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Market design alternatives for a smart electricity market

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Motivation

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- Problem:
  - Increase of generation from RES, esp. wind power, that lead to frequent grid congestions

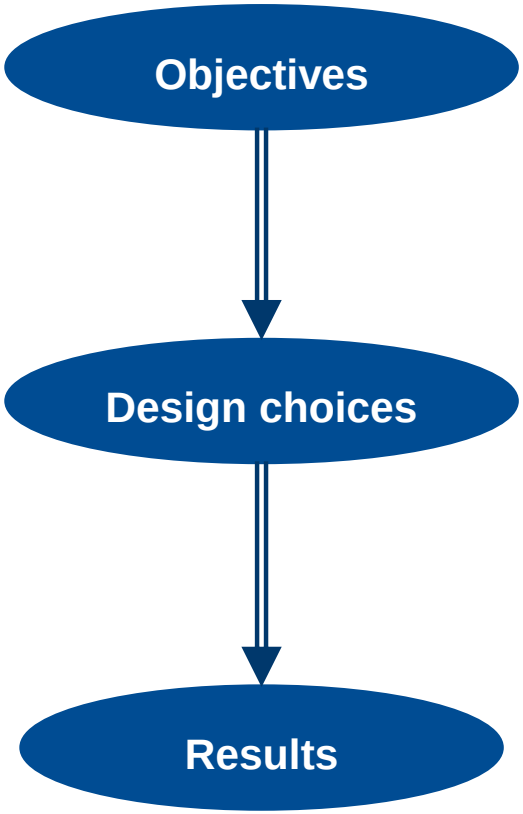
- General Solutions:
  - Grid extensions
  - Curtailment of wind and solar power: “Einspeisemanagement” (EiSMan)
  - Smart grids/markets

- The latter option is expected to enable large scale renewable additions at lower overall costs

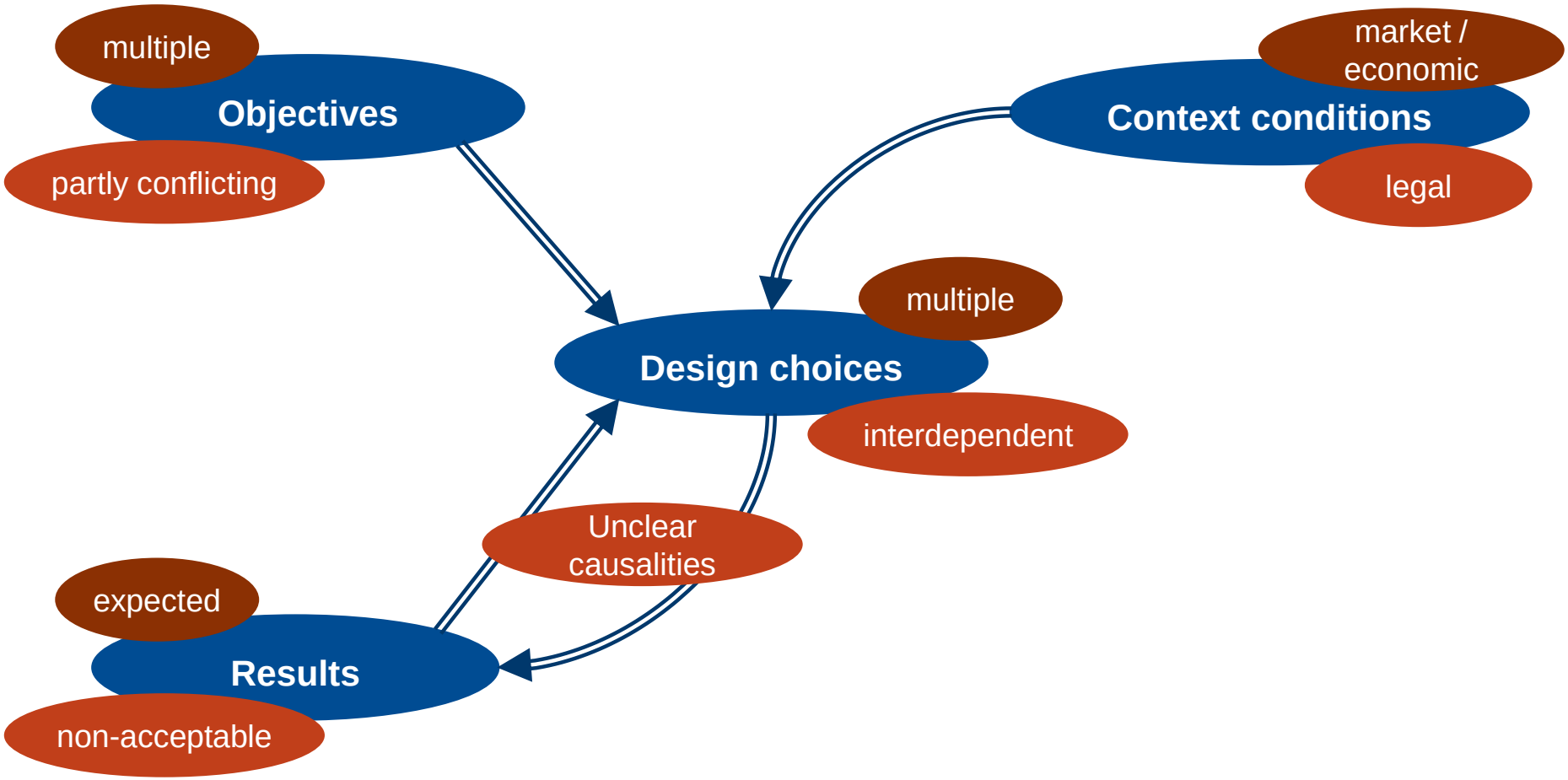
➢ Obvious solution?

