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SMART GRID – VISION AND REALITY

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21.03.2014, OBERNAI

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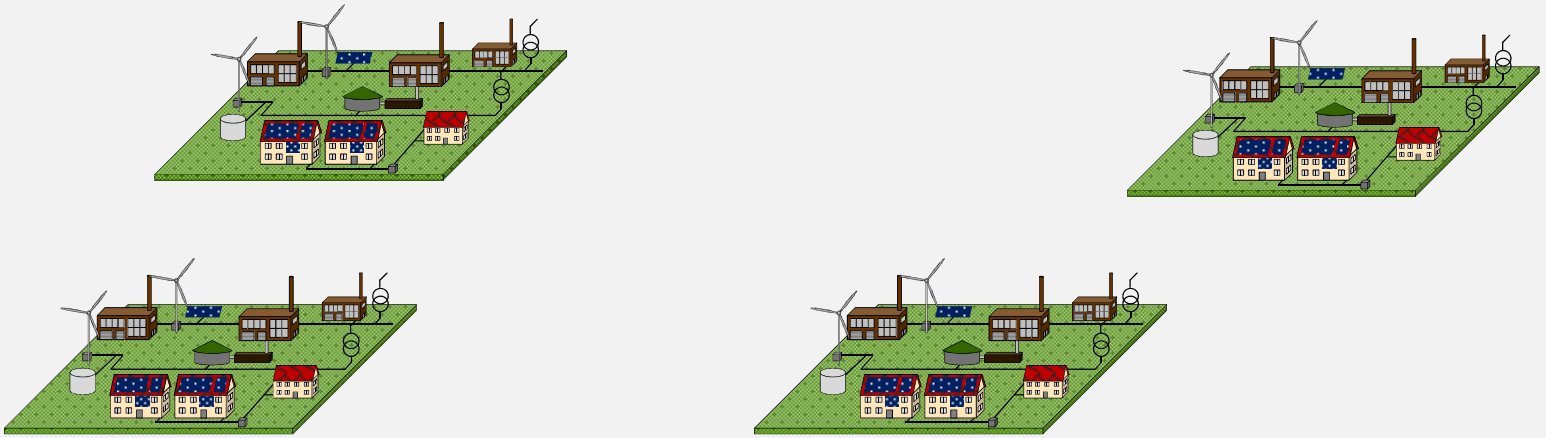
Assumption – 100 % Smartness

Smart Grids and Transmission Networks

— **DSO - Security of supply of its end-consumer** and distributed generation management (Smart Grid)



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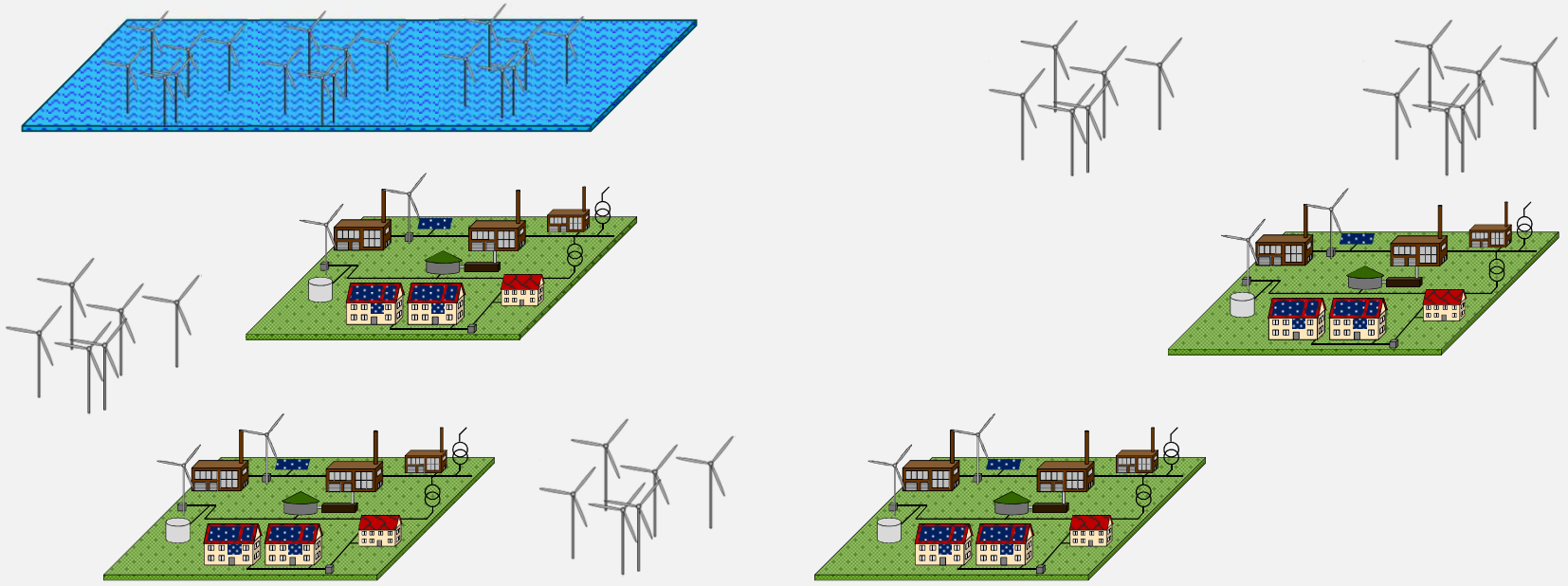
Assumption – 100 % Smartness

Smart Grids and Transmission Networks

- **DSO - Security of supply of its end-consumer** and distributed generation management (Smart Grid)
- **What about wind parks?**



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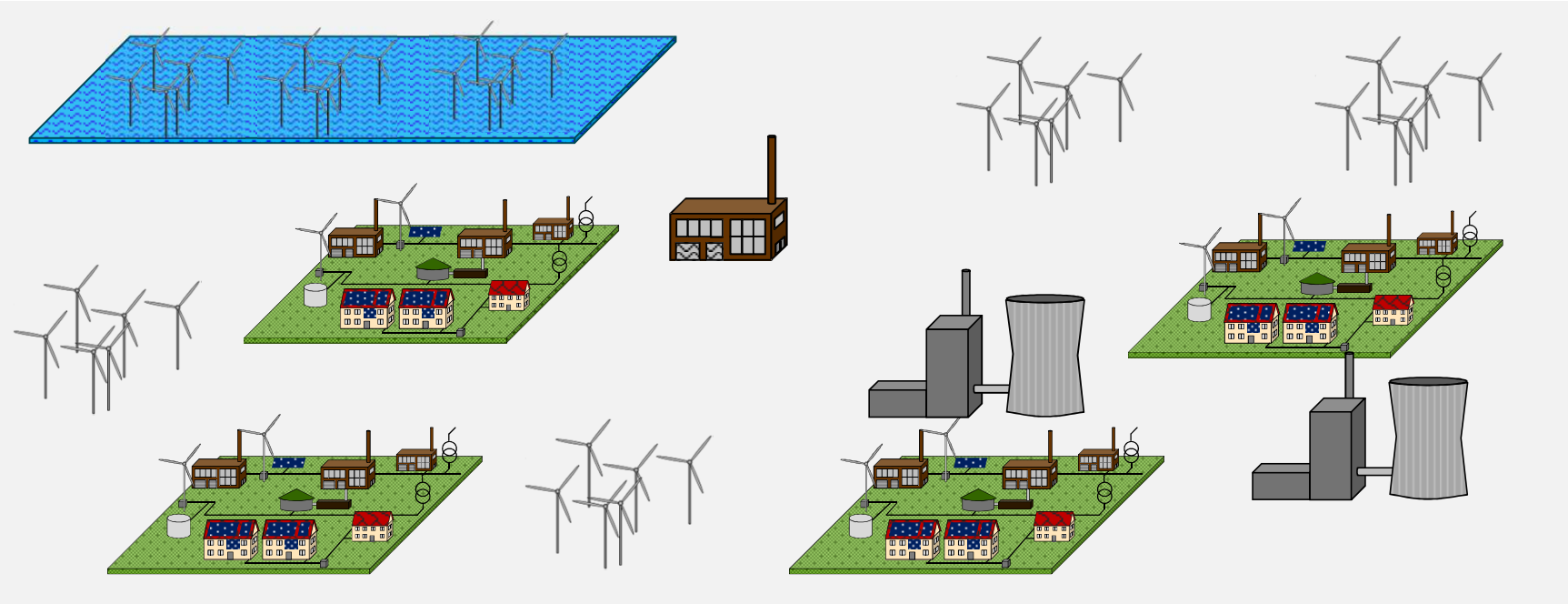
Assumption – 100 % Smartness

Smart Grids and Transmission Networks

- **DSO - Security of supply of its end-consumer** and distributed generation management (Smart Grid)
- **Industrial loads? Back up power plants?**



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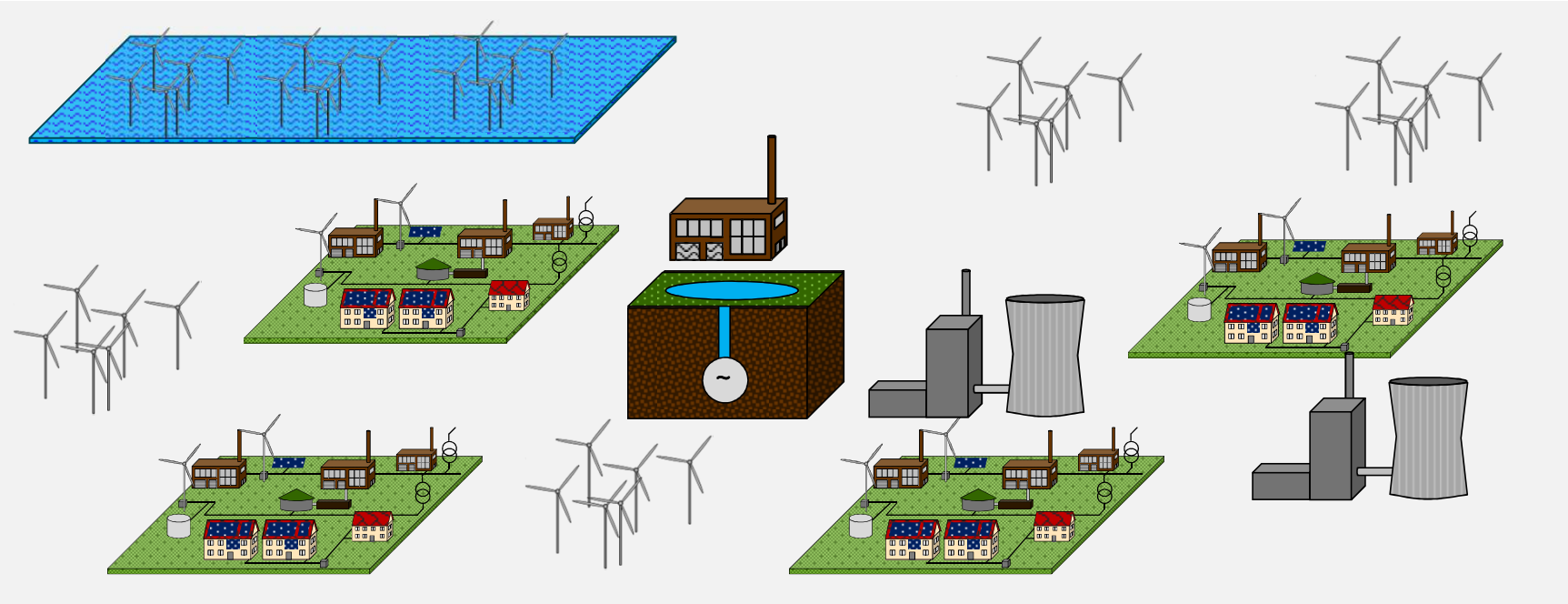
Assumption – 100 % Smartness

