GEOELEC training course Strasburg

Session VII: Plant operation, energy supply and grid integration

Grid Integration of an Increasing Share of Renewable Power Generation

Geothermal Power

Challenges for Network and System Operation-

Name: Dr.-Ing. Franz Heilemann

Organisation: EnBW Regional AG, Germany

Strasburg, 8th November 2012

Supported by INTELLIGENT ENERGY EUROPE

Grid Integration of an Increasing Share of Renewable Power Generation

- Geothermal Power: Challenges for Network and System Operation-

Aims, Developments and Expectations of RES

Challenges for Network and System Operation

Smart Tools and Smart Grids

Geothermal Power Plant Connection

Procedure, Checklists and Costs

Results/Summary and Outlook

GEOELEC Training Course Strasbourg
5.- 9. Nov. 2012

Dr.-Ing. Franz Heilemann
EnBW Regional AG

Brief portrait
EnBW Energie Baden-Württemberg AG

- One of the largest energy companies in Germany and Europe
- Business segments:
  electricity generation and trading, electricity grid and sales, gas, energy and environmental services
- Annual revenue 2011: in excess of € 18 billion
- Customers: some 5,5 million
- employees: some 20,000

Some figures of EnBW Regional AG

Status December 2011

Network customers		Mil.	2,95
Employees			3,283
High voltage network	(110 kV)	km	7,620
Medium voltage network	(30/2010 kV)	km	30,200
Low voltage network	(0,4 kV)	km	66,700
Transformer stations			329
Network stations (own)			26,500
Surface of network area		km^2	18,800

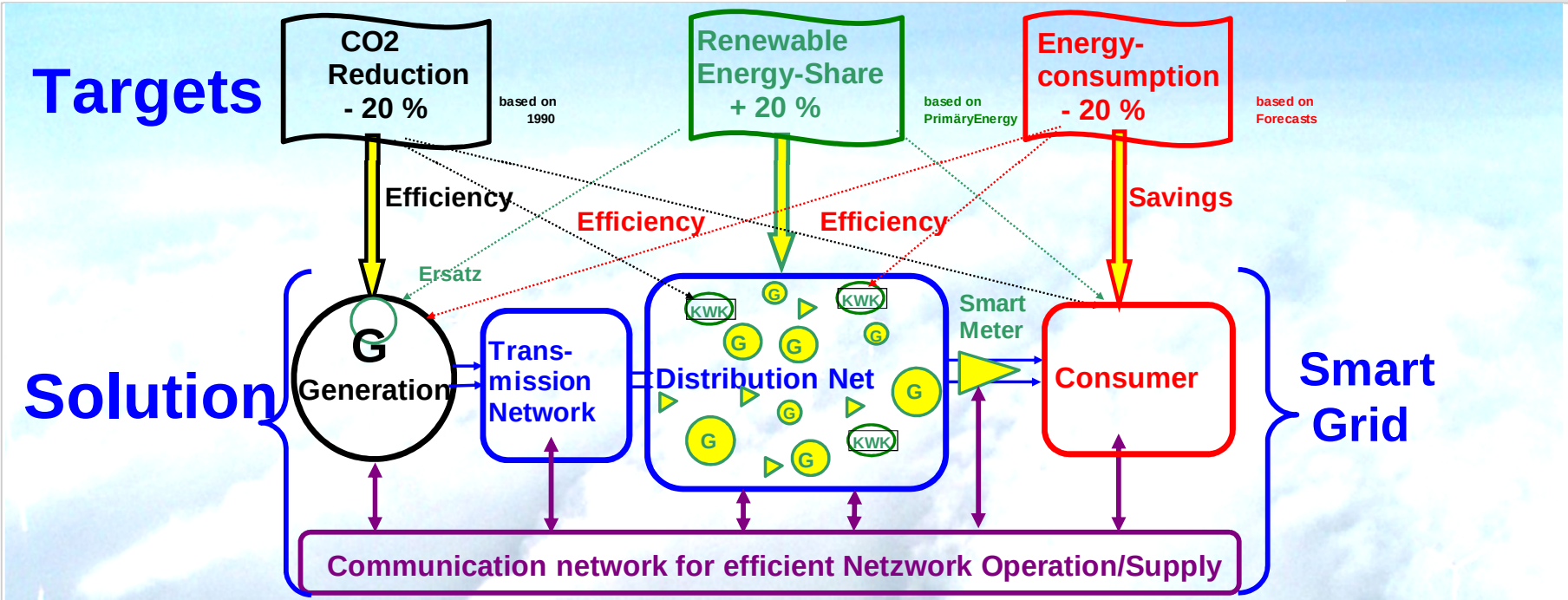
Framework conditions for power system development

The Measure of all Things

The 20-20-20 Energy and Climate Targets of the EU for 2020

The Ambitions for 2050

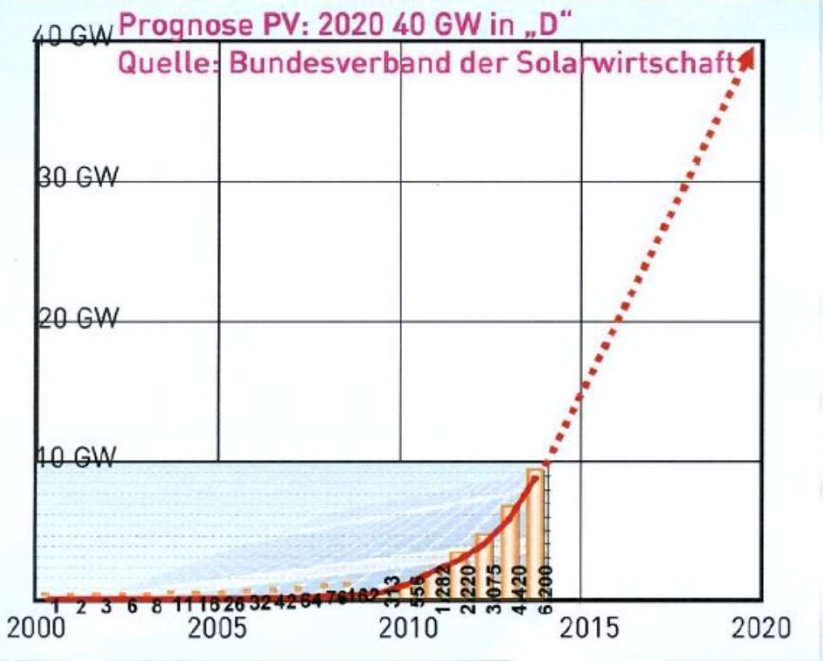
The EU 20-20-20 energy- and climate targets for 2020
The evolution of networks: Smart Grids

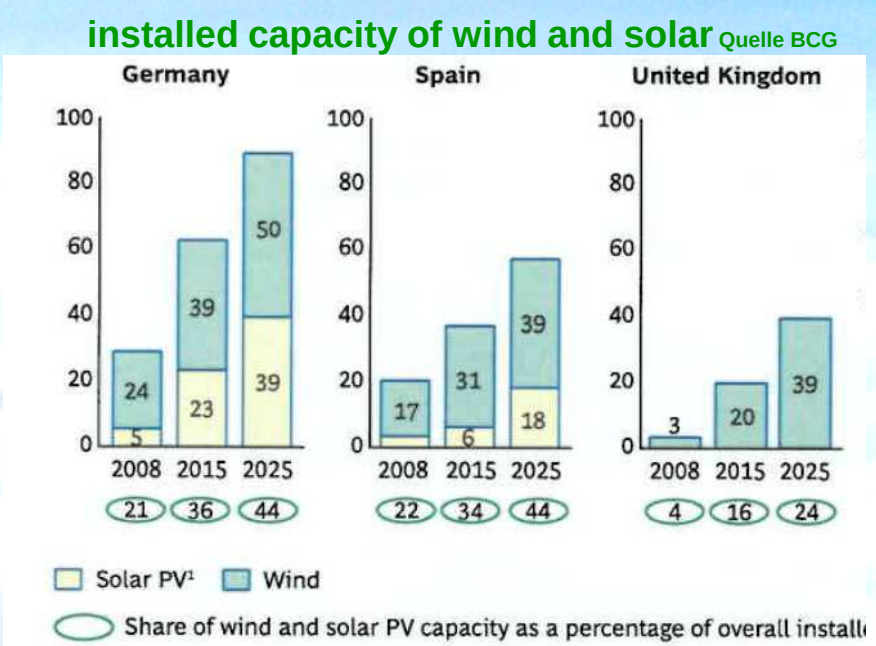


Challenge 35 % generation from RES in Germany

„In this new World, it may not be economically feasible to operate the system as it is done today. Significantly more system monitoring and intelligent control will need to be introduced to securely meet the demand for energy with the optimum level of generation and network capacity. This will be achieved by the evolution of electricity networks: in short: Smart Grids“ (ERGEG)

Rapid installation of renewable generation
Lucrative promotial concepts





Renewable generation 2020
ca. 70.000 MW

⟺

Current peak load in Germany
ca. 80.000 MW !!

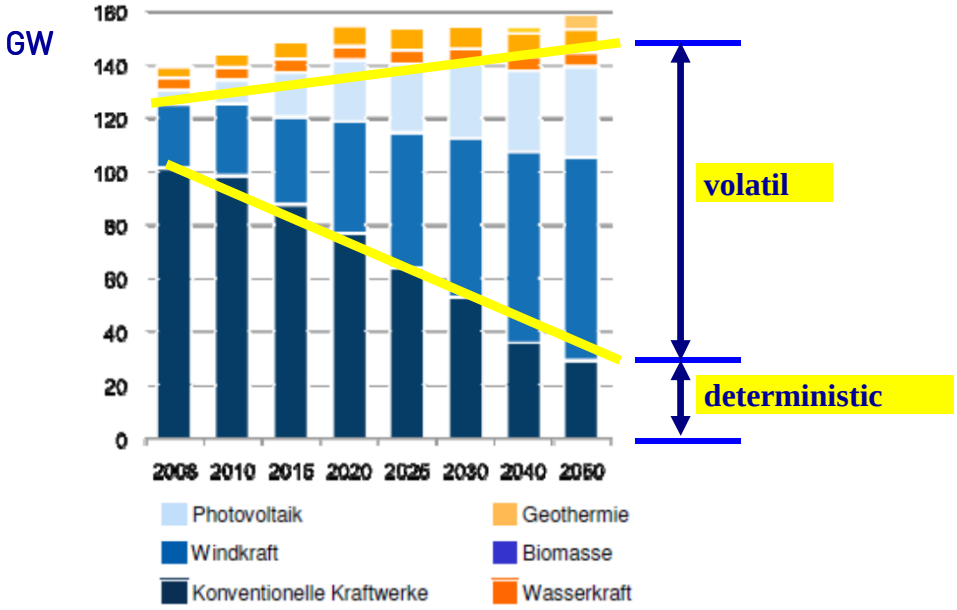
!!