➢ No! Details matter!

Market Design – the idealistic view



Market Design – the realistic view



Key Objectives for a "Smart Market"

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1. **Integration (of large amounts) of renewables into the energy system**

2. **Focus on regional grid bottlenecks and there contribution to grid congestion management**

3. **Efficient solution, i.e. more cost-effective than grid expansion and conventional infeed management**

➢ All objectives are necessary conditions for success

Key Context Elements

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- **Existing national (and European) electricity markets**
  - **Law of one price**
- **Existing regulations on renewable support**
  - Infeed tariff and in the future procurement auctions
  - **Infeed management and compensation rules ("Einspeisemanagement", EEG §11, §12)**
- **Existing grid tarification rules**
  - Two-part grid tariffs for larger customers: capacity and energy charge
  - Special rules for energy intensive consumers (StromNEV §19)
- **Existing revenue regulation for grid operators**
  - Incentive regulation, cost-pass-through regulation

Market Design Choices

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- **What?**
  - Energy (MWh) or Capacity/Reserve (Option, MW) products
  - Active power or Active + Reactive power
  - Regional granularity
  - Temporal granularity (of the delivery period)
- **Who?**
  - Mandatory or optional participation
  - Unilateral or bilateral market (only grid operators or all participants demand)
- **How?**
  - Day-ahead or/and intraday or/and …
  - Auction(s) vs. continuous trading or hybrid solution
  - Financial vs. physical products (Futures/Options vs. Forwards vs. Spot)
  - Complex/smart bids vs. simple bids (simple price-quantity-combinations)
  - Extent of the integration with current market platforms (e. g. EPEXSpot)

Key design choice

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- **Regional Market**
  - **i.e. market with specification of infeed / outtake localization at a subnational level**

- Justification
  - **Without regional products no contribution to grid congestion relief**

- Implication
  - **Link of regional market to national/international market key for efficiency**
  - ➢ **Law of one price**

Law of one price

Assume

- **different prices** for a single identical good in **two locations**
- no transport costs and
- no economic barriers between both locations.