Smart Grids and Transmission Networks

- **DSO - Security of supply of its end-consumer** and distributed generation management (Smart Grid)
- **Wouldn’t it be nice to store wind?**



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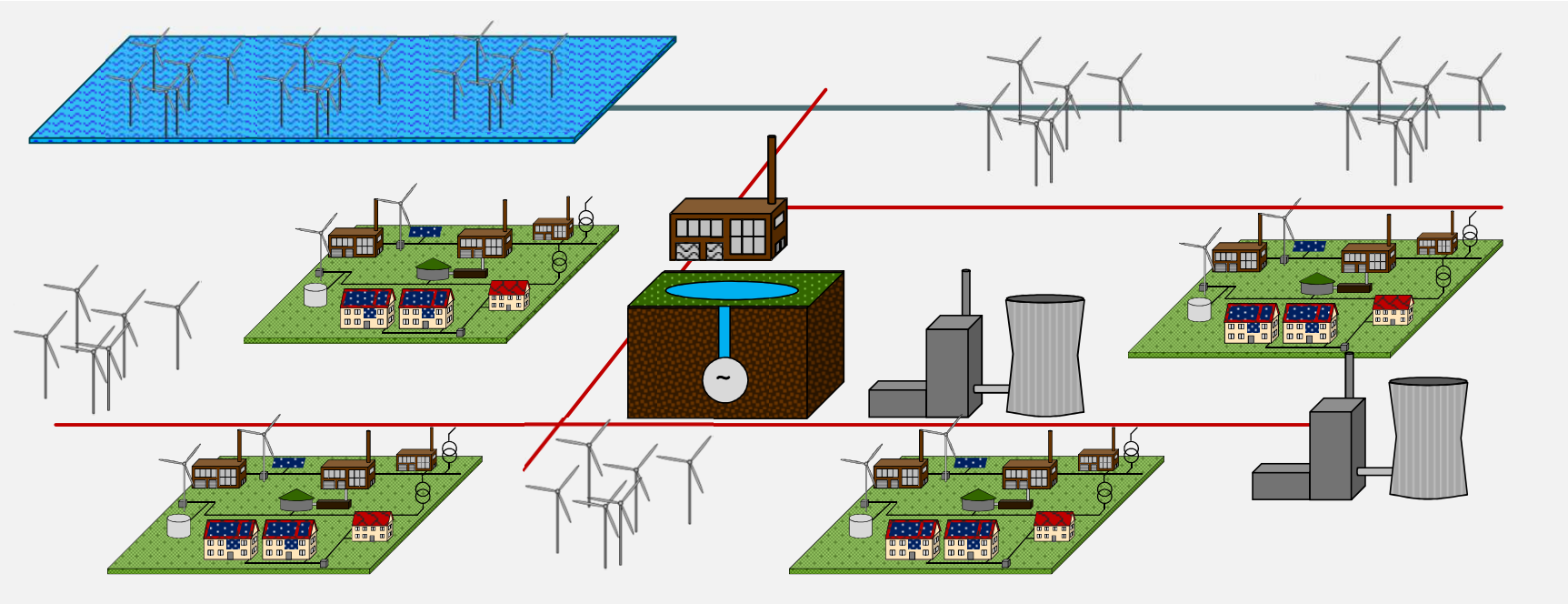
Assumption – 100 % Smartness

Smart Grids and Transmission Networks

- **DSO - Security of supply of its end-consumer** and distributed generation management (Smart Grid)
- **TSO - Security of supply of the whole energy system**
- **Smart Grids must be applied in the global context!**



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TransnetBW – Short Profile

Smart Transmission

- Geographical area: 34.600 km²
- Length of transmission lines: 3.331 km
- 47 substations
- Peak load at 220-kV in 2013: 12.1 GW
- Yearly energy consumption: 67 TWh

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Transmission System Operator

1 Transportation of Electricity from the Power Plant to the Consumer

Generation | Transmission Network | Distribution Network | Consumption

2 Legal Framework – § 11 Energy Industry Act (Energiewirtschaftsgesetz)

Responsibility for

- transparent and non-discriminatory grid access
- security of energy supply

Tasks

- Coordination of non-discriminatory grid access
- Planning, construction and operation of the transmission network
- System balance
- Management of balancing responsible parties
- Procurement of system services
- Schedule management and congestion management

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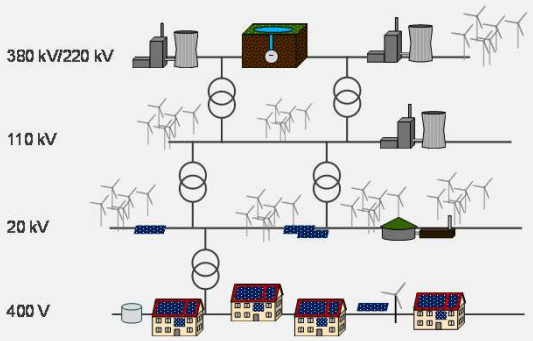
Smart Grid

Smart Grid - a Definition

"The conventional **grid** becomes a Smart Grid

Grid



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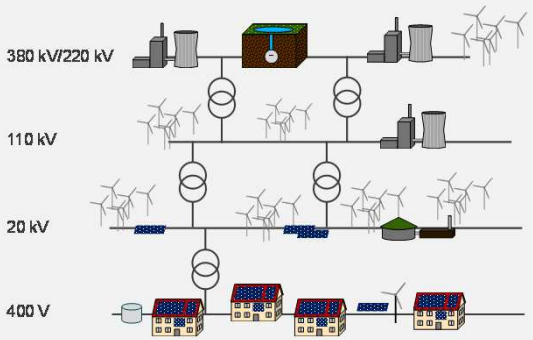
Smart Grid

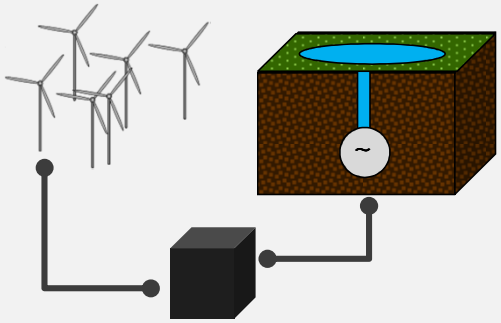
Smart Grid - a Definition

"The conventional **grid** becomes a Smart Grid, if it is upgraded with **communication**, **measurement**, **control**, automation and IT components. In result, "smart" means that the **network state can be observed in "real-time"**

Grid



Sensors, Actuators and Communication



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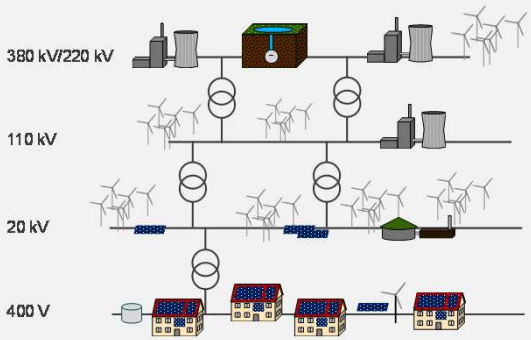
Smart Grid

Smart Grid - a Definition

"The conventional **grid** becomes a Smart Grid, if it is upgraded with **communication**, **measurement**, **control**, automation and IT components. In result, "smart" means that the **network state can be observed in "real-time"** and there **possibilities** for feed-forward and feed-back **control** of the networks **enabling the full usage of the existing transmission capacity**."

BNetzA (2011), "Smart Grid" and "Smart Market" (own translation)

Grid



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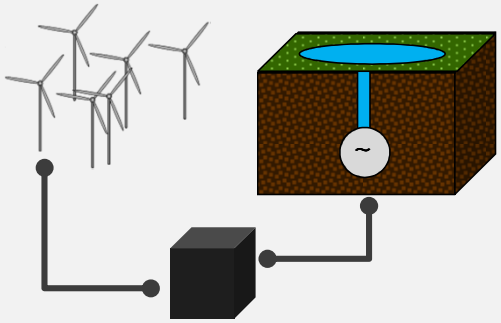
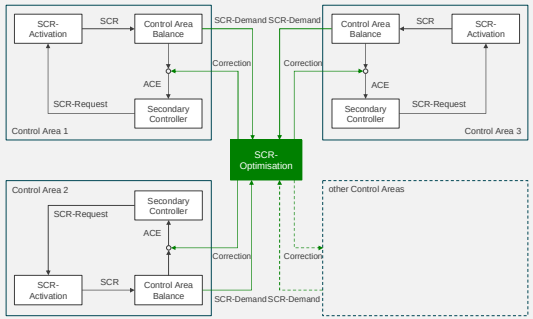


Control Concepts



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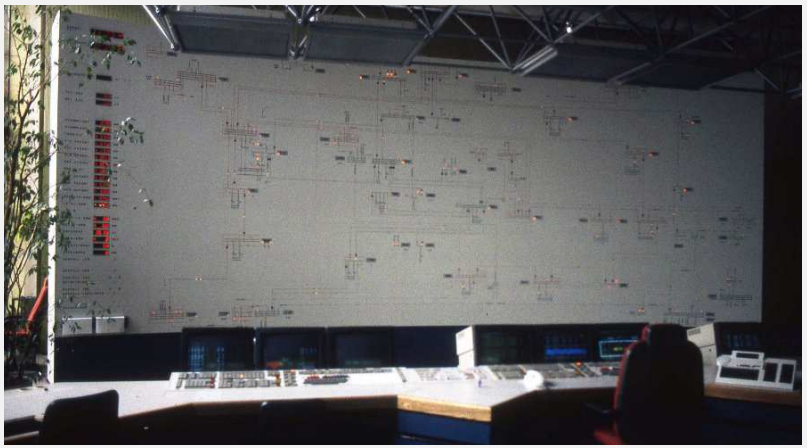
Smart Transmission

Smart Transmission

- **The European transmission networks have been smart for a long time and continue to become smarter**
- Examples: automatic frequency control, real-time state estimation, real-time operational security analysis, European Awareness System, operational planning **etc…**

