Smart Self-* Features in Power Utilities and Grids

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Trends, Prospects and Risks

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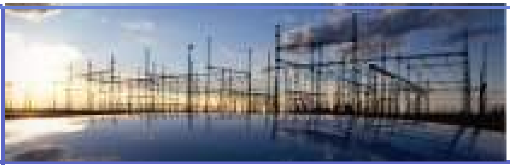
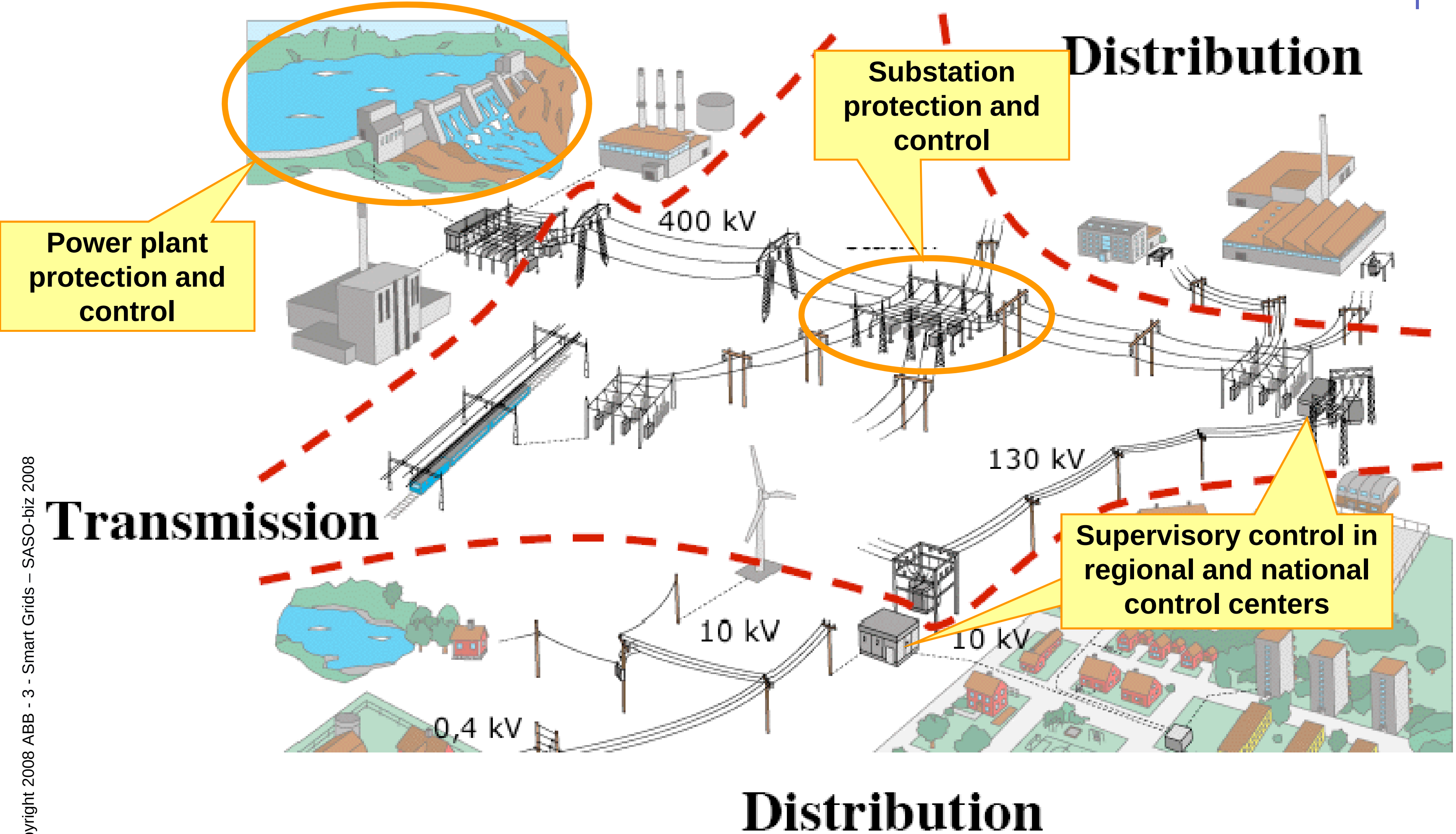


