Building a secure, reliable electricity grid

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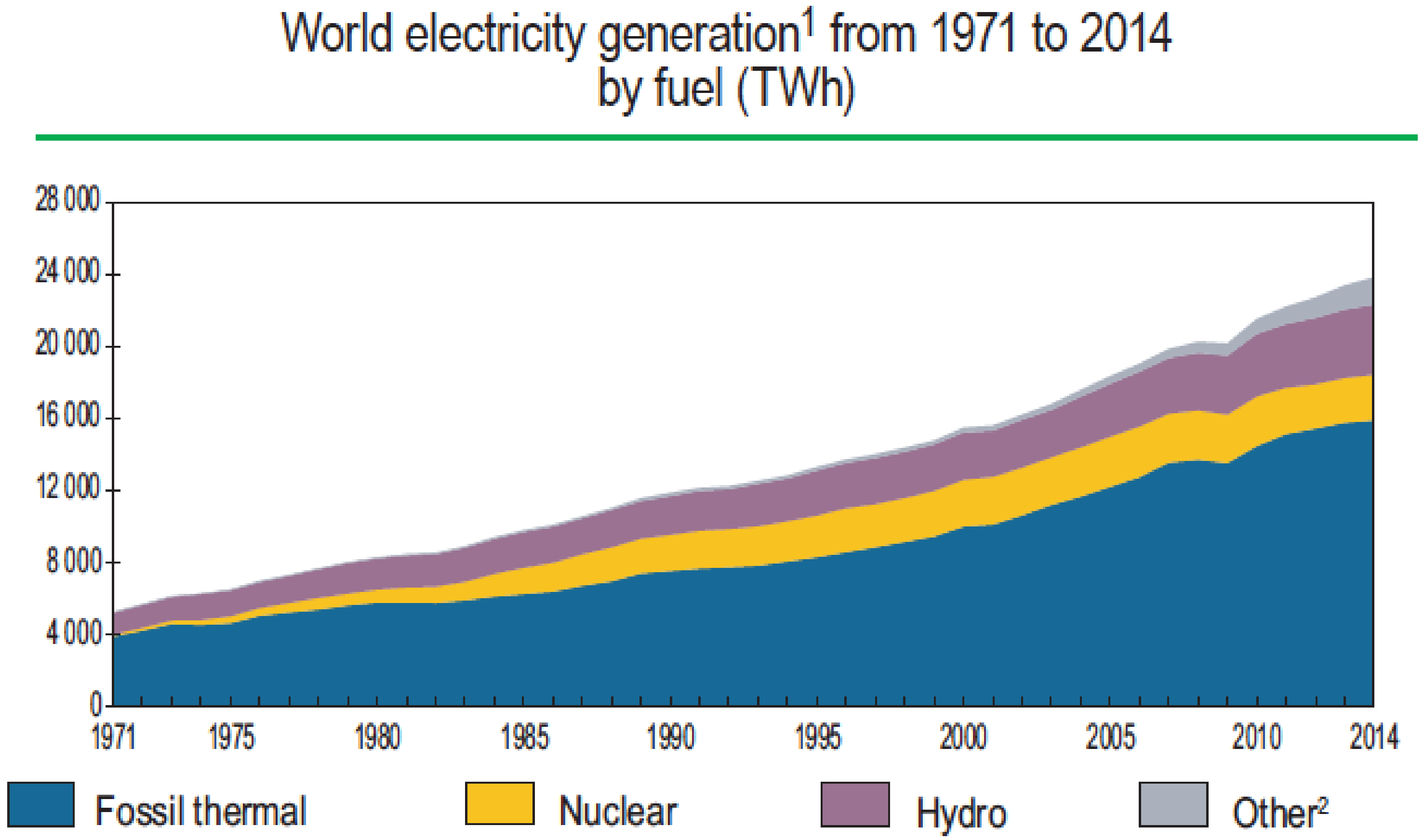
Outline

- Good ol’ electric grids
- Challenges (past, present and future)
- Make it Smart!
- Building a secure, reliable electricity grid