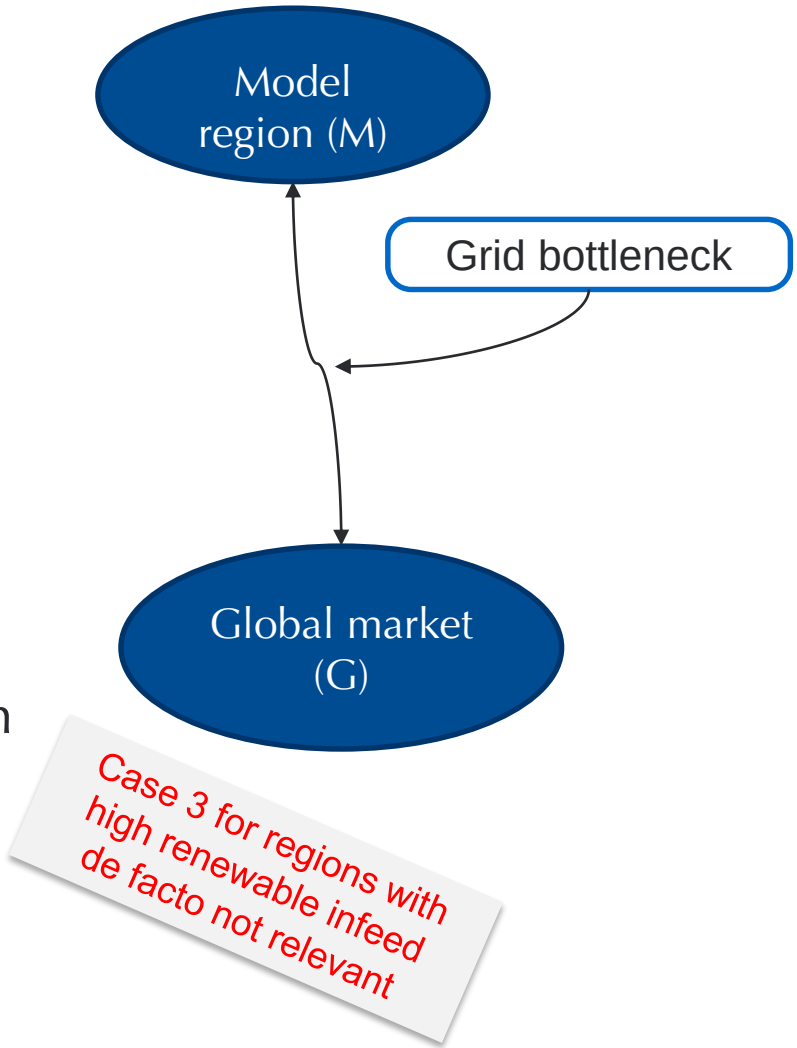
- **Arbitrage**
- All sellers have an incentive to sell their goods in the higher-priced location
  - Supply increases there and prices go down
  - Supply decreases in the lower-priced location and prices go up
- For buyers the opposite holds
- Only a **single price** is a plausible (or rational) economic outcome

