The Smart Grid – Research Projects in the Distribution and Low-Voltage Grid

Andreas Lugmaier, Head of “Industrial Networks”, Corporate Technology
Agenda

1. Motivation
   • Framework for active network management

2. MV distribution networks
   • Challenges for MV networks
   • Projects considering MV networks

3. LV distribution networks
   • Challenges for LV networks
   • Projects considering LV networks

4. Summary
Agenda

1. **Motivation**
   - Framework for active network management

2. **MV distribution networks**
   - Challenges for MV networks
   - Projects considering MV networks

3. **LV distribution networks**
   - Challenges for LV networks
   - Projects considering LV networks

4. **Summary**
Active Network Management
A new layer in Network Management Systems

<table>
<thead>
<tr>
<th>Protection, A &amp;C</th>
<th>Active Network Management</th>
<th>Supervisory Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic</td>
<td>Autonomous</td>
<td>Human operator</td>
</tr>
<tr>
<td>Firmware (or electro-mechanical)</td>
<td>Software</td>
<td>Software</td>
</tr>
<tr>
<td>Unit/non-unit</td>
<td>Defined network area</td>
<td>Whole network</td>
</tr>
<tr>
<td>Local/Distributed</td>
<td>Locally-centralised &amp; Local/Distributed</td>
<td>Centralized</td>
</tr>
<tr>
<td>Deterministic</td>
<td>Deterministic</td>
<td>Non-deterministic</td>
</tr>
</tbody>
</table>

Source: CIRED 2013; Smarter Grid Solutions Ltd
## Contribution of an Active Network Management for enhanced network capacity utilization

<table>
<thead>
<tr>
<th>Voltage Level</th>
<th>Percentage Change</th>
<th>Voltage Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV 29.49kV</td>
<td>+7% 246,1/428V</td>
<td>LG 3% Voltage rise by DG in 0.4-kV-grid</td>
</tr>
<tr>
<td>LV 29.2kV</td>
<td>+5% 241,5/420V</td>
<td>LG 2% voltage rise by DG in 30-kV-grid</td>
</tr>
<tr>
<td>LV 28.91kV</td>
<td>+4% 239,02/416V</td>
<td>LG 1% Control deviation</td>
</tr>
<tr>
<td></td>
<td>+3% 236,9/412V</td>
<td>LG 1% of voltage tap control</td>
</tr>
<tr>
<td></td>
<td>5% U_n 230/400V</td>
<td>MV 5% voltage drop by 30-kV-line-impedance</td>
</tr>
<tr>
<td>LV 27.55kV</td>
<td>-2% 225,4/392V</td>
<td>MV 2% voltage drop and off load tap changer at 30/0,4-kV-transformer</td>
</tr>
<tr>
<td></td>
<td>-4% 220,8/384V</td>
<td>LV 6% voltage drop by 0.4-kV-lines to the point of Hand over</td>
</tr>
<tr>
<td></td>
<td>-6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-10% 207/360V</td>
<td></td>
</tr>
</tbody>
</table>

*source: CIRED 2010, Session 5 Paper 0198*
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4. Summary
Challenges for MV networks

There are
• hardly any huge PV plants feeding in into MV networks

but there are
• an increasing number of small hydro and biomass power plants (500kW up to 10MW)
• a focus on preventing voltage band violations in rural MV (one long branch in a valley)
Challenges for MV networks

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

SMARTGRIDS
Model Region Salzburg

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Projects considering MV networks
ZUQDE

Within project ZUQDE an automated voltage-var-control (VVC) has been integrated in an existing Siemens network control system (SCADA). Therefore two new applications have been implemented and tested in closed loop operation the first time.

Distribution System State Estimator (DSSE)
• software application to the estimate actual MV network state
• for preparation a Data Validation Tool was used

Central voltage-var-control (VVC)
• software application to optimize voltage settings and reactive power flows in distribution networks
Projects considering MV networks
Results ZUQDE

ZUQDE – without DG control

ZUQDE – with DG control

normal operation
Projects considering MV networks
Results ZUQDE
Projects considering MV networks  
DG DemoNetz

**RANGE Control:** Optimize voltage range to fit into allowed voltage band, by controlling DG to provide Q (and P)

**LEVEL Control** Calculate set points for OLTC's to shift all voltages into the band

Strategies: Upper Limit, Centered, Lower Limit, Minimum Tapping
Projects considering MV networks
Results DG DemoNetz

Generator's capability to follow reactive power set values - Retrofitted DG
Projects considering MV networks
Results DG DemoNetz

Generator's capability to follow reactive power set values - **Modern DG**
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Challenges for LV networks

**Voltage problem**

asymmetrical load flows

real peak load

potential voltage band violations

overvoltage caused by (asymmetrical) DG and/or load

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

monitoring and management of voltage band become necessary standardized limits:

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

load flow problem

load flow management to protect network infrastructure become necessary limits:
cable loading

cable (I_{max} = 355A)

overloading

355A → 375A → 395A
Projects considering LV networks
ISOLVES - Power Snap Shot Analysis by Smart Metering (PLC – CX1)

„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
Projects considering LV networks
Smart Low Voltage Grid (SLVG)

Smart LV Grid Konzepte
Smart planning, monitoring, control

Feld Test Gebiete
Köstendorf/S – Eberstalzell/ÖÖ

„Validation of solutions for future problems!“

Photovoltaic
every 2nd roof

E-Car
„every 2nd car“

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Projects considering LV networks
Smart Low Voltage Grid (SLVG) – Intelligent Monitoring & Control

Field Test
- LV OLTC & Control
- Data concentrator
- Powerline-Communication
- LV Grid

Modell / Simulation
- Grid Controller
- Substation Automation Model
- Communication Simulator
- Power Grid Simulator
- Simulation Message Bus (SMB)

Illustration: Abart/Kupzog
Projects considering LV networks
Smart Low Voltage Grid (SLVG) – Intelligent Monitoring & Control

Smart Planning, Monitoring & Control

Field Test 1: Eberstalzell / Energie AG Netz / Upper Austria
Projects considering LV networks
Smart Low Voltage Grid (SLVG) – Intelligent Monitoring & Control

Field Test 2: Köstendorf / Salzburg Netz / Salzburg
Projects considering LV networks
Smart Low Voltage Grid (SLVG) – Intelligent Monitoring & Control

LV Grid – Testsystem
Agenda

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   - DSO challenges - the Austrian point of view
   - Management of network capacity
   - Framework for active network management

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Summary

- Sensor MV
- Sensor / Smart Meter LV

**G1 Grid Controller MV**

**Task:**
- observe voltage band
- preventing overloading (due to DG)

**Input variables:**
- U, I from MV sensors

**Regulating variables:**
- reactive/active power from DG feeding in
- settings for OLTC/transformer HV/MV

**G2 Grid Controller LV**

**Task:**
- observe voltage band
- preventing overloading (due to DG and loads)

**Input variables:**
- U, I from LV sensors

**Regulating variables:**
- reactive/active power from DG feeding in
- control/switching of flexible loads and charging devices
- settings for OLTC/transformer MV/LV
Thank you for your attention!

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Industrial Networks Austria

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