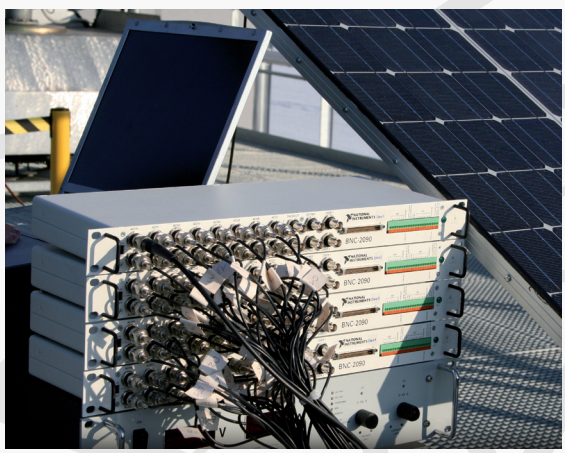
DERlab

European Distributed Energy Resources Laboratories

Activity Report 2011 to 2012



European Distributed Energy Resources Laboratories

Activity Report 2011/2012

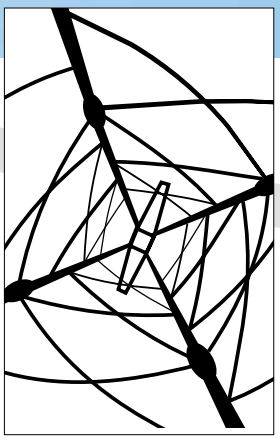
Including the final report of the EC Network of Excellence 2005-2011 DERlab

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 decentralised power generation.



Preface

As a well-established international association, DERlab e. V. defines itself as

> a supporter for a harmonised integration of distributed energy resources to the grid.

The association's researchers and laboratory infrastructure offer the necessary expertise and equipment in a coordinated manner, thereby fostering the transition to a sustainable power supply.

As proof of the success of the last six years of cooperation within the network of excellence, the DERlab association along with its sixteen world-class member institutes has become an important player in the international arena of Distributed Energy Resources and Smart Grids.

For this accomplishment we acknowledge the support of Dr. Wiktor Raldow, Dr. Manuel Sánchez-Jiménez and Dr. Patrick van Hove from the European Commission and Prof. Juergen Schmid from Fraunhofer IWES (formerly ISET). We would also like to also thank the coordinator of the DERlab NoE, Dr. Thomas Degner (Fraunhofer IWES) and all project partners as well as the DERlab office staff for their strong commitment.

After the completion of the DERlab Network of Excellence project at the end of October 2011 the association will continue its successful work.

> The DERlab Association will continue its activities in pre-standardisation, pre-normative research and knowledge dissemination by actively supporting the technical work of European standardisation bodies as well as by enhancing the collaboration among world-class laboratories working in the field of Smart Grids and Distributed Energy Resources.

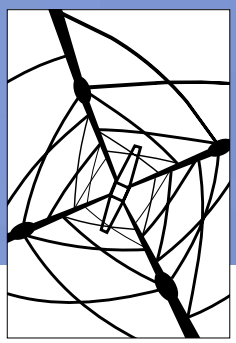
These activities were also acknowledged in 2011 by CENELEC, the European Committee for Electrotechnical Standardisation, which appointed DERlab as an official Technical Liaison Partner.

We are pleased to announce that numerous membership applications from high class laboratories from around the world have been received in 2011. DERlab will officially welcome new members in the near future.

This 3rd DERlab activity report serves as a record of key activities in science and networking amongst the contributors of the DERlab project and the members of the association *European Distributed Energy Resources Laboratories (DERlab) e. V.*

Roland Bründlinger
Spokesperson of the
Board of Association

Dr.-Ing. Philipp Strauss
Head of DERlab NoE Governing Board
Member of Board of Association
and Former Spokesperson



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Foreword

As a consequence of the Fukushima nuclear disaster the German government reconsidered its national Energy strategy. On June 6th 2011 the government announced that the share of renewable energies in electricity generation should reach 80 percent by 2050 and that the last German nuclear power station is to be shut down in 2022. Meanwhile at European level, Smart Grids appear in the legislation, for example with the smart grids mandate M490 or the smart metering mandate M441. Also in the US Smart Grid activities have been launched to modernise the nation's electricity grid.

These are only a few examples showing the increasing effort taken by countries worldwide to support the transition of the current power systems towards those that are increasingly based on renewable energies. No wonder, since this is an enormous shift from the old power grid that was originally designed to deliver electricity from the generating units to the end consumer. A large amount of electricity is produced today by millions of smaller power generators which has lead to the need for a new distribution power system concept and is, of course, technically challenging.

The speed of change is well depicted by the fact that distributed photovoltaic stations have been installed with their total output of 17 GW by last year – and this number only in one country, Germany. In order to take full advantage of these distributed power systems and to ensure the power security, necessary standards and regulative norms, strong scientific research for testing the new concepts and ideas are urgently needed in all fields of the Smart Grid related activities. If the requirements of DER grid interconnection are not properly defined, a shutdown of the distributed photovoltaic system stations could potentially lead to the blackout of the surrounding power grid. Many technical questions in distribution systems such as power supply and storage interconnection need to be solved urgently.

> The German example demonstrates the speed of the transformation: A total installed power of 17 GW from distributed photovoltaic systems had already been integrated in the power grid by 2010.

In order to modernise the interconnected European power grid in an efficient and sustainable way, international cooperation is needed more than ever. DERlab is a network of high-class laboratories from EU member states complemented by strong international members providing a platform for common research and knowledge transfer around Distributed Energy Resources, renewable energies and their interconnections and interoperability. These activities support the more decentralised power generation that will lead to a future less dependent on our limited energy resources.

Dr. Thomas Degner,
Fraunhofer IWES
Project Coordinator
DERlab – Network of
Excellence

Dr. Diana Craciun
Research Coordinator
European Distributed
Energy Resources
Laboratories (DERlab) e.V

"How are the smart grids today, Mr. van Hove?"

Interview with Dr. Patrick van Hove, Research Program Officer at the European Commission, who has been involved with research programs in the European Commission since 1988. He is currently working in the smart grids field.

Text: Sini Numminen
Layout: Taina Numminen
Photos: Juha Roininen / EUP-Images

How smart are European electricity grids?

Basically the term Smart Grids refers to the process of modernising the electricity networks. Many industries such as banking, travel or communication have already gone through this kind of a smart evolution but the electricity networks have been a little bit more hesitant, partly because they have been functioning quite well up to now. In order to integrate more renewable energies, so that most of them will be distributed, we need a much more complex system and new technologies, such as sensors for measuring energy consumption as well as intelligence for deciding how to tune the production. We expect this to be a long-term evolution.

On a scale of one to ten, at which step are we now with this evolution?

Maybe at step three or four. The first step is the realisation that something has to be done. In the second step we realise what needs to be done and, in the third step we know now, that who needs to act and how. Of course, research has been carried out in parallel for quite a while. We do have most of the elements of smart grids but we still need to demonstrate how they all work together.

How about the 20-20-20 targets in general, are we able to reach them?

