bring together all involved stakeholders. The conclusions of the workshops were used as input to a new draft of the technical specification circulated by CENELEC for comments in March 2010.

Work on the electromagnetic compatibility of DER

In order to improve the quality of supply in the electricity grid, DERlab supported the ensuring of the electromagnetic compatibility (EMC) of DER from the very outset. DERlab participates in the project IEC 61000-3-15, Electromagnetic compatibility (EMC) – Part 3-15: "Limits – Assessment of Low Frequency Electromagnetic Immunity and Emission Requirements for Dispersed Generation Systems in LV Networks" which is also chaired by an expert from a DERlab partner. In parallel, DERlab has prepared a comprehensive guide "Electromagnetic Compatibility for Distributed Energy Resources" in January 2007 that is available online on the web pages of DERlab. The second version will be issued in October 2010.

Electromagnetic compatibility chamber in Derio, Spain

Pre-Standardization

Round-robin Tests of Photovoltaic Inverters

As most of DER interfaces to the electrical network are realized through inverters, DERlab decided to pay particular attention to their testing procedures. DERlab selected two single-phase inverters and their performance was tested in a round-robin test at nine laboratories around Europe during 2009.

Similar tests in nine European laboratories

The aim was to find the anomalies that occur when the same device is tested according to the same standards by different laboratories. The measurement steps and the standards to be followed were described in a pre-requisite document "PV inverter testing procedures" drawn up by DERlab experts.

Each laboratory conducted such tests and listed the problems that had occurred. On the basis of the analysis of these remarks, a list of suggestions for improvements to the standards will be forwarded to the relevant standardization groups. The results are also disseminated at DERlab events.

The tests were performed for anti-islanding protection detection (protection intervention test on grid connection), for harmonic currents (power quality test on grid compatibility) and for DC current injection (power quality test on grid compatibility). Full descriptions of the testing procedures, the equipment used and the final results are available on the web pages of DERlab. Some examples of the results are given below.

Use of current sources in inverter tests

Testing a PV inverter that is connected to the electricity network requires a direct current (DC) source that provides a due DC input, and an alternative current (AC) source or a simulator that is able to supply the right voltage value and receive the power produced by the inverter under test.

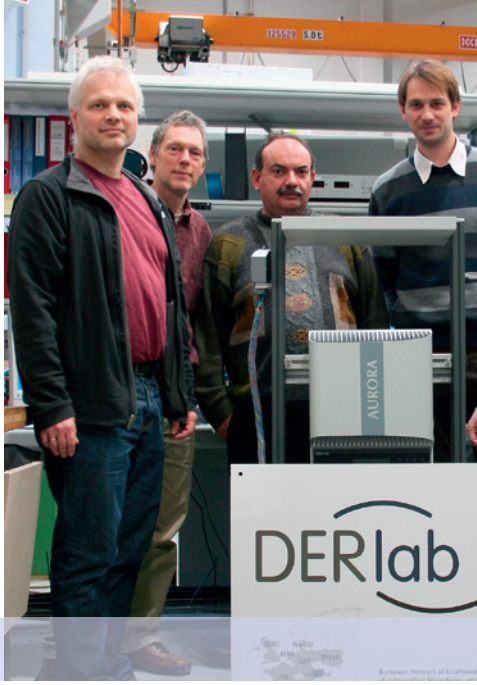
Test procedures usually define exact values of power produced by the inverter and stable functioning conditions are required during the test. If a DC generator is used, these needs frequently cannot be fulfilled; in fact, the working point defined by the MPPT usually corresponds to the current limitation point of the generator and that produces a sudden variation. The MPPT, which continuously changes the working point, interferes with the limitation control of the generator, thus the working point cannot be stable. This aspect is more relevant when the ratio between the output power and the nominal power of the inverter is low.

In order to reduce this problem and smooth the current voltage I-V curve, a series resistance between the generator and the DC input of the inverter can be used, but a better solution is a photovoltaic simulator that can produce the necessary photovoltaic specific P-V curve. Attention must be paid to the characteristics of the photovoltaic simulator. In order to avoid interferences and guarantee an adequate and stable test condition, its control must be much faster than the MPPT control of the inverter to be tested.

