DISPOWER – Distributed Generation with High Penetration of Renewable Energy Sources

Philipp Strauss[1], Tim Meyer[2], Thomas Erge[2] and Thomas Degner[1]

info@dispower.org
http://www.dispower.org

[1] Institut fuer Solare Energieversorgungstechnik
ISET, Koenigstor 59, D-34130 Kassel, Germany
Tel: + 49 561 7294-243, Fax: -400

[2] Fraunhofer Institute for Solar Energy Systems
ISE, Heidenhofstr. 2, D-79110 Freiburg, Germany
Tel + 49-761 4588-5229, Fax –9229

Abstract

The increasing penetration of RE Sources (RES) and other distributed generation (DG) in the European energy supply leads to numerous technical challenges. For maintaining a reliable and even cost effective energy supply, new efforts have to be undertaken for the management of energy networks, integration of RES and other decentralised units in the distribution networks, for load management and shaping, as well as technical and socio-economic aspects of decentralised energy markets. The DISPOWER European project is intended to support the transition of nowadays energy supply towards a more decentralised and market oriented supply structure. New concepts, strategies and tools will be developed and implemented in order to improve the production and distribution of electricity and heat and supporting the opening of new market opportunities in a growing electricity market [1]. This paper presents selected results produced by the consortium of the DISPOWER project during the first two years. For further reading please visit the Internet address http://www.dispower.org.

1 Background

Due to the ongoing process of liberalisation of the European energy market, the unbundled energy sector is now in transition to more competition in electricity generation, distribution and trading. With open access to the electricity distribution grids and suitable energy wheeling conditions, new players will arrive in the competitive market. They will further support the already existing trend towards more distributed gen-

eration (DG) of power, which until now has mainly been induced by the increasing integration of Renewable Energy Sources (RES) and cogeneration. This development will lead to technological challenges as well as challenges concerning the regulatory and legal framework. For maintaining a reliable and cost effective electricity supply, new efforts will have to be undertaken for the management of electricity networks, integration of RES and other DG units in the distribution networks – for load management and load shaping etc. Furthermore, energy markets will be strongly affected in respect to technical and socio-economic aspects.

The DISPOWER project intends to support the transition process mentioned above towards a more decentralised and market oriented supply structure. New concepts, strategies and tools are being developed and will be implemented in order to improve the production and distribution of electricity and heat. This will support the opening of new market opportunities for renewable energies and distributed generators. Thus, the DISPOWER project will help to prepare the safe, reliable and high quality implementation of distributed generation into European grids, focussing on the efficient integration of renewable energy sources.

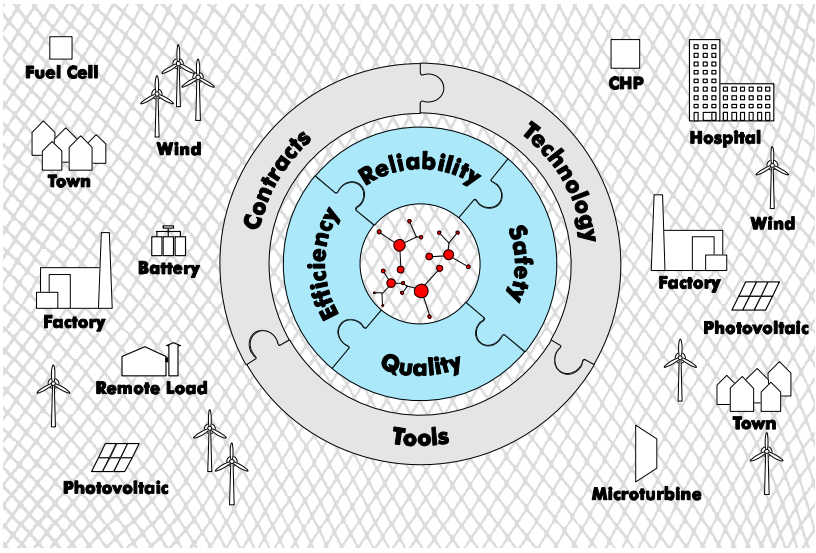


Figure 1: Objectives and integrated approach of the DISPOWER project

2 Objectives and strategic aspects

Three independent trends - utility industry restructuring, increasing use of RES, and technology advancements - are laying the groundwork for the widespread introduction of cleaner technologies and decentralised generation. Through this development, more and more emphasis has to be given to aspects related to the systems technology for the integration into present energy networks. The increasing penetration of renewable energy sources and other decentralised generation in the European energy supply will also lead to numerous technical and non-technical challenges.