I think we are well on track of reaching the target of 20 % renewable energy resources and the target of reducing greenhouse gas emissions by 20 %. More difficult to achieve is the 20 % energy efficiency target. Many solutions are available for improving efficiency, but we do not have binding targets at this point in time. The Commission recently published a communication Energy Efficiency Plan 2011 suggesting some ways forward.

Are there any countries more advanced in introducing Smart Grids?

An interesting factor is that different countries are advanced in different parts of the puzzle. Denmark, for example, has made great advances in installing many variable renewable power generators per inhabitant. Germany and Spain are also advanced in this area. Italy and Sweden have already installed smart meters for most of their customers and the UK has done many experiments in market-liberalisation. Several smaller countries experience large cross-border transfers of electricity.

What is the importance of European cooperation here?

I am happy to see that many smart grid stakeholders are now cooperating across borders. Transmission and distribution operators, product manufacturers and energy regulators have all strengthened their willingness to work together. Networks of excellence, such as DERlab, are one of the ways to progress the concept of the European research area and to fight fragmentation in Europe by trying to create enduring cooperation amongst the research actors.

With which concrete actions does the European Commission promote the deployment of Smarter Grids?

The SET-plan is an example of concrete action in the field of research and deployment of low-carbon technologies. This plan looks at how key factors such as different generation technologies, grid connections and energy efficiency would support the climate and energy goals. The European Energy Research Alliance (EERA) is the contribution of national energy research centres to the SET Plan. These centres have committed to work together on a number of joint programmes, including the one on smart grids.

How could DERlab support its activities?

Since the expertise of DERlab covers one important part of smart grids, it could, for example, be an important building block in the joint programme of smartgrids. If similar joint programmes were created in the future in other fields, DERlab could bring its precursor experience in figuring out which measures ensure that laboratories co-operate fruitfully and beneficially.

Could you name one standard that is most crucially needed in the smart grids context?

Standardisation is important for the deployment of smart grid technologies, so that manufacturers do not need to tailor their development for every single country and networks have a choice of different providers. The most urgent standard is perhaps the one on smart meters, and it is progressing well. In the recently published third energy market package, member states are required to install smart meters for 80 % of customers by 2020 so this standard is rather urgent now.

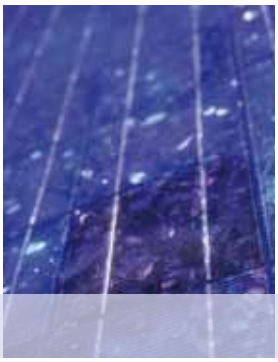
How will smart grids be accepted by the general public?

Public engagement is a very crucial aspect. I wish the general public would widely accept smart grid technologies, in the same way as they have adopted mobile phones. For smarter grids quite a level of automation needs to take place and this has made some people afraid that their privacy would be affected. Thus, the public needs to be made aware of the benefits, as well as of the promises. Booklets that are tainted by technological terms are not sufficient. We have to be able to explain that in our world of finite resources we have to find a way for each one of us to contribute to the efficient use of resources. Smart grids are an important tool in helping us to achieve this.

"STANDARDISATION IS IMPORTANT FOR THE DEPLOYMENT OF SMART GRID TECHNOLOGIES, SO THAT MANUFACTURERS DO NOT NEED TO TAILOR THEIR DEVELOPMENT FOR EVERY SINGLE COUNTRY"

Research for the future:

Smart Grids with Millions of Distributed Power Units


DERlab is a European association of independent laboratories working on the integration of distributed energy resources into electricity grids.

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 decentralised power generation. The association pursues its purpose by fostering and maintaining the exchange of scientific information and views and by training its members as well as by organizing events for knowledge transfer.*

During the six years of cooperation, the member institutes have, for example, prepared an international white paper dealing with future requirements for static converters that can contribute actively to a smart operation of the power systems considering in particular ancillary services, disturbed network conditions, and control and communication requirements.

The DERlab network has developed interconnection requirements for decentralised energy resources (DER) as well as testing procedures for power system services.

The DERlab standard on long term PV outdoor tests represents one of the pre-standardisation activities performed within the association.

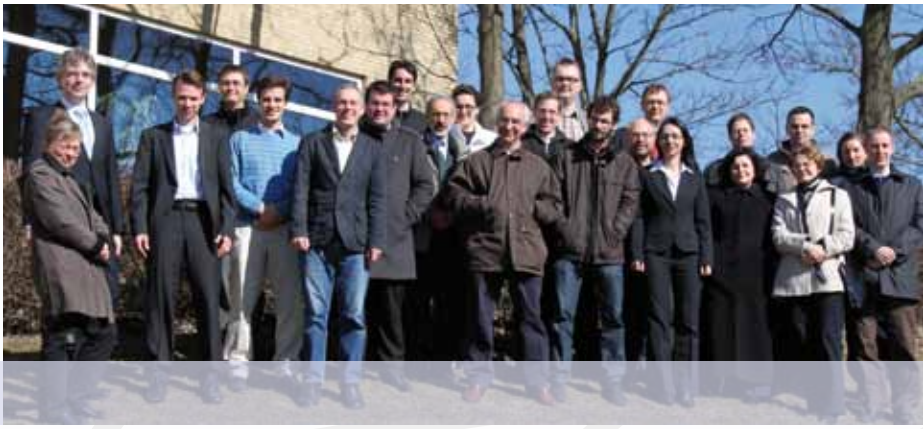
DERlab Background

One of the first Smart Grid projects was European DISPOWER, funded under the 5th Framework Programme of the European Commission (EC). DISPOWER contributed to the further development of technology in integrating small and distributed generators into the electricity distribution grid. Particularly, DISPOWER identified the need for clustering the international expertise on distributed energy resources.

The large project cluster IRED connected several European smart grid projects and has supported cross-cutting activities in research and pre-standardisation since 2004. It contributed to the set up of the European Technology Platform on Smart Grids.

In this context, the EC enabled the establishment of a European Network of Excellence (NoE), dealing with the sustainable grid integration of DER. European Network of Excellence of DER Laboratories and Pre-Standardisation – DERlab was launched in 2005, with one of its major goals being to create a sustainable legal entity. The association European Distributed Energy Resources Laboratories (DERlab) e. V. was founded in 2008.