Law of one price + two stylized regions

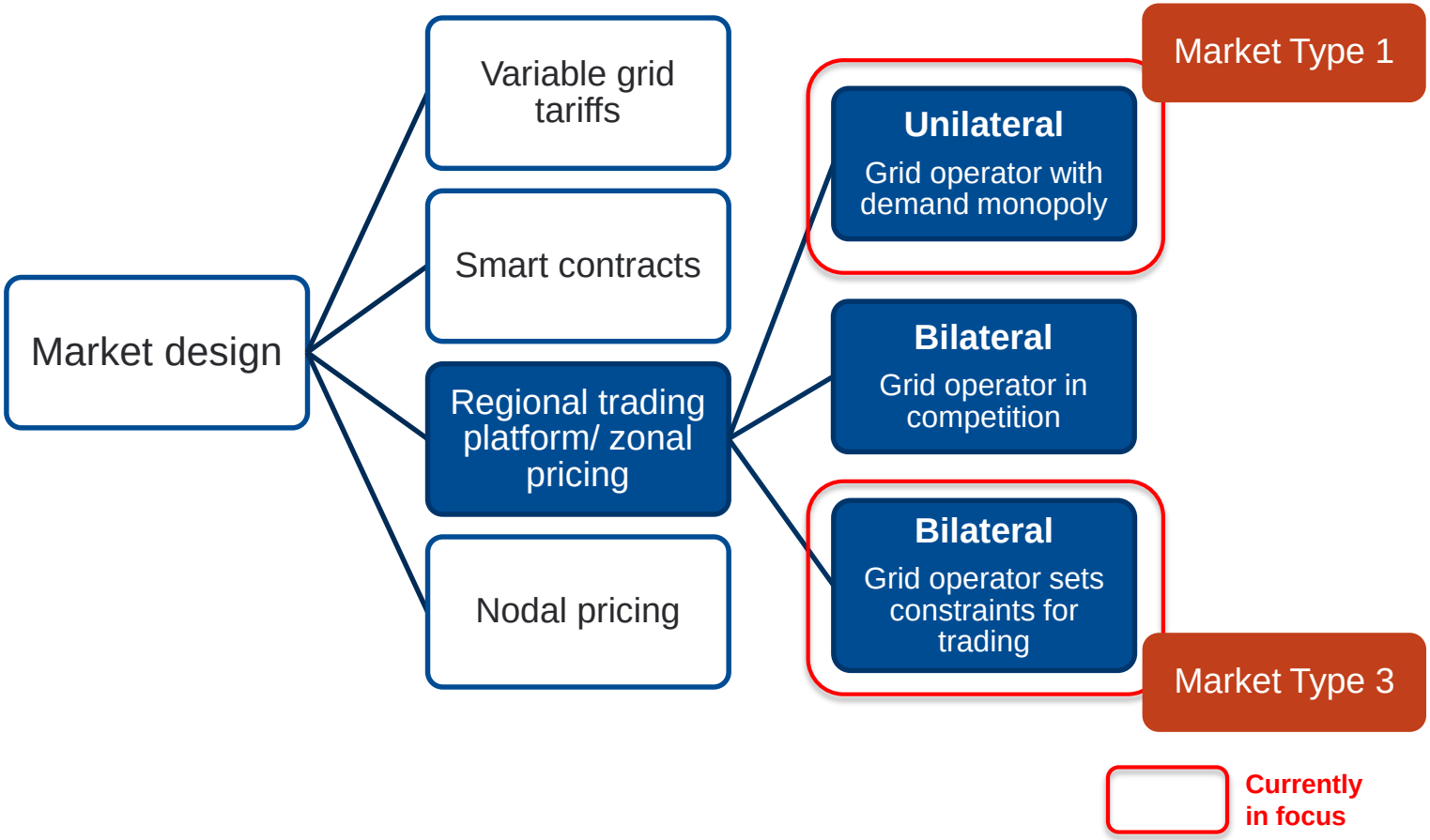
- 1st case: grid bottleneck not binding
  - no limitations to exports/imports
  - No limits to arbitrage
  - Law of one price applies

- 2nd case: excess feed-in in model region
  - Exports out of model region constrained
  - Technical barrier to trade
  - Law of one price does not apply

- 3rd case: excess demand in model region
  - Imports into model region constrained
  - Technical barrier to trade
  - Law of one price does not apply



