Stakeholders Workshop on System Operation

Load Frequency Control

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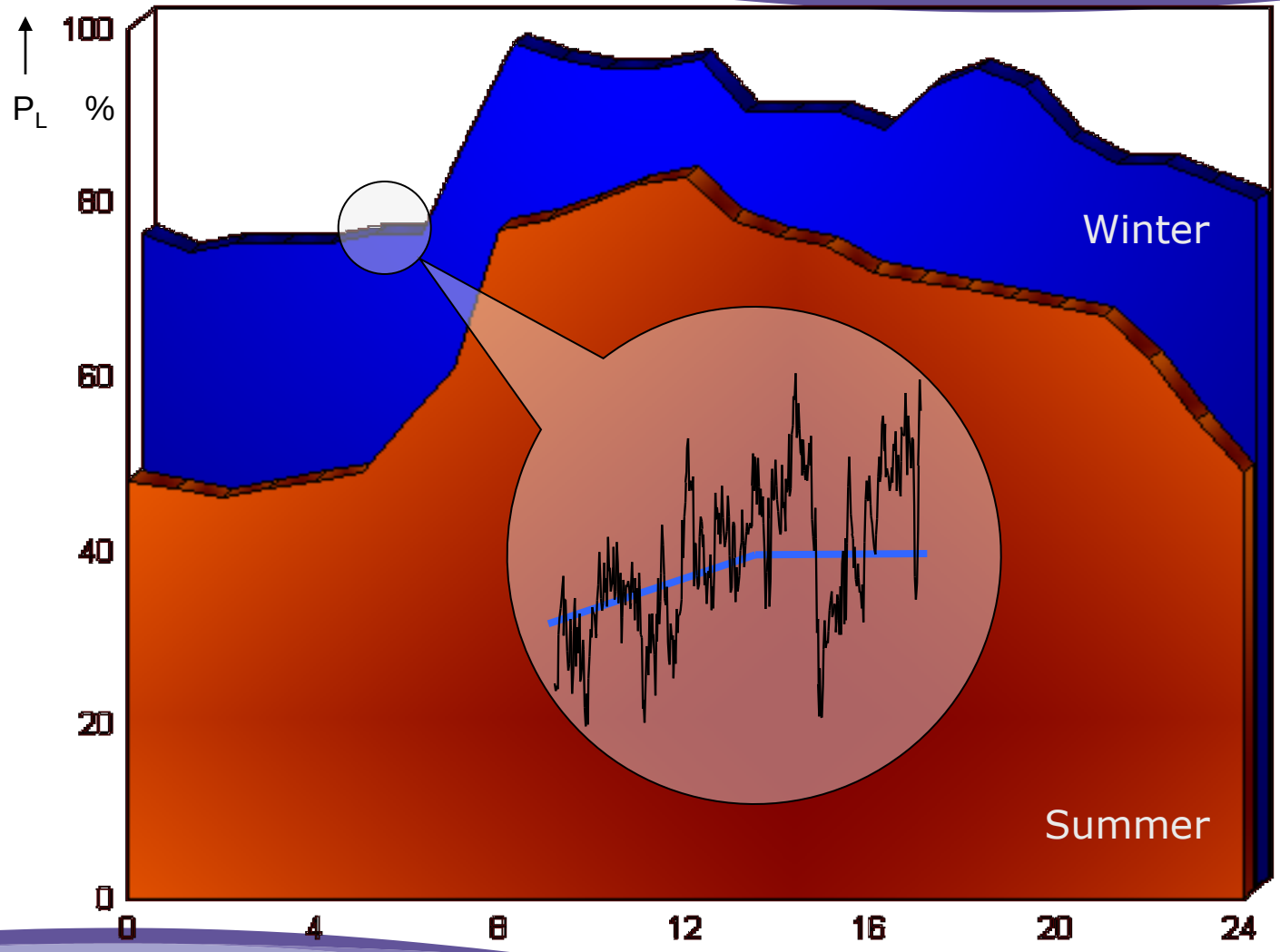
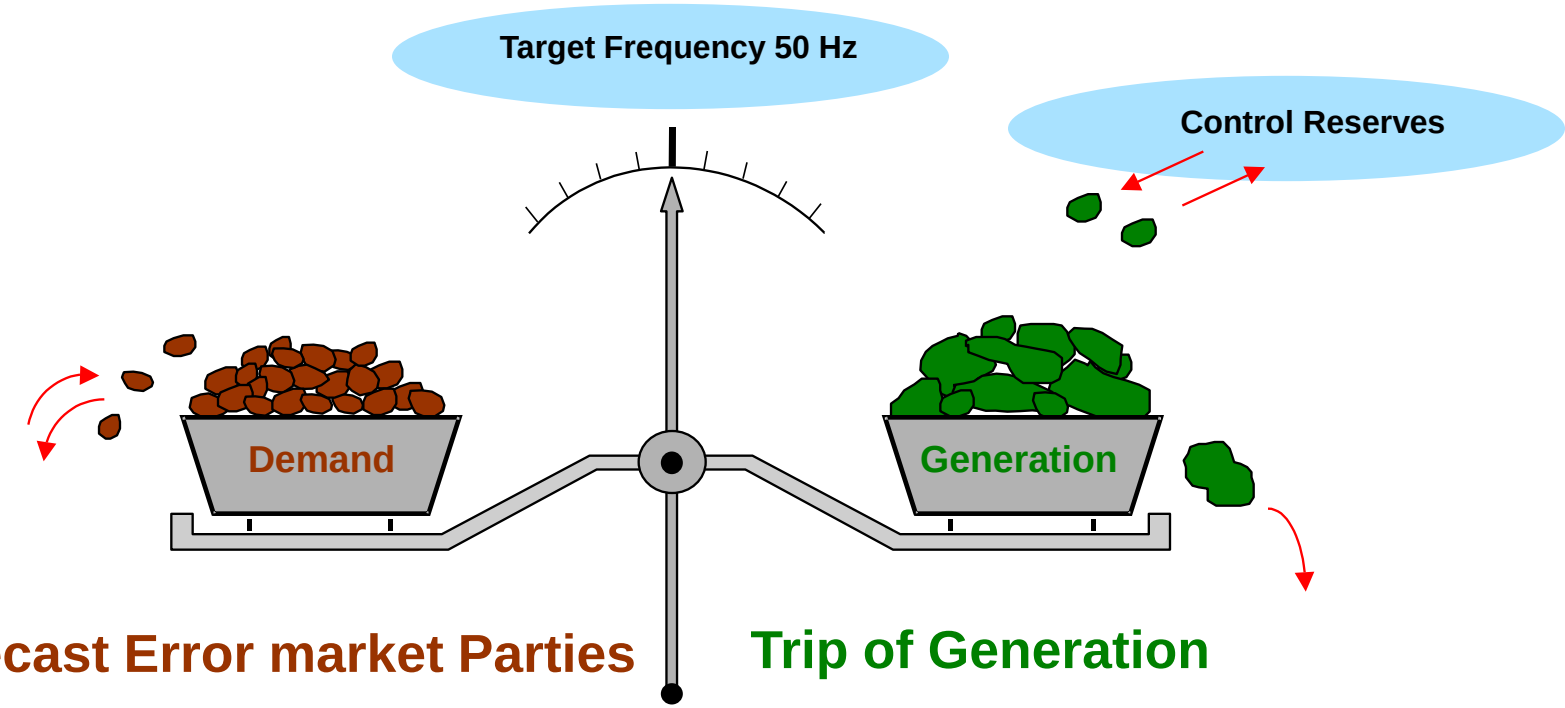
Reliable Sustainable Connected

