Incentive regulation for network operators and the integration of distributed generation power plants: barriers and solutions

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Agenda

1. **Basics of incentive regulation**
2. What is distributed generation (DG)?
3. Barriers for DG integration within the incentive regulation regime
4. Solutions and approaches
5. Outlook

Regulation in a narrow sense

- Regulation in a narrow sense ("economic regulation") embraces
  - rates and tariffs
  - revenues and profits
  - quality of service and security of supply
- Technical, environmental and siting rules are not part of economic regulation

Why regulation?

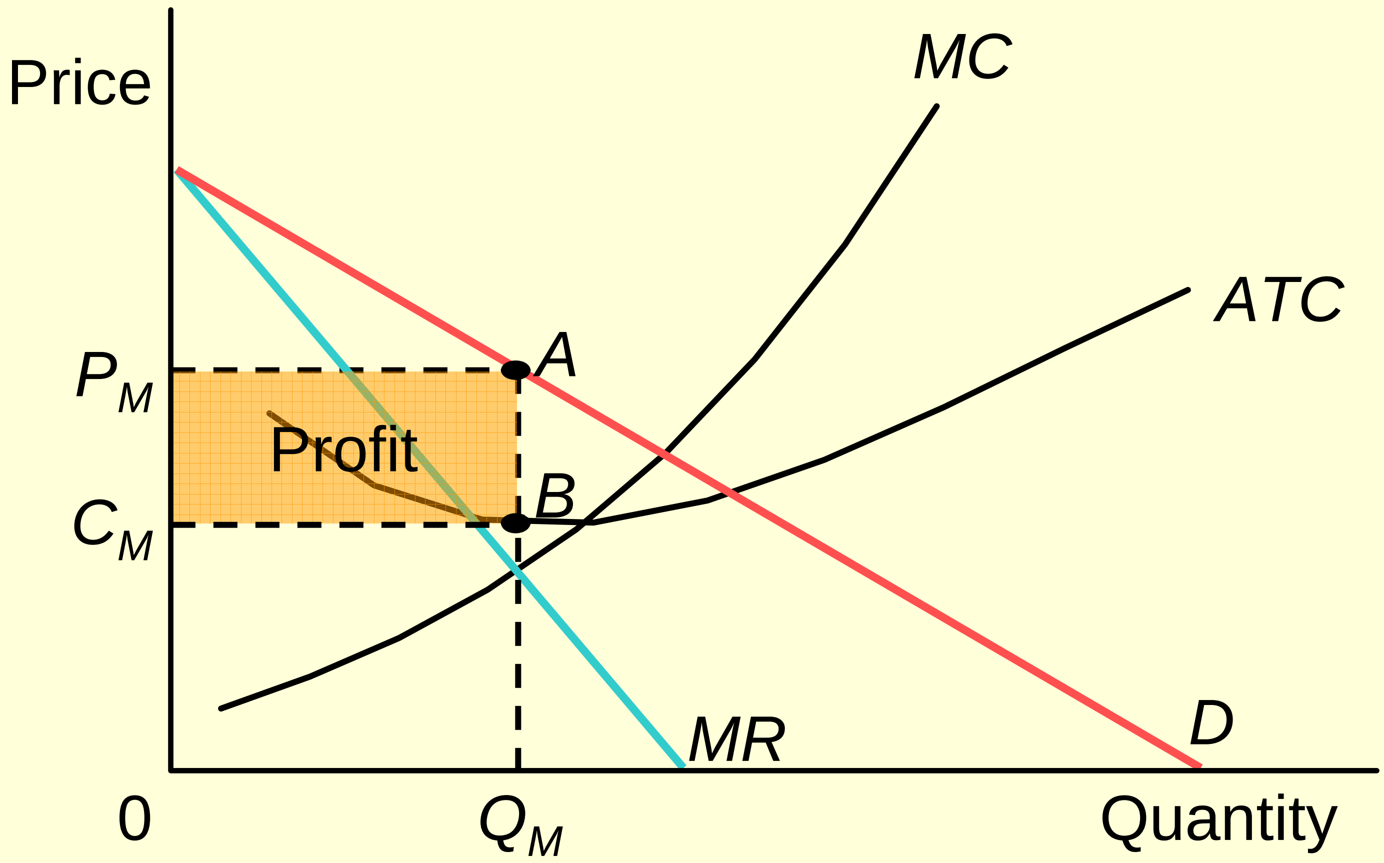
Natural monopoly is a market structure wherein a single seller (the natural monopolist) can, owing to the importance of economies of scale, supply the socially optimal quantity of output at the lowest possible total cost.

Electricity Networks are natural monopolies because

- the cost function is subadditive
- many network investments are irreversible

- A cost function is subadditive if $K(x) \leq K(\alpha_1 x) + K(\alpha_2 x) + ... + K(\alpha_n x)$ with $\sum_i \alpha_i = 1$ and $\alpha_i \geq 0$

Monopolies tend to take monopoly prices



Regulatory objectives

- general
  - economic efficiency (static and dynamic)
  - prevention of monopoly profits
  - administrative practicability and effectiveness
- specific
  - maintain the financial integrity of the network company if it is “good” managed
  - allow the recovery of “prudent” incurred costs
  - maintain security of supply