The grid simulator has to provide a sinusoidal voltage without harmonic distortion. In addition, the simulator must be able to absorb the AC power generated by the inverter under test – without this capability the operator will need to connect a balanced load to the output of the inverter. The load must have characteristics that are suited to a continuous connection at the maximum power value.

Harmonic current measurements

The aim of the test on harmonic current is to assess the current harmonics injection of the PV inverter into the grid, in a range of power between 5 % and 120 % of the nominal power of the inverter. Several tests have been performed in compliance with the requirements of EN 61000-3-2.



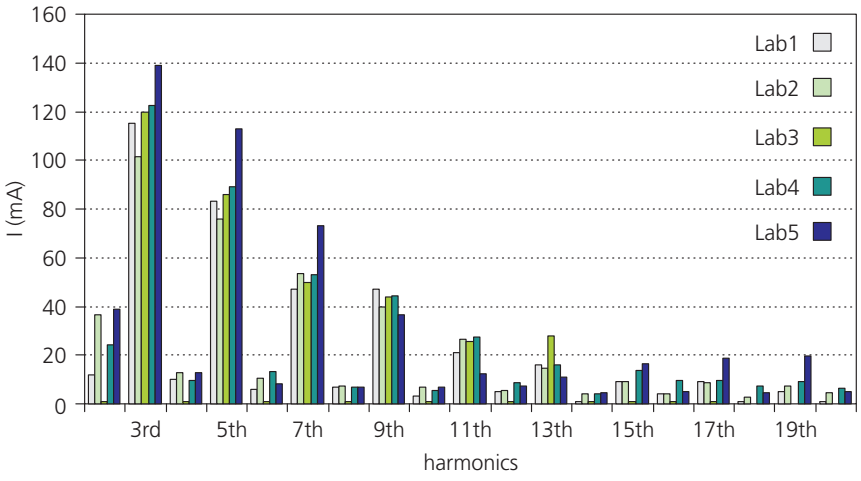
Due to the fact that the actual voltage total harmonic distortion (THD) may have a strong impact on the inverters current THD, the requirements specify values for the test voltage and its harmonic ratios.

Test equipment and preparation

The inverter is connected on the DC side to a PV simulator because the test requires that the harmonics are measured for fixed different power outputs. The inverter is connected on the AC side to an adjustable grid simulator, or to a low voltage single-phase real grid. This is to be done only if it fulfills the requirements of EN 61000-3-2. A power analyzer is positioned on the AC side for the harmonics measurement.

Procedure

The test procedure describes the steps that should be followed by technicians to measure the current harmonics from 2nd to 39th: the inverter is turned on and the current harmonics are measured on the inverter output, by means of a grid analyzer installed on the AC output; the current THD and the current harmonics are recorded and their values are verified according to the limits expressed by the IEC 61000-3-2. The current THD and the current harmonics from 2nd to 39th must be recorded for values of output power equal to 5 %, 10 %, 20 %, 25 %, 50 %, 75 %, 100 % and 120 % of the inverter rated power.



First 20 current harmonics, measured in different laboratories (P/Pn= 50%)

Results

The testing procedure measures the amplitude of the harmonic distortion of the inverter output current, relating to different values of the power supplied. Measurements have been performed for single harmonic, till the 40th one and computation has been done for the THD factor. The THD was measured for the same inverters in different laboratories. The consistency among the measurements performed in the different laboratories is relatively high; the measure scattering increases, when the power supplied by the inverter becomes lower.

In spite of the good consistency of THD measurements, some relevant differences are observed for the measurements of single harmonic components related to the same inverter situation as shown in the figure.

In order to increase the results' repeatability, a better definition of the characteristics of the measurement equipment is necessary, as is a more accurate indication of the measures' elaboration. For the harmonic calculation it is necessary to use a time slot large enough to represent the average level of the current harmonics. The value scattering shown in the figure can likely be produced by the use of time slots of different lengths and by application of an inadequate data average.

