

Virtual Power Plants: Fiction or Reality?

Lessons Learned and Challenges Ahead

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Topics

- Short history of the electrical power supply
- The electric power supply of tomorrow
- Future roles of the electric grid
- Technical challenges
- Current research

Two definitions

A renewable resource is an energy source that is regenerative or virtually inexhaustible.

PURPA (Public Utility Regulatory Policies Act, USA)

Distributed generation is an electric power source connected directly to the distribution network or on the customer side of the meter.

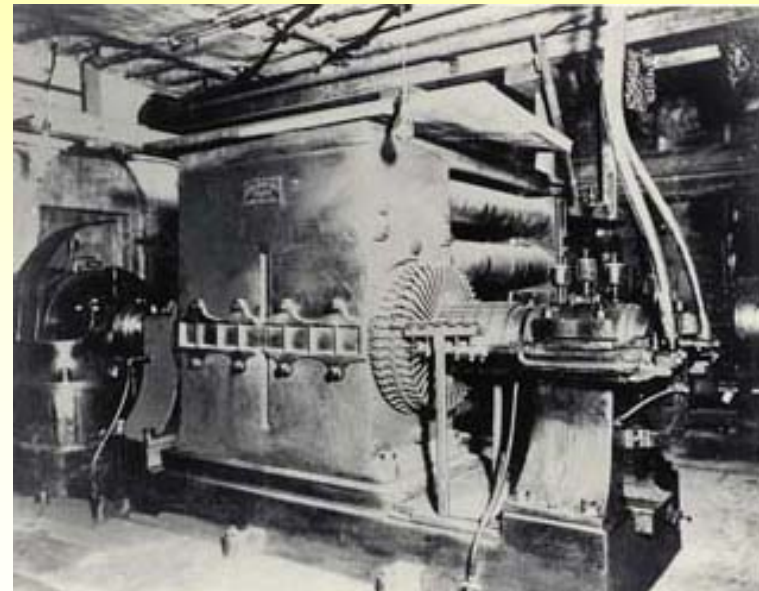
**Distributed generation: a definition; T. Ackermann,
G. Andersson, L. Söder, Electric Power Systems
Research 57 (2001) 195 - 204**

**The first electric power systems (1870 -1885)
were distributed !**

- Small hydropower plants (< 100 kW)**
- Thermal power plants (< 100 kW)**

**Pearl Street station, New York:
Edison Electric Illuminating Company (EEIC)
1882: $U = 115 \text{ V}$, 1200 bulbs
1888: 64 000 bulbs**

Pearl Street Station (1882 – 1890)