Key alternative market designs



Market Type 1: Unilateral – Grid operator with demand monopoly

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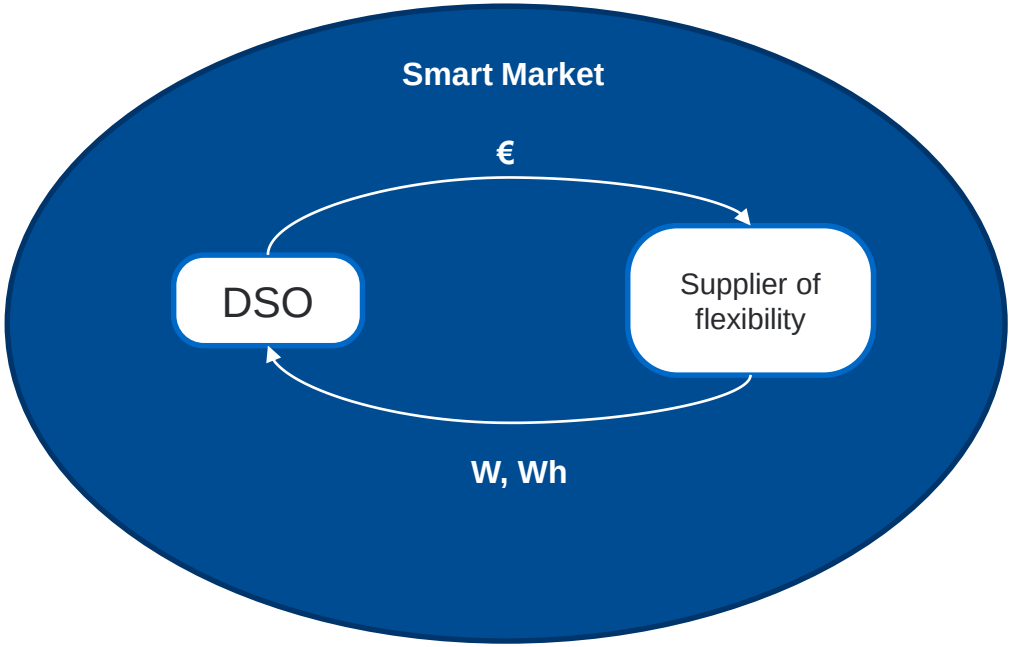
- Regional market for flexibility

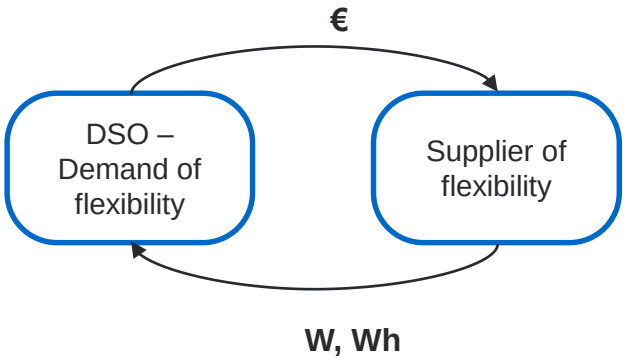


- Market mechanism analogue to balancing power market

Market Type 1: Purchase of flexibility by grid operator

- 1st case: no congestion
  - no demand for flexibility by grid operator

- 2nd case: excess feed-in in model region
  - congestion at regional border
  - Grid operator demands decremental flexibility
  - pays for reduction of generation
    - …of flexible plants → generation shift or reduction
    - …of supply dependent plants → generation curtailment
  - or for increase of demand in model region
    - …of flexible loads → load shift or increase



- Grid operators pay for production curtailment or demand flexibility
  - Cost pass-through to end customers through grid charges
  - … or no use of such a market mechanism