Smart Transmission Grid - Past and Present



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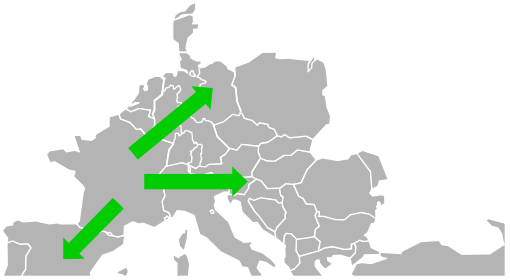
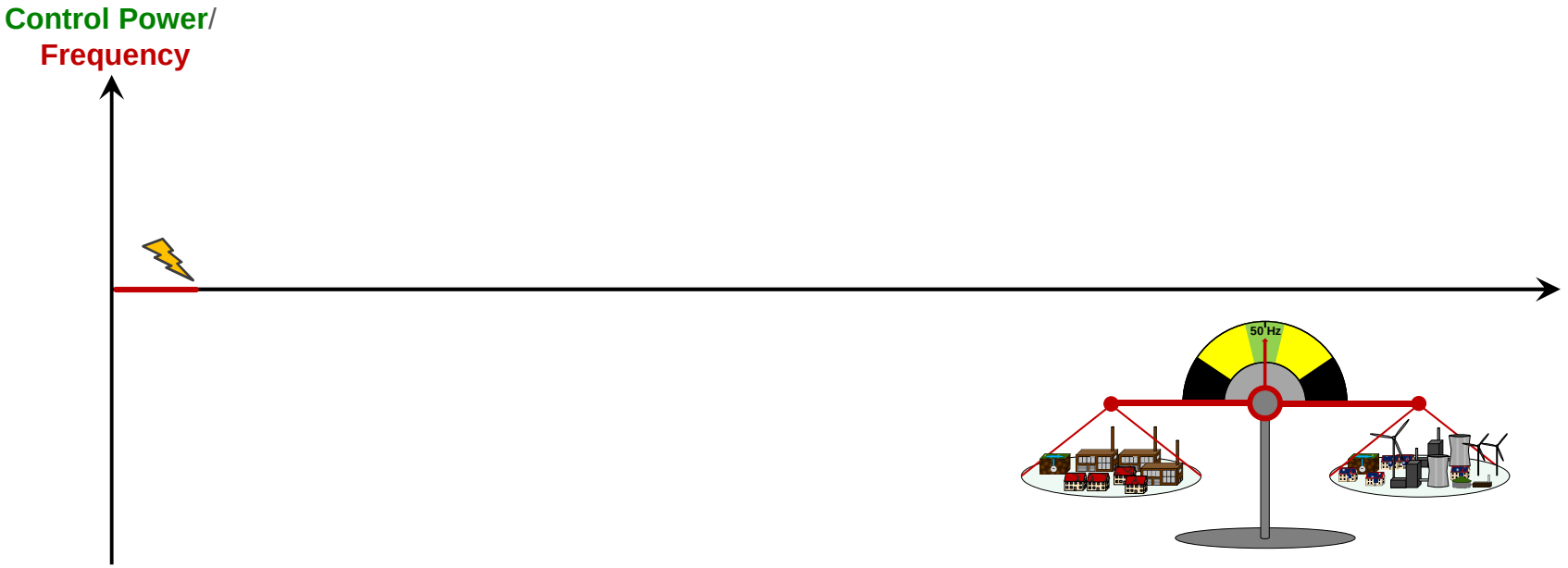
Example: Load-Frequency Control





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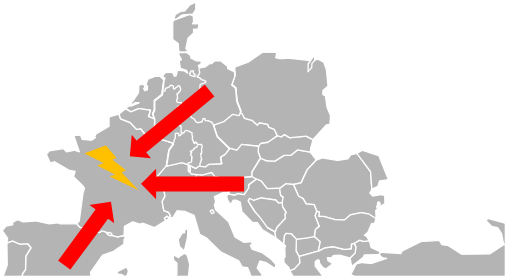
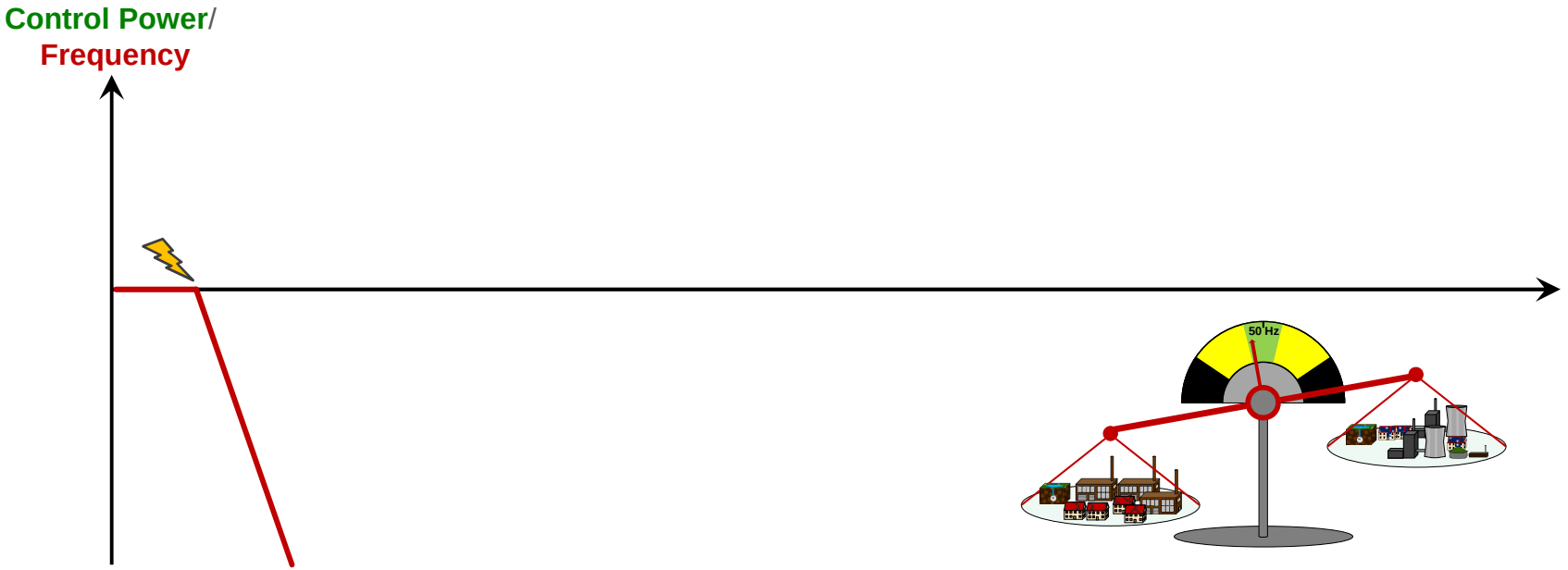
Example: Load-Frequency Control





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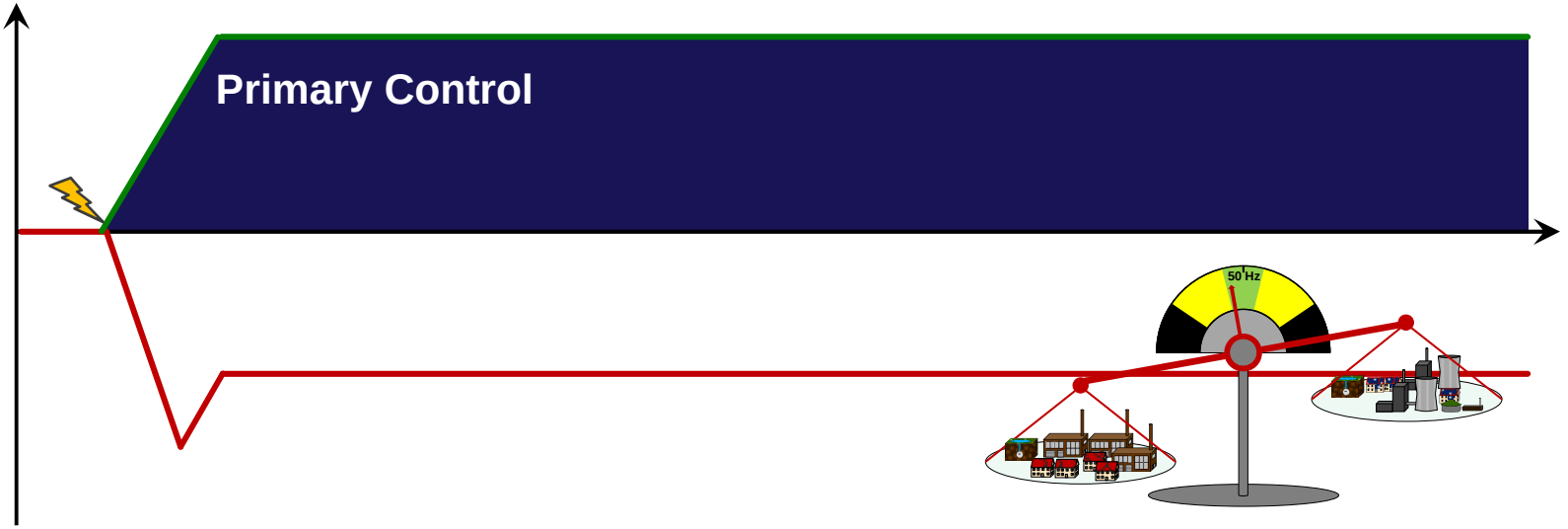
Example: Load-Frequency Control

Stabilisation (solidary)