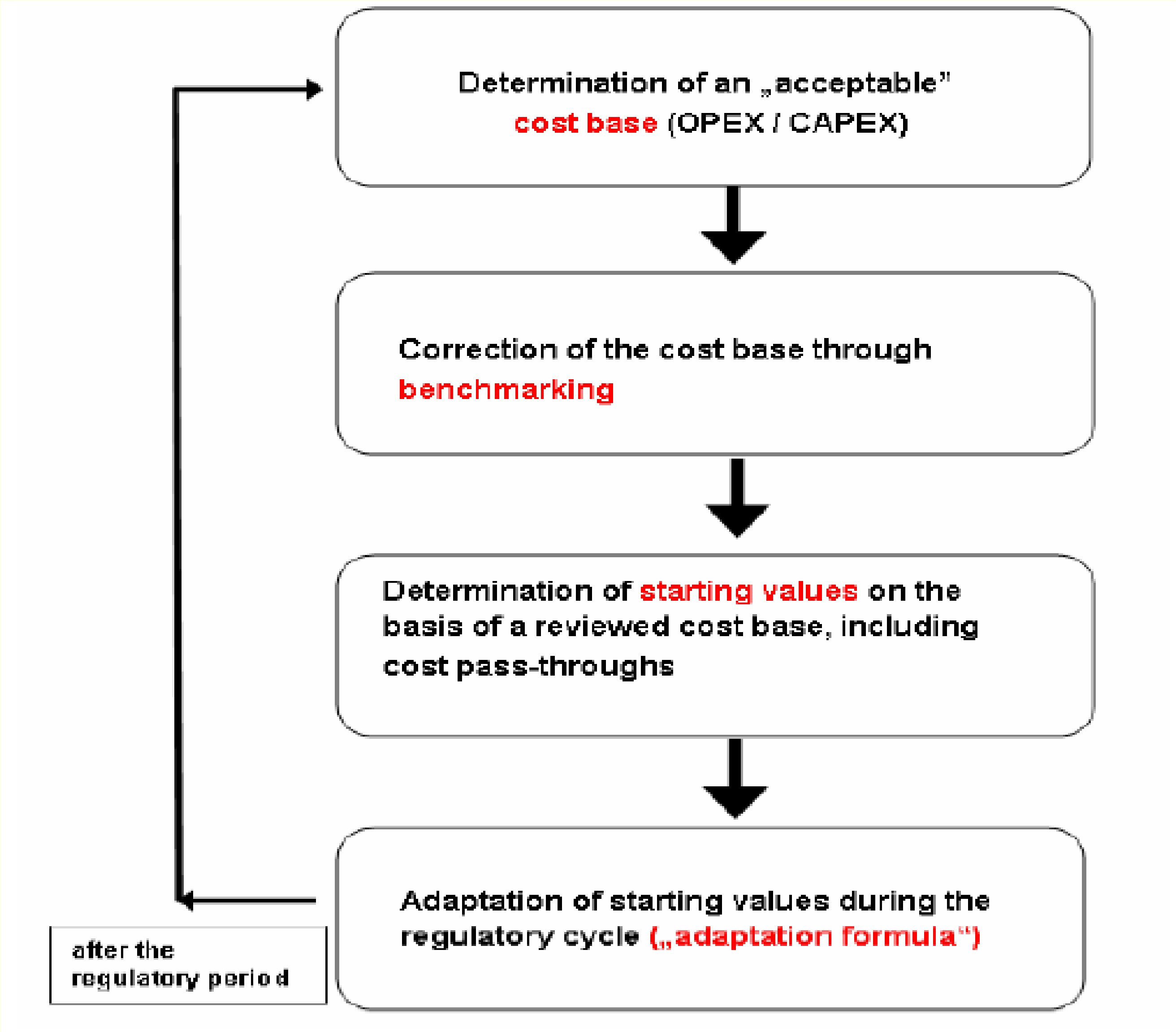
Main objectives of incentive regulation

decoupling costs from revenues

Close connected to this main objective are:

- efficiency incentives to the network companies
- the foundation of a regulatory cycle / regulatory period which provides reliability to the network companies for a certain period of time
- the relief of the regulatory authority from annual cost checks (“lean regulation”)

The logic of a regulatory cycle



The logic of a revenue cap

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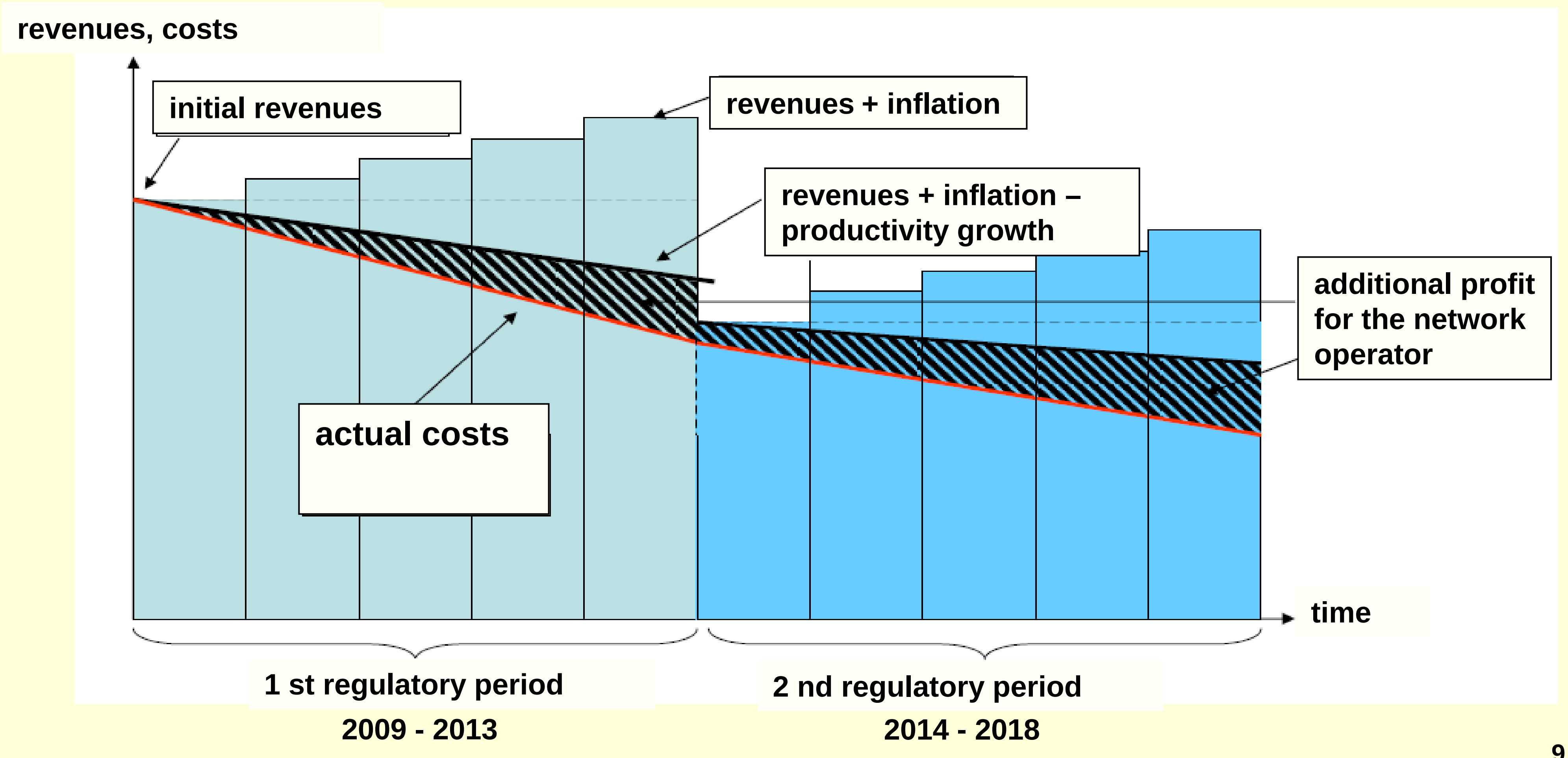
$$R(t) = R(t-1) * (1 + CPI - X)$$