Milestones



2005

European Community project **Network of Excellence – DERlab** starts its activities in pre-standardisation, joint research and knowledge dissemination

2008

Association **European Distributed Energy Resources Laboratories (DERlab) e. V.** is founded by 11 leading European DER research institutes

2009

International **White Book** on the Grid Connection of Static Converters published

First **seminar for PhD students** organised in Athens

Round-robin **tests of photovoltaic inverters** were performed in 8 DERlab laboratories

2010

University of Strathclyde becomes the 12th member of the association

Training course for industry takes place in Manchester on network protection

2011

New member institutes in Finland, the U.S., Belgium and Luxembourg

Establishment of the **official technical liaison with CENELEC TC8X**

Publication of the **DERlab standard** on long-term testing of photovoltaic modules

General assembly in Roskilde, Denmark in 2011. Photo: Risø

Member Institutes of DERlab

Member List (September 2011)

Fraunhofer IWES	DE
University of Manchester	UK
KEMA Nederland BV	NL
TECNALIA Research & Innovation	ES
Austrian Institute of Technology (AIT)	AT
National Technical University of Athens (NTUA) Institute of Communication and Computer Systems (ICCS)	EL
Commissariat à l'énergie atomique et aux énergies alternatives CEA The French National Institute for Solar Energy (INES)	FR
Technical University of Sofia Research and Development sector (TUS R&DS)	BG
Technical University of Łódź	PL
Ricerca sul Sistema Energetico – RSE	IT
Technical University of Denmark Risø National laboratory for Sustainable Energy	DK
University of Strathclyde	UK
VTT Technical Research Centre of Finland	FI
University of Luxembourg Interdisciplinary Centre for Reliability, Security and Trust (SnT)	LU
K. U. Leuven for EnergyVille	BE
Sandia National Laboratories, New Mexico Distributed Energy Technologies Laboratory	US

General Assembly 2011: New members from four new countries

DERlab aims to cluster the best European DER laboratories from each EU member state.

The founding members of the association were the partner institutes of the EC project DERlab – the Network of Excellence. In March 2011 the association accepted four new members from four new countries that will all bring their valuable expertise to the network.

While VTT Technical Research Centre of Finland provides multifunctional environments for researching the technical solutions and products for distributed energy systems, the Interdisciplinary Centre for Reliability, Security and Trust at the University of Luxembourg will bring expertise in the field of reliability and security of information and communication technology.

The new member from Belgium is K.U. Leuven for the new knowledge institute EnergyVille, that was recently founded by K.U. Leuven and Vito for innovative research in green energy and energy technology.

The fourth new member is Sandia National Laboratories from the USA. It is DERlab´s first non-European member institute and conducts research to integrate emerging energy technologies into new and existing electricity infrastructures.

Pre-standardisation and Networking

The standardisation of the grid interconnection requirements for distributed generators, storage units and controllable loads, generally known as Distributed Energy Resources (DER), is an urgent matter, as nowadays the significant penetration rate of such units in the electricity grids leads to important changes in its dynamics.

The future grid requirements ensuring its appropriate operation foresee DER ancillary system services as a prerequisite for their interconnection.

DERlab speeds the DER compliance with these requirements by developing appropriate harmonised test procedures for the necessary quality assurance.

	DERlab members are represented in the 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

DERlab to support European Electrotechnical Standardisation: Establishment of a technical liaison with CENELEC TC 8X

The technical expertise of DERlab has been acknowledged by the CENELEC Technical Board, which awarded DERlab official "Technical Liaison Partner" of the committee TC 8X in 2011.

CENELEC develops European standards and harmonisation documents in electrical engineering. Its technical committee TC 8X prepares and develops standards on system aspects of electrical energy supply. The DERlab representative will attend the technical meetings of the committee and coordinate communication among the network members.

Completing the European grid codes

Given the intermittence and difficulties of DER observation and control, the absence of harmonised interconnection standards has been identified as one of the most critical obstacles towards the wide deployment of DER and for the change towards active distribution electricity networks.

In this respect, the European Network of Transmission System Operators for Electricity (ENTSO-E) is elaborating new network codes as part of the European transition towards a harmonised set of grid code requirements. DERlab shared comments on the working draft concerning *"Requirements for Grid Connection applicable to all Generators"* on topics with regards to DER grid interconnection.

DERlab's approach: Networking and assessing future needs

Sharing of information and expertise on standardisation and roadmap developments is the added value brought by the DERlab Network of Excellence. The member institutes of DERlab actively participate in the national standardisation processes and in several international standardisation committees under IEC and CENELEC. On behalf of the Association's networking activities, the normative situation at European level is assessed, international gaps are identified and harmonise, and requirements and guidelines are being provided to the European standardisation bodies for the further development of European standards related to electricity grids.

Pre-standardisation




Work on the Interconnection requirements

DERlab contributed actively to the recent standardisation projects pursued by working group 3 of CENELEC TC 8X. With respect to the European standard EN 50438 *"Requirements for the connection of micro generators in parallel with public low voltage distribution networks"* DERlab coordinated the comments on the recent draft revision by bringing together the expertise and visions of the different partners.

From the very beginning, DERlab experts have also been actively involved 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 harmonised technical specification for the connection of larger DER to the European electricity grids.

DERlab Guide: Electromagnetic compatibility (EMC) of Distributed Energy Resources (DER)

In order to improve the quality of supply in the electricity grid and reduce possible malfunctioning of equipment due to nearby electrical or electronic systems, DERlab supported the ensurement 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 DERlab partner expert. Edition 1 of this Technical Report is in its final stage; the Draft Technical Report was sent to the National Committees at the end of March 2011 for voting.

In parallel, DERlab prepared a comprehensive guide "Electromagnetic Compatibility for Distributed Energy Resources". The Guide emphasised the legal procedure for EMC certification according to the European EMC Directive (2004/108/EC), revising also the diverse requirements specified by a broad range of standards for the different electromagnetic phenomena. The 2nd edition of the guide was released in 2011 and is available online on the web page of DERlab.

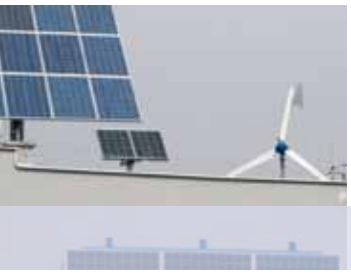
Measuring the meteorological PV testing conditions at the laboratory of CRES in Greece

Participants in the PV workshop 2011 in Kassel, Germany

Premises of CEA-INES in France, Photo: Jean Claude Rifflard

High penetration PV Systems at the Distributed Energy Technologies Laboratory (DETL) in New Mexico, the US

DERlab standard on PV outdoor tests

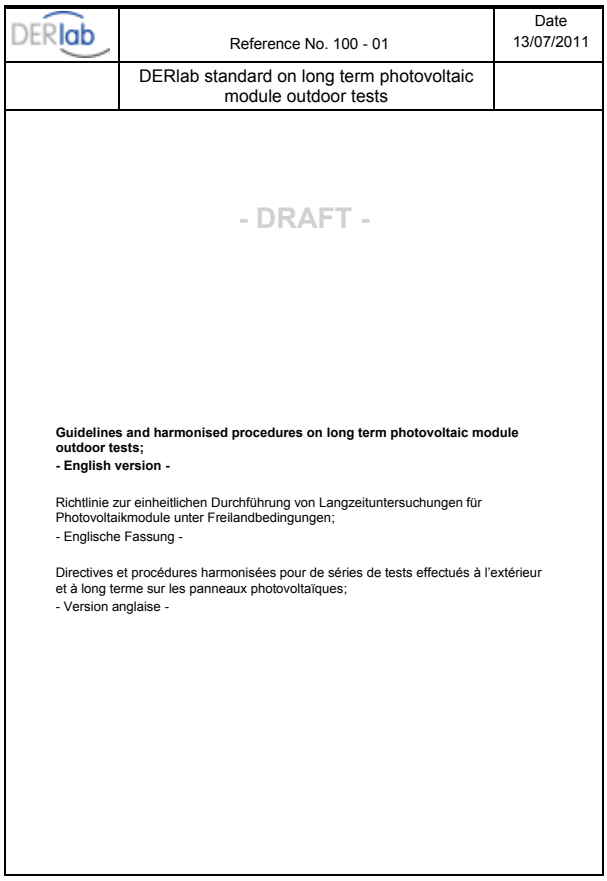



Quality standard for outdoor tests allows Reliable Benchmarking of Photovoltaic Modules

DERlab Standard on testing of photovoltaic modules answers PV industry needs for a common testing standard. The standard is developed with the support of the PV experts of DERlab partners.