Outline

- Today’s electrical grids
- Smart grids
  - What are they?
  - Why?
- Smart grids and self* features
- Example
- Conclusions

Background: What is a Power System? (1)



Background: What is a Power System? (2)

- Transmission (higher voltage, meshed, linked to generation)
- Distribution (lower voltage, operated as a tree, only loads)
- Main functions:
  - Protection
    - Embedded devices – Intelligent Electronic Devices (IED)
      - Preconfigured (not adaptive generally)
    - Communicates with control centre
    - Substation automation system
      - IEDs communicate among themselves
  - Monitoring
    - Supervision & Control & Stability
    - SCADA system at control centre
    - (Substation monitoring system)

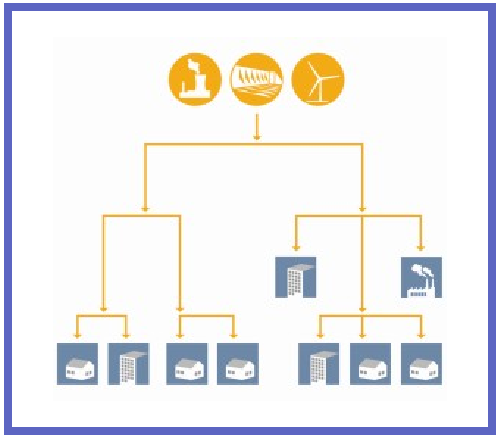
*** SCADA = Supervisory Control and Data Acquisition**

Drivers for Smart Grids – what is changing?

- Environmental concerns: CO_2 reduction
- Introduction of wind, solar, renewables ....
  - EU & US have plans for 20 % renewable production
  - … a challenge due to intermittencies
  - … a challenge due to new topologies
- Energy/Grid efficiency
  - … with a reliability prerequisite (no blackouts!)
- Demand side: increased customer participation & choice
  - Smart homes, automated metering
- Regulatory support
  - Smart Grids act (US)
  - Liberalization of markets

Traditional versus Smart Grids – a transition

traditional grid



- Centralized power generation
- One-directional power flow
- Generation follows load
- Top-down operations planning
- Operation based on historical experience

smart grids

- Centralized and distributed power generation
- Multi-directional power flow
- Consumption integrated in system operation
- Operation based on real-time data

Differences to today

	Current Grid	Smart Grid
Communications	None or one-way; typically not real-time	Two-way, real-time
Customer Interaction	Limited	Extensive
Metering	Electromechanical	Digital
Operation & Maintenance	Manual equipment checks, time-based maintenance	Remote monitoring, predictive, condition-based maintenance
Generation	Centralized	Centralized and distributed
Power Flow Control	Limited	Comprehensive
Reliability	Prone to failures and cascading outages	Pro-active, real-time protection and islanding
Restoration	Manual	Self-healing
Topology	Radial	Meshed

Where are self* features needed? (1)