Source: VIK 2005

Comparison of different regulation schemes

Regulation Scheme	Revenue Driver	Main Incentive	Other Aspects
Rate-of-Return (ROR)	distributed kWh; rate-base	maximise sales; maximise rate-base	no incentive for cost minimisation
Price-Cap (PC)	distributed kWh	maximise sales, minimise costs	security of supply in jeopardy
Revenue-Cap (RC)	distributed kWh	maximise sales, minimise costs	security of supply in jeopardy
Revenue-per-customer-cap (RPCC)	# of customers	maximise # of customers	incentive to minimise sales to customers
Multiple Driver Target (MDT)	multiple: peak load, grid length, ...	depends	high data requirements
Benchmarking	distributed kWh	maximise sales, minimise costs	security of supply in jeopardy

Main incentives of pure incentive regulation schemes

- cost minimisation
- volume maximisation
- negligence of service quality and reliability
- a preference for low network charges

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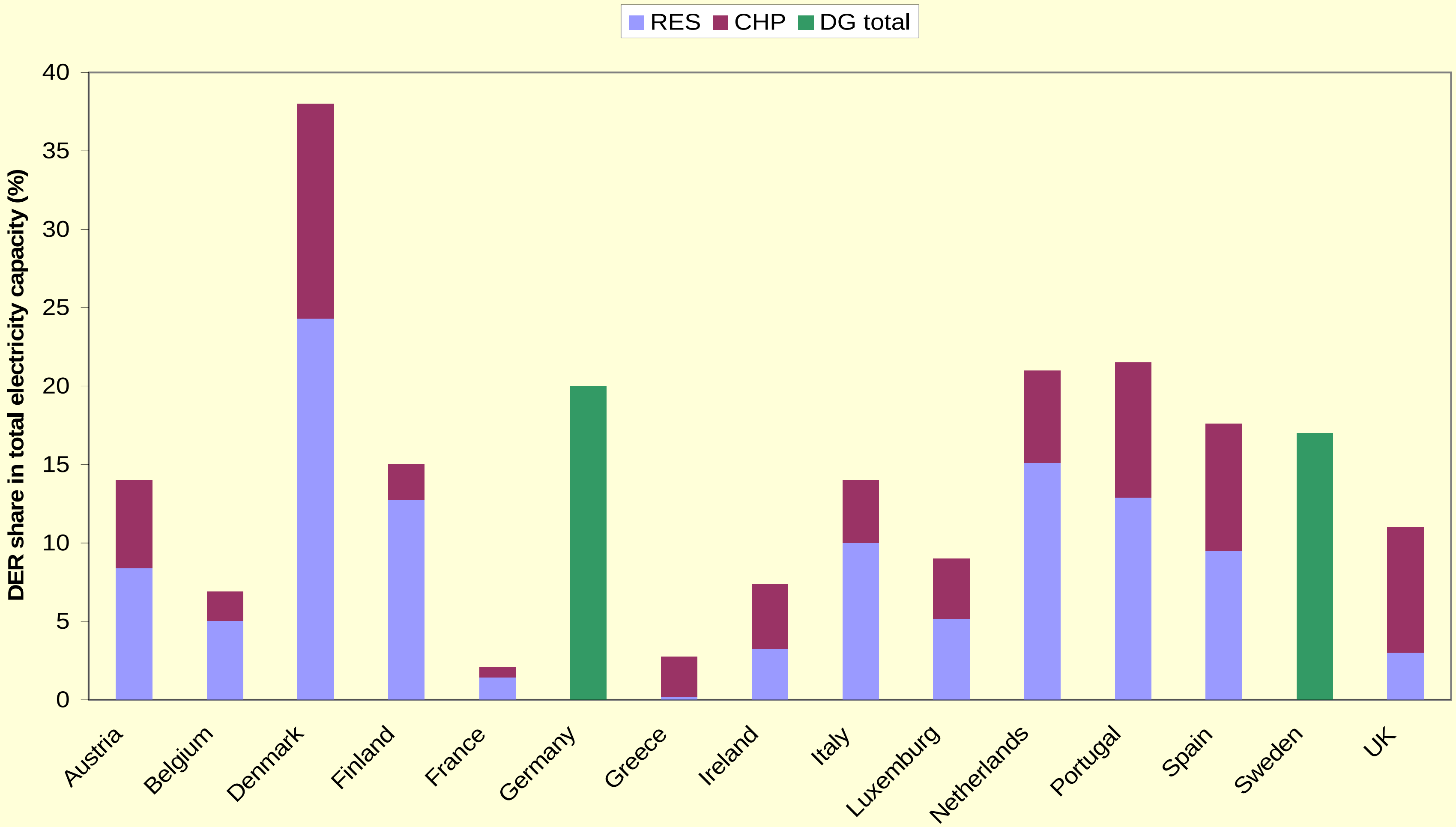
Distributed Generation (DG) Power Plants: Definition