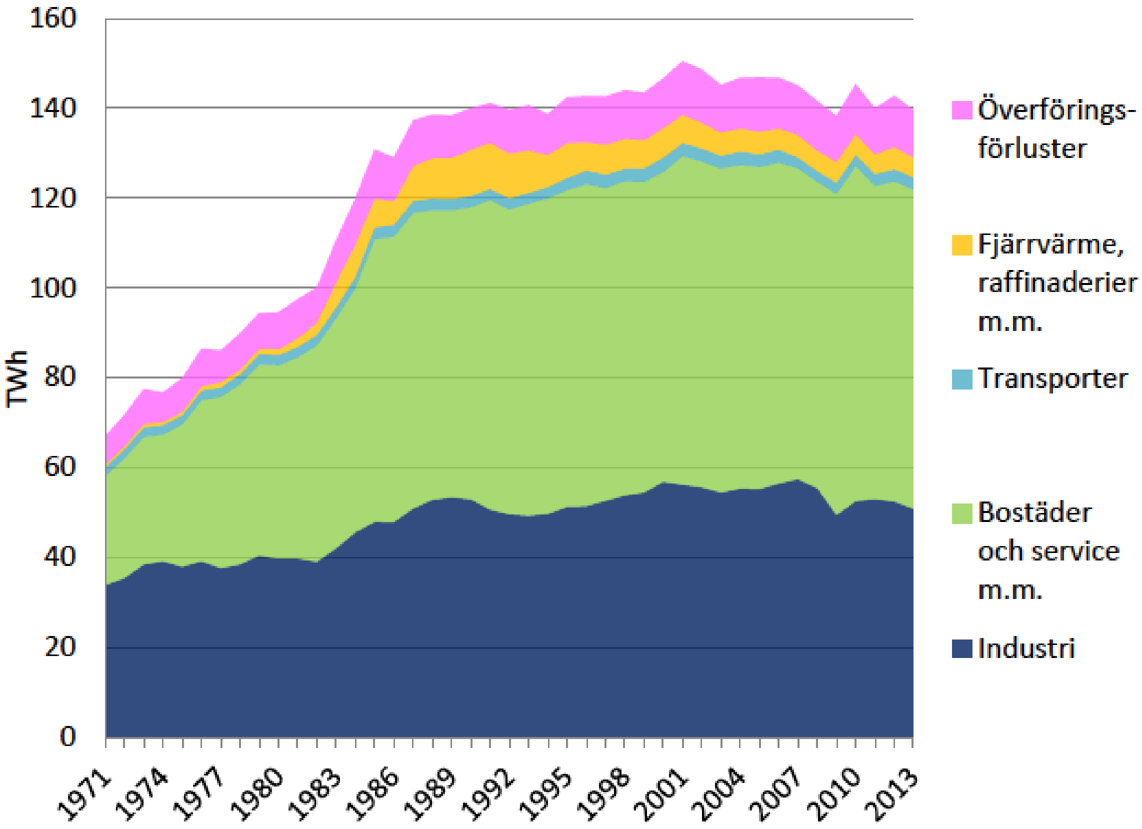
World Electricity Generation



IEA - Key World Energy Statistics

Electricity in Sweden

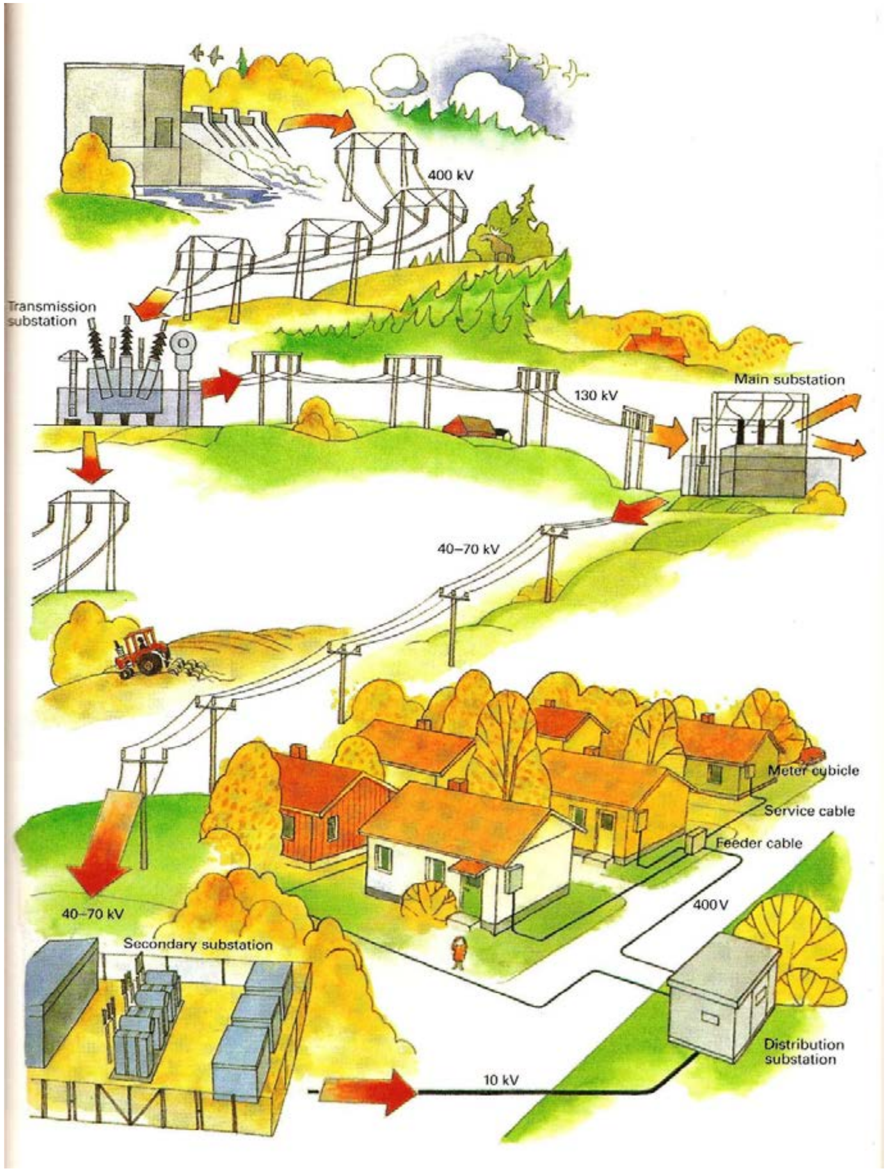
Figur 14 Elanvändning per sektor 1971 – 2013, TWh



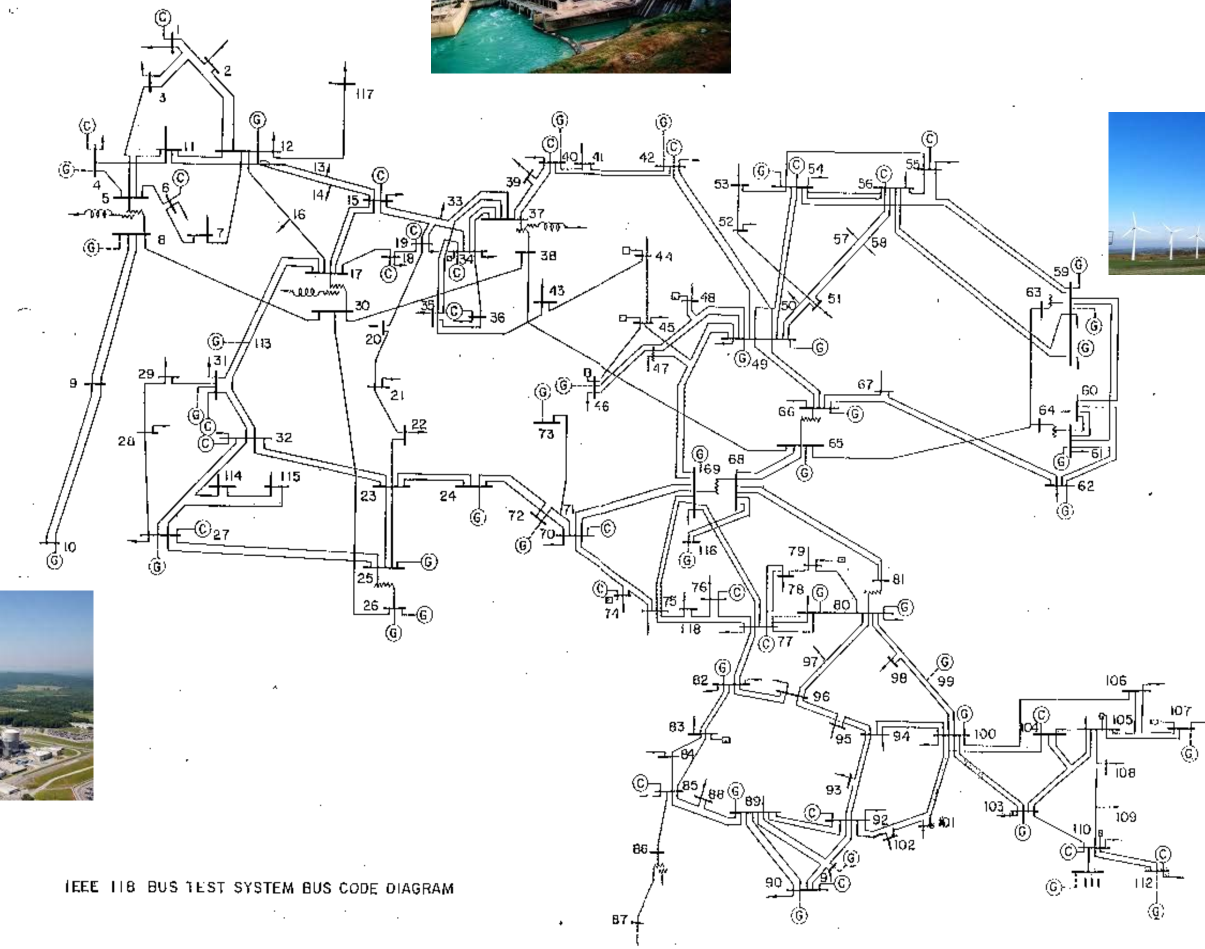
Källa: Energimyndigheten och SCB.

