

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 Potsdam
15.- 18 April 2013**

**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

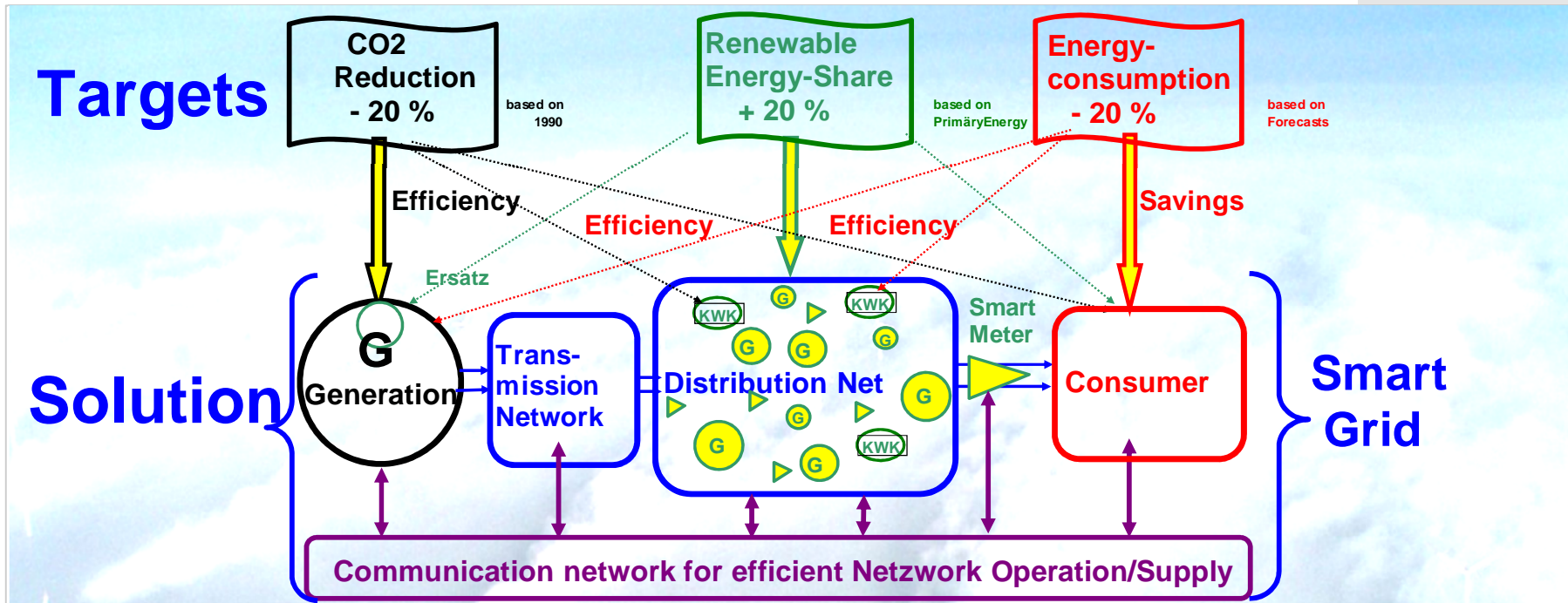
The Measure of all Things

**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



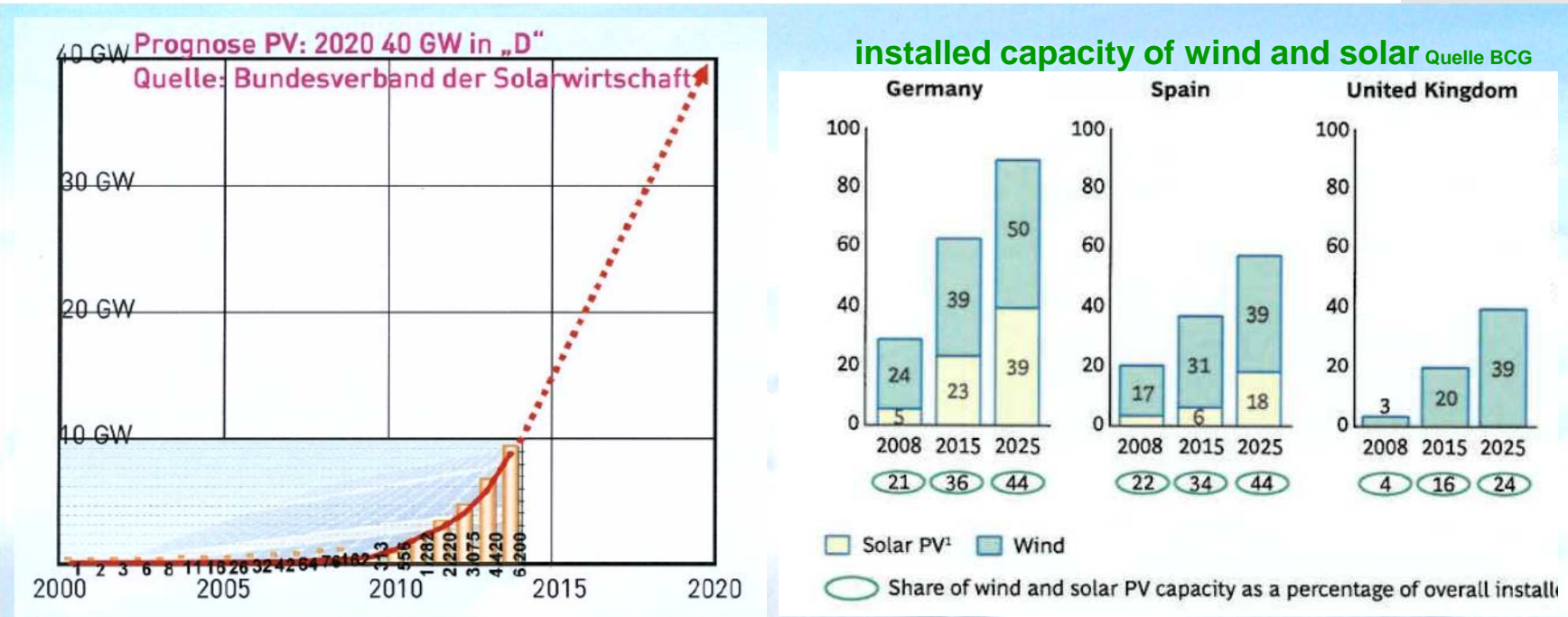
Challenge 35 % generation from RES in Germany

„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)

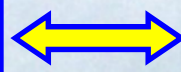
Rapid installation of renewable generation

Lucrative promotial concepts

Tendencies



**Renewable generation 2020
ca. 70.000 MW**



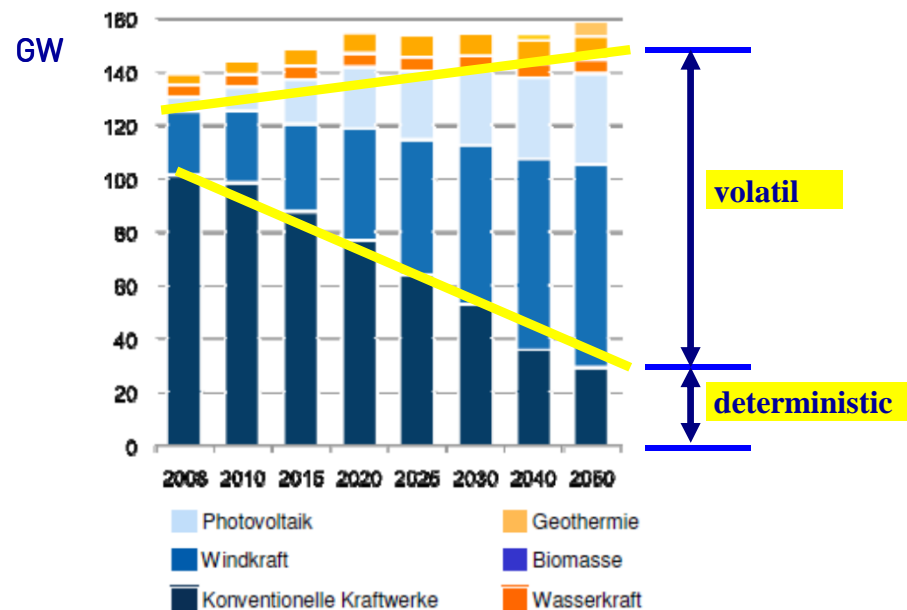
**Current peak load in Germany
ca. 80.000 MW !!**



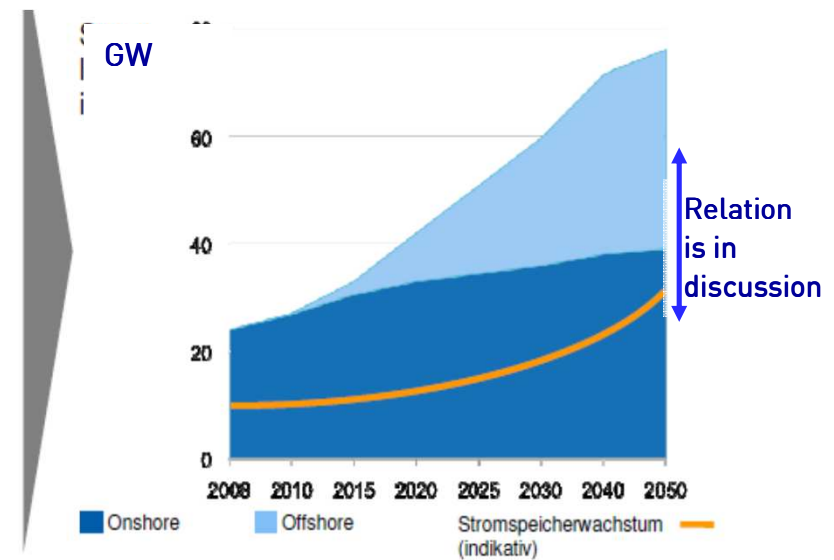
- ➔ Substantial network problems (P, Q, U, f) (locally, regionally, holistically)
- ➔ Network related load-/feed-in management for cost efficient network operation is indispensable !