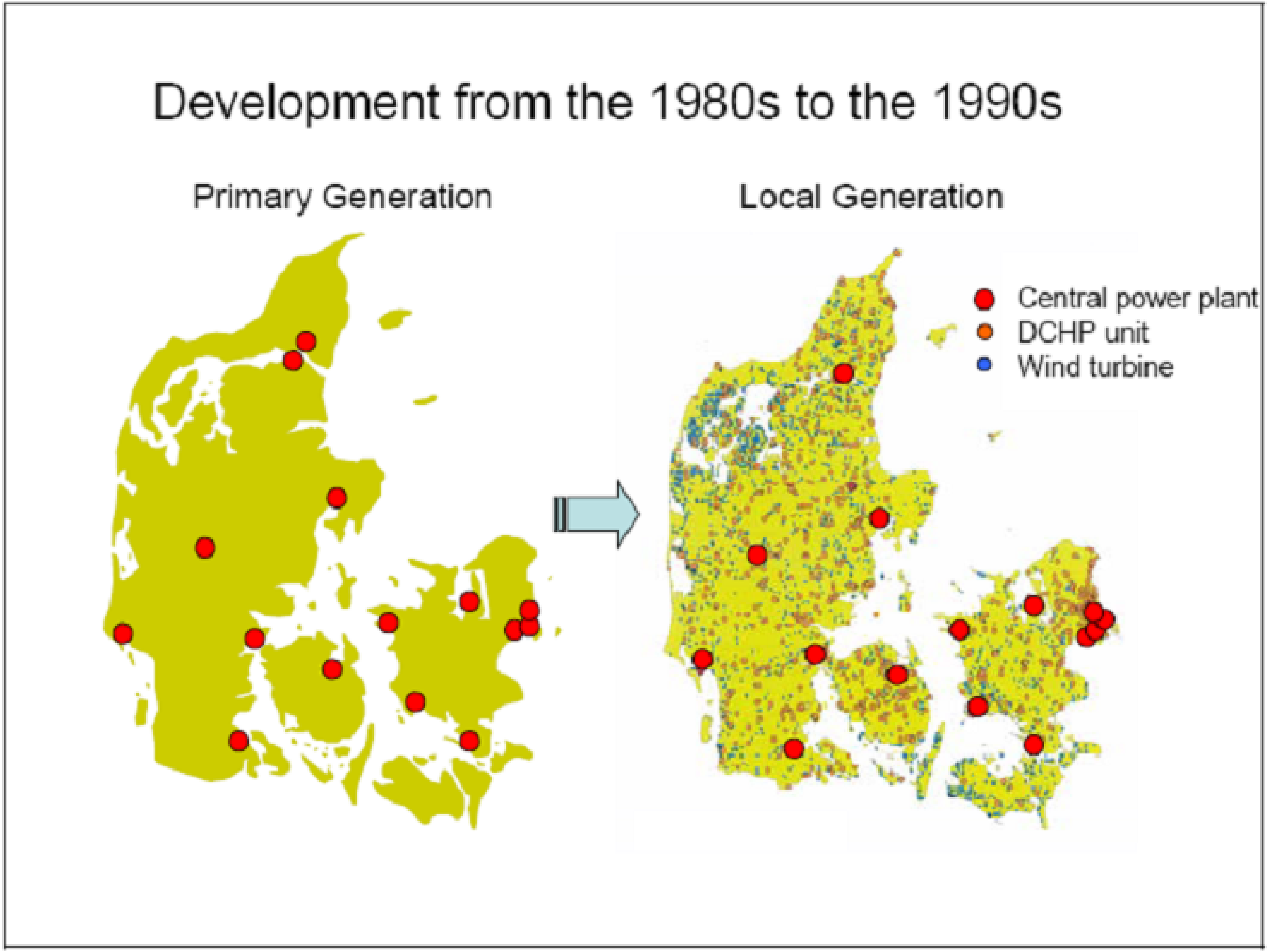
- are directly connected to the customer side of the meter <u>or</u>
- are connected directly to the distribution network (low or medium voltage level) <u>and</u>
- are located near loads/customers
- Examples: CHP plants; on-shore wind; PV; small hydro
- <u>not</u> DG: off-shore wind; solar thermal power plant parks

