DERlab

European Distributed Energy Resources Laboratories

Activity Report 2012/2013

Working with EU FP7 DERri

DERri

SEVENTH FRAMEWORK PROGRAMME

European Distributed Energy Resources Laboratories

Activity Report 2012/2013

“Many technical problems have to be solved to cope with these challenges and to prepare the interconnected European power grid in an efficient, reliable and sustainable way.“

Foreword

Europe and the rest of the world is heading towards unprecedented changes in the power system caused by the transition to a sustainable energy supply. This is a rather volatile process, with the change in Germany’s energy strategy embarking on an “Energiewende“ and the estimated share of renewables of 80% by 2050, the discovering of large quantities of shale gas in the US, the North sea grid initiative for connecting a large number of off-shore wind power plants and the first thoughts of creating a meshed hybrid (AC+DC) grid to strengthen Europe’s ageing transmission system. At the same time the deployment of smart meters, experiments with active demand and demand response, the rise of Electric Vehicles and the massive installation of solar (PV) systems have become apparent at the distribution level.

From the grid’s perspective, capacity management, voltage control, protection and reliability of the system are the four major issues. The new components, ranging from smart meters and inverters to controllable, flexible DC links and subsystems, will be integrated in the power system and not only call for new regulation and legislation but for new ways of testing to safeguard correct operation and prevent outages. In a recent book by Marc Elsberg, the author illustrates a scenario of the possible consequences of a cyber attack on the energy system, which results in a blackout throughout Europe.

A broad variety of technical issues will have to be resolved in order to cope with these challenges and to prepare the interconnected European power grid in an efficient, reliable and sustainable way. With many of the challenges going far beyond national borders, international cooperation and collaboration are required more than ever before. The DERlab association and its members have long been recognizing these challenges and are working on solutions to ensure the smooth transition towards a sustainable supply. Offering the world’s most comprehensive and diverse range of research and testing services and supported by cutting edge infrastructure in the field of Smart Grids, DERlab member institutes have proven their position as reliable partners for the electricity industry as well as institutional stakeholders.

Celebrating its 5th anniversary in 2013, the Association is looking forward to broadening its member base and taking over a leading role in the global Smart Grid community.

Peter Vaessen
Member of the board of DERlab
DNV KEMA

Roland Bruendlinger
Spokesperson of the board of DERlab
Austrian Institute of Technology (AIT)

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Network Excellence for Smarter Grids

Europe has started a fundamental transformation process of the electrical power supply. The transition towards high shares of renewable energy and the tendency to a more decentralized energy supply requires a smarter grid with sufficient hosting capacity and the ability to manage the power fluctuation of the renewable sources. In order to ensure the stability, reliability and security of the future smart grids, the structural changes and the required behaviour of the power units have to be anticipated in a holistic approach.

"There is a need for extensive standardization of smart grid components behaviour. The European smart grid laboratories accelerate and support this standardization process."

There is a need for extensive standardization of smart grid components behaviour. The European smart grid laboratories accelerate and support this standardization process. Within these laboratories a common European understanding of the future European smart grid is being elaborated. This is of key importance for the security and quality of the European electricity supply.

The European Distributed Energy Resources Laboratories (DERlab) e. V., which was founded for such purposes within the frame of the FP6 European funded Network of Excellence (NoE), supports the co-ordination as well as organizes the European access for research activities of universities, research institutes, industry and grid operators, both for training and demonstration purposes.

Dr. Diana Craciun
Research Coordinator of DERlab

DERlab is an association currently connecting twenty research institutes in the field of Distributed Energy Resources (DER) and Smart Grids in sixteen countries from Europe and the United States. With various activities in research, networking and awareness-raising, the association fosters the preconditions of pre-normative research for a more environmentally sustainable power generation in the future. DERlab and its member institutes work together to develop joint requirements and quality criteria for the grid-integration of distributed power generation.

The network conducts and participates in projects dealing with research on DER devices and systems, with the focus on optimization of test procedures and on the development of research infrastructure. DERlab has an official technical liaison with the European standardization body CENELEC TC 8X, actively contributed to the development of EN50438 and to TS50549 and foresees its involvement in the setup of DER-related testing procedures.

In 2012 DERlab has reached an important milestone becoming a key partner of the Smart Grid International Research Facility Network (SIRFN) in the International Smart Grid Action Network (ISGAN) of the International Energy Agency (IEA) by strongly supporting the development of the SIRFN network structure and the definition of its objectives. Furthermore, DERlab has been actively contributing and supporting the activities of the European Energy Research Alliance Joint Programme on Smart Grids (EERA JP Smart Grids) and joined the Secretariat of the Smart Grids European Technology Platform (Smart Grids ETP). One of DERlab's main contributions to the activities of Smart Grids ETP was to support the update of the Strategic Research Agenda (SRA) 2035 by bringing in its own expertise and the coordinated contribution of its member institutes.

From PowerPoint to Power System

Professor Ronnie Belmans: "I want to see real Smart Grid implementation instead of talks and presentations"

The Global Smart Grid Federation gained European management in September 2012, when Professor Ronnie Belmans from KU Leuven, former Chairman of the Belgian Transmission System Operator ELIA, was chosen as the Executive Director. The Global Smart Grid Federation (GSGF) is an industry-based global collaborative effort among fourteen continental, national and regional smart grid associations.

How do different continents look at Smart Grids?

Approaches are distinctly different. In the US, for example, the ICT is the driving technology while in Europe the expectations are put especially on power engineering and automation. In Europe a lot of emphasis is also put on retail market developments, something that we also see in Australia. Japan together with Europe has a strong emphasis on renewables. The basic idea of the smart grid is globally the same, but the centres of gravity are set differently. Currently it is not clear at all which approach will show to be the most efficient.

"In the US the smart grid driver is the ICT while Europe relies on power engineering. It is not clear at all which is the most efficient approach."

International collaboration is very important in this aspect because the Smart Grid is still developing rapidly and a lot of deployment is to a large degree incomplete. We have to learn from each other's mistakes and good practices.

What could the global Smart Grid society learn from Europe?

Europe has the leadership in many smart grid aspects. European countries have top-ranked industrial companies and a developed grid with a lot of renewables already incorporated. We can use this as the export product but also other countries are moving fast. On the other hand, many other countries are picking up quite fast and there are new approaches introduced, like IT approach, which can also be a solution. So in the next 10 – 20 years a lot of new things will be introduced and we, as Europe, should not relax in the current position.

Global Smart Grid Federation report in April 2012 listed three main challenges to smart grid success: renewing the infrastructure, finding the businesses and engaging the consumers. Which one is the most urgent?

These all are very important long-term challenges. In short-term it is urgent to identify which concrete Smart Grid business ideas work and for which reasons.

As an example, there has been a lot of talk about charging batteries in electro-mobility but this idea seems not to take off. The working group of the GSGF on electro-mobility will study this urgent issue and find the reasons why this idea has not worked yet and what can be done to take this hurdle. So attention now should be paid on real feasibility.

This is exactly what the Global Smart Grid Federation wants to address. Our working group on electromobility is studying the reasons that stop very good market ideas from succeeding. We are also collecting successful business examples in different countries and then we bring these results to the global scale, so we can prevent the same mistakes being replicated.

"It is urgent to investigate which Smart Grid business ideas have broken through and for which reasons and spread the knowledge on the global scale."

There are a lot of words and talks about Smart Grids. Also, a lot of research is being conducted, but not enough real business cases are implemented. In other words, we should focus on the implementation –"from PowerPoint to power system".

What are the concrete activities of GSGF?

GSGF continuously updates the status and shares information on Smart Grid developments among the participating countries and regions, which facilitates mutual learning. GSGF has also three global working groups, each of them led by a person from a different economic zone. The group that discuss the integration of small storage and electric vehicles is led by a colleague from Japan. The leader of the group on interoperability comes from the EDSO for Smart Grids from Europe. The third one on the integration of small generation units is led by the US. Thus, all working groups are global, covering three different economic zones. There is continuous knowledge and information sharing through meetings, the website, the newsletter and in March the first joint congress was held in Brussels.

What can Smart Grids bring for the general public?

The essential part is to clearly show what is the added value for the customer. We have to demonstrate that with smart grids we can integrate more renewables at acceptable costs, so that system remains reliable at the same time. Smart Grid can realize the political wish of the public for more renewables, less CO_2 emissions and electro-mobility, for instance. But with the current grid we cannot make such changes in energy supply, so the transition is not yet feasible.

What is your favourite Smart Grid success story?

The dramatic change in the German grid operation in the last five years is an amazing story. The grid still works, with wind and sun integrated at incredible levels. New technology was pushed forward with the impact of solar forecast and wind forecast. The fact that all this happened in the middle of Europe without troubles in the reliability of the European power system is the most stimulating part of the whole story.

What would you like to add?

"No grids – no party". By this I want to say that if the grid development does not keep the pace, other developments will slow down too. We need young people who are interested in the smart grid challenge. Young and experienced people should work together for the benefit of society. And that is what a smarter world is about.

Dr. Ronnie Belmans

- Obtained his PhD at the University of Leuven (KU Leuven) in 1984
- Professor of Electric Power Energy Systems of KU Leuven since 1991
- Head of the Electric Energy Division 1993 – 2012
- Chairman of the Board of Directors of ELIA 2002 – 2010
- Honorary Chairman of the Board of Directors of ELIA since 2010
- Chairman of the European Technology Platform Smart Grids 2010 – 2012
- Executive Director of the Global Smart Grid Federation since 2012

Networking and Dissemination

DERlab becomes key partner in the Smart Grid International Research Facility Network (SIRFN)

Impressions from the conference IRED 2012

A key to advancing the deployment of a smarter electric grid is the development of technologies and systems that function effectively in a variety of grid environments and locations. In order to accelerate this development, the IEA Smart Grids Action Network (ISGAN) has endorsed the Smart Grid International Research Facility Network (SIRFN), which right from its kick-off in early 2012 has been acting as a coordinated network of smart grid research and test facilities in countries participating in the ISGAN Implementing Agreement.

The need for multilateral collaboration on smart grid RD&D has been widely recognized as one of the main drives for the establishment of the European Network DERlab. Extending its activities beyond Europe, DERlab has been recognized as an establishment of strong collaborative test and evaluation capabilities that can be leveraged by the international community as a central enabler of the design and implementation of smart grids.

DERlab has been strongly supporting the development of the SIRFN network structure as well as defining its objectives from the very beginning. In this frame, DERlab team and board members have been actively participating in SIRFN events, such as the APEC-ISGAN Smart Grid Test Bed Networks Workshop held in Washington DC in January 2012, where the SIRFN work program has been defined, and a meeting with SIRFN representatives. In December 2012, DERlab and EPRI hosted a dedicated SIRFN workshop organized in the frame of the 5th International Conference on the Integration of Renewable and Distributed Energy Resources, Berlin. The objectives of the workshop were to offer an overview and an update on the SIRFN activities and how it relates to the larger ISGAN effort. Extensive discussions were also focused on the joint effort between Sandia and DERlab on inverter testing protocols, which was then used as an example of how further SIRFN activities might be organized.

In addition to DERlab's involvement in SIRFN, a number of member institutes are also actively participating in SIRFN and contributing to its activities and projects.