Daily Demand Curve



Keeping the Balance



Forecast Error market Parties

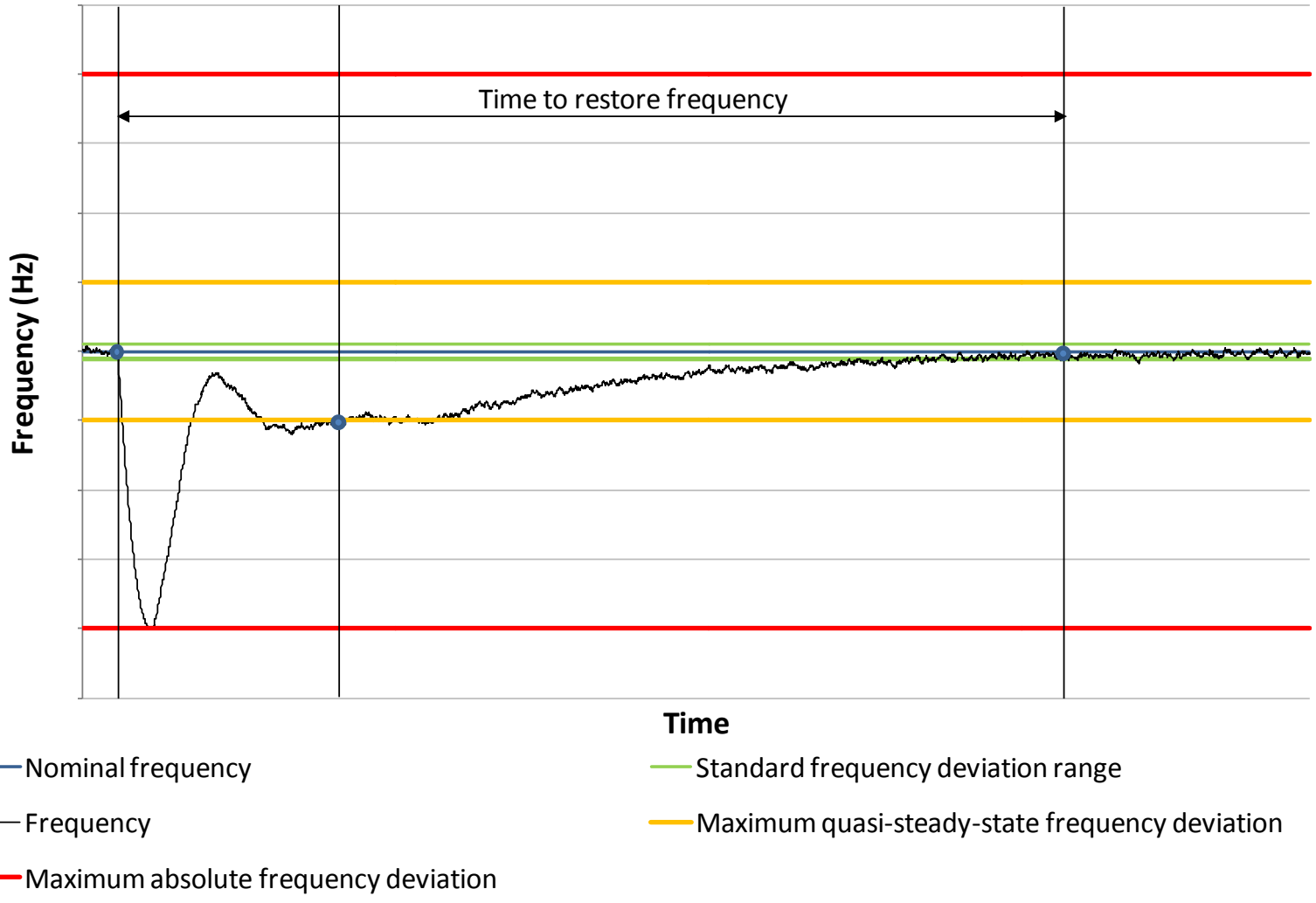
Load Noise

Trip of Load

