Engpassvermeidung in Übertragungsnetzen durch Online Dynamic Security Assessment

12. Symposium Energieinnovation, 15-17.2.2012 Graz/ Austria

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www.siemens.com/energy/power-technologies
Blackouts

Source: NY-Times – Sunset during Blackout
Idyllic New York Blackout USA August 14. 2003
White Night Blackout Italy September 28. 2003
Santiago Chile, September 24. 2011
## Features over time

<table>
<thead>
<tr>
<th></th>
<th>Past</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network construction</td>
<td>Priority</td>
<td>Subject to severe environmental constraints and public debates</td>
</tr>
<tr>
<td>Network</td>
<td>Over-dimensioned</td>
<td>Under-dimensioned</td>
</tr>
<tr>
<td>Generation</td>
<td>Close to load</td>
<td>Far from urban areas</td>
</tr>
<tr>
<td></td>
<td>Conventional and controllable</td>
<td>Conventional + Distributed not controllable</td>
</tr>
<tr>
<td>Unit commissioning</td>
<td>Long-term plan</td>
<td>Intense DG (government supported)</td>
</tr>
<tr>
<td>Interconnections</td>
<td>Increase security</td>
<td>Transit power flows</td>
</tr>
<tr>
<td>Market</td>
<td>Regulated</td>
<td>Deregulated</td>
</tr>
<tr>
<td>Security</td>
<td>Simple to enforce</td>
<td>Hard to enforce</td>
</tr>
</tbody>
</table>
“New Electricity Age” in Europe
Windfarm-Projects in Northern Waters

100GW Potential in Northern Waters, thereof today 1.5% installed
"New Electricity Age" in Europe
Predictability and Dynamics of Wind Power

Example: Vattenfall Europe Transmission, Feb. 2008


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Page 5
“New Electricity Age” in Europe In the South: The “DESERTEC Super-Grid”
“New Electricity Age” in Europe
Predictability and Dynamics of Solar Power

Sunny Day, April: 1.9 MWh

Cloudy Day, April: 1.2 MWh

Source: Michael Weinhold & friends
Security of Electrical Energy Supply Systems
Future Challenges in Germany

Today: balanced generations and loads

Future: Generations far from loads

Voltage-Problems

Power-Swings

REQUIREMENTS:
- Steady-state and dynamic reactive power compensation
- Fast controlled FACTS-Elements for power-swing damping
- Overlayed control
- Predicting steady-state and dynamic contingency management

Source: CIGRE SC C2, RWE, 19.11.2008
Static and Dynamic Security Assessment System Operations

Static Security
- Validation of voltages and power flows
- N-1, N-2-1 etc

Dynamic Security
- multiple faults;
- cascading events;
- switching;
- generator, line outages
- stability issues

FOR CURRENT AND FUTURE OPERATING POINTS
Aim of on-line security assessment

Remove uncertainties related to day-ahead assumptions

- calibration of security margins and limits power flows;
- minimum damping of oscillations;
- transient stability;
- voltage stability
- limits on dynamic frequency excursions;
- limits on dynamic voltage excursions;
- grid code compliance.
Voltage Stability
Small signal stability
Angle
Energy margin
Maximum frequency deviation
Frequency recovery time
Frequency gradient
Dynamic voltage
Quasi-steady-state voltage
Fault ride through
Line power flow
Load shedding
Transformer power flow
Nodal loading

Results Scaling

0 … 1

Voltage Stability Index (VSI)
Small Signal Stability Index (SSSI)
Angle Index (AI)
Energy Margin Index (EMI)
Maximum Frequency Deviation Index (MFDI)
Frequency Recovery Time Index (FRTI)
Frequency Gradient Index (FGI)
Dynamic Voltage Index (DVI)
Quasi-Steady-State Voltage Index (QSVI)
Fault Ride Through Index (VRTI)
Line Power Flow Index (LPFI)
Load Shedding Index (LSI)
Transformer Power Flow Index (TPFI)
Nodal Loading Index (NLI)
Example: A realistic network

- 400kV, 275kV and 132kV,
- 140 generators,
- 1200 power lines,
- 1700 nodes,
- 650 loads (sum 40.00GW)
- 1200 transformers

More than 4500 observed elements!!!
Information reduction

- Small Signal Stab. Ind.
- Angle Ind.
- Max. Freq. Dev. Ind.
- Freq. Recov. Time Ind.
- Dyn. Volt. Ind.
- Power Flow Ind.
- Load Shed. Ind.
- Nodal Loading Ind.
- Approximate Collapse Power Ind.
- Power Transfer Stability Ind.

System state:
- INSECURE
- DANGER
- ALERT HIGH
- ALERT LOW
- SAFE
SIGUARD® DSA
Research and development

Hardware
• Generic notebook computer
• Intel i7 technology
• Quad-Core
• Clock frequency 1.87GHz
• 8GB RAM

Application
• Testing
• Pilot customers

SIGUARD® DSA Prototype in Control Room at Transelectrica
SIGUARD® DSA Professional

Hardware
15 Server with each:
• 2 Intel XEON 6 Core
  3.46 GHz = 180 Cores
  • 13 Computation nodes
  • 2 Application server (redundancy)
• 48 GB RAM
• Network
  • 2xGigabit LAN
  • 1x 20 Gigabit Infiniband

Application
• Development tests
• Live Demonstration
• Factory acceptance tests
SiGuard®-DSA
On-line Security visualization

- Dynamic security (all contingencies)
- Contingencies’ security
- Static security (EMS/SCADA snapshot)
Intelligent Dynamic Power-System Measurement, Analysis, Protection and Control

- Combined power system measurement and model based analysis
- Observing dynamics with time-synchronized PMUs
- Predicting critical dynamic system states
- Protection system audits for speed and selectivity
- Autopilot by wide-area protection and control

Customer Value
- Blackout prevention
- Reduction in customer outage costs
- Enhancement of power system utilization
- Decision support for system operator
- Future autopilot for power system control
SIGUARD® Offline and Online
The New Siemens Power-System Security Solution

FORECASTING SYSTEM SECURITY

+45MIN
+60MIN
+75MIN

NOW

1. Re-dispatch → Status: OK

WARNING   ALERT   BLACKOUT

ACTIONS REQUIRED IN 60 MINUTES!

Reason: Voltage problem
Possible actions: 1. Re-dispatch
2. Topology change
3. Load shedding
Status: not advised
Summary

- Power systems (transmission and distribution) are not being used in a way they were designed for
- Reconsideration of control concepts is required
- On-line security assessment is a suitable solution
- Increase operational awareness
- Proofing of operators’ actions and evaluation of remedial measures
Thank you for your attention!

Let’s keep the lights on!

Contact:
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