The main objectives of the project are:

- Elaboration of strategies and concepts for grid stability and system control in distributed generation (DG) networks
- Preparation of safety and quality standards in DG networks and investigations on power quality improvements and requirements by decentralised inverters and generation systems
- Assessment of the impacts on consumers by ICTs, energy trading and load management
- Development of planning and design tools to ensure reliable and cost effective integration of DG components in regional and local grids
- Creation of Internet based information systems for improved communication, energy management and trading
- Investigations on contract and tariff issues regarding energy trading, wheeling, and ancillary services
- Improvement and adaptation of test facilities and execution of experiments for further development of DG components, control systems as well as design and planning tools
- Successful dissemination and implementation of concepts and components for an improved integration of DG technologies in different European electrical network environments

In order to achieve these challenging objectives, a competent consortium has been set up covering all major key actors in the energy sector such as electrical utilities (DSO and TSO), power industry, consultants and research institutions. This consortium ensures a streamlined technological development on a broad European basis making use of different national resources.

3 Selected Project Results

In the following Chapter we intend to set some highlights on selected project results that have been achieved so far. A complete updated list is available on the project's webpage [1]. This webpage includes a new project management tool that was especially designed for this project and is available for other projects, too.

3.1 Set up of DER Laboratories and Testing

CESI and ISET have completed their laboratories for testing new concepts and performing experimental work concerning system aspects of the integration of DER components in the distribution grid. These laboratories will not only support the experiments planned in the project but will be used further on for supporting pre-standardisation work by developing testing procedures for DER components. A detailed description can be found in [2].

Figure 2: MV and LV supply, switching and interconnection boards at CESI's DG-lab [3]