➔ **Substantial network problems (P, Q, U, f) (locally, regionally, holistically)**

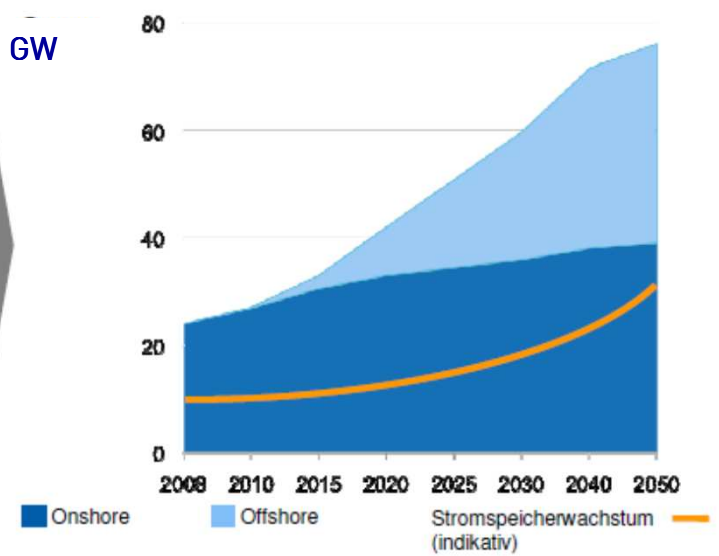
➔ **Network related load-/feed-in management for cost efficient network operation is indispensible !**

Changing the dynamic control capability of generation
Redeployment from transmission- to the distribution network

Development of installed capacity in Germany
Reference szenario of the BMU



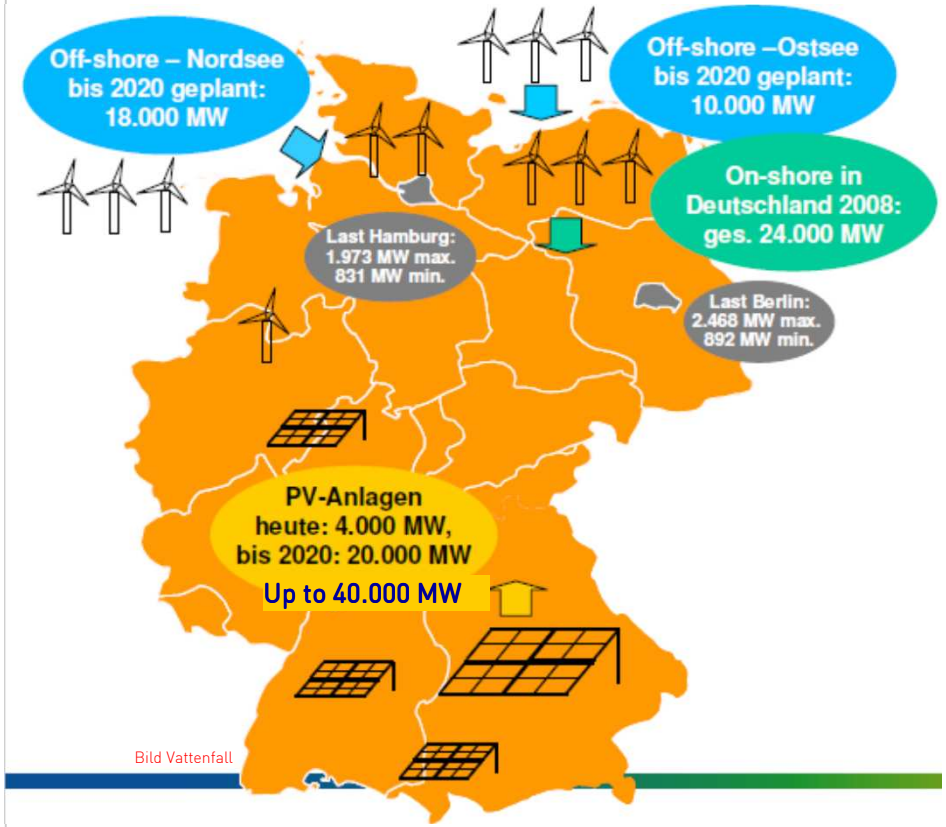
Development of installed wind power



The contribution of generating units in the distribution network for the control will have to increase substantially

- **Frequency-Load Control**
- **Primäry control, loss of inertia of the system/network needs to be compensated**
- **Mastery of faults (fault ride through)**
- **Voltage control**
- **Integration of storages (medium-term and long-term)**

Increase of generation
Determinants for the Networks
The North-South Bottleneck



Wind Power
- already today critical network situations
- Massive expansion of off-shore plants in the North of Germany repowering of excisting plants
- In-feed direction: from high voltage to medium /low voltage

Solar Power
- Massive expansion of PV-plants in the South of Germany
- In-feed direction: from low votage level to high voltage level

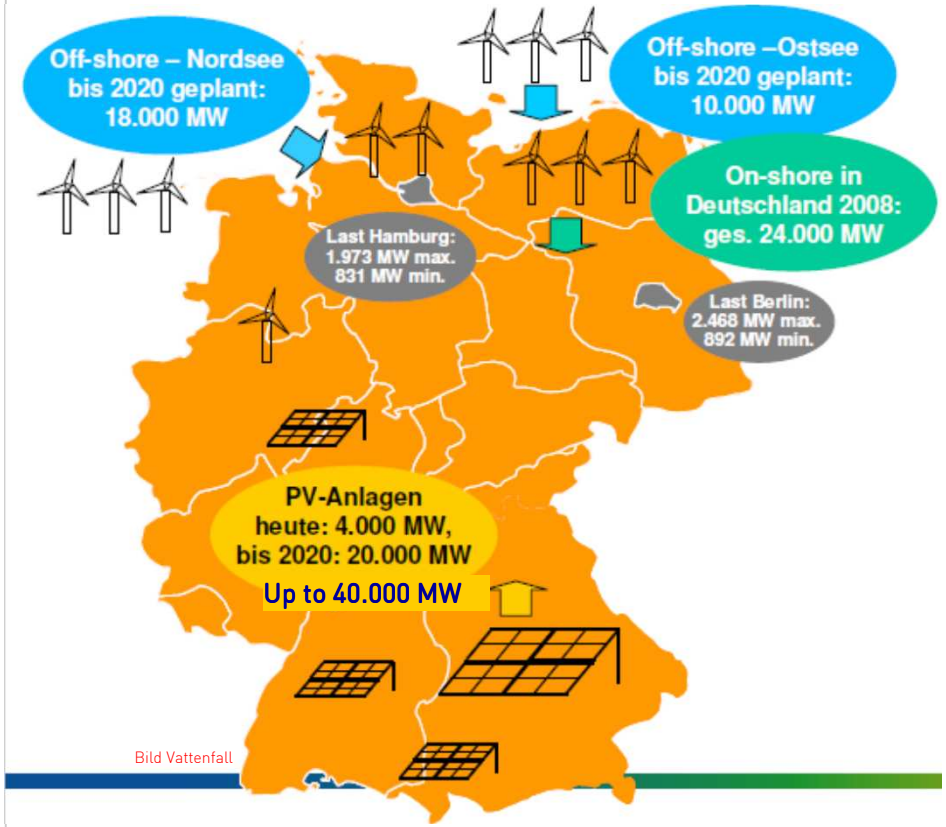
Bottleneck

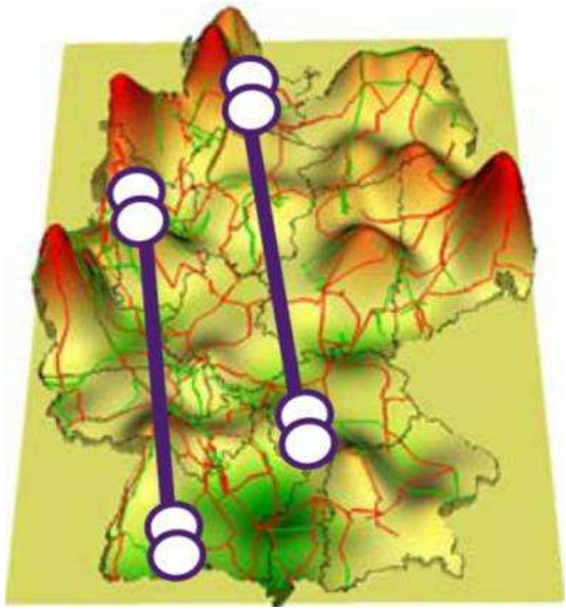
North-South

Overlay grid?

Congestion Management: 2 Trading Zones ?

Increase of generation
Determinants for the Networks
The North-South Bottleneck





Bottleneck

North-South

Overlay grid? **Congestion Management: 2 Trading Zones ?**

Increase of generation
Determinants for the Networks
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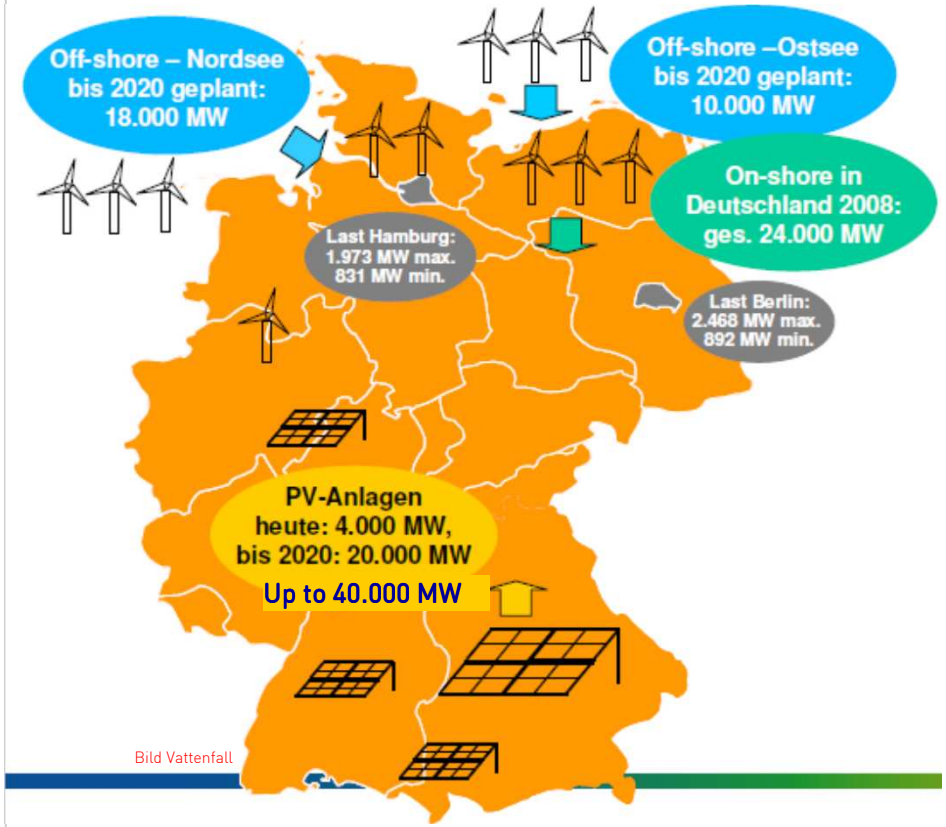


dena network study II

a) 3.600 km 380 kV of lines
10 Mrd. €
0,2-0,5 Ct / kWh (High Voltage)

b) 1.700 +(5.700) km 380 kV
high temperatur Ropes
17 Mrd. €

c) 3.400 km HGÜ
22-29 Mrd. €

Approvals ? , t= ? …….

