GRID INTEGRATION OF PV

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AGENDA

The Challenge
Solutions for grid integration
Grid planning with renewables
Conclusion
What is the challenge for grid integration? And its classical solution

- Decreasing of line impedance $Z_L$
- Voltage band violations
- Current lead to heating of cable
- Increase cross section of cable

$$U_2 = U_1 - Z_L I \rightarrow \text{voltage decrease}$$
$$U_2 = U_1 + Z_L I \rightarrow \text{voltage increase}$$
Optimal grid expansion
Avoid grid reinforcement

Cost optimal grid
Operation of Local Systems

Electric thermal systems
- Thermal storages offer the possibility to decouple thermal and electric processes

PV-Battery Systems
- Local self consumption of electricity from PV
- Grid oriented operation

What are services for the Smart Grid?
Grid-friendly operation of PV battery systems

- Self consumption optimization does not avoid grid peaks
- Grid friendly operation: up to 66% surplus PV can be installed.
Increasing feed-in of fluctuating renewables affects grids operation.

Feed-in management becomes more important.

Decentralized feed-in of renewables influences dimensioning of electricity grids.

This energy can be used better instead of shutting off.
Integration: reactive power control

- Voltage will be stabilized by changing the phase between voltage and current.
- Increasing of inverter nominal power
- Increasing of losses
- Reactive power control is defined in grid connection guidelines.
Integration: voltage control with tap changer

- Usage of variable tap-changer at transformer
- Dynamic adaptation of voltage a point of connection
- Usage of the full voltage range
- No reduction of PV necessary.

source: Maschinenfabrik Reinhausen
The planning process of a local DSO

1. Data Export
2. Calculating grid load
   - Testing measures
   - Economical evaluation
3. Import changes

GIS System

Grid planning
Expected Development

- Decentralized production
  - Photovoltaic: 180 kWp
  - Combined heat: 0 kW

- Heat
  - Needed heat: 50 MWh
  - Heat pump: 50%
  - Storage per HP: 3 h

- Electrical Storages
  - EV: 0
  - PV-batteries: 0 kWh
NEMO Use Case – Reference Ringkøbing

Step 2: Identifikation

- Heatpumps dominate
- Low voltages

- Winter: high trafo load by HP
- Summer: Inversed power flow because of PV
NEMO Use Case – Reference Ringkøbing
Step 3: Definition of possible solutions

Solution possibilities

- Grid reinforcement
  - ✔ conventional
  - □ OLTC
  - □ Q-Control

- Intelligent Control
  - ✔ Demand Side Management
  - □ Local energy management
  - □ grid friendly PV
NEMO Use Case – Reference Ringkøbing
Step 4: Solution with convention reinforcement

Starting point

Expansion

Conventional reinforcement

- Replace cables: 1,1 km NAYY 4x240
- Change transformer: 400 kVA

Cost*: 93,000 €

* 1 km NAYY240 57,000€ (inkl. Verlegung)
Transformator 400 kVA: 9,000 €
NEMO Use Case – Reference Ringkøbing
Step 5: Solution with Demand Side Management

Status Quo

Demand Side Management

- Reducing peak load: 220 kW → 170 kW
- Replace cables: 0.3 km NAYY 4x240
- Change transformer: not necessary

Cost*: 23,000 €

* 1km NAYY240 57,000€ (inkl. Verlegung)
Transformator 400 kVA: 9,000 €
Conclusion

- Decentralized generation can lead to
  - Violations of voltage bands
  - Violation of thermal restriction

- Beside conventional reinforcement
  - Energy Management
  - Low voltage on load tap changers
  - Reactive power control

Gird planning has become a multi criteria optimization problem.
Thank You!

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