Smart grids, smart cities – a new direction for a new energy era

Dr. Jan Mrosik
Cities are the growth engines for their national economies

Megatrends imply significant challenges for city decision makers

**Megatrends**

- **Globalization & Urbanization**
  - 2030: 60% of population in cities
  - Energy / buildings / mobility / water infrastructure are key

- **Demographic Change**
  - 65+ generation will nearly double by 2030 (from 7% to 12%)
  - Need for adequate infrastructures as well as health- and elder care

- **Climate Change**
  - Cities responsible for ~80% GHG
  - Need for resource efficiency and environmental care

**Sustainable Urban Development**

- Cities are competing globally to make their urban areas attractive to live and to invest in

**Challenge** to balance between competitiveness, environment and quality of life

- Competitiveness
- Governance
- Environment
- Quality of Life

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Energy Sector
Improvement of capacity

Growth of population and energy demand

Grid capacity must be extended by

- Grid expansion
- Intelligent usage of the grid

Power Consumption (Germany)*

-5.8%

<table>
<thead>
<tr>
<th>Year</th>
<th>Renewables</th>
<th>Conventional</th>
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<tbody>
<tr>
<td>2009</td>
<td>594 TWh</td>
<td>83.5%</td>
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<td>2020</td>
<td>560 TWh</td>
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Fossil energy sources

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-5,8%

*Source 2009 AGEB, Bericht Feb. 2011
2020 BMWU Leitstudie 2010, Szenario A
Increase of sustainable energy resources

Climate change - the need for CO$_2$ reduction
Integration of more renewables these are
- Decentralized
- Stochastic

Renewable Power Consumption (Germany)*

\[ +109\% \]

$225.3 \text{TWh}$

$108 \text{TWh}$

2009 2020

Water Wind Solar Bio Others

$225.3 \text{TWh}$

* Source BMWU Leitstudie 2010, Szenario A
Integration of renewable generation
Power flow in a transformer substation

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

Leistung in kW

source: LEW
Already 2009 reversal power into 380 kV-net system occurs due to the PV production. This appears in 2011 weekly.

source: LEW
Reliability

The need to improve the reliability of the infrastructure

- Aging infrastructure
- Capacity shortages
- Decentralized and stochastic energy generation
Paradigm shift in power grids: The new age of electricity

20th Century
Unsustainable energy system

Fossil energy sources
'Generation follows load'

End of 21st Century
Sustainable energy system

Renewable energy sources
'Load follows generation'
Drivers for a Smart Grid

Balancing

Load shifting

Outage prevention and restauration

Efficiency

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Energy Sector
The smart grid ensure balance between generation and consumption

Smart Grids will ensures active load management and grid reliability
Virtual power plant –
the control of distributed energy resources

Integration of distributed and renewable energy sources

- More reliable forecasting and planning
- Decentralized power generation managed like a single power plant
- Energy trading
Technical Structure of Virtual Power Plants

- Biomass Power Plant
- Block-type Heating Power Plant
- PV Power Plants
- Fuel Cells
- Distributed Small Fuel Cells
- Concentrator
- Wind Power Plants
- Distributed Loads
- Energy Exchange
- Billing
- Meteorological Service
- Flexible Loads
- Communication Network
- Communication Unit
- Decentralized Energy Management System
- Network Control System
- Meter Reading
Demand Response – load follows generation

Management of demand

- Optimize generation cost
- Maximum use of CO₂ free energy
- Optimal use of valuable grid assets
Demand Response
Smart Grid Smart Building integration

EMS = Energy Management Syst.
DRS = Demand Response Server
DRC = Demand Response Ctrl.
Improvement of reliability and efficiency

Ensure the energy supply

Through

- Black out prevention
- Distribution automation
- Smart Metering
- Asset management
Distribution Networks & Distributed Energy Resources

Drivers in Europe

Today

- Radial system
- Simple protection
- Simple or no automation
- Simple or no communication