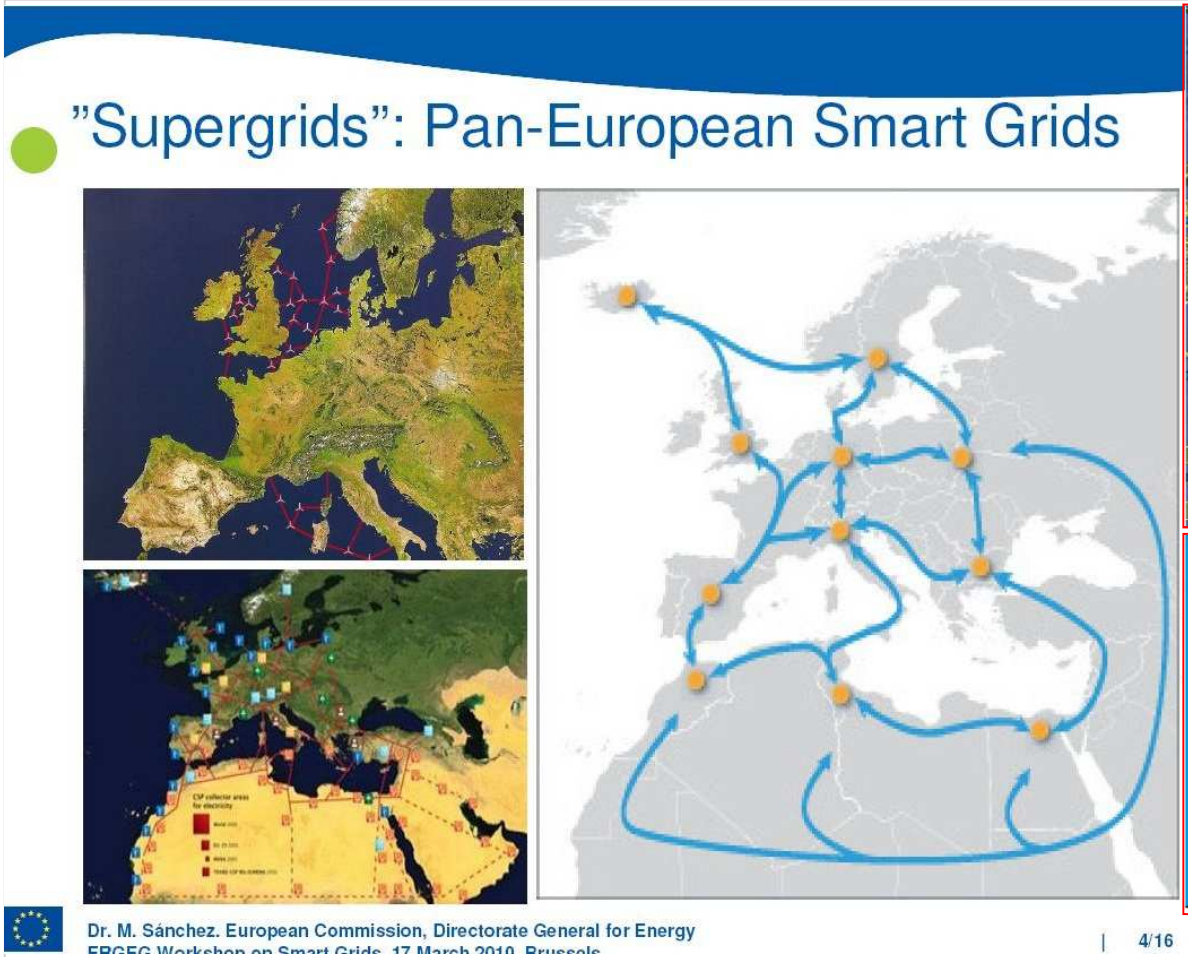
Bottleneck

North-South

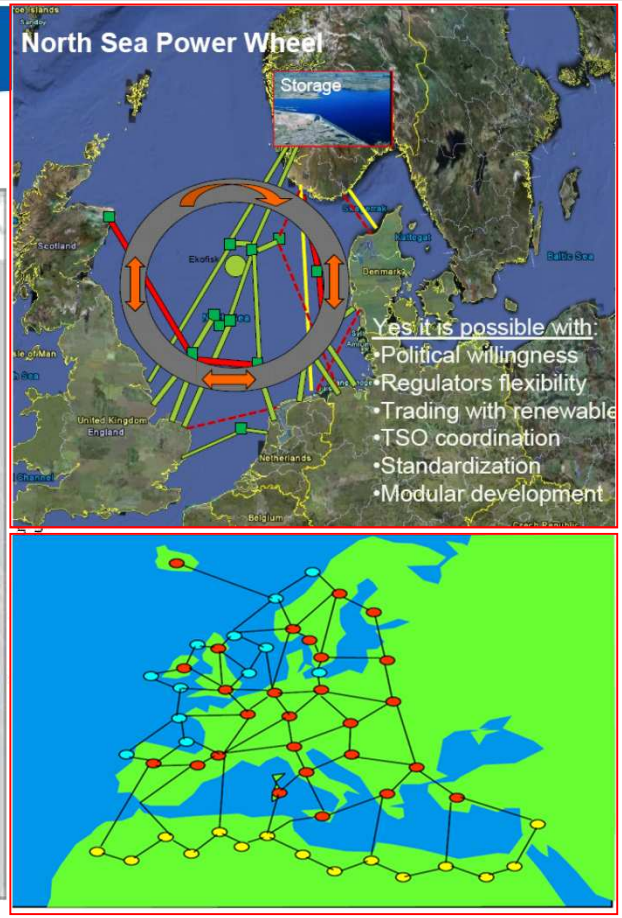
Overlay grid?

Congestion Management: 2 Trading Zones ?

2020 was the beginning! Stepwise towards the supergrid
2050 80 % from renewable energy is targeted
Dessertec und Seatech inspire the phantasie



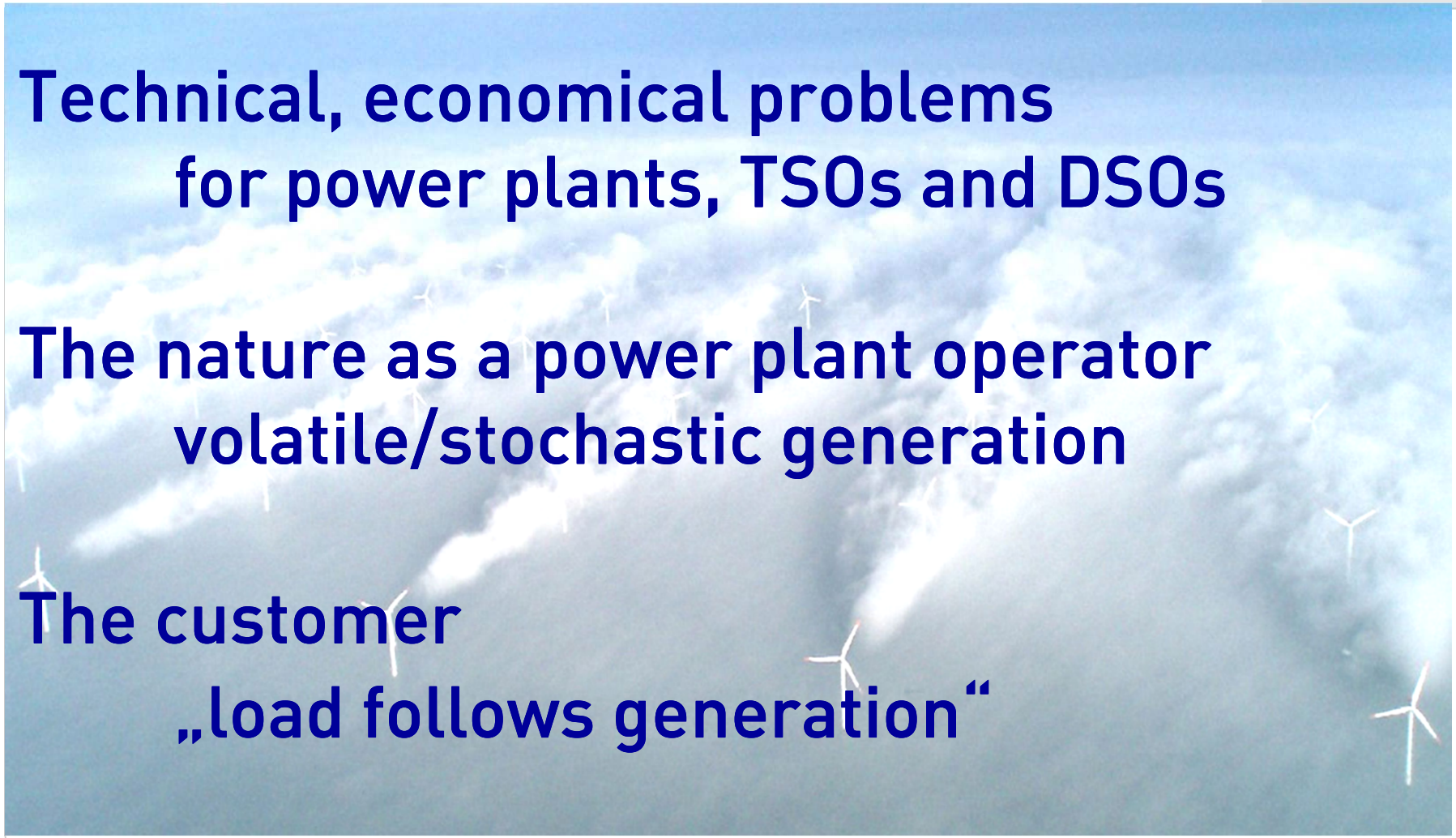
Coordinated planning of new transmission capacities of the TSOs



15% from the dessert

The future has already begun
EnBW with Baltic I as a pionier
Off-shore hot spot Nord Sea and Baltic Sea

Baltic I	**48 MW**	**21 wind turbines**	**2010**
Baltic II	**288 MW**	**80 wind turbines**	**2013**
Others are in planning/construction			**…….**
Sum		**10.000 MW**	**2020 (total for planning horizon)**


Technical, economical problems
for power plants, TSOs and DSOs
The nature as a power plant operator
volatile/stochastic generation
The customer
„load follows generation“

Problems for the Distribution System Operator
What must be mastered?

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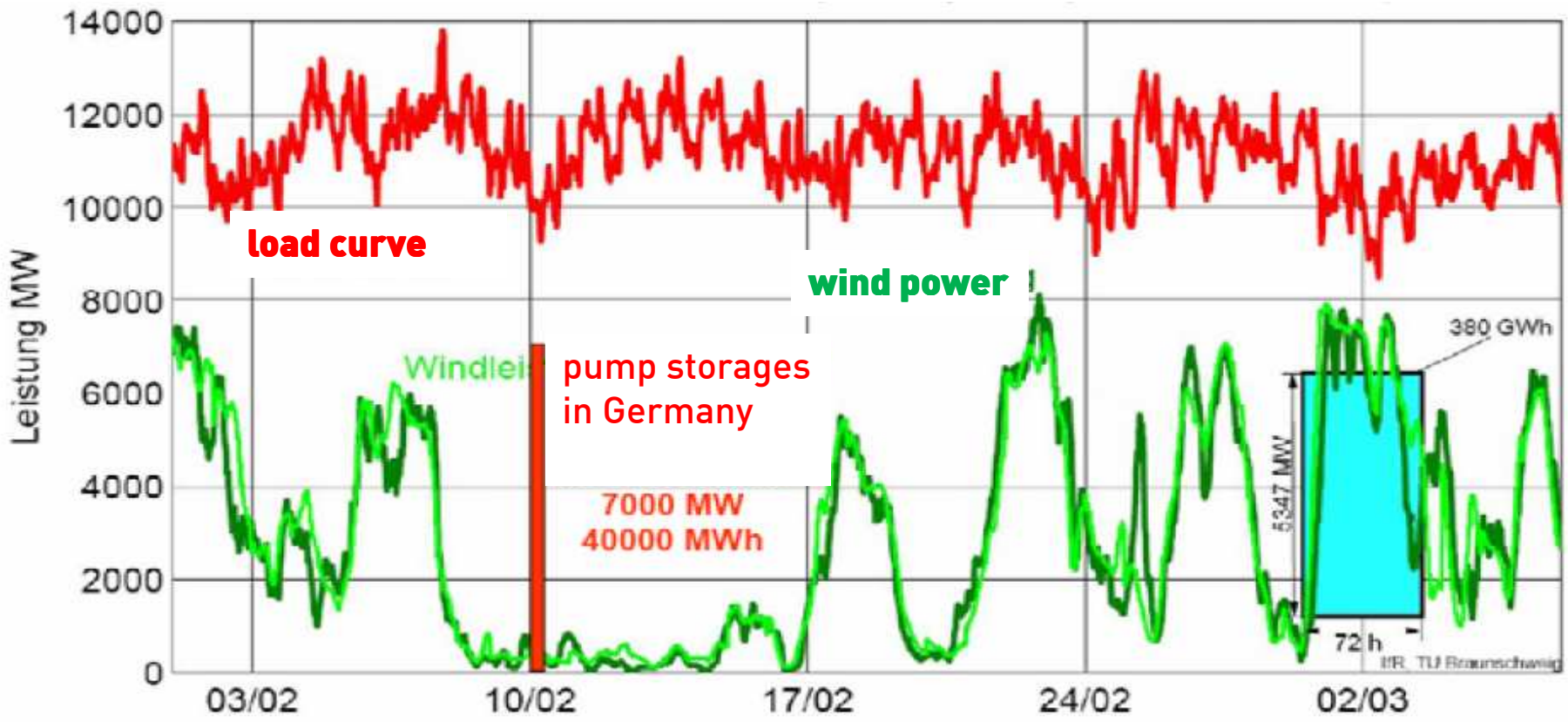
Enormous increas of RES in 2020 ca. 80% of today‘s peak performance !
Extremely higt volatility/intermittency of the generation

Substantial network problems (P, Q, U and f), (locally, regionally, holistically)



Problems for the Distribution System Operator
What must be mastered?