Grid structure

- Transmission
- Regional transmisson
- Distribution

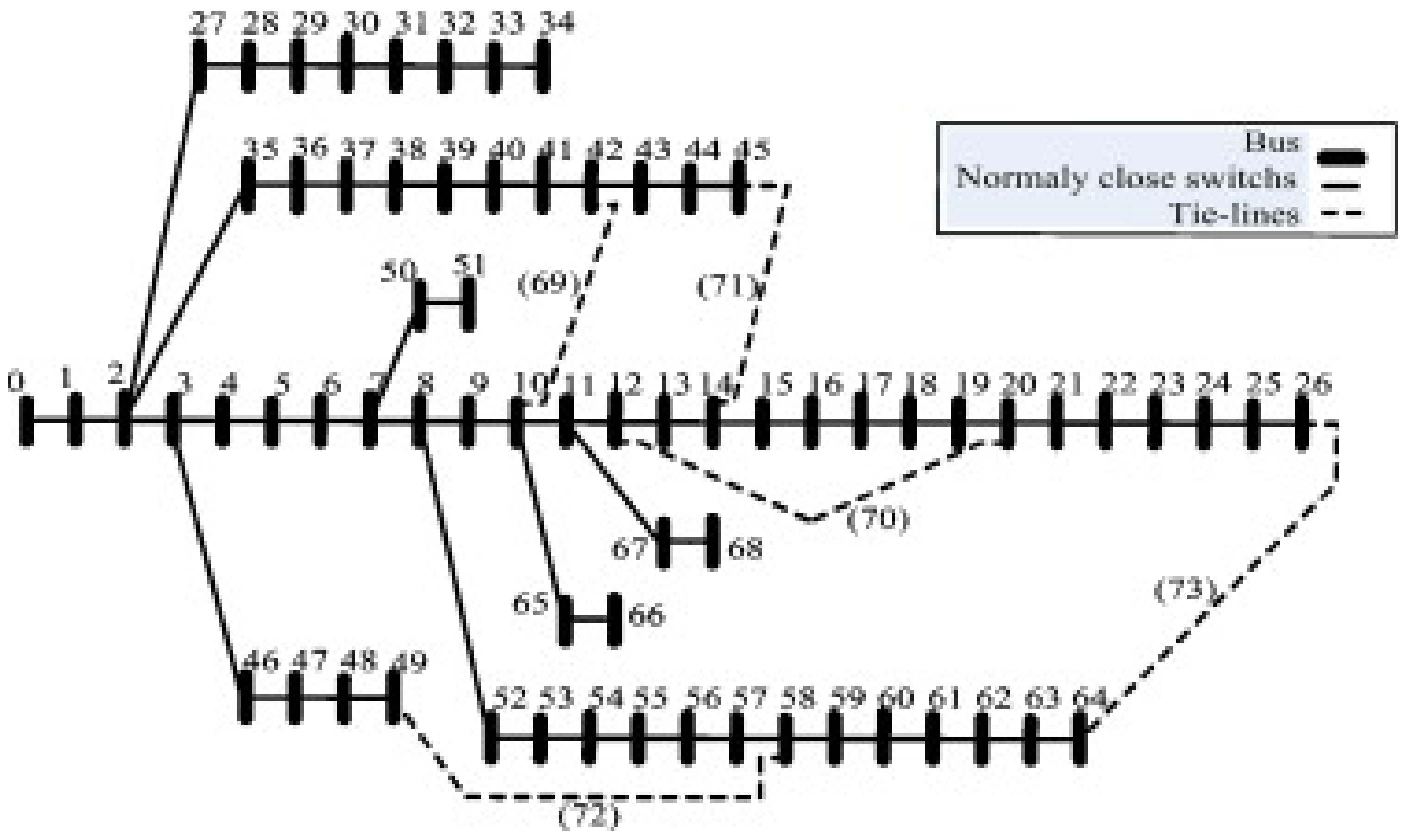


Transmission Grids



Transmission Substation

Meshed MV Grid



Distribution Substation

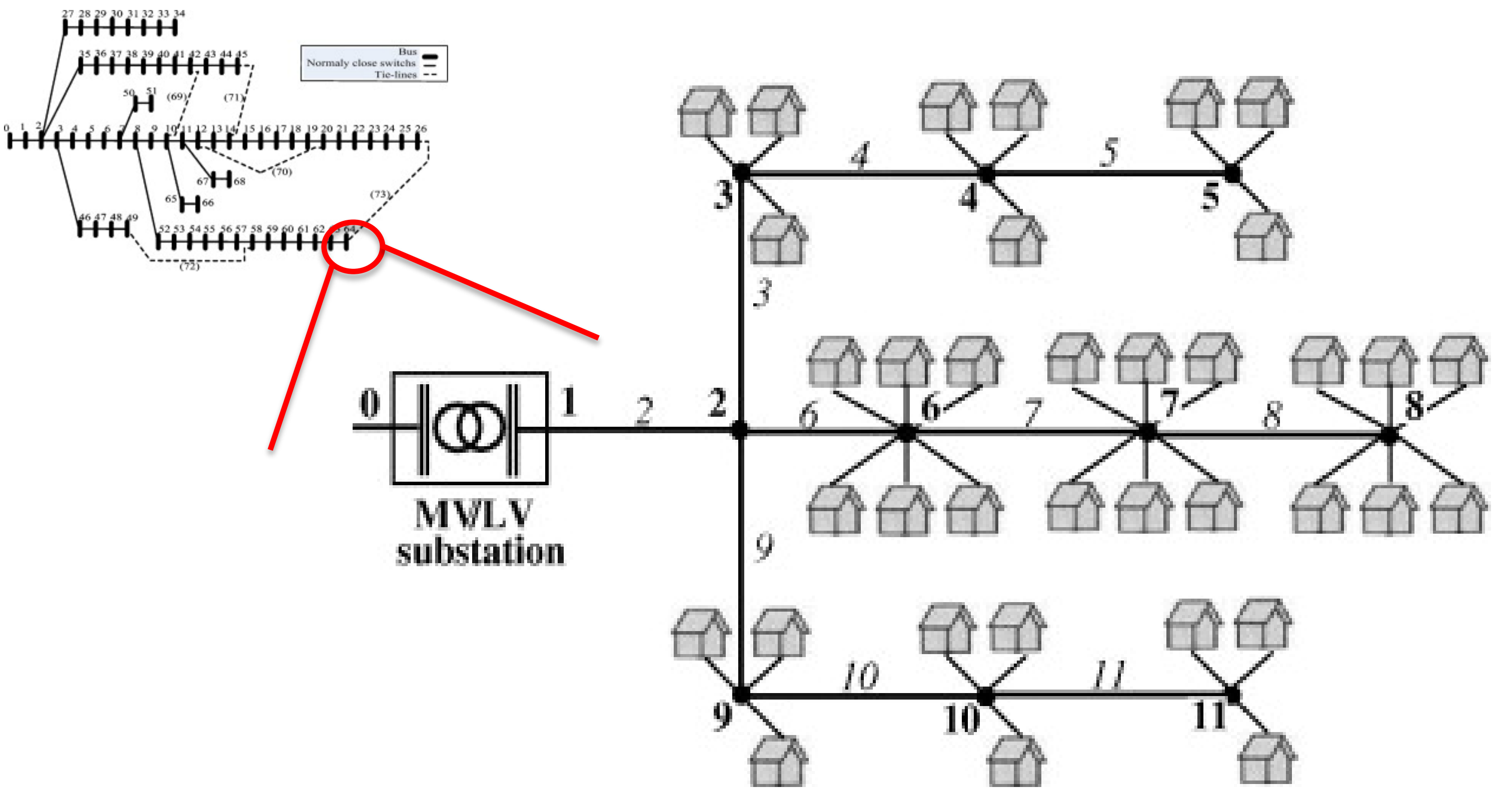
10 - 25 kV range

Equipment housed in compartments

Separate compartments for

- Disconnector
- Breaker
- Feeder
- Measurement

LV Feeders



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Power System Control fundamentals

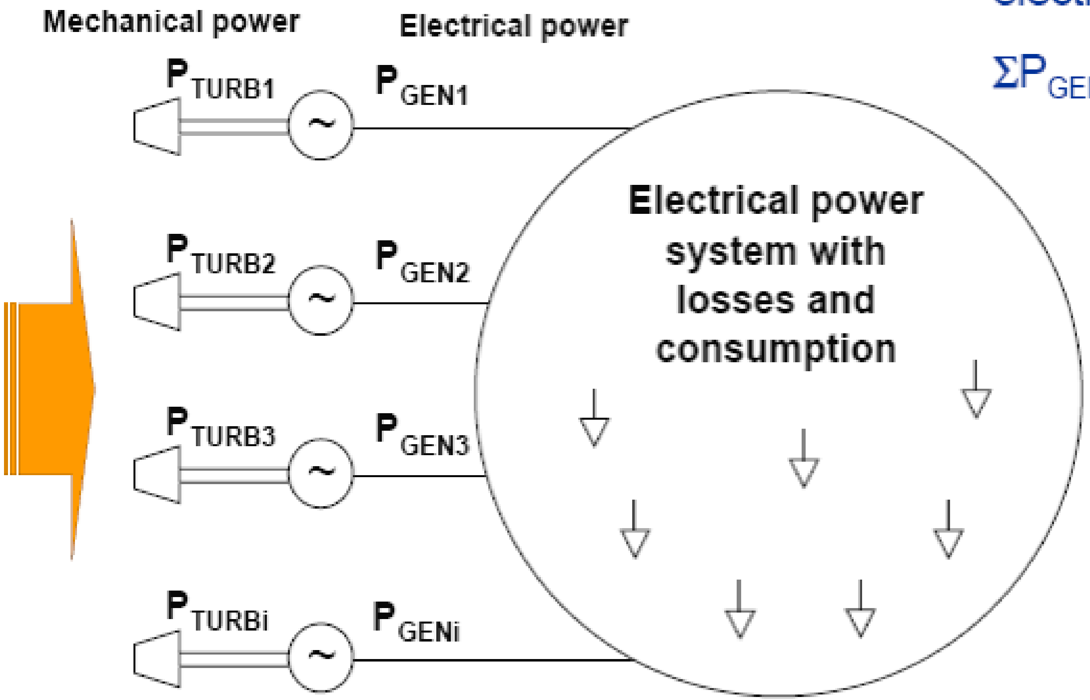
Two parameters are the the main concern for power system control: Frequency & Voltage

Equipment connected to the grid is design for nominal voltages and frequency, deviations can damage equipment

An even voltage profile is a means to reduce losses.