Round-robin tests at the Labein laboratory in Spain

DERlab experts after the round-robin test at the AIT laboratory in Vienna

DERlab Networking

DERlab members organize many events at local level on DER topics where the knowledge can be effectively disseminated. DERlab is also active in international and intercontinental networks. Some examples are given here.

Audience at INVEX 2009 in Milan

Energy forum in Varna

The Bulgarian national DERlab workshop took place at the International Home of Scientists "F. J. Curie" at the "St. St. Constantine and Helena" seaside resort in Varna, during the Energy Forum in June 2009 with over 80 participants from transmission and distribution networks operators, industrial companies in the field of transmission of distribution system operators and electrical power companies, universities and governmental bodies.

The main DERlab activities relating to the requirements for the interconnection of DER to electrical networks were presented as well as training activities and ideas towards an active smart grid. A discussion concerning the gaps in harmonization documents and problems of voltage stability and control was held. The main standards that are recognized by the EU in Bulgaria were specified.

It was concluded that many existing standards in Bulgaria should be harmonized. At the moment, there is no common regulation for testing, monitoring, for information exchange, control and operation in order to better integrate DER into the electric power systems. DER is expected to make an impact on frequency stability and on voltage stability. This will necessitate the controllability of active and reactive power production and the availability of local storage. The possibility for the creation of "micro smart grids" in Bulgaria connected to LV distribution network with help the of DERlab e. V. was discussed with the representative of a Distribution Network Operator CEZ-Bulgaria and NTUA, a member of DERlab.

Inverter day in Milan

In November 2009 a unique initiative INVEX took place in Milan, Italy. The event was dedicated to photovoltaic operators dealing with all aspects of inverters from the choice of the device, the integration of DER in the electricity grid, up to the efficiency of the anti-islanding protection of photovoltaic inverters and the economic aspects of the industry.

INVEX 2009 has been one of the main events where the results of the DERlab activity on PV inverter round-robin testing procedures have been transferred. The DERlab member RSE held a presentation about the method used by DERlab partners to validate photovoltaic inverters testing.

INVEX 2009 was completely dedicated to the inverter industries and it took place at the fair centre Milano-Rho. The success of the event went beyond all expectations, with more than 450 participants.

DERlab and the International Conference on the Integration of Renewable and Distributed Energy Resources

DERlab members supported the establishment of the International Conference on Integration of Renewable and Distributed Energy Resources from the very beginning. This conference series is a major event for the DER network integration community and covers Australia, Japan, North America and Europe.

The DER integration conference builds a platform for international exchange and harmonization. The conference gives an overview on experiences in demonstration projects as well as policy and regulation, economic aspects, and also offers in-depth workshops.

On the 3rd DER integration conference that took place in December 2008 in Nice, France, DERlab concluded a workshop series on the grid integration of static converters. The outcome of this workshop series is a White Book that is available in the web pages of DERlab.

In the DER integration conference in Albuquerque, United States, in December 2010 DERlab supports a workshop dealing with DER communication and smart grids.

The DERri project

DERri - Distributed Energy Resources Research Infrastructure – provides external European researchers access to the DERri partners' laboratories free of charge, in the field of electrical systems including DER.

Using DERri structures, research projects can be carried out at different facilities over Europe. The organized infrastructure of DERri has the advantage of enabling better communication and dissemination of the results. When work is performed both in the Network Activities and in the Joint Research Activities, the aim is to reach similar procedures, standards and interfaces in all the facilities.

DERri is an Integrating Activity – Combination of Collaborative Project and Coordination and Support Action (FP7) that makes up an exceptional DER research infrastructure with the leading DER expertise in Europe. The DERri consortium includes all the members of DERlab, with the addition of the partners Électricité de France (EDF-SA), University of Strathclyde and The Technical Research Centre of Finland (VTT).

For more information please visit http://www.der-ri.net

DERri

List of Common Publications

The research outcomes of the DERlab network are actively disseminated. For further information on a specific publication please contact us.