Enormous increas of RES in 2020 ca. 80% of today's peak performance !
Extremely higt volatility/intermittency of the generation

Substantial network problems (P, Q, U and f), (locally, regionally, most early)

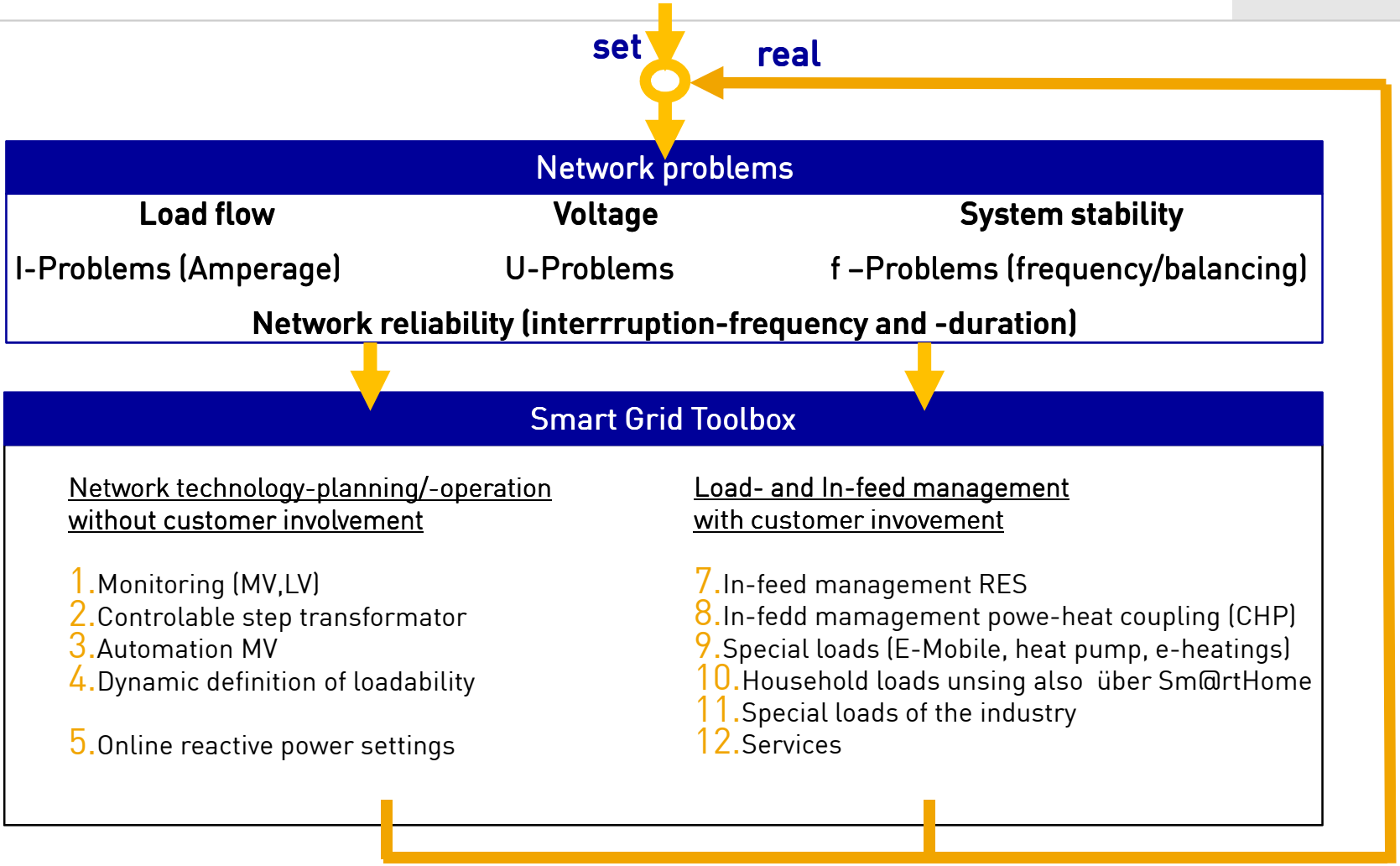
TSO ==➔ „Load Leveling“ / “Balancing“ ➔ Net-/system stability
reinforcement of transmission system

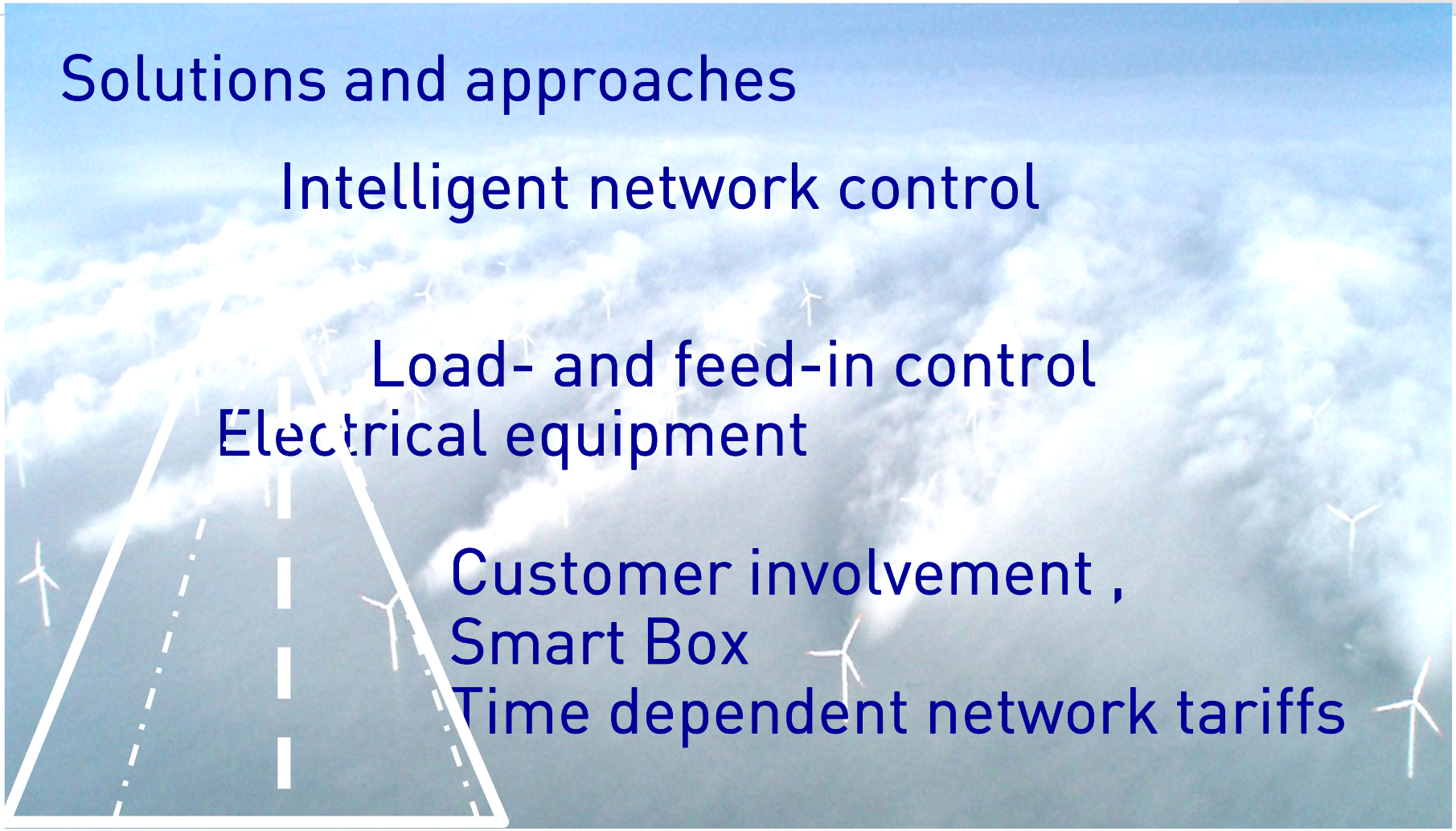
DSO ==➔ „Peak Shaving ➔ (Load flow, Voltage
network related preventive coordinated Customer Supply,
load- and in-feed management
costefficient network operation
automation of network, network expanson

Regulatory Framework
==➔Recognition of the DSO costs/ invests
==➔ requirement for an investment-friendly climat

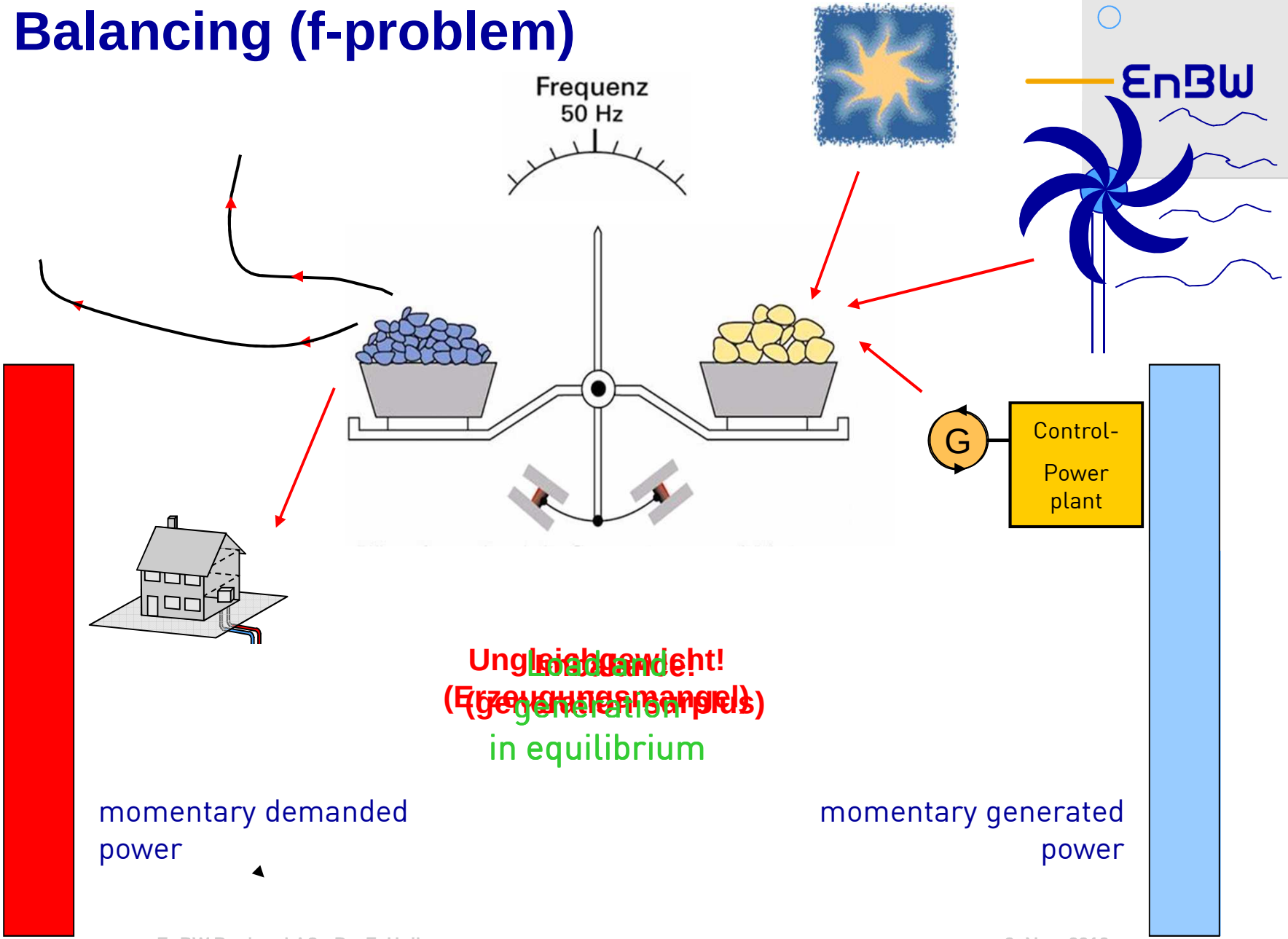
Invest EU-wide up to 2020
1,000 Bill. Euro
500 Bill. Generation
100 Bill. Transmission
400 Bill. Distribution

Control loop to efficiently solve network economic and network technical problems Overview of the Smart Grid Aaproaches