Market Type 3: Bilateral
- Grid operator sets constraints for trading

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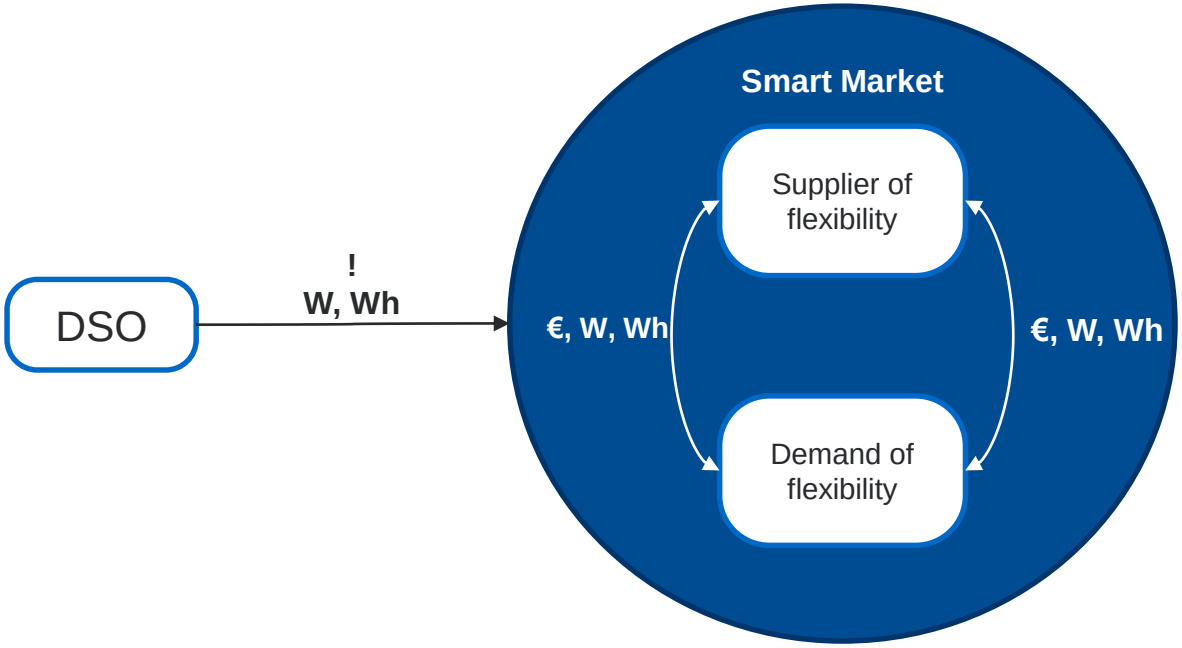
- Regional price zone



- Market mechanism analogue to market splitting in energy market

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Market Type 3: Activation of flexibility through (market) price signals

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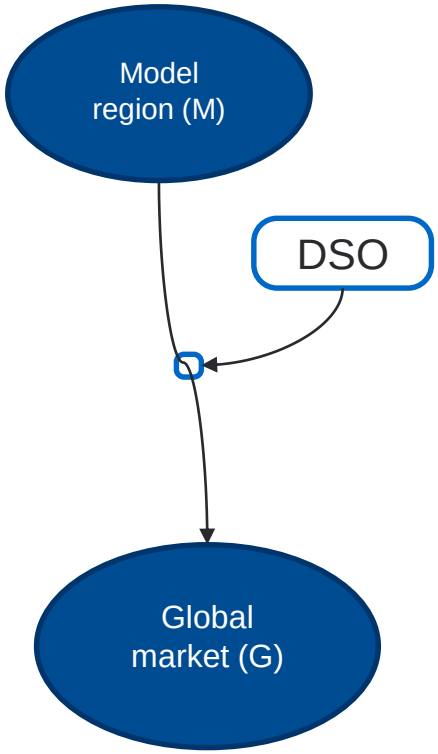
- 1st case: no congestion
  - Uniform price $P_M = P_G$

- 2nd case: excess feed-in in model region
  - congestion at regional border
  - Price signal: $P_M < P_G$
  - Incentives for reduction of generation
    - …of flexible plants→ generation shift or reduction
    - …of supply dependent plants → generation curtailment
  - or/and increase of consumption in model region
    - …of flexible loads → load shift or additional consumption



- Supplier in model region realise (without compensation) lower revenues
- And/or the demand side pays lower prices

Results

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- **Still to be researched!**