Date	Title	Authors	Place of publication	Leading Partner
May 2008	Redefinition of the European efficiency – finding the compromise between simplicity and accuracy	B. Bletterie, R. Bründlinger, H. Häberlin, F. Baumgartner, H. Schmidt, G. Klein, M. A. Abella	4th European PV-Hybrid and Mini-Grid Conference in Athens, Greece	AIT
May 2008	DERlab Objectives and Activities	T. Degner, W. Heckmann, P. Strauß, J. E. Rodriguez, E. Zabala, R. Bründlinger, N. Hatziargyriou	4th European PV-Hybrid and Mini-Grid Conference in Athens, Greece	IWES
May 2008	Performance Evaluation of the Gaidoroumandra Mini-Grid with Distributed PV Generators	R. Geipel, M. Landau, P. Strauß, M. Vandenbergh, S. Tselepis	4th European PV-Hybrid and Mini-Grid Conference in Athens, Greece	IWES
May 2008	NoE DER-Lab – Network of Excellence for Distributed Energy Resources and Pre-Standardisation	A. Krusteva, T. Degner	Elektronica 2008, National Conference with International participation, Sofia, Bulgaria	TU Sofia
September 2008	Redefinition of the European efficiency – finding the compromise between simplicity and accuracy	B. Bletterie, R. Bründlinger, H. Häberlin, F. Baumgartner, H. Schmidt, G. Klein, M. A. Abella	European Photovoltaic Solar Energy Conference, Valencia, Spain	AIT
September 2008	DERlab: European Network of Excellence of DER Laboratories and Pre-Standardisation – Objectives and Activities	T. Degner, W. Heckmann, P. Strauß, J. E. Rodriguez, E. Zabala, R. Bründlinger, P. Mora, J. Merten	13th Kasseler Symposium Energy Systems Technology, Kassel, Germany	IWES
October 2008	DER Laboratory in Institute of Electrical Power Engineering of Technical University of Łódź	R. Mienski, R. Pawelek, P. Gburczyk, I. Wasiak, T. Degner	13th International Conference on Harmonics and Quality of Power in Wollongong, Australia	TU Łódź
October 2008	Research Facility of Technical University of Łódź – a Powerful Tool for Microgrids Analysis	R. Mienski, R. Pawelek, P. Gburczyk, I. Wasiak, T. Degner	5th International Conference on Power Systems, Control, Quality and Efficiency of Utilisation in Blagoveshchensk, Russia	TU Łódź
December 2008	Making European Interconnection Requirements Transparent – The New DEDIS Data Base from DERlab	T. Degner, W. Heckmann, J. E. Rodriguez, E. Zabala, R. Bründlinger	3rd International Conference on Integration of RES and DER in Nice, France	IWES
March 2009	Nachweis der elektrischen Eigenschaften von PV-Wechselrichtern gemäß den deutschen Netzanschlussrichtlinien	G. Arnold, T. Degner, R. Bründlinger	Symposium Photovoltaic Solar Energy in Staffelstein, Germany	IWES
June 2009	Estimation of Voltage controllability of Distribution Systems with Locally Distributed Sources	R. Stanev, P. Nakov, A. Krusteva, P. Romanos, B. Bletterie	Energy Forum 2009, Varna, Bulgaria	TU Sofia
June 2009	Network of Excellence DERLab activities for transition towards more decentralised Energy Systems	A. Krusteva, T. Degner, J. Mutale, E. Kolentini, I. Wasiak	Energy Forum 2009, Varna, Bulgaria	TU Sofia
June 2009	Application of Active Power Filters in Distributed Energy Systems	M. Antchev, M. Petkova, A. Krusteva, D. Geibel, H. Antchev	ICEST'09, Veliko Tarnovo, Bulgaria	TU Sofia