Control Power/ Frequency



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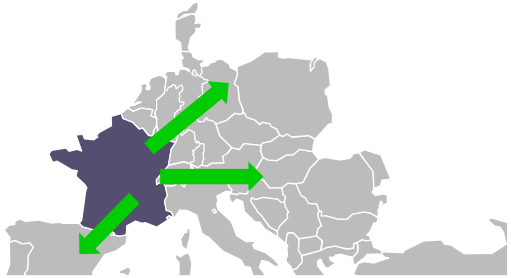
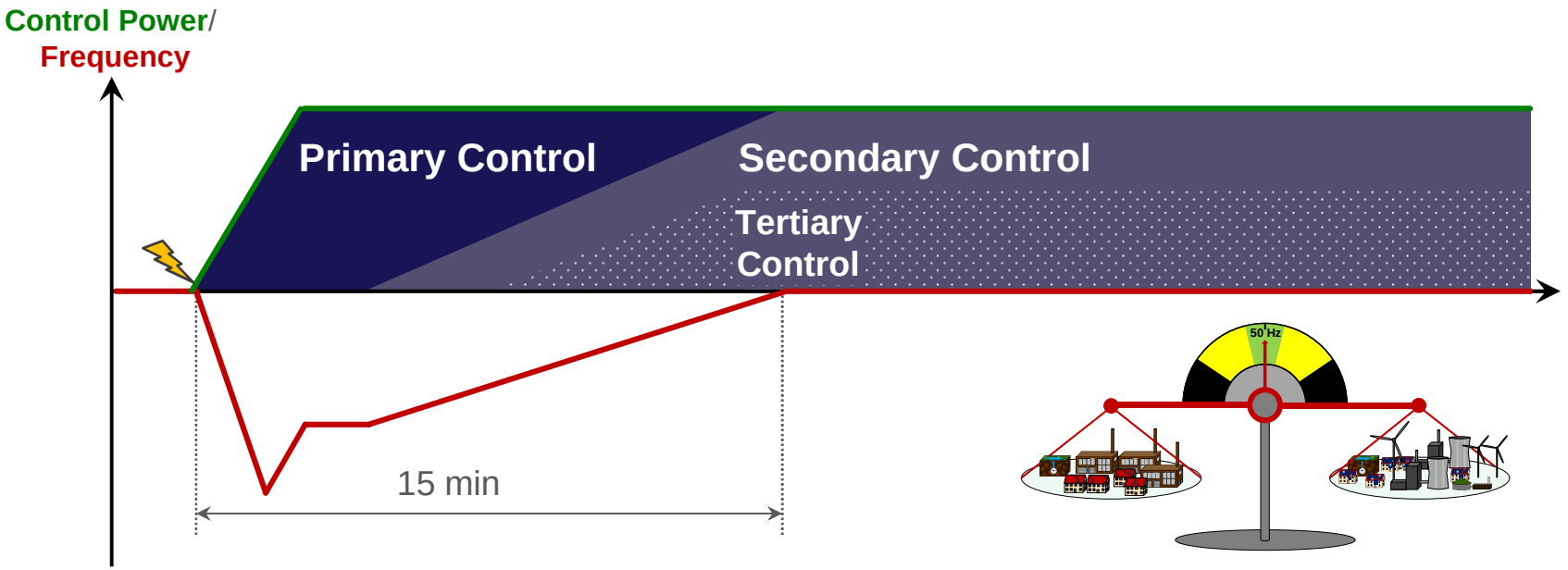
Example: Load-Frequency Control

Stabilisation (solidary)

Control to Setpoint (for each Control Area)





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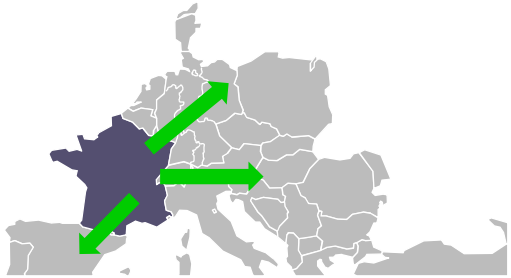
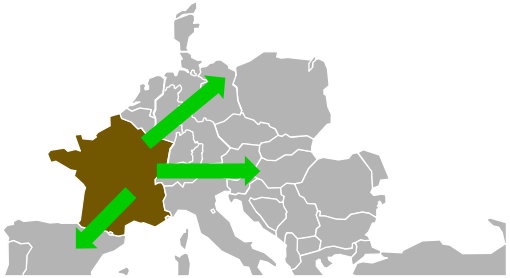
Example: Load-Frequency Control

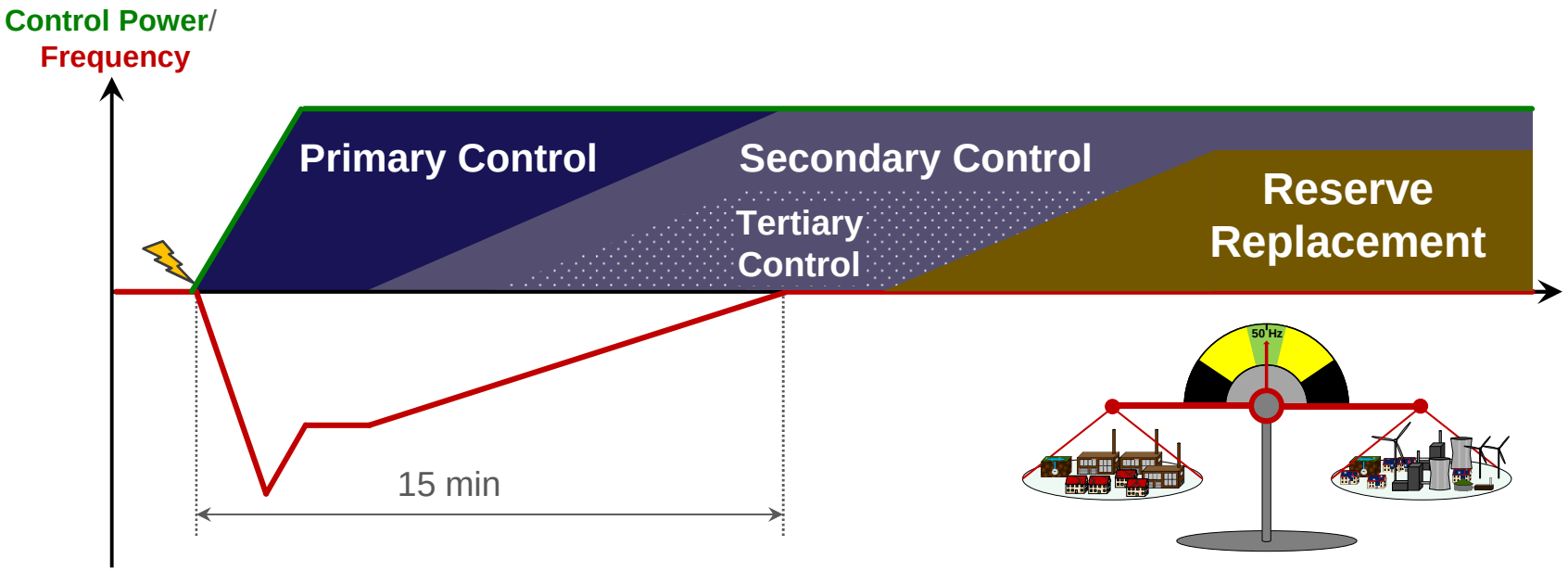
Stabilisation (solidary)

Control to Setpoint (for each Control Area)



Replacement of Fast Reserves (for each Control Area)





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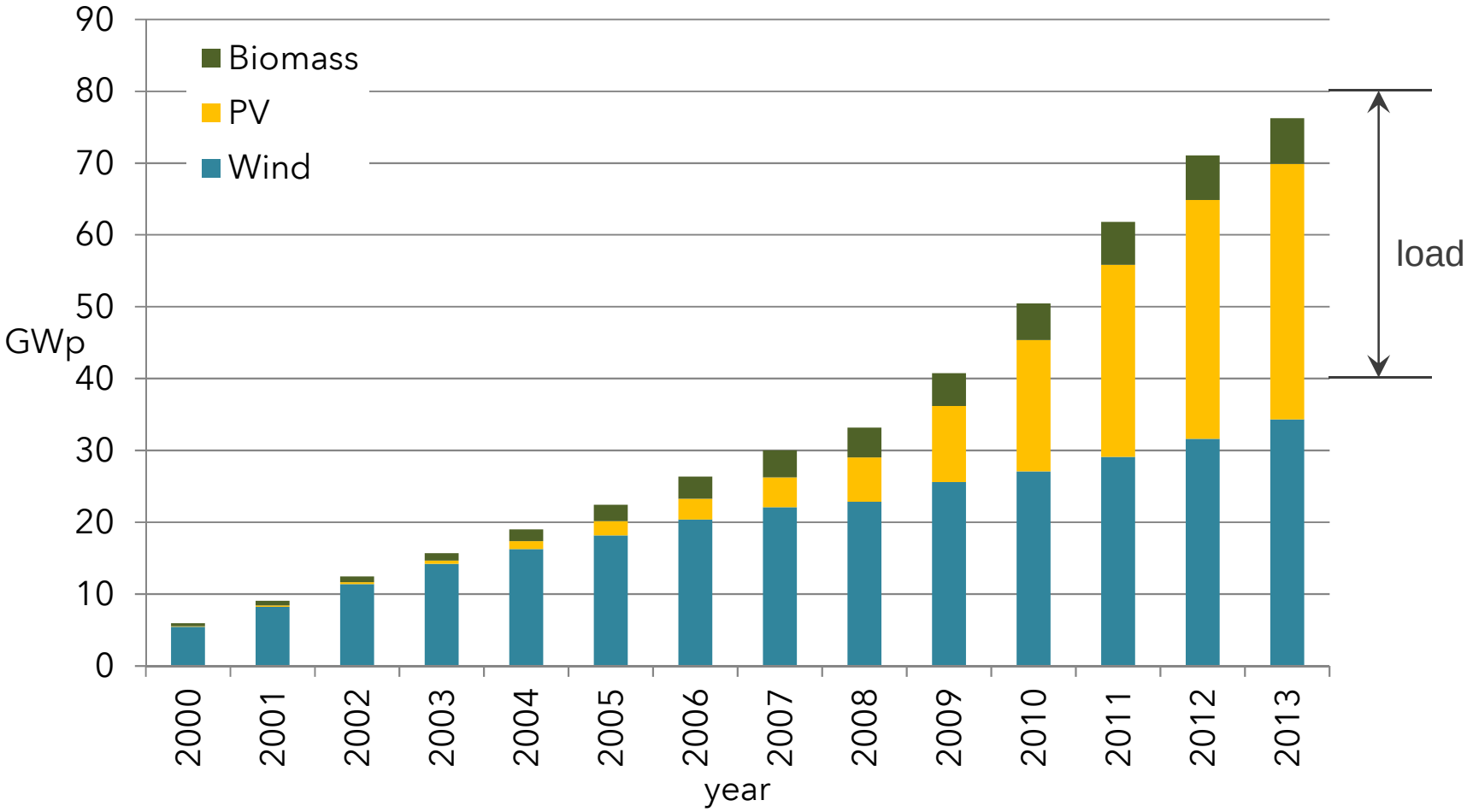
Installed Renewable Capacity in Germany