Additionally, the control and monitoring of power flows is important for loss minimisation, thermal limit control and market management.

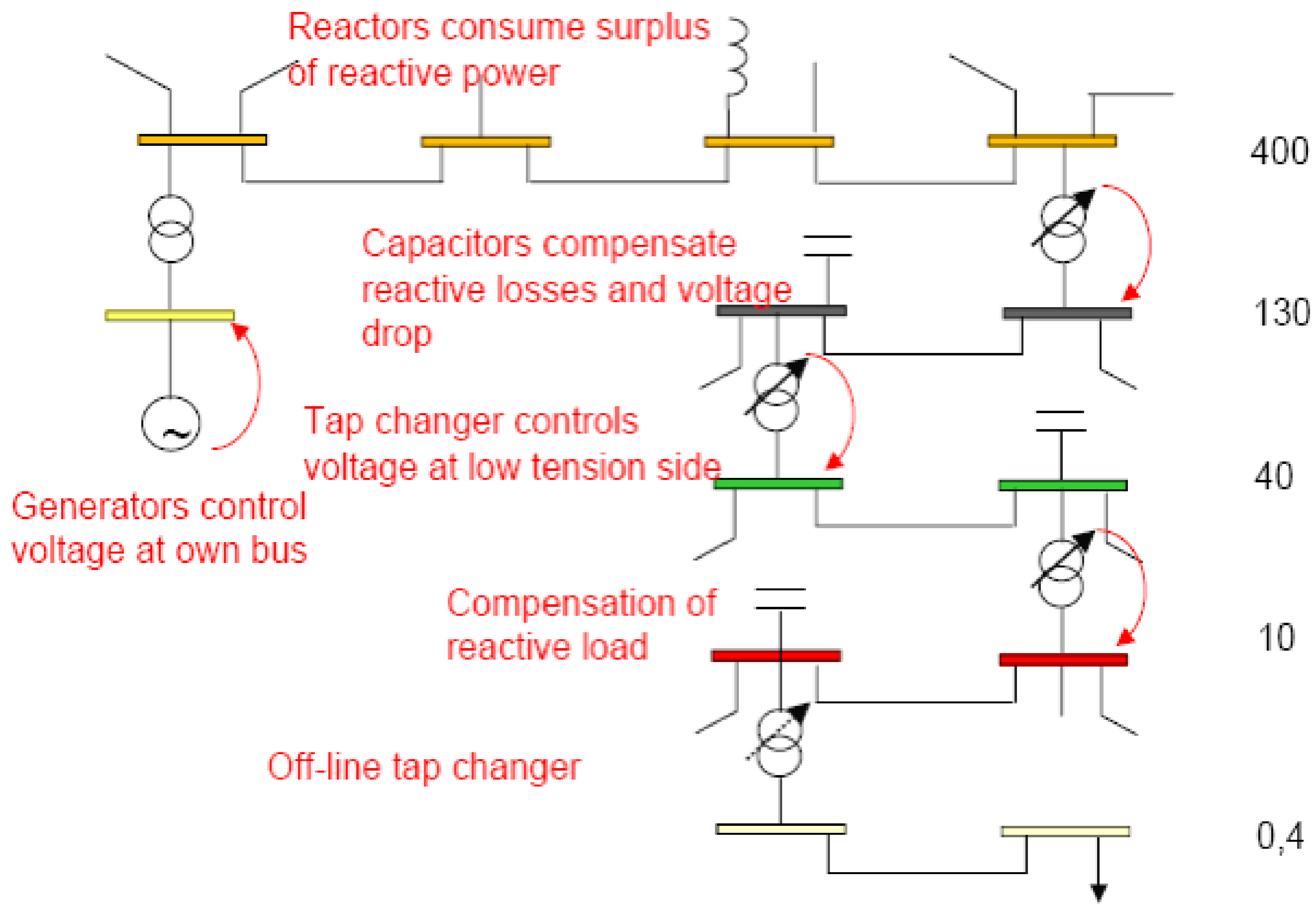
Frequency Control



Always balance in the electrical system:

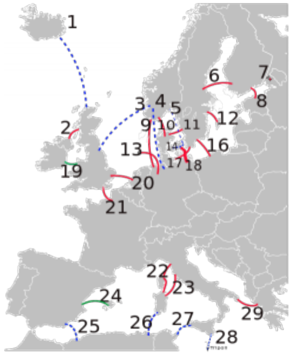
$\Sigma P_{GEN} = \Sigma P_{LOAD} + \Sigma\ P_{LOSS}$

Voltage Control Hierarchy

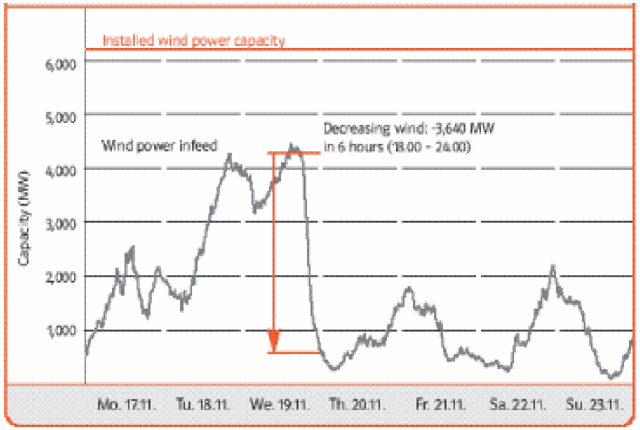


At the Transmission level

Increased market coupling leads to larger variations in power flow.

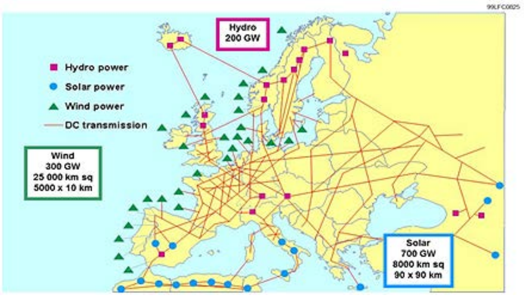


Source: Tintazul, Maix, J JMesserly;



E.On Netz (2004), *Wind Report 2004.*

Large amounts of renewables not in close proximity to load centers, new grids?