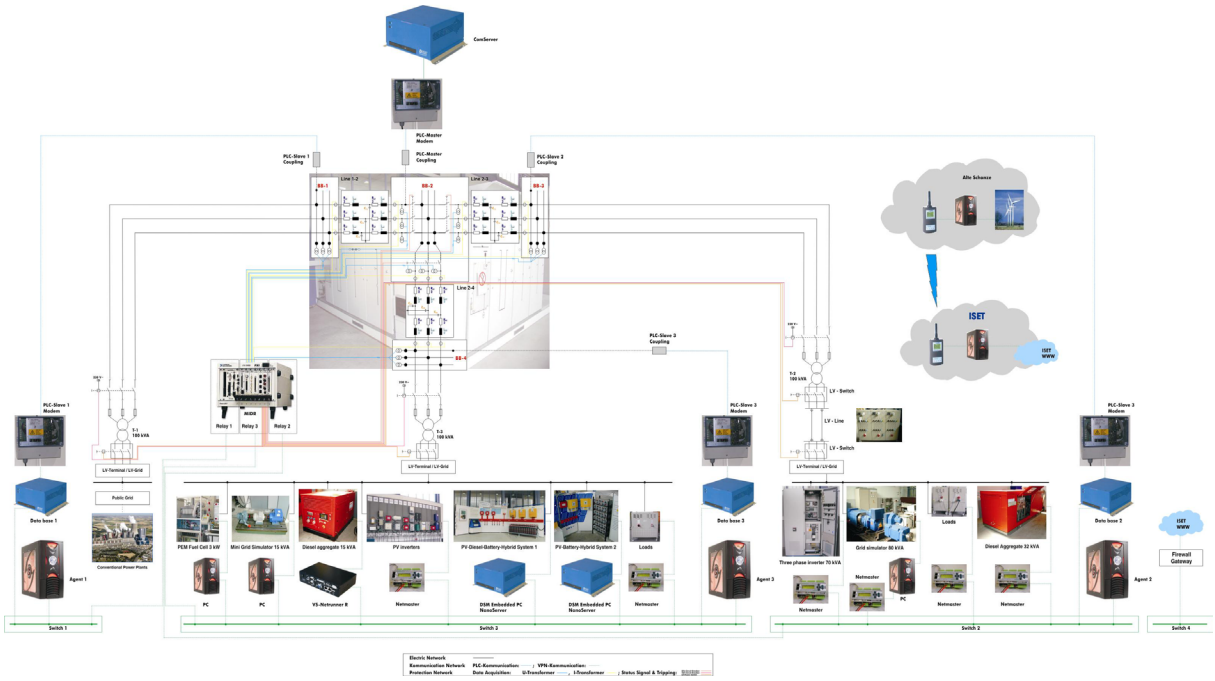


Figure 3: Block diagram of ISET's DG-equipment applied for tests

3.2 Operator Training Facility for Distributed Generation

Grid operator training is inevitable in order to guarantee the efficient and reliable grid and power plant management. The project partner DUtrain in cooperation with the University Duisburg-Essen operates a highly professional training environment. High shares of dispersed generation require the implementation of new models into the training equipment mainly due to the following (cited from [4]):

- Unpredictable in-feed power (especially in the case of RE sources)
- Unusual power flows
- Problematic voltage profiles
- Unfamiliar or even incorrect protection behaviour in the case of failures

Appropriate models for DG have been implemented successfully in the project.

Figure 4: Training course with involvement of several control centres for network operation and power production [4]

3.3 Integration of Wind Power

Electricité de France (EDF) has completed the EUROSTAG simulation software for the simulation of power system dynamics by adding new wind turbine generator models to simulate doubly fed wind turbines, induction wind turbines with dynamic slip control, permanent magnet synchronous wind generators, induction or synchronous wind turbine generators connected to the grid through back-to-back power electronics converters and a model of high voltage direct current (HVDC) links for offshore wind farms [6].

A wind power prediction tool for market-based electricity trading systems such as in the UK was developed based on ISET's wind prediction models. With this tool the following results could be achieved [5]:

- improved calculation of energy bids
- improved accuracy compared to persistence
- 1420 MW (2,7%) avoided energy lack
- 1750 MW (3,3 %) avoided energy surplus

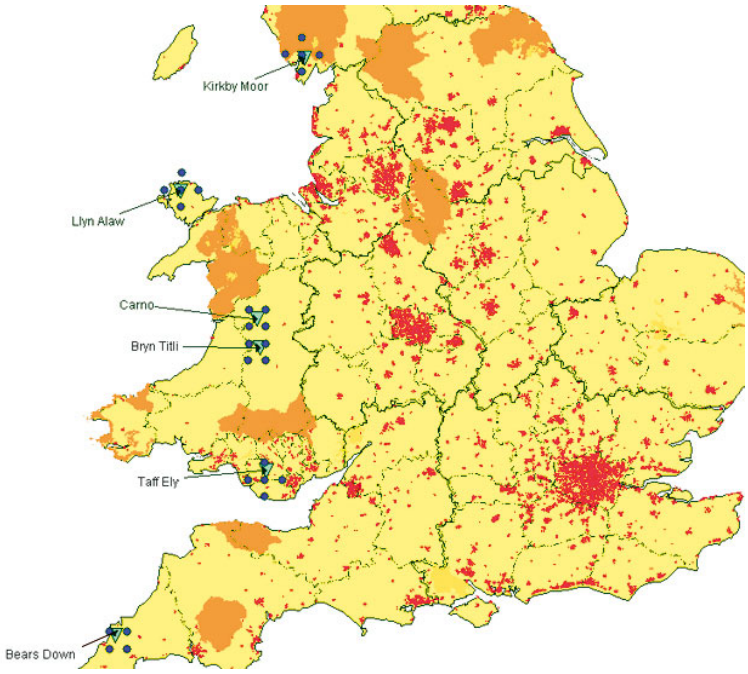
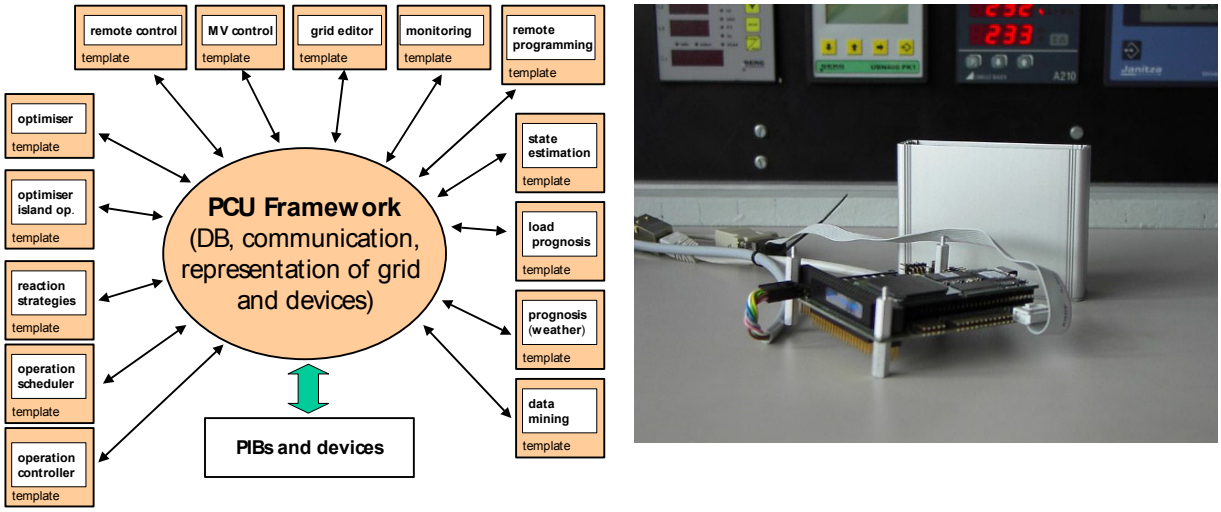