DG Share of total generation capacity in 2005 in Europe



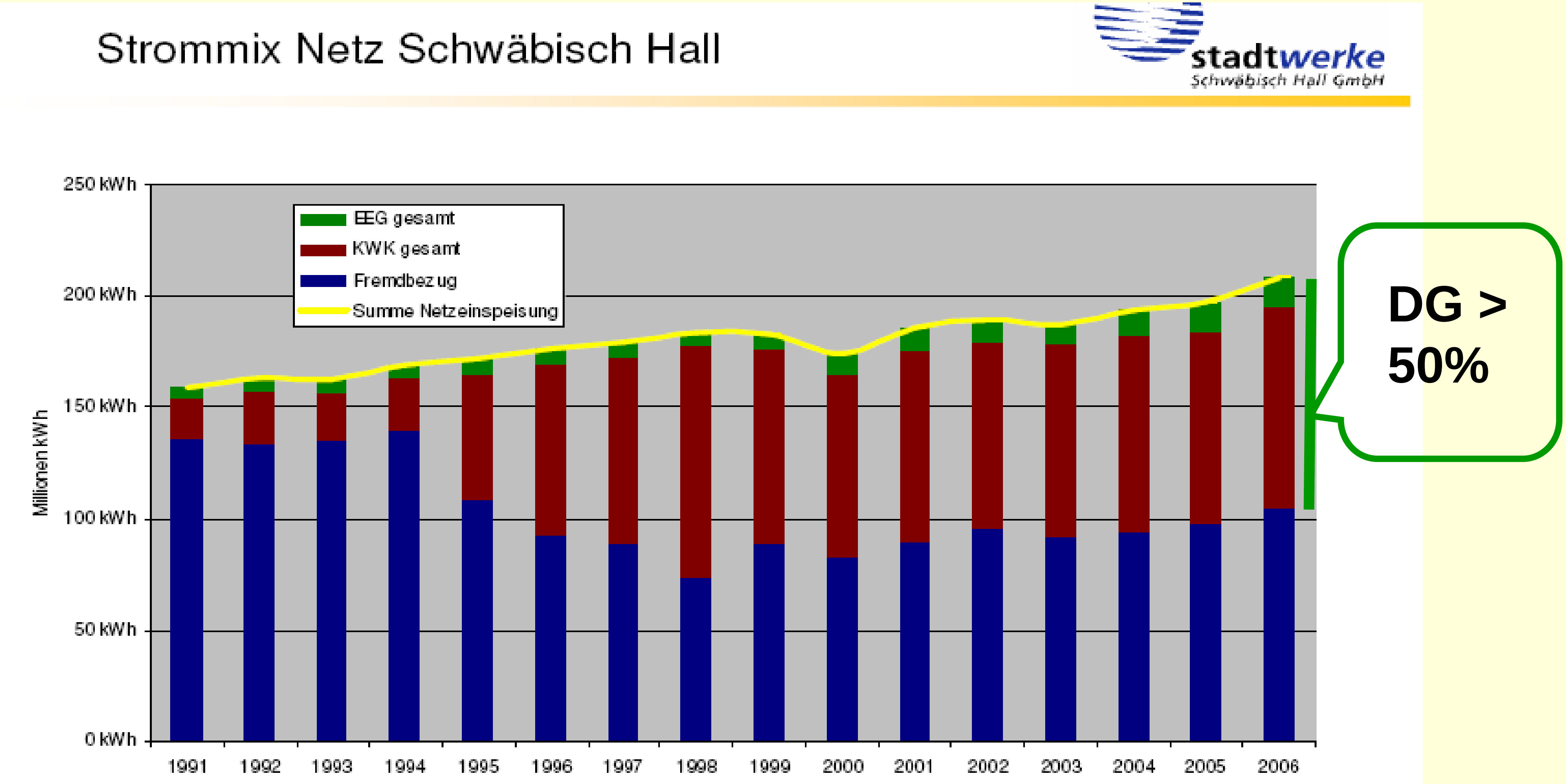
Source: DG Grid 2007

The growth of DG in Denmark



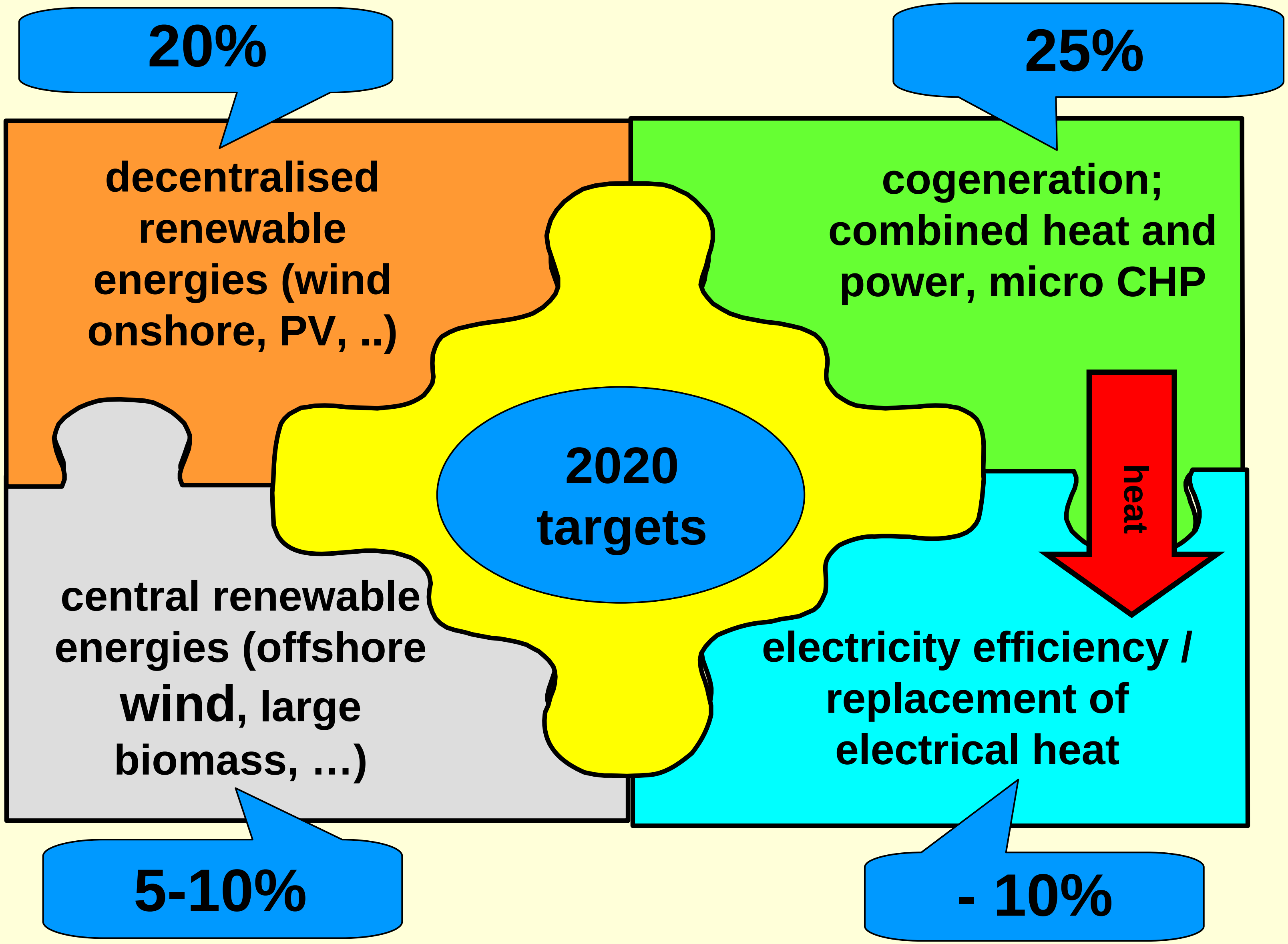
Source: Eltra (now energinet.dk)

Example of a DG oriented German municipal utility



Source: van Bergen 2007

Meseberg decisions of the German government in 2007: electricity targets



The economic benefits of DG (1)

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- Potential network-related benefits
  - distribution capacity cost deferral
  - operational cost savings, especially reduction of line losses
  - reliability improvement
- Potential energy-related benefits
  - Contributions to (peak) load reduction, backup capacity and balancing power
  - flexible option values
    - improvement of security of supply
    - avoidance of overcapacities

The economic benefits of DG (2)

have to be analysed with respect to

- a single plant vs. millions of plants
- short-term vs. long-term benefits
- controllable vs. intermittent load supply
- benefits to the distributed generator, to the DSOs, the customers or the society as a whole

Overall the benefits depend on technologies, sites and specific situations.

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Barriers of network connection

- **Legal options to refuse connection**
  - if the DG plant does not meet the technical requirements ➔ grid code design
  - if the costs are "too high" / not "just and reasonable" ➔ design of the incentive regulation regime

- **High costs to prohibit connection economically**
  - locational signals / what is the "optimal" connection point from an economic point of view, and who decides?
  - method of connection charging

Barriers of network access

- **Not sufficient network capacity available?**
  - Which plants must close down first? (Germany: absolute priority access for renewable energies, even with respect to CHP)
  - Who pays if the plants have to close down?
  - Can connection of renewable plants be refused if the plant operators do not sign contracts that allow for automatic plant control as part of the network management of the DNOs?
- **“Slow” network operators?**
  - Who controls whether network operators are too slow? What is “too slow”?
  - Are there penalties for the DNOs if the network was not reinforced/upgraded “early enough”? What is “early enough”?

Barriers of network usage

- Do the DG plants have to pay network charges? (Not in Germany!)
- Does the regime of fixing the network charges allow for
  - the recovery of costs associated with the connection of new and existing DG plants (one-time and continuous costs)
  - the consideration of adequate structural parameters in the benchmarking procedure
  - the approval of costs associated with a good service quality for DG plant operators?

➔ Does the incentive regulation regime neutralize any negative incentive that the DNOs might have towards the connection of DG plants in their network territories, and does it even give some positive incentives to encourage further expansion?

The costs of DG (1)

- network-related costs
  - connection costs
  - costs for network upgrade and extension
  - metering costs
  - transaction costs

- energy-related costs
  - reserve costs (plant reserve, network res.)
  - balancing costs
  - control costs
  - costs for other system services

The costs of DG (2)

Some of the mentioned benefits of DG could in fact be costs especially in the short run:

- Induced network extension costs instead of capacity cost deferral
- Higher line losses (e.g. wind parks)
- Higher operation and maintenance costs
- Less reliability

Barriers with respect to network optimization

DIRECTIVE 2003/54/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 26 June 2003

concerning common rules for the internal market in electricity and repealing Directive 96/92/EC

Article 14

Tasks of Distribution System Operators

7. When planning the development of the distribution network, energy efficiency/demand-side management measures and/or distributed generation that might supplant the need to upgrade or replace electricity capacity shall be considered by the distribution system operator.