For further details and information on how to participate in SIRFN see the ISGAN-SIRFN website (www.iea-isgan.org) or contact the DERlab Team at office@derlab.net.

Joint SIRFN workshop organized by DERlab and EPRI in the frame of the 5th International Conference on the Integration of DER, Berlin, December 2012

Info

SIRFN

The Smart Grid International Research Facility Network (SIRFN) gives participating institutions the ablity to evaluate technologies and systems approaches in a wide range of smart grid implementation use cases using common procedures.

In the frame of joint projects, smart grid research test facilities will conduct specialized, controlled laboratory evaluations of integrated smart grid technologies focusing on topics such as renewable energy integration, EV integration, energy management, automated metering infrastructure, protection, network sensing, cyber security and similar applications.

In this way, research within each individual member country will derive the value of the unique capabilities and environments of the other partner nations. Joint projects conducted within SIRFN will accelerate the development of smart grid system technologies and enabling policies.

Areas of work identified at joint SIRFN-APEC workshop in Washington DC in 2012

The 5th International Conference on Integration of Renewable Energy and Distributed Energy Resources (IRED 2012) in Berlin, Germany, was attended by over 200 participants from 29 countries and covered the latest technical, market and policy aspects related to integration of renewable and distributed energy resources and smart grids. The conference supports the interdisciplinary discussion among different stakeholders and promotes lasting collaboration among key players from all over the world. DERlab and its members have participated in the conference organization since the first conference in 2004. The next IRED will take place in Japan in 2014.

5th International Conference on
Integration of Renewable and Distributed Energy Resources
December 4-6 2012 | Berlin, Germany

DERlab joins the secretariat of the Smart Grids European Technology Platform (SmartGrids ETP)

The European Technology Platform for Electricity Networks of the Future (SmartGrids ETP) brings together key stakeholders from the electricity networks sector, the network operators, generation, technology suppliers, research community, regulators and related European and global organizations, platforms and initiatives. In autumn 2012 DERlab joined the secretariat, which supports the work and the activities of the platform.

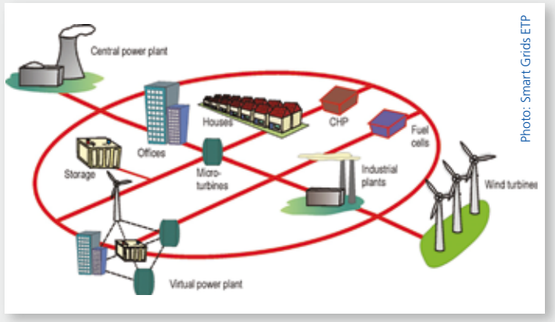


Photo: Smart Grids ETP

Smart Grids ETP formulates proposals and recommendations for the European Electricity Grid Initiative under the framework of the SET-Plan and organizes events and dissemination activities. DERlab is coordinating the organization of the workshops that are linked with on-going strategic processes of the platform. A wide participation from different stakeholders in industry, academic institutions, public authorities and non-governmental institutions is expected.

One of the key publications of the platform is the Strategic Research Agenda 2035 (SRA 2035), published in early 2012, that describes the urgent research that is necessary for the advancement of the Smart Grids by 2035.

The following Smart Grids research areas have been identified in the SRA 2035:

- Integrated electricity systems
- Smart distribution
- Smart transmission
- Smart retail and consumer systems
- Socioeconomics and ecosystems

Each of these research topics have several subtopics. During 2012 and 2013 they will be set in order of priority with the support of a wide community of technical experts from industry and academia. This is made possible due to the introduction of questionnaires and the workshop organized in connection with the IRED conference 2012 in Berlin, Germany. DERlab supports the process by bringing in its own expertise and the coordinated contribution of its network.

Info

SmartGrids-ETPS-III: Secretariat of the technology platform for the electricity networks of the future
Duration: October 2012 – October 2015
Support: The Seventh Framework Programme of the EC
Partners: ZABALA INNOVATION CONSULTING (coordinator), Bacher Energie AG, KU Leuven and DERlab

For further information please visit **www.smartgrids.eu.**

Workshop on New European Smart Grids Research Infrastructure

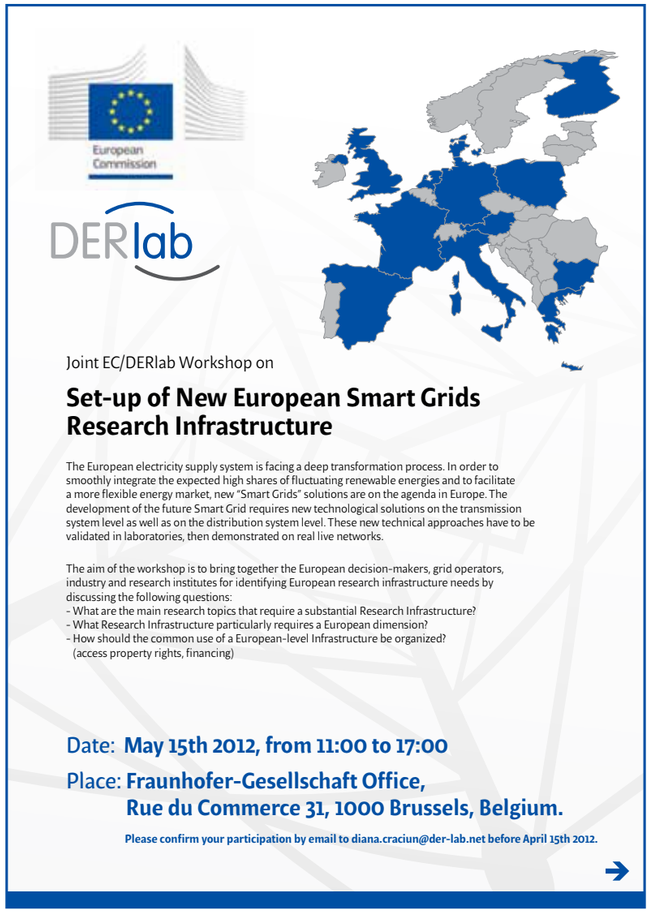
The European electricity supply system is facing a deep transformation process. In order to smoothly integrate the expected high shares of fluctuating renewable energies and to facilitate a more flexible energy market, new "Smart Grids" solutions are on the agenda in Europe. The development of the future Smart Grid requires new technological solutions on the transmission system level as well as on the distribution system level. These new technical approaches have to be validated in laboratories and then demonstrated on real networks.

On May 15th 2012, DERlab organized in Brussels a joint workshop with the European Commission (EC) with the aim of bringing together the European decision-makers, grid operators, industry and research institutes for identifying European research infrastructure needs by discussing the following questions:

- What are the main research topics that require a substantial Research Infrastructure?
- What Research Infrastructure particularly requires a European dimension?
- How should the common use of a European level infrastructure be organized?

The result of the workshop was a stakeholder statement and a proposal on how to develop and finance a European Smart Grid Research Infrastructure.

Furthermore, the outcome of the workshop was the basis of the DERlab coordinated response to the Open EC Consultation on possible topics for future activities for integrating and opening existing national research infrastructures, which was sent in October 2012.



High penetration PV in electricity grids – DERlab contributing to a research programme of the International Energy Agency (IEA)

DERlab is collaborating with utilities, Distribution Network Operators (DNOs), industries, manufacturers, universities and agencies in the IEA-PVPS Task 14 High Penetration of PV Systems in Electricity Networks of the International Energy Agency (IEA). The aim of the group is to promote the use of grid connected PV as an important source in electric power systems, particularly on a high penetration level, and where additional efforts may be necessary.

Under the guidance of the DERlab member AIT (Austria), fourteen countries are represented by technical experts, bringing in their knowledge on technical requirements for PV and electric power systems. Several DERlab members take part in the work of the group as well. The results are presented in various publications such as country reports from the US, Europe, Japan and Australia.

Smart Inverters have been a specific focus of the group since its beginning. 2012 has seen significant results in issues such as reactive power provision for voltage support, support of frequency control, remote dispatch and supply of reactive current during grid faults (LVRT fault ride through). These features will enable the active integration and further deployment of PV in the electricity grids.

Since 2012 DERlab has been participating in the work by bringing in the expertise gained in PVGRID project on technical and regulatory solutions enabling higher grid hosting capacity.

For further information please visit **www.iea-pvps.org.**

IEA-PVPS Task 14 workshop in Niestetal, Germany, at the premises of SMA Solar Technology AG

EERA programme strengthens the Smart Grid research in the EU

The Joint Programme on Smart Grids of the European Energy Research Alliance (EERA) has since 2010 strengthened the collaborative research in the field of smart grids in the European Union. The programme has aligned its R&D activities to the needs of the SET-Plan of the European Commission, and hereby support the development needed in the medium- to long-term scenario in the EU. Centers involved in the programme are mainly European public research centers that perform basic and applied research.

Moreover, the programme promotes international collaboration on smart grids. The continuous dialogue and coordination among the different smart grids initiatives, organizations, associations, and projects across Europe (such as EEGI, ETP SmartGrids, KIC Innoenergy, DERlab, GRID+) are needed to achieve economies of scale and reach the level of excellence required to address the smart grids development and deployment challenge.

An open EERA JP on Smart grids workshop in Milan, Italy, in June 2012 welcomed over 40 presenters dealing with next-generation smart grid technologies, systems and applications. The workshop program included five technical sessions and a plenary session involving representatives from the European Commission, ENTSO-E, ETP SG, T&D Europe, ISGAN and NEDO from Japan.

The workshop concluded with a round-table considering the ongoing and future actions towards next-generation smart grid technologies, systems, and applications.

Plenary session in the workshop in Milan, Italy, in 2012

Programme meeting at the premises of VTT in Espoo, Finland, in 2012

EERA
European Energy Research Alliance
Smart Grids Joint Programme

Supporting European Access to Research and Testing Facilities

Examples of DERri User Projects during 2009–2012

Distributed Energy Resources Research Infrastructure (DERri) has been providing European research groups with financial support for performing short-term research projects abroad since 2009. Researchers sent their applications to the laboratories within the DERri project consortium. Diverse testing facilities, simulations facilities as well as DER know-how in different technical fields were available. Due to the support of the Seventh Framework Programme of the European Commission, researchers were reimbursed for all expenses, including travel and accommodation.

DERri has significantly boosted the European research on Smart Grids and Distributed Energy Resources as well as staff and knowledge exchange.

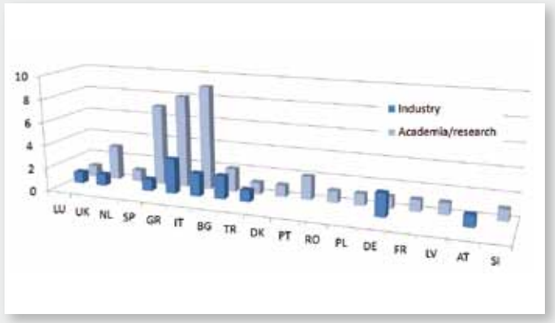
Scientists from European universities, organizations or companies performing experiments

As many as 55 proposals from industry, universities or research institutes in 17 different countries were submitted for the DERri scientific commission during 2009–2012.