≈1885 began the development of large scale power grids

- Introduction of three phase AC

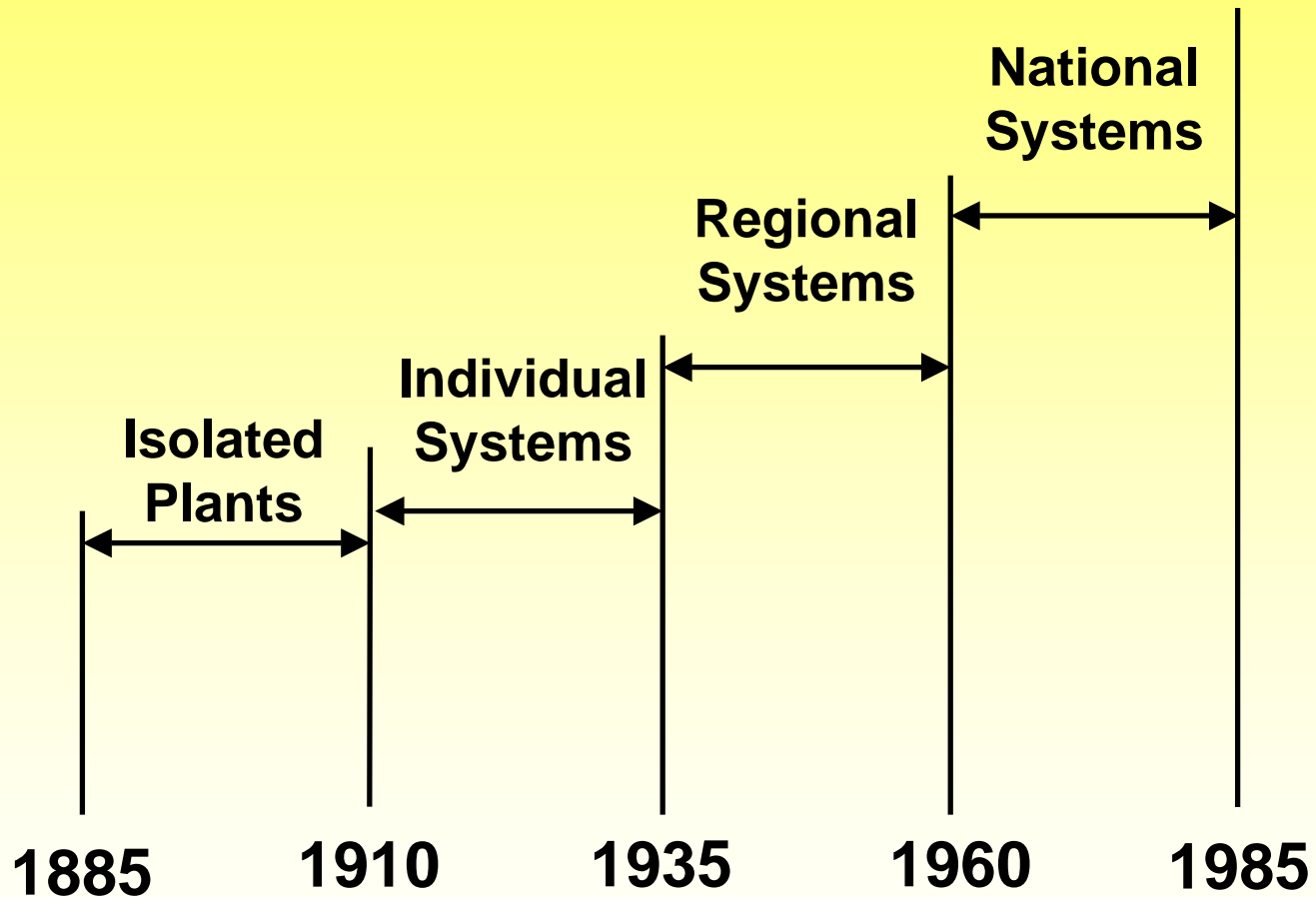
- Efficiency of thermal power < 10%



- Hydro power very competitive

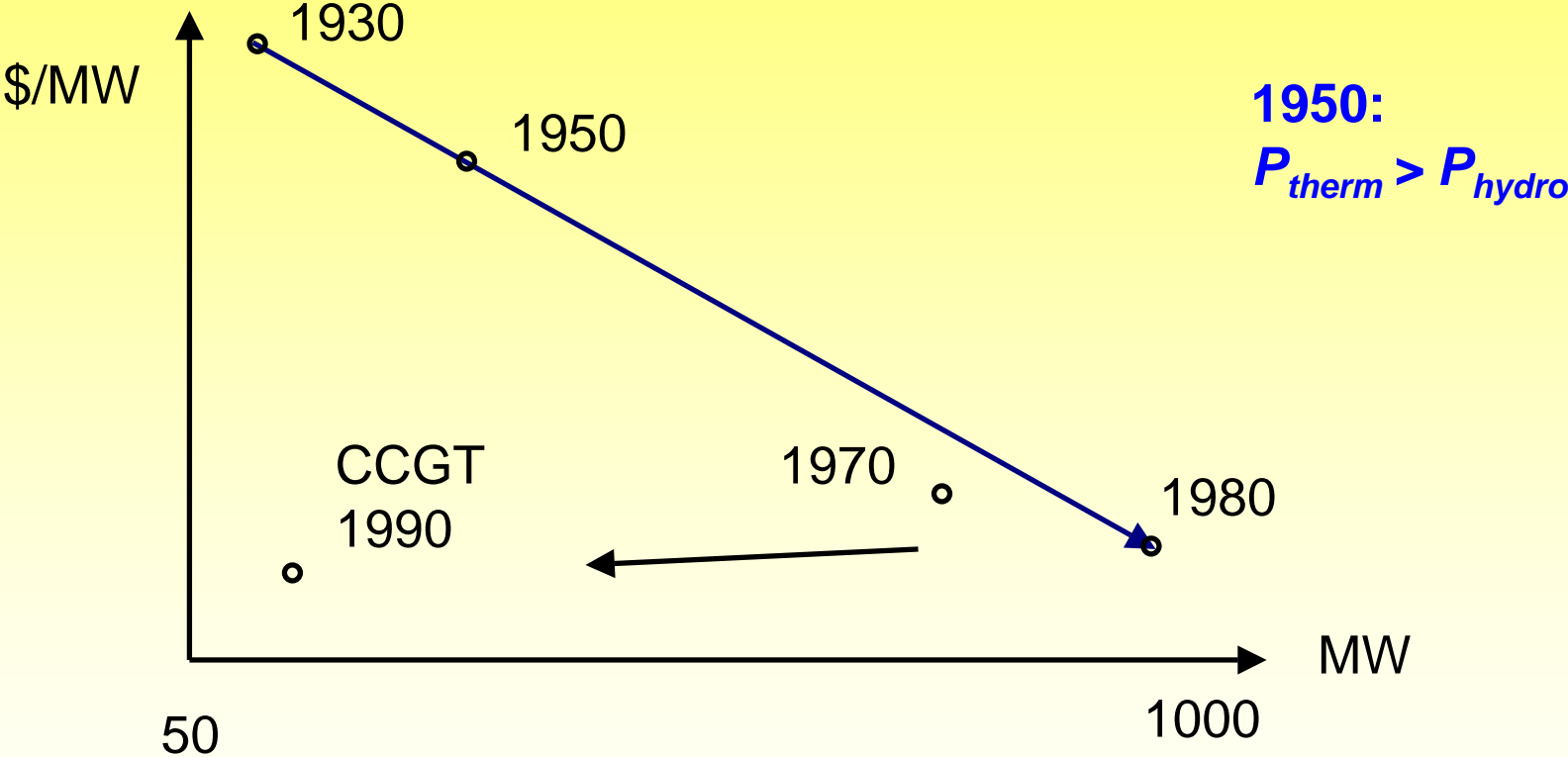
- Economy of scale

The development of the electric power grid



Economy of Scale

The optimal size of thermal power plants



The traditional tasks of the power grid

- Transmission of large power/energy quantities
- Optimisation of the operation
- Increase the reliability
- Offer redundancy
- Make a power market possible

