IntelliSub
Europe 2013

Smart Substation Investment
Brief portrait
EnBW Energie Baden-Württemberg AG

› One of the largest energy companies in Germany and Europe

› Business segments: electricity generation and trading, electricity grid sales, gas, energy and environmental services

› Annual revenue 2012: in excess of € 19 billion

› Customers: some 5.5 million

› Employees: some 20,000

Network grid lengths of the EnBW group

› Transmission grid
  › Extra-high voltage 380 kV: 2,000 km
  › Extra-high voltage 220 kV: 1,700 km

› Distribution grid
  › High voltage 110 kV: 8,600 km
  › Medium voltage 30/20/10 kV: 46,200 km
  › Low voltage 0.4 kV: 96,300 km
The Energy Turnaround means new Tasks for Network Infrastructure

**Historical**
Directed transmission of Energy from big Powerplants to customer

2000 MW

200 MW

20 MW

0.02 MW

**Current additional**
Generation in all network levels with infeeding backwards

X MW z.B. Offshore Wind

50 – 100 MW

0.2 – 0.5 MW

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Location of Generators in Voltage Levels
Infeed in Lower Levels and Transmission Backwards

Extra High Voltage (Transmission Grid, 380/220 kV)
Function: Transport (European area)

High Voltage (Distribution Grid, 110 kV)
Function: Wide Area Distribution

Ca. 5 GW Wind and others

Low Voltage Grid (Distribution Grid, 0.4 kV)
Function: Household Connection (up to 300 m)

Ca. 9 GW PV-Generation

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The Energy Turnaround of Germany is located at the Distribution Grid

Appearance of Area-Powerplants

Decentralized renewable Generation in Baden-Württemberg …

Challenge for Distribution Grids
Dezentralized Generation (in MW)


Infeed from overlaying Network

Infeed backwards in overlaying Network

Clearly growing infeed backwards in coming years

Quelle: EnBW ODR AG
Growth of renewable Energy in Germany
Expecting double to third Amount of installed Capacity

<table>
<thead>
<tr>
<th>Installed Capacity [GW]</th>
<th>Scenario NEP B 2012</th>
<th>Scenario of German states</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
<td>2020</td>
</tr>
<tr>
<td>Wind</td>
<td>35,6</td>
<td>44,1</td>
</tr>
<tr>
<td>Photovoltaics</td>
<td>38,4</td>
<td>48,0</td>
</tr>
<tr>
<td>Biomass</td>
<td>6,4</td>
<td>7,8</td>
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<tr>
<td>KWK</td>
<td>19,6</td>
<td>20,7</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Total of installed Capacity in 2030*</th>
<th>Percentage of Brutto-Consumption in 2030*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario NEP B 2012</td>
<td>166 GW</td>
<td>62 %</td>
</tr>
<tr>
<td>Scenario of German states</td>
<td>222 GW</td>
<td>82 %</td>
</tr>
</tbody>
</table>

* Numbers under consideration of all REN-Technologies
Influence of Measures for Investments
Possible Reduction by using Smart Technologies

- Innovative Grid Assets
- New technical Standards
- Cut of Infeed Peaks
- Network oriented Usage of Storage
- Forecasting Network Planning

Network oriented Loadmanagement
Reduction of Load
Market oriented Loadmanagement
Market oriented Usage of Storage

Estimation of Potential by calculation of single loadcases

Quelle: Verteilnetzstudie

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### Smart Grid Tool Box
Which Solutions are on the Way to be developed

<table>
<thead>
<tr>
<th>Kind of Problem / Use Case</th>
<th>Voltage Limits</th>
<th>Capacity Limits</th>
<th>Security of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Network Asset</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stepable Secondary Substation Transformer</td>
<td></td>
<td></td>
<td>Earthfault and Short circuit fault detection</td>
</tr>
<tr>
<td>Phase Shifting Line Transformer</td>
<td></td>
<td></td>
<td>Remote Ring Main Unit</td>
</tr>
<tr>
<td>Smart Network User</td>
<td></td>
<td>Infeedmanagement</td>
<td>Decentralized Automation</td>
</tr>
<tr>
<td>(Decentral) Reactive Power Management</td>
<td></td>
<td>Loadmanagement</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage</td>
<td></td>
</tr>
</tbody>
</table>

**Smart Metering - Forecast - and ICT-Technology**

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How to develop smart Solutions
Analysing new Technology in an real Grid Environment

Netlab closes the Gap between
- Ideas and concepts in the environment of Smart Grid research
- Use and operation of solutions in the real network and the advise of Asset Management Management

