Towards an exciting future - Efficient integration of Renewables in Distribution networks

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Efficient integration of Renewables in Distribution networks

- Changing Power Scenarios
- Network Analysis and Planning
- Network Modernisation
- Network Stabilisation and Control
- Energy Balance and Trade
- Conclusion
A gust of renewables
– sweeping the Power Utilities

- World Wind Energy Association (WWEA) observed that installed capacity increased from 282 GW in 2012 to 318 GW in 2013.
- In 2013, China became the leading country in terms of installing wind turbines and invested more in renewables than in fossil power for the first time.
- As per Fraunhofer Institute for Solar Energy Systems (ISE) the installed capacity for conventional power stations (nuclear energy, lignite, hard coal and natural gas) totals 82.4 GW, and for renewables (wind power, solar energy, biomass and hydropower) amounts to 82.9 GW in Germany.
Energiewende – transition to a new Energy Mix in Germany

- Challenging the status quo

- In terms of renewable energy capacity (excluding hydropower) per person, Germany leads the world
- Municipal and regional utility companies and distribution system operators are key players in the “Energiewende,”
- They face fundamental changes in their business environment, as that is where the decentralized energy generators are connected - the conversion and expansion of both the transmission and distribution grids are important
- The German Association of Local Utilities representing the interests of the municipal utilities (VKU), sees particular need for action in this area, since 97% of renewable energy is currently fed in at a distribution grid level
Significant changes in energy systems
From centralized, unidirectional grid ...

Existing distribution grids were designed for the
• conventional grid philosophy design,
• standard operating methods
• existing grid components, such as transformers, switchgear, remote control and protective
devices and
• the associated software landscape for flow of power from central power stations ran via a
hierarchically arranged power network (high-voltage, medium-voltage, low-voltage grid)
down to the distributed consumers
Significant changes in energy systems ... 
... to distributed energy & bidirectional energy balancing
Changing in feed patterns challenge existing grid infrastructures

Weekly burden of a transformer station in the rural area the LEW-Verteilnetz GmbH – 2003 and today

Load profile 2003
Load profile today

New scenarios of overloading, over-voltage and damage of equipment
Changing equations leading to pressure globally......

.............. looking for newer solutions
Changing energy system requires new solutions

Challenges in changing energy system

- Renewable and distributed generation
- Limited generation and grid capacity
- Aging and/or weak infrastructure
- Cost and emissions of energy supply
- Revenue losses, e.g. non-technical losses

Smart Grid offers solutions

- Balancing generation & demand, new business models
- Load management & peak avoidance
- Reliability through automatic outage prevention and restoration
- Efficient generation, transmission, distribution & consumption
- Full transparency on distribution level and automated loss prevention
Step by Step approach for sustainable integration of renewable energy

Network Analysis and Planning

Network Modernization

Energy Balance and Trade

Network Stabilization and Control
Network Analysis and Planning – a strategic approach

Smart Grid Compass
A consulting and evaluation approach that provides safe navigation toward the network of the future.

Smart Grid Diagnostic Kit
Provides concrete recommendations for efficient grid expansion based on exact measurements and precise knowledge of the grid situation. It uncovers problem areas and helps reinforce grids in a targeted, anticipatory manner. This approach makes grids more efficient and reduces costs, as wrong investments are prevented.

Network calculation tool PSS® SINCAL is a high-performance design program to simulate, evaluate and optimize supply grids. A classic planning tool, it is best suited for calculating grid capacity and designing the grid expansion with protection strategies as an integral component.

Protection Security Assessment SIGUARD® PSA is an evaluation tool makes it possible to create an automated simulation of the selectivity, sensitivity and speed of the protective system for a range of grid and operating conditions, to evaluate them and improve them as appropriate.
Possible Solutions as outcome of Network Analysis

1. Network Extensions/Strengthening
   - Resolving
   - Overloading problems
   - (Voltage drop)

4. Regulated distribution transformers
   - Resolving
   - Voltage drop problems

2. Changes in network structure
   - Resolving
   - Overloading problems
   - (Voltage drop)

5. Load management
   - Resolving
   - Overloading problems
   - (Voltage drop)

3. Control of reactive power
   - Resolving
   - Voltage drop problems

6. Energy storage
   - Resolving
   - Overloading problems
   - (Voltage drop)
Network Modernization
- making it fit for the future

- The additional capacity required due to the expansion of renewable energies can be provided through simple grid expansion, but effects resulting from the alternating direction of power flow, load fluctuations, and voltage range limitation can only be handled with *intelligent solutions*.