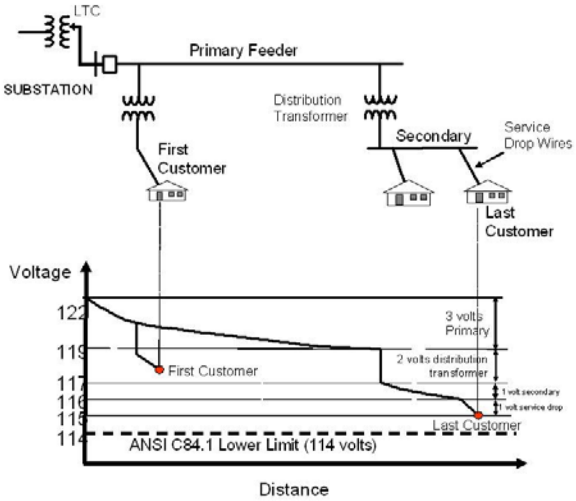
Source: Gunnar Asplund, Elways AB

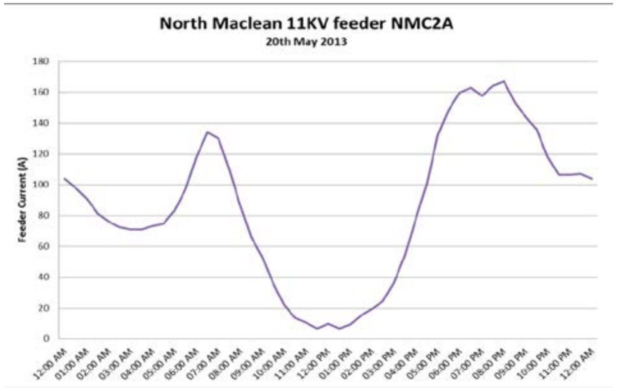
Inherent variability of supply increases stress to the system

At the Distribution level

Prosumers as market participants

Voltage control in active feeders





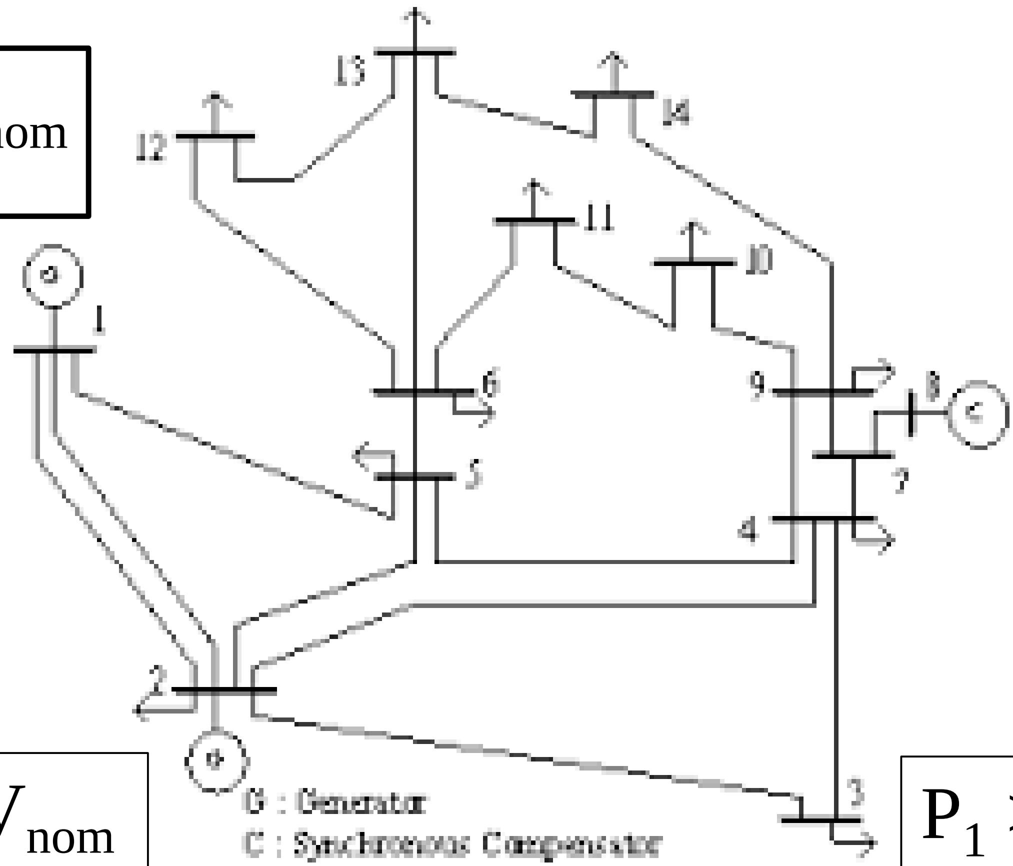
Source: Giles Parkinson RE Economy

Protection settings under varying load & production

New types of load – ancillary services?

Local vs Global Challenges

$P_G < P_L \qquad f < f_{nom}$



$V_1 > V_{nom}$

$P_1 > P_{lim}$

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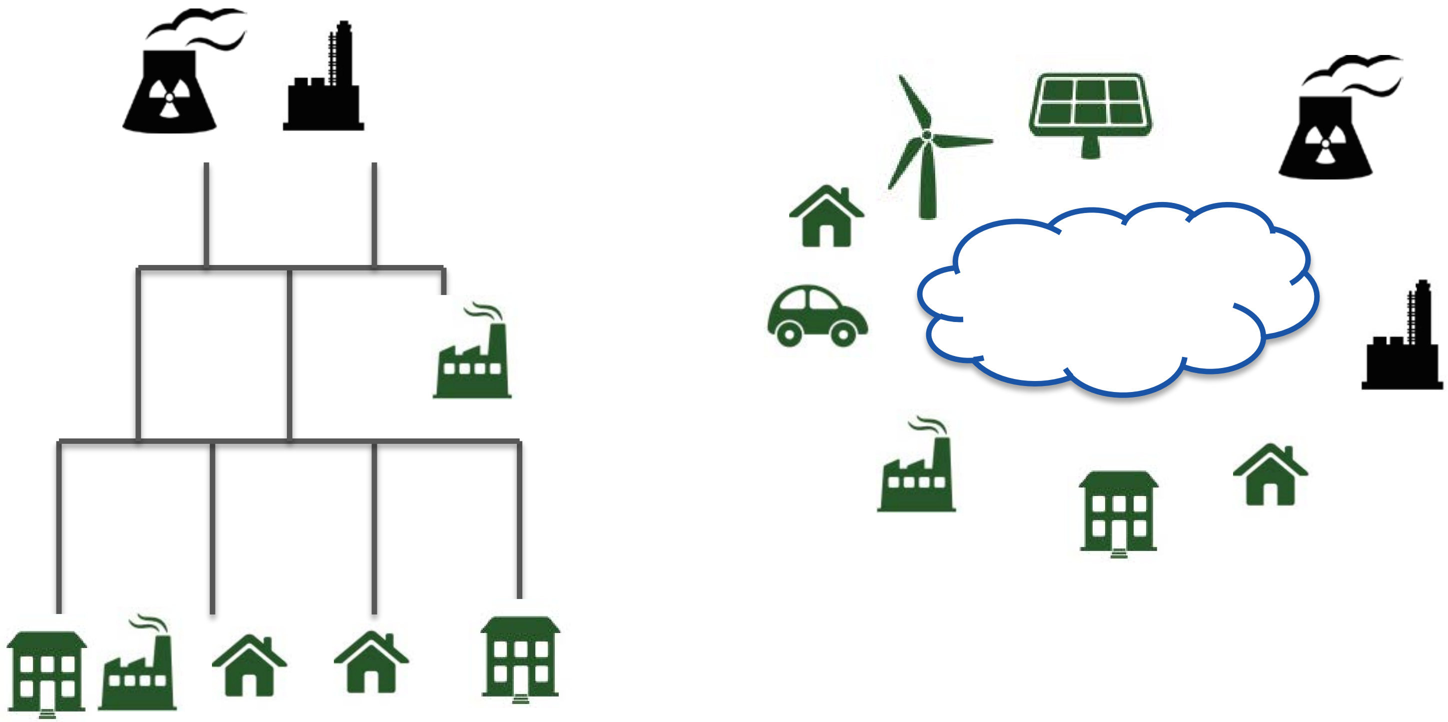
The Future Power System a.k.a. Smart grid

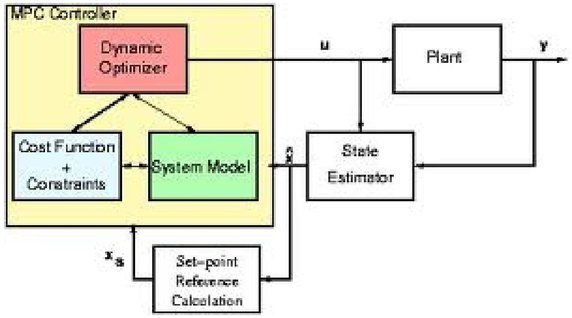
Migrating from a hierarchical system into a peer to peer model