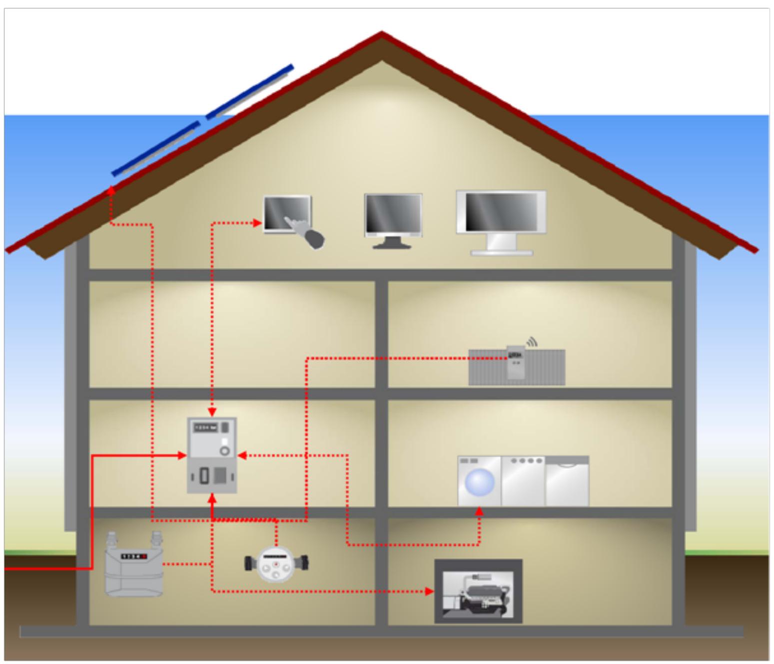
- **(Re) engineering**
  - Very complex
  - Aging workforce
  - Automate parts of the process
  - ➢ Automatic configuration of the communication
    - ➢ Protocol mappings
  - ➢ Automatic configuration of operator’s display
- **Protection of the grid**
  - Distribution network will be much more dynamic
  - Local generation
    - Fault currents can vary a lot
  - ➢ Adapt protection parameters and/or protection functions

Where are self* features needed? (2)

- **Supervision**
  - Ensure stability
  - Local generation control
  - Minimize losses
  - Smart load shedding
  - ➢ Need better data
  - ➢ Hierarchical and distributed
    - ➢ At substation, control centre…
- **Restoration**
  - Automatic blackout resolution
  - ➢ Need better overview picture
    - ➢ What happened?
    - ➢ Fault location

Where are self* features needed? (3)

- **Demand-side involvement**
  - Smart home
    - Smart Meters allows utility customers to participate in time-of-use pricing programs and have greater control over their energy usage and costs
  - Automated metering infrastructure
  - ➢ Market-based system



- Exploit real-time pricing
- Optimization of energy costs
  - Switch gas / electricity
  - Run washing machine off peak
- Transparency of energy costs
- Intelligent control

Self* features enablers

- Communication infrastructure
  - Services
  - Protocols
  - Must be standardized
- Semantics
  - Ontologies
    - At all levels
  - Must be standardized

