Smart Grid – Integration of Distributed Generation

Role, Opportunities and Challenges in Future Power Generation Systems

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DISTRIBUTED GENERATION TECHNOLOGIES

- Wind Energy
- Solar Energy (photovoltaic & thermal)
- Bio-energy and Fuels
- Marine and Hydro Power
- Geothermal
- Fuel Cells
- Combined Heat & Power (CHP)
Vision for future energy distribution network

Source: EU communities 2006
Technical, Economic and Environmental Benefits of DG Integration in Smart Grid

- Transformation from a centralized, producer controlled network to one that is less centralized and more consumer interactive
- Smart Grid accommodate connection of widely distributed, renewable energy sources across the network
- Facilitate market interactions, providing customers access to products and services with choice, based on price and environmental concerns
- Improvement of energy system reliability and flexibility
- Energy efficiency
- Optimizing electricity infrastructure replacement investment
The majority of renewable energy will be achieved by DG units connected to the LV or MV network. As a result, the distribution network operators will face a number of difficulties.

How much DG can be tolerated on each voltage level of a network and concerns about stability and intermittency are among the issues to be analyzed?
Conceptual Design for Distributed Generation

- Energy management at the distributed power system.
- Management of power flow constraints, voltage & frequency.
- Device & interface response and intelligence requirements.
- Protection options for networks of variable configurations.
- Standardization of technical and commercial protocols and hardware.
Transmission grid

- >110 kV
  - Large central power plants
  - Biomass cofiring
  - Interconnections to other countries

Distribution grid

- 60 - 110 kV
  - Large industrial CHP
  - Large-scale hydro
  - Offshore wind parks

- 10 - 60 kV
  - Onshore wind parks
  - Small-scale hydro
  - Other biomass systems
  - Tidal and wave systems
  - Commercial and greenhouse CHP
  - Solar thermal and geothermal systems
  - Large photovoltaic arrays
  - Small industrial CHP

- 230/400 V
  - Individual photovoltaic panels
  - Microchip-CHP systems
Future Distributed Electricity Network

Reliable, Flexible, Accessible and Cost-effective

- Creating a toolbox of proven technical solutions that can be deployed rapidly and cost-effectively, enabling existing grids to accept power injections from all energy resources.

- Harmonising regulatory and commercial frameworks to facilitate trading, ensuring that they will accommodate a wide range of operating situations.
Inadequacy of existing dynamic simulation / analytical tools to study planning and development of networks taking into account the stochastic nature of DG, both in steady state and under dynamic conditions.

Differentiated definitions of grid connection requirements for the various types of generators are needed because of their different nature.
Establishing shared technical standards and protocols that will ensure open access, enabling the deployment of equipment from any chosen manufacturer.

Developing information, computing & telecommunication systems to utilise innovative service arrangements to improve energy efficiency, control, management and trading.

Ensuring the successful interfacing of new and old designs of grid equipment to ensure interoperability of automation and control arrangements.
Smart Distribution Infrastructure

- New architectures for system design, new concepts to study DG integration, advanced forecasting techniques, customer participation
- Innovative energy management strategies for large DG penetration, storage and demand response
- Effective distribution control for the benefit of power quality and reliability enhancement at the connection point (active and reactive power)
- A system engineering approach to study the operational integration of distributed generation & active customers
Interoperability of DG (T&D)

- Advanced forecasting techniques for sustainable operations and power supply
- Advanced operation of the high voltage system – seamless smart grids
- Pre-standardisation research
- Long distance energy supply
- Storage and its strategic impact on grids
Mechanisms by which DGs can participate

- Trading.
- Tariff.
- Real Time Control.
- Automatic Control
Role of a cell (MGCC)

- To enable decentralized active network control using local DERs
- To enhance reliability and power quality of supply locally
- To promote autonomy for local system management including capability of islanded operation and synchronization to the main grid
- To enhance energy efficiency by coordinating consumption of energy (heat, power)
- To provide a test system for future technologies
- VPP to enable efficient participation in energy market
Functionality of Controller in Each Area

- Maintaining voltage, power flows and frequency within the limits
- Optimizing generator schedules and controllable loads
- Forecasting energy demand, availability from renewables
- Optimizing control of network switching to minimize interruptions
- Managing restoration process
- Maintaining power (active & reactive) / energy balance
- Voltage control and balance during normal operation
- Stability in case of incidents on power lines or generation units, power quality issues
- Network protection issues
- Communications & integrity of remote control signals, technical standards
- Use of plug-in hybrid and all electric vehicles
- New Design for information sharing and transacting in an energy exchange system
- Regulatory framework, business models in the new energy enterprise,
Thank you