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

Development of installed capacity in Germany
Reference scenario of the BMU



Development of installed wind power

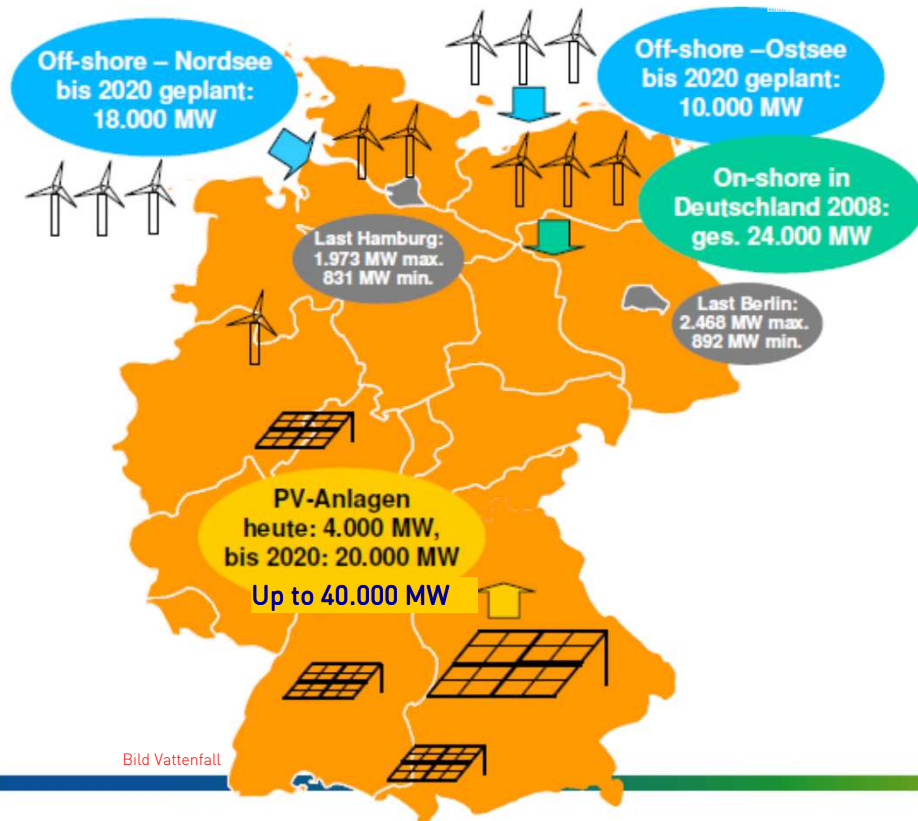


The contribution of generating units in the distribution network for the control will have to increase substantially

- Frequency-Load Control
- Primary 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

Discussed Tendencies



Wind Power

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

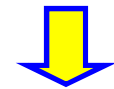
Solar Power

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



Bottleneck

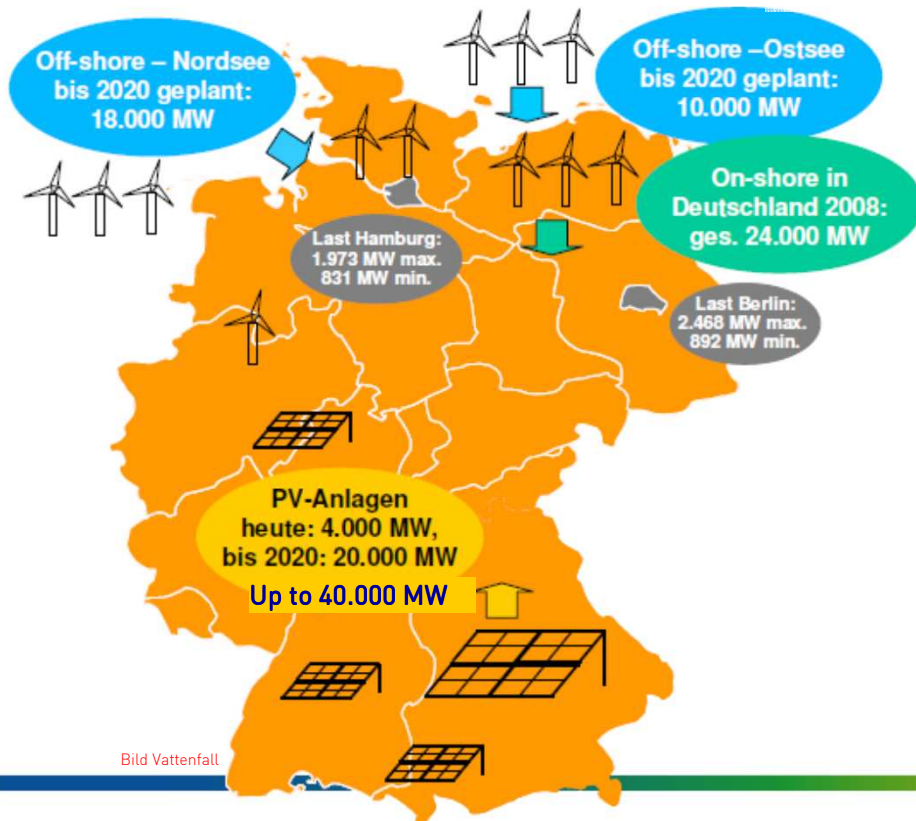
North-South



Overlay grid? Congestion Management: 2 Trading Zones ?

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

Discussed Tendencies



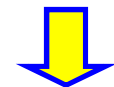
dena network study II

- 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

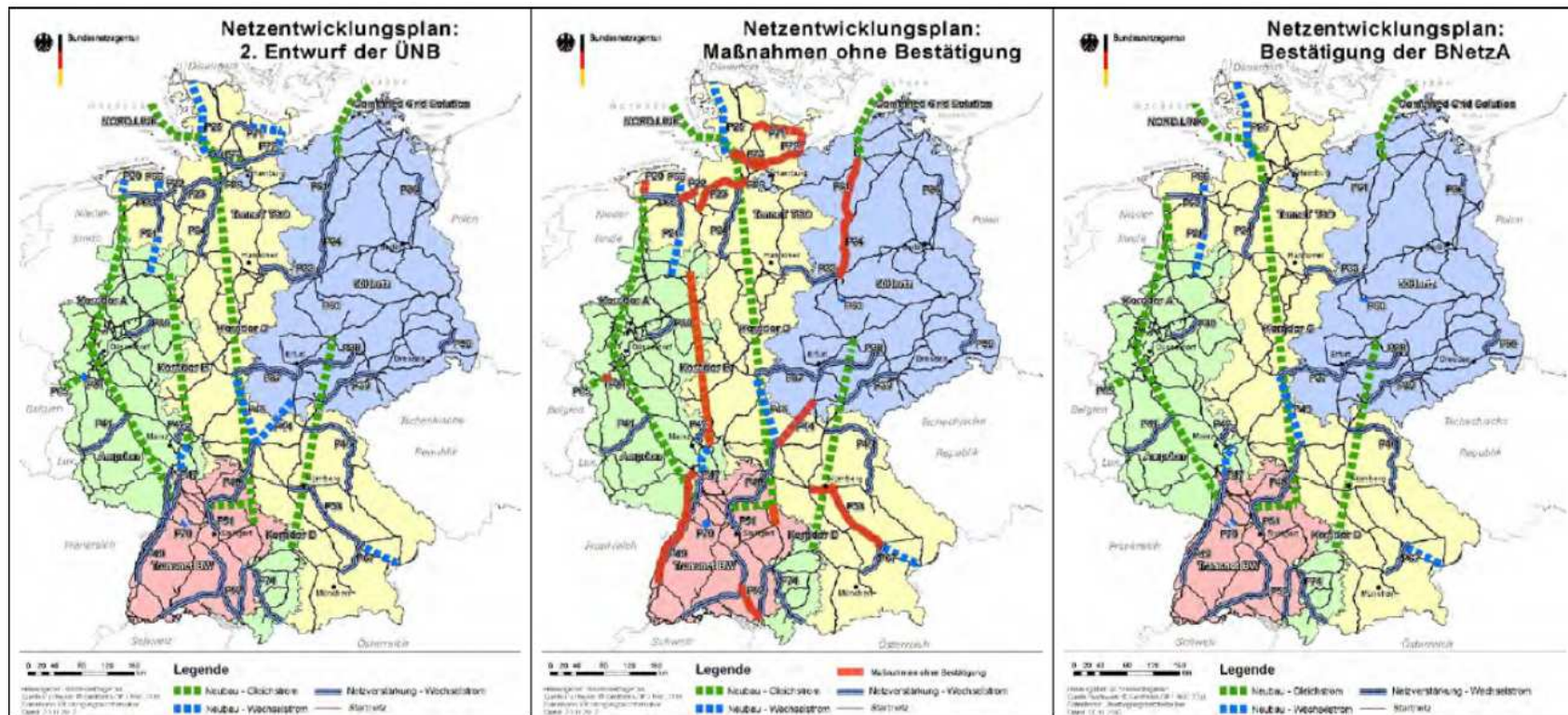
North-South



Overlay grid? Congestion Management: 2 Trading Zones ?