- **How to „consider“ DG plants within the network management of the DNOs?**
  - **How to use DER (distributed energy resources) to enhance existing network capacity?**
  - **How to create a “level playing field” for DER and network extension options?**
- **How to incentivise the DNOs to consider DER in their planning process?**

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DG related regulatory objectives

- non-prohibitive connection charging
- proper allocation of DG costs and benefits
- neutralisation of any bias in favour of centralised power generation
- neutralisation of the volume maximisation incentive
- optimisation of the network with regard to local/regional DG potentials

Network access and connection charges

- DG usually should have priority access to the network for reasons of investment security, low transaction costs and the acknowledgement of DG system benefits
- Shallow connection charges encompass only the direct costs of connection; costs for possible network reinforcements and upgrades are socialised among the network users and paid through the network charges.
- Shallow connection charges seem to be the best economic signal for DG integration in order to
  - keep the barriers to entry as low as possible
  - keep the calculation simple and transparent
  - lower transaction costs to DG plant operators

Guidelines for setting up DG connection charges

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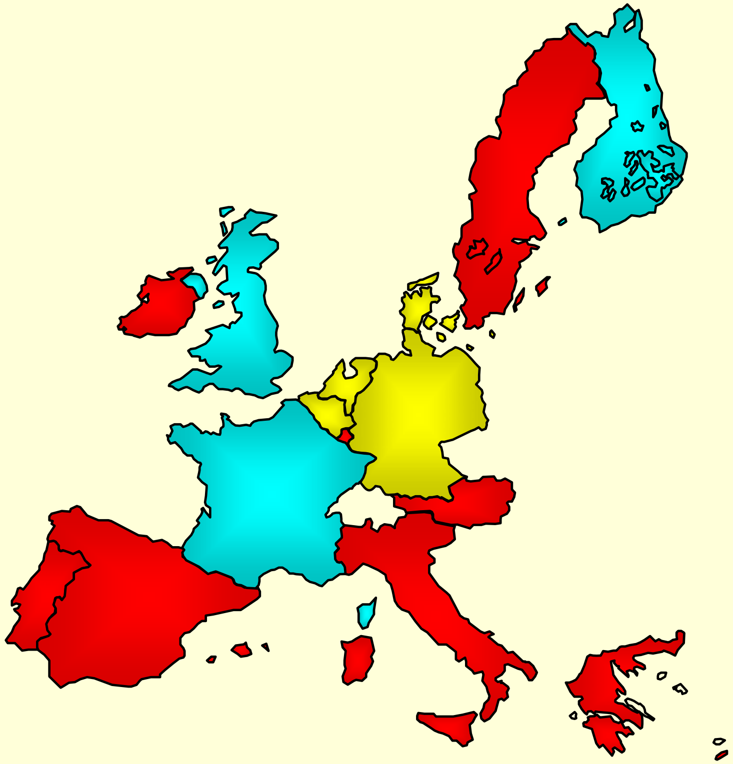
Choose shallow connection charges and individual entry charges which

- give incentives to select the optimal location in the network
- have to be considered in the calculation of the network charges (their balance)

The difference between shallow and deep connection charges should be socialised (part of the network charge).

Connection charging in Europe



Predominant Charging Philosophy

- Deep
- Mixed or no standard
- Shallow

Charging Method	Summary
"Shallow"	Generator pays only for the cost of equipment needed to make the physical connection to the grid. Costs of reinforcement are borne by DNOs.
"Deep"	Generator pays all costs associated with its connection. Includes the cost of physical connection to the grid and any upstream grid reinforcement costs.

Source: Knight 2006

Connection charging methodologies

Charging Method	Summary	Advantages	Disadvantages
"Shallow"	Generator pays only for the cost of equipment needed to make the physical connection to the grid. Costs of reinforcement are borne by DNOs.	• Lowest cost for DG & RES • Transparency & consistency • Reinforcement costs can be recovered via tariff system	• Poor locational signals • DNO reinforcements can add project delays
"Deep"	Generator pays all costs associated with its connection. Includes the cost of physical connection to the grid and any upstream grid reinforcement costs.	• DG & RES generally don't pay UoS charges • Provides a degree of locational signal	• Cost uncertainty, often prohibitively high for DG/RES • Significant DNO power • One generator can pay for reinforcements caused by others
"Mixed"	Generator pays for the physical connection to the grid, plus a proportion of any upstream grid reinforcement costs based on its proportional use of new grid assets	• Reinforcement costs paid by generator relate to his use of the new connection assets • Provides some locational signals to generators	• Clear rules needed to determine proportional costs • Reliant on DNO to perform upstream reinforcements • Costs can still be high for DG
"True"	Generator pays a cost equivalent to the cost of connecting to the nearest point on the grid with sufficient capacity to accommodate the generator without reinforcement	• Provides some locational signals to generators	• Connection costs potentially very high (especially for remote wind farms, etc)

Source: Knight 2006

Network usage and use-of-system charges (UOS)

- Network or Use-of-system charges are the main revenue source for DNOs and hence the key for their economic incentivisation
- The regulation of UOS charges should incentivise active network management by integration of DG through
  - recovery of costs associated with DG
  - correction of simple benchmarking procedures
  - acknowledgement of service quality to DG plant operators
- UOS charges for DG plants could be an instrument to give economic signals to them with respect to location and time of use

The German regulation formula for DNOs

$$EO_t = KA_{dnb,t} + (KA_{vnb,0} + (1 - V_t) \cdot KA_{b,0}) \cdot \left(\frac{VPI_t}{VPI_0} - PF_t \right) \cdot EF_t + Q_t$$

- in the cost factors (KA) the costs associated with new and existing DG plants should be included
  - CAPEX: network reinforcement costs
  - OPEX: contractual costs, transaction costs, control costs, ..
- in the individual efficiency factor V the number and size of DG plants should be reflected
- in the quality factor Q costs of a good service quality for DG plant operators could be approved

Recovery of costs associated with DG

- Target: Recovery of all those costs that are necessary for an efficient network operation
- Solution: Calculation and approval of lump-sum costs associated with DG that were estimated with regard to efficient solutions
- Example UK: approval of 1,5 £ / kW and year for new DG power plants in the network territory in addition to the revenue cap (plus 1 £ / kW and year for maintenance)
- First estimates for Germany: unique costs between 1.000 and 10.000 Euro/plant and continuous costs between 5 and 10% of the initial costs

Advantage of lump-sum cost recovery: preservation of the efficiency incentive

The expansion factor (EF)

Changes within the regulatory period caused by the expansion of the supply function are taken into account by applying expansion factors when calculating the revenue cap

- size of the area supplied / of the geographical area
- number of connection points per network level
- load per network level

Solution for DG: include the connected load per network level of DG power plants in the list of approved expansion factors