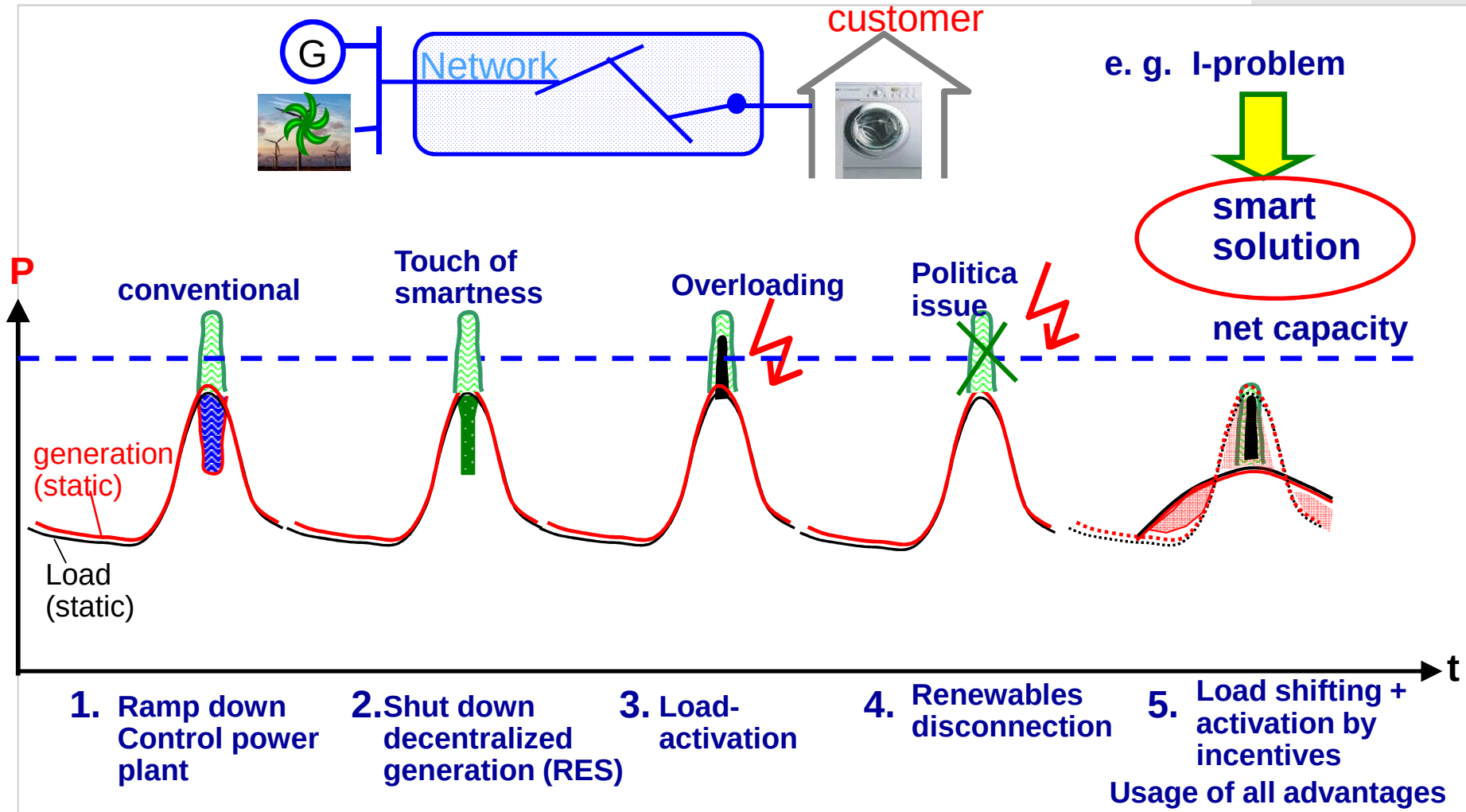

Solutions and approaches
Intelligent network control
Load- and feed-in control
Electrical equipment
Customer involvement ,
Smart Box
Time dependent network tariffs

Balancing (f-problem)

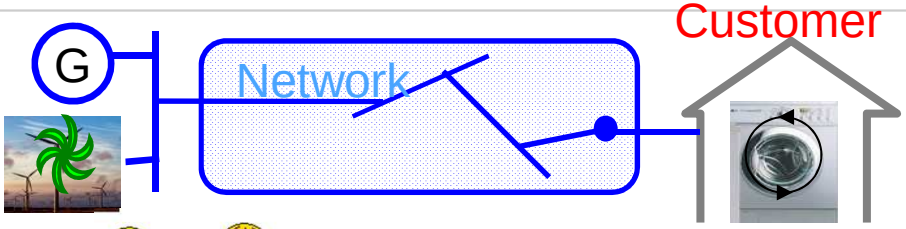


Unbalance!
(Erzeugungsmangel)
in equilibrium

Intelligent, preventive and netzwork-related load-/in-feed management
Options for costefficient network operation

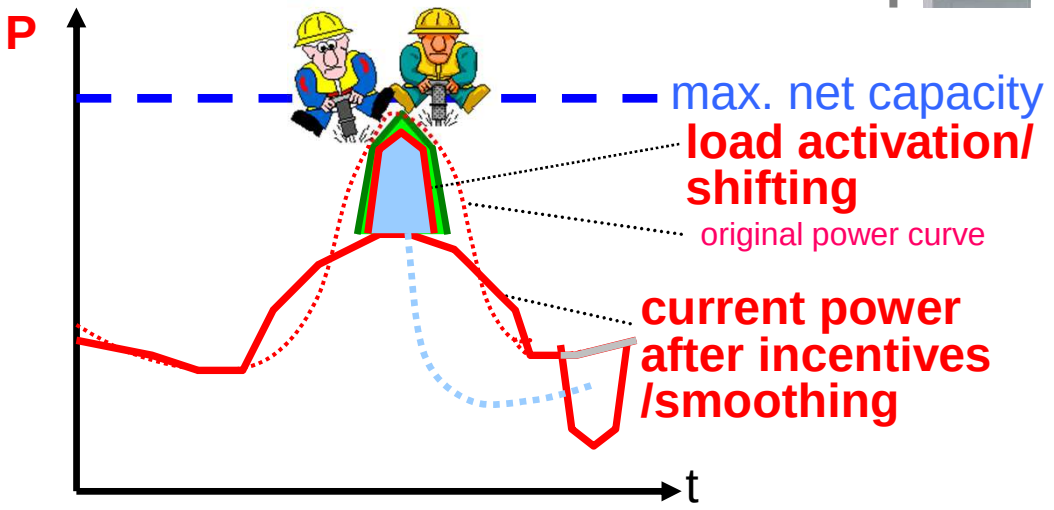


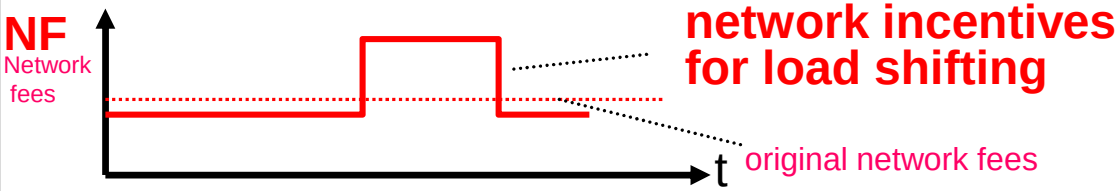
Intelligent, preventive and network-related load management
Load follows generation (paradigm change)