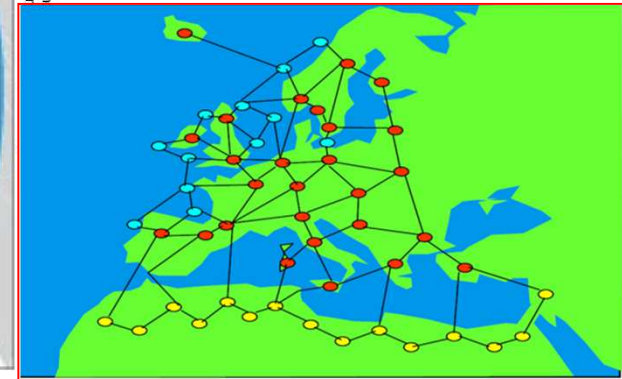
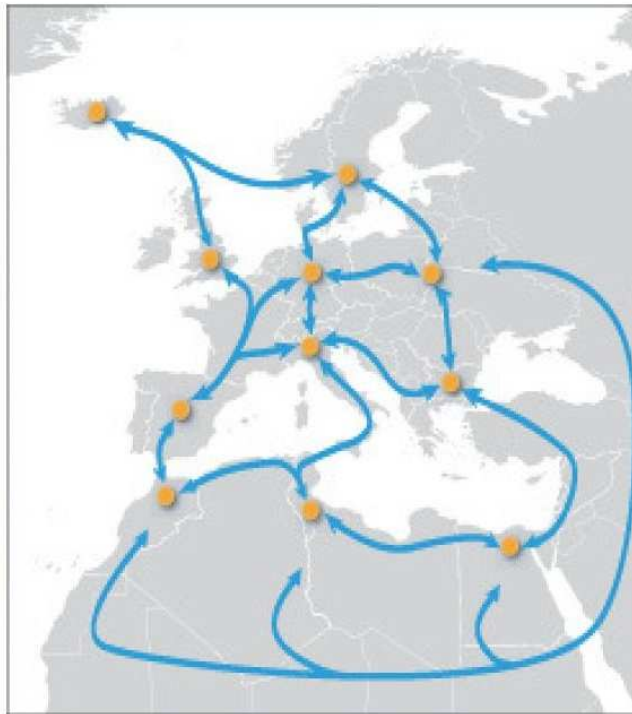
Discussed scenarios for grid reinforcements

discussed scenarios for grid reinforcements



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

”Supergrids”: Pan-European Smart Grids



Dr. M. Sánchez, European Commission, Directorate General for Energy
 ERGEC Workshop on Smart Grids, 17 March 2010, Brussels

| 4/16

Coordinated planning of new transmission capacities of the TSOs

15% from the desert

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



Fresh Energy



Baltic I	48 MW	21 wind turbines	2010
Baltic II	288 MW	80 wind turbines	2013 planned
.....			
Initial future planning: in total 1200 MW			

**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?

EnBW

Enormous increase of RES in 2020 ca. 80% of today's peak performance!
Extremely high volatility/intermittency of the generation
Substantial network problems (P, Q, U and f), (locally, regionally, holistically)

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

DSO ==> „Peak Shaving“ -> (Load flow, voltage, Customer supply)
network related preventive coordination
load- and in-feed management
costefficient network operation
automation of network, network expansion

Regulatory Framework

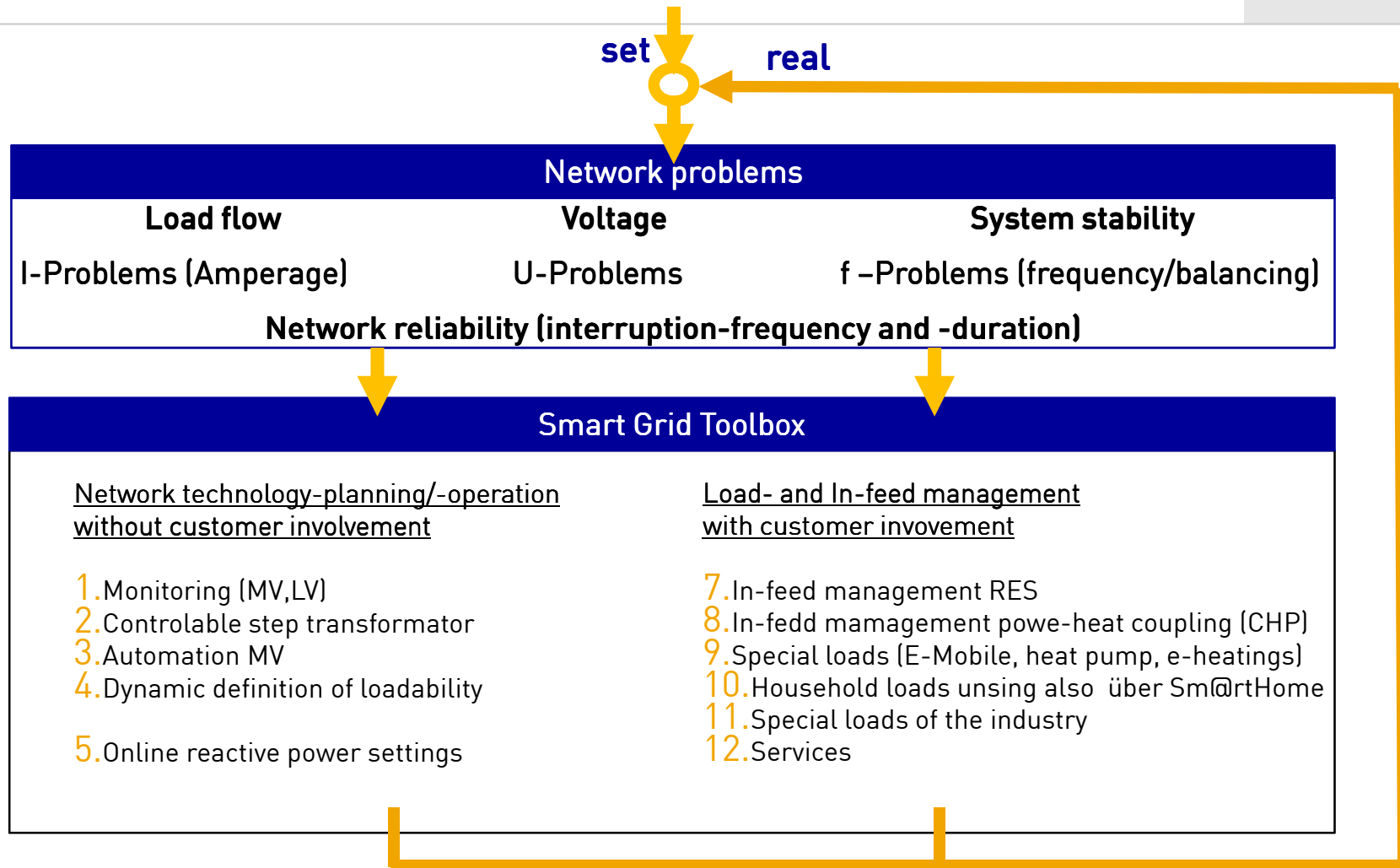
- ==> Recognition of the DSO costs/ investments
- ==> requirement for an investment-friendly climate

**Invest EU-wide up to
approx. 1.000 Bill. Euro
500 Bill. Generation
100 Bill. Transmission
400 Bill. Distribution**

accord. to EURELECTRIC

Control loop to efficiently solve network economic and network technical problems