June 2009	Network of Excellence DERLab activities for transition towards more decentralised Energy Systems	A. Krusteva, T. Degner, J. Mutale, E. Kolentini, I. Wasiak	ICEST'09, Veliko Tarnovo, Bulgaria	TU Sofia
June 2009	Grid integration issues for EVs / PHEVs: the DERlab approach	E. Lemaire, J. Merten, P. Nørgård, H. Bindner, P. Mora, E. Kolentini, E. Zabala, J. E. Rodriguez, M. Stifter, R. Bründlinger, S. Tselepis, T. Degner, W. Heckmann	European Conference Smart Grids and Mobility in Würzburg, Germany	CEA
June 2009	Demand Side Management in Smart Buildings	T. Romanos, N. Hatziargyriou, J. Schmid	European Conference Smart Grids and Mobility, Würzburg, Germany	NTUA
September 2009	PV for Smart Buildings	T. Romanos, N. Hatziargyriou, J. Schmid, J. Mutale	24th EUPVSEC, Hamburg, Germany	NTUA
September 2009	PV Inverters supporting the grid – First experiences with testing and qualification according to the new grid interconnection guidelines in Germany, Austria and France	R. Bründlinger, B. Bletterie, G. Arnold, T. Degner, C. Duvauchelle	24th EUPVSEC, Hamburg, Germany	AIT
September 2009	EN 50530 – The new European Standard for Performance Characterisation of PV inverters	R. Bründlinger, N. Henze, H. Häberlin, B. Burger, A. Bergmann, F. Baumgartner	24th EUPVSEC, Hamburg, Germany	AIT
September 2009	International white book on the grid integration of static converters	P. Strauß, T. Degner, W. Heckmann, I. Wasiak, P. Gburczyk, Z. Hanzelka, N. Hatziargyriou, T. Romanos, E. Zountouridou, A. Dimeas	10th International Conference on Electrical Power Quality and Utilisation EPQU'09, Łódź, Poland	IWES
September 2009	Inverter interconnection tests performed in the LABEIN-Tecnalia microgrid involved in the DERlab round-robin testing activity	A. Gil de Muro, J. E. Rodriguez-Seco, E. Zabala, C. Mayr, R. Bründlinger, G. Romanovsky, O. Gehrke, F. Isleifsson	10th International Conference on Electrical Power Quality and Utilisation EPQU'09, Łódź, Poland	Labein
September 2009	Improvement of Power Quality and Reliability with Multifunctional PV-Inverters in Distributed Energy Systems	D. Geibel, T. Degner, C.Hardt, M. Antchev, A. Krusteva	10th International Conference on Electrical Power Quality and Utilisation EPQU'09, Łódź, Poland	IWES
November 2009	Characterizing the Overall Performance of Grid-connected PV power converters with the new European Standard EN 50350	R. Bründlinger, N. Henze, H. Häberlin, B. Burger, A. Bergmann, F. Baumgartner	19th International Photovoltaic Science and Engineering Conference and Exhibition, ICC Jeju, Korea	AIT
May 2010	Analysis of Test Procedures For PV Inverter Performed In The DERab Testing Activities	O. Perego, P. Mora, N. Hinov, T. Hristov, A. Krusteva, G. Romanovsky, D. Geibel and other DERlab experts	Elektronika 2010, Sofia, Bulgaria	RSE
September 2010	Bringing together international research on High Penetration PV in Electricity Grids. The new Task 14 of the IEA-Photovoltaic Power Systems Programme	R. Bründlinger, C. Mayr, H. Fechner, M. Braun, K. Ogimoto, K. Frederiksen, B. Kroposki, G. Graditi, I. F. MacGill	25th European PVSEC, Valencia, Spain	AIT

DERlab e.V.

Building up the association

With the foundation of the non-profit association "European Distributed Energy Resources Laboratories" (DERlab) in 2008, DERlab partners sealed their co-operation and to continue to jointly use the laboratory infrastructure and exchange research results, personnel and know how.

According to its statutes, the purpose of the DERlab association is to achieve a more environmentally sustainable power generation by supporting the transition of energy supply systems towards more decentralized power generation. The association pursues its purpose by fostering and maintaining the exchange of scientific information and views and by training of its members as well as by organizing events for knowledge transfer.

In 2010, the association's office was established at the premises of Fraunhofer IWES. Three people have been employed to take care of the daily business and the internal co-ordination of the association. Dr. Debora Coll Mayor took over the general management that used to be led provisionally by Dr. Thomas Degner from Fraunhofer IWES. Thus, the activities will continue also after the termination of the European project "DERlab – Network of Excellence".

R. Bründlinger (AIT, Austria), M.-L. Rizzi (RSE, Italy), P. Strauß (IWES, Germany) (from left to right)

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