The standard enables direct comparison of specific energy yield of different PV modules tested in different locations for at least one year. Optionally, the seasonal effects and the influence of weather conditions on the PV modules performance can be evaluated.

Directly before its final publication, DERlab hosted a workshop where over 20 PV experts from academic institutes and industry contributed to the DERlab standard. The workshop was an official side event of the ISES Solar World Congress in Kassel, Germany in August, 2011.



DERlab	Reference No. 100 - 01	Date 13/07/2011
	DERlab standard on long term photovoltaic module outdoor tests	

- DRAFT -

Guidelines and harmonised procedures on long term photovoltaic module outdoor tests;
- English version -

Richtlinie zur einheitlichen Durchführung von Langzeituntersuchungen für Photovoltaikmodule unter Freilandbedingungen;
- Englische Fassung -

Directives et procédures harmonisées pour de séries de tests effectués à l'extérieur et à long terme sur les panneaux photovoltaïques;
- Version anglaise -

PV tested on the roof of Technical University of Łódź in Poland

PV testing equipment of Fraunhofer IWES in Germany

PV tested at the Austrian Institute of Technology

Participants of the PV workshop 2011 in Kassel, Germany

DERlab Networking

DERlab participates in several international research projects and networks, as well as in conferences in the field of renewable and distributed energy resources.

DERlab active in European Energy Research Alliance (EERA)

The European Energy Research Alliance (EERA) was established in support of the Strategic Energy Technology (SET) plan of the European Commission. Having strong knowledge in SmartGrids pre-standardisation and testing procedures, DERlab will support the research activities of EERA. Official terms of partnership will be decided upon by the end of 2011.

International Conference on Integration of Renewable and Distributed Energy Resources

Albuquerque, New Mexico (US), 2010

A pre-conference workshop *Research and Development Collaboration for Distributed Generation (DG) Ready Grid Architecture* was organised by DERlab in collaboration with Sandia National Laboratories (USA) and Public Service Company of New Mexico (USA). Necessary research and future standards for new grid architecture were discussed with several case studies from all around the world. The presentations are available in the website of DERlab.

The 4th *International Conference on Integration of Renewable and Distributed Energy Resources* is a major platform for the exchange of knowledge, deployment experience and research results in Europe, North America and Asia. The conference has been supported by DERlab since its initiation. The 5th DER integration conference will be held in Europe, in Germany in 2012.

American and European SmartGrids researchers and developers in a collaborative meeting of EERA and the U.S. Department of Energy in Colorado (US) in May 2011

The U. S. Secretary of Energy, Prof. Steve Chu, being introduced to the power-hardware-in-the-loop facilities of the University of Strathclyde

DERlab in European Community Research Projects

DERlab association currently participates in the following European research projects.

DERri – Distributed Energy Resources Research Infrastructure provides free access to the best testing facilities for European researchers. External researchers can apply to use facilities of 13 European research laboratories. The partners in the project consortium also conduct joint research activities. DERlab took over the dissemination activities of the DERri project in July 2011.

SOPHIA – PhotoVoltaic European Research Infrastructure forms an umbrella over European photovoltaic research infrastructures. Having 21 partner institutes from 10 countries and covering the whole PV chain from materials research to PV systems, it strengthens the research cooperation around PV in Europe and enables more efficient use of laboratory infrastructures. SOPHIA is supported by the European Commission and will last until 2015. As a project partner DERlab participates in the work with PV module performance tests. An online database on infrastructure for EU researchers is also being compiled by DERlab.

European Smart Grids testing facilities presented by Dr. Coll-Mayor (DERlab e. V.) at the Smart Grids and E-Mobility Conference in Brussels in 2010

Laboratory of CEA-INES in France

Partners of SOPHIA in the meeting in Amsterdam in February 2011

Joint Research

Research activities initiated by DERlab will provide the required technical information on the performance of the distributed power units to be integrated in future smart grids.

Grid Integration of Static Converters

Most electrical grid interfaces of Distributed Energy Resources are realised through inverters and the inverters thus play a key role in the future smart grid.

International White Book on the Grid Integration of Static Converters

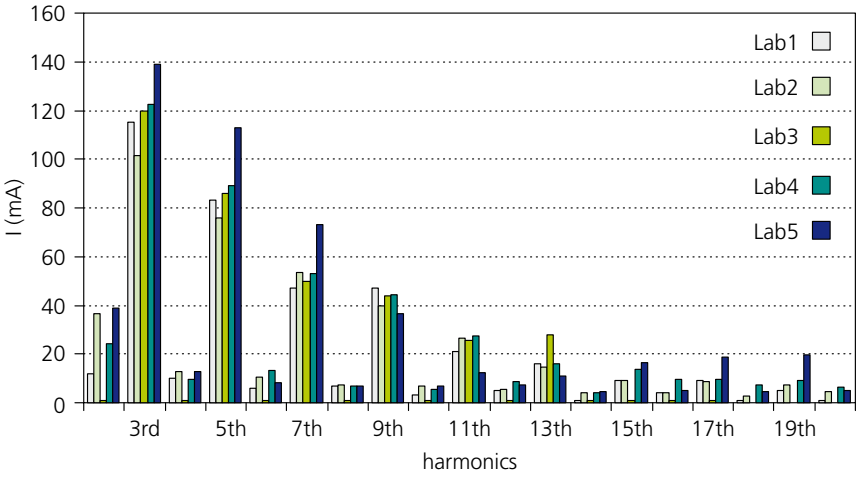
The second edition of DERlab's International White Book on the Grid-Integration of Static Converters will be published in 2011. Covering ancillary services, EMC and power quality, behaviour under fault conditions as well as control and communication, the White Book gives a survey on opportunities and challenges of an elevated number of converters connected to the electricity grid. In particular it highlights the standardisation needs.

In comparison to the first edition, an update to the fault-ride-through behaviour and its testing will be revised. Few requirements have been established because of the strong growth in both photovoltaic and wind installations within recent years.

The White Book as well as conference papers, where the work has been presented, are available on the DERlab web site.

Inter-comparison ('round-robin') tests were conducted among different DERlab laboratories for singe-phase photovoltaic (PV) inverters. A common understanding of the differences and remarks collected during the analytic phase of the round-robin yielded the refinement of the testing procedures and the elaboration of suggestions to standardisation committees.

Four mandatory tests were performed: harmonic current measurement, DC current injection, anti-islanding and PV leakage current protection. The tests and the DERlab procedure are presented in the annual report 2008 to 2010.