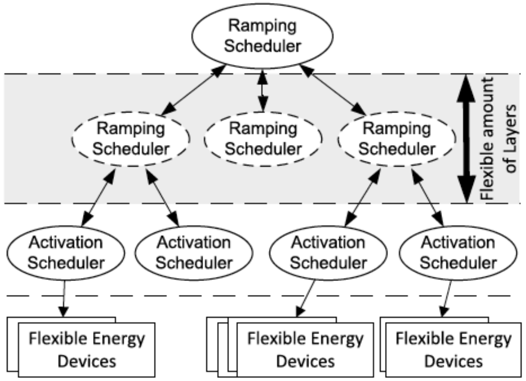
From centralised to distributed optimisation and decision making

Means to manage the challenges

More copper

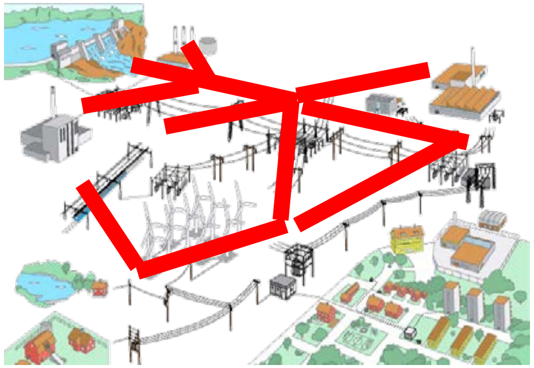


New control strategies enabling distributed optimised control



Source: Prof Sebastian Lehnhoff,

New services: Microgrids, Virtual Power Plants & ancillary services.



An interoperable reliable, secure and high-performing communications infrastructure

BEA Systems, Inc. (Nasdaq: BEAS), the E-Commerce Transactions Company(TM), announced that [redacted], one of the largest energy companies in Europe, is using BEA's WebLogic product family of industry --leading e-commerce transaction servers, along with BEA components, to build an integrated network A network that supports both data and voice and/or different networking protocols for providing 'smart building' subscription services throughout Sweden. The services let customers remotely monitor their refrigerators, ovens, electricity consumption and power mains status, and control their burglar alarms and heating and air conditioning air conditioning, mechanical process for controlling the humidity, temperature, cleanliness, and circulation of air in buildings and rooms.. [redacted] estimates that, before the end of next year, 150,000 Swedish households will be using the new services, and hopes to add 200,000 new customers a year en route to a customer base of one million households within five years.

United States Patent [19]

Bateman et al.

[11] **4,240,030**

[45] **Dec. 16, 1980**

[54] **INTELLIGENT ELECTRIC UTILITY METER**

[76] Inventors: **Jess R. Bateman,** 1516 Esplanade Ave., Redondo Beach, Calif. 90277; **Robert L. Carpenter,** 12,032 Freeman Ave.; **Ross K. Smith,** 5435 W. 124th St., both of Hawthorne, Calif. 90250

[21] Appl. No.: **969,303**

[22] Filed: **Dec. 14, 1978**

[51] **Int. Cl.**[3] **G01R 1/00**

[52] **U.S. Cl.** .... **324/110;** 346/14 MR; 235/449

[58] **Field of Search** .... 324/51, 110, 113, 157; 364/483; 235/449, 493; 346/14 MR; 307/140

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3,835,301	9/1974	Barney	235/61.11
4,019,135	4/1977	Lofdahl	324/110

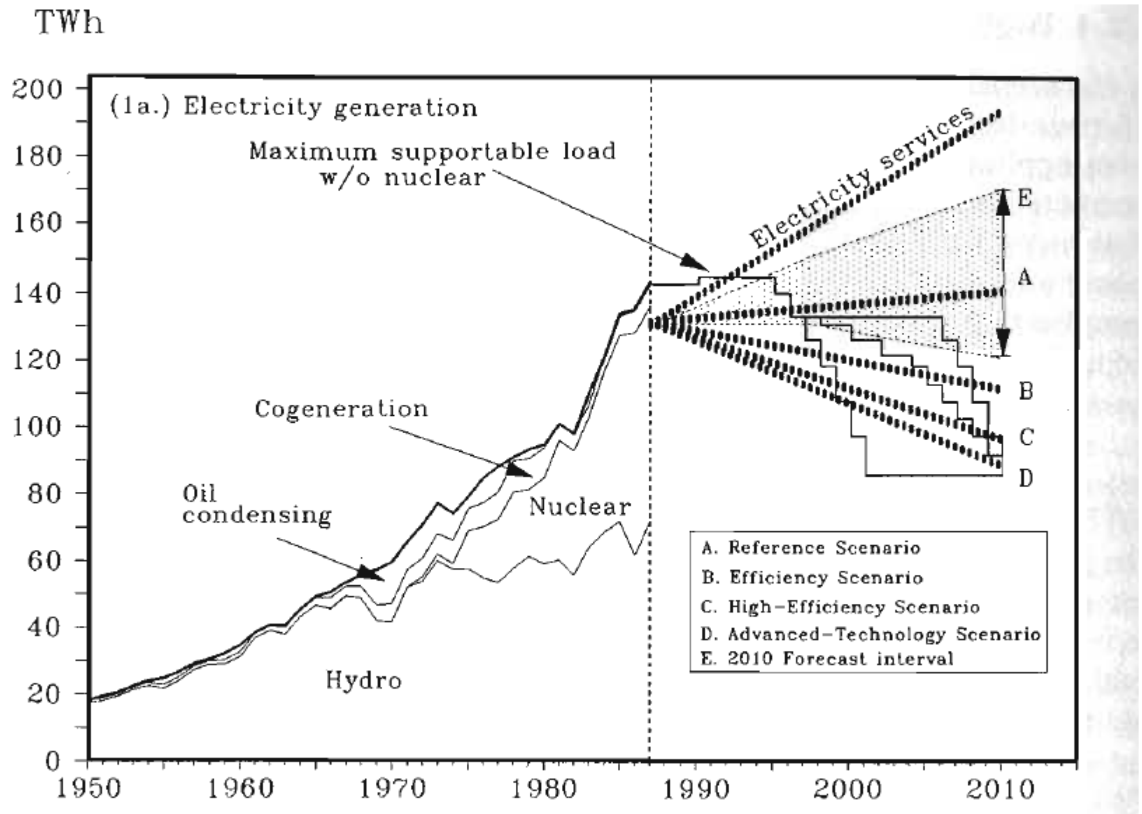
Primary Examiner—Michael J. Tokar
Attorney, Agent, or Firm—Poms, Smith, Lande & Rose

[57] **ABSTRACT**

A conventional electric utility meter is equipped with special circuitry and components which work in conjunction with an inserted magnetic card to regulate the supply of electricity to the structure to which the unit is attached. In addition to including the conventional dials which indicate overall kilowatt hours, the exterior of the unit includes a receptacle for the card and additional displays which show the kilowatt hours, and corresponding dollar value thereof, for the current payment period. The special circuitry includes a microprocessor, a set of magnetic read/write/erase heads, and a power relay. The circuitry interfaces with the conventional meter components by means of a photocell positioned above apertures or notches in the rotating disk of the meter. In the primary mode of operation, a prepayment card is inserted containing a predetermined kilowatt hour credit. The special circuitry senses this amount and adds it to the amount of power the customer is entitled to receive. Also, the circuitry warns the customer when only a small electricity credit remains. In an alternative mode, a blank postpayment card is inserted into the unit and the amount of the electricity utilized during the current payment period is encoded on the card. The card is then sent to the utility company as the basis of a future billing. Finally, the unlocking of the meter unit case is controlled by a special card code.

15 Claims, 6 Drawing Figures

Energiwende – Swedish style



What can we learn from the past?

It seems a lot of technology has already been invented and tested in various forms. In several cases, the visions did not really come true.