Number of applications	55
Number of users	86
Days of stay	988
Days of use of installations	695

By March 2013, a total of 45 user projects were in progress at different laboratories or have been completed. As a rule, a user group of three people would spend twenty days in the hosting infrastructure conducting technical experiments. The number of days varied from one to one hundred, depending on the requirements of the user project as well as the availability of the hosting laboratory.

Here we present a few examples of the user projects. Further information is on the project website **www.der-ri.net.**



Distribution of the 55 submitted user project applications

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Integrated control strategies for distribution systems

The energy storage, when coupled with the wind generation system, can smoothen the generation output power of the wind power system. In addition, on request from the Distribution System Operator (DSO), the storage can ensure that there has been no power transfer for a certain period of time. These features of storage systems were tested by a research group from the DITEN-IEES Intelligent Electric Energy Systems Laboratory from University of Genova, Italy, during a DERri User Project RESSIC. The host was SYSLAB laboratory of the Technical University of Denmark in Roskilde during a four-month period in 2011 and 2012.

User group of the RESSIC project at DTU

The project, named Renewable Energy Sources and Storage for Integrated Control in electric distribution system (RESSIC), aimed to describe and validate small wind turbines, storage systems and integrated control strategies of the whole renewable microgrid. The research group has validated a model for the analysis of short and long term dynamics of storage and tested the system benefits that the storage can provide.

The user group demonstrated that the storage system consisting of a Vanadium Redox Battery (VRB) is able to regulate both frequency and voltage and to keep the islanded system in stable operation. In addition, the battery was proved to be very fast in changing its power injections. It was also demonstrated that the critical aspect is the communication bandwidth and delays. The group of professor Silvestro is continuing the research on estimating the regulation burden of batteries and other controllable RES.

Solving Electromagnetic Compatibility problems of grid-connected PV inverters

Electronic smart meters are being installed in European electricity networks at an increasing rate. However, due to a gap in standardization of both immunity and emissions in the range of 2–150 kHz, there have been problems in Electromagnetic Compatibility (EMC). In particular, many countries have detected the malfunction of electronic meters when used in combination with PV inverters. Therefore, there is a certain need for definition of limits on immunity and emissions, as well as for development of laboratory setups.

Having experience in tackling EMC problems and having a unique laboratory environment for such experiments, Fraunhofer IWES was selected as the host by the user group from Public Power Corporation and National Technical University of Athens from Greece. During the user project ElectroMagnetic Compatibility of PV inverters and electronic Meters (EMC-PV-M) immunity tests on three electronic meters in the 2 kHz –150 kHz range were performed at two different laboratory setups of indirect and direct feed. In addition, the user group measured the harmonic emissions of two PV inverters.

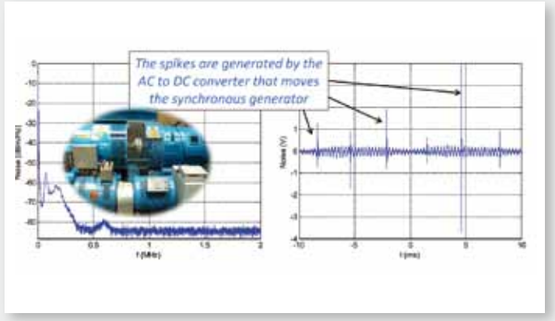
EMC laboratory of Fraunhofer IWES

Planning to develop a laboratory setup for the immunity of electronic meters, the research group gained important experience in laboratory procedures, equipment, potential problems, solutions and challenges.

Supporting European Access to Research and Testing Facilities

Power line communications for Smart Grid

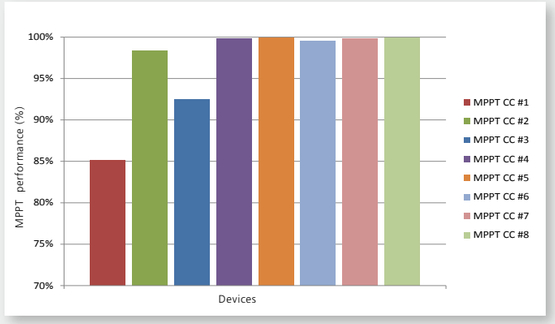
In project "POLSAR", a team from the University of Udine's Wireless and Power Line Communications Lab investigated power line carrier performance in smart grids containing DER. This was conducted within the D-NAP microgrid at the University of Strathclyde. The collaboration demonstrated the effectiveness of alternative power line communications (PLC) technologies in distributing controls and measurement signals within a network of changing load, generation and topology. The experimental results indicated the anticipated performance of PLC options in future public network trials and are guiding the ongoing work of the team.



Measurement of noise from an 80 kVA generator set

Comparative study for MPPT charge controllers and battery inverters

In the course of the user project "TESCABI" a team from the manufacturer Steca Elektronik in Germany lead a comparative study of Maximum Power Point Tracking (MPPT) charge controllers in the Distributed Generation Laboratory of the Austrian Institute of Technology (AIT). A specific procedure for measuring the performance of the devices was developed. Tests on eight different devices by seven manufacturers showed various differences in input/output specifications, DC/DC conversion efficiency and, in particular, in maximum power point tracking. The results of the research clearly highlighted that individual products still have significant needs for development or optimisation.



Comparison of the static MPPT performance (%) according to EN 50530

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Power-Hardware-In-The-Loop simulation on asymmetrical grids

In the user project "ENERGYMAD", a PhD student from University Politehnica of Bucharest in Romania developed and tested 3-phase asymmetrical grids with photovoltaic generation in a Power-Hardware-in-the-Loop (PHIL) environment. Having the necessary realtime simulator and power amplifier for performing PHIL simulations, the Institute of Communication and Computer Systems at the National Technical University of Athens in Greece (ICCS-NTUA) was selected as the host.

Preparing the real-time simulator at ICCS-NTUA

Innovative solutions for industrial lead acid batteries

Acid betteries under test at CEA-INES

In the course of the user project "INVERTER", a research team from the manufacturer Amer-Sil in Luxembourg tested and developed new separators and new gauntlets for industrial lead acid batteries.

The test bench was set up at the laboratory infrastructure of CEA-INES in France, which has one of the largest facilities in Europe for studying renewable energy storage. Initial capacities and charge acceptances of the batteries were determined during over 100 testing days.

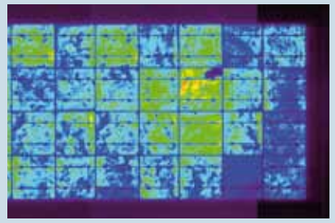
Validating equivalent models of microgrids

Researchers from the University of Thessaloniki directed the user project "MoDERN" within the University of Strathclyde's D-NAP facility. In this project experimental results from dynamic measurements of load and generation step changes were used to calibrate and refine a dynamic equivalent model of the microgrid based on Prony analysis.

Along with step changes in load and generation, the generators were tested in different operating modes and with different control parameters, exploiting the flexibility of the D-NAP laboratory. The validation achieved with this study has demonstrated the potential use of these equivalence models in supporting dynamic security assessment associated with VPP's, microgrids, and DER-rich distribution networks.

User group of the MoDERN project at the University of Strathclyde

Pre-standardization and Recommended Practices



Technical Guidelines for the Test Procedures of PV Modules in Outdoor Conditions

Measurement procedures for long-term tests of photovoltaic modules in outdoor conditions have so far only found limited consideration by international standardization committees. In the interests of customers and of the industry, many PV laboratories perform long-term outdoor tests, but due to the lack of standardization, these tests are partly performed in accordance with internal procedures. Due to a variety of applications, e. g. Building Integrated Photovoltaics (BIPV) or Concentrated Photovoltaics (CPV), not in each case standardized procedures will meet the requirements considering the real application of photovoltaic modules.

DERlab has set up common testing procedures resulting in the publication of the **DERlab Technical Guidelines on Long-term Photovoltaic Module Outdoor Tests** in February 2012. The guidelines are elaborated with experts from DERlab members Sandia, IWES, NTUA, CRES and AIT who are all performing photovoltaic module tests in outdoor conditions.

By following the guidelines one can directly compare the energy yield of solar modules site-specifically in different locations and under the most diverse operating conditions. By offering several test sites DERlab is able to coordinate PV outdoor tests ensuring common and comparable quality criteria at different test sites. PV outdoor tests have been performed respecting the DERlab guidelines in Fraunhofer IWES, NTUA and CRES. The first results have been presented in international publications.

The second edition of the guidelines will enlarge the scope of the testing conditions and elaborate on measurement uncertainties. It will be developed also in cooperation with partners of the SOPHIA project.

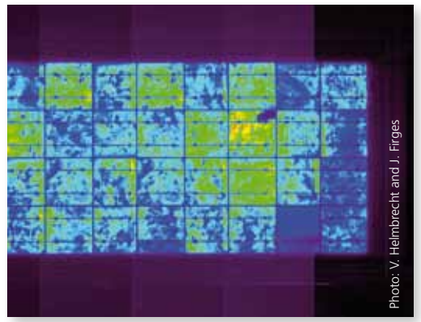
The guidelines can be purchased on **http://shop.der-lab.net**

Test site of the Centre for Renewable Energy Sources and Saving (CRES) in Greece

Maintenance of global horizontal and diffuse horizontal pyranometers at Fraunhofer IWES in Germany

Verifying the Models for PV Performance

Accurate energy yield predictions of photovoltaic modules over the whole lifetime have become an important issue for investors due to the recent cuts in feed in tariffs within European countries. Not only the electrical characteristics of single cells are in the focus of PV modeling but also the interactions of PV modules with power conditioning units and balance of system (BOS) components. Models are used in the whole technology chain: for material characterization for electrical equivalent circuit or thermal descriptions, as well as for modeling of operation control in large-scale PV plants.



Electroluminescence image of the PV module

However, during a typical lifetime of 20 years, PV modules are exposed to environmental stress. At the same time inherent electrochemical reactions cause performance degradations. By first understanding the electrochemical processes occurring in PV modules e.g. ion migration, cracking of bonds or formation of new bonds, modeling helps to localize possible failures and determine the probability of occurrence during their lifetime. Within the SOPHIA project different performance models for PV modules will be validated with data sets from real module measurements recorded by different partners of the SOPHIA project.

In February 2013 the French National Solar Energy Institute (INES) invited partners of the SOPHIA project with external experts to a two-days workshop. Different models of PV performance were presented and aspects of physical modeling of the entire technology chain were discussed. In a next step, the models are evaluated with real measurement data to form a conclusion about which models are the most accurate in energy yield prediction.

The fundamental preconditions for verifying the accuracy of a model are high quality measurements with low uncertainties from the measurement systems. As uncertainties do not simply occur from the measurement equipment itself, but also environmental impacts like soiling of module and sensor surfaces, the maintenance of the test site is of particular importance. Stakeholders from the PV industry emphasized in the workshop the significant need for excellent long-term measurement data sets.