First 20 harmonics measured in different laboratories (P/Pn=0,5)

Power System Services from Distributed Units

Power system services are required for the proper operation of the power system. In the future grid, a significant part of ancillary services will be provided from a large number of small contributor units that are distributed in the grid.

DERlab has developed a procedure to test the contribution to the power system services provided by the aggregated response from a huge number of DER units based on a common request signal, broadcasted to all the units. The method enables testing aggregated response under real conditions in a 'noisy' environment.

The key assumptions are that the contributions from the individual units may be too low to justify individual two-way communication to all units, and that the number of active units is too high to test all the units in a controlled environment.

The method has been also elaborated in public workshops (at the Microgen conferences 2010 and 2011 at the University of Strathclyde, UK and in the SmartGrids and E-Mobility Conference in Brussels, Belgium in 2010). The method has recently been presented in an IEEE Smart Grid Transaction article and will later be presented in a DERlab White Book.

DERlab common testing event on inverter-coupled generation in the laboratory of Fraunhofer IWES. Photo: Heidi Grell

Joint Research




Grid-Connected Storage

Storage and storage systems interconnected to the electricity grid are needed, when a higher number of DER and RES are integrated in the power grid. Energy storage will increase its flexibility and reliability, providing ancillary services and supporting DER deployment.

European White Book on Grid-Connected Storage

In spite of several studies on the possible applications of storage, and of several on-going demonstration projects, important information is still missing. Issues such as technical requirements, especially interconnection issues, tariff structures and more generally economic aspects, test procedures for selecting storage, etc. are still unclear.

The White Book is a contribution to the better deployment of storage systems as a whole as seen from the grid (including converters) rather than any individual device or application. The book not only tackles complex technical issues such as requirements on interconnections, or test procedures for selecting a suitable storage technology, but presents also clarifications on tariff structures and other economic aspects.

The paper has been elaborated in a series of workshops held at conferences on storage systems, where experts were given the possibility to contribute to the paper. The White Book will be presented at the IRES conference 2011.

Facilities of CEA-INES

Power-hardware-in-the-loop

Since the technical integration of DER has a more profound impact on the grid stability, reliability and availability, it is no longer sufficient to only test and validate individual power components. Instead, the whole complex system should be tested.

Hardware-in-the-loop (HIL) is an approach that combines simulation with hardware experimentation. It distinguishes the testing of Control-HIL, such as protection relays, power converter controllers and power quality regulators from Power-HIL, the individual power devices. This approach allows equipment to be validated in a virtual power system under a wide range of realistic conditions, repeatedly, safely and economically.

European White Book on Real-Time Power-Hardware-in-the-Loop testing

The European White Book on Real-Time Power-Hardware-in-the-Loop testing is the most recent White Book of DERlab. It has been written and compiled by the experts from KEMA, the University of Strathclyde, AIT, ICCS-NTUA and IWES. It serves as a reference document for testing electrical power equipment in the future, with specific focus on the emerging HIL activities and application thereof within testing facilities and procedures.

The book gives an outlook of how this powerful tool can be utilised to support the development, testing and validation of specifically DER equipment. It aims to report on international experience gained thus far and provide case studies on developments and specific technical issues, such as the hardware/software interface.

DERlab partners performing a joint P-HIL experiment in the AIT Smart Grids laboratory in May 2011

Joint Research

Network protection facing a high share of Distributed Energy Resources

As DER technologies and operating conditions become more complex, novel DER and network protection schemes emerge. Barriers to their deployment are investigated while discussing integration strategies for new protection technologies through effective testing.

International White Book on testing requirements for network protection

A DERlab white book has been produced to provide an informative insight into the issues surrounding the impact of increasing levels of DER on the generator and network protection and the resulting necessary improvements in protection-testing practices. Particular focus is placed on an ever-increasing amount of inverter-interfaced DER installations and the challenges of utility network integration.

Existing protection-testing practices are evaluated for their effectiveness under operating conditions stipulated by international grid codes. Emphasis is made on the importance of dynamic testing that can only be delivered through laboratory-based platforms such as real-time simulators, integrated substation automation infrastructure and flexible, inverter-equipped testing micro grids.

In order to support the issues discussed in the white paper, a comparative case study between UK and German DER protection and scheme testing practices is presented. This also highlights the difficulties associated with standardisation and approval mechanisms adopted by different countries.

Advanced protection testing facility at the University of Strathclyde

Training Courses and Seminars for Young Researchers

Training courses for industrial practitioners

DERlab training courses are designed for technical staff and managers from industry, research and academic staff from educational and research institutions, willing to improve their knowledge on distributed generation.

The Training course at the School of Electrical & Electronic Engineering of the University of Manchester in March 2011 was organised in collaboration with DERlab in the framework of Electric Energy Systems University Enterprise Training Partnership (EES-UETP).

An international group of 20 industrial specialists was introduced to operating principles and main features of protection schemes and the protection principles which will be utilised for the protection of future smart grids. The course provided the knowledge and practical skills necessary to apply these relays and schemes to the protection of power plants and systems.

Examples of recent courses:

"Power Quality Issues in Contemporary and Future Power Networks" (Training course in Manchester, United Kingdom, 2010)

"Advanced Protection of Future Networks with high penetration of DG sources" (Training course in Manchester, United Kingdom, 2011)

International opportunities for academics

DERlab seminars for early career researchers and PhD students are opportunities to exchange knowledge and experience with other European researchers and students.

The seminar hosted by the University of Strathclyde in early spring 2011 was attended by 20 PhD students from eleven different universities or research institutes in Europe. The presentations and discussions included connection arrangements of inverter-based sources, economic aspects of distributed generation, laboratory demonstrations and demand side modelling. The participants were also introduced to the Distribution Network and Protection Laboratory in the university.

Examples of recent courses:

"Integration of Distributed Generation and Distributed Energy Systems into power systems" (seminar for PhD students and young researchers in Athens, Greece, 2009)

"Distributed Generation and Renewable Energy Sources" (seminar for PhD students and young researchers in Glasgow, UK, 2011)

Prof. Vladimir Terzija hosted the Training Course in 2011 at the University of Manchester. Photo: Francisco M. Gonzalez-Longatt

Demonstration at the Laboratory of the National Grid Research Centre, UK, during the Training Course in 2011. Photo: Francisco M. Gonzalez-Longatt

PhD seminar in Glasgow in 2011

DERlab Services:

Testing and Training

Testing services

Characteristics of single devices, such as grid inverters, or their grid compliance can be tested in line with the wishes of the client using the most suitable testing facilities.

PV Module Outdoor Tests

Performance tests can be carried out under different climate conditions according to the DERlab testing standard.

Training courses "DER in contemporary and future world"

DERlab courses are designed for technical and research staff, both from industry and academic institutions, willing to improve their knowledge of Distributed Generation.

Consulting services

With its wide range of international members DERlab has a broadly based technology portfolio and knowledge of local and global regulations.

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Network modelling equipment at TU Łódź

Switching panel of the micro grid testing facility at TU Łódź

On-site measurement field of VTT

Testing Laboratories

Each member laboratory of DERlab is strong in specific DER related areas and together they cover the whole field of distributed generation and smart grids.