- an **active distribution grid** with intelligent transformer substations that turns the inanimate distribution grid into a fully automated, intelligent reliable infrastructure without the need for expensive grid expansion measures.
Newer paradigms in Distribution networks

- Intelligent Sub-stations
- Controllable Distribution Transformers
- Greater visibility of distribution feeders
- Increased communication between Distributed generators, consumers and Distribution System operators
- Large scale energy storage
- More visibility, intelligence and communication
- Flexible control of consumption
These intelligent transformer substations contribute to active load management in the distribution grid:
- Early detection and controlling of overload situations,
- Rapid, automatic fault clearance in case of blackouts
Robust foundation – RMUs and GIS

- RMUs & GIS switchgear family of Medium Voltage switchgear
- The centerpiece of an intelligent transformer substation is the modular and compact gas-insulated 8DJHST medium-voltage switchgear design enables a multitude of configurations and offers more space for additional feeders as per field requirements
- The hermetically sealed enclosure makes switchgear insensitive to aggressive ambient conditions and tight to ingress of external objects thus forming an intelligent transformer sub-station
Regulated Distribution Transformer

- On-load tap changer with three tap steps at LV side
- Characteristics and size are nearly identical to standard distribution transformers
- Additional tap changer available on HV-side

variable input voltage, constant output voltage
Secondary Distribution Automation System architecture (typical)

- **SICAM FRTU**: Compact RTU especially designed for Secondary Substations
- **SICAM FPI**: Fault Passage Indicator
- **MCU**: Motor Control Unit
- **SICAM P85X / P50**: Power Meter and PQ Recorder (optional)
- **SICAM FCM**: Feeder Condition Monitor with integrated Medium-voltage sensors
- **Modbus RTU**
- **Distribution Management System**
  - Wireless (GSM / GPRS)
  - IEC 60870-5-104

Electronic switch controller in 8DJH (applicable just in case of Siemens RMUs)
Outdoor Distribution Automation
SIPROTEC 7SC80 - Current Jump Detector

5060N
Current jump detection
OR
Start fault isolation

5060N
Current jump detection
OR
Start fault isolation

5060N
Current jump detection
OR
Start fault isolation

IEC 61850
Communication network
Distribution Automation needs a well-thought solution suite, not just puzzle pieces.

The choice depends on the operating practices of the utility.
Network stabilization and control

**Spectrum Power (Active Network Management) ANM**
- displays the current load flow directions and calculated load values as well as voltage range violations and overload situations.
- convenient voltage range and capacity utilization management. This makes it easier to predict voltage violations and equipment overloads and substantially reduce them with control algorithms.
- integrated analysis and archiving functions, allowing automatic result validation and comparison as well as reports for meaningful short-term and long-term views.
Intelligent Storage - SIESTORAGE

Pilot in operation since February 2012

Connection to MV network of Italy’s largest power utility ENEL

Power Rating: 1 MVA
Energy Capacity: 500 kWh

Usage:
- Frequency/primary control
- Integration of photovoltaic units
- Fast charging station of electrical vehicles
- Black-start capability
Energy Balance and Trade

To Drive full throttle on renewable energy

- Generation from renewable sources varies too much for reliable planning
- As individual units, the DER are too small to allow for efficient energy trading
- Unless properly managed DER cannot sustain without unending subsidies

The solution is to combine them into a large unit – an efficient virtual power plant

- System stabilization through forecast based load balancing
- Inclusion of smaller units in economically optimized fleet management
- Enhanced business cases for small decentralized generation e.g. participation in reserve markets or energy exchange
Virtual Power Plant – a solution for renewables

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Virtual Power Plant: Stadtwerke München (SWM)

- Bundles several plants with capacities between 30 kW and 6 MW. Total capacity of about 65 MW, which is generated from wind and hydropower, photovoltaics, biogas and biomass, gas turbines and also has switchable loads.

- Opens up additional electricity marketing alternatives. One example on electricity exchanges and operating control power markets.

- The virtual power plant is centrally controlled and regulated, depending on demand in the power network. Temporary fluctuations in the power network can be balanced out because the partners in the virtual power plant can have adjustable capacities available in very short time, which improves the stability of the grid.
Siemens and AÜW with other partners, including two universities, are working on project IREN in a small community of ~200 homes.

- 5 MW of solar PV, 11 wind turbines with a total capacity of more than 12 MW, a biomass district heating network, three small hydro power plants and 2,100 square meters of solar thermal systems and 138 kWh of battery storage and 32 E-Cars
- Over 200 measuring devices are monitored to maintain balance of energy.
- The energy farmers produce 5 times their consumption.

Challenges - Integrate such a large local surplus of renewable energy into the greater grid while maintaining network stability.

The goal of IREN2 is to study how energy systems with distributed power generation, battery storage, district heating, biogas plants and diesel generators can be technically and economically optimized.
Siemens and Stadtwerke Krefeld are transforming the existing power supply system in Wachtendonk into a Smart Grid.

Five new intelligent transformer substations will help ensure greater stability. They will compensate for voltage dips that can result when clouds form over the solar panels.

Siemens installed smart meters in about one hundred homes to collect the status-related data needed to operate a Smart Grid. The smart meters feature a special power snapshot analysis that turns the devices into »eyes« for the monitoring of the grid.
Conclusion: Changing Grid realities can be managed only by a systematic step by step approach with right skills and products and solutions.