Info

SOPHIA: Photovoltaic European Research Infrastructure brings together research organisations across Europe to optimise the use of research infrastructures and improve their performance.
Duration: February 2011 – January 2015
Funding: The Seventh Framework Programme of the EC
Partners: 18 research institutes and DERlab, the European Photovoltaic Industry Association (EPIA) and the European Renewable Energy Centres Agency (EUREC). Coordinator: The French National Solar Energy Institute (CEA-INES)

For further information please visit **www.sophia-ri.eu.**

SOPHIA European Research Infrastructure

Harmonising Hardware-in-the-Loop Simulation Procedures

Photo: Pawel Kelm (TU Lodz)

Hardware-in-the-loop workshop of DERri in ICCS-NTUA laboratory in Athens.

Currently, there are no standardized modelling, simulation procedures or data formats for the exchange of real-time models for hardware in the loop (HIL) experiments in the domain of power and energy systems. Partners of the Distributed Energy Resources Research Infrastructure (DERri) have taken the existing testing procedures of the partner laboratories as a basis and have defined a set of common parameters and interfaces to describe the behaviour of Distributed Energy Resources (DER) components connected to the grid.

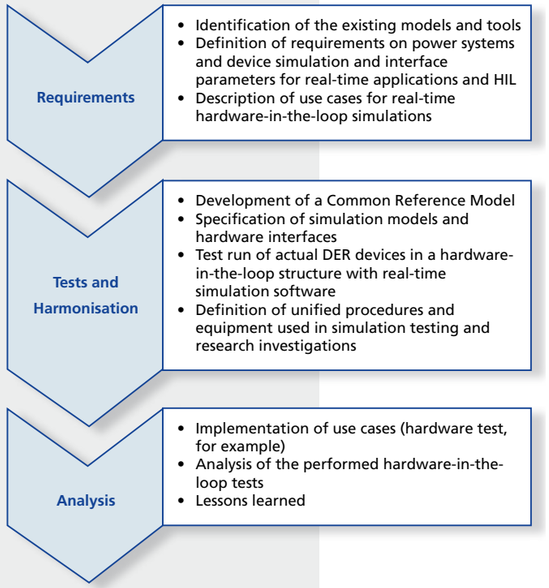
Towards a Common Reference Model (CRM) for DER Components

During the first year of the DERri project, the partners analyzed and reviewed the different simulation approaches, tools and DER models that are currently in use in all DERri laboratories. The consortium has facilities for performing real-time simulation covering the full range of HIL simulations, such as controller-hardware-in-the-loop, hardware-in-the-loop testing of protection equipment and power-hardware-in-the-loop simulation.

The results of this study showed that the descriptions of the models are very heterogeneous and that their comparison is often very difficult. The partners have different real-time simulator equipment, variable power interfaces (i.e. switched-mode amplifier, linear amplifier and synchronous generator) as well as variable laboratory procedures.

Moreover, such models are specified in different simulation languages. This complicates the exchange of the models between the DERri partners and other research groups. Therefore, the consortium decided to create a common reference model (CMR) to define a set of common parameters and interfaces describing the resulting behaviour of DER components when connected to the grid. As a first step, different DER devices were categorized into different fields of application (e.g., in generation, storage, conversion, compensators, protection) and into different model/simulation types (i.e. steady-state, dynamic, offline, real-time, etc.).

Based on collected use cases and requirements a CRM was defined which allows a simpler exchange of model data. The CRM improves the portability and exchangeability of DER device models for different simulation experiments, especially for real-time simulations. Therefore, multiple simulation models can be associated with the CRM for a specific DER in order to cover different usage. Moreover, the CRM also contains an interface description, which can be used for its different instances, for example for offline and for real-time simulation experiments.



On the way to more harmonized PHIL simulation procedures

Along the course of the project, many technical workshops were organised, and one of them was hosted by ICCS-NTUA in April 2012. A laboratory PHIL experiment on a PV inverter was performed and evaluated. The partners had the opportunity to discuss the technical issues and challenges and plan further collaboration on the HIL topic.

Reference:

T. Strasser, F. Lehfuss, P. Kotsampopoulos, P. Crolla, C. Tornelli, and S. Numminen, "Harmonising hardware-in-the-loop simulation procedures for power systems and distributed energy resource components", 5th International Conference on Integration of Renewable and Distributed Energy Resources, Berlin, Germany, 2012

Info

Distributed Energy Resources Research Infrastructure (DERri) project consortium has worked with common testing procedures and improved laboratory capabilities in European DER laboratories since 2009.

DERri is a collaborative research project, supported by the Seventh Framework Programme of the European Commission. In 2011 DERlab joined the project consortium, led by Ricerca sul Sistema Energetico (RSE) from Italy. The other partners are Austrian Institute of Technology (AIT), Centre for Renewable Energy Sources and Saving (CRES), the EDF group, Fraunhofer IWES, The French National Institute for Solar Energy (CEA-INES), DNV KEMA, National Technical University of Athens (ICCS-NTUA), University of Manchester, Technical University of Lodz, Technical University of Denmark (DTU), TECNALIA, Research and development sector of the Technical University of Sofia (TUS-RDS), University of Strathclyde and VTT Technical Research Centre of Finland.

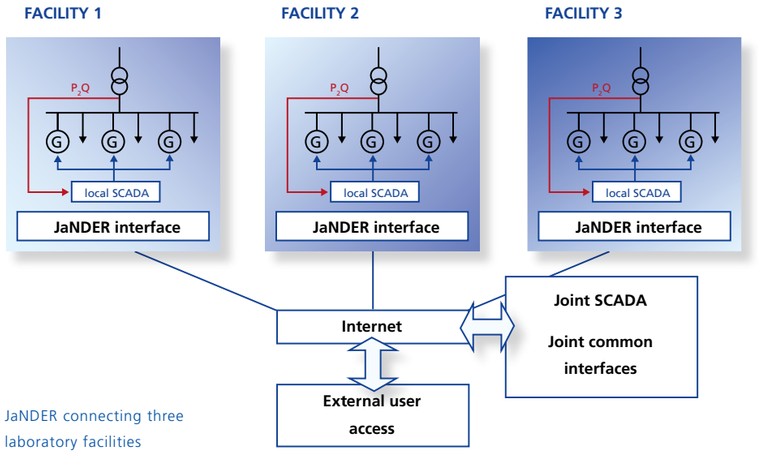
For further information please visit **www.der-ri.net.**

CAPACITIES

DERri

Virtual Demonstration Laboratory for Remote Testing and Control

The communication interface has an essential role when it comes to the efficient integration of laboratories. DERri project partners developed a new concept, Joint Test Facility for Smart Energy Networks with Distributed Energy Resources (JaNDER) which is a virtual entry point to the smart grid research laboratories. Various tests on DER devices can be observed remotely via an online interface.



JaNDER connecting three laboratory facilities

In short, the JaNDER concept is the interconnection between laboratory systems. This interconnection enables the performing of joint tests, simulations, remote monitoring or measurements. For example, JaNDER allows a researcher without the suitable equipment to test an algorithm for grid connected battery systems. The algorithm is uploaded on the server which is connected to the necessary equipment in the distant laboratory.

The JaNDER gateway connects the communication interface to the laboratory infrastructure and ensures the timeliness between the physical laboratory and the remote test equipment. The timeliness is achieved by the JaNDER real-time repository that is installed in each JaNDER gateway in each JaNDER laboratory. This database manages the correct processing of inputs and outputs of the testing process sequences. Therefore, possible latencies that could arise during the simultaneous usage of equipment are avoided. JaNDER enables the joint operation of tens of control approaches.

Currently ten DERri laboratories in RSE, AIT, VTT, TU Lodz, IWES, TUS-RDS, TECNALIA, University of Strathclyde, CRES and EDF are being connected to the JaNDER interface, allowing remote observation or control. The project results will be available on the project website in late 2013.

DERri

Finding Technical Solutions for Large-Scale Grid Integration of Photovoltaics

In recent years, a completely new situation has emerged in several European countries where distribution grids have to deal with very high shares of PV generation, leading to new technical, economical and administrative challenges.

This is an important issue for Europe's energy future. As PV becomes a mature and mainstream technology, it will need to integrate seamlessly into the electricity grid. This will require some changes from grid operators, from policymakers and from the PV industry. But the challenges are not insurmountable.

DERlab is coordinating the technical work for identifying and analyzing the technical solutions for the large-scale integration of PV systems in saturated distribution grids in the project PV GRID.

Working groups involving technical experts have been set up to analyze technical solutions, identify regulatory and normative barriers and bring forward concrete suggestions for integrating higher shares of PV.

Until now, the Working Groups have identified 18 technical solutions to integrate higher shares of PV in saturated distribution grids. Depending on where they are implemented, the technical measures are categorized in:

DSO solutions
- Installed and managed on the grid side and do not require any communication with the consumers or the PV plants.

Prosumer solutions
- Installed beyond the point of common coupling without any communication need with the DSO.

Interactive solutions
- These are a variable set of solutions requiring a communication infrastructure linking the hardware located in different grid locations.

The technical solutions are ranked against predefined criteria such as investment costs, technology readiness, impact on voltage quality and congestion. The applicability of the solutions within the existing regulations is also analyzed.

While the ranking is applied for rural LV/MV grids, and suburban LV/MV grids, external experts from research and industry are involved in the ranking process. As a second step also the normative and regulatory framework will be analyzed in another working group. Together with the technical analysis PV GRID project will give a set of recommendations.

The results will be presented in scientific conferences and on the project website on www.pvgrid.eu.

Info

PV GRID: Reducing barriers hampering large-scale integration of PV electricity into the distribution grid. This project targets to overcome regulatory and normative challenges linked to the integration of high shares of PV electricity in the distribution system across Europe.
Duration: May 2012 – October 2014
Funding: Intelligent Energy – Europe (IEE) programme of the EC
Partners: 20 project partners including National PV industry associations, the European Photovoltaic Industry Association (EPIA), DERlab, three Distribution System Operators (DSOs), eclareon Management Consultants, COMILLAS Pontifical University and the German Solar Industry Association (BSW-Solar) (coordinator).

For further information please visit **www.pvgrid.eu.**

PV GRID
Make it smart!

STARGRID addresses focal points in Smart Grid standardization

In the past three years several national and international standardization organisations have established Smart Grid task forces and implemented ambitious working plans, among them IEC, NIST and the European organisations CEN, CENELEC and ETSI. These latter three, in particular, under EC mandate M/490, have already produced an overview of standards in the Smart Grid context and proposed an analysis methodology.

STARGRID – STandard Analysis supporting smart eneRgy GRID development, a two years project launched in October 2012, will analyze the impact of current standardization frameworks on the effective Smart Grid deployment.

As a first step STARGRID consortium will collect relevant documents and information from standardization bodies and industry initiatives. STARGRID identifies provisions or lacks that enable or limit important Smart Grid use cases and business models, or are decisive for the interaction of different Smart Grid components.

STARGRID wants to especially investigate and address the opinion of the industries (utilities, electricity suppliers, manufacturers, aggregators and plant operators and the ICT sector) by means of interviews, questionnaires and workshops.

Project results are released in a series of publications, also giving recommendations for decision-makers, standardization bodies and industries themselves.

Funded by the European Commission (EC) within the seventh framework programme (FP7), the project consortium has a European focus, but takes also global Smart Grid developments into account.