Overview of the Smart Grid Approaches



Solutions and approaches

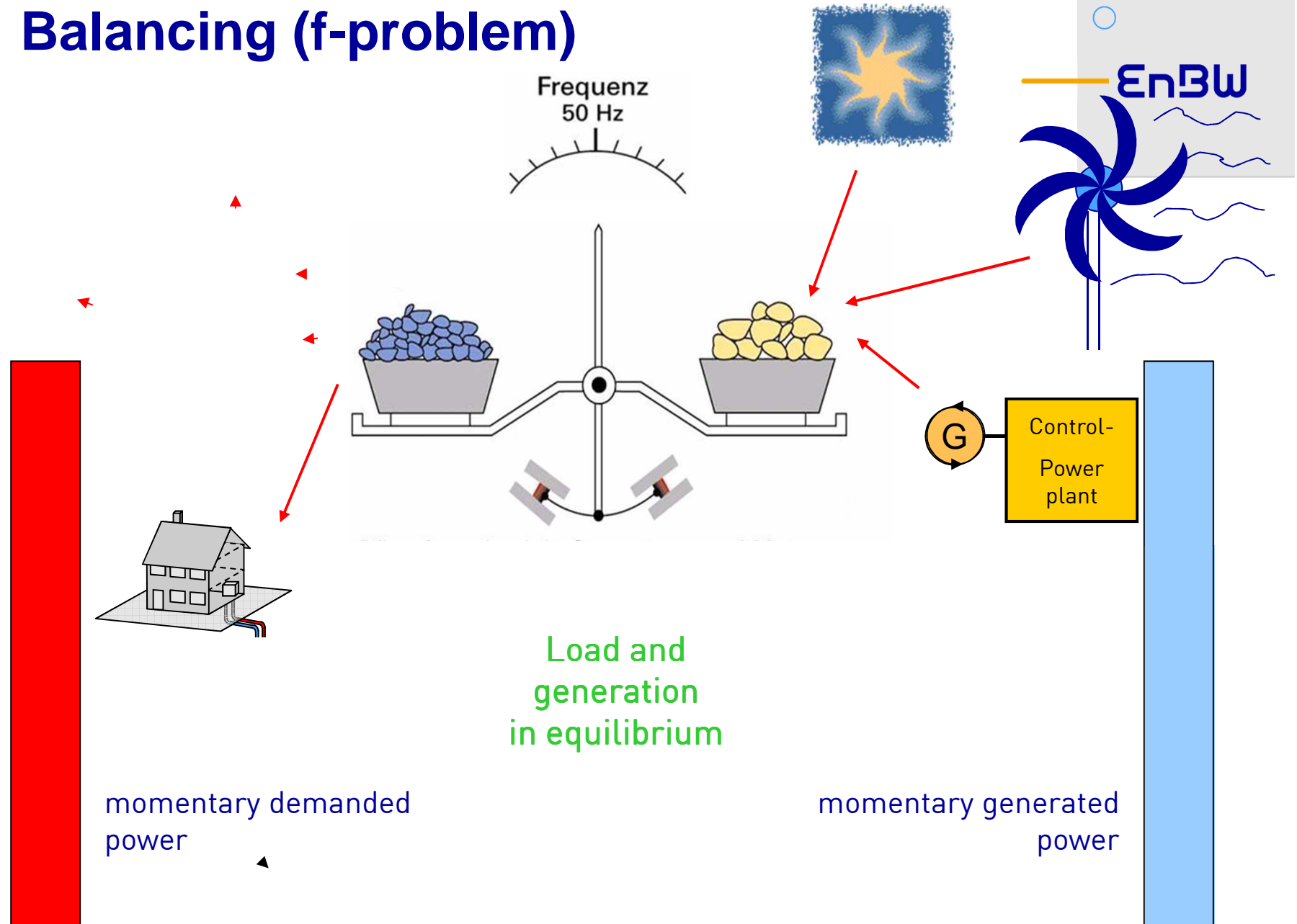
Intelligent network control

Load- and feed-in control
Electrical equipment

Customer involvement ,
Smart Box

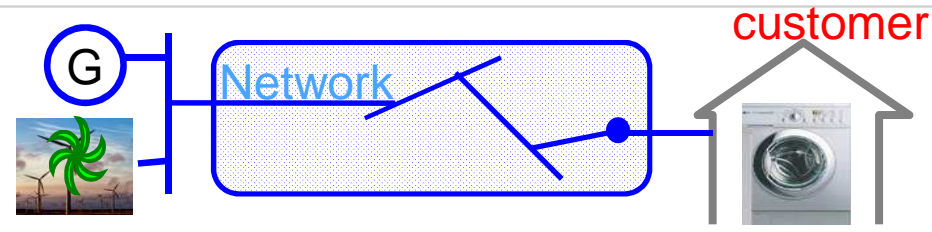
Time dependent network tariffs

Balancing (f-problem)

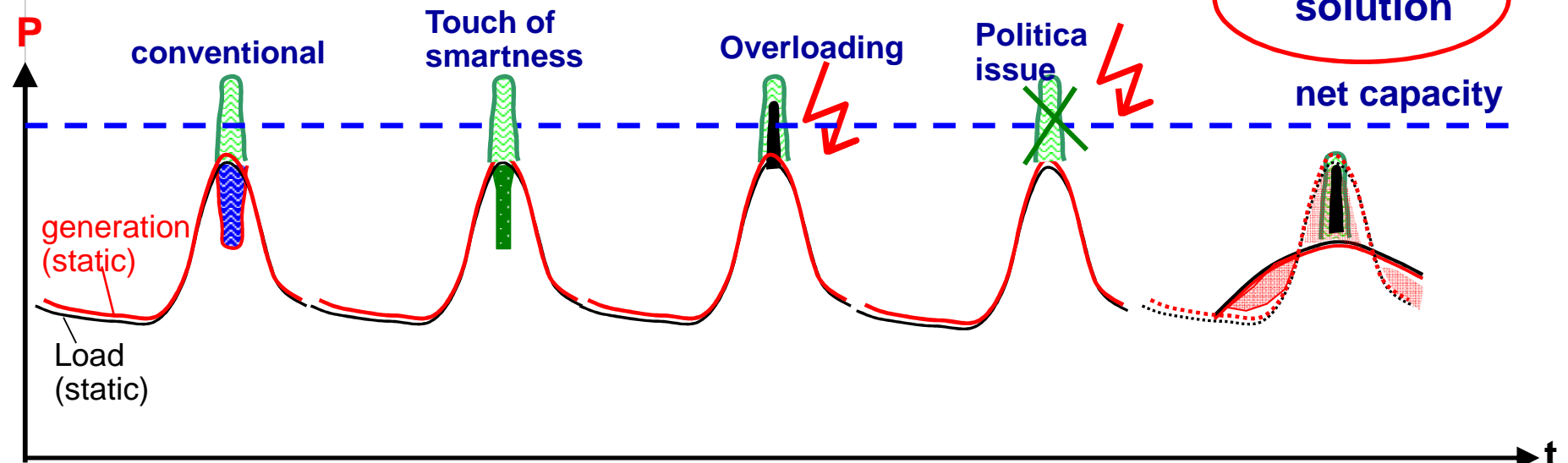
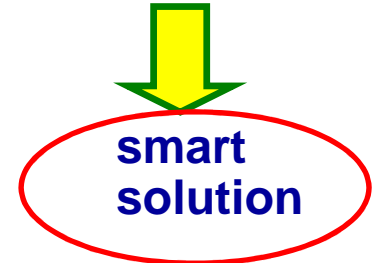


Intelligent, preventive and network-related load-/in-feed management

Options for costefficient network operation



e. g. I-problem



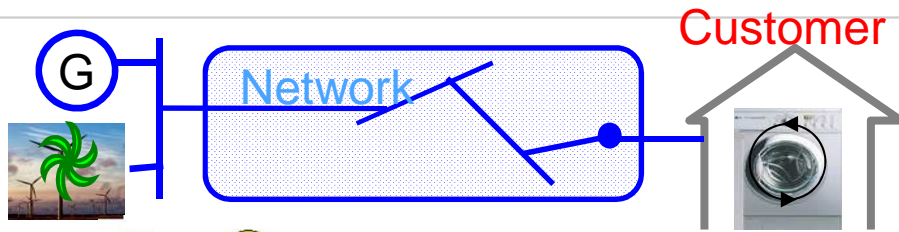
1. Ramp down Control power plant
 2. Shut down decentralized generation (RES)
 3. Load-activation
 4. Renewables disconnection
 5. Load shifting + activation by incentives
- Usage of all advantages

Intelligent, preventive and network-related load management

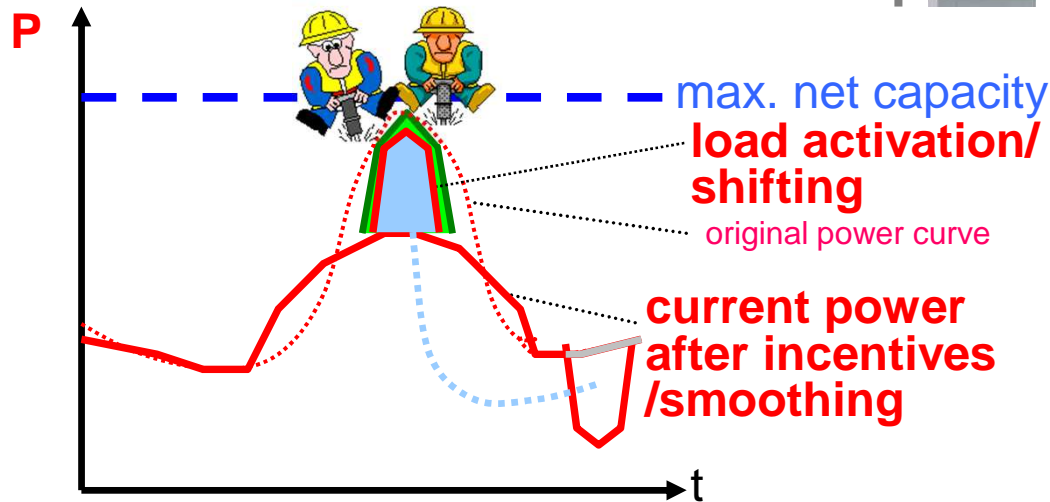
Load follows generation (paradigm change)