Today Distribution Grid EnBW Regional AG
- Innovative Hard-/Software Assets
- Measurement of Components
- Estimation of Network Situation
- New Functions SCADA, etc.
- Safe and reliable Communication

Netlab:
- No Blindfold Network-operation (SCADA)
- Efficient Systemdevelopment (Planning)
- Faster, targeting Analysis and Correction of Faults (Networkoperation)
- Grid is ready for „Smart Market“ (Retail)

Strategy Asset Management

Future operational Roll out „Distribution Grid“
Netlab of EnBW Regional AG
Solutions for Medium- and Low-Voltage Grid

For development and test of new technologies for the toolbox EnBW Regional AG started already in 2009 to build and develop a netlab in two special locations in Baden Württemberg aufgebaut und weiterentwickelt.

Municipality with a big area, broad mix of generation and characteristic rural distribution grid
**Focus Medium-Voltage Grid**

Small municipality with massive growing of PV-generation
**Focus Low-Voltage Grid**

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From Conventional to Smart Secondary Substation
Which are the new Applications

Use Cases:

Voltage problems LV-Grid
Stepable distribution transformer

Maximum installation of REN
Remote Metering of LV load

Network capacity gap
Concentrator of smart meter data; Input for infeed management

Optimisation for fault management
Remote fault detection and switches for faster resoration of load

Optimisation of network operation
Detailed data of load and generation, remote switches for working cases

Actual information about network condition for market operations

Functionality/Technology:

A) Local fault detection (short circuit sensor)
   Local maximum load meter
   Local volt meter

B) Remote identification of short circuit failure
   Remote metering devices in several feeders
   Stepable distribution transformer
   Defining direction of load flow
   Remote switches on medium voltage (LV optional)

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A) Conventional Setup

B) Smart Setup
Using existing Standards for Smart technology
Concept for Rollout Strategy

New Set-Up:

„ICT-Niche“
- Display of measurement devices
- Remote control device
- Emergency Energy System
- Transformer Control

Separating Wall

Internal Interfaces:
- Measurements
- Control

› **Advantage:** Separated access to ICT, without live working mode
› **Criteria:** limited Space, Warming, EMC
How to develop a Rollout Strategy
Example for Smart Secondary Substations

Total amount of Secondary Substations

Investment reasons:
- Replacement strategy
- Quality reasons
- Changed Law/Standards
- New customers/generators

5-10 years network development

Criteria:
- Economical calculation
- Quality Impact
- Target Networks

Expected percentage of Smart Secondary Substations
Decision Making for the use of Smart Technology
Viewing Network Structure for Quality Use Cases

Economical scenario analysis for the use of smart technology needed
- Cost of additional technology including remote connection
- Benefit via more network expenses in an quality regulation system
- Reduced opex by decreasing effort of failure management and load restoration
- Reduced OPEX by reducing effort of operational switching (e.g. for line inspection)

But optimal rollout-scenario can be supplemented with smart stations needed for external influences like new generation sites
External Influences Analysis as Input Data
Target Network Planning is a main Use Case

› Analysis of potential renewable generation in the different network areas (PV and Wind) differentiated to the grid voltage levels
› Evolve target network plans especially in the medium voltage grid and define best positions for smart secondary substations

Combining Information

Combined network plan from PV/ Wind potential generation and network planning standards based on existing grid structure.
Development of Smart Grid in an ongoing Process

What are the next Steps implementing Smart Stations

Total volume of secondary substations at EnBW Regional: ~ 28,000
Estimated percentage of smart stations in the grid: ~ 15 %
=> Installation of ~ 4,200 smart stations up to 2030

Project launched with the following Milestones for 2014:

• Fixing the technical standard and specification of smart stations for EnBW Regional
• Analysis of the most efficient projects in the distribution grid regarding quality improvement
• Identifying 30 medium voltage strings to be instrumented with smart Grid technology
• Realising Scenario 3 per string with the roll out of 90 smart stations
• Additional installing smart single stations where needed through growth of decentralized RES
Because of the energy turnaround we are facing in Baden-Württemberg a generation capacity of nearly 14 GW in the distribution grid.

Medium- and low-voltage grids will be used up their thermal limits and if available smart network technologies should be used before increasing networks conventionally.

Smart secondary substations are one of the favorite tools to meet the challenges in the low voltage distribution network in case of massive installation of new active components.

Because of long investment turns you have to prepare with an early partial rollout which can be done economically by reducing failure costs. End-rollout will be defined by target network plans and replacement strategy.

The increase of generation plants has to be synchronized with the ability of network increase and development. We have to get the view for the whole system including new challenges especially from smart markets or E-mobility.
Energie braucht Impulse

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