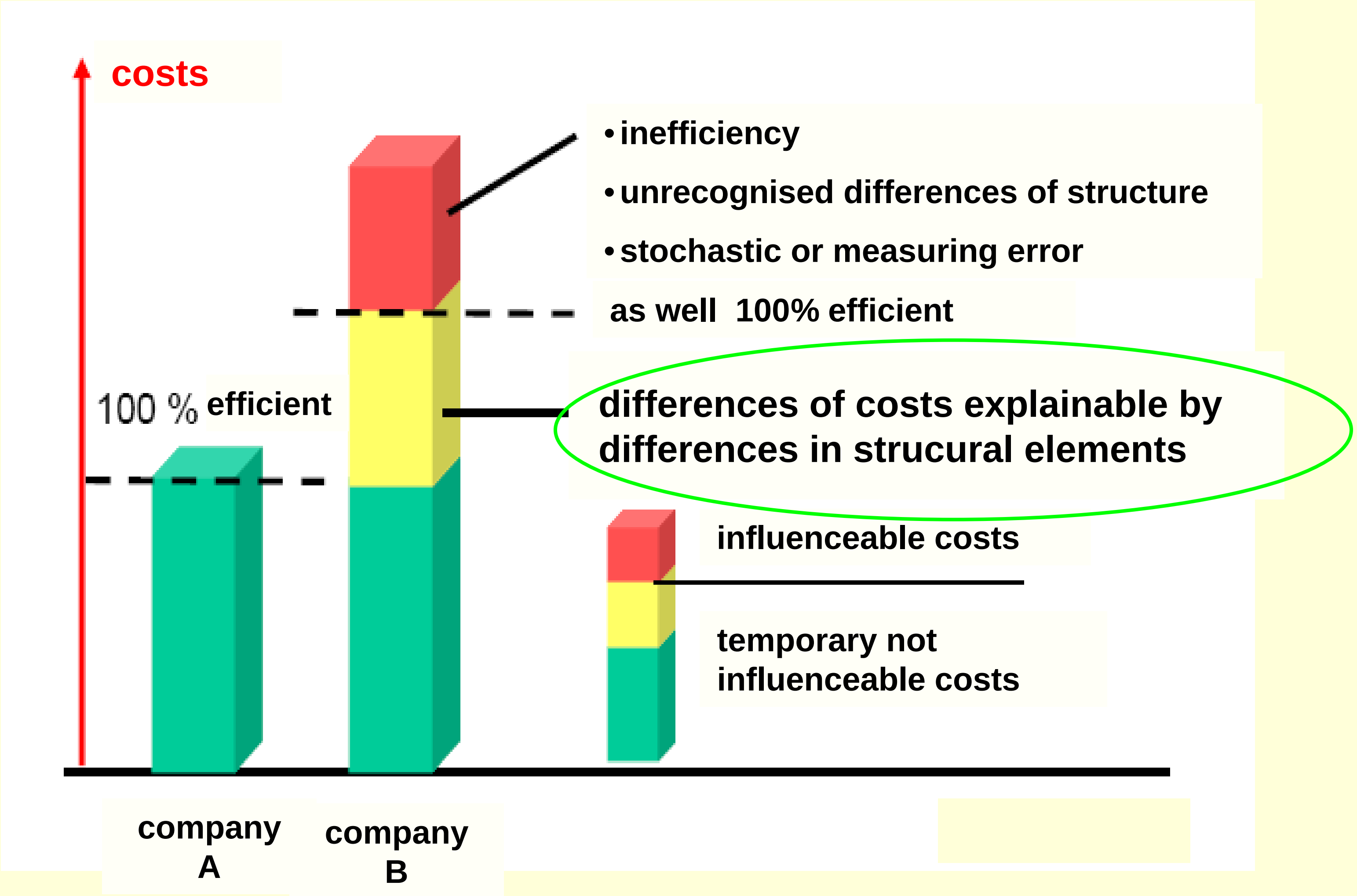
The regulatory account

The regulatory account

- is included in one of the cost factors in the formula
- balances the volume fluctuations across regulatory periods
- especially neutralises volume reductions through
  - customer movement
  - auto-production
  - (stand-alone) areal networks and micro-grids
  - enhanced electricity efficiency activities by the customers

The regulatory account is thus an important element in trying to neutralise the DNOs towards DG power plants in their network territory.

Benchmarking and structural elements



Structural elements and DG

In a benchmarking procedure comparing different DNOs some of the cost differences can be explained by structural elements like

- number of connection points
- geographic area
- grid length
- synchronised annual load

The list of approved structural elements should be completed by the connected DG load per network level in order to improve the benchmarking results.

Quality regulation

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… as the twin of incentive regulation with four dimensions

Safety	Preventing damage/injuries to people and property of a third party (technical safety)
Product quality	Technical minimum requirements for transmitted energy (e.g. voltage fluctuation; Wobbe index)
Network reliability	Ability of a supply network to deliver energy without interruptions
Service quality	Relationship between system operator and network customer (e.g. complaints management)

Quality regulation and DG

Include a bonus payment in the revenue cap formula if the DNO

- enhances "decentralised efficiency" through e.g.
  - increasing the amount of DG load covering the annual network load
  - minimising the connection capacity of the upstream network
  - increasing network reserve capacities through DG
  - etc.
- provides "good service" to the DG plant operators as network customers

Innovation: The role of network regulation

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- Innovation necessary to – efficiently – accommodate a rising share of DG
- DNOs have a role to play in developing these innovations
- DNOs have mainly been low risk and low innovation businesses
- At the moment many regulatory approaches hamper innovations
- Regulator needs to provide incentives for innovations

Innovating regulation

- How can regulation develop appropriate instruments and become more innovation and future-oriented?
- Short-term solutions should be compatible with possible long-term developments
- ->Development of a regulatory scenario with a shared vision

Regulatory innovations in the UK

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Distributed Generation Incentive

.... to encourage efficient investment in DG connections and to be proactive

- Allowed pass through of 80% of costs
  - Recovered over 15 years
- Recover £1.50 / kW connected / year
  - For 15 years (assumes connection cost £50/kW)
- £1 / kW ongoing Operation and Maintenance cost allowance
  - To 2010 (reset at DPCR5)

ofgem

Registered Power Zone

....to encourage development of, more cost effective ways of connecting and operating generation

- Additional £3 / kW / year for five years
- Must demonstrate innovation
- Two applications per licence - £2.5m max over five years