Where is the hang-up?

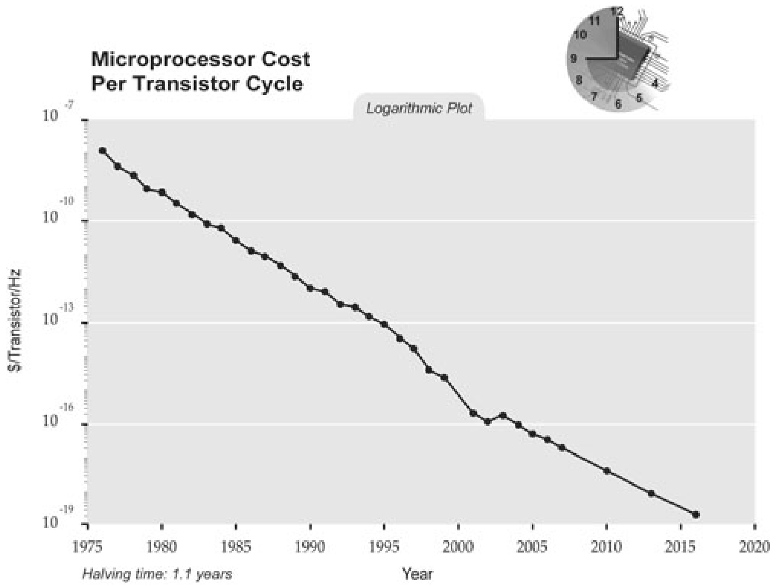
Building the future

Eric S. Raymond

Irrational Infrastructures

Even more irrational:
Sharing – not owning

Computing everywhere



www.singularity.com

What are the real drivers for change?

Increased Power System variability

Variability in previously stable and predictable quantities like voltage, power flow, frequency and prices increase due to large quantities of renewables.

Increased efficiency

Constant push to reduce operational costs, technical losses and environmental impact from shareholders and regulators.

Business chain separation

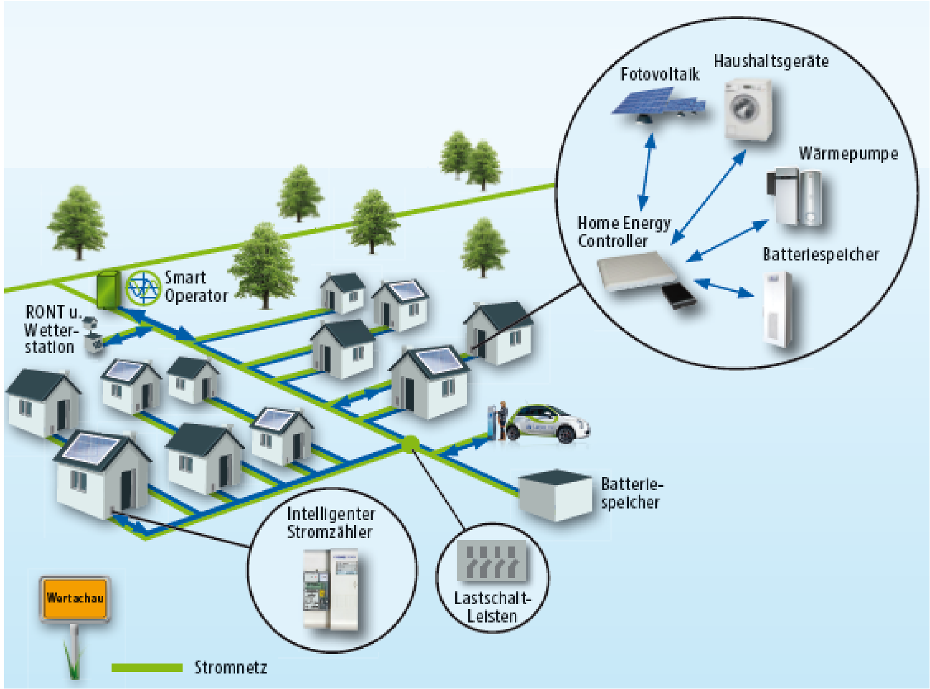
Unbundling and re-regulation is separating the business chain from generation to consumption creating addtional actors all leading to increased need for coordination, communcation & control.

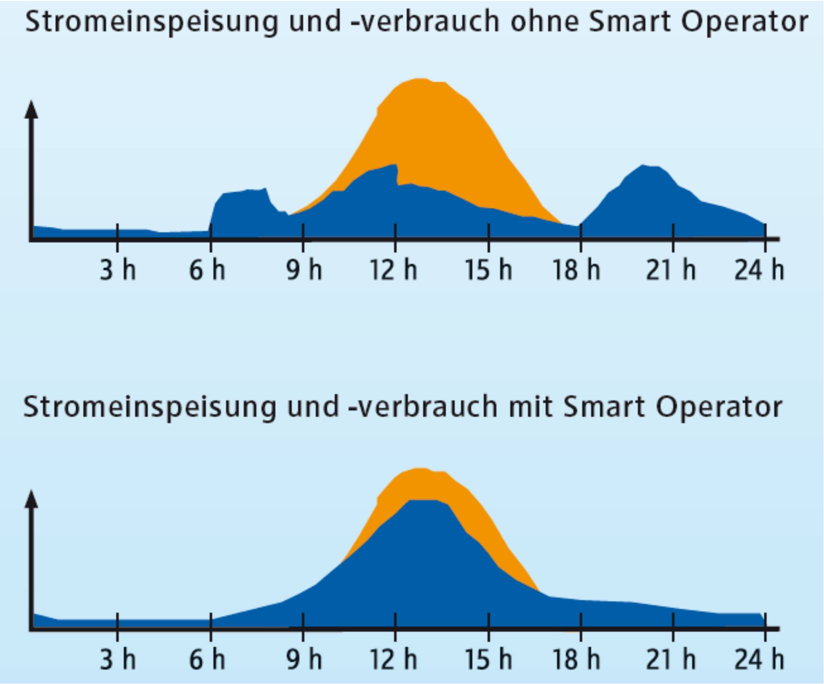
Ubiquity of computing

Computing (and communcation) capabilites are available at low costs everywhere with high capability.

Smart Operator

Fully Automated Load Management in the LV grid
Developed by RWE Germany, due to real challenges in LV
Balancing of load & PV to manage congestion and voltage



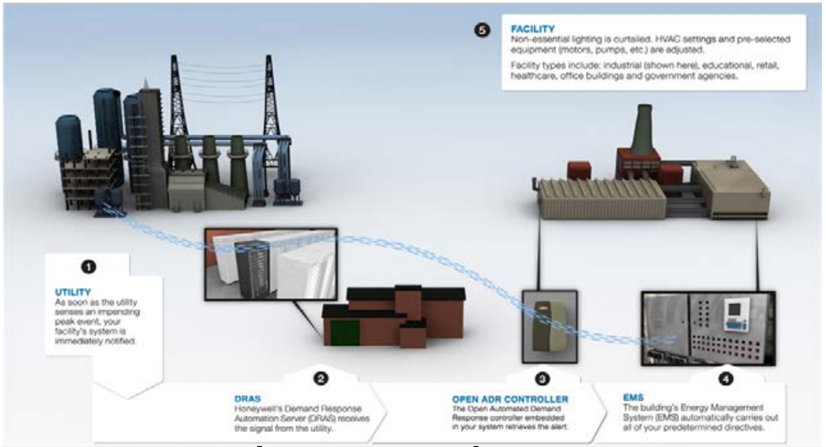


Source: www.discern.eu

Thames Valley Vision

Scottish and Southern Energy
Power Distribution

Understand	Anticipate	Support
Customer end-point monitors	Network Modelling Environment [Electric Office & Cymdist]	Automatic Demand Response
Substation monitors	Distribution Management System [Power On Fusion]	Electronics & Batteries
Smart Metering	Aggregation & Forecasting	Thermal storage (hot and cold)
Categorisation		Commercial Models
Listening		Smart Control