e.g. I-Problem



Satisfaction

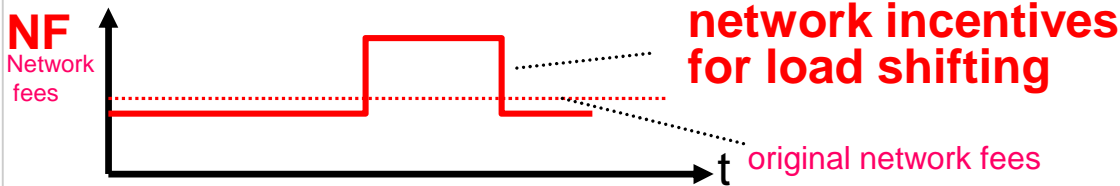


➔ Cost efficient smart and economic network operation

➔ Preventiv Load management

➔ Priority feed-in for RES

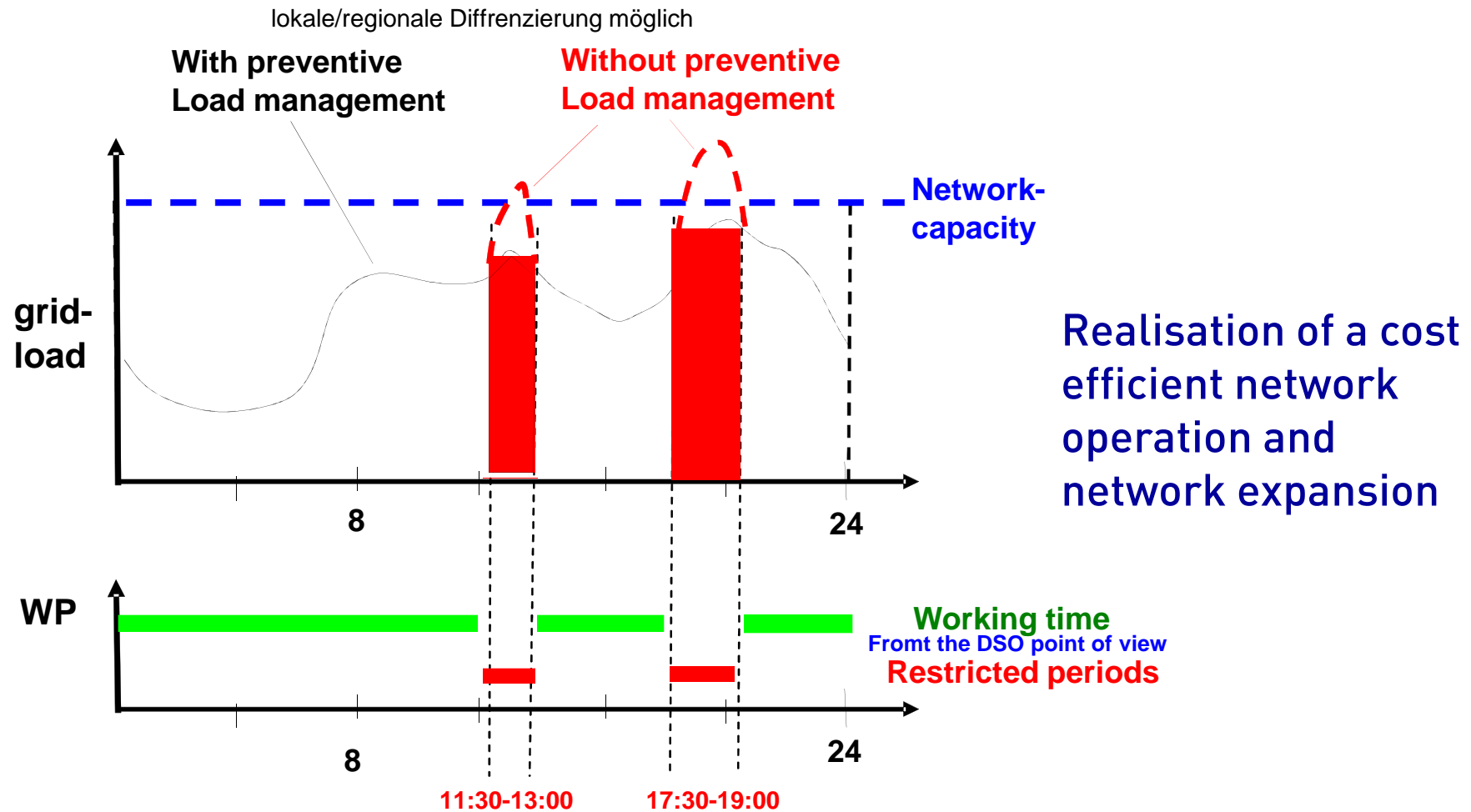
➔ Usage of RES by load activation



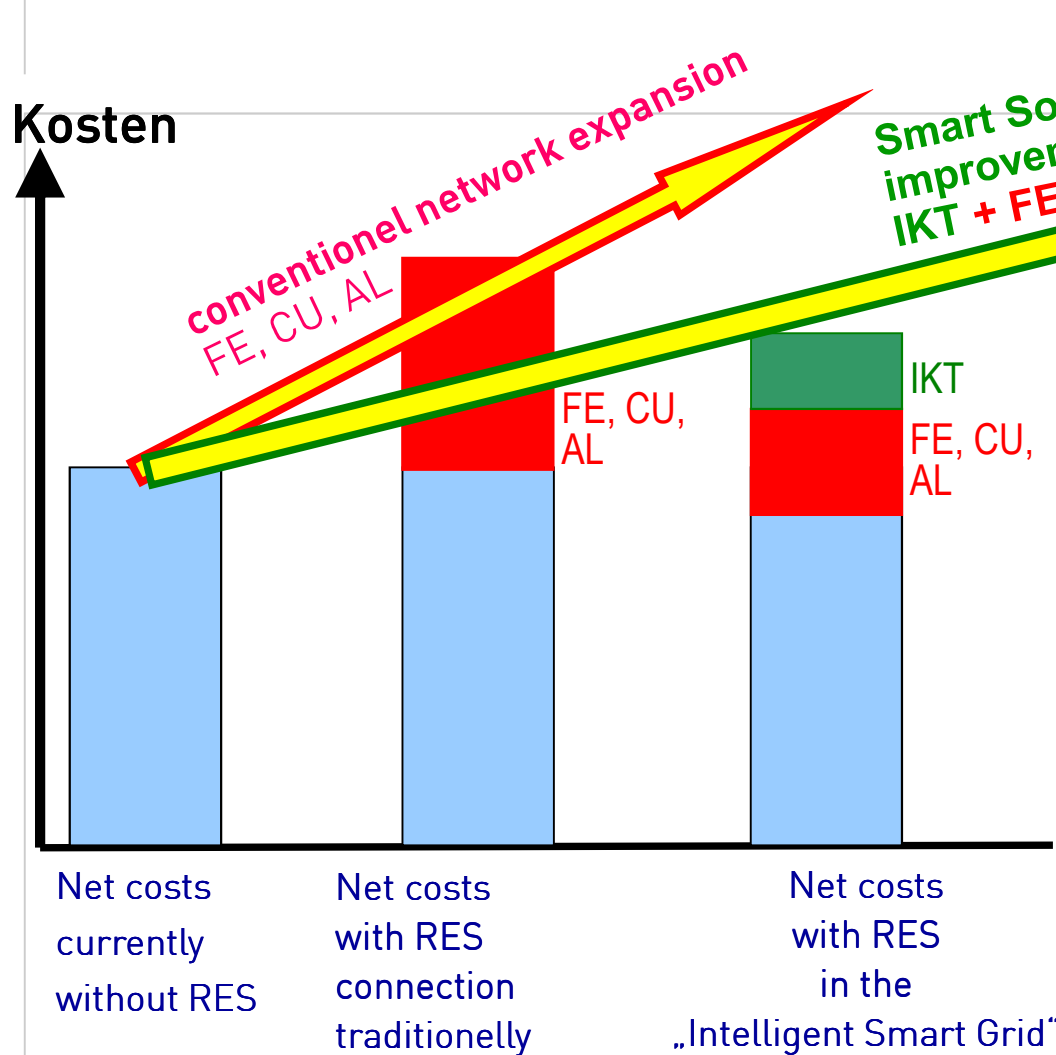
➔ Preventiv net expansion

➔ 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

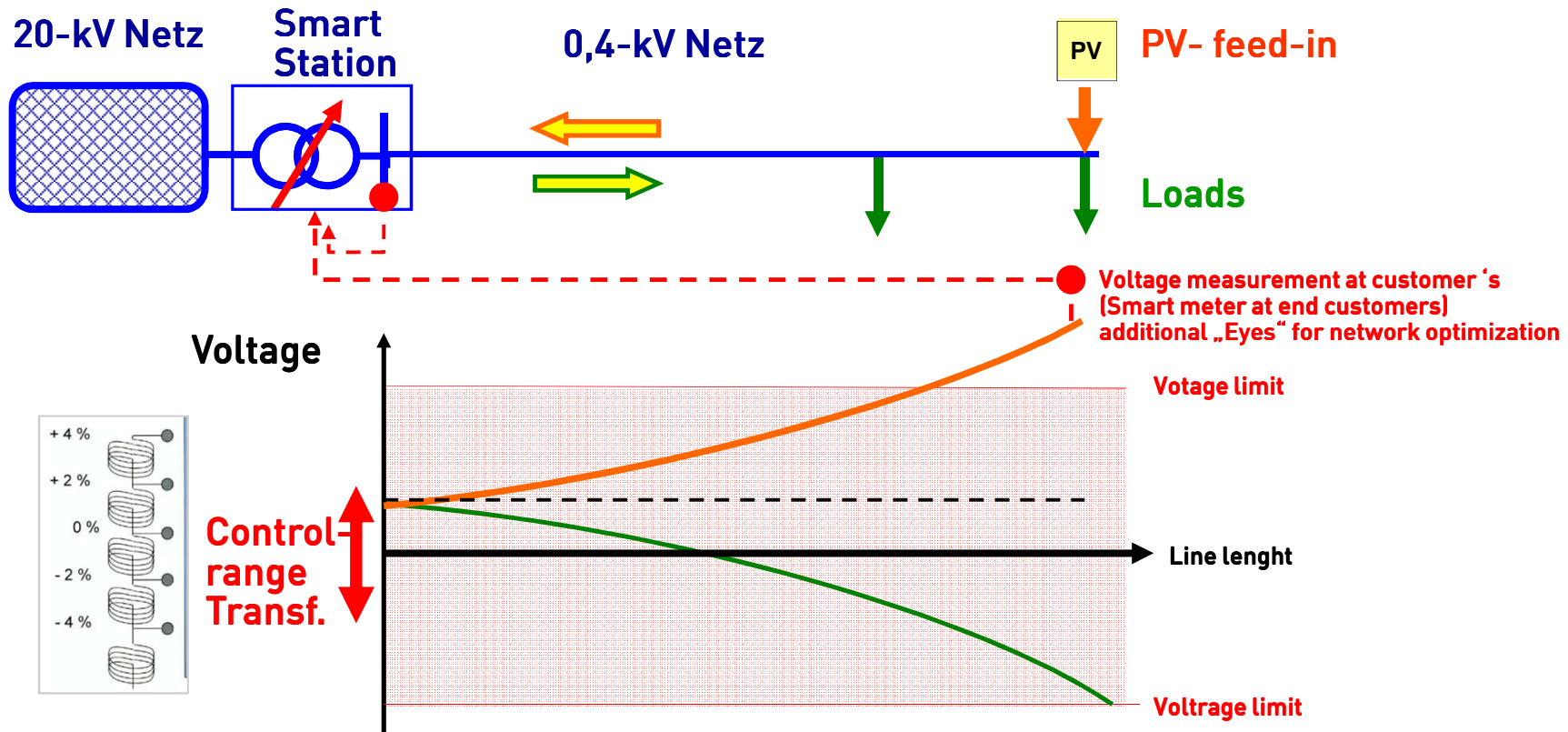
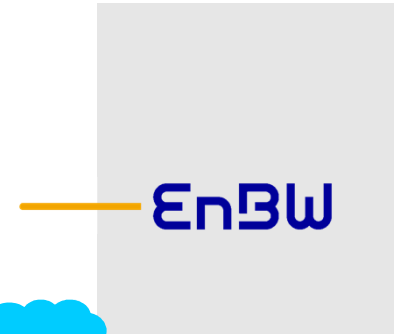


Smart grids may mitigate the cost increases of the integration of renewable energy sources.