For further information please visit **www.stargrid.eu.**

Advanced Test Protocol for Inverter Interoperability Functions

Distributed energy resources (DER) such as photovoltaic (PV) systems, when deployed in a large scale, are capable of influencing significantly the operation of power systems. Looking to the future, stakeholders are working on standards to make it possible to manage the potentially complex interactions between DER and the power system.

In 2009, the Electric Power Research Institute (EPRI), Sandia National Laboratories (SNL) with the US Department of Energy (DOE), and the Solar Electric Power Association (SEPA) initiated a large industry collaboration to identify and standardize definitions for a set of communications-based DER grid support functions. While the initial effort concentrated on grid-tied PV inverters and energy storage systems, the concepts have applicability to all DER. A partial product of this on-going effort is a reference document (Definitions Document) that has become the basis for expansion of related International Electrotechnical Commission (IEC) standards, and is supported by the US National Institute of Standards and Technology (NIST) Smart Grid Interoperability Panel (SGIP). Some industry-led organizations advancing communications protocols have also embraced this work.

As standards continue to evolve, it is necessary to develop test protocols to independently verify interoperability and electrical compatibility between DER and utility power systems. This document describes test protocols initially developed by SNL to evaluate the electrical performance and interoperability for PV inverter and energy storage described in the Definitions Document. While many of these functions are not required by existing grid codes or may not be widely available commercially, the industry is rapidly moving in that direction. Interoperability elements have already been incorporated in large demonstration and commercial projects. The test protocols are intended to be used to verify acceptable performance of inverters within the standard framework described in the Definitions Document. These test protocols, being refined and validated over time, can become precursors for future certification test procedures for DER advanced grid support functions.

DERlab has been actively supporting the development and refinement of the aforementioned testing protocols.

Automation and Energy Management Solutions for Neighbourhoods

Photo: Arkkitehtitoimisto Petri Rouhiainen Oy

EEPOS demonstration site: low energy housing area Nupuri in Espoo, Finland

Deployment of Renewable Energy Sources (RES) for the energy supply for buildings and residential areas is increasing significantly. Even today many consumers have begun to produce electricity locally and thus become "prosumers".

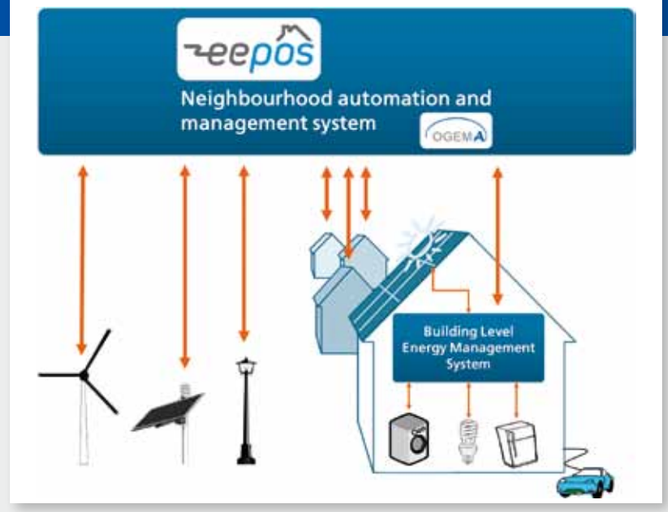
At high RES penetration, in times of high wind or photovoltaic energy production, the availability of electricity may exceed the consumption. Without proper energy management, this surplus amount of produced energy may be lost. Bidirectional energy management systems can help to cope with these challenges, for example by the exploitation of load shifting or virtual storage potentials. The EEPOS research and development project aims at the realization of the idea of energy positive neighbourhoods in Europe.

DERlab leads the development of the EEPOS neighbourhood automation and management system platform. The platform will be based on OGEMA, an open source software gateway supporting standardized automated energy management and the respective energy management and automation applications. OGEMA is provided by the Open Gateway Energy Management Alliance (OGEMA).

DERlab will set up and implement a laboratory test bed for the EEPOS neighbourhood automation and energy management system prototype in the laboratory testing facilities of Fraunhofer IWES in Kassel, Germany. Two extensive field tests in Espoo, Finland, and Langenfeld, Germany, as well as a complementary simulation based virtual demonstration study for the municipality of Asparrena, Spain, will be launched for the validation of the EEPOS system in the second half of 2013.

Photo: Dan Hildebrandt (enowatts GmbH)

EEPOS demonstration site Langenfeld, Germany



System diagram for the planned EEPOS laboratory test bed

EEPOS pilots will be designed to address a significant number of situations that could appear in other similar neighbourhood sites in Europe. The neighbourhoods are characterized by a wide diversification of buildings. Therefore, aspects like interoperability and scalability will be mandatory and considered in the ICT solutions developed within the project. This will enable the transfer of the newly developed ICT solutions to other neighbourhoods' building and lighting areas with different characteristics. The laboratory tests will focus on the functional efficiency of the smart neighbourhood level applications of the EEPOS platform designed for automation, operation, predictive control, brokering and monitoring purposes.

The system diagram shows the planned system. Different Energy management systems (EMS) on the building level will be connected to the EEPOS neighbourhood automation and management platform. The testing of the EEPOS automation and energy management system will be carried out with respect to the use cases and according to the testing procedures developed and described at an earlier stage of the project.

The performance criteria for the EEPOS system defined at the beginning of the project and covering energy efficiency, energy management, integration capability, usability, and IT-system integration aspects will be evaluated in the laboratory in line with the field tests. To be able to rate potential energy efficiency gains, and load and generation shifting potentials obtained by the neighbourhood level management, a reference scenario will be defined for the model neighbourhood represented in the laboratory. Among others, this scenario will comprise energy consumption and generation profiles for the modelled neighbourhood without management.

Info

EEPOS: Energy management and decision support systems for Energy POSitive neighbourhoods
Duration: October 2012 – September 2015
Funding: The Seventh Framework Programme of the EC
Partners: The EEPOS consortium includes eight academic, industrial and public organizations from four European countries located in different EU climate zones.

For further information please visit **www.eepos-project.eu.**

Research Infrastructure

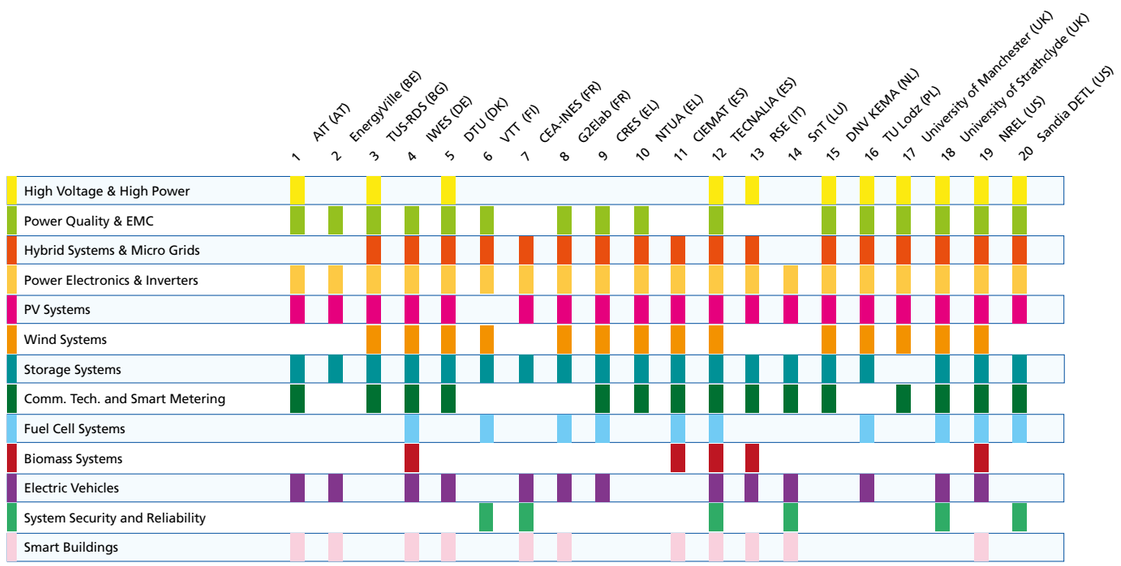
Photo: TU Lodz

Microgrid testing facility
at the Technical University
of Lodz

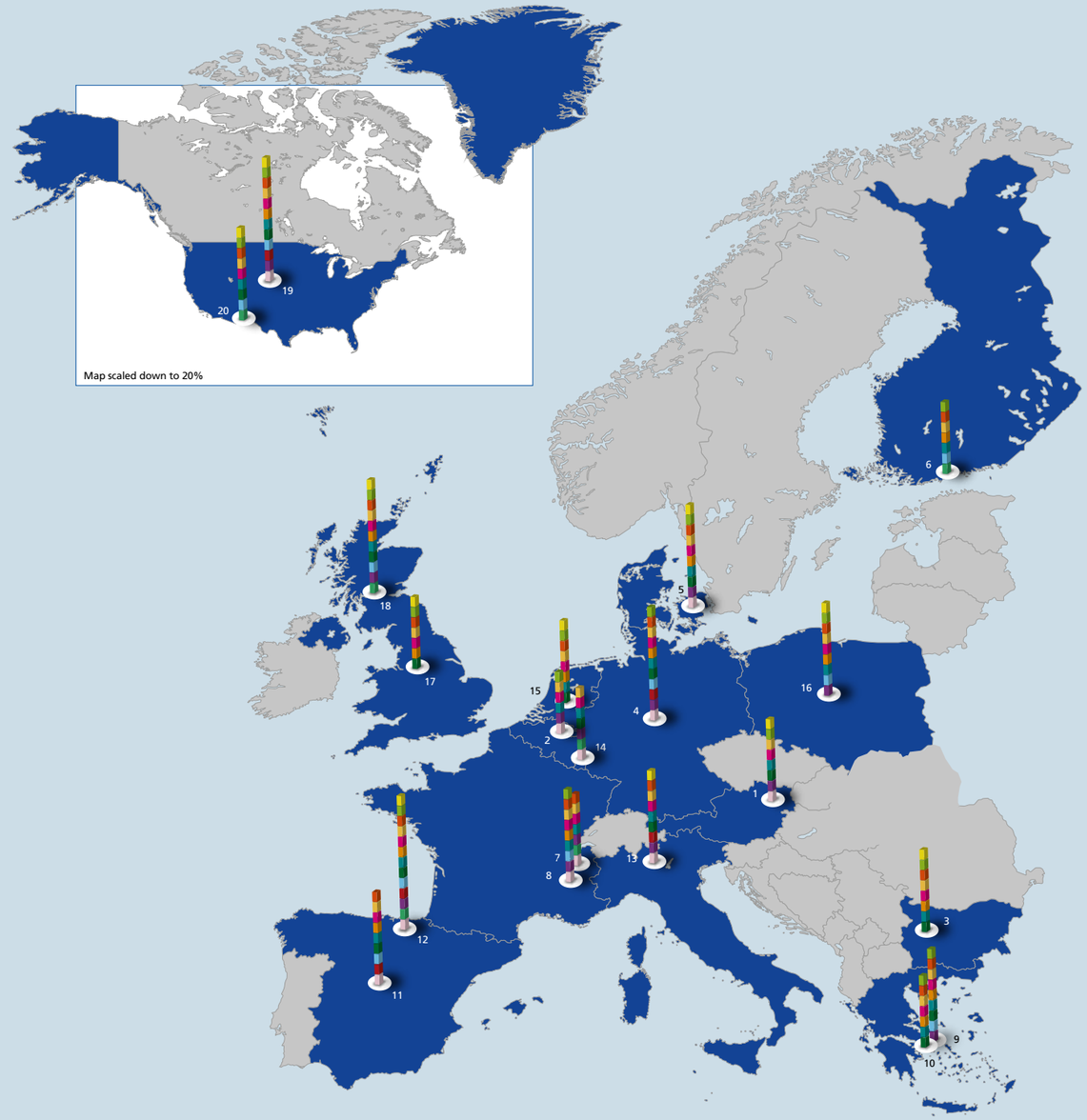
Research Infrastructure

The transition towards high shares of renewable energy and the tendency to a more decentralized energy supply requires a smarter grid with sufficient hosting capacity and the ability to manage the power fluctuations of the renewable sources. High level research and laboratory tests are vital to tackling these challenges. Individual components, such as DER converters or storage, as well as complete systems can be tested at DERlab laboratories that have the expertise and laboratory capabilities to perform tests.