The future electric power supply

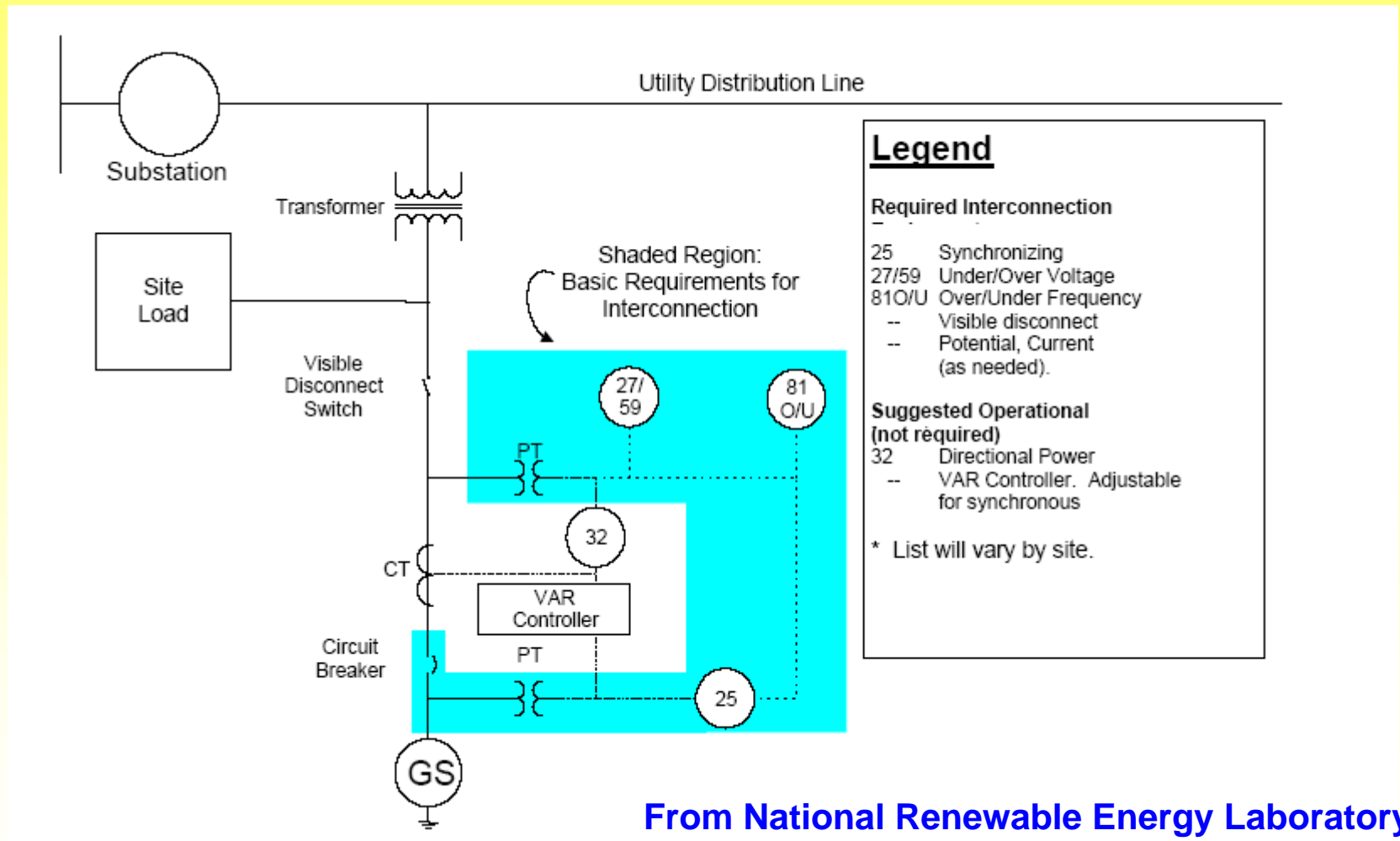
A scenario for Europe:

- 20% distributed generation ($P < 1\text{-}2\text{ MW}$)
- A substantial fraction of CHP (Combined Heat and Power)
- "Conventional" power plants

Note:

- Distributed generation often stochastic (non-dispatchable)
- CHP produce electricity **and** heat