e.g. I-Problem

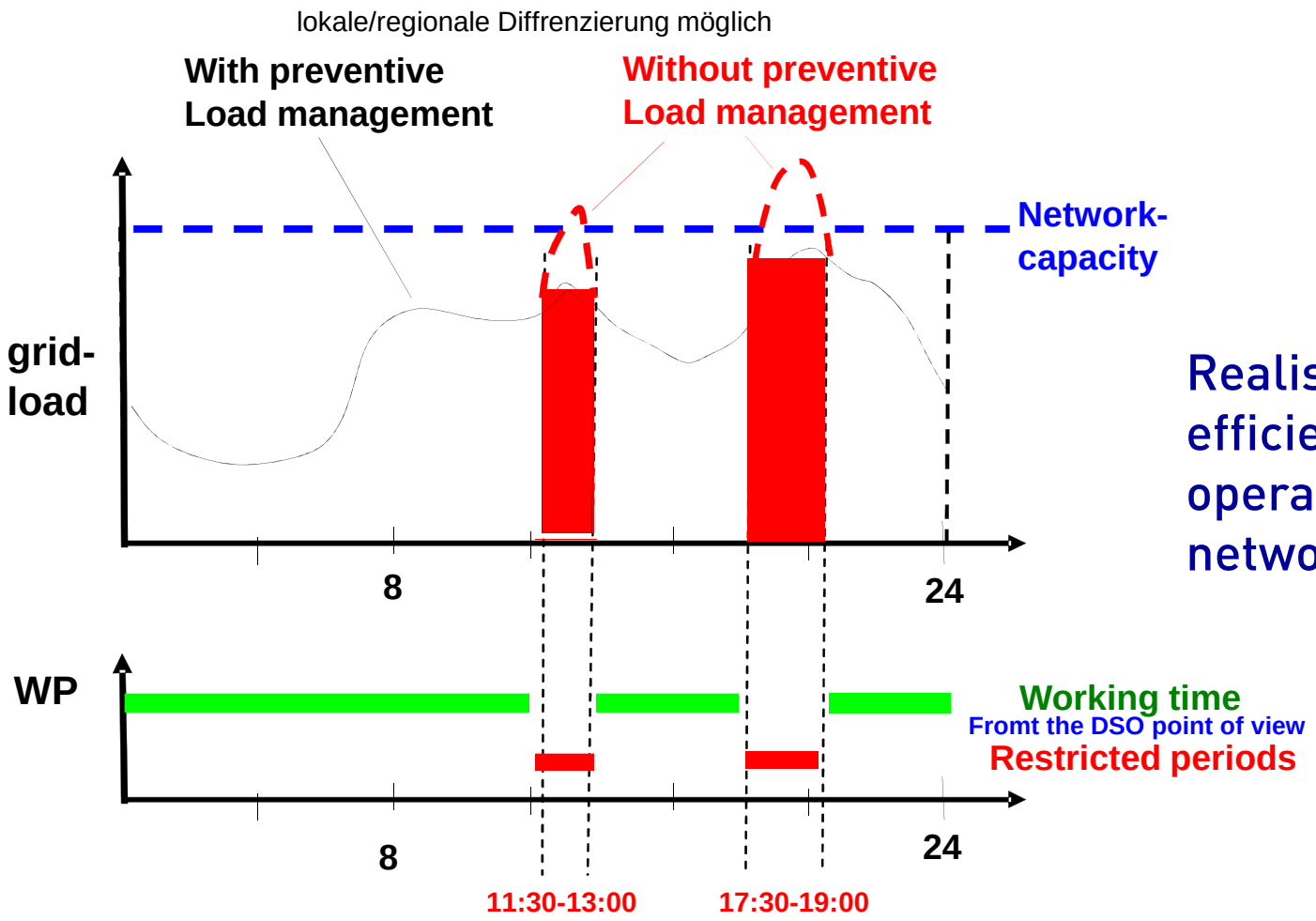
Satisfaction





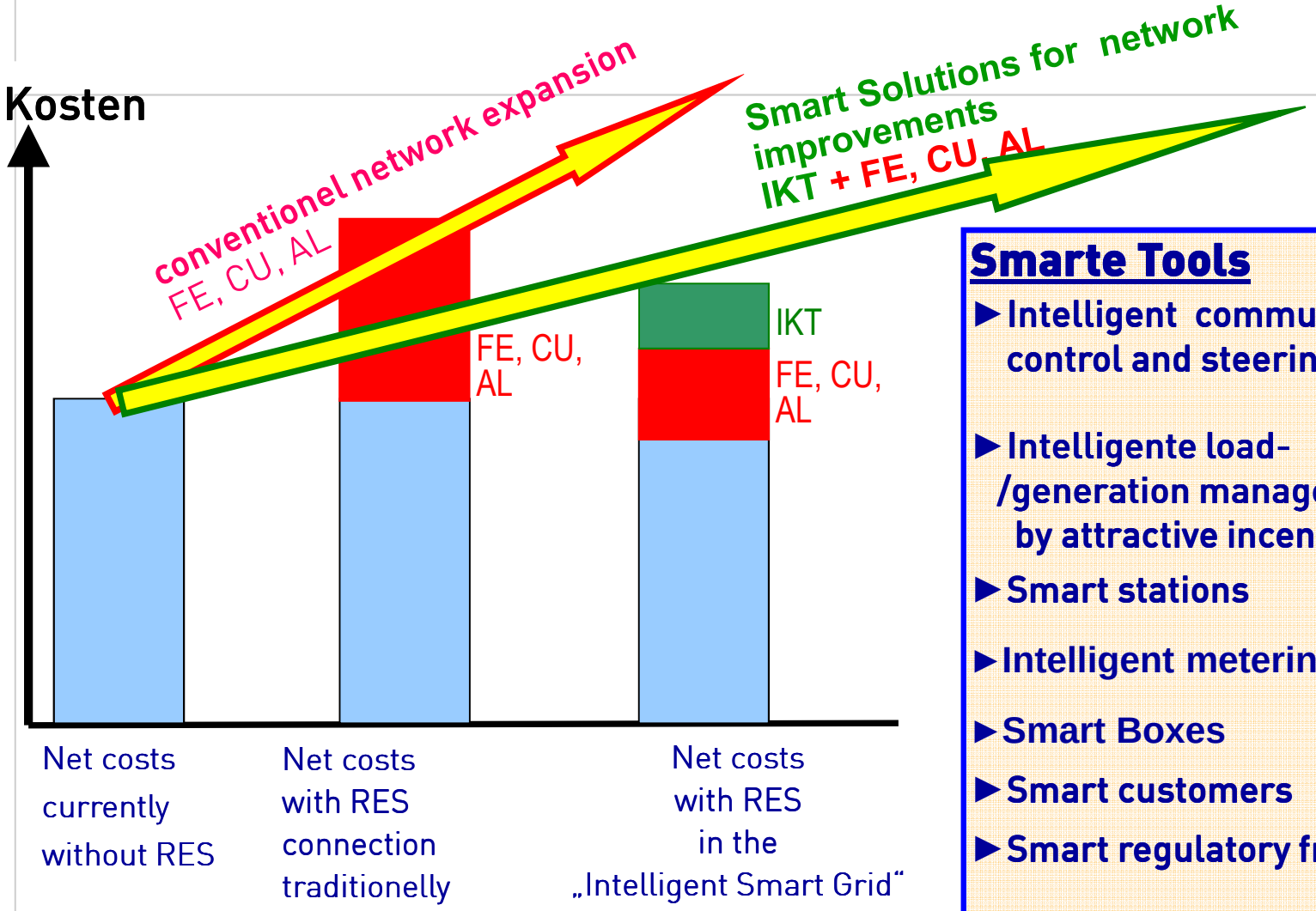
- Cost efficient smart and economic network operation
- Preventiv Load management
- Priority feed-in for RES
- Usage of RES by load activation
- Preventiv net expansion
- Preventiv control power

Incentives for network friendly/related load management e. g. Heat pump (by the DSO) by means of release and cut-off times



Realisation of a cost efficient network operation and network expansion

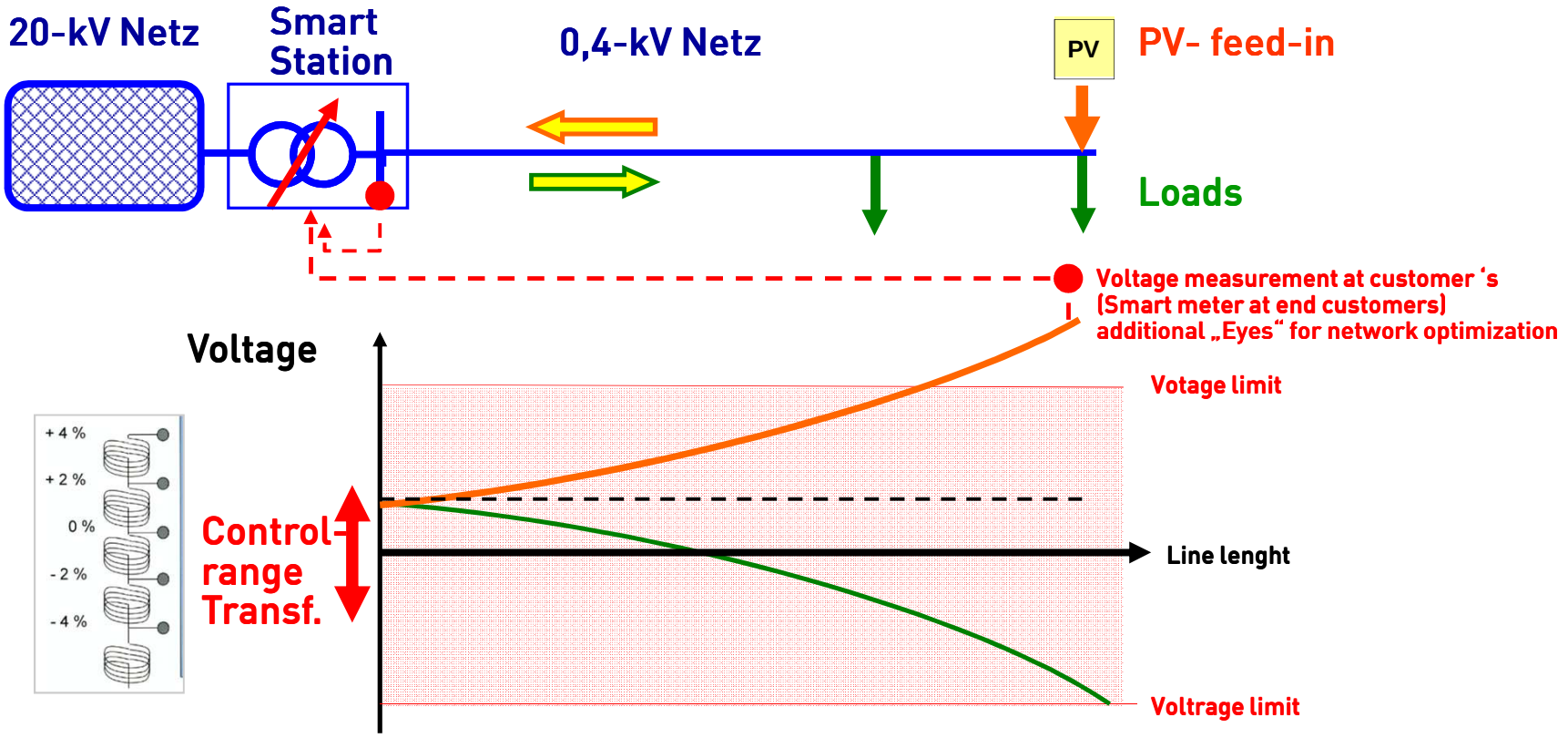
Smart grids may mitigate the cost increas of the integration of renewable energy sources.



Smarte Tools

- Intelligent communikation-, control and steering technology
- Intelligente load-/generation management by attractive incentives
- Smart stations
- Intelligent metering systems
- Smart Boxes
- Smart customers
- Smart regulatory framework

Smart Station (I) , controllable step transformers
Avoidance/postponement of net and line constructions
Dynamic voltage control: Voltage problem (U-problem)



Smart Station (II)
Avoidance/postponement of net and line constructions
Dynamic load control

20-kV Netz

Smart Station

0,4-kV Netz

z.B. warm-water

PV

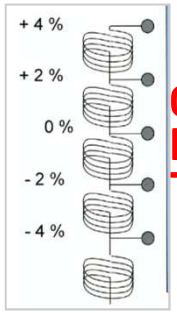
PV-feed-in

Loads

Voltage measurement at the costomer 's (Smart meter at end customer additional „Eyes" for network optimization

Voltage

Voltage limit



Control Range Transf.

Line lenght

Voltage limit

Smart Station (III)
Aditional features and advantages

Measured data for network monitoring and state estimation

➔ Advantage for planning, steering ad asset management

- Loading control/monitoring of the equipment

  ➔Protection and optimal use of assets (lines, transformers, network configuration)

- Data hub for smart meter data

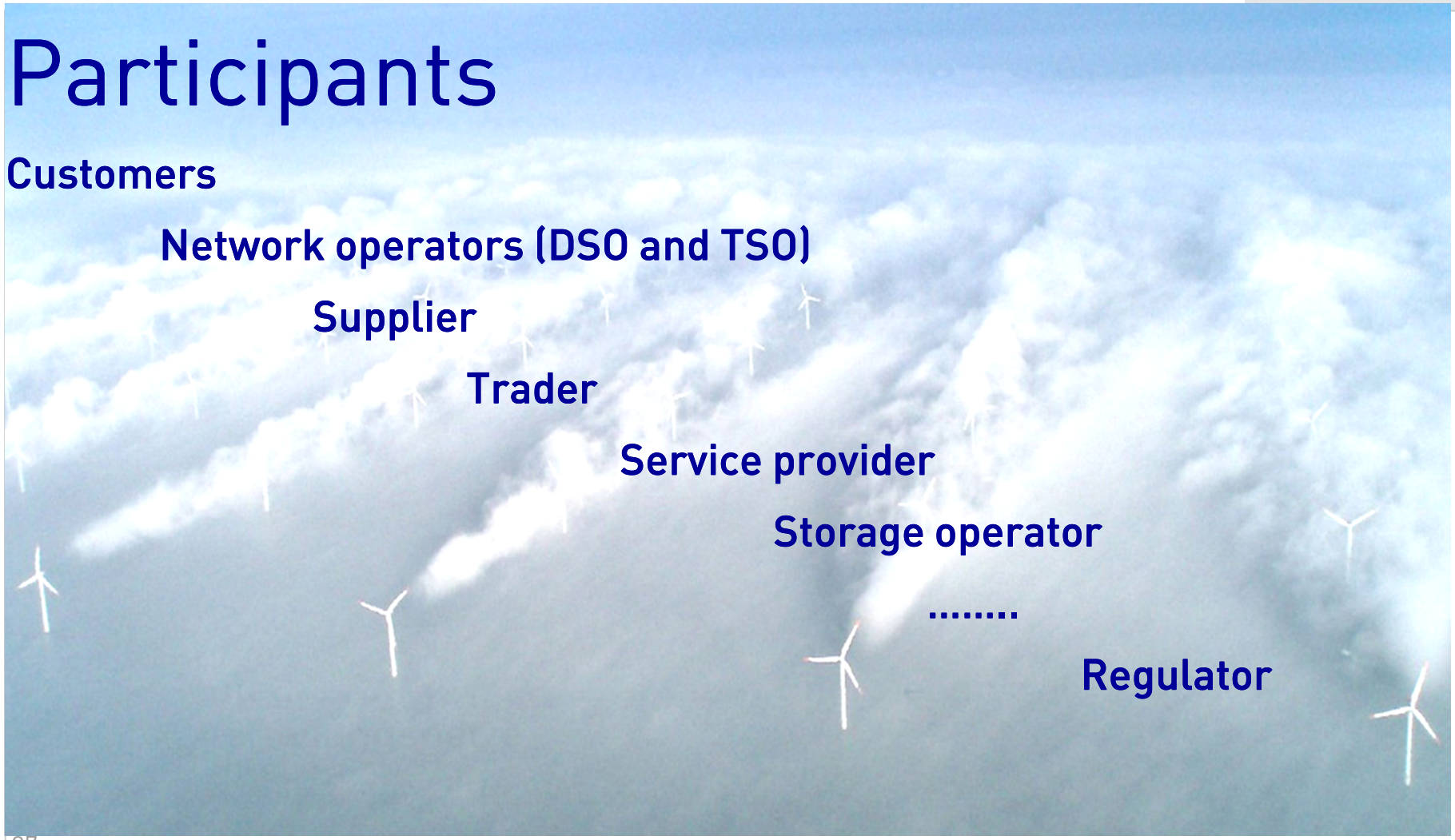
  ➔ Synergies for data systems

- Remote control of swiches and status feedback of: short circuit & eath fault indicators to control centre