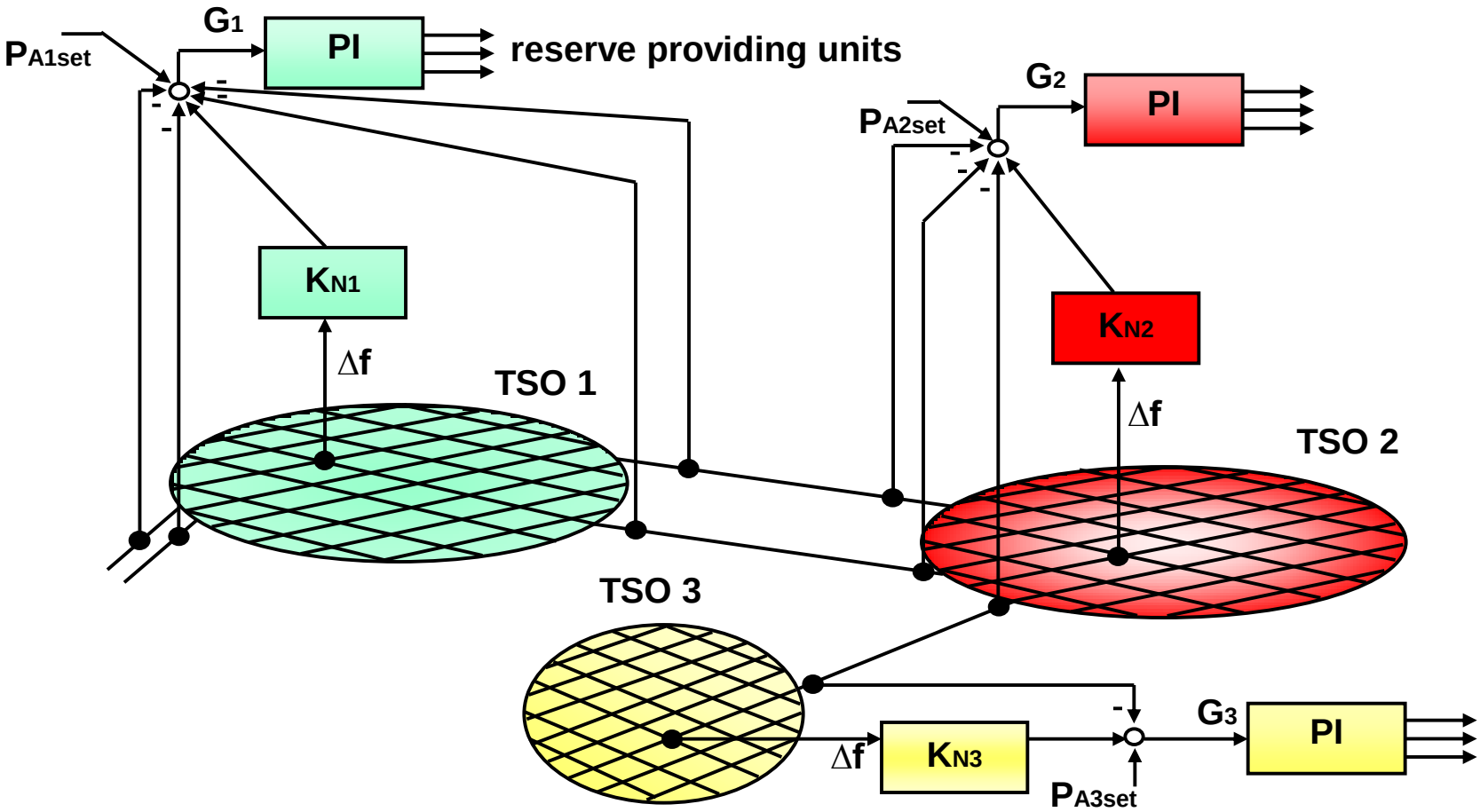
Trip of Generation

Forecast Error Renewables

Frequency Concept



Interconnected Operation of TSO's