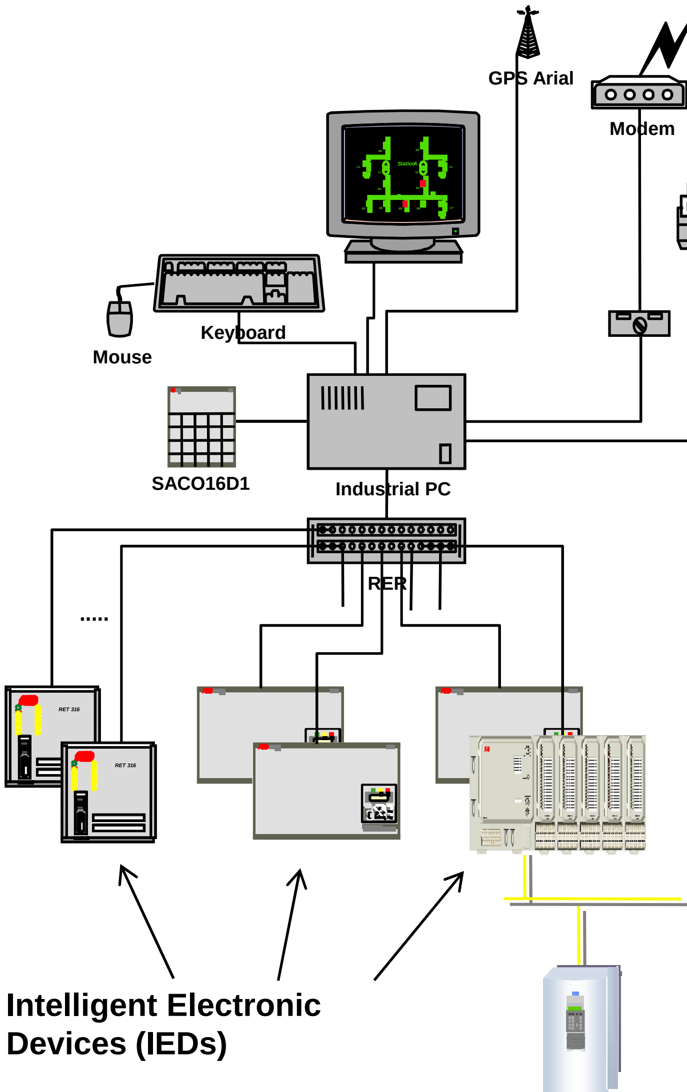
➢ **Need standards!**

➢ **Need automation framework(s)!**

Example: substation automation

- **IEC 61850**
  - “Communication networks and systems for power utility automation”
  - Standard for electrical substation automation
- Defines:
  - Communication services and protocols
  - Data model
    - Ontology
  - Substation Configuration description Language (SCL)
    - Engineering process
- Thus allows some automatic features
  - Plug & play systems

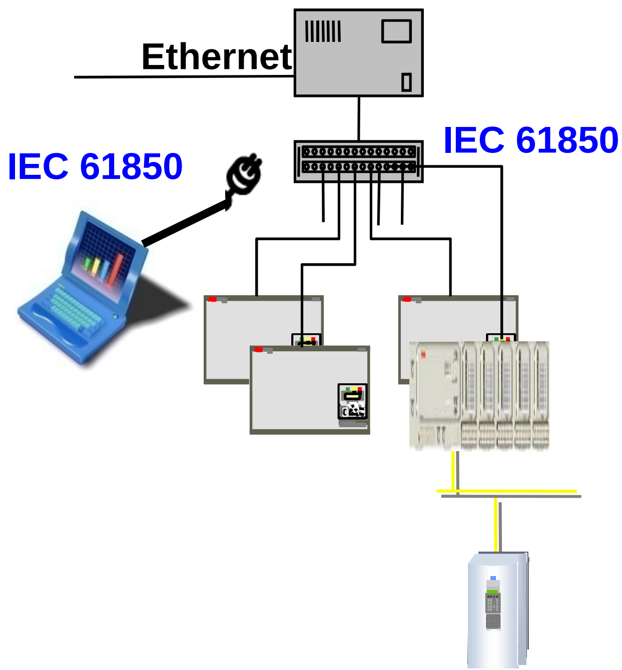
Substation automation system



- Complex configuration required for getting real-time information.
  - Each vendor has its own configuration tool(s)
  - Proprietary protocols
- Now: IEC 61850
  - Automatic discovery of internal IED configuration
  - Identify relevant data (process, config, etc.)
  - Plug & play Substation Monitoring System (SMS)