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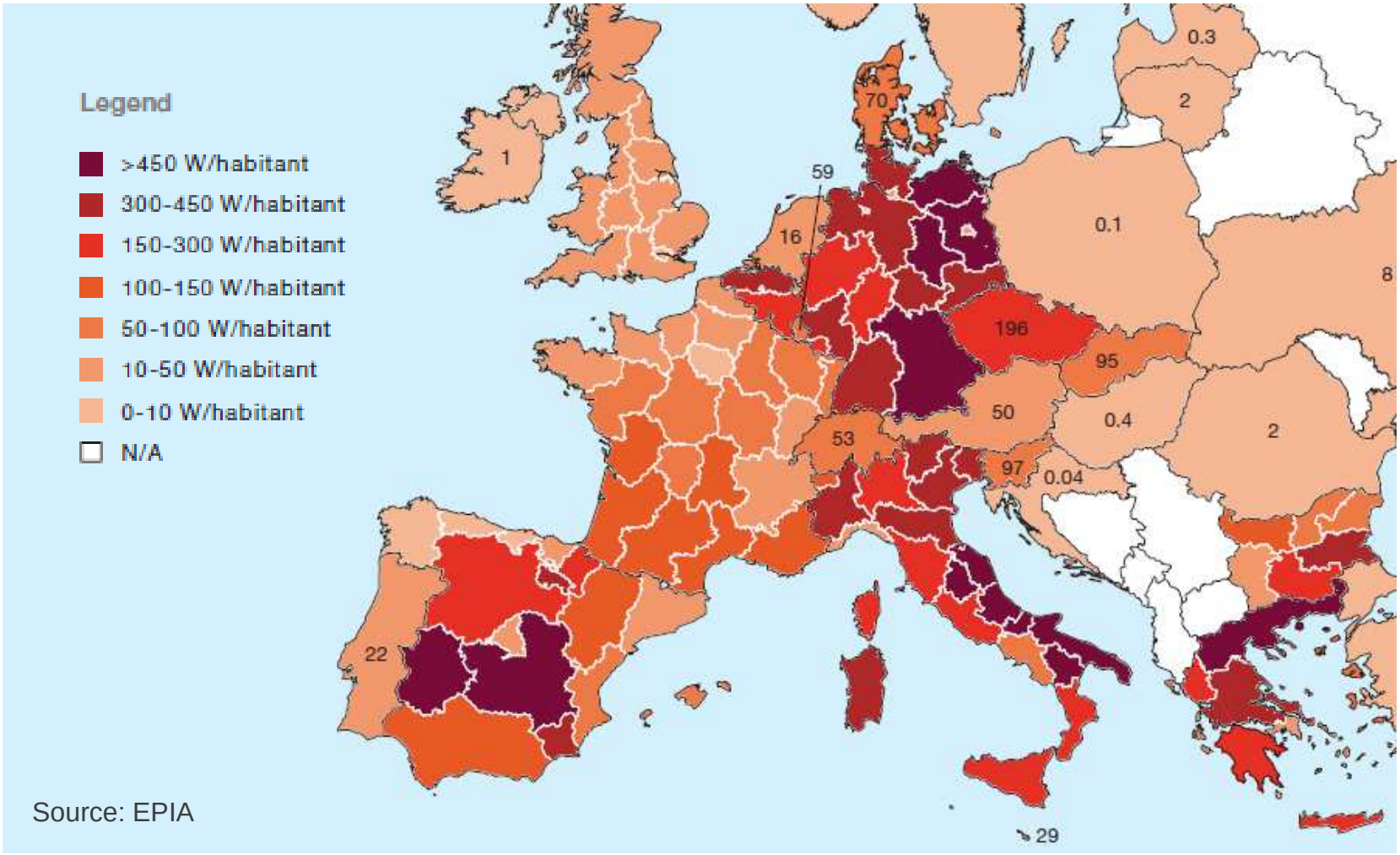
Distributed Generation ≠ Regional

Installed PV-Capacity per Capita in 2012



Source: EPIA

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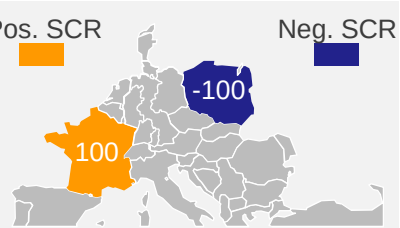
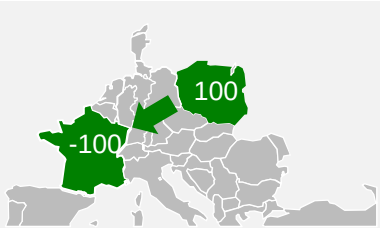
Smart Grid: Grid Control Cooperation

Smart Transmission - Imbalance Netting	Scenario	No Optimisation	Imbalance Netting
			

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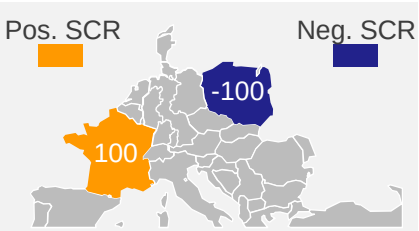
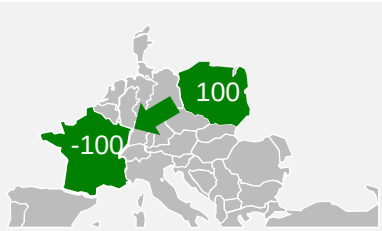
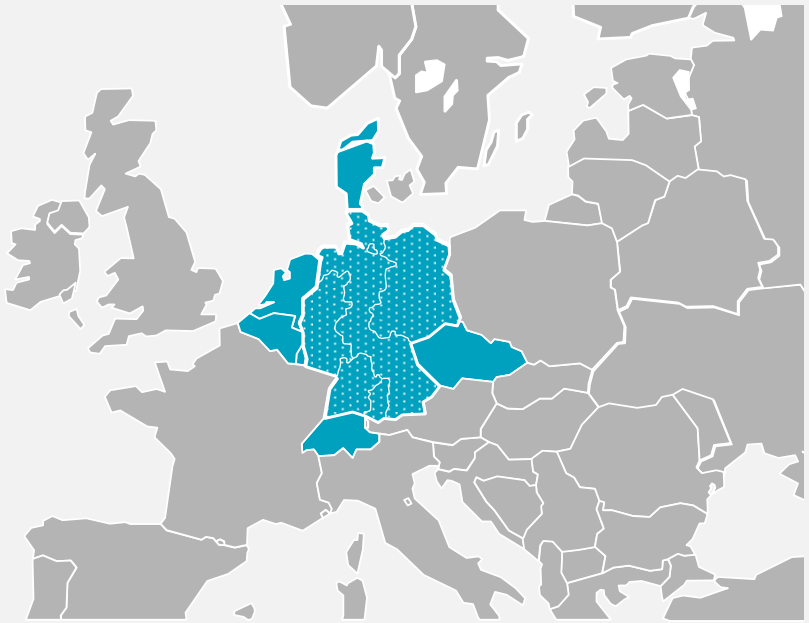
			

- Grid Control Cooperation (Imbalance Netting, optimisation of dimensioning and costs)
- International Grid Control Cooperation (IGCC) (Imbalance Netting)



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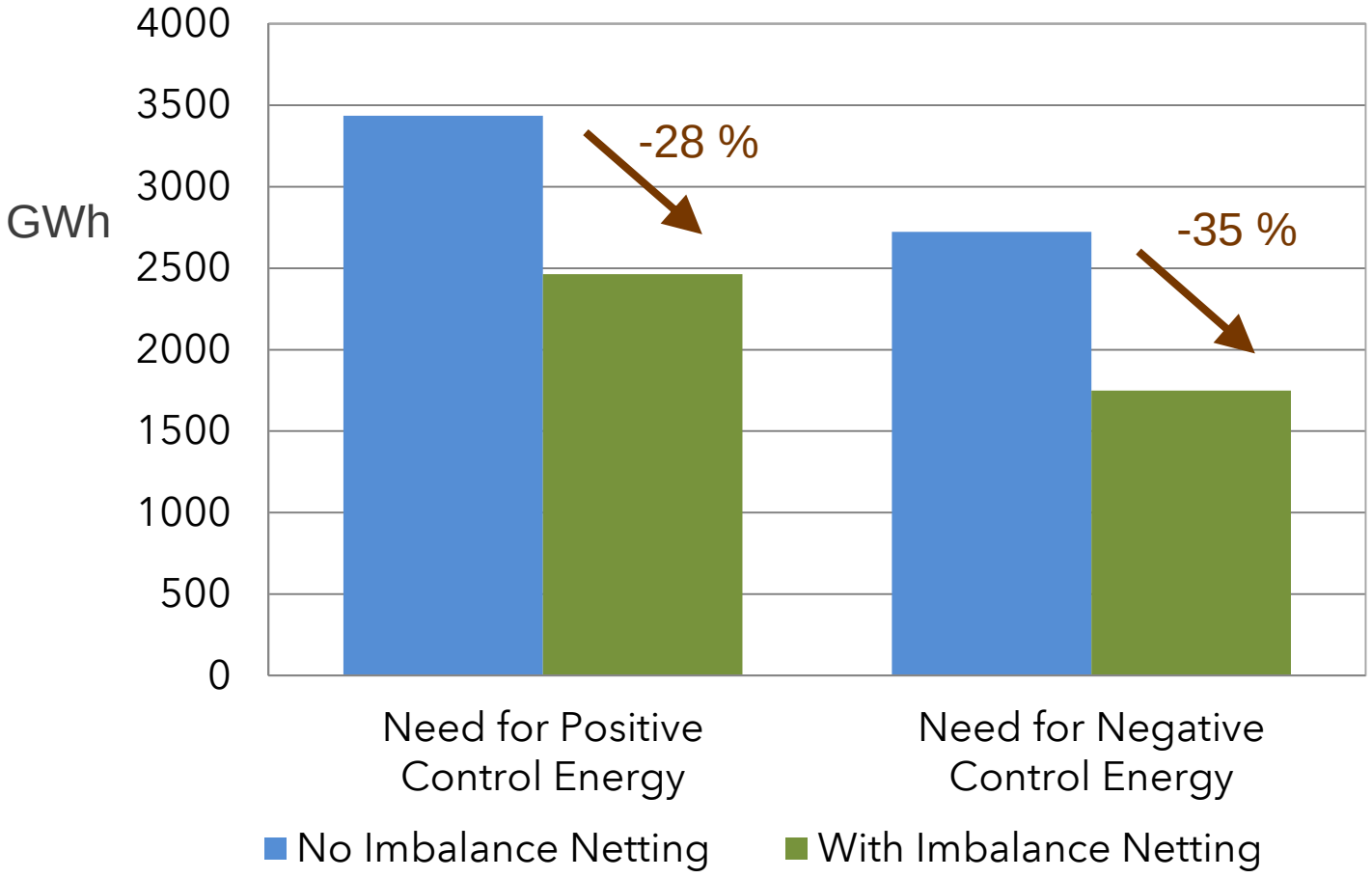
Example: Imbalances of Renewables in Germany