The DERlab association offers an access point to the testing capabilities. Testing of the qualifications of system components and products according to standards or customer specifications can be performed.

Pool of testing facilities of DERlab

	High Voltage & High power	Power Quality & EMC	Hybrid Systems & Micro Grids	Power Electronics & Inverters	PV Components & Systems	Wind Components & Systems	Storage Components & Systems	Communication Technologies and Smart Metering	Fuel cell Components & Systems	Biomass system	Electrical vehicles	System Security and Reliabilty	Smart Building & Efficiency in Buildings
IWES		●	●	●	●	●	●	●	●	●	●		●
KEMA	●	●	●	●	●	●	●	●					
AIT	●	●		●	●		●	●					●
NTUA		●	●	●	●	●	●	●					
CRES		●	●	●	●	●	●	●	●				
CEA INES			●	●	●		●				●	●	●
TUS-RDS	●	●	●	●	●	●	●	●					
TU Łódź	●	●	●	●	●	●	●		●				
RSE	●		●	●	●		●	●		●	●		●
RISØ DTU	●	●	●	●	●	●	●	●			●		●
University of Strathclyde	●	●	●	●	●	●	●	●	●			●	
VTT		●	●	●		●	●		●			●	
SnT				●	●		●	●			●	●	●
EnergyVille *)		●		●	●		●				●		●
Sandia (DETL)	●	●	●	●	●		●	●	●			●	
University of Manchester	●	●	●	●	●	●		●					
TECNALIA	●	●	●	●	●	●	●	●	●		●	●	●

*) The new knowledge centre for green energy and energy technology EnergyVille will be fully operational in 2012.

Testing Laboratories

DeMoTec test center in IWES

Fraunhofer IWES

Design-Center for Modular Supply Technologies (DeMoTec) and Test Center for Smart Grids and Electromobility (SysTec) in Kassel, Germany

The DeMoTec and SysTec test centers focus on research and testing of grid integration and interoperability of decentralised generators, storage systems, electrical vehicles and novel energy management systems. In DeMoTec a reproducible hardware simulation of a 90 kVA grid connection and an adjustable direct current source allow accredited testing of grid converters. SysTec comprises an outdoor test field of PV systems and small wind turbines and test stands for low and medium voltage converters as well as mobile containers for system service testing allowing the fault-ride-through tests of electricity generators of up to 6 MVA.

Impression of FPGLab testing facility

KEMA

Flex Power Grid Lab (FPGLab) in Arnhem, The Netherlands

The Flex Power Grid Lab in Arnhem takes a unique position in the world because of the voltage and power range of 24 kV and 1 MVA together with a bandwidth of 2.4 kHz (for harmonic superposition). The laboratory is built around a fully programmable four-quadrant power electronics converter that can either create a grid with a customisable 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.

Inverter test laboratories at AIT

Austrian Institute of Technology (AIT)

Distributed generation laboratory (AIT DG Lab) and Power Service Center (AIT PSC) in Vienna, Austria

The Distributed generation laboratory and the Power Service Center of AIT offer a comprehensive portfolio to test and analyse components and systems from small power electronic converters (up to 30 kW) up to high power and high current devices. The laboratories enable standard test procedures on power system devices and renewable energy components to be performed as well as research and development on hybrid switches, power converters and power system networks. The main activities of AIT DG Lab are the development of solutions for efficient realisation of decentralisation with the focus on "Power Quality and Safety", while the main activities of AIT PSC are providing development infrastructure, focusing on the development of small, efficient and cost effective components.

National Technical University of Athens (NTUA)

Institute of Communication and Computer Systems in Athens, Greece

The microgrid, which has been installed at the National Technical University of Athens, comprises two PV generators, battery energy storage, controllable loads and a controlled interconnection to the local LV grid. Both the battery unit and the PV generators are connected to the AC grid via fast-acting DC/AC power converters. The central component of the microgrid system is the battery inverter, which regulates the voltage and frequency when the system operates in island mode, taking over the control of active and reactive power. The DC/DC converter provides the constant 380 V DC voltage to the DC/AC converter input.

Load controller at the laboratory in NTUA

Center for Renewable Energy Sources (CRES)

CRES Microgrid test site and PV systems Laboratory in Pikermi, Greece

CRES includes laboratories and equipment that are able to cover research activities and services in the field of photovoltaics and distributed generation. This includes the following: PV testing laboratory including solar simulator, climatic chamber and portable I-V tracer for evaluation of PV cells, modules and arrays up to 100 kWp; the power electronics laboratory including PV array and grid simulator, load bank and measuring instruments for inverter testing; the battery testing laboratory including battery cycling equipment, dischargers, water bath and climatic chamber and experimental microgrid including PVs, battery storage, diesel generator, grid interconnection and SCADA system used for research in the field of microgrids, smartgrids and distributed resources.

Measuring the meteorological PV testing conditions at CRES's facilities

Commissariat à l' énergie Atomique et aux énergies alternatives (CEA)

The French National Institute for Solar Energy (INES) in Savoie, France

The R&D activities at INES cover PV and solar thermal energy, including storage, from the materials to components and systems up to energy-efficient buildings. A demonstration platform allows the performance assessment of components, systems and models. The experimental platforms offered by INES include STORE, which allows testing and validation of storage technologies (especially electrochemical) and their management strategies and, PRISMES which is a modular platform for testing and evaluating of DER systems up to 100 kW. Its AC and DC microgrid networks cover the whole INES campus, which includes 4 experimental energy intelligent houses.

Battery test bench and climate chamber for performance and lifetime testing of Li-ion batteries

Testing Laboratories

Testing equipment of PV modules at the Power Electronics Laboratory

Technical University of Sofia

Technical University of Sofia Research and Development Sector (TUS-RDS) in Sofia, Bulgaria

TUS RDS offers four experimental installations as a complex for testing electrical equipment HV/MV/LV, model representation of DER devices and electrical network regimes; the Power Electronics Laboratory (PEL), the Advanced Control Systems Laboratory (ACSL), the Renewable Energy Sources Laboratory (RES) and the High Voltage Laboratory (HVL). New hybrid installation was installed in 2011 in the PEL laboratory: 6 PV modules Sharp ND-175, system power 1,05 kWp, inverter Sunny boy 1200; Sunny Island 2224, Sunny sensor box, Sunny web box, storage, DC line, AC line, controllable DC and AC loads, monitoring with internet connection, network-connected and island operation.

PV and wind test fields in TULodz

Technical University of Łódź

Laboratory of Distributed Generation in Łódź, Poland

Laboratory of Distributed Generation serves for testing the integration of distributed generation with the distribution power networks. The laboratory network is built based on the model of the distribution MV / LV network with a nominal power of 70 kVA. Using the crossing panel one can build multiple variants of the low voltage network arrangement with all the devices interconnected to any node. An additional device installed in the crossing panel can perform one, two or three-phase short-circuit for a specified duration causing different voltage dips and enabling testing.