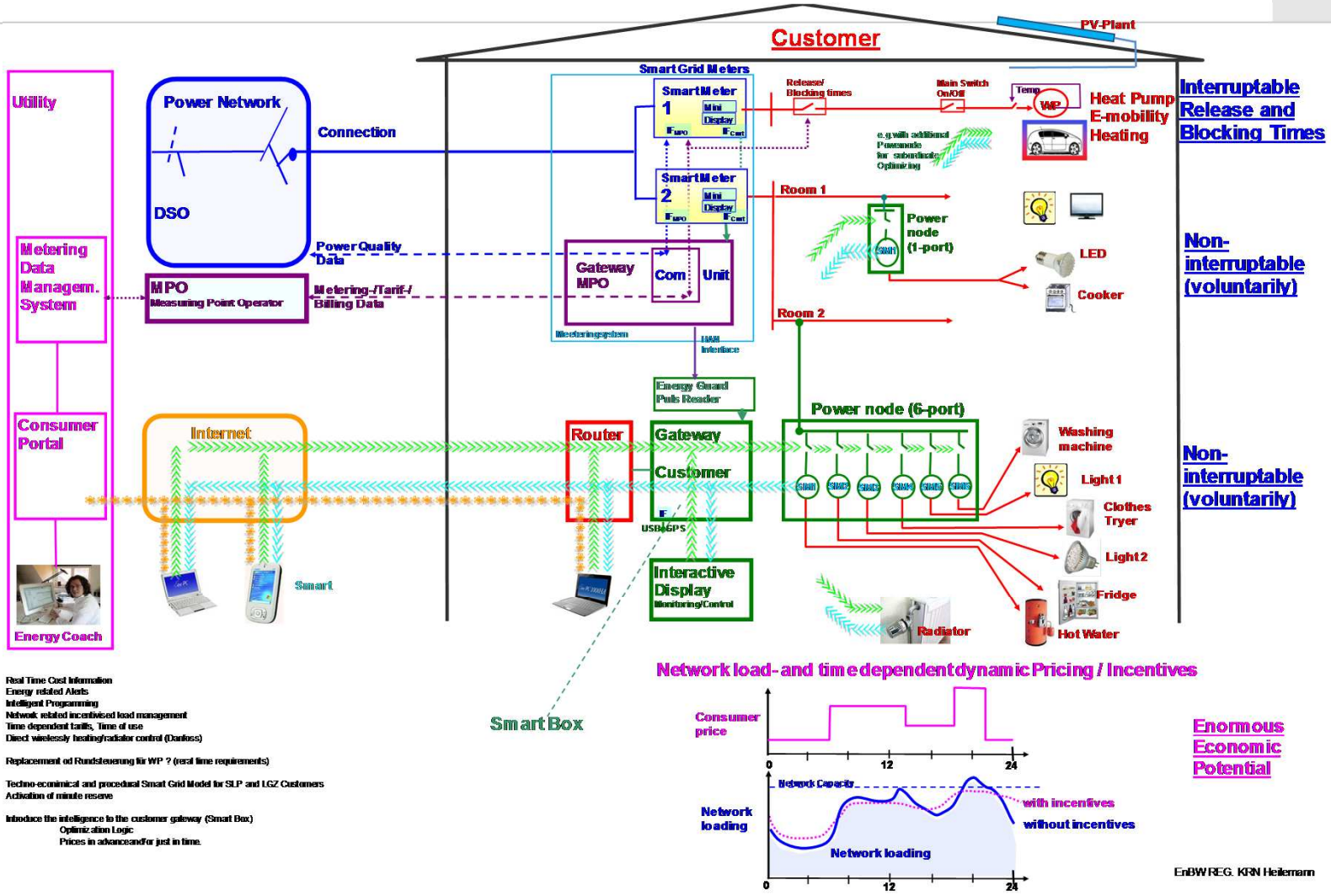
  ➔ Fast fault localisation/remedy. Improvement of the reliability and quality of supply

Installation of BB Powerline coupling in an open air station

Interaction of paticipants in the Smart Grid



A Smart Grid Approach: Power network- and customer friendly demand side management (DSM). Time of use pricing, incentives, interuptable and uninteruptable loads



Connecting and integrating geothermal power plants

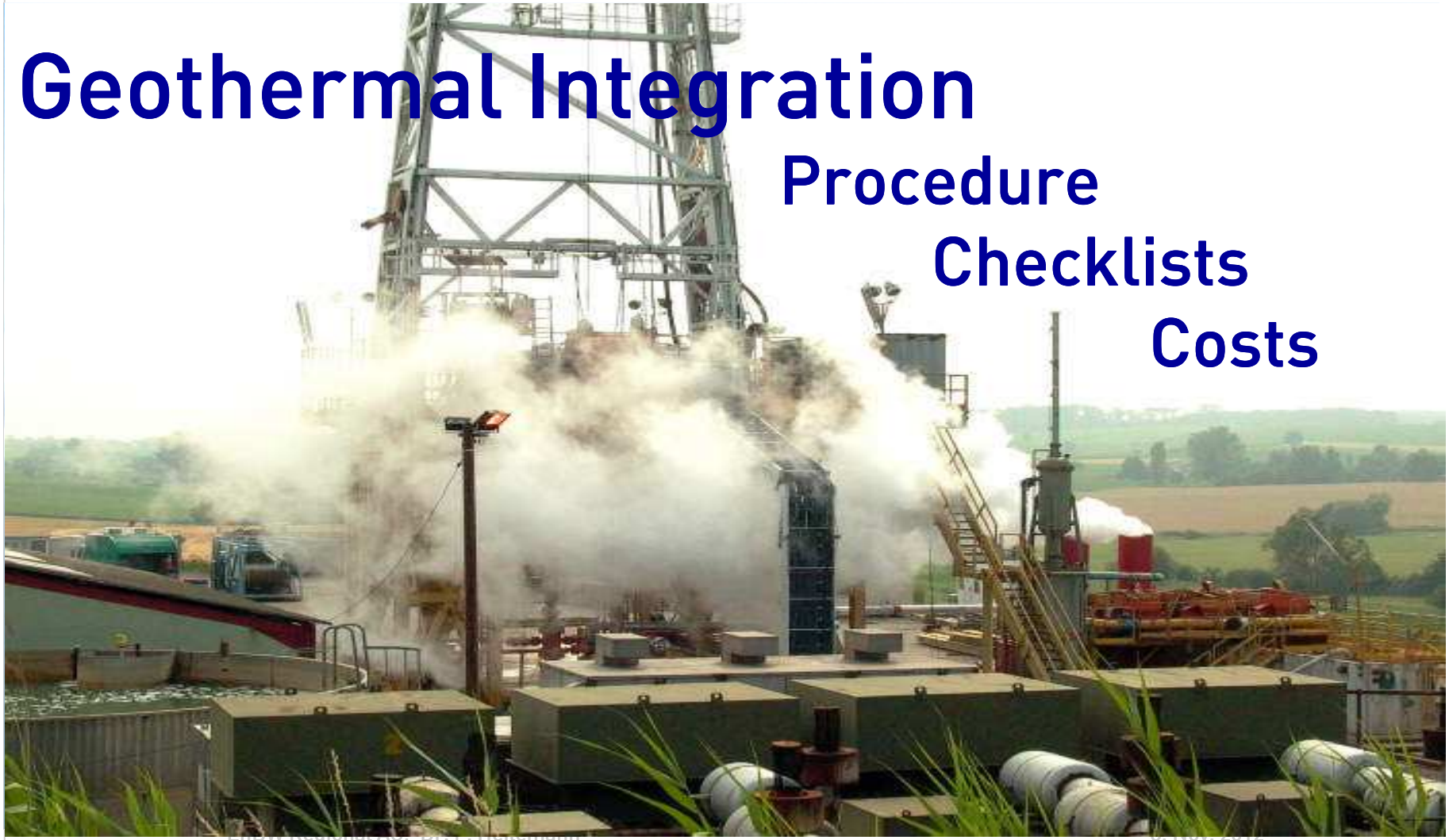
EnBW

Geothermal Integration

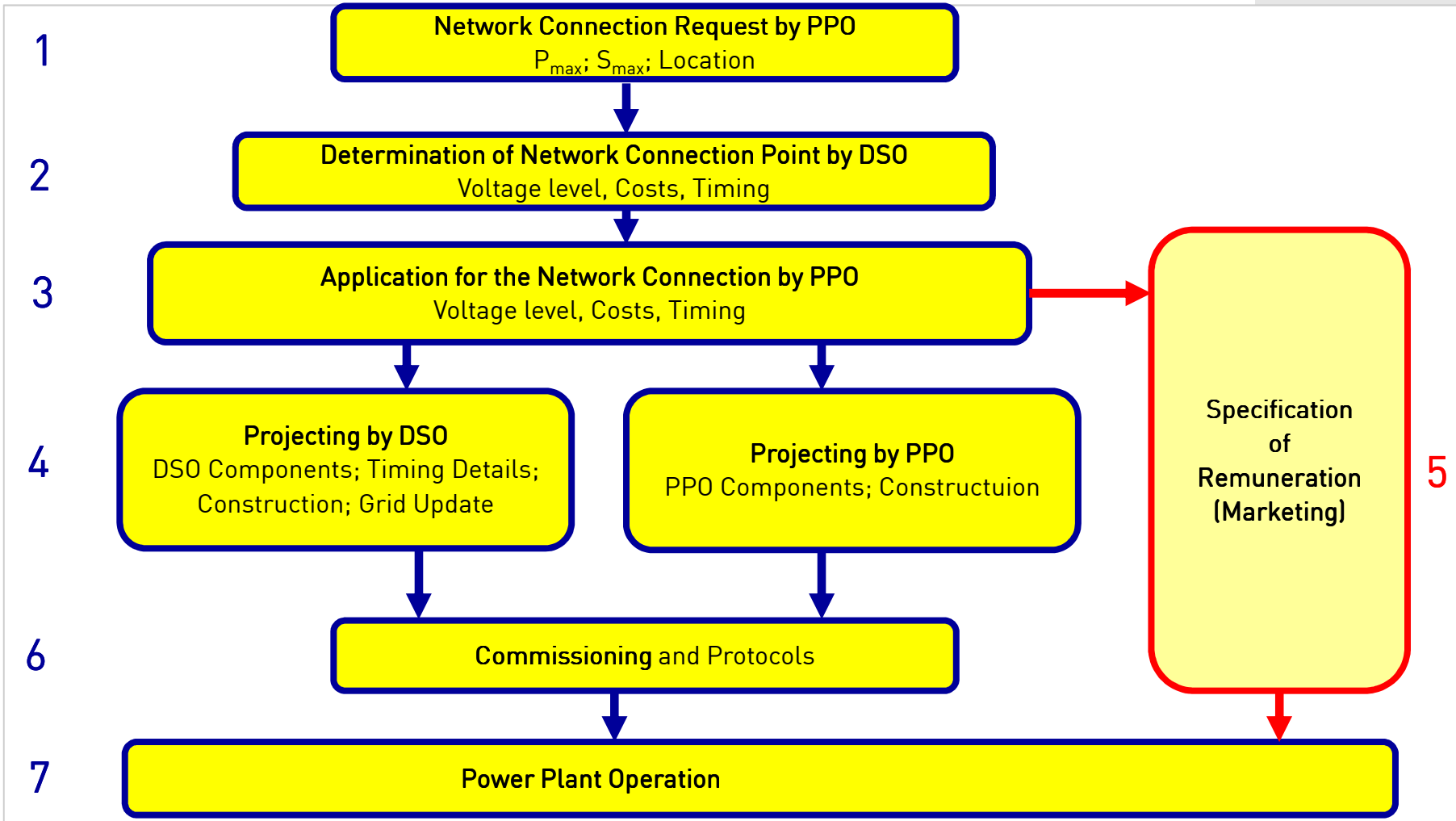
Procedure

Checklists

Costs



Flow diagram: Connecting a power plant to the network



Checklist for documents required (categories) for application and commissioning of generating units

- Request/Enquiry
  - General data, max feed-in power, location, DSO form, Site plan.....
- Application form for connecting a generating plant
  - DSO form
  - Measurement concept
  - Declaration that the construction is made in accordance with applicable laws and official directives as well as accepted enegeering standards VDE.
- Provisions before connecting the generating unit to the general supply grid
  - Proofs and certificates
  - Constructions to VDE guidelines, Attestation of conformity
  - Construction to bdew guidlines (connection to the medium voltage network
  - Any other network operator relevant regulations
- Documents for the commissioning of the power generating unit.
  - Data sheets / protokolls
  - other generating units, number size and complemetary documents

Enquiry for connection

Request for connection of a generating plant and order to perform network calculations.