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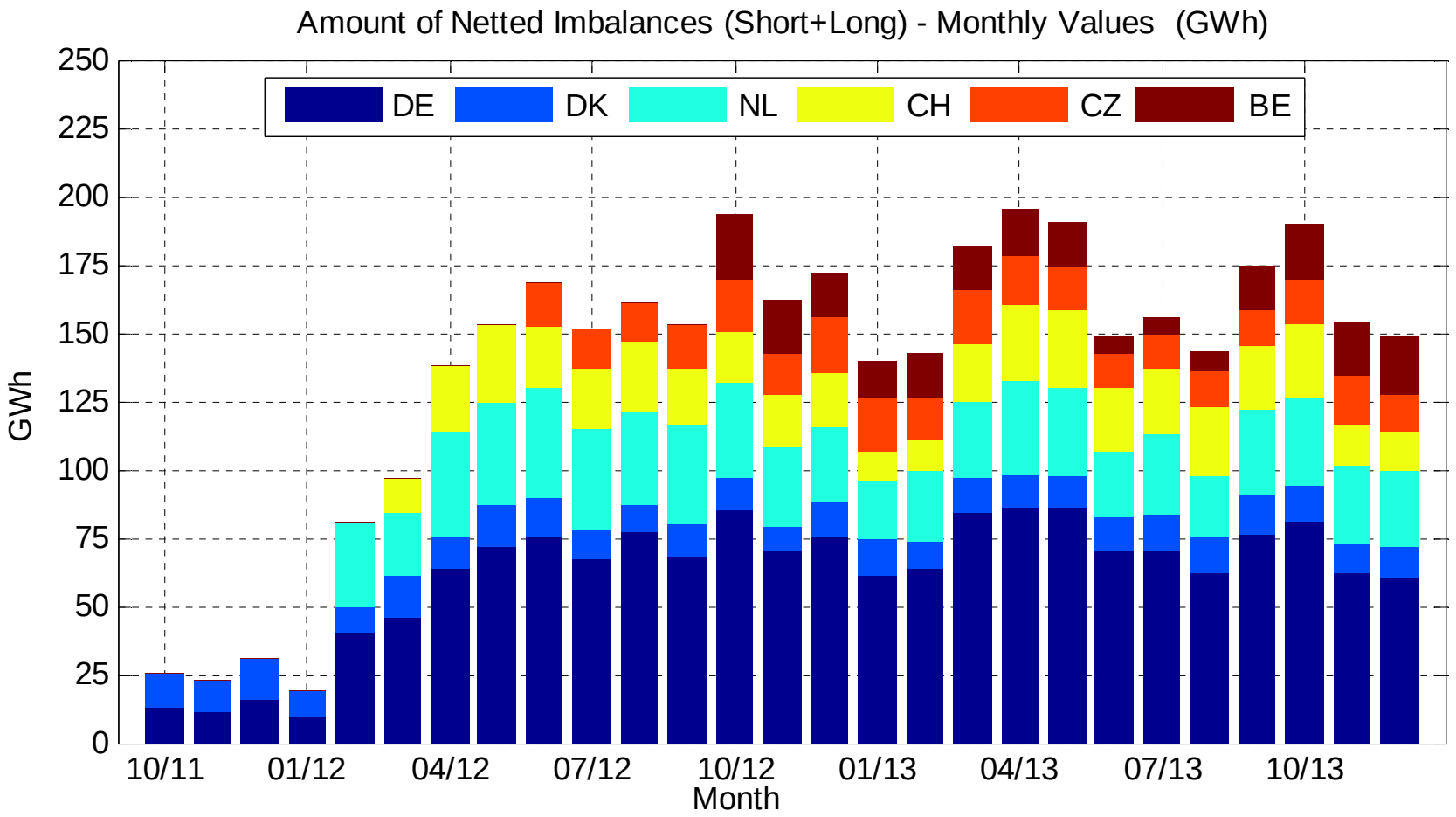
Imbalance Netting between Countries in GWh



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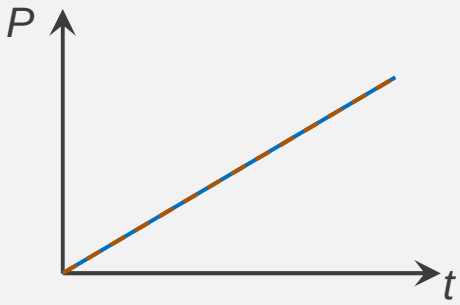
Example 1: “Transaction Costs”

Before Liberalisation –
Power Plants Follow the Load



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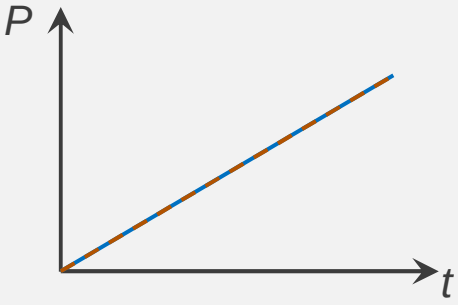

load

generation

imbalance

perfect forecast
- no imbalance

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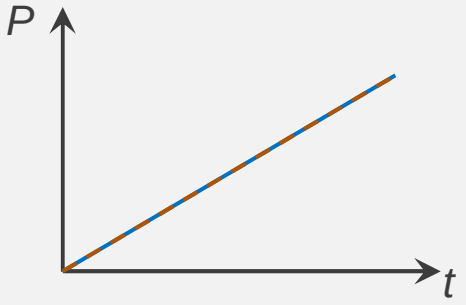
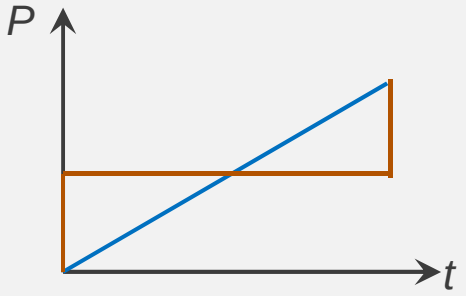
Example 1: “Transaction Costs”

Before Liberalisation – Power Plants Follow the Load



perfect forecast - no imbalance

After Liberalisation – Power Plants Follow a Contract



- Trading requires **standard products**.
- For energy trade this means that the power plant production is **not** a **continuous** spline **but a series of “steps”**

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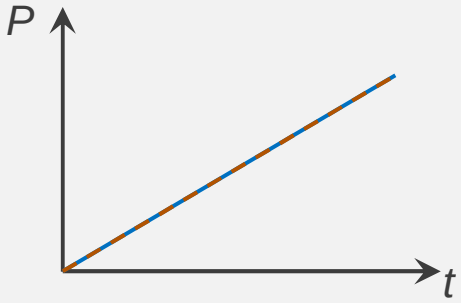
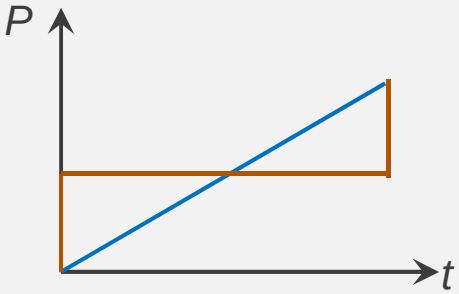
Example 1: “Transaction Costs”

Before Liberalisation – Power Plants Follow the Load



perfect forecast - no imbalance

After Liberalisation – Power Plants Follow a Contract



perfect forecast but imbalance due to discretization

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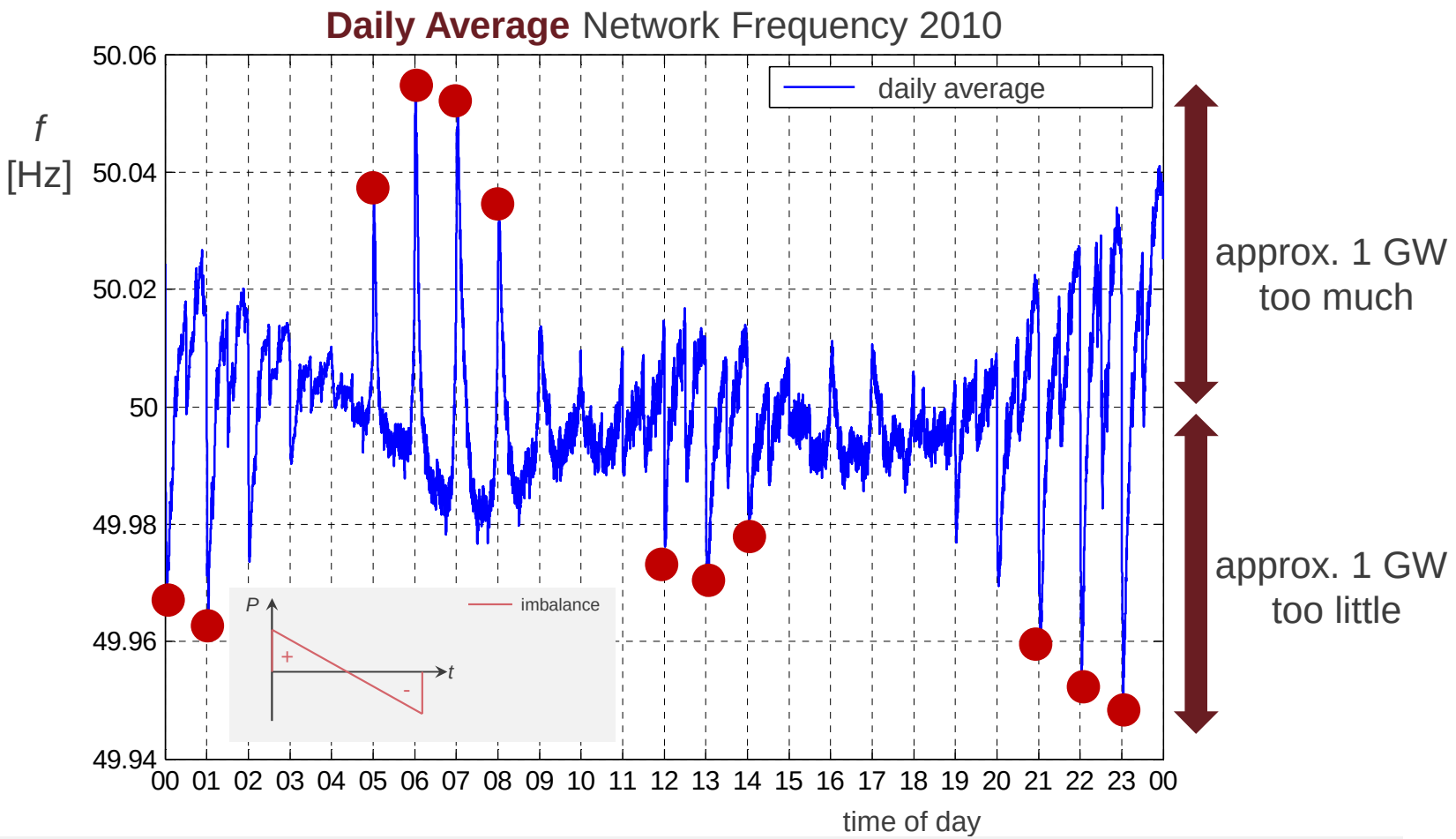
Example 1: 1 Hour Energy Product



Power plants dispatch based on step-shaped contracts **decreases** the quality of the network frequency and therefore the **system security level**

