Practical Experiences with Smart Grid Deployment

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CEER Workshop on Smart Grids
June 29, 2009 - Brussels
Balancing the magic triangles – for a sustainable energy system
Energy Sector

CO2 emissions are constantly on display

large centralized power plants supply the majority of power demand

wireless sensors and smart metering coupled to load management and market driven energy supply software

car-parking for plug-in vehicles, buy or sell electricity shaving peak loads

large and very small generation plants need to be managed in parallel

storage plants buffer fluctuating generation

energy corridors underground by Gas Insulated Lines or cables (DC or AC)
Roadmap for the Future Grids in Europe

1. Ideas to support the European agenda
2. Potential solutions
3. Innovations & Technologies
4. Implementation & Facilitation processes
1. Ideas to support the European agenda

2. Potential solutions

3. Innovations & Technologies

4. Implementation & Facilitation processes
Preparing a Transmission Grid for Europe, to support the European political goal...

Connecting renewable & expanding to offshore grids

Including cross-borders power highways
Challenges in grid operation require new technological solutions.

To maintain grid stability: generation equals consumption is required.

Stochastic Renewables  Large number of Prosumers

Smart Grids will ensure active load management and grid reliability.
From traditional “Generation follows Load” to “Load follows Generation”
Grid operations are also impacted by forecasted grid developments

Consequences for Power Transmission
- Monitoring input from large wind and solar parks
- Efficiency in power plant economics
- Preventing Blackout occurrence & propagation
- Keeping system integrity
- Integrating Electricity brokerage

Consequences for Power Distribution
- Monitoring input from renewable energy
- Managing bi-directional load flow
- Driving networks to the accepted limits
- Adapting operation to serve stochastic loads

Consequences for Power Consumption
- Dealing with Smart Meters monitoring intelligent buildings
- Integrating Electricity brokerage down to the end consumer
But also working on solving present issues.

Some issues:

- Efficiency of electricity transmission & distribution
- Ageing assets
- Level of Short Circuit Current
- Stability of the combined European grids
- Environmentally friendly grid expansions
- Security of supply
1. Ideas to support the European agenda

2. Potential solutions

3. Innovations & Technologies

4. Implementation & Facilitation processes
Key technologies are mostly available ... 
... but radical innovation is needed in specific areas

Super Grid
   HVDC from Point-to-Point connections to fully meshed DC networks
   UHV AC -systems
   Right of way optimization: upgrading existing lines, underground power carriers

Smart Grid
   Advanced Energy Management Systems - Substation automation - FACTS
   Blackout Prevention (phasor measurement, wide area monitoring, state estimator, ...)
   Last Mile Smart Metering - Meter Data Management
   Energy Marketplace - Building Automation

Living with ageing infrastructures
   Condition monitoring
   Life time extension and On-site repair and maintenance

Smart Cities and Smart Buildings
   Autonomous buildings and energy management
   Active building (‘Prosumer’)

Energy Storage
   large scale (Compressed Air (CAES), Hydrogen)
   medium size ( SMES, Flywheels, heat pumps ...)
   small scale (Lithium-Ion battery, Redox-flow battery)
... and solutions should focus on Grid Intelligence ...

[Diagram of Smart Grid with various components and subcomponents, including:
- Reliability and efficiency planning
- Managed operational reliability
- Resource optimization
- Smart Grid
  - Transmission grid
    - Decision support system integrity protection
    - Advanced Energy Mgmt. System (EMS)
    - Power electronics
    - Substation automation and protection
    - Condition monitoring
    - Distribution automation and protection
    - Smart meters / demand response
  - Distribution grid
    - Asset management
    - Distribution Management Systems (DMS)
    - Smart Grid
- Common information models and communications protocols
- Smart generation
  - Wind power
  - Distant solar power
  - Distributed energy resources
  - E-cars, batteries
- Smart consumption
  - Industrial and commercial loads
  - Residential loads
  - E-cars, batteries
- Need for grid operators' feedback]
... very large and in-depth integration!