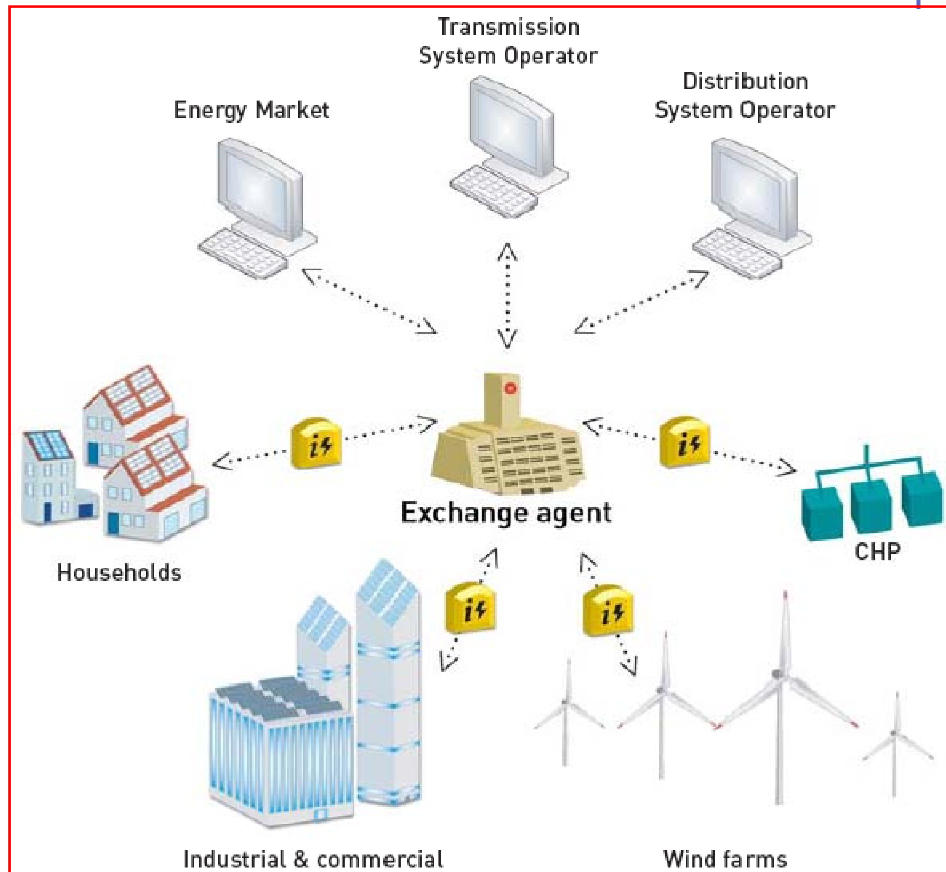
Plug and play substation monitoring with IEC 61860

1. Connect laptop to the substation network
2. The SMS automatically detects substation configuration:
   - Get SCL file(s), or
   - Detect configuration of IEDs
3. Build GUI for available data
   - Automatically!
4. Operation:
   - Display real-time data, obtained through standardized services.
   - Log events (= change of status values)
   - Parameterization of protection functions…



Smart grids vision in short

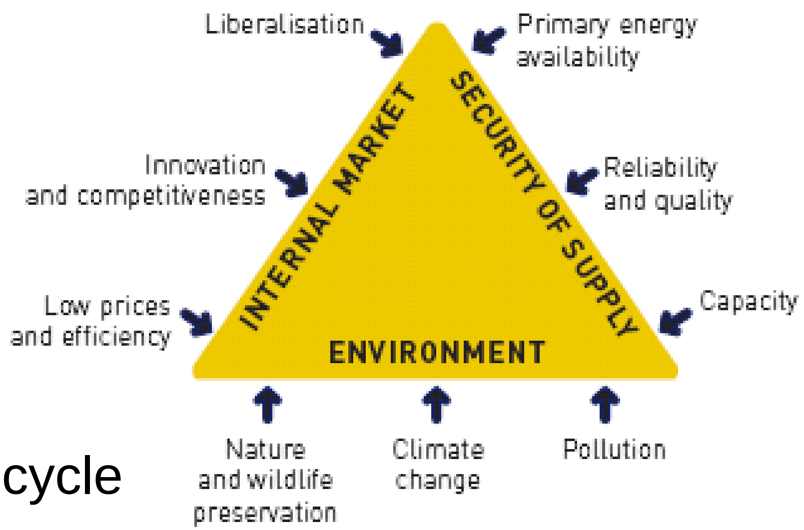
- Adaptive, with less reliance on operators, particularly in responding rapidly to changing conditions
- Predictive, in terms of applying operational data to equipment maintenance practices and even identifying potential outages before they occur
- Integrated, in terms of real-time communications and control functions
- Optimized to maximize reliability, availability, efficiency and economic performance
- Interactive between customers and markets
- Secure from attack and naturally occurring disruptions