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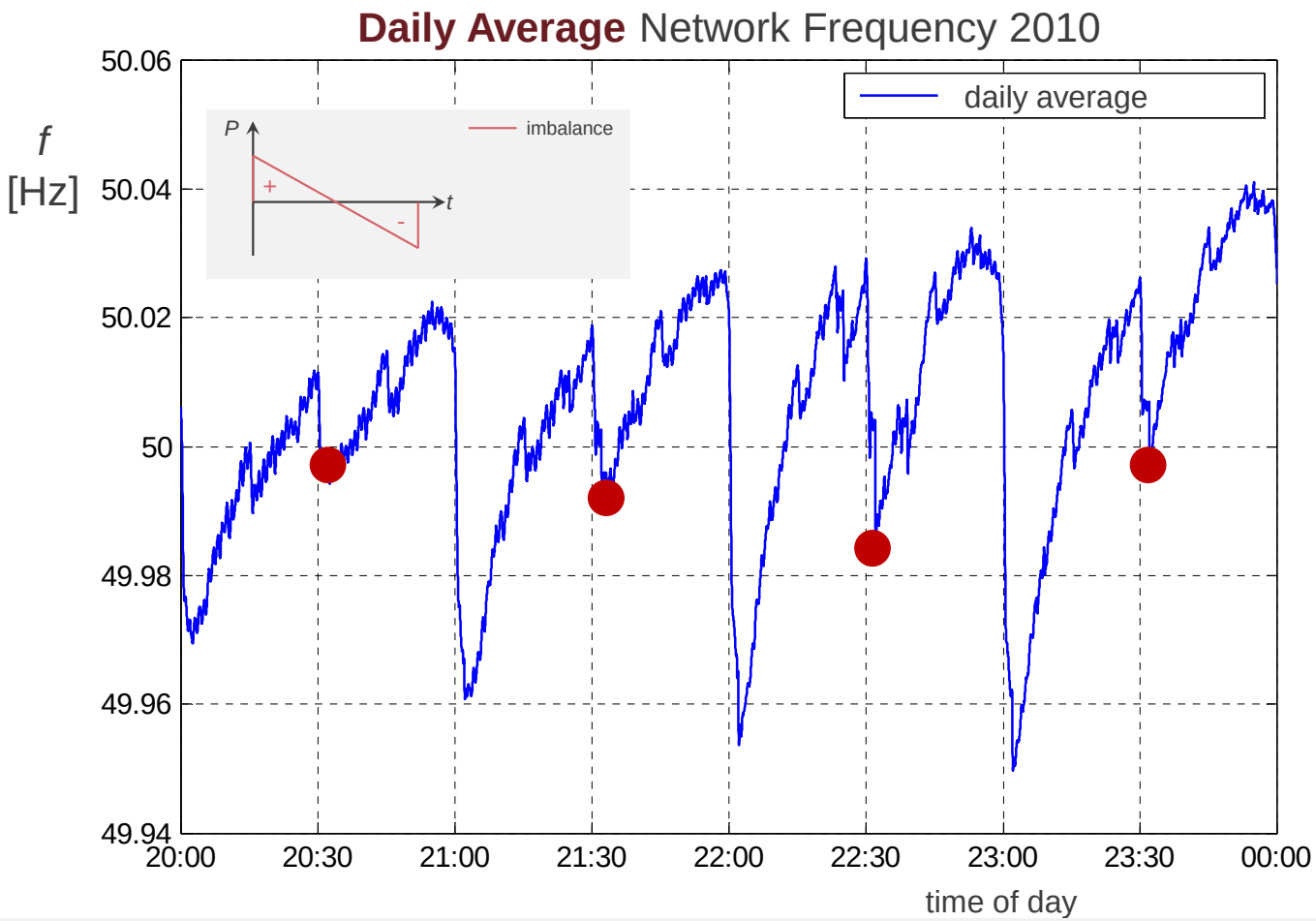
Example 1: 1/2 Hour Energy Product



Power plants dispatch based on step-shaped contracts **decreases** the quality of the network frequency and therefore the **system security level**

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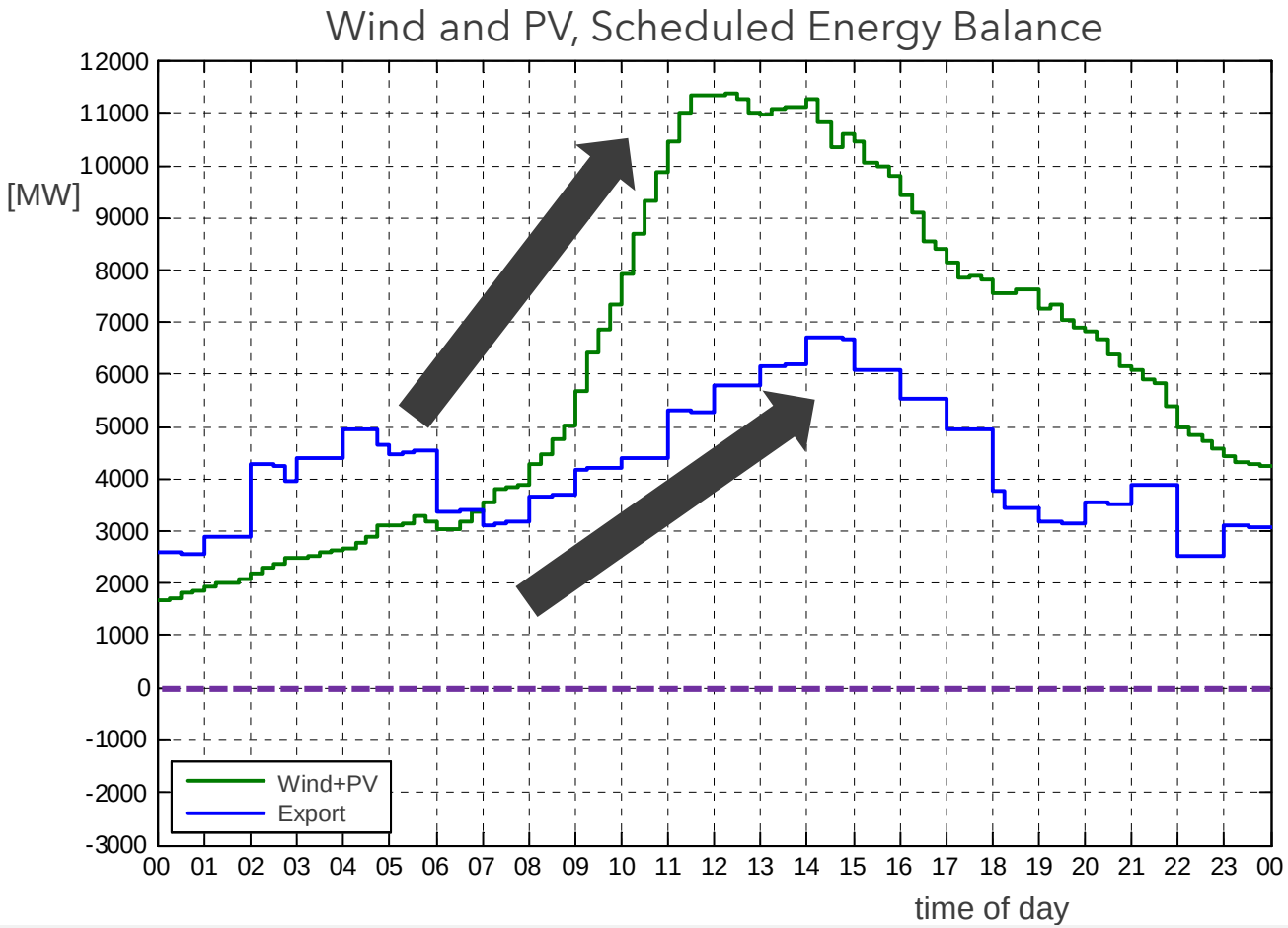
Example 2: Cold Day in February



Relatively high wind and PV generation

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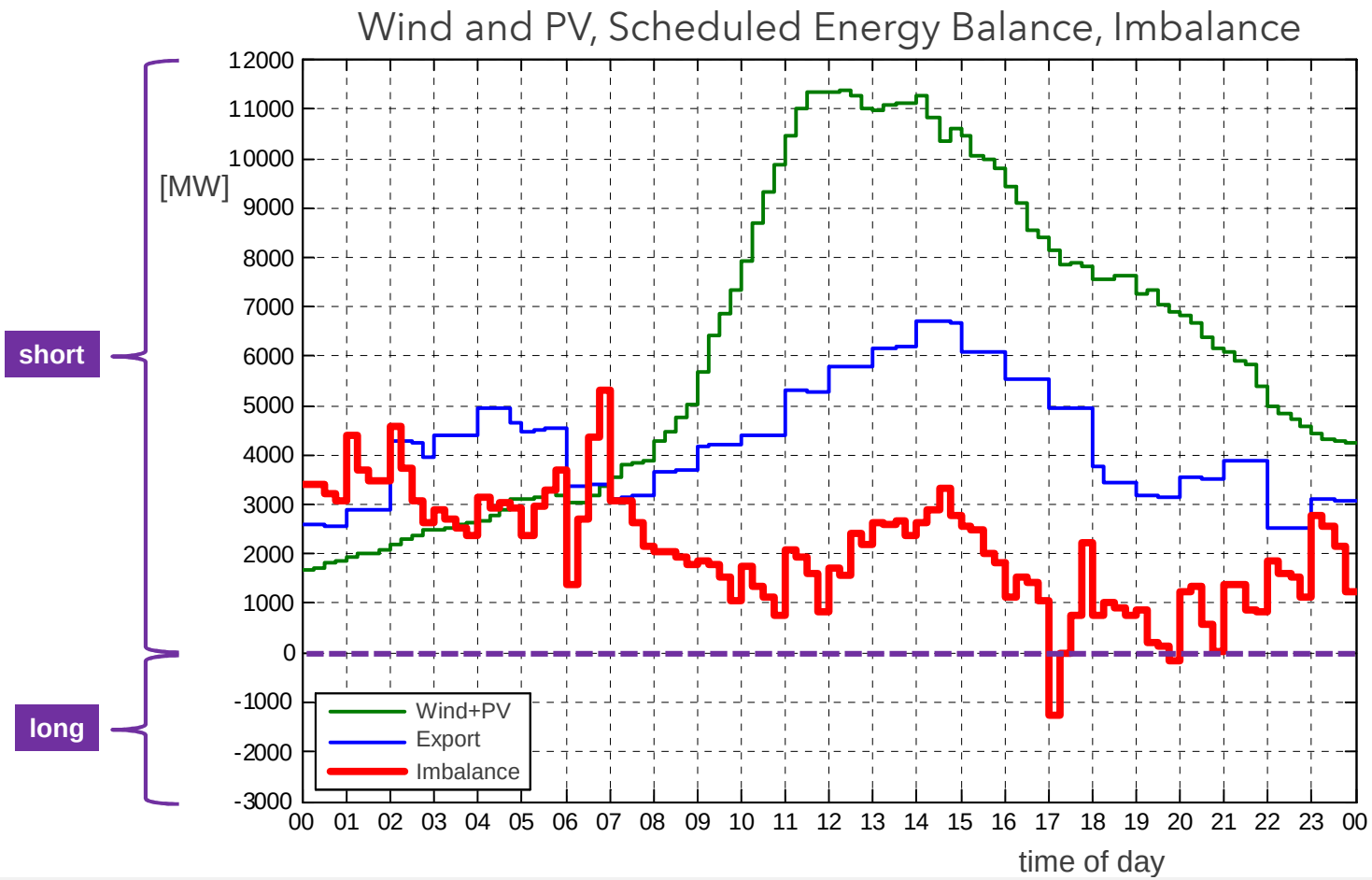
Example 2: Cold Day in February