Futhermore, various effects that units have on the power systems can be verified in compliance with international and national standards or certification procedures.



Research infrastructure of the member institutes of DERlab association cover the whole scope of distributed generation and Smart Grids



New Laboratories

ESIF Building of NREL

Testing large-scale integration of Distributed Generation at the new AIT SmartEST laboratory, Austria

The new AIT SmartEST Laboratory was opened in spring 2013 for testing, verification and R&D for large scale DG/RES integration and Smart Grids applications. The laboratory infrastructure accommodates such DG components as inverters, storage systems, CHP units, voltage regulators/ controllers and other types of related electrical equipment. Powerful controllable AC and DC sources allow full-power testing capability up to 800 kVA (AC), including a high- performance PV Array (DC) Simulation with 960 kW/1500 V_DC.

The equipment available at the AIT SmartEST Laboratory opens the path for new, innovative approaches for testing and investigation of DG system Integration issues. New methods available at the lab include real-time (RT) Power-Hardware-in-the-loop (P-HIL) simulation combining close-to-reality hardware testing with the flexibility of numerical simulation.

Services:

- DR component and systems testing with highly flexible grid and primary energy source (e.g. PV) emulation
- Electrical interconnection, functionality and performance testing according to standards
- Simultaneous testing of power and communication interfaces of DR components
- Performance and lifetime testing under controlled environmental conditions
- Simulation and testing of single components and whole generation systems / plants
- Power-hardware-in-the-loop experiments by the means of Real Time Simulation and CoSimulation in Multidomains (Rapid Modeling and Prototyping of DER systems and components)
- Emulating smart grids scenarios

Photo: AIT

Architectural design of the AIT SmartEST Laboratory

Megawatt-scale integration of renewables in the new Energy Systems Integration Facility (ESIF) laboratory at NREL, the U.S.

At its General assembly in April in Athens 2012, DERlab welcomed the National Renewable Energy Laboratory (NREL) to its network. NREL is the only U.S. national laboratory solely dedicated to advancing renewable energy and energy efficiency technologies from concept to commercial application.

In early 2013, NREL opened its newest campus addition, the Energy Systems Integration Facility (ESIF). It is one of the first facilities in the U.S. with the ability to conduct integrated megawatt-scale research and development of the components and strategies needed to safely move clean energy technologies into the energy system at the speed and scale required to meet national goals.

Research, development, and experimentation conducted in the ESIF will aim to overcome a variety of challenges facing the energy system in the U.S. These include integrating higher levels of renewable energy into the electrical grid, developing advanced fuels such as hydrogen to replace petroleum, evaluating the use of advanced energy storage technologies, and electrification of the transportation system. Areas of research will include electric systems, buildings and facility systems, community power generation and microgrids, utility generation, thermal and hydrogen systems, energy efficient and advanced grid technologies, electricity system architectures, and interoperability of components and systems.

Deployment research on smart low-voltage and medium-voltage grids in the new SysTec laboratory at Fraunhofer IWES, Germany

In its new 80,000 m² Test Centre for Smart Grids and Electromobility (IWES SysTec), Fraunhofer IWES is developing and testing new equipment and operation strategies for smart low and medium voltage grids. Investigations regarding grid integration of photovoltaic systems, wind energy plants, storage, electric vehicles and hybrid systems are carried out under realistic conditions. A mobile test container with the ability to measure the fault-ride-through of generation plants has been integrated into the laboratory as well. In IWES SysTec enables the development and the testing of the electrical properties and, in particular, the ancillary services of remote generators in the power range up to 6 MVA.

Services:

- Examination of generation plants in accordance with different grid connection guidelines (low voltage, medium voltage)
- Fault-ride-through measurements of generation plants up to 6 MVA using a mobile test container
- Metrological examination of performance (tripping characteristic) of protection devices at distribution grid components
- Measurements of grid quality and analyses of performance
- Determination of energy yields and comprehensive characterisation of photovoltaic modules and systems under realistic operational conditions
- Field and laboratory tests of hybrid systems, small wind power plants and individual components as well as tests with hardware emulations under defined operating profiles
- Real time distribution grid simulations to test control centres and the grid integration of distributed generators, electric vehicles and power storage (hardware-in-the-loop)

Photo: Fraunhofer IWES | Frank Hellwig

Fault-ride-through measurement containers in IWES SysTec

Architectural design of TECNALIA Smart Grids Laboratory and Interoperability Centre

INGRID – TECNALIA Smart Grids Laboratory and Interoperability Centre, Spain

TECNALIA Research & Innovation test facilities for smart grids are organized around INGRID – TECNALIA Smart Grids Laboratory and Interoperability Centre, which will be officially inaugurated in April 2013.

Advanced power system architectures, microgrids for buildings and districts, new power converters for grid connection, smart metering and grid automation, electric mobility (infrastructure, V2G), demand side management and demand response are the key research and testing activities of this laboratory. The Laboratory consists basically of a set of interconnected testing and research platforms, most of them already in operation, such as:

- Electrical equipment testing platform (includes high power lab and MV&LV lab)
- Microgrid and Distributed Energy Resources (DER) testing platform
- Energy storage platform
- Smart grids communication platform
- Renewable energy testing platform
- Electric Vehicle testing platform
- Power electronics and energy conversion platform

INGRID – TECNALIA Smart Grids Lab, is an accredited laboratory according to EN ISO/IEC 17025 and, among others, a member of IEC/TC57 ("Power systems management and associated information exchange"), CENELEC/TC210 ("EMC"), Group of Notified Bodies under the EMC Directive (ECANB), and many Technical Committees of AENOR (Spanish Association for Standardization and Certification).

Power Networks Demonstration Centre – a new University of Strathclyde facility in Cumbernauld, UK

The Centre's network provides a flexible arrangement of primary and secondary equipment to represent rural, urban and suburban networks (11 kV and 400 V). The network can be supplied either from the grid or a 5 MVA motor-generator with variable frequency. The network is a mixture of cables and overhead sections. Variable lumped impedance equivalents provide a more dispersed network within the footprint available.

A primary substation replica allows for voltage control via on-load tap changers and automated ring main units. The capability to apply resistive balanced and unbalanced faults at both voltage levels is also present.

Operator instructions can be supplied either through SCADA or from profiles through a RTDS. In addition, there is a high-speed measurement and data logging system installed in parallel to SCADA in order to provide better understanding of system behaviour. The network has fibre-optic communications throughout and easily accessible connection points to allow quick changeover between systems.

Services:

- Controlled component and systems testing with highly flexible grid and primary energy source to include soak testing under various scenarios.
- Electrical interconnection, functionality and performance testing according to standards
- Testing of power and communication interfaces across a distribution network
- Power-hardware-in-the-loop capabilities to test, demonstrate and analyze novel adaptive network and protection algorithms.

The Power Networks Demonstration Centre at the University of Strathclyde

NetPower lab at the Interdisciplinary Center for Security, Reliability and Trust (SnT), Luxembourg

The NetPower lab at the Interdisciplinary Center for Security, Reliability and Trust (SnT) at the University of Luxembourg offers a structure for hardware in the loop testing and real-time experiments. Up to Mhz scanrates are employed to engineer failproof signal processing and constructive solutions, e.g. in power electronics in their systems context.

The NetPower lab equipment covers real-time software simulation, backed up by fast FPGA-signal processing hardware, extended to real-physics electrical power in the 100 kVA range. Several freely programmable 3-phase voltage source inverters with access to any low level routine, allow for close reproduction of grid dynamics, electromechanical conversion and power electronics units.

Integration of major real-time fieldbus protocols allow safety, security and reliability test runs of networked SCADA systems in real-time in real or virtual environment and failure scenarios. The Netpower DemoLab investigates communication structures and power grid structures under different aspects of security and reliability.

Inverter testing at Netpower Demolab at SnT

Electric Vehicle Research and Testing Facilities of the Institutes of DERlab Association

Photo: Fraunhofer IWES | Volker Beusjaarten

The electric vehicle (EV) deployment will require a large effort in standardization, infrastructure investment and technical skills in the upcoming years in order to assess the performance of the EV charging equipment and EV interoperability in particular. In the following section we give an overview of different facilities and the available expertise at some of the DERlab laboratories which focus on electric vehicles research and testing. The complete overview of all research and testing capabilities of DERlab will be offered by the Database of DER and Smart Grid Research Infrastructure.

Austrian Institute of Technology (AIT)

AIT Austrian Institute of Technology covers the whole spectrum of EV related technologies, from the development of power electronics to the comprehensive integration of e-mobility in the available distribution system infrastructure. The latter is seen as a key requirement for increasing EV market penetration. This involves charging scheduling and forecasting as well as enabling future V2G (vehicle-to-grid) capabilities for grid stabilization and smoothing of energy demand peaks. Power electronics development and testing (e. g. bi-directional on-board charger), performance improvement of electric drives and EV-battery management systems for performance optimization and lifetime enhancement are performed at AIT's laboratories.

Photo: AIT

Testing of EV components at AIT

Electrical Vehicles Laboratory of the Technical University of Sofia, Bulgaria

Electrical Vehicles Laboratory (EVL) serves for modeling, testing, research and development of low power drive trains for small electric vehicles – hybrid and plug-in types. The laboratory enables carrying out mechanical and electrical tests of small internal combustion engines, drive electrical motors, drive trains with fuel cells and ultra-capacitors. The work on electronics systems of the EV is carried out in cooperation with Power Electronics Laboratory in the frame of Research and Development Sector (TUS RDS).