Typical Interconnection of Distributed Generation



From National Renewable Energy Laboratory

**Walt Patterson in
*Going all the way; From distributed generation to
decentralized electricity:***

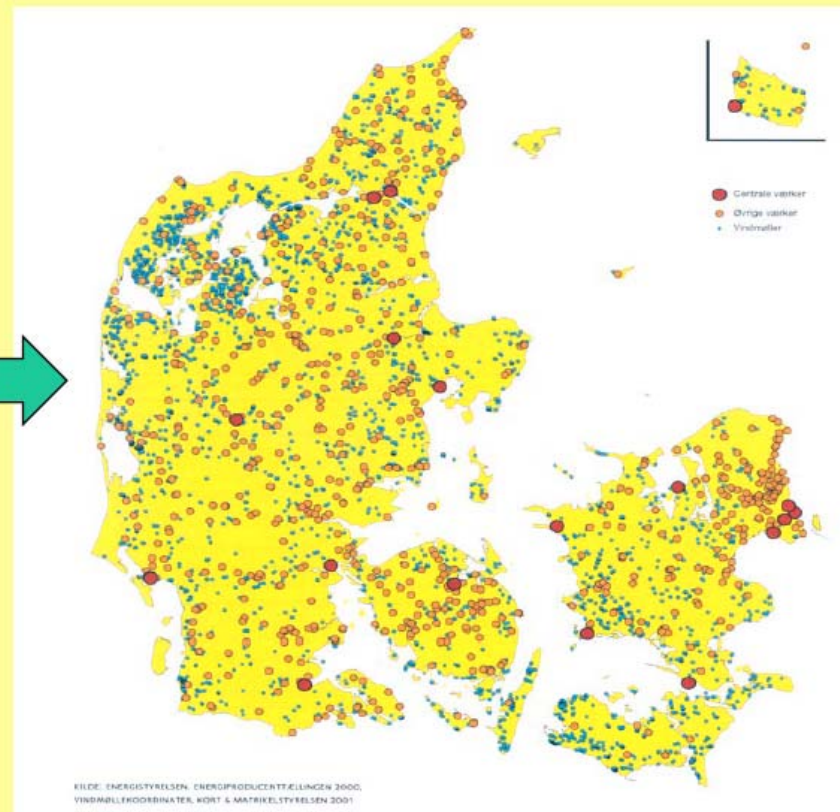
**”After more than 120 years, electricity may be
starting to come full circle.”**

Udviklingen fra 80'erne til 90'erne

Central produktion



Decentral produktion



The new tasks of the electric power grid

- Transmission of large power/energy quantities
- + Optimisation of the operation
- + Increase the reliability
- Offer redundancy
- + Make a power market possible

The virtual power plant

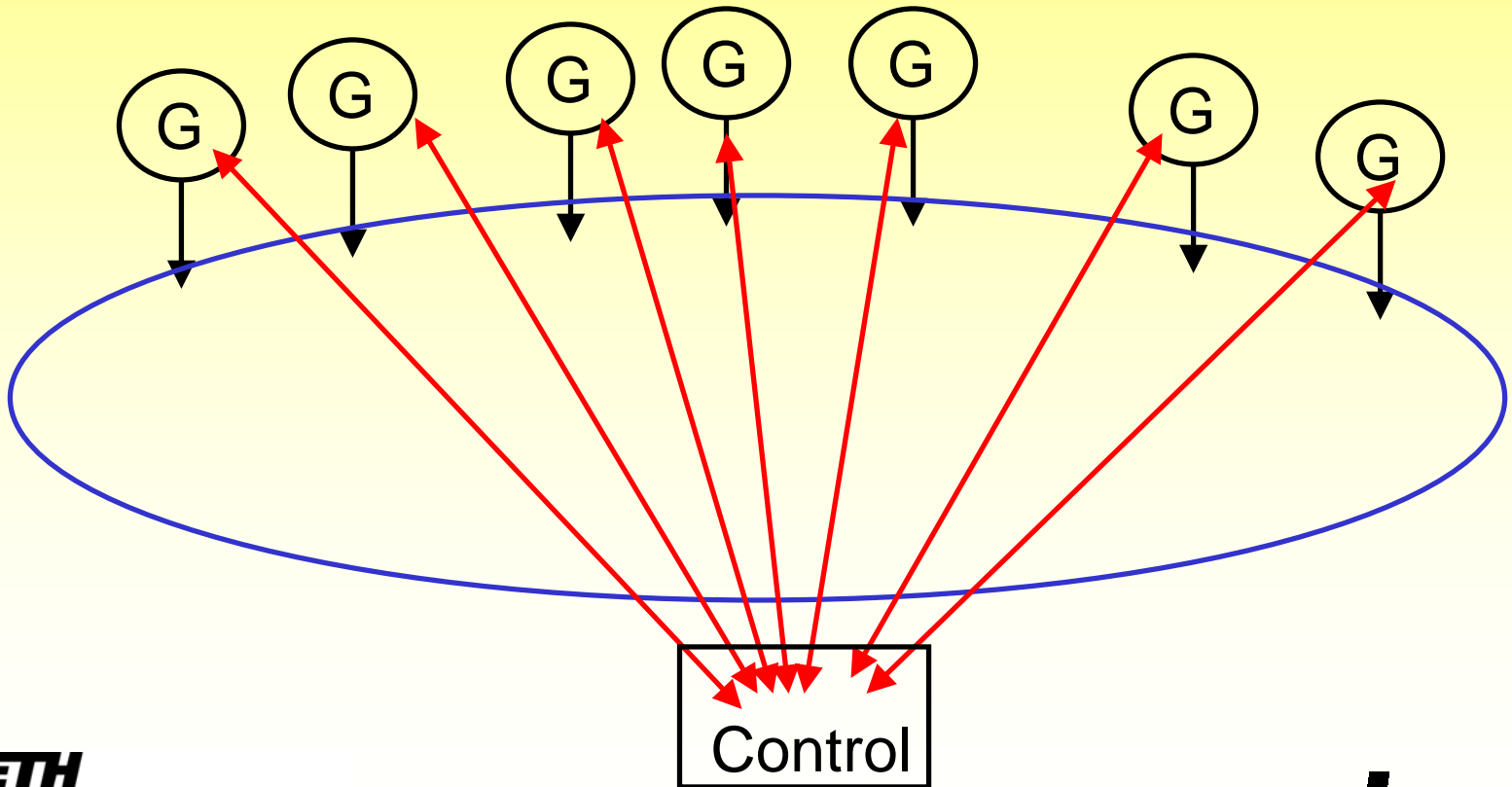
Many DG units are too small to provide value-added benefits to the electric power system.