Relatively high wind and PV generation, still an **unplanned energy shortage** – market participants have not adapted the load forecast

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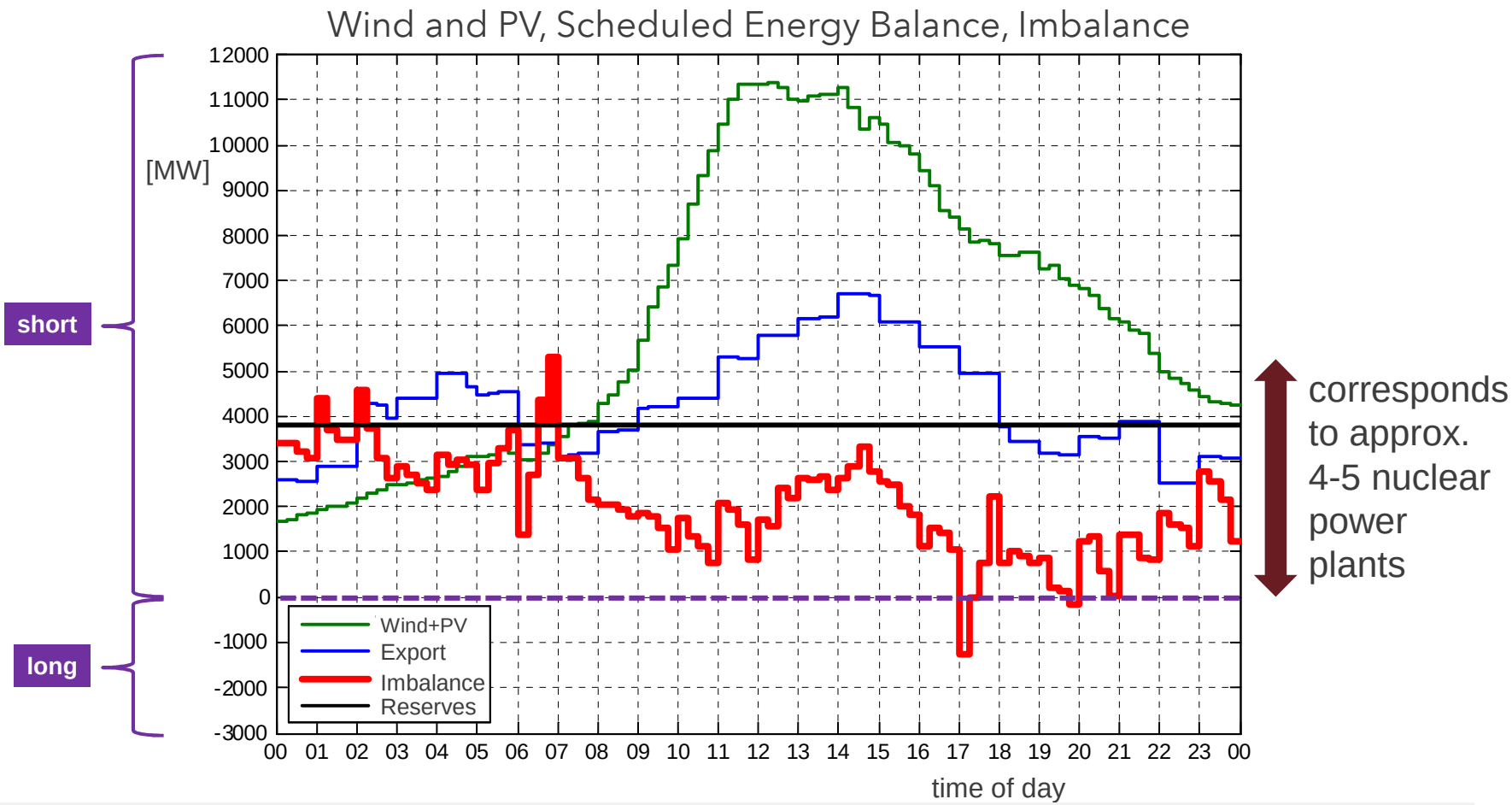
Example 2: Cold Day in February



Relatively high wind and PV generation, still an **unplanned energy shortage** – market participants have not adapted the load forecast

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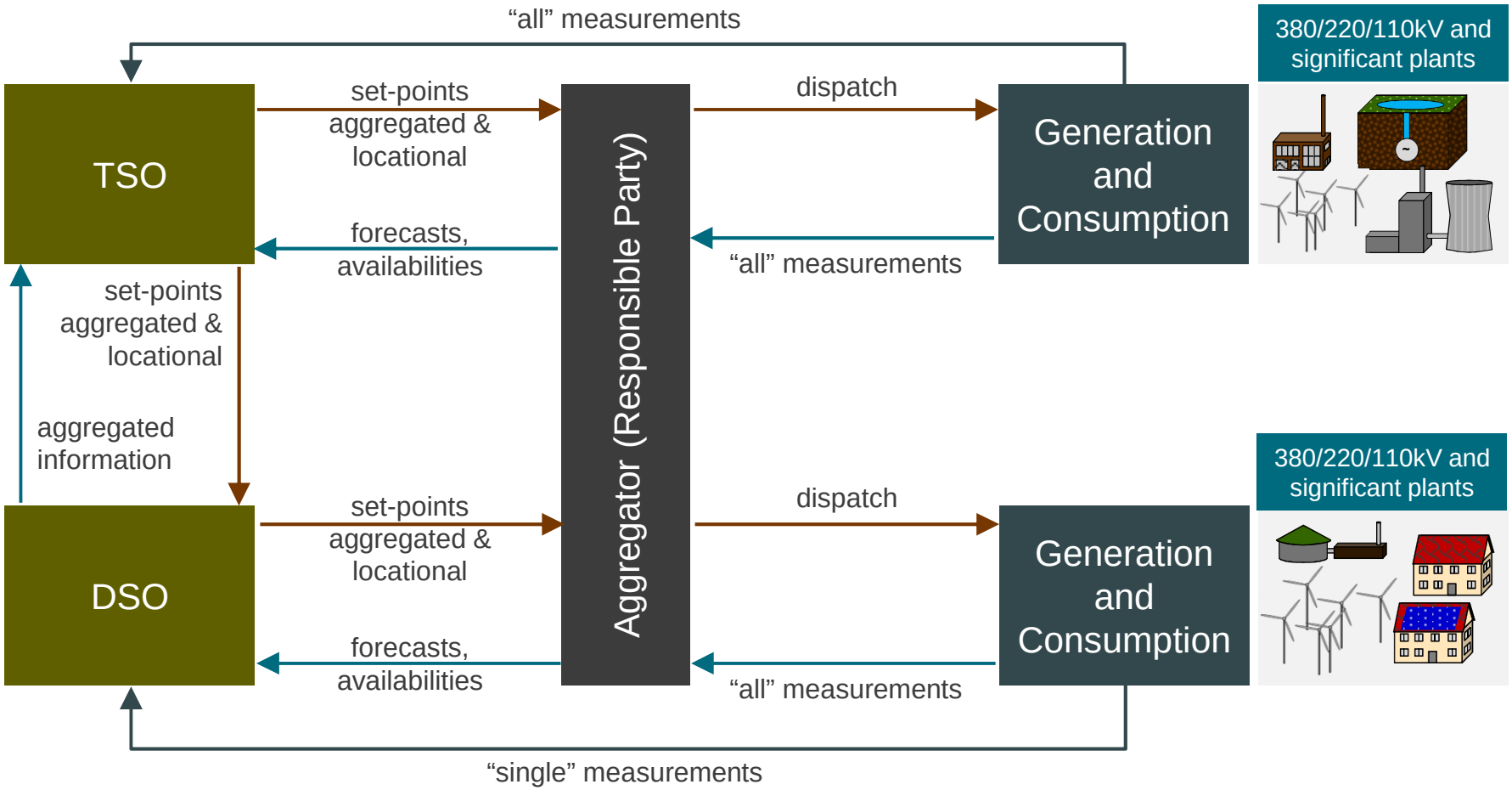
Smart Grid – Simplified Information Flows



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Current State

Measurements	— Generally, the TSOs **have measurements of all relevant power plants and demand connected** at high voltage level — Estimation of the **end-consumption** is **difficult due to dispersed generation**
Aggregation	— **Aggregation** (“Virtual Power Plant”) **is state of the art** in energy trade and power plant dispatch — **Demand and small power plants (biomass) are already providing system services**
Forecasts	— **Quality** of forecasts highly **depends** on the **flexibility** given to the **market participants** — In Germany - efforts to improve quality of forecast (rules to be fixed by the regulator)
Smart Meter	— Smart Meters are tested in pilot projects — **Benefit for the end-consumer is questionable** and therefore the business model

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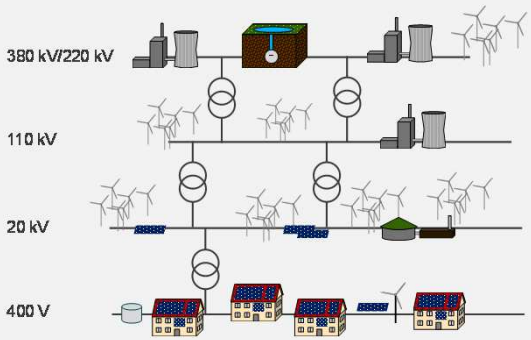
Summary and Outlook

Smart Grid - an Outlook

- **Smart Grid already exists at the TSO level for many years**
- The German TSOs **successfully operate** a system with **over 70 GW of installed renewable capacity**
- Biggest challenge and therefore the direction for further Smart Grid development is to **bring back the information lost due to liberalisation and distributed generation**

Grid



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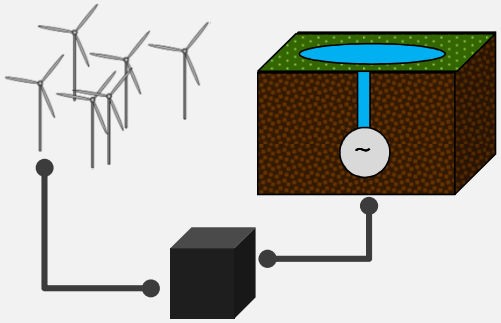

Control Concepts