- Smarte Tools**
- ▶ Intelligent communication-, control and steering technology
 - ▶ Intelligente load-/generation management by attractive incentives
 - ▶ Smart stations
 - ▶ Intelligent metering systems
 - ▶ Smart Boxes
 - ▶ Smart customers
 - ▶ Smart regulatory framework

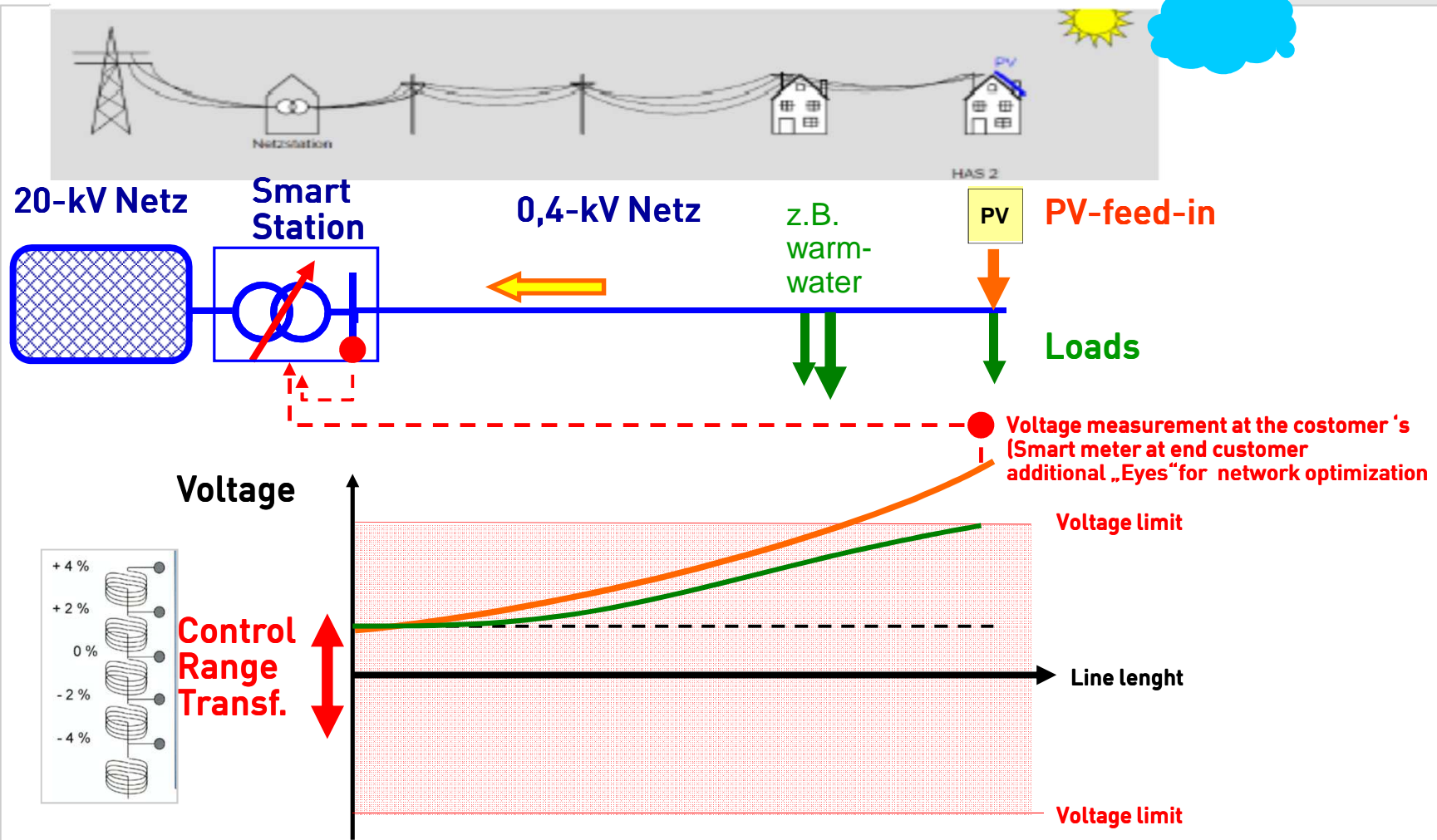
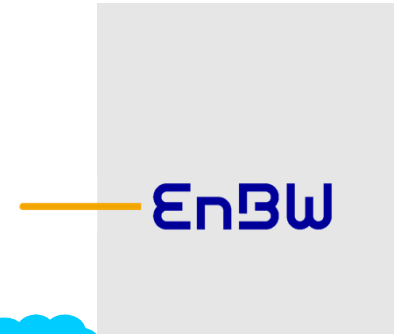
Smart Station (I) , controllable step transformers
 Avoidance/postponement of net and line constructions
 Dynamic voltage control: Voltage problem (U-problem)



Smart Station (II)

Avoidance/postponement of net and line constructions

Dynamic load control



Smart Station (III) Additional features and advantages

Measured data for network monitoring and state estimation

➔ Advantage for planning, steering and asset management

➤ Loading control/monitoring of the equipment

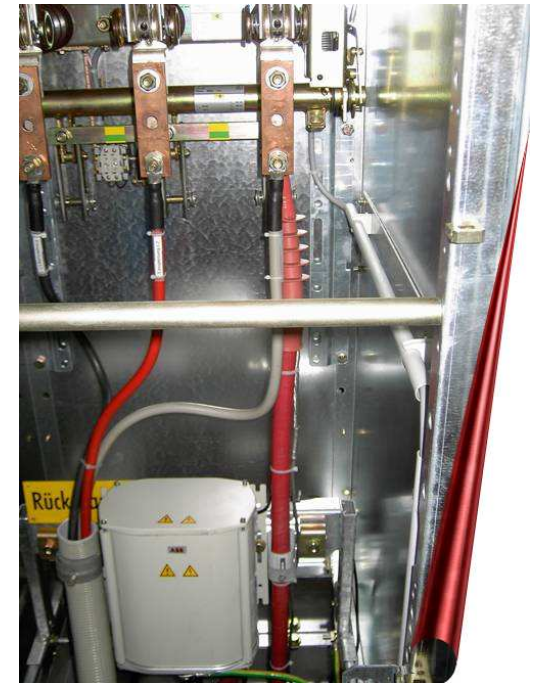
➔ Protection and optimal use of assets
(lines, transformers, network configuration)

➤ Data hub for smart meter data

➔ Synergies for data systems

➤ Remote control of switches and status feedback of:
short circuit & earth 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

Participants

Customers

Network operators (DSO and TSO)

Supplier

Trader

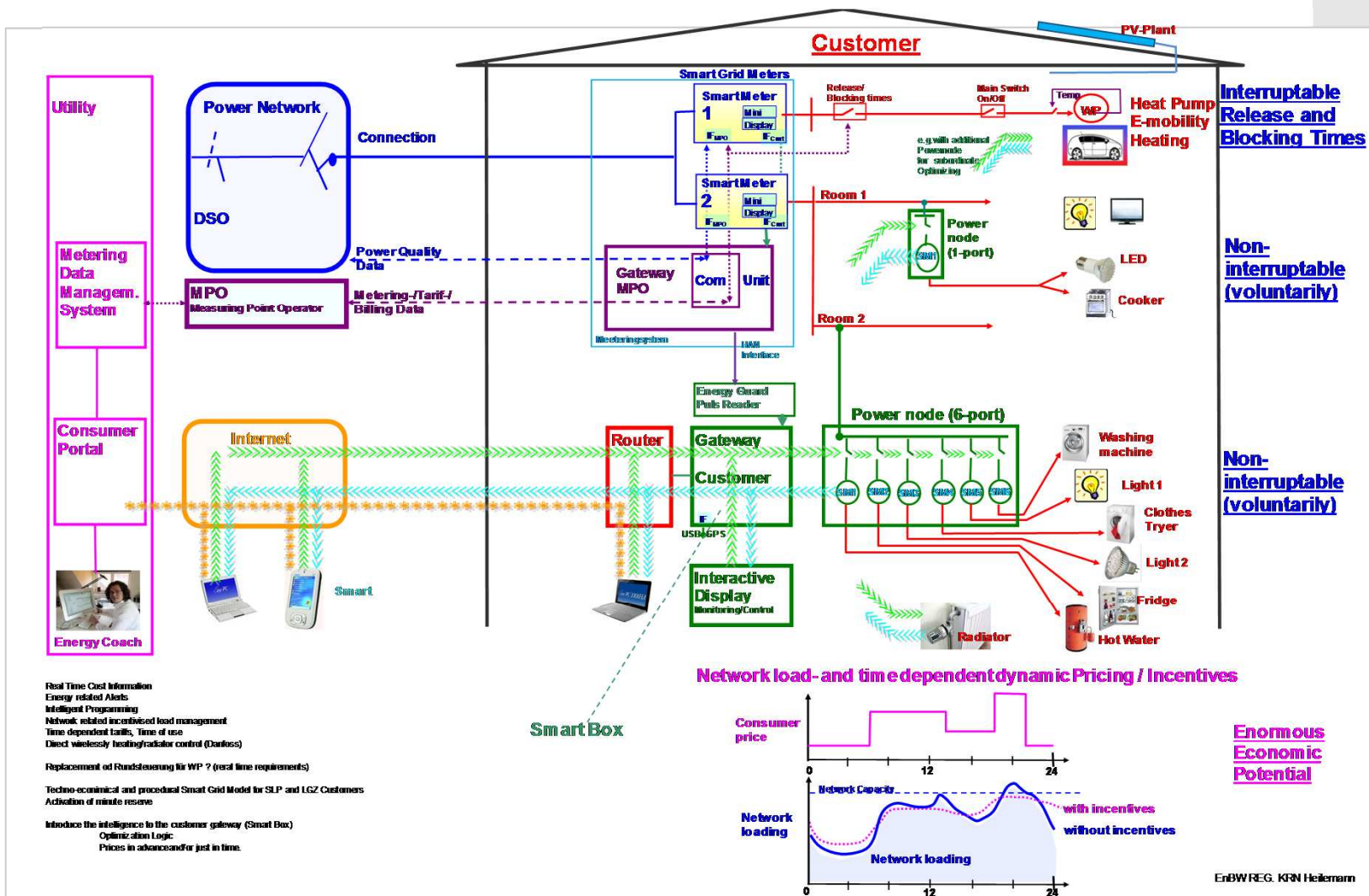
Service provider

Storage operator

.....