Source: European SmartGrids Technology Platform

Conclusions

- Power grid will change
  - Complex issues – need self* capabilities
    - -Configuration
    - -Healing
    - -Diagnosis
    - -Arbitrating
- Critical infrastructure
  - No blackouts – power always on!
- Issues:
  - Very conservative industry
  - There are many stakeholders
  - Installed equipment has a long life-cycle



Source: European SmartGrids Technology Platform

➢ We need widely accepted standards!
  - First steps available (IEC 61850, IEC 61970, …)

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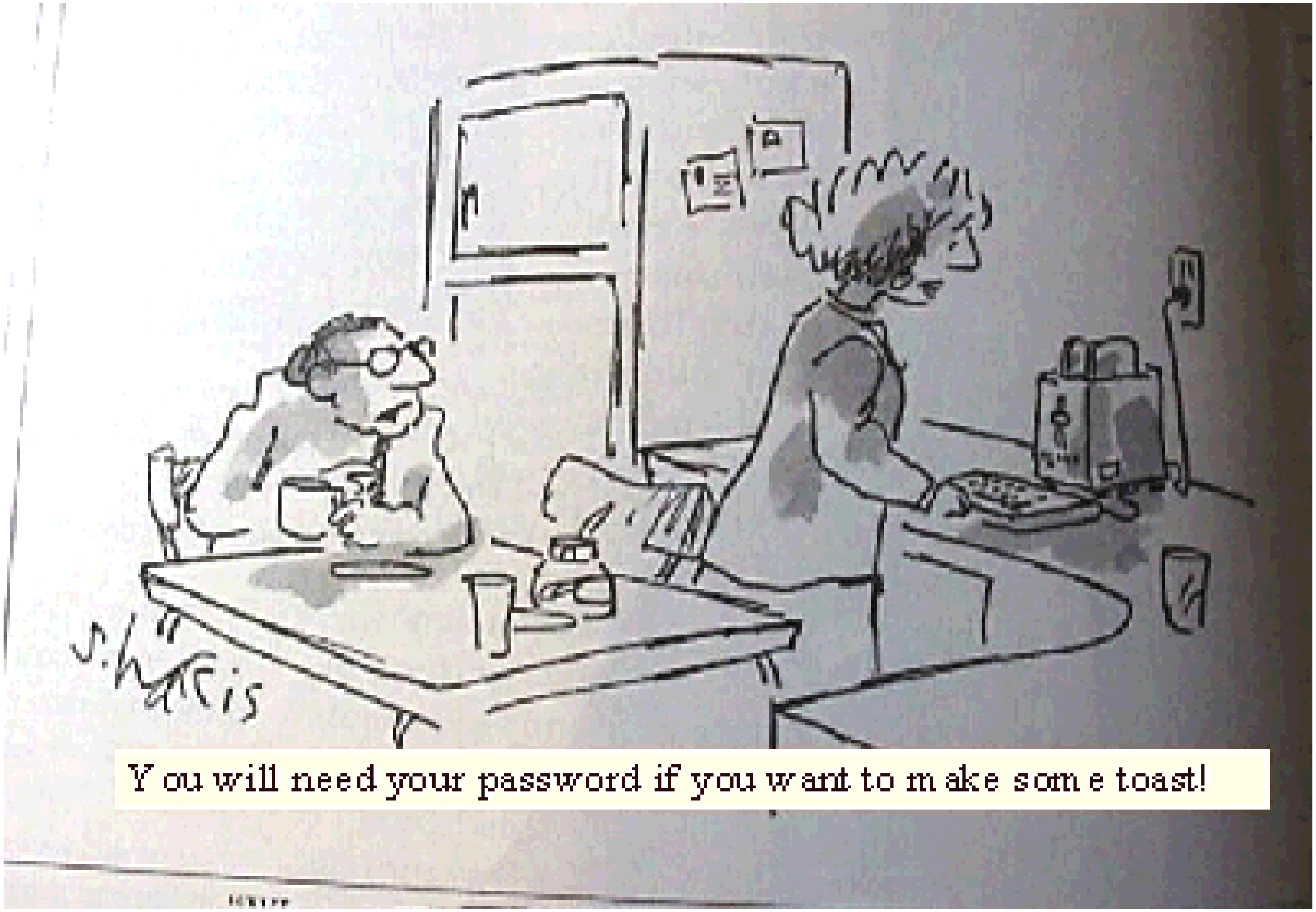
Let’s not make it too smart !