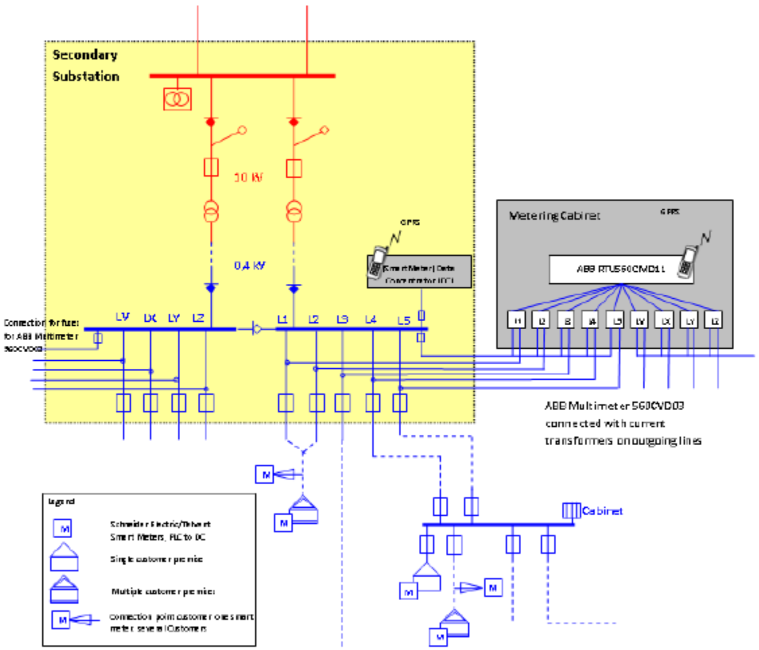
Automated Demand response

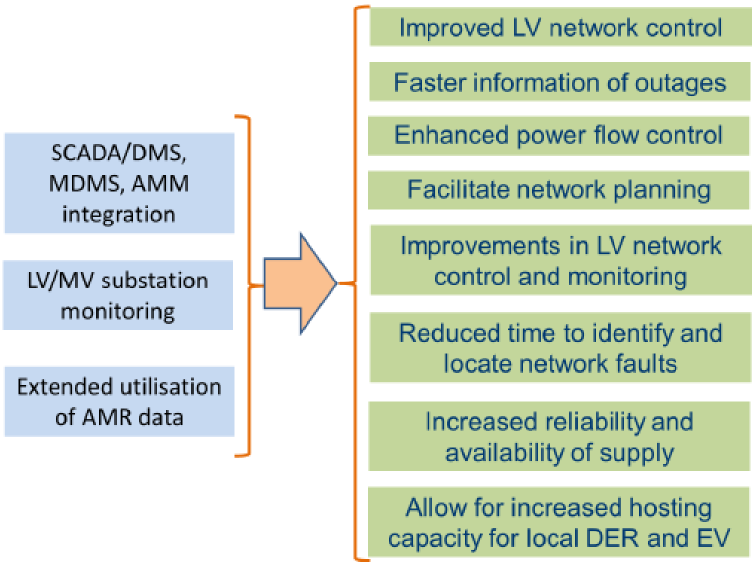
Comprehensive project to help the DNO to understand, anticipate and support changes in customer behaviour to develop an efficient network for the low-carbon economy?

Source: www.discern.eu

Low Voltage Observability

Combined LV station and AMR monitoring to provide increased observability.



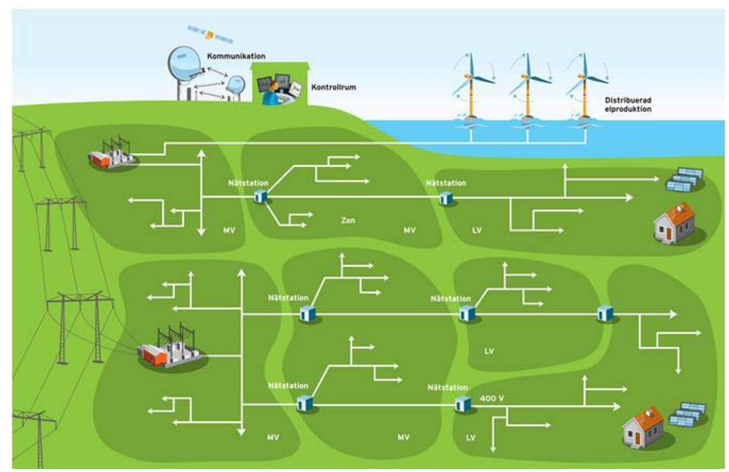


Smartgrids Gotland

- Maximise Wind utilisation, minimise export to mainland
- Consumer engagement via price incentives directly to smart devices

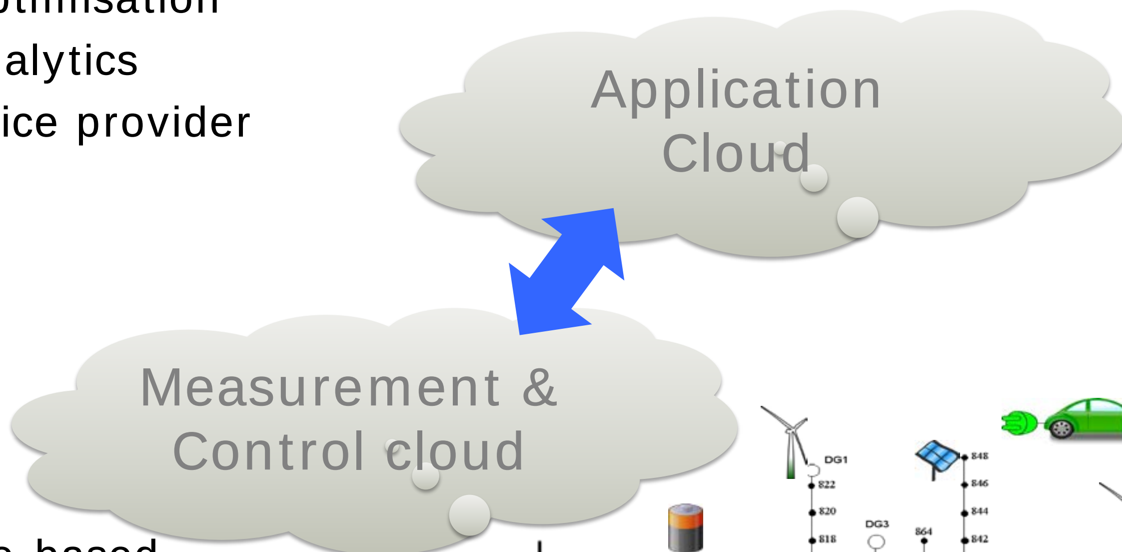
- Improve power quality
  (interruptions and voltage)

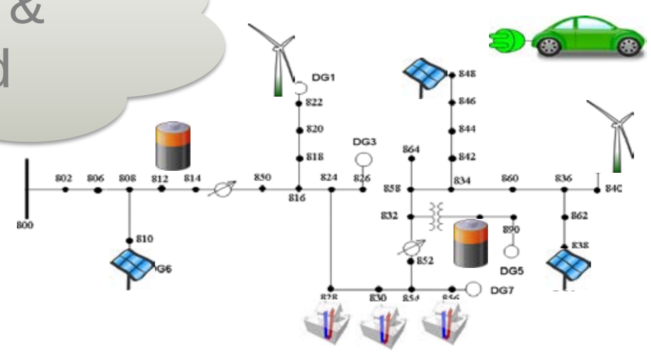
- Cost reductions at utility and minimised risk for QoS failure charges



In a not so far future....

- Control and optimisation
- Large scale analytics
- 3rd party service provider access.





- Open, yet secure role-based access to data
- Control functions ”on-demand” as ancillary services.

Like we are already seeing in other industries

Summary

The vision for a better more efficient society will always be there, the name we put on the way to get there may differ.

Keeping focus on the real problem is the only way to gain traction. Only real problems need to be solved.

The societal context for the problem solving is different now than it was 10 years ago, and will again be different in ten years

The Smartgrid hype has actually led to some real problems being adressed