Steps toward a wide-area protection system

Khoi Vu
ABB Corporate Research
Raleigh, North Carolina
Agenda

- ABB?
- Wide-area control/protection systems – Philosophies
- Wide-area systems – Field deployment and the Norwegian experience
- The missing link…
Facts about ABB

- Headquarters: Zurich, Switzerland
- About 103,000 employees in around 100 countries
- Revenues: $20+/- billion
- Listed on stock exchanges in Zurich/London, Stockholm, Frankfurt and New York

A leading power and automation technology company with strong market positions in its core businesses

Two divisions: Power Technologies, Automation Technologies
R&D investment: $ 907 million in 2004
R&D priorities

- Create more value through technology
- Be responsive to external world
- Build partnerships with customers and universities
Universities: partnership for technical excellence

- Massachusetts Institute of Technology U.S.
- Carnegie Mellon University U.S.
- Stanford University U.S.
- Cambridge University U.K.
- Imperial College U.K.
- Federal Institute of Technology CH
- Chalmers University SE
- Royal Institute of Technology SE
- RWTH Aachen DE
- Technical University Berlin DE
- Karlsruhe University DE
- Tsing Hua University CN

and more than 50 other partners
Research close to customers and universities

Global labs for power and automation technologies

Raleigh U.S.  
Wickliffe  U.S.  
Västeras SE  
Baden CH  
Ladenburg DE  
Krakow PL  
Oslo NO  
Vaasa FI  
Beijing CN  
Shanghai CN  
Bangalore IN  

600 people in 11 Research Centers
Current research programs

Securing and developing ABB’s core competence

- Power device technology
- Power transmission and distribution applications
- Power electronics
- Mechatronics and robotics application
- Control and optimization
- Automation networks and devices
- Software architecture and processes
- Advanced material
- Manufacturing technologies
Wide-area control/protection systems - Philosophies
Electrical Network and Automation

Communication
Control of:
Generation Plants - generators
Substations - devices
Loads - customers

Co-ordination
Data and control

Physical Power Grid
Generation Plants
Substations
Loads (Customers)

Smart use of local measured quantities
Technology Solution: G vs. L

- GLOBAL solution
- MIXed solution
- LOCAL solution
PsGuard™ - global solution for monitoring, control and protection
VIP (Voltage Instability Predictor) – example of local solution

Maximal power transfer

\[ |Z_{\text{NET}}| = |Z_{\text{app}}| \]

Algorithm tracks system strength based on local V & I
The Norwegian Intellectric Project (NiP)

An example of field deployment
5 Nordic TSOs in close collaboration.

Deregulated market since 1991.

Norway:
- TSO = Statnett
- Hydropower ~ 100%
- Hasle as the most critical bottleneck for energy transfer
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**420-kV grid**

- **Generation**
- **Substation**
- **Substation (no load)**

**Locations**:
- Oslo
- Hallingdal corridor
- Flesaker corridor
- Ødal
- Ådal
- Ringerike
- Sylling
- Tveiten
- Hasle
- Follo
- Tegneby
- Saurdal
- Hole
- Usta
- Dagali
- Aurland
- Sima
- Skogssäter
- Borgvik
- Flesaker

**Network Connections**:
- 420-kV grid
Issues pondered by Statnett

- 19xx-1999: New grid asset or new information system?
- 2000: launched the Norwegian Intellectric Project.
- 12/2000: installed 3 PMUs and 1 VIP.
- 2000-2003: data analysis, field tests; also, wide-area monitoring. Confidence in VIP grew.
- 2004: first commercial order of VIP for an industrial site in Western Norway; VIP box is linked to SCADA and load shedding.
- 2005+: New R&D project to deploy more IEDs; bring in other TSOs.
General VIP/PMU terminal

- **PMU**
  - Measurement of Voltages & Currents
  - Synchronized with GPS with one or several PMUs
  - Two PMUs may calculate the Phasor differences between bus bars where the PMU are sited

- **VIP**
  - Measurement of Voltages & Currents
  - Calculates Stability Indices and Power Transfer Margin

- **Applications: PMU & VIP**
  - Active & Reactive Power
  - Stability Indices
  - Trip Signals
  - Control Signals

Data Communication

- GPS synch.
- PsGuard
- SCADA
- To other SPT

Current & Voltage Measurements

- SPT – Standard Protection Terminal

Output Signals

VIP or PMU functionality
REAL-LIFE TEST:
- Date: Jan-18-2002, ~noon.
- Transfer of 1300MW to Sweden through the Hasle corridor.
- Line Tegneby-Hasle was disconnected at 1210 and reconnected at 1220.
- Issue: how did the VIP box respond?
Performance verification (2)

- This was how the VIP box responded.

- Yeah… but how can one be sure that the values were correct?
Performance verification (3)

Response from the VIP box (during the event)

Network Simulation by SINTEF and Statnett (after-the-fact)
The missing link in wide-area systems

Building the “last 10 meters”
Load Shedding vs. Load Rationing

- Load shedding is a very economical and effective control.
- But how is it done today?

- Would it be nice if one can do “load rationing” instead of “load shedding”?
  - If each customer cuts back kWh by 10%, the burden on the substation is reduced by ~10%.
  - 10% is approximately 1 light bulb per customer.
Enabling technology for the last 10 meters

- Normal operation, user control; 99.999% of the time
  - Features and functionality
  - Value for user
- Emergency operation; 0.001% of the time
  - Features and functionality, including response time
  - Value for Utility