Figure 6: Wind farm sites with surrounding grid points of the UK-Met-Office weather model [5]

3.5 Distributed Power Operation and Power Quality Management in Low Voltage Grids

FhG-ISE jointly with partners has designed a power operation and power quality management system (PoMS) for application in low voltage grids. PoMS is a LV electricity grid optimisation tool which optimises grid infrastructure operation, distributed generation control and demand side load management. On this basis, it enables and mediates integration of dispersed energy sources into energy grids at high penetration level and supports grid management in liberalised energy markets as well as integration of renewable energy sources.

PoMS will be installed at the test facilities of CESI and Iberinco, and it will be applied for demonstration and testing to real grid segments of the project partners MVV Energie and SWK. The final results will comprise a general concept for hardware and software including control algorithms for PoMS, a prototype of PoMS ready for implementation in test sites using standard hardware and interfaces, and a report on operation and improved version of PoMS in LV grids.



Figures 7: (a) PCU Software Framework for the PoMS system and (b) embedded system for power interface boxes (PIB)

3.6 Pilot test sites

PoMS will be implemented in cooperation with MVV Energie at the pilot installation site Stutensee in Germany. Stutensee is an area with 101 residential units where a 40 kV combined heat and power unit is installed. Additionally a 30 kW PV-plant and a battery connected with an 80 kW inverter (222 V / 880 Ah) will be integrated in the PoMS management system.

A further test site will be the “Supply Centre East” in Karlsruhe, Germany. The project partner Stadtwerke Karlsruhe selected it as a study case in order to test the new concepts and components in a business area with a 20 kW to 40 kW load, 35 kW distributed generation and a 100 kW storage system (for one hour).

The test site of S. Agustín is a Technology Demonstration Center where it’s possible to find different kinds of renewable energy generators and several segments of grid (LV & MV). Different combinations of DG components will be studied.

4 Acknowledgement

We would like to express our thanks to the European Commission for the support of the project DISPOWER (ENK5-CT-2001-00522). The results have been produced by partners of the DISPOWER project consortium and do not reflect the opinion of the European Commission.

5 References

[1] http://www.dispower.org/

[2] Ph. Strauss, T. Degner: "*European Laboratories for Distributed Energy Resources – Technology and International Co-operation."* World Renewable Congress VIII, Denver, Colorado (USA), 29. August - 03. September 2004

[3] Claudio Bossi, Alessandro Bertani, Achille Marcoli: The Distributed Power Generation Test Facility in CESI, DISPOWER Project Highlight No.04, ISET, Kassel, 10/2003

[4] Carsten Roggatz, Jens Matics: Operator Training for Distributed Generation, DISPOWER Project Highlight No.09, ISET, Kassel, 1/2004

[5] Kurt Rohrig, Bernhard Ernst: Wind Power Prediction Tool Successfully Adapted, DISPOWER Project Highlight No.02, ISET, Kassel, 08/2003

[6] Regine Belhomme, Pierre Bousseau: Wind Turbine Generator Models for Simulation of Power System Dynamics with the EUROSTAG Software, DISPOWER Project Highlight No.05, ISET, Kassel, 11/2003