Regulator

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



Connecting and integrating geothermal power plants



Geothermal Integration

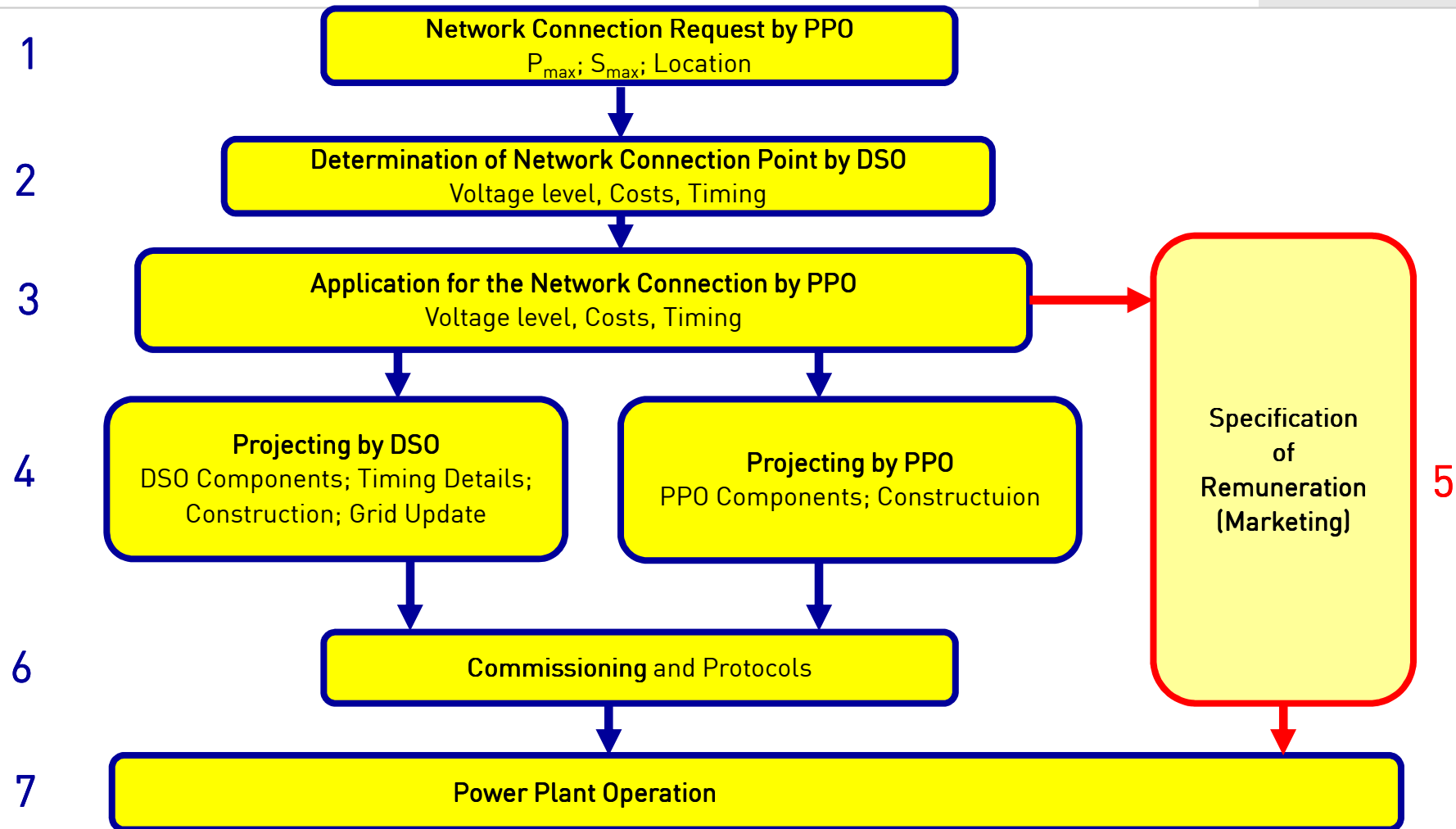
Procedure

Checklists

Costs



Flow diagram: Connecting a power plant to the network



Enquiry for connection

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



Required data for the DSO:

- ✓ Name/Addresses 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 asynchronous 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

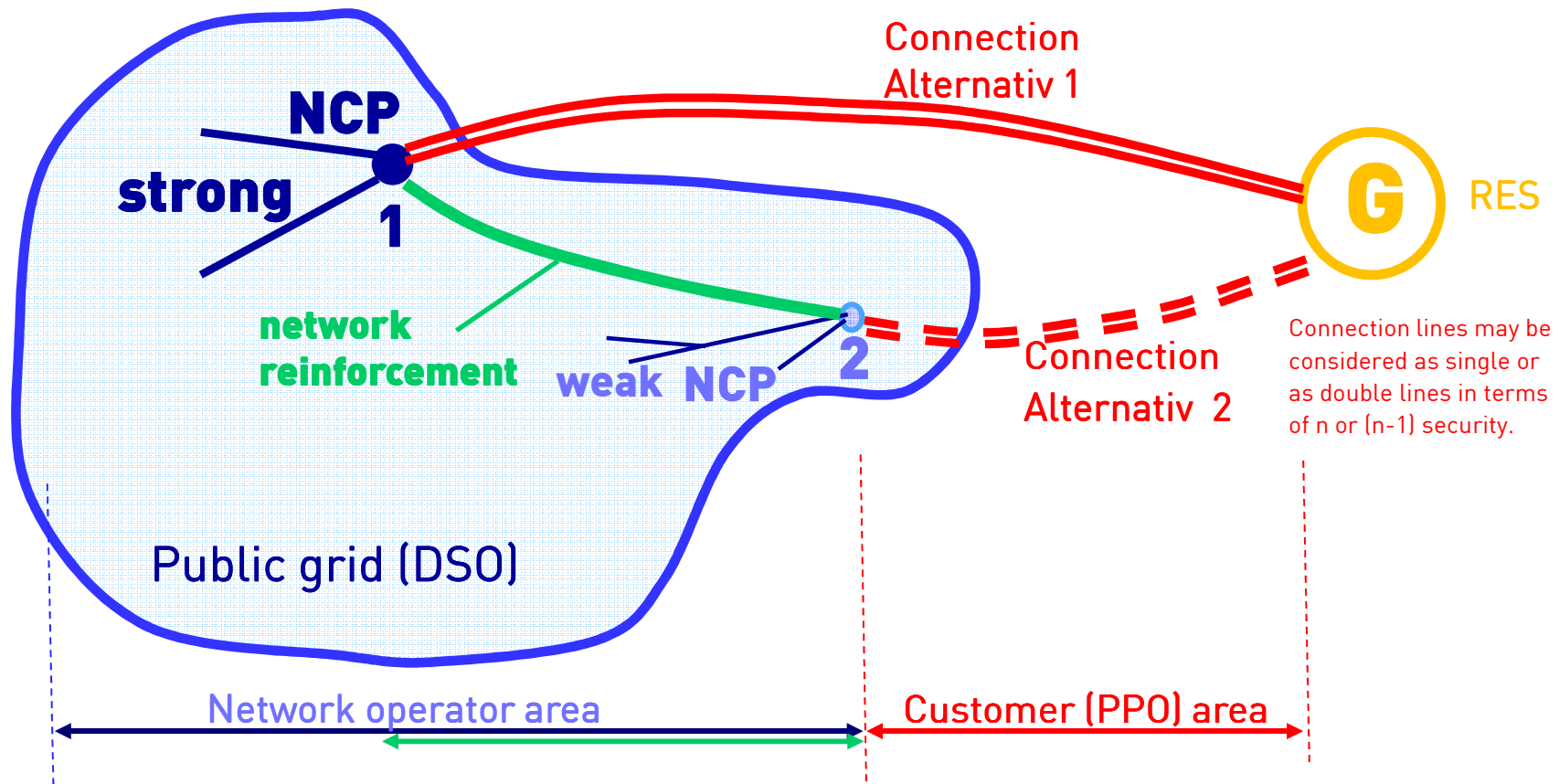
- ✓ Planned commissioning of the power plant
- ✓ Assignment for the accomplishment of network calculations (< 30 kW)
 - cost absorption declaration (blanket 1200 €)

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.