Innovative Grid

Siemens Smart Grid Approach

Enterprise resource planning
Business processes – customer and market
Grid operation
Plant operation
Power grid
Metering
Meters

Information and Communication Technology

Generation  Transmission  Distribution  Consumption
1. Ideas to support the European agenda

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Transmission Grids developments to support the European agenda

- A super European UHV DC grid allowing inter-regional massive power transfers
- Complement existing grids with off-shore grid solutions to tap wind energy and facilitate power exchange
- Implementing a Higher Voltage level for the Transmission grid
- Designing higher Isc withstand specifications and Fault Current Limiters
- Re-use of existing right of ways and underground transmission solutions
- Storage as key element in the future infrastructure

- Connect load centers to far-away generation centers
- Continuously assess grid stability
- Overcome present bottlenecks
- Optimize existing right-of-ways
- Handle and balance stochastic in-feed and stochastic loads
Example: a super grid (DC) roadmap

**Embedded HVDC** (Thyristors)
- Technology available
- References in Australia, China (800 kV), USA (New York & San Francisco), India
- Projects in the pipe line

**HVDC PLUS** (Transistors)
- Technology available

**Multi terminal HVDC**
- Technology under development
- New control algorithms and implementation

**Meshed DC grid**
- Technology not available today
- DC Circuit Breakers
- Protection systems
- Power control centers
Example: development of higher AC voltage levels

The European Transmission Grid concept – with a voltage level of 420kV – has proved extremely stable for the last 50 years! Will it last another 50 years?

Shouldn’t a higher voltage level, i.e. 550 or 750 kV be introduced?

1. 110 kV Lauchhammer - Riesa / Germany (1911)
2. 220 kV Brauweiler - Hoheneck / Germany (1929)
3. 287 kV Boulder Dam - Los Angeles / USA (1932)
4. 380 kV Harspranget - Halsberg / Sweden (1952)
5. 735 kV Montreal - Manicouagan / Canada (1965)
6. 1200 kV Ekibastuz - Kokchetav / USSR (1985)
Example: right of ways optimization

Transmitting 3 GW over long distances

- re-use of existing right-of-ways by replacing AC overhead lines with DC systems.
- re-use of existing right of ways by combining AC & DC overhead lines on same towers
- for urban areas, natural parks or sensible places like airports, develop underground power carriers, like High Voltage cables or Gas Insulated Lines, either DC or AC, EHV or UHV.
Example: Energy Storage roadmap

**SMES**
- Cope with lack of primary reserve
- Time scale: from a second to some minutes
- Week spots on the grid

**e-vehicles / batteries**
- Cope with stochastic in-feed from renewable
- Time scale: from few minutes to some hours
- Close to the loads

**Hydrogen**
- Cope with seasonal unbalance of renewable
- Time scale: from a day to some weeks
- Close to the generators

Source: Institut NÉEL
Increase situational awareness and transparency of grid state

From

Limited situational awareness

To

Full transparency of the entire system in real time including all (dynamic) phenomena

- Phasor Measurement Units and Wide Area Measurement may allow on-line detection of swing phenomena and the introduction of a system level protection scheme
- New visualization concepts

➡ Better understanding of system dynamics
➡ Implementation of automated counter measures
Smart Buildings as a “prosumer” - a new active element within Smart Grids

**Low energy tariffs**
- Intelligent filling of storage capacities, e.g.:
  - Load e-car
  - Load thermal storage (boiler, ice, building structure, indoor air)
- Minimal use of CHP
- Use comfort band to build reserves

**High energy tariffs**
- Use energy from storage, e.g.:
  - Use reserves in e-car
  - Empty thermal storages
- Maximum use of CHP
- Minimize el. consumption within comfort band
- Use or sell self produced energy (PV, wind, CHP…)
- Switch to oil or gas