Photo: TU of Sofia

Team of Prof. Traykov won the 2nd place in Shell Eco-marathon 2012 in energy efficiency of small urban cars

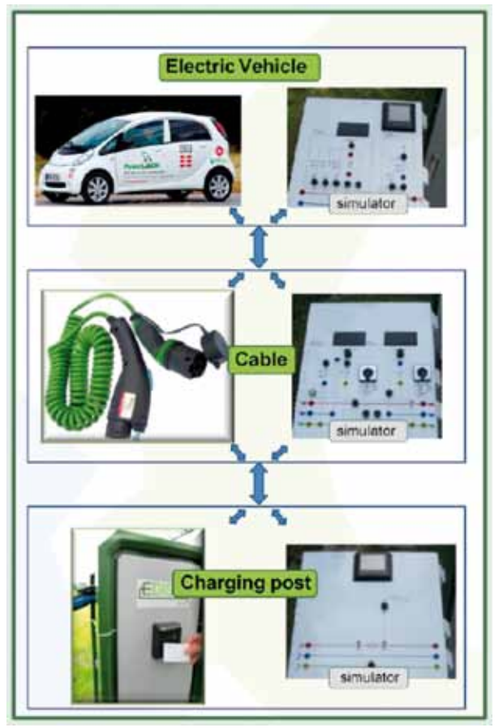
Testing Centre for Electromobility of Fraunhofer IWES

The Testing Centre for Electromobility (TPE) of IWES determines the efficiency of the battery charge of the Electric Vehicles and evaluates charging strategies. Grid disturbance and susceptibility of the electric vehicles can be checked in accordance with the applicable standards. In addition, TPE realistically simulates the charging performance of a series of electric vehicles. The focus of investigation is set on the energy management of the temporal connection of renewable power generation. Prototypes of electric vehicles can be investigated using newly developed testing procedures in a confidential environment. A test track enables the testing of inductive charging systems.

Roller dynamometer test bench for electric vehicles at IWES

Nordic Electric Vehicle Interoperability Center at the Technical University of Denmark (DTU)

Nordic Electric Vehicle Interoperability Center (NEVIC) was established in 2012 and is located in the DTU Electrical Engineering Department at Risø Campus in Roskilde, Denmark. NEVIC has the flexibility to undertake experiments in a live laboratory for intelligent, active and distributed power system. NEVIC performs interoperability testing according to IEC and SAE standards. The facilities are equipped with the required capacity to supply several charging posts and fast charging equipment from the EV operators in the Danish market. NEVIC performs interoperability tests of electric vehicles, cable cord sets, and EVSE in various research projects. NEVIC has developed simulators where the equipment can be tested to and beyond the limits of the standards. The setup is flexible and can be quickly adapted to new technology add-ons. The connected infrastructure enables vehicle-to-grid testing in a live laboratory for intelligent, active and distributed power.



NEVIC

Test combinations within the limits of the standards and recommendations, DTU

Electric Vehicle Research and Testing Facilities of the Institutes of DERlab Association

Solar Mobility at INES

The Interoperability Centre for Electric Vehicles at TECNALIA

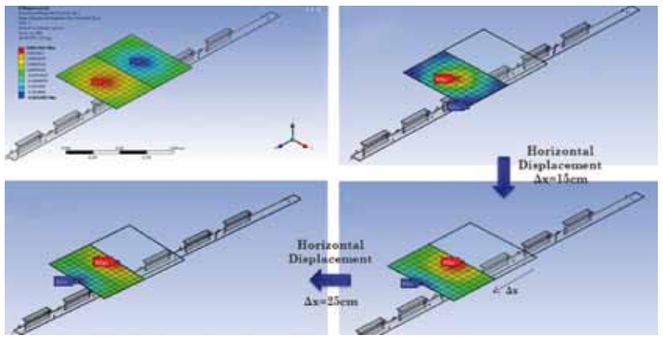
TECNALIA has an advanced platform for characterising, developing and validating mechanical and electrical components which can be combined with high performance electric vehicles. TECNALIA especially focuses on EV integration within the smartgrid, BMS development, test benches, business models analysis, fast charge and other advanced power electronics based systems. Further fields of research include tele-management as well as data collection systems (EVSE, EVSP, DSO). For wireless charging TECNALIA has developed a system based on a resonant magnetic coupling, able to charge an EV at 3.3 kW with a performance above 93%.

TECNALIA complements the research with accredited testing capabilities to measure and assess the compliance of products with Standards and Regulation. TECNALIA already offers some services for assessing compliance for EV and their charging infrastructure, such as: Low Voltage and EMC Directives; 61851: Charging Systems for EVs; IEC 15118: EV communication interface and EN 61439-7 Low-voltage switchgear, and control gear assemblies.

Wireless charging of an electric car at TECNALIA's parking lot

National Technical University of Athens (ICCS-NTUA), Greece

The Institute of Communication and Computer Systems (ICCS) of NTUA has developed an evaluation suite of tools for analyzing and optimizing the process of charging electric vehicles. The use of simulation tools enables both static and dynamic analyses of EV grid integration. Various technical, economic and environmental issues can be investigated, including network power losses and loading, voltage and frequency profile, energy market prices, ancillary services and generation adequacy, as well as CO_2 emissions. Furthermore, the NTUA laboratory can perform 2D and 3D magnetic field analyses to define the operational challenges of different inductive charging infrastructures.



Magnetic field analysis of inductive charging infrastructures

PRISMES Platform at the French National Institute for Solar Energy (INES) at CEA

The Solar Mobility concept of The French National Solar Energy Institute (INES) assures the maximum solar share during the charging of electric vehicles and to minimize the impact on the grid. The facilities at INES include more than ten electric vehicles and charging stands from different manufacturers, both integrated to the multi-microgrid PRISMES platform of INES. The availability of a real time simulator allows to test advanced inverter concepts for the vehicles. PRISMES allows to integrate PV generators, stationary storage, and energy management systems to validate smart grid integration concepts for electric vehicles. A centralised supervision system is visible in a control room, demonstrating the operation of the vehicle charging platform and the aggregation of energy management systems. There is also a second solar charging station located at CEA in Grenoble, and both facilities enable technology development and demonstration for industrial partners.

Electric vehicle and battery laboratory of VTT Technical Research Centre of Finland

Ebus for testing of storage and electronic components at VTT Technical Research Centre of Finland

VTT has increased the operations in its vehicle laboratory in Espoo, Finland, to meet the development needs of electric vehicles. The new power supply unit is capable of both simulating the battery system of a heavy electric vehicle and performing full-scale battery charge-discharge cycles. In addition, a totally new battery laboratory was opened in September 2012. It concentrates on measuring the performance of battery cells, modules, and complete energy storage systems for electric vehicles in a repeatable manner under variable controlled circumstances for different standardised and application-specific duty cycles.

Electric vehicles and their powertrain can be studied in both laboratories jointly as an entity, including electric motors, electronics and batteries.

Centre for Renewable Energy Sources and Saving (CRES), Greece

Battery testing at CRES

CRES is actively involved in testing, evaluation and dissemination of Electric Vehicles (EV). CRES has designed, developed and evaluated a Simplified Monitoring System (SMS) for performance monitoring of EV fleets with built-in GPS capable of performance evaluation and fleet management. CRES has received a patent for the SMS. CRES is also carrying out EV performance, energy consumption, battery testing and related studies. It also has laboratories for EV battery and electrical subsystems testing, such as battery units and battery management systems. Last year CRES participated in a report prepared for the Ministry of Environment, Energy and Climatic Change, titled: "Investigating ways for the development and penetration of electric vehicles in Greece."

Electric Vehicle Research and Testing Facilities of the Institutes of DERlab Association


Photo: TU Lodz

DER laboratory at the Technical University of Lodz

Distributed Energy Resources Test Facility (DER-TF) at Ricerca Sistema Energetico (RSE), Italy

RSE activities in this area have a multidisciplinary approach and aim at evaluating the effects of electric mobility on the whole power system, addressing regulatory aspects and relations with smart cities and communities. Studies concern the analysis of different scenarios of electric mobility, including evaluating their influence on air quality at local and national level; development and application of methods to predict and monitor the impact on the distribution power grid: i. e. evaluation of hosting capacity and dynamic grid behaviour. Experiments deal with technological aspects: interoperability; control and communication issues of V2G services; ultra-rapid recharge and aging of batteries and super capacitors.


Photo: RSE

Electric vehicle recharging station powered by renewables at RSE

Vehicle Testing and Integration Facility (VTIF) at the National Renewable Energy Laboratory (NREL), Colorado, the U. S.

The Vehicle Testing and Integration Facility (VTIF) at the National Renewable Energy Laboratory was built with a specific focus on testing electric vehicles, charging options, and grid integration – all of which are critical for expanded transportation infrastructure around plug-in electric vehicles (PEVs). Capabilities at the VTIF include vehicle energy management within smart grids, vehicle charge integration with renewable energy resources, bi-directional vehicle charge testing and demonstration and vehicle thermal management. Four test bays at the facility allow for multiple tests to be conducted simultaneously in controlled environments and can accommodate a wide variety of vehicles, including one test bay built specifically to conduct testing on heavy duty vehicles. An upcoming addition to the capability of the facility is an 18 kilowatt solar array which will be tied directly to vehicle charging and will allow researchers to undertake more expanded work around the use of solar energy to charge electric vehicles within microgrids.


Photo: Dennis Schroeder, NREL/PIX 19931

Car undergoing climate control analysis at the VTIF

Laboratory of Distributed Generation at the Technical University of Łódź, Poland

The laboratory of the Technical University of Lodz serves for testing the integration of distributed generation with the power networks. The facility enables simulating and testing EV charging stations and their interoperability with power networks. Furthermore, the laboratory facilitates evaluation of the immunity to disturbances and the energy management strategies of the EV charging stations connected to the grid containing RES. It is equipped with Real Time Digital Simulator having a EmTest multifunctional AC/DC power source, a flywheel and battery storage devices, PV panels, wind generators, fuel cell system, microturbine system and loads.

Development of electric vehicles management system at CIEMAT, Spain

Since October 2012 the Centre for Energy, Environment and Technology Research (CIEMAT) has participated in the Spanish national project VE2, Intelligent Building Energy Management using Electric Vehicles. The project is initially based on the study of energy consumption of buildings and electric vehicles, with the boundary conditions set on legislation and the market. The conducted work aims to develop a business model that facilitates a new kind of intelligent device management of all systems involved (buildings, electric vehicles, distributed generation, etc). VE2 assists electric vehicle integration into society with the focus on energy management in smart cities.

Wind Energy Unit at CIEMAT

The Power Networks Demonstration Centre (PNDC) at the University of Strathclyde, UK

PNDC has capabilities for researching and demonstrating the interaction between the grid and electric vehicles. The facilities include plug-in AC and DC charging stations connected to the 400 V network and a wireless 60 kW inductive charging station for heavy-duty vehicles. The network is controlled using an RTDS or SCADA and can run between 49.6 – 61 Hz. This allows investigations into network effects on vehicle charging processes and battery life and the use of smart grid components such as distributed storage and generation. There is also a unique tool to investigate and model vehicle state of charge to support control and forecasting as well as passenger comfort.