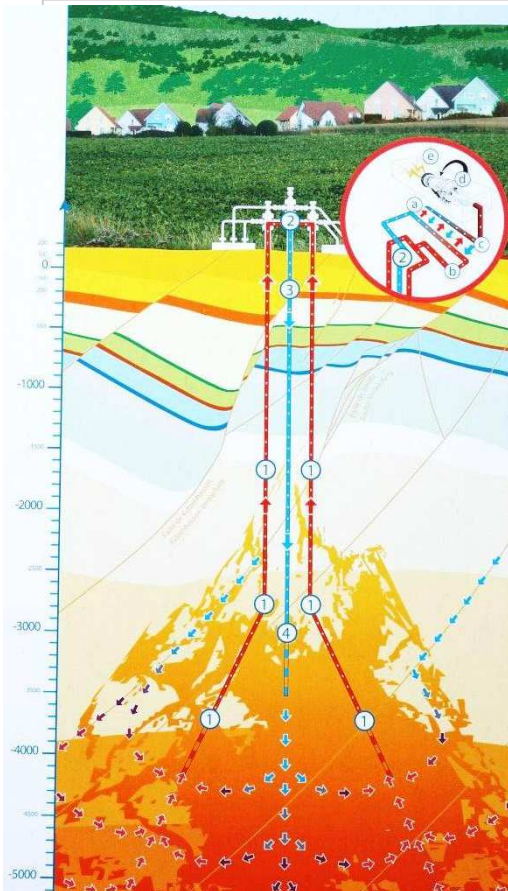
Determination of the Network Connection Point (NCP)

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

The Soultz Project Geothermal plant in the Upper Rhine Valley.



Exploitation of 1 production well, 5000 m , 200 °C hot rock, and 2 injection wells

Power plant with Organic Rankine Cycle (ORC) process, 1,5 MWe

The Soultz Project

Geothermal plant in the Upper Rhine Valley.

Technical components



separators

OCR process and components



technical facilities



generator (12.000 rpm) and gear box



long shaft pump

long shaft pumping motor



The Soultz Project

Geothermal plant in the Upper Rhine Valley.

Electrical connection scheme and supply devices



20 kV customer switchgear

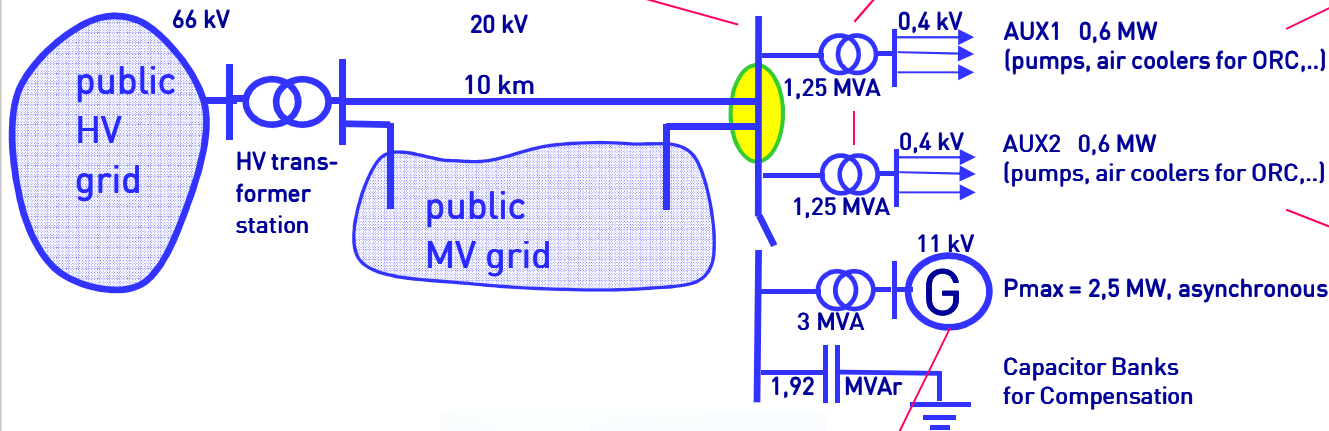
capacitor banks



20/0,4 kV transformer station



flywheels for stabilizing supply



Pumps ORC process

Network Connection Point (NCP).
Relevant for responsibilities and costs



11 kV Asynchronous generator (12.000 rpm) and gear box



control devices

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

Soultz Project

Generation

- Transformer generator 46 T€
- Switchgear equipment 68 T€

Auxiliaries.

- Transformer 93 T€
- Switchgear 112 T€

Compensation

- Capacitor banks 24 T€

Network Connection Point is in front of the site

- No construction subsidy for the network

Connection devices in general

- 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, power plant key figures, local infrastructure,.....

Plants bigger than approximately 20 MW connected to 110 kV, depending on network conditions

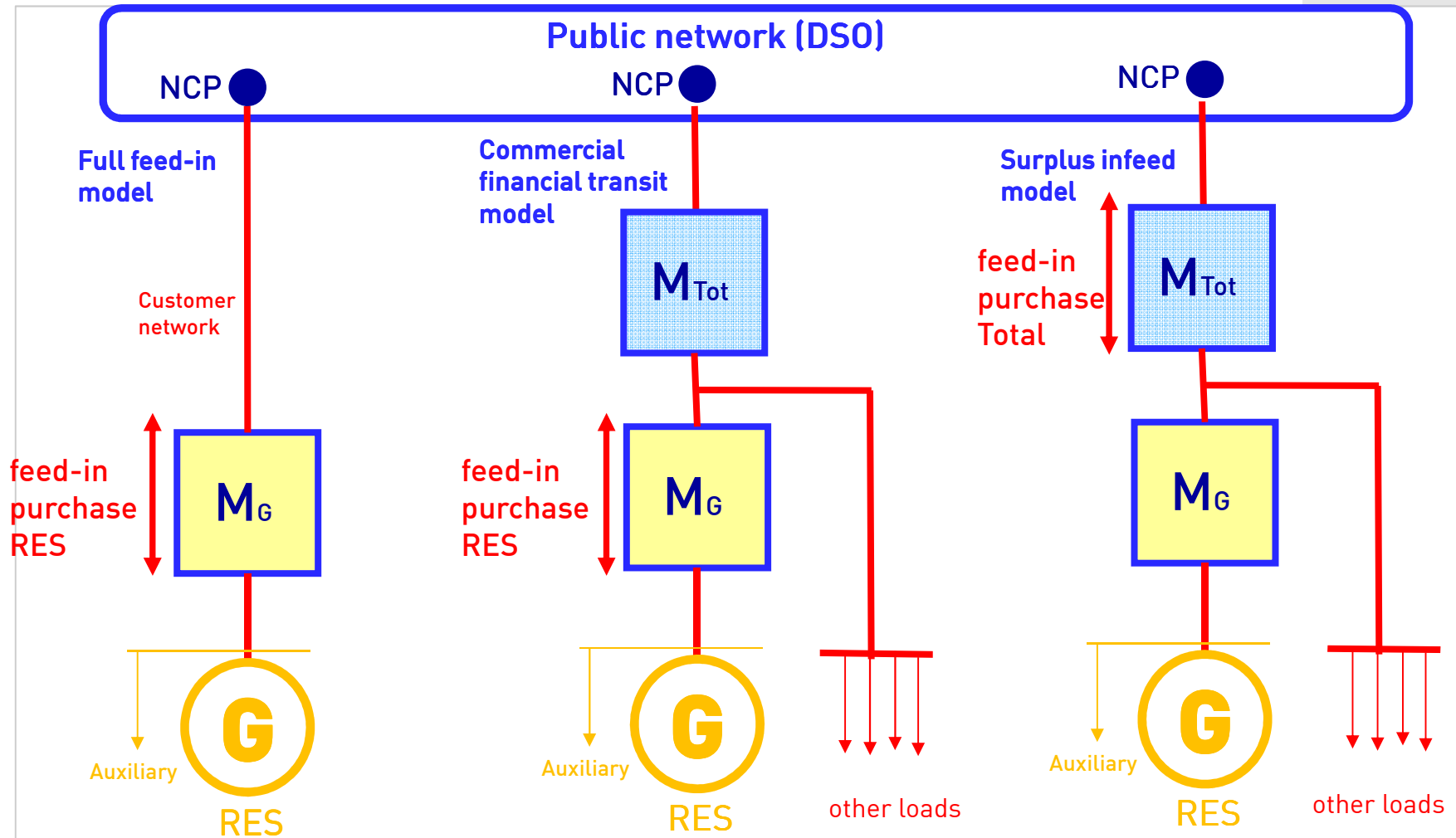
Checklist for documents required (categories) for application and commissioning of generating units



- ❖ 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 engineering 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 guidelines (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 complementary documents

Measurement concept and counting for the remuneration of RES

“Full feed-in”, „commercial financial transit“ and surplus feed-in“ model



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

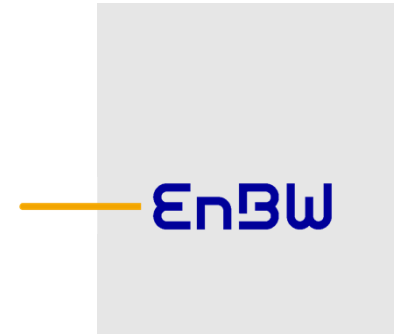
Commissioning protocol (form)

according to VDE-AR-N 4105

- Plant address, plant installer
- Max apparent power S_{max} , 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 U_n
- 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 P_{max}
- Carrier frequency locks are proved. Protocols
- Date of commissioning

Market and remuneration models

Choice of the power plant operator (PPO)



Remuneration models (Germany)

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

(In case of the Soutlz Project, the remuneration is 20 Ct/kWh)

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)

in 2009 total installed capacity
in 2013 total installed capacity

7.5 MW_{el}
forecast 30 MW_{el}

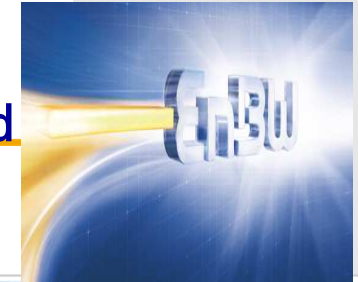
Potential up to 2030

200-500 MW ??

Uncertainties due to geological uncertainties and technical risks

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 enormous 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 through incentives



Geothermal generation and connection is no problem in general

- Potentials are relatively low compared to wind, PV and biomass from a today's 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

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Thank you for your attention

GEOELEC Training Course Potsdam
15.- 18. April 2013

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