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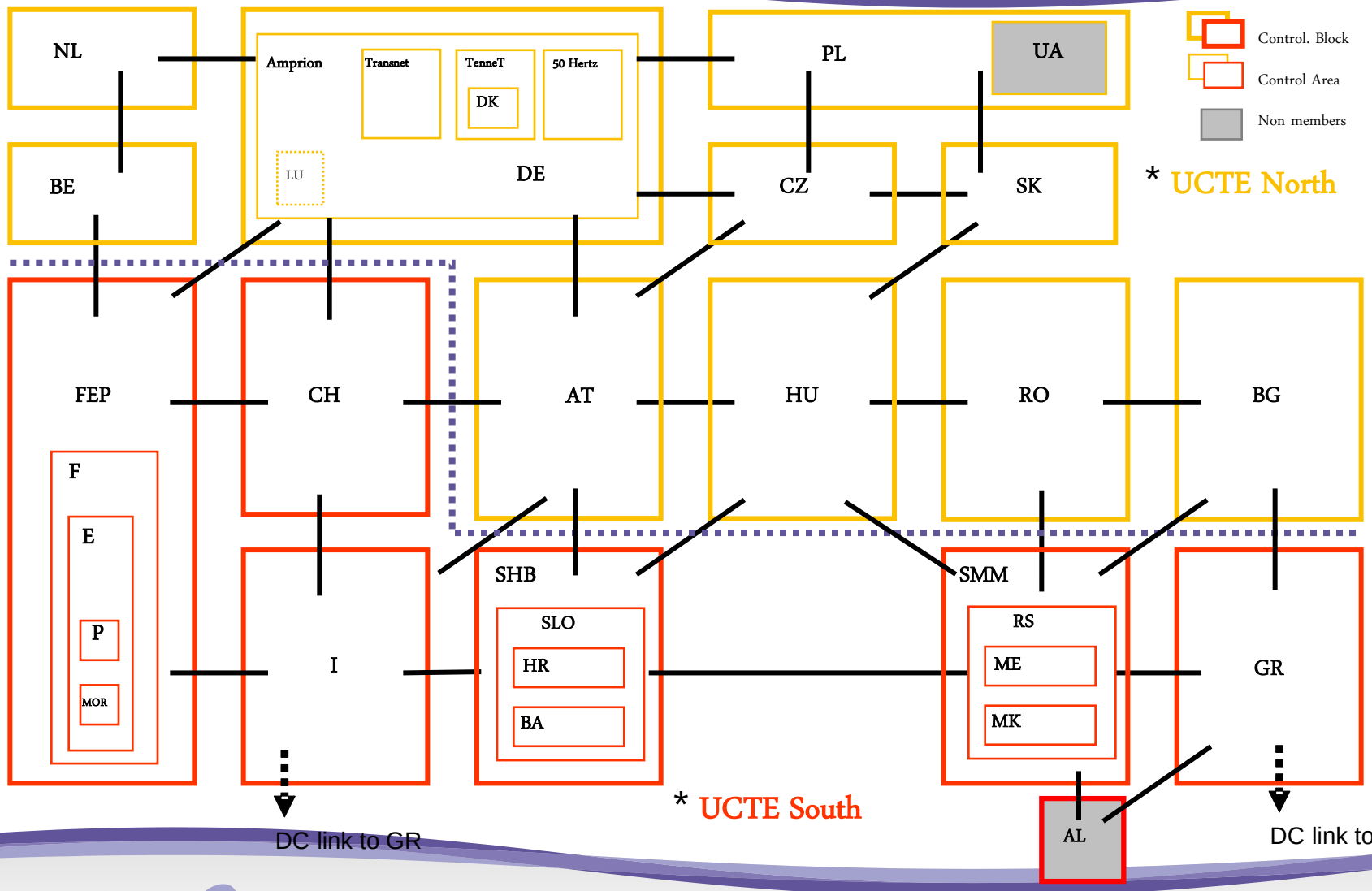
Control Structure in Continental Europe