Furthermore their outputs are stochastic

Solution:

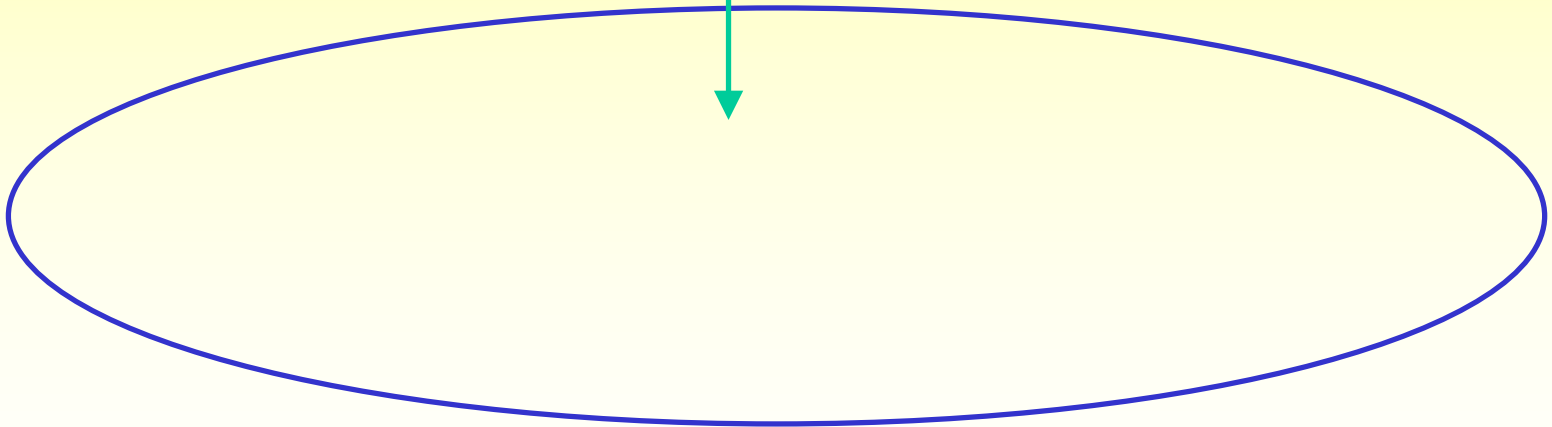
Network a number of small generators and control them to provide the equivalent of a multi-megawatt generator:

The Virtual Power Plant

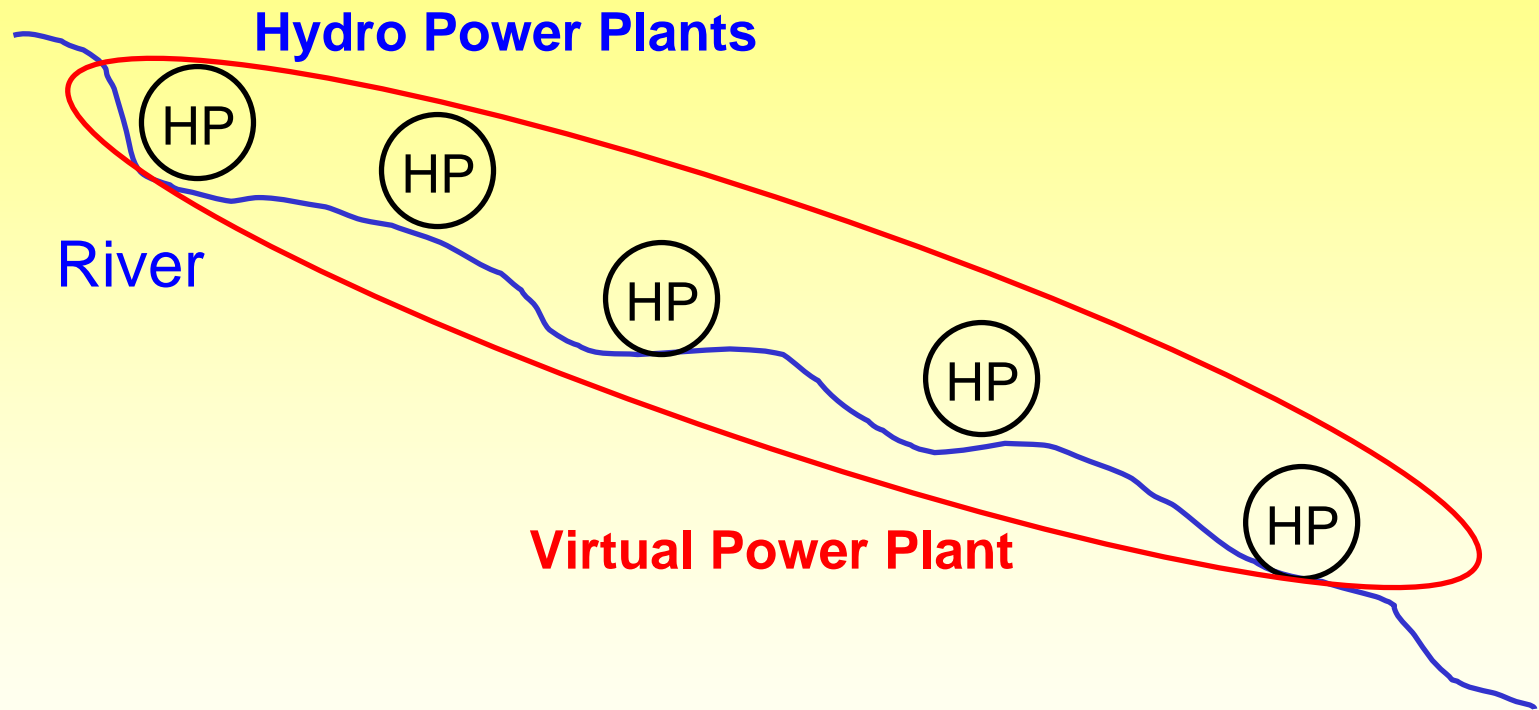




Virtual Power Plant



The Virtual Power Plant Concept is not new



The new challenges

- Different power sources to be coordinated (solar, wind, ...)
- Sizes of power sources might vary considerably
- Communication needs to be fast and reliable
- Different stakeholders need to be integrated

The prospects

The virtual power plant concept is an attractive way
to make distributed generation competitive

Thank You!

ETH

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eeh *power systems*
laboratory