Electric vehicle recharging station, powered by renewable energies at RSE

Ricerca Sistema Energetico – RSE

Distributed Energy Resources Test Facility (DER-TF) and Demand Side Management Experimental Houses (DSM-EH) in Milan, Italy

RSE offers two experimental installations: DER-TF consists of a LV microgrid, connected to the main grid with a LV/MV transformer. It is constituted of several generators with different technologies (renewable and conventional), controllable loads and storage systems, including electric vehicles. The maximum available electrical power can reach 350 kW (with 250 kW thermal power). Due to its configurable architecture and its programmable control system, DER-TF allows users to perform tests on single DERs and equipment and on new control algorithms. The central element of DSM-EH is a Home Energy Manager and gateway, combining signals received from retailer (tariffs), distributor and user preferences regarding comfort and energy saving. This facility makes it possible to carry out several tests on different energy management strategies, but also simulates the user presence.

Technical University of Denmark (DTU)

Risø National laboratory for Sustainable Energy in Roskilde, Denmark

The SYSLAB research facility is a full-scale distributed laboratory for experimental testing of distributed, intelligent power systems with real power system components. It is based on an 3-phase 400 Vac micro grid which can be operated in isolated mode or connected to the public distribution grid. SYSLAB is constantly developed and extended. Core of the SYSLAB concept is the idea of a universal modular communication & control node unit – containing a standard computer, data storage, measurement hardware, I/O interfaces, backup power and an Ethernet switch – combining SCADA and distributed intelligence and control.

Testing in SYSLAB. Photo: Torben Nielsen

University of Strathclyde

Distribution Network and Protection Laboratory (D-NAP) in Glasgow, United Kingdom

The Institute for Energy and Environment at the University of Strathclyde offers the experimental facility "Distribution Network and Protection Laboratory", D-NAP. This comprises a 100 kVA microgrid that can operate grid connected, or variously islanded, integrated with a real-time digital network simulator and protection injection laboratory. The facility offers a power hardware-in-the-loop capability, and incorporates various programmable loads and generators. A number of different substation computing platforms facilitate the deployment and testing of new communication and distributed control solutions. The University of Strathclyde is also constructing the Power Network Demonstration Centre adding the facility to demonstrate and test within a flexible 11 kV network.

Testing facilities in D-NAP

VTT Technical Research Centre of Finland

MultiPower Research Environment in Espoo, Finland

At the VTT MultiPower research environment, new technical solutions and products for distributed energy system can be tested in a multifunctional environment. Using several interconnected but independent testing facilities, control and loading concepts as well as energy storages of different sizes and technologies can be tested. The testing environment is connected to the distribution network by a transformer. The whole system is equipped with control and measuring systems so that the result is a unique small scale DG development platform. Testing possibilities cover development, operational, acceptance and commission tests for the distributed generation products and systems. Both electrical and thermal energy testing possibilities are available.

Switchgear in VTT

Testing Laboratories

Interdisciplinary Center for Security, Reliability and Trust (SnT)

NetPower DEmoLAb in Luxemburg

NetPower DemoLab is a research environment focusing on topics such as reliability and vulnerability of electricity networks, secured design of distributed grid control, geo-integration of renewable energies and distributed generation and optimal dispatching in partgrids. NetPower DemoLab is devoted to the integration of most diverse components, exchanging grid state and internal information and meta data through Supervisory Control Data Acquisition (SCADA) systems. For the physical quantities digitalised and processed by microcontrollers and the aggregated information sent via a communication link to the other ICT (Information and Communication Technologies) nodes, there is a high diversity in hardware and software components on all levels.

EnergyVille in Genk, Belgium

EnergyVille will be a knowledge-centre focusing on green energy and energy technology which at its start will host some 200 researchers. The following laboratories will be available in the infrastructure; Control space smart grid, lighting, storage (electric - batteries & heat), hybrid drive train, thermotechnical lab and climate room. The technological developments within Energyville will promote related business development and the creation of spin-offs. Energyville will bring together the strengths and expertise of its founders, K.U.Leuven and Vito with the aim of answering prominent ecological and energy-related questions, and promoting innovation and economic development for the region and the world. Energyville will be fully operational in the summer of 2012.

High penetration PV Systems at DETL

Sandia National Laboratories

The Distributed Energy Technologies Laboratory (DETL)
in New Mexico, USA

DETL conducts research on the integration of emerging energy technologies into new and existing electricity infrastructures and the accommodation of the nation's increasing demands for clean, secure, and reliable energy. The generation sources include 130 kW of multiple grid-connected PV arrays, a 30 kW microturbine, a 75 kW diesel genset, fuel cells, and additional interchangeable generators. Storage capabilities include a 500 kWh lead-acid battery bank, along with several additional batteries of smaller size. More than 350 kW of programmable resistive loads are combined with programmable inductive, capacitive, and motor loads. This equipment is available for use on both a three-phase 480 V microgrid and a 240/120 V single-phase microgrid to test various arrangements of distribution grid models and interoperability scenarios.

University of Manchester

National Grid High Voltage Research Centre in Manchester, United Kingdom

The National Grid High Voltage Research Centre at the University of Manchester contains the following equipment: 2 MV impulse generator, 800 kV AC test set, 600 kV DC test set, 20 kVA high current source (configurable to maximum current of 10 kA), salt fog and environmental test chambers, modern digital measurement equipment in addition to material processing and characterisation equipment. The laboratory also has equipment for use in the testing of power system protection and power system communications. This includes a real time digital simulator (RTDS) in which devices can be tested in real time.

2MV impulse generator

TECNALIA

TECNALIA RESEARCH & INNOVATION in Derio, Spain

The Centre for Development and Demonstration of DER technologies of TECNALIA has different generation and storage devices and several loads, with a manageable power of 250 kVA. The facility deals with the connection, integration and validation of technologies related to DER, as well as with the operation and control strategies of the entire microgrid. It is possible to connect, disconnect, and operate the different systems, allow testing of equipment, assess operation and control algorithms, and evaluate the impact and consequences for the network. The microgrid equipment includes generator sets, network simulators, storage devices, loads, power converters, a microgrid switching and connection system and an electrical vehicle platform.

Laboratory of Energy Efficiency in Buildings and wind turbine prototype for urban environments in TECNALIA

EC Network of Excellence

Final Activity Report

SIXTH FRAMEWORK PROGRAMME

Between 2005 and 2011, 11 research institutes from 11 European countries collaborated in a European funded project "European Network of Excellence of DER Laboratories and Pre-Standardisation".

This section provides a summary of the activities performed and results achieved within the frame of the EC project. An overview of the work programme is given here, while a more extended description of the results achieved can be found in the other parts of the report.

The project DERlab's scopes and overall objectives

- Setup of distributed, independent world-class DER laboratory for Europe
- Support the development of European and international standards
- Achieve durable networking between European laboratories

DERlab's intention is to provide support for the sustainable integration of renewable energy sources (RES) and distributed generation (DG) in the electricity supply by describing common requirements, developing quality criteria, and supporting international pre-standardisation activities. In particular the network is working on test and certification procedures concerning connection, safety, operation and communication of DG components and systems.

