



DISPOWER

**Distributed
Generation
with
High
Penetration
of
Renewable
Energy
Sources**

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Result realised by:



Operator Training for Distributed Generation

Results:

Development of an interactive Operator Training facility for power systems with dispersed generation by

- > *complementing an existing training simulator by various models of distributed generation sources as well as the appertaining control structures and*
- > *procurement of appropriate training programs for both smaller dispersed generation based systems as well as large transmission systems under the influence of strong wind generation.*

Dispersed generation, from the viewpoint of electric power system operation, is connected with occurrences such as

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

While these effects are inevitably dominating the operation of small and detached power systems, with respect to the installation of very large wind farms they also get increasing significance for large interconnected transmission systems.

Training of the operator personnel in the control centres to master these phenomena is an appropriate measure. A high fidelity power system operator training simulator can procure a realistic platform to perform such training in systematic manner, pro-

vided that it truly models the complete power system under regard, including protection and control systems as well as the interfaces with external entities such as power plants (conventional and/or dispersed ones) and neighbouring systems.



Training course with involvement of several control centres for network operation and power production



Trainer desk (interactive access to training course process)



Functionality of operator training simulator

An operator training simulator (OTS) briefly described consists of three principal components.

The SCADA system comprises the operational user interfaces and the process data handling. The telemetric line interface is used for the connection of, and the data exchange with, the models for the technical equipment such as switching and protection devices, automatic tap changers, generation units, load performance, etc. The power system calculation engine simulates the physical performance of the entire power system represented by the actual topology retrieved from the SCADA system and the physical parameters of its equipment. The calculation results are sent back to the SCADA system as measurement values.

Additional features of the OTS (DUtrain PSH) used here are:

- Representation of power system control hierarchical organisation comprising several control centres in parallel.
- Splitting of grid control and generation control, each represented in specifically customized control centres.
- Capability of technical equipment models and power system calculation engine for 'normal' and 'abnormal' operational conditions up to system restoration after full blackouts.
- Powerful scenario management.

In order to cope with today's challenges of system operation caused by dispersed generation, new technical DG models for the OTS as well as new control and user interfaces for the SCADA system are being developed and implemented.

Dispersed generation models

The realised concept of modelling distributed generation sources such as wind turbines and parks, micro gas turbines, fuel cells, Diesel generators, photovoltaic and storage systems provides individual dispersed generation block modules, consisting of primary sources, electrical machines and converters where applicable (see table). From these block modules the individual configurations can be composed; in the case of aggregation of identical installations (e.g., wind parks) the models can be set up in concentrated form, then also considering influencing effects such as mutual shadowing in the case of wind generation. For wind speed and solar irradiation the random weather conditions are simulated, too. Storage systems are modelled regarding their storage capacity, efficiency, time dependent loss factor and the maximum charging / discharging power.

All DG models are developed using the Matlab/Simulink? environment (offering a very detailed time resolution and versatile use) converted into C code and implemented into the OTS using clear interfaces for data exchange.

Development and performance of training programs

Despite any changes due to dispersed generation, operators in the grid control centres and power production centres have to run the power system in appropriate manner to guarantee reliable supply of the customers with electrical energy. Therefore specific theoretical knowledge as well as practical experience of controlling the whole process and the coordination and communication of the involved entities are required.

Specifically designed training programs regarding dispersed generation contain:

- Background of dispersed generation modules, their physical performance and control possibilities.
- Influence of dispersed generation on today's power system control procedures (e.g. power reserve management).
- Mutual influence of dispersed generation and overall system's operational performance.

The practical experience can be gathered in the frame of training simulator sessions.

For the training sessions the simulator is updated with a replica of the selected power system under regard. Scenarios derived from day-to-day operation are prepared as dedicated examples to demonstrate the system control requirements (e.g., voltage profile, power exchange, unpredicted power flows).

These training programs give operators hands on experience and insight in controlling power systems with dispersed generation. At the same time the cooperation of, and the communication between, all involved entities is trained. Furthermore the simulator set-up can be used for analysis and feasibility studies of control strategies in the power system environment.

Source	El. Machine			Converter		Reactive power compensation
	SM	ASM	DFIG	IGBT	THY	
Photovoltaics				x		
Microgasturbine				x		
Fuel Cell				x		
Wind	x	x		x	(x)	(x) x
Diesel	x		x	x		
Storage Systems						
Hydrogen				(x)		
Compressed air	x			(x)		
Battery				x		
Flywheel	x			x		

Realised concept of distributed generation sources and storage systems

MASTHEAD

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