Tomorrow

- Meshed system
- Adaptive protection
- High degree of automation
- Bidirectional communication

110 kV

20 kV

0.4 kV

Unidirectional power flow

Simple distribution transformer

Bidirectional power flow

Generation at LV level

Intelligent meters

Energy Storage

Tap changer distribution transformer

Generation at MV level

e-car infrastructure

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Energy Sector
Feeder Automation
Consists mainly of 2 Application Areas

Cable network automation (Ring Main Unit)
- Compact switch gear with load switch / CB
- Compact RTU with back-up power supply
- Communication, e.g. cellular, wireless, PLC
- Integration in RMU (GIS) or external cubicle (AIS)
- Load-flow & status monitoring and control

Overhead line automation (Pole Top)
- Recloser automated → sequentially open/closes in case of a fault; w/o communication
- Sectionalizer / Switch load switch to isolate permanent faults
### A&N Pilot Project Feeder Automation
Eastern Shore in Virginia USA

<table>
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<tr>
<th>The challenge:</th>
<th>The solution:</th>
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<tr>
<td>▪ A&amp;N had a distr. feeder in its network feeding a critical hospital load that was manually controlled</td>
<td>▪ High Speed – System Operation in seconds not minutes</td>
</tr>
<tr>
<td>▪ An outage caused by a fault in the connected feeder could lead to a long outage before the system could be reconfigured to supply power to the hospital from an alternate substation source</td>
<td>▪ Decentralized system design</td>
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<td></td>
<td>▪ Standardized Communication (IEC 61850 &amp; DNPi)</td>
</tr>
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<td></td>
<td>▪ No Master required</td>
</tr>
<tr>
<td></td>
<td>▪ Simplified sequential logic structure</td>
</tr>
<tr>
<td></td>
<td>▪ New protection features</td>
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### It’s pioneering because ...

- High Speed Fault Location
- Developed High Speed Logic for Reconfiguration
- First Ever IEC61850 applied over WiMax
- New Protection Solution for Automated Distribution Feeders
- Use Standard Siemens software and hardware components
### The challenge:

**German municipality with high infeed from renewables (PV)**
Region faces already situation that is expected for Germany in ten years
- Production from renewables often higher than municipality can consume

### The solution:

**Installation of a measurement and control system for renewable generation and e-cars**
- Voltage control via switchable transformers.
- Control of active and reactive power.
- Storage of solar energy stationary batteries and e-cars during peak times

### It’s pioneering because ...

- First customer deployment of the Self-Organizing Energy Automation System SO EASY
- Field-testing of measurement and control equipment for Evaluation of current network situation and real-time controlling of the actuators
- Development and deployment of a simulation tool, linked to a scenario database in order to enable partly automated network analysis
E-DeMa – Vision of the marketplace and the ICT-Box

Market Place
Using incentives of energy exchange, energy supply companies and network operators

ICT-Box
Value-Added Services
- Information about actual energy consumption
- Information about price signal
- Load management, ...

Bi-directional communication for technical and commercial data (e.g. meter data, measured values, commands...)

Smart Metering for electricity, gas, district heating, water...
Load management of appliances
Management of distributed generation

In-house applications

Market for energy services

Distribution Network
Operation with online information about medium and low voltage grids (Smart Grid)

Gefördert durch den BMWi
A vision to become reality: Smart Grid solutions made by Siemens

- **CO₂ emissions are constantly on display**
- **micro generation (PV) as part of smart buildings**
- **large centralized power plants still supply the majority of power demand**
- **wireless sensors and smart metering coupled to load management and market driven energy supply software**
- **car-parking for plug-in vehicles, buy or sell electricity shaving peak loads**
- **storage plants buffer fluctuating generation**
- **large and very small generation plants need to be managed in parallel**

Smart Grid by Siemens

A vision to become reality: Smart Grid solutions made by Siemens