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Blackout Europe 2006-11-04

- UCTE blackout, >10 Mio people
  union for the co-ordination of transmission of electricity
  - HV line switched off to let a ship pass
  - → lead to overloading of lines
  - → finally to splitting of the Union
- On a parallel line / overcurrent protection (from UTCE report) …
  - Protection settings on both sides of the Ladesbergen-Wehrendorf line were different!

Recommendation #4
UCTE has to set up an information platform allowing **TSOs** to observe in real time the actual state of the whole **UCTE** system in order to quickly react during large disturbances.

Functional Examples

- **Real-time situational awareness** and analysis of the distribution system can drive improved system operational practices that will in turn improve reliability
- **Fault location** and isolation can speed recovery when outages do occur by allowing work crews to drastically narrow the search for a downed line
- **Substation automation** (SA) enables the ability to plan, monitor, and control equipment below the control center, which in turn makes better use of maintenance budgets and boosts reliability
- **Smart Meters** allows utility customers to participate in time-of-use pricing programs and have greater control over their energy usage and costs
- **SCADA/DMS** (distribution management systems) put more analysis and control functions in the hands of grid operators
- **Voltage control** through reactive power compensation and the broader application of power electronics improves both transmission capacity and the resiliency of the system overall

(non-exhaustive list)

What drives the introduction of Smart Grids?

Increasing electricity consumption
Global electricity consumption will grow by 70-90% between 2005 and 2030

Environmental concerns - reduction of CO_2

Security of energy supply
Reduced dependency on fossil fuels from sensitive regions

Reliability of electricity supply

- Aging infrastructure
- Aging workforce
- IT security

Growing share of renewable power generation

Wind will grow from 111TWh in 2005 to 1,000-1,800TWh in 2030

Solar will grow from 3TWh in 2005 to 160-350TWh in 2030

Energy efficiency

T&D losses – target reduction of 2% in 2020 (EU)

Significant portion of **renewable power generation** will be **distributed** and **intermittent**

Open energy market

Consumer pricing to foster demand response

Impact on grid stability and efficiency

Introduction of Smart Grids

- Information and control technologies to achieve the required grid stability
- Requires regulatory support (only exceptional business cases) and development of standards

Smart Grids – geographical overview

NAM

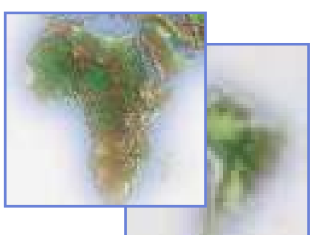
- Government and industry groups driving Smart Grids vision
- Strong trend among utilities
- Strong federal/state involvement

Europe

- Strong interest, mainly from large utilities
- Strong involvement from EU
- Influenced by the NAM vision

Asia

- Emerging interest from larger utilities
- Main focus on adding capacity
- Will emerge in 5-10 years



Middle East Africa South and Latin America

- Some emerging activities