Required data for the DSO:

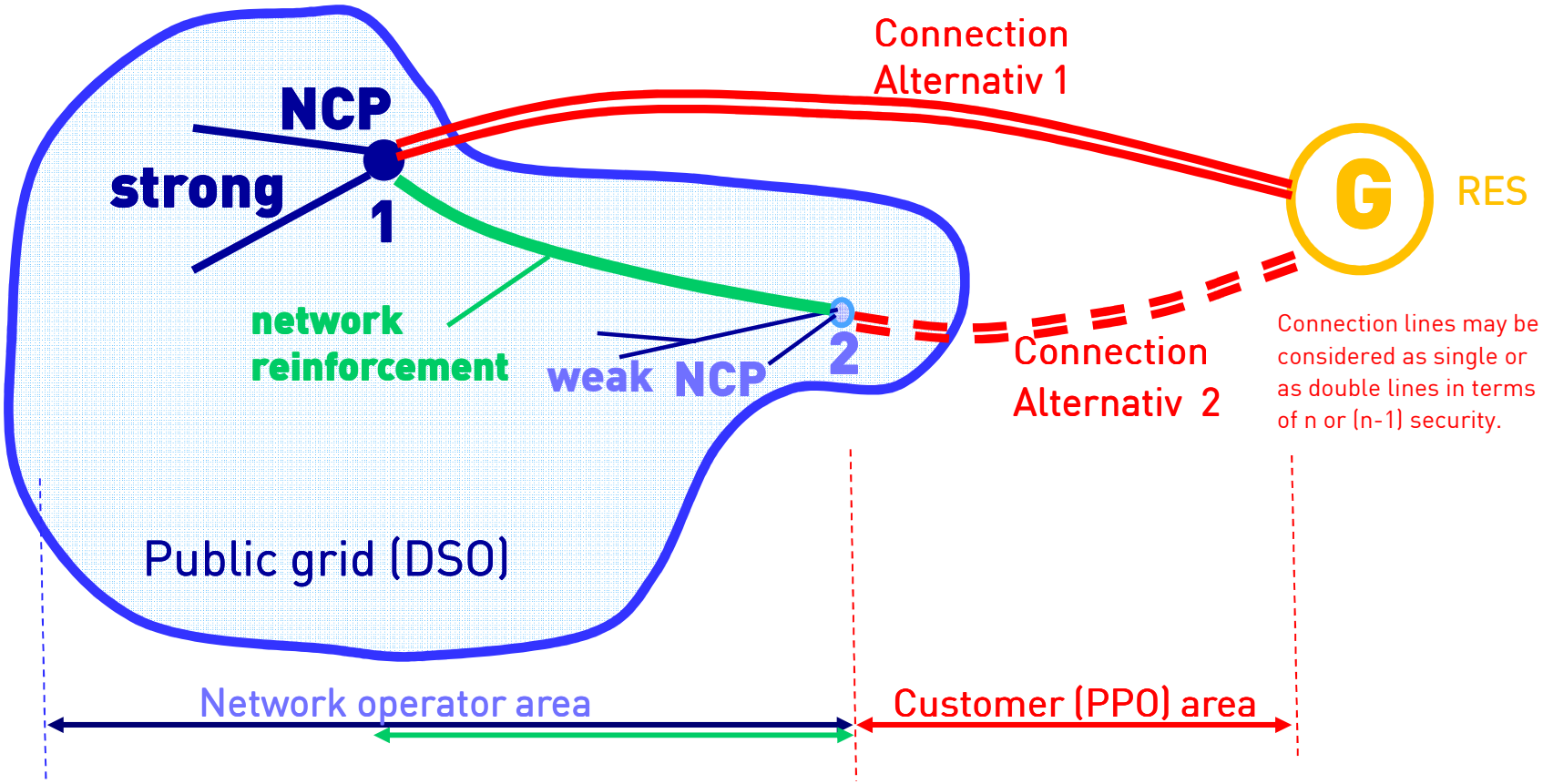
- ✓ Name/Adresses of the DSO, the customer/client, communication partner , installer
- ✓ System/plant location and a true to scale site plan

- ✓ Plant data: RES-feed-in according the law (e. g. EEG),
- ✓ Type of the generator
  - -- synchronous, asynchronous, double fed asyncronous generator
  - -- max real power P, max apparent power S, additional feed-in, ..
- ✓ Mandate for ordering a data signal transmission device according to the law (EEG)
  - -- incl. a cost absorption declaration
- ✓ Selecting the measuring concept
  - -- direct measurement, commercial financing transit or full feed-in model, need for a metering exchange

- ✓ Planned commissioning of the power plant
- ✓ Assignment for the accomplishment of network calculations (< 30 kW)
  - -- cost absorption declaration (blanket 1200 €)

Regarding the remuneration/feed-in compensation, the customer itself must inform.
The Reservation of the feed-in power are binding for six month. Afterwards extension is possible.

Determination of the Network Connection Point (NCP)
Most significant key point for connecting a power plant considering costs, property borders and operating responsibilities



Criteria for the determination of the network connection point (NCP) is the minimum of "Total Costs" incl. reinforcement of the network

Costs of some main components for connecting a power plant to the grid (Rough figures) Choice of voltage level

EnBW

Connection devices

Medium voltage lines/cables	70 -120 €/m
Medium/Low voltage substation	30 - 50 T€
High/Medium voltage transformer station	1 - 1,5 Mil €

Influencing circumstances:

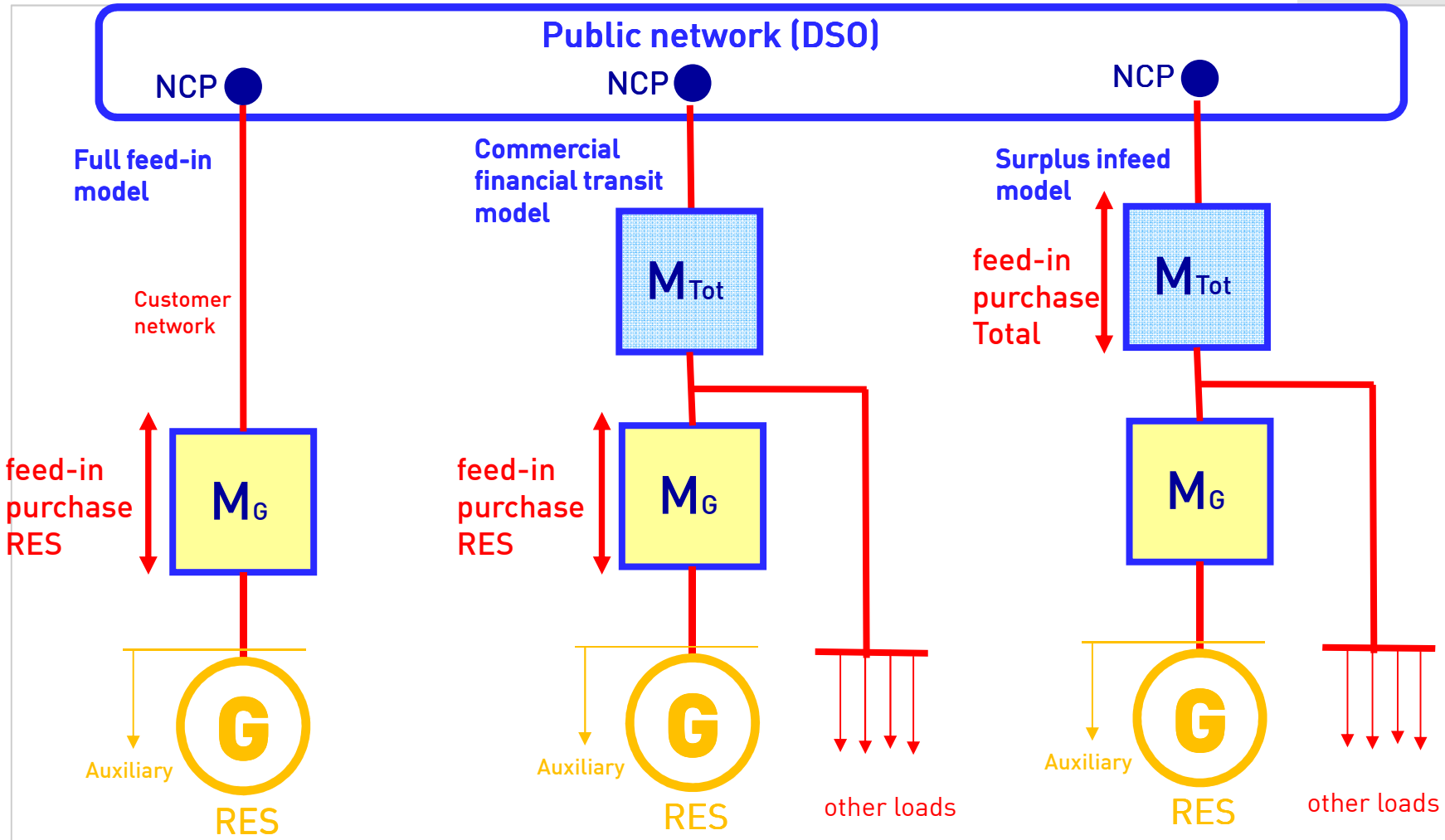
- Terrain conditions (buildings, soil, terrain ...)
- Power plant key figures
- Condition of the local infrastructure

Choice of voltage level

Plants bigger than approximately 20 MW connected to 110kV

Depending on network conditions

Measurement concept and counting for the remuneration of RES "Full feed-in", „commercial financial transit" and surplus feed-in" model



Commissioning protocol (form)

according to VDE-AR-N 4105

- Plant address, plant installer
- Max apparent power Smax, max real power P_{max}, cos phi (0,95 0,9)
- Peak power of the individual modules/generators kWp
- Order for commissioning is available
- Compliance with data
- Measurement for billing was tested
- Conformity evidence
- Protection devices
  - Set point for voltage control U_n
  - Set value on integrated protection of the net connection Un
- Trip test performed
- Feed-in management according to §6 EEG is well functioning
  - including power reductions to several levels (e.g. 70%,....)
- Limitation of the maximum power according to the contracted value Pmax
- Carrier frequency locks are proved. Protocols
- Date of commissioning

Required capabilities for generation units (RES)

Feed-in management according to EEG §6

- In general all plants > 100 kW
  remote controllable steps (60%, 30%, 0%, 100%) of P_{max}
- PV plants > 30 kW < 100 kW
  remote controllable steps (60%, 30%, 0%, 100%) of P_{max}
- PV plants < 30 kW
  choice of the PPO
  - like bigger plants
  - fix limitation of peak power to 70%

In addition all PV plants < 10 kW will be equipped with frequency relays to drop them when frequency > 50,2 Hz (according to the system stability act).

Bigger plants need to participate to the primary control

Market and renumeration models
Choise of the power plant operator (PPO)

Remuneration models (Germany)

1. Feed-in according to the EEG. Will be payed by the DSO

Geothermal 25Ct/kWh (§28, 33)

2. Direct Marketing models (PPO has to clarify with a supplier)

- Direct Marketing + Avoided Network Charges
- Direct Marketing (green power privilege)
- Direct Marketing + Avoided Network Charges + Market premium

Avoided network charges for the next higher network level.

Market premium accord. to current market situation

Payed by the supplier

Payed by the network operator

Compensation of the power plant operator (PPO) in case of feed-in management by the network operator

In case of an impending network bottleneck, the DSO is entitled to reduce the generated power (0, 30, 60,....%)

General convention with regard to the law (EEG §11):

Compensation of lost revenues "As if"

Two variants for free choice for the PPO

- Blanket remuneration (Ct/kWh) according to the last actual performance for the time in question
- Billing based on a detailed generation profile (pointed billing)

BNetzA guideline for wind and association agreement for other sources.

Realistic potentials of geothermal power plants

Medium term (within the next 15 years)
probably no unit size bigger
than 100 MW in low enthalpy areas
not anticipated at present

Germany

biggest plant currently 3.3 MW_{el} (Unteraching Munich)

Potential up to 2030
200-500 MW
Uncertainties

Summary
EU 20-20-20 targets and challenges for the energy turnaround
Green light for geothermal generation

Building up Smart Grids to integrate the renewable sources is a huge network economic challenge for distribution- and transmission system operators (DSOs,TSOs)

- Additional integration of new loads (e-mobility and storages) make it further challenging
- DSOs as carrier of enourmous investments. Increased pressure for efficiency
- Integrated perspectives needed. Network operators in the centre of responsibility
- Paradigm change „Load Follows Generation“
- Fundamental challenge for planning construction and operation of networks by means of
  - system monitoring, communications systems, smart Meters as well as
  - feed-in and preventive load management trough incentives

Geothermal generation and connection is no problem in general

- Potentials are relatively low compared to wind, PV and biomass from a todays grid point of view
- Checklists for connection should be available at the local DSO
- Larger units are required to attend primary and voltage control
- The power plant operator can select a model to market its current
- Obstacles to the development of geothermal power plants should in general not be expected from the part of the network

Smart Customers

- Incorporation and empowering of the customer is required including Home Automation Systems.

Smart Regulation

- Incentives for implementation of Smart Grids are overdue. Creating an investment-friendly climate

Grid Integration of an Increasing Share of Renewable Power Generation

- Geothermal Power: Challenges for Network and System Operation-

Thank you for your atttention

GEOELEC Training Course Strasbourg
5.- 9. Nov. 2012

Dr.-Ing. Franz Heilemann
EnBW Regional AG