Robust Cellular Systems

A defence against network disturbances

Presentation at CoNDyNet Industry Workshop
Frankfurt, 22.11.2016
Thomas Walter, Easy Smart Grid GmbH
Agenda

- Overview of energy systems threats
- The N-1 principle
- Dynamic excitation
- Cyber attacks
- Cautiousness - robust by design
Overview of energy system threats
Self-Assessment „Grid+“ Project

Not relevant

Ready to deploy at large scale
Need more demonstration or pilot project to validate the maturity
Need moderate development
Require more research (work with research institutes)

Source:
Michele de Nigris, GRID+ COORDINATION ACTION IN SUPPORT TO THE EEGI: RECENT UPDATES
Overview of energy system threats
Situations to be considered

The N-1 principle
No system damage if any component fails

Dynamic excitation
master all transients
(shortcut, open loop)

Cyber attacks
systems attacked for fun, money or war

Plan for unplanned
even ultra reliability
systems will fail
The N-1 principle
Attention to mission critical components

- Communication infrastructure
  - Reserve communication
  - Need diversity: Wireless to be complemented by e.g. cable

- Central decision computer
  - Example flight computer: 2 out of 3 voting
  - But: Need 3 diversitary redundant computers

- System critical subsystem
  - Reduce „monopolistic“ impact
  - Split up and/or increase „liquidity“
Dynamic excitation
Transients become ever faster

Example:
5 minute prices at Ecogrid/DK
Dynamic excitation
Some information theory basics

Ensure stable control loop

Nyquist
Sample at least at double system bandwidth

Latency
Information delay creates poles (inherently unstable)
Cyber attacks
M2M: Risks are growing quickly

Billions of devices on grid invite attacks
Open 24/7 without supervision!
How to regain control on distributed system?
Cautiousness – robust by design?
Today: Five parallel Control Processes

GU 1 ➔ GU 2 ➔ GU 3 ➔ GU 4 ➔ GU n

Electric Grid
Grid User
Communication

Control P ➔ Status P
Control S ➔ Status S
Control T ➔ Status T
Control ID ➔ Status ID
Control DA ➔ Status DA

P, S, T: Frequency for technical control
ID, DA: Price for control via electricity exchange
Cautiousness – robust by design
Cellular system - spatial redundancy

<table>
<thead>
<tr>
<th>Energy Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 0-2.5 GW (Ø-Generation times four)</td>
</tr>
<tr>
<td>• Energy exchange</td>
</tr>
<tr>
<td>• Flexibility exchange</td>
</tr>
<tr>
<td>• System services, Self balancing</td>
</tr>
<tr>
<td>• Island-/Black Start modes</td>
</tr>
<tr>
<td>• Grid and Market Area - integrated</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Neighbours</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Energy exchange (Δ Price)</td>
</tr>
<tr>
<td>• Flexibility exchange (Δ Price)</td>
</tr>
<tr>
<td>• Access to Neighbour n+2</td>
</tr>
<tr>
<td>• Isolation in case of Failure</td>
</tr>
<tr>
<td>• Special cases: Energy Source Energy Sink</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmission Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>• „Motorway“ HVDC</td>
</tr>
<tr>
<td>• Large Area Integration</td>
</tr>
<tr>
<td>• Not defined by Voltage Level</td>
</tr>
<tr>
<td>• Coupling of Special Zones:</td>
</tr>
<tr>
<td>• Offshore, „Desertec“</td>
</tr>
<tr>
<td>• Large Consumers „NRW“ (an energy intensive area in Germany)</td>
</tr>
</tbody>
</table>
Thank you for your attention and questions!

Thomas Walter
Easy Smart Grid GmbH
thomas.walter@easysg.de
+49 171 229 4629
www.easysg.de