General Electric

Universal Interconnection System Development

Goals

To make integration with the grid feasible for distributed generation (DG), a cost-effective, mass-produced universal interconnection (UI) system is needed. To facilitate DG interconnection, General Electric (GE) is working to develop a UI system. The GE approach is to:

- Develop a virtual test bed (VTB) for DG and its utility interface that incorporates models of the DG, its loads, and the effected electric power system (EPS) components
- Conduct case studies to evaluate DG's effect on EPS power quality, protection, reliability, and stability
- Determine the effect on the utility network of increased DG penetration relative to existing network hardware such as reclosers and the ability to respond to faults
- Develop, build, and test an interface for safe and reliable DG interconnection.

Results

Virtual Test Bed

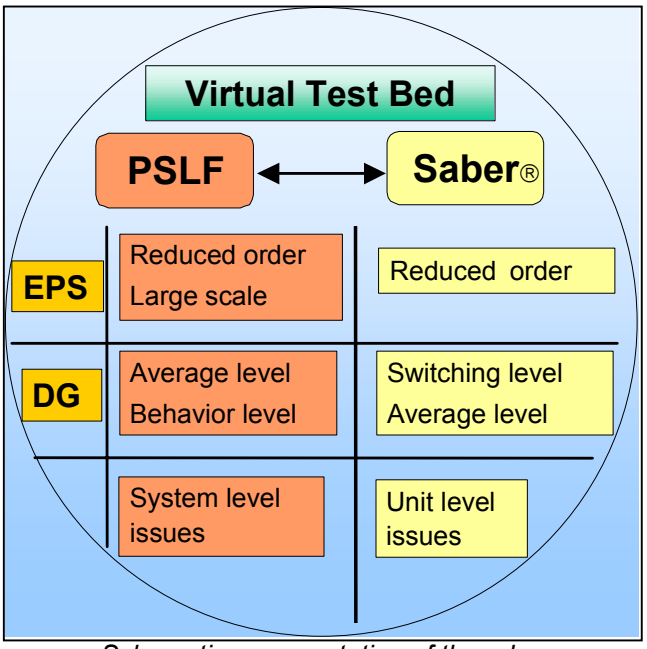
To study interconnection issues, GE designed a VTB, a computer simulation package that includes EPS, DG, and load models. This enables GE to clearly understand, study, and resolve interconnection issues before a UI is built. The VTB will be a tool for the power industry for planning and systems analysis.

The VTB includes two modeling programs: Saber® and Power System Load Flow (PSLF). Saber is a system-modeling tool that uses differential analysis suited for mixed technologies and detailed component modeling. PSLF is optimized for very large systems. The combination allows detailed analysis of large interconnection systems.

Case Studies

GE modeled case studies to understand potential effects on power quality, safety, and reliability.

For power quality (voltage regulation, flicker, voltage imbalance, harmonic distortion, and DC current injection), GE evaluated the effects of DG penetration on the EPS. Protection and reliability case studies focused on transient response and fault behaviors,



Schematic representation of the roles of the two modeling programs

recloser coordination, anti-islanding, and power system dynamics and stability. Extensive white papers were developed to present the findings on penetration effects and anti-islanding studies.

Universal Interconnection System Design

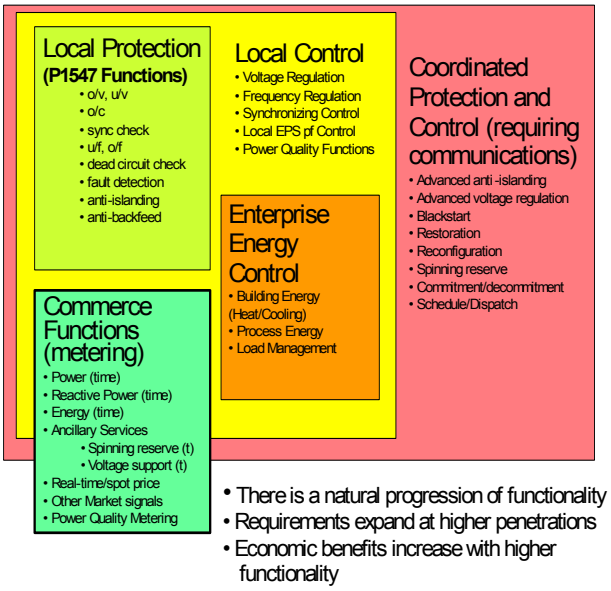
Based on what it learned, GE modeled an optimal UI design and recommended that the system be:

- Technology-neutral – able to connect all kinds of distributed resources to the utility grid.
- Modular – able to meet a minimum level of functionality and customizable for installation-specific needs. Modularity permits a combination of building blocks.
- Scaleable – scaleable to the size and level of functionality required or desired.

GE defined five levels of functionality for a UI.

1. Local protection – the minimum protective functions per IEEE 1547 standards
2. Local control – a range of DG controls such as voltage and frequency regulation

3. Coordinated protection and control – need to function properly and reliably, with networked communications, emphasizing area electric power system reliability
4. Enterprise energy and control – energy management (e.g., gas and water management) to minimize costs while maximizing efficiency
5. Commerce – monitor spot pricing, demand, resource costs, etc., to operate the DG



Representation of a modular UI system design

Construction and Testing

GE constructed a UI platform based on these design parameters. It built and tested a prototype and, based on that, refined the system. There are now two test facilities: one at GE and one at the National Renewable Energy Laboratory.

The GE UI can be operated through a front panel display or from a remote computer through a network connection. It can work in three modes to facilitate different applications. When the DG is running in grid-parallel mode, the power can be imported from or exported to the grid. In standalone mode, the DG supplies the local load, or the load can be isolated from the DG completely.

Practical testing is now in full swing at GE and the National Renewable Energy Laboratory's Distributed Energy Resources Test Facility. Multiple configurations are being tested using different types of DG, including reciprocating engines, fuel cells, wind turbines, photovoltaics, and hybrid systems. Microgrids and grid simulators are also used to test a variety of conditions.

Publications

GE Corporate Research and Development. "DG Power Quality, Protections, and Reliability Case Studies Report." NREL/SR-560-34635. August 2003.

GE Corporate Research and Development. "Reliable, Low-Cost Distributed Generator/Utility System Interconnect: 2001 Annual Report." NREL/SR-560-3464. August 2003.

Miller, N.; Ye, Z. "Report on Distributed Generation Penetration Study." NREL/SR-560-34715. August 2003.

Ye, Z.; Finney, D.; Zhou, R.; Dame, M.; Premerlani, B.; Kroposki, B.; Englebretson, S. "Testing of GE Universal Interconnection Device." NREL/TP-560-34676. August 2003.

Publications are available on the NREL publications database, http://www.nrel.gov/publications/.

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