**Grid**

- Building is energy consumer to grid
- Building may even deliver energy to grid

**CHP**
- Combined Heat & Power

**BMS**
- Building Management System

**PV**
- Photo Voltaic
Example: building automation roadmap

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<thead>
<tr>
<th>Building Automation</th>
<th>Autonomous Buildings</th>
<th>Building to Grid Integration</th>
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<tr>
<td>▪ Local control of sensors and actuators</td>
<td>▪ Energy consumption optimization</td>
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<tr>
<td>▪ optimization of energy consumption</td>
<td>▪ Managed load</td>
<td>▪ Integrated load forecast</td>
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<tr>
<td>▪ Building as a drain for energy</td>
<td>▪ Virtual Power Plant (Decentralized Energy Management DEMS)</td>
<td>▪ Floating tariffs</td>
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Example: building automation roadmap
Reference project for Energie AG Oberösterreich, Austria:
The most important reasons for the implementation of an AMIS system are

- Automated metering processes (meter reading, blocking of customer installations, billing, prepayment services, etc.)
- Significant improvement of customer processes
- Implementation of various tariffs
- Quality improvement of consumption data due to monthly meter reading
- Replacement of ripple control
- Recording of customer supply
- Automation of the transformer stations
- Support of Energie AG’s energy efficiency program
Smart metering:
Reference example Asia / Pacific

Transitioning 800,000 retail customers in New Zealand to smart metering:
Meter data management solution (EnergyIP) provides

- High volume meter data management for gas and electricity
- Time-of-use-based billing
- Residential load management
- Exception reporting and integration of field workforce
- Automated commissioning of each meter installation
- Detailed reporting for retail and distribution applications
- Web-based energy Information portal
- Integrated wireless in-home display
- Fully managed smart service
Example: smart metering roadmap

- **Meters**
  - No communication
  - Manual reading
  - Very limited tariff options

- **Smart Metering**
  - Variable tariffs
  - Monthly billing
  - Reduction of no technical losses

- **Smart Metering as Gateway for “Prosumer”**
  - Integration of generation and load information
  - Enhanced load management
Easy integration of engineering, IT security and end-to-end communication

**Engineering**
- Harmonized tools and optimal coordination
  - Workflow optimization at operators’ plant
  - Easy to use
  - Reusable assets

**IT Security**
- Integrated IT security across the entire automation chain
  - Hardened products and secure solutions
  - Standardized mechanisms and functions
  - Integrated security processes and guidelines

**Communication**
- Harmonized interfaces and interoperability
  - Standard protocols, data models based on IEC 61850/IEC 61970
  - A platform for vertical and horizontal integration
1. Ideas to support the European agenda

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3 key forces for developing the future sustainable energy system

Climate-compatible energy technologies
Efficiency increase, CO₂ sequestration, wind, solar thermal ...

1. Technology push
   - R&D funding for key technologies
   - Funding for full-scale demo projects
   - Fair risk sharing between suppliers, operators and the public

2. Market pull
   - Reliable long-term investment incentives
   - Global perspectives for equipment suppliers

3. Legal basis and acceptance
   - Public relations in an open dialogue
   - Cooperation of politics, industry, NGOs

If politics, utilities and supply industry join their forces sustainable energy systems can become reality.
Developing applications and field experience:

- Mixed R&D -Teams and R&D co-financing
- Standardization and specification harmonization committees
- Develop pilot projects and business models

Communication:

- Long term policy deployment - addressing all stakeholders (including regulators)
- Cooperation T&D Europe, ESMIG - ENTSO-E, “ENDSO-E” - ACER - CENELEC, DG-TREN
- Communication for public acceptance

Pre-requisites to implement innovative solutions

- Approvability (reliability references, regulation compliance, failure redundancy)
- Feasibility (engineered solution to be disclosed to authorities and regulator)
- Public acceptance (sustainability value, right of way)
- Economic value (business plan, stable planning conditions, financing)
### Siemens view

#### Key messages for grid regulators

1. **Common goal**
   - Industry (system operators, utilities and manufacturers) fully supports the European agenda fighting climate change

2. **Supergrid**
   - Technology roadmap exists, limited risk foreseen in development
   - Main hurdle lies in right-of-way optimization

3. **Smart Grid**
   - Building blocks are identified, technology roadmaps available
   - Main hurdle: value proposition not fully shared by stakeholders

4. **Initiatives**
   - Commitment to push for demonstrator- and pilot projects
   - Standardization of functionalities’ description
Many thanks for your kind attention!
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