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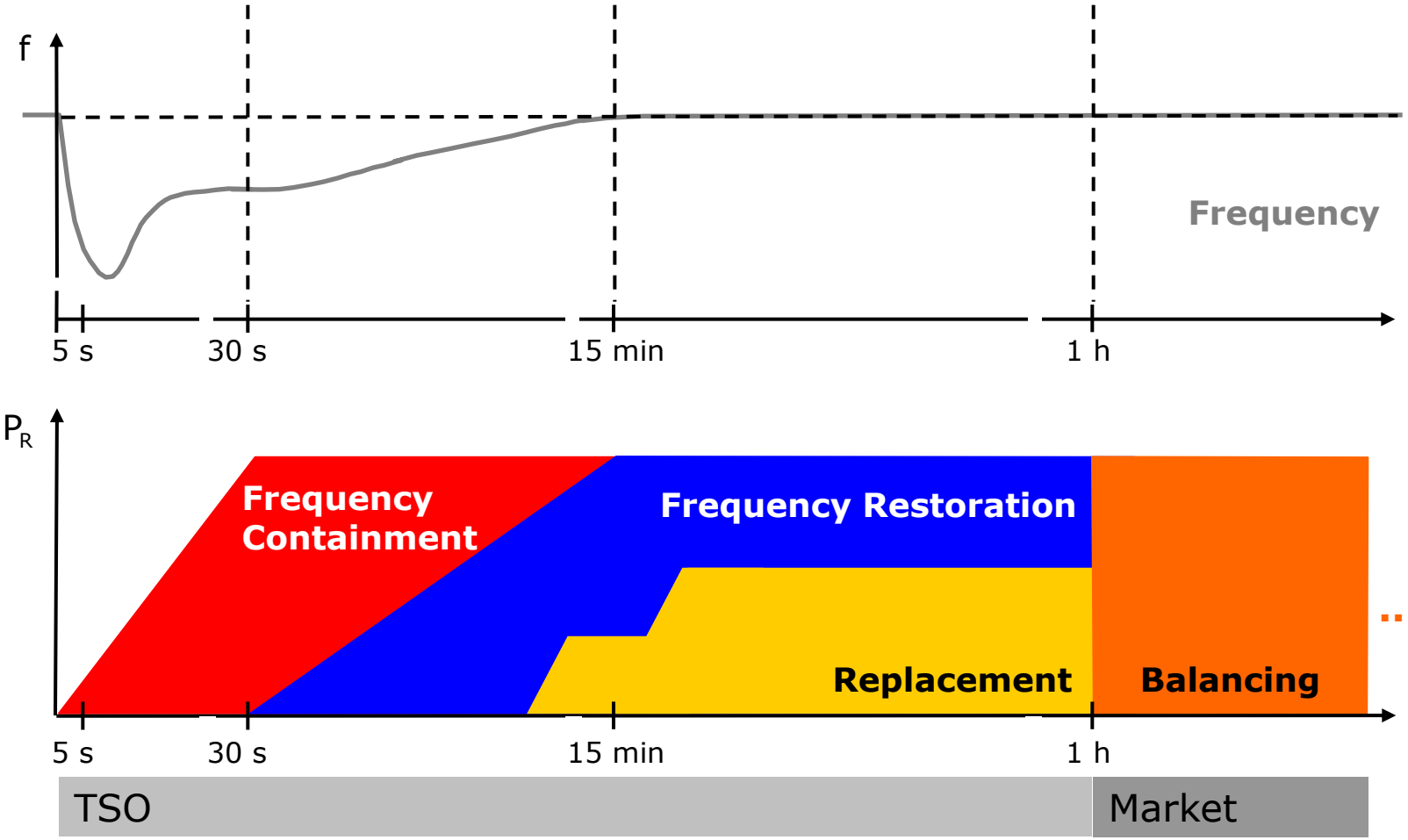
Different Kind of Reserves and Sourcing

Frequency Containment	Frequency Restoration	Replacement
automatic activation	**automatic activation**	**manual activation**
firm Capacity	**firm Capacity**	**firm Capacity** / **activate Market**
	manual activation	
	firm Capacity / **activate Market**	

Application Concept of Reserves (1)



Application Concept of Reserves (2)

After a disturbance of the balance between generation and demand the following steps are performed:

Automatic procedures

- Frequency Containment (0 – 30 sec)
- automatic Frequency Restoration (30 sec – 15 min)

Manual Procedures

- manual Frequency Restoration
- Replacement of Frequency Restoration
- Balancing Energy from Market Parties

Characteristics of Reserves

<1min

1..15min

>15min

- **Frequency Containment Reserve** (FCR)
  - De-central automatic activation (at reserve provider)
  - Fast activation (within 30 s)
  - Common responsibility of TSO‘s within Synchronous Area
- **Frequency Restoration Reserve** (FRR)
  - Central automatic / manual activation (at TSO site)
  - Activation within 15 min
  - responsibility of TSO
- **Replacement Reserve** (RR)
  - central manual activation (at TSO site)
  - responsibility of TSO
  - Activation within 15 min

Reasons for System Imbalances

- types of reasons for system frequency deviations
  - disturbance / outage of generation or load or HVDC interconnector
  - stochastic imbalances in normal operation
  - market driven imbalances – e.g. ramping at the hour shift
  - network splitting
- As a medium term target model, market driven imbalances should be mitigated by integrated measures taken with market participants
- The duration of the system frequency deviation is an important parameter
  - stochastic and market driven imbalances are transient and vanish after some minutes
  - imbalances caused by a disturbance / outage or even network splitting are persistent and have to be covered permanently by operational reserves
- One essential aspect of keeping the power equilibrium is the management of the flows induced for this purpose. Rules for border-crossing exchange of reserves and the distribution of reserves serve have to be established