Key Objectives for a "Smart Market"

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Basic criteria for assessing market designs

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- **Effectiveness** (achievement of the given targets) → objective 1 & 2
  - Increase of the integrated (i.e. not down regulated) RE quantities
  - Improvement of the congestion management compared to the Status Quo
    - Less congestions
    - Higher transportation quantities (without grid extension)
    - Less risk
- **Efficiency** (cost-effective achievement of the given targets) → objective 3
  - Minimisation of the system costs (generation, grid, consumers) incl. transaction costs
  - Allocative efficiency (optimal usage of scarce resources, e.g. flexible demand)
  - Information efficiency (quickest possible adoption to new information, e.g. storm front)
  - Avoiding/limiting of strategic behaviour/market power
  - Static vs. dynamic efficiency (incl. long-term incentive effects)
- **Practicability** → context conditions
  - Compliance with the current legal framework
  - No excessive distribution effects (ideally: win-win for all participants)
  - Realisation in the given project timeframe and -budget

Further criteria for the assessment of market design (1)

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In view of effectiveness

- Contribution to grid congestion management
  - Without contribution to grid congestion management no need for a regionalised market
- Possibility to define and handle adequate products
  - Products are the basis for offers & demand by market participants
  - Without adequate products neither enough market uptake nor enough impact for grid congestion management is achieved

In view of static efficiency

- Connectivity with national/international Spot market
  - Prerequisite for efficiency, cf. Law of one Price
- Low transaction costs
  - Both upfront (fix) costs and operational (variable) costs
- Limitation of market power
- Liquidity
  - In fact multidimensional construct
  - Normally limits market power and contributes to efficiency

Further criteria for the valuation of market concepts (2)

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In view of dynamic efficiency

- **Participation incentives for market players**
  - The market players will not participate in an optional trading without own benefits
- Low market entrance barriers
  - Effective limitation of market power
- Incentives for location choices
  - Especially for renewables, potentially also for large loads & storages
- Possible trade-off between information efficiency and allocative efficiency
  - Immediate processing of information (contin. trading) vs. simultaneous pricing so that allocative efficiency occurs (auctions) (cf. Bellenbaum et al. 2014)

In view of practicability / context conditions

- Compatibility with regulation
  - Regulation necessary because grid operator constitute natural monopolists
  - Interface between market and grid is important for (system-) efficiency
- Connectivity with the traffic light concept of BDEW

Participation incentives (1)
Incentives for generators

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- **Key objective of generators: Higher profits**

- **Reference profit in the current regulation regime:**
  - **Without congestion: global market price + market premium**
  - **With congestion: Einspeisemanagement (EiSMan)-compensation or global market price + market premium**

- Without congestion: no need to participate in the regional market
- Market Type 1 with congestion:

  Grid operator has to pay at least the EiSMan-compensation

  → no advantage for grid operators compared to EiSMan
- Market Type 3 with congestion:

  Customers have to pay at least the EiSMan-compensation

  → above global market price → no market participation of customers

Participation incentives (2) Customers

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- **Key objective of customers: Cheap electricity**

- **Reference costs with the current regulation regime:**
  - **Without congestion: global market price + grid charges**
  - **With congestion: global market price + grid charges**

- Without congestion: no need to participate in the regional market
- Market Type 1 with congestion:

  Grid operator pays customer for additional consumption

  → generally attractive for consumer except the net charge is increasing
- Market Type 3 with congestion:

  Customer pays for generator

  → at least EiSMan-compensation under current regulation regime
  → no market participation of the consumer

Final remarks

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- Multiple design choices have to been made for regional smart markets
- Incentives for market participation are key for a successful market
  - Market participation key to limit market power
- Current regulation puts important impediments to smart markets
  - EiSMan leads to strong incentives for renewables not to participate in a regional smart market
  - Grid tariff structure limits incentives for loadsto participate in a regional smart market

➢ Research, Demonstration & Flexible Regulation needed