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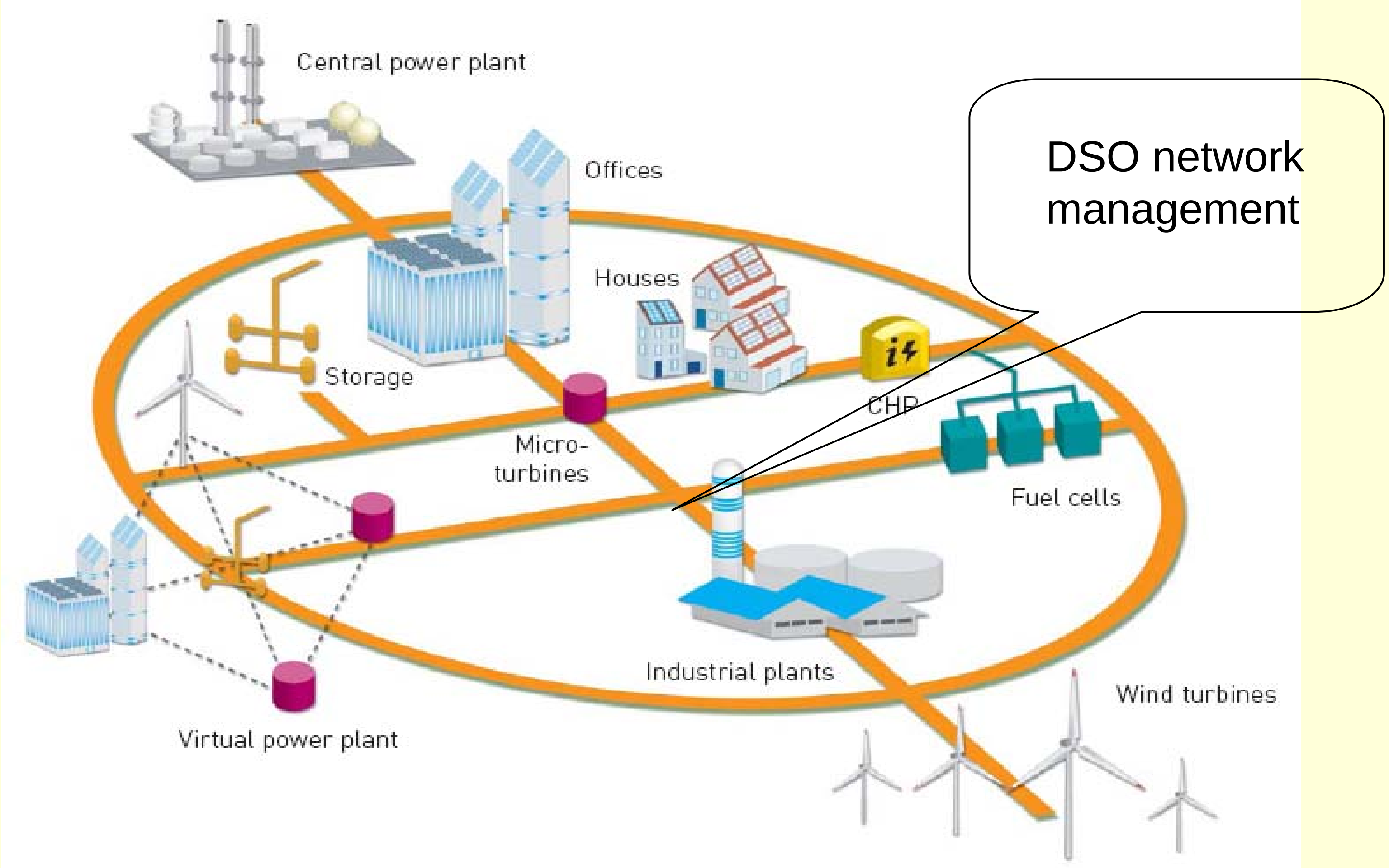
The distribution system operation might become a real challenge



Source: EU „Smart Grids“ 2006

An „active“ distribution network operator (DNO) (1)

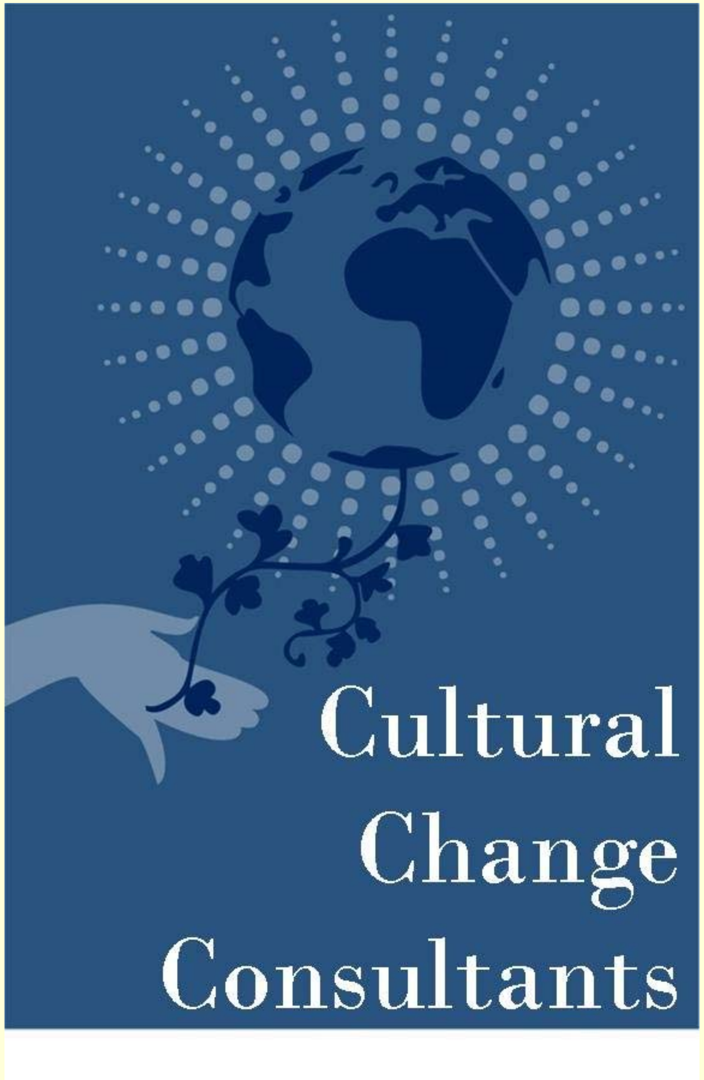
- should be considered as a highway operator who provides connectivity between generators and customers
- should design and operate its network in an economic optimised way (short run/long run)
- should provide correct price signals to generators and customers
- should interact with its customers through IC technologies

An „active“ distribution network operator (DNO) (2)

- will be a decentralised “energy manager” between supply and demand
- will take over responsibilities for system services
- can be a partner for DG operators who want to participate in the system services markets
- will initiate and support economically viable decentralised supply and grid solutions
- can be an efficiency partner for end use customers

Finally …

Beside the economics: to become an active distribution network operator is a cultural challenge as well !



Thank you very much for your kind attention !

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