Research and Migration path on Active Network Management and intelligent Secondary Substations

Andreas Lugmaier, Head of Research Group “Industrial Networks”

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Agenda

1. Motivation
   - Challenges for MV / LV Grids
   - Smart Grid Migration Path
   - Smart Grids 2.0

2. Examples for Renewable Integration R&D projects
   - MV - Active Network Management Field Trial
   - “Eyes” in the LV Grid
   - Smart LV Grid Control and Management

3. Summary
1. Motivation
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3. Summary
Challenges for MV / LV networks

monitoring and management of voltage band become necessary standardized limits:
nominal voltage (230V) +/- 10%

asymmetrical load flows

real peak load

decentralized generation

potential voltage band violations

overvoltage caused by (asymmetrical) DG and/or load

dropping below lower limit due to loads/charging e-cars

nominal voltage (230V) +/- 10%
Challenges for MV / LV networks

load flow problem in LV networks

load flow management to protect network infrastructure become necessary limits: cable loading
**Smart Grid Migration Path**

**Goal:** Optimising of **CAPEX + OPEX**!

<table>
<thead>
<tr>
<th>Grid Monitoring</th>
<th>Efficiency gain without active control</th>
<th>Efficiency gain with active control</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗ Contious grid monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✗ Data validation</td>
<td></td>
<td></td>
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<tr>
<td>✗ Topology mapping</td>
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<tr>
<td>✗ Big Data</td>
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<tr>
<td>✗ Business Analytics</td>
<td></td>
<td></td>
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<tr>
<td>✗ Operative and strategic grid planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✗ Voltage Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✗ Overload Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✗ Automatic Switching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✗ Smart Market / Smart Grid / Smart Building interaction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Smartgrids 2.0

Future Active Network Management

<table>
<thead>
<tr>
<th>Voltage Level</th>
<th>Voltage (kV)</th>
<th>Change</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV</td>
<td>+3% 30,08kV</td>
<td>3%</td>
<td>+10% 253/440V</td>
</tr>
<tr>
<td></td>
<td>+7% 246,1/428V</td>
<td>2%</td>
<td>3% Voltage rise by DG in 0.4-kV-grid</td>
</tr>
<tr>
<td></td>
<td>+5% 241,5/420V</td>
<td>1%</td>
<td>+7% 246,1/428V</td>
</tr>
<tr>
<td></td>
<td>+4% 239,02/416V</td>
<td>1%</td>
<td>+5% 241,5/420V</td>
</tr>
<tr>
<td></td>
<td>+3% 236,9/412V</td>
<td>1%</td>
<td>+4% 239,02/416V</td>
</tr>
<tr>
<td>MV</td>
<td>29,49kV</td>
<td>1%</td>
<td>5% U_n 230/400V</td>
</tr>
<tr>
<td></td>
<td>1% 230,4/392V</td>
<td>5%</td>
<td>2% Voltage drop by 30-kV-line-impedance</td>
</tr>
<tr>
<td>LV</td>
<td>-6% 27,55kV</td>
<td>2%</td>
<td>-2% 225,4/392V</td>
</tr>
<tr>
<td></td>
<td>-4% 220,8/384V</td>
<td>6%</td>
<td>-2% 225,4/392V</td>
</tr>
<tr>
<td></td>
<td>-10% 207/360V</td>
<td>6%</td>
<td>-4% 220,8/384V</td>
</tr>
</tbody>
</table>

Smart ICT & Web down to the field

Smartgrids 2.0

source: CIRED 2010, Session 5 Paper 0198
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3. Summary
MV - Active Network Management Field Trial

Important data:

- Voltage: 30kV
- maximum load ~23 MW
- DG status quo ~5.6 MW
- additional DG ~ 6.6 MW
- Problems with voltage control

Possibilities:
- conventional investment in grid (reference scenario)
- or intelligent voltage control

Field trial region Lungau, Salzburg

- additional Hydropower
- current Hydropower
- current Photovoltaic
- current Biomass
MV - Active Network Management Field Trial
Results: Active Network Management in a Control Center Solution

Technical Solution:

Normal operation:

Central voltage and var control (CVVC)
“Eyes” in the LV Grid:
Results: Power Snap Shot Analysis by Smart Metering

ISOLVES PSSA-M erster SnapShot

“Smart Meters as eyes in the grid …”
... especially for unbalanced loads in the LV-grid as a four-wire system ..!
Source: Energie AG Oberösterreich Netz GmbH, A. Abart

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“Eyes” in the LV Grid:
Results: Advanced Metering, Grid Monitoring Device & Data Evaluation Tool
Smart LV Grid Control and Management
R&D and Field Tests in Upper Austria / Salzburg

Smart LV Grid Konzepte
Smart planning, monitoring, control

Feld Test Gebiete
Köstendorf/S – Eberstalzell/OÖ

„Validation of solutions for future problems!“

Photovoltaic
every 2nd roof"

E-Car
„every 2nd car“
Smart LV Grid Control and Management
Results: R&D and Field Tests in Upper Austria / Salzburg

Graphs and data visualizations related to grid control and management results in Upper Austria and Salzburg.
## Smart LV Grid Control and Management
Solution for automated intelligent Secondary Substation Node

<table>
<thead>
<tr>
<th>Components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RTU – e.g. Modbus connection with MV FCM</td>
</tr>
<tr>
<td>2</td>
<td>Feeder Condition Monitor (in LV)</td>
</tr>
<tr>
<td>3</td>
<td>Power Quality Recorder (in LV)</td>
</tr>
<tr>
<td>4</td>
<td>USV</td>
</tr>
<tr>
<td>5</td>
<td>Free space for Modem</td>
</tr>
</tbody>
</table>

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Smart LV Grid Control and Management
Controllable Tap Changer within intelligent Secondary Substation Node

- Range of ratings up to 630 kVA; highest voltage for equipment: 36 kV
- Low-voltage load regulation range in three steps
- Additional setting range on the high-voltage side for optimum operation
- Integrated IEC 60870-5-104/101 und Modbus RTU Kommunikation

The principle of switching under load in the low-voltage system
A control unit clocks the triggering and deactivation of the contactors:
I. Contactor at Bypass gets closed
II. Faultless switch-over of the mechanical contactors with no unwanted peaks
III. Bypass gets opened and the transformer is in the target position
Smart LV Grid Control and Management
Development of intelligent, distributed monitoring & control

- Scalable deployment if requested, massively distributed) without engineering effort
- Autonomous, self-contained control and monitoring solution
- (Web) Interfaces to other systems available

embedded Service Bus (eSB) & Smart Grid Dashboard for distributed self organizing Monitoring and Control (R&D application)
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Summary

From Research to Implementation to Migration Path

R&D, Test systems & Field tests

Implementation & Migration Path

1. Grid Monitoring
2. Efficiency gain without active control
3. Efficiency gain with active control

Optimising of CAPEX + OPEX!
Thank you for your attention!