The Power Networks Demonstration Centre at the University of Strathclyde

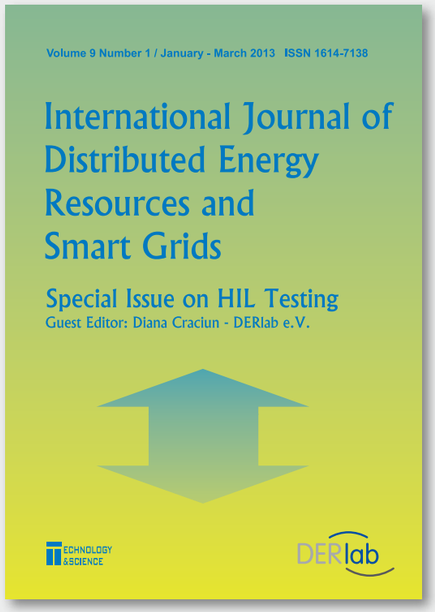
Publications

Journals

FPGlab of DNV KEMA

Photo: DNV KEMA

International Journal of Distributed Energy Resources and Smart Grids is a scholarly peer-reviewed archival Journal. It publishes experimental, theoretical and applied results in both science and engineering. DERlab was the quest editor of the special issue on Harware-In-the-Loop Testing.



"The technical integration of distributed energy resources (DER) into public distribution and transmission grids, often performed by power electronics, will have an increasing impact on the quality, reliability and availability of supply as the penetration of DER increases. The role of stringent testing in combination with in-depth simulation will therefore become more prominent to ensure, or even improve, the current level of quality of supply. The testing and validation of individual components will no longer suffice on its own.

For the purpose of de-risking equipment in complex grids under dynamic situations, the testing should include the entire system. The combination of simulation together with hardware experimentation promised by hardware in the loop techniques will be inevitable to allow the validation of the system at the required complexity including the highly dynamic and transient power system behaviour under real-time constraints. Hardware in the loop techniques will help to advance the development of suitable testing and validation methods to ensure quality, reliability and availability of energy supply within the more dynamic, demanding and DER integrated grids of the future."

Extract from the paper The Role of Hardware in the Loop in Validation and Testing by E. de Jong, P. Vaessen, R. de Graaff (DNV KEMA). Published in International Journal of Distributed Energy Resources and Smart Grids, Volume 9, Number 1

Content of the International Journal of Distributed Energy Resources and Smart Grids

Special issue on Hardware-In-the-Loop Testing, Volume 9, Number 1, January–March 2013

- The Role of Hardware in the Loop in Validation and Testing
  E. de Jong, P. Vaessen, R. de Graaff
- An Advanced Platform for Development and Evaluation of Photovoltaic Inverters Using Hardware-in-the-Loop
  B. Lundstrom, S. Chakraborty, B. Kramer, D. Terlip, B. Kroposki
- A Development and Validation Environment for Real-Time Controller-Hardware-in-the-Loop Experiments in Smart Grids
  F. Andrén, F. Lehfuß, T. Strasser
- Power-Hardware-in-the-Loop Simulations for Electrical Generators in LV Grids
  G. Lauss, B. Bletterie, C. Mayr, F. Lehfuß, R. Bründlinger
- A Power-Hardware-in-the-Loop Facility for Microgrids
  P. Kotsampopoulos, A. Kapetanaki, G. Messinis, V. Kleftakis, N. Hatziargyriou
- Power-Hardware-in-the-Loop Test Bed for Integration of Alternative Energy Sources
  C. Molitor, X. Wu, A. Helmedag, A. Benigni, A. Monti
- Hardware-in-the-Loop Multi-Objective Optimization of Electromagnetic Actuators
  O. Craciun, G. Stengel, C. Reuber
- Hardware-in-the-Loop Testing of DSP Based Distance Relay of STATCOM Connected Transmission Line
  M. V. Sham, V. K. Panduranga
- HIL-Methods Supporting the Development Process from Simulations to Real Environment Testing
  R. Brandl, H. Hernandez, D. Geibel

Next Issue

DERlab special issue on Grid Integration of Electric Vehicles

International Journal of Distributed Energy Resources and Smart Grids
Submission deadline for papers: 30 April, 2013
Further information on **www.der-journal.org**

Conference Papers

Cooperative scientific articles by DERlab e. V. or by the member institutes of DERlab e. V. in 2012

Title	Authors	Place of the publication	Affiliation
The EU DERri Project: open use of Research Infrastructures for experimental activities in the field of integration of Distributed Energy Resources	G. Franchioni[1], P. Mora[1], M. Rizzi[1], S. Numminen[2], D. Craciun[2]	IRED 2012	1. **RSE**, 2. **DERlab e. V**.
Harmonising hardware-in-the-loop simulation procedures for power systems and distributed energy resources components	T. Strasser[1], F. Lehfuß[1], P. Kotsampopoulos[2], P. Crolla[3], C. Tornelli[4], S. Numminen[5]	IRED 2012	1. **AIT**, 2. **ICCS-NTUA**, 3. **University of Strathclyde**, 4. **RSE**, 5. **DERlab e. V.**
Harmonised Procedures on Photovoltaic Modules Long-Term Energy Yield Measurements and Performance Evaluation under Outdoor Conditions	D. Craciun[1], V. Helmbrecht[1], P. Funtan[2], P. Strauss[1,2], S. Misara[2], A. Ellis[3], R. Bruendlinger[1,4], S. Tselepis[5], A. Kyritsis[5], N. Hatziargyriou[6], K. Latoufis[6]	EU PVSEC 2012	1. **DERlab e. V.,** 2. **Fraunhofer IWES**, 3. **Sandia National Laboratories**, 4. **AIT**, 5. **CRES**, 6. **ICCS-NTUA**
SOL-ION PV Storage System: Field Trial Results, Spread of Operating Conditions and Performance Evaluation based on field data	J. Binder[1], H. D. Mohring[1], M. Danzer[1], O. Schanz[1], A. U. Schmiegel[1], A. Linhart[2], M. Landau[3], J. von Appen[3], F. Niedermeyer[3], M. Braun[3], D. Magnor[4], D.-U. Sauer[4], H. Schuh[5], U. Thomas[6], N. Martin[7], J.-C. Marcel[8], C. Jehoulet[9]	EU PVSEC 2012	1. ZSW, 2. voltwerk electronics GmbH, 3. **Fraunhofer IWES**. 4. ISEA RWTH, 5. Saft Batterien GmbH, 6. E.ON Bayern AG, 7. **CEA-INES**, 8. Tenesol, 9. Saft Batteries
Numerical Analysis of the Impact of Environmental Conditions on the BIPV Systems, an Overview of BIPV Modelling in the SOPHIA Project	Y. B. Assoa[1], S. Zamini[2], W. Sprenger[3], S. Misara[4], M. Pellegrino[5]	EU PVSEC 2012	1. **CEA-INES**, 2. **AIT**, 3. **Fraunhofer ISE**, 4. **Fraunhofer IWES**, 5.ENEA.
RESERVICES - Economic Grid Support from Variable Renewable: System Needs	M. Rekinger[1], G. Masson[1], S. Wokke[2], F. Van Hulle[2], H. Holttinen[3], D. Craciun[4], P. Kreutzkamp[5], N. Cutululis[6]	EU PVSEC 2012	1. EPIA, 2. EWEA, 3. **VTT**, 4. **Fraunhofer IWES**, 5. 3E. 6. **DTU**

Title	Authors	Place of the publication	Affiliation
Free access to 48 Photovoltaic Research Infrastructures: The Sophia Project	P. Malbranche[1], G. Siefer[2], M. de Bruijne[3], I. Gordon[4], P. Sommer-Larsen[5], N. Taylor[6], I. Lauermann[7], J. Hüpkes[8], I. Anton[9], F. Aleo[10], F. Paletta[11], R. Gottschalg[12], F. Roca[13], S. Rousu[14], T. Pettersen[15], S. Zamini[16], M. Rekinger[17], G. Arrowsmith[18], E. Román Medina[19], D. Craciun[20]	EU PVSEC 2012	1. **CEA-INES**, 2. **Fraunhofer ISE**, 3. ECN, 4. imec, 5. **DTU**, 6. European Commission DG JRC, 7. HZB, 8. Forschungszentrum Juelich, 9. UPM, 10. ENEL, 11. **RSE**, 12. Loughborough University, 13. ENEA, 14. **VTT**, 15. SINTEF, 16. **AIT**, 17. EPIA, 18. EUREC, 19. **TECNALIA**, 20. **DERlab e. V.**
Improving the Portability and Exchangeability of Model Data for Smart Grids focusing on Real-Time Simulations – Definition of a Common Reference Model	T. Strasser[1], M. Stifter[1], W. Hribernik[1], E. Lambert[2], P. Kotsampopoulos[3], P. Crolla[4], C. Tornelli[5]	CIGRE Session 44 Paris, France, August 2012	1. **AIT**, 2. EDF, 3. **ICCS-NTUA**, 4. **University of Strathclyde**, 5. **RSE**
Comparison of multiple Power Amplification types for Power Hardware-in-the-Loop Applications	F. Lehfuß[1], G. Lauss[1], P. Kotsampopoulos[2], N. Hatziargyriou[2], P. Crolla[3], A. Roscoe[3]	IEEE Workshop on Complexity in Engineering (COMPENG 2012), June 2012	1. **AIT**, 2. **ICCS-NTUA**, 3. **University of Strathclyde**
Harmonized procedures for long-term energy yield measurements and performance evaluation of PV modules in outdoor conditions	V. Helmbrecht[1], D. Craciun[1], A. Ellis[2], J. Granata[2], S. Tselepis[3], A. Kyritsis[4], N. Hatziargyriou[4]	Photovoltaics International Journal, February 2012	1. **DERlab e. V.,** 2. **Sandia National Laboratories**, 3. **CRES**, 4. **ICCS-NTUA**
Is the Distribution Grid Ready to Accept Large Scale Photovoltaic Deployment? – State of the Art, Progress and Future Prospects	M. Braun[1], T. Stetz[2], R. Bruendlinger[3], C. Mayr[3], K. Ogimoto[4], H. Kobayashi[5], H. Hatta[5], B. Kroposki[6], B. Mather[6], M. Coddington[6], K. Lynn[7], G. Graditi[8], A. Woyte[9], and I. MacGill[10]	Progress in Photovoltaics, November 2011	1. IEH, University of Stuttgart, 2. **Fraunhofer IWES**, 3. **AIT**, 4. University of Tokyo, 5. CRIEPI, Japan, 6. **NREL, US**, 7. US Department of Energy, 8. ENEA, 9. 3E, 10. CEEM, Australia

DERlab Association

DERlab is the network of leading research institutes working together for the grid integration of distributed power generation. The association develops joint requirements and quality criteria for the connection and operation of Distributed Energy Resources (DER) and strongly supports the consistent development of DER technologies. DERlab offers testing and consulting services on grid integration of distributed generation and conducts research on a wide range of related topics, such as:

- Interconnection requirements of DER
- DER and Smart Grids related R&D
- Grid-connected storage
- Electromagnetic compatibility requirements for DER
- Static converters in grids
- DER testing procedures
- Ancillary services
- Communication
- Photovoltaic modules
- Hardware-in-the-Loop
- Network protection
- Electric Vehicles

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Imprint

Activity Report 2012 / 2013

published by

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34119 Kassel / Germany
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www.der-lab.net

supported by

Distributed Energy Resources Research Infrastructure (DERri)

Kassel, April 2013

Layout:
Karen Marschinke | formkonfekt.de

Print:
Strube Druck & Medien OHG, Felsberg

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