Integration of Smart Grids and Renewables – Achievements in Sweden

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In Summary

• Governmental Actions on Smart Grid

Four cases:
• Smart Grid Gotland – Increased Grid Reliability and Enabling Wind
• Dynamic Line Rating – Enabling Wind
• Ngenic Tune – Flexible Ground Heat Pumps
• FerroAmp – Enabling Solar Based Micro Grids
The Swedish electricity market

<table>
<thead>
<tr>
<th>Electricity supply</th>
<th>2015 prel.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro power</td>
<td>75 TWh</td>
</tr>
<tr>
<td>Wind power</td>
<td>16.5 TWh</td>
</tr>
<tr>
<td>Nuclear</td>
<td>54 TWh</td>
</tr>
<tr>
<td>Other thermal power</td>
<td>13.5 TWh</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>159 TWh</strong></td>
</tr>
<tr>
<td>Export</td>
<td>22.5 TWh</td>
</tr>
</tbody>
</table>
Swedish Coordination Council for Smart Grid

Appointed by the Swedish Government 2012 – 2014

The Council: 15 members with key positions within industry, academia and governmental authorities

Final report delivered in December 2014 – A national action plan for smart grid

A national knowledge platform for smart grid established

Cooperation, knowledge transfer and discussions among stakeholders
The way forward…

• The government has appointed a Energy Commission to agree on a future energy policy – proposal to be delivered 1.1 2017
• A national Forum for smart grid starting Q1 2016
• Mission for the Forum
  – Monitor implementation of the action plan
  – Identify need for supplementary measures
  – Coordinate activities among authorities
  – Promote dialogue between actors involved
  – Manage and develop the knowledge platform
    www.swedishsmartgrid.se

www.swedishsmartgrid.se
Smart Grid Gotland
General Objectives

A research, development, demonstration and pilot project with the ambition to upgrade an existing rural distribution system, on a deregulated market, to a modern smart grid.

• Increase hosting capacity for renewable power in the distribution grid with 5% by use of load shift from active customers

• Improve power quality for customers by a decrease of the number and duration of power outages with 20%

• Attract 2000 residential and 30 business customers to become active on the electricity market
Security of Supply – Rural
– Zone concept with centralized intelligence

10 kV station, 3 feeders

- OVR Trip
- Fault Information in Relay Protection sent to SCADA/DMS
- Fault isolated to smallest possible grid section

Suggested action: Connect OVR

The operator starts Restoration and Switching Analysis, RSA, which will initiate a Load Flow Analysis

Energized
Deenergized

10 kV Feeder
Dynamic Line Rating – Öland
Background

- 48 MW off shore wind at Öland
- Existing 50 kV-network allowed maximum 30 MW installation due to thermal limitation
- Also 130 kV cable to mainland has limitations
- Reinforcement overhead lines 60-100 MSEK
- New cable to mainland ~ 200 MSEK
- **Dynamic Line Rating was an alternative!**
If the temperature on the supervised lines rises over accepted level, the generation will be curtailed.

Installation of dynamic line rating (temperature supervision)
- In Köping, sensors, and one weather station, are placed.
- In Högsrum, equipment are installed for communication on the power line.
- In Linsänkan, sensors, and one weather station, are placed.
- From the PLC in the stations, temperature signals are sent to a PLC in Föra.
- The PLC in Föra are calculating which of the two units that is most critical and is after that sending a signal to the wind power plant.
A smart THERMOSTAT
Three Wishes

• Efficient use of energy (kWh)
• Enable renewables – flexible use
• Increase customer satisfaction
  • Better comfort, better control, automatic
  • Lower cost
  • Contribute to a better world
Cloud service for Demand Side Load Balancing

- Grid Load (local, regional, national)
- Production forecast, Import/Export
- Building dynamics
- Weather forecast
- Day-ahead market
- Intraday markets
- Balance market
- Power reserve
Results of field trial

- January 15 2016, 4-5 PM: Local peak load 66 MW
- Average outdoor temperature: –17°C
- 100 homes participated
  - All heating turned off during the hour
  - Only water based heat pumps participated
  - Average indoor temperature drop: 0,2 °C
  - ~ 200 kW power load reduction
  - No returning load peak
- Value on spot and balancing market ~ 600 SEK
- Value on purchased power for local grid: 60 000 SEK
- Potential in local grid 10 MW
  - Value 1,8 MSEK/year
Solar and storage solutions
Modular PV + storage solution

EnergyHub system description

- Supporting a sustainable and Smart Grid
- Distributed power tracking
- Safe and smooth expansion
- Adaptive Current Equalization
- Powerful EV charging
- EnergyHub Scalability and flexibility
- Integrated energy storage
The next ”killer app”

“The solar market is massive, will generate $5 trillion in revenue by 2030 and solar plus storage is the next killer app.”

Deutsche Bank

Thanks!

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