Project Partners

- Fraunhofer Institute for Wind Energy and Energy System Technology IWES (Germany) (coordinator)
- The University Manchester (United Kingdom)
- KEMA (the Netherlands)
- TECNALIA (Spain)
- Technical University of Denmark, Risoe National Laboratory for Sustainable Energy (RISOE-DTU) (Denmark)
- Austrian Institute of Technology AIT (Austria)
- National Technical University of Athens, Insitute of Communication and Computer Systems (NTUA-ICCS) and Center for Renewable Energy Resources (CRES) (Greece)
- Ricerca sul Sistema Energetico – RSE (Italy)
- Commissariat à l'énergie atomique et aux énergies alternatives, The French National Institute for Solar Energy (CEA-INES) (France)
- Technical University of Sofia, Research and Development Sector (TUS R&DS) (Bulgaria)
- Technical University of Lodz (Poland)
- DERlab e.V. (Germany)

The joint programme of activities

The joint programme of activities (JPA) of the network of excellence comprises the following activities:

Integration activities:

- JPA 1.1: Integration of management and business development
- JPA 1.2: Staff exchange
- JPA 1.3: Common management and sharing of lab infrastructure
- JPA 1.4: Preparation of common research programmes and new projects

Joint research activities:

- JPA 2.1: Grid interconnection and EMC requirements for DER
- JPA 2.2: DER testing procedures
- JPA 2.3: DER white papers

Spreading of excellence activities:

- JPA 3.1 Standardisation, national and international networks
- JPA 3.2 Workshops for industry, DSO, TSO
- JPA 3.3 Common publications and dissemination

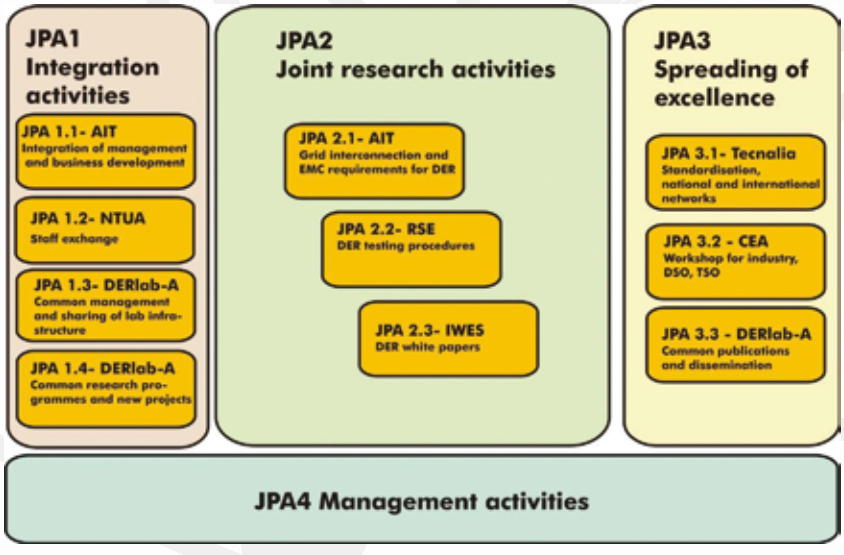
Main Outcomes of the project

Integration

The overall objective of the network of excellence was to establish a durable and long-lasting cooperation and integration between the European laboratories working in the area of distributed energy resources. This objective was achieved by establishing the association "European Distributed Energy Resources Laboratories (DERlab) e. V." as a legal body, which became an active and well known player in this field in Europe. Regular exchange and research activities between the partners took place and the cooperation was strengthened. With the recent extension of the membership the grouping has increased its basis and influence.

Spreading of excellence activities, national and international networking

DERlab established links to many players in the field of DER. Examples are the technical liaison with the European Standardisation organisation CENELEC TC8X and the involvement of DERlab in the Smart Grid International Research Facility Network (SIRFN) – a coordinated network of test beds located in International Smart Grid Action Network (ISGAN) member countries. Furthermore there is a regular international exchange with other laboratories world wide and DERlab is regularly performing workshops as part of the „International Conference on Integration". Besides this further specialists workshops were performed, young researchers and PhD seminars took place and several DER training courses were successfully conducted. Finally DERlab members established their national and regional networks as a platform to strengthen the information exchanges between European and national activities.



Graphical representation of the work programme

Joint Research

Several joint European research activities were performed. Common European standpoints were ascertained, which serve as inputs for international standardization bodies. The results from the joint research activities have been documented and made publicly available as "DERlab technical reports". The most relevant research reports produced within the frame of the European Network of Excellence project are:

- International White Book on the Grid Connection of Static Converters
- European White Book on Grid-Connected Storage
- Testing of Power System Services of DER
- Electromagnetic Compatibility for Distributed Energy Resources (EMC for DER)
- Hardware in the Loop Testing of DER components
- Network protection issues in the face of increased penetration of DER

These reports, as well as other public material are available in the website of DERlab.

We kindly acknowledge the long-lasting support by the European Commission, DG Research and our project officer Dr. Patrick van Hove under Contract SES6-CT-2005-518299.

The project duration was 1.11.2005 until 31.10.2011.

Project Coordination: Dr. Thomas Degner, Fraunhofer IWES, Germany.

EC Network of Excellence

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List of Common Publications

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

Title	Authors	Place of publication	Partners (lead partner in bold)
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, 2008	**AIT**, Berne University of Applied Sciences, Zürcher Hochschule für Angewandte Wissenschaften, Fraunhofer-IWES, Ciemat - Avda.
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, 2008	**IWES**, CRES
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, 2008	**AIT**, Berne University of Applied Sciences, Zürcher Hochschule für Angewandte Wissenschaften, Fraunhofer-IWES, Ciemat - Avda.
DER Laboratory in Institute of Electrical Power Engineering of Technical University of Lodz	R. Mienski, R. Pawelek, P. Gburczyk, I. Wasiak, T. Degner	13th International Conference on Harmonics and Quality of Power in Wollongong, Australia, 2008	**TU Lodz**, IWES
Research Facility of Technical University of Lodz – 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, 2008	**TU Lodz**, IWES
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, 2008	**IWES**, TECNALIA, AIT
Nachweis der elektrischen Eigenschaften von PV-Wechselrichtern gemäß den deutschen Netzanschlussrichtlinien	G. Arnold, T. Degner, R. Bründlinger	Symposium Photovoltaic Solar Energy in Staffelstein, Germany, 2009	**IWES**, AIT
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**, NTUA, AIT
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**, IWES
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, 2009	**CEA**, RISOE, RSE, NTUA, TECNALIA, AIT, CRES, IWES
Demand Side Management in Smart Buildings	T. Romanos, N. Hatziargyriou, J. Schmid	European Conference Smart Grids and Mobility, Würzburg, Germany, 2009	**NTUA**, IWES, TU Sofia
PV for Smart Buildings	T. Romanos, N. Hatziargyriou, J. Schmid, J. Mutale	24th EUPVSEC, Hamburg, Germany, 2009	**NTUA**, IWES, University of Manchester
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, 2009	**AIT**, IWES
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, 2009	**AIT**, IWES

Title	Authors	Place of publication	Partners (lead partner in bold)
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, Lodz, Poland	**IWES**, TU Lodz, NTUA
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, Lodz, Poland	**TECNALIA**, AIT, University of Manchester, RISOE
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, Lodz, Poland	**IWES**, TU Sofia
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