Generic View: Influencing Factors Control Reserves

System Parameters

- Load Forecast Error
- Production Forecast Error (RES)
- Production Unit Outage
- DC-Link Outage
- Load Noise
- Production Noise
- Ramping of exchange programs

Means / Market Design

- Product Design: Control Reserves
- Availability of Control Reserves
- Specification of Reserves
- Responsibility of Market Parties for Balancing
- Market Design for Balancing (Penalties)

Output Variables

Control Quality

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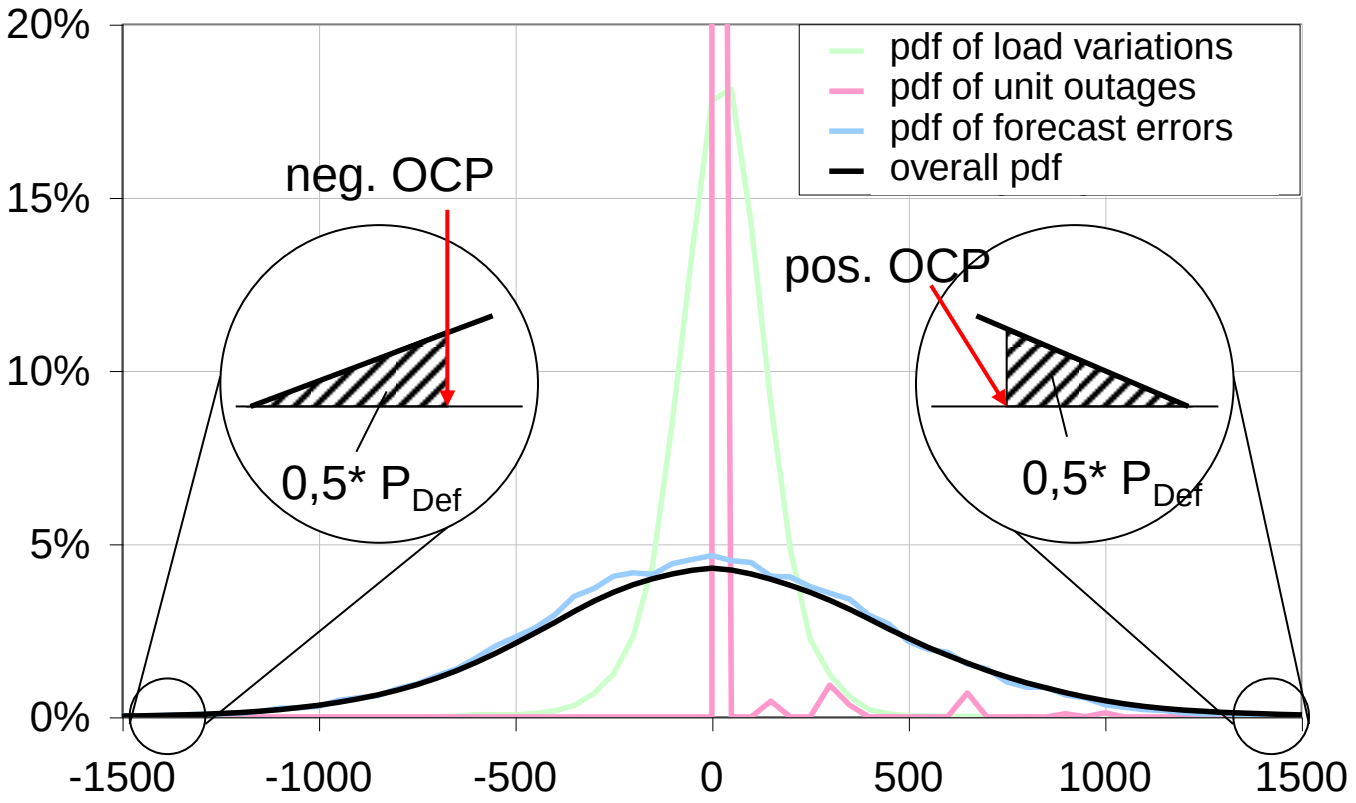
Reserve Dimensioning - Statistical approach

- Example of an overall probability density function (pdf):



During 2*P_{Def} per year (~20h) the available amount of Control Power is not sufficient