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Partner in the Umbrella Project

Key issues for the electricity market design from a grid operator perspective

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Brussels, INNOGRID2020+ conference, February 21, 2013

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Key requirements

1. System security responsibility of the system operators
2. Markets must align on physics not the inverse
3. Adequate information for the system operators
4. Adequate means for the system operators

1. System security responsibility of the system operators

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- Increasing uncertainties in transmission grid operation
  - Renewable power infeeds
  - Intraday trading

➔ Additional security margins required for real time grid operation

← Markets expect more leeway for integrated operation

- Current practice:
  - Load flow calculations and (n-1)-contingency analysis show if violation of security conditions are expected to occur
  - Measures that remedy congestions are selected based on experience
- Increasing number of possibilities for load flow control
  - Topology changes
  - Redispatch
  - FACTS-devices
  - HVDC-terminals
  - Phase shifting transformers

➔ Operational degrees of freedom become more powerful and important

➔ Potential for optimized use of power transmission capacities in grid operation

➔ Improved methods required

1. System security responsibility of the system operators

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Steps towards optimal use of existing transmission capacities

1. Identify the uncertainties
   i. Analysis of uncertainties in transmission grid operation
   ii. Time-adaptive forecast of uncertain parameters and critical system state parameters

2. Optimize transmission grid operation
   i. Optimization algorithms for operational planning
   ii. Optimization of operational planning considering uncertainties
   iii. Short term optimization methods for real time operation

2. Markets must align on physics not the inverse

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- Long-term framework to provide adequate incentives for flexible generation and demand
- Adequate pricing zones to prevent excessive congestions
- Reliable schedules submitted by market participants
- Sufficient reserve power to cope with disturbances
- Use of grid related measures to support the market while preserving security of supply
- Better alignement of energy policies among member states would reduce pressure on transmission system operators

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Key Issues

- Wind and solar power forecasts including uncertainty
- Intraday trading anticipation
- (Load forecasts and power outages)
- Deriving forecast distributions for the system state
- Identification of critical system states

- Key steps:
  - Improve accuracy
  - Provide distribution forecasts
  - Refine spatial resolution

4. Adequate means for TSOs

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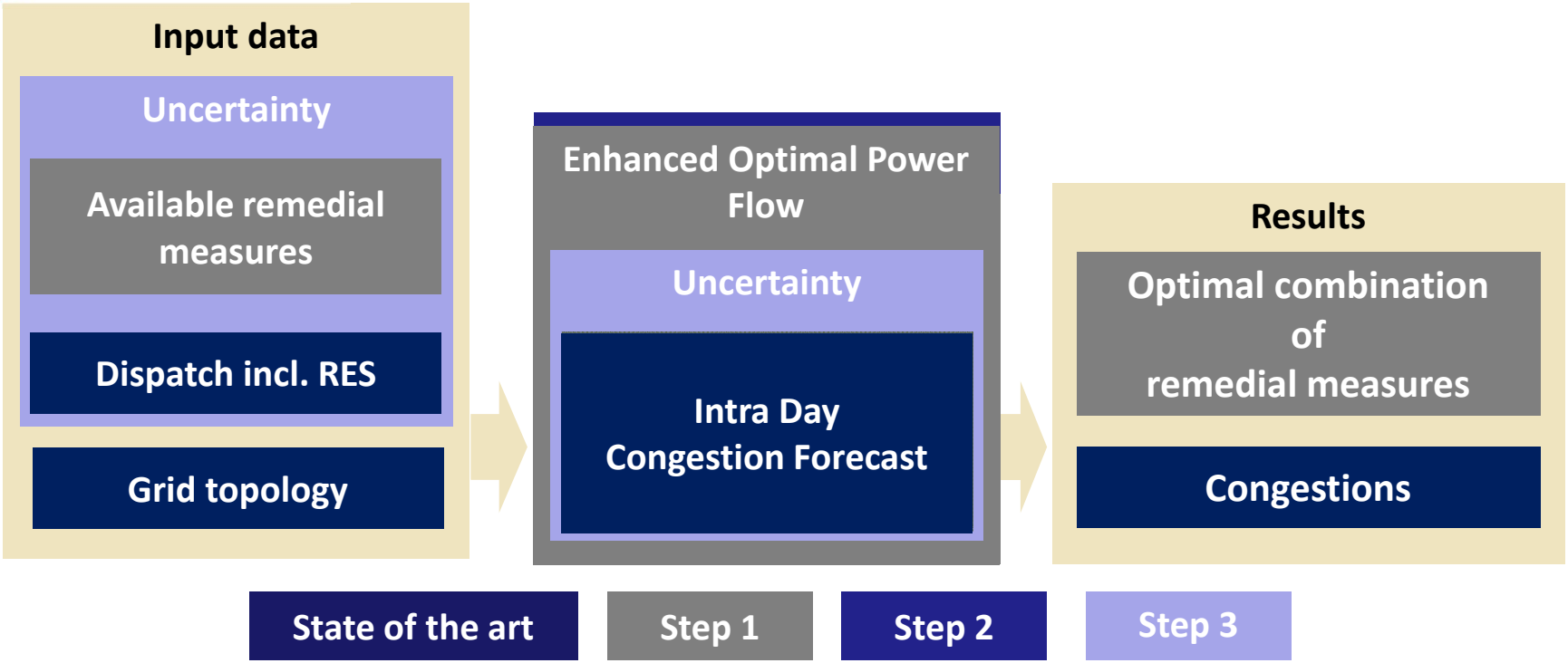
Concept



Step 1: Optimization algorithms supporting operational planning process

Step 2: Short term optimization methods for real time grid operation

Step 3: Optimized uncertainty accounting in operational planning

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Many thanks!

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Back up

3. Adequate information for TSOs

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Key Issue: Wind and Solar Forecasts

- **Improve accuracy:**
  - Using spatio-temporal information
  - Providing also time-adaptive intraday forecasts that make use of the newest information (IDCF)
- **Provide distribution forecasts:**
  - Describes the stochastic nature of RES precisely
  - Quantiles could be integrated into the DACFs
- **Refine spatial resolution:**
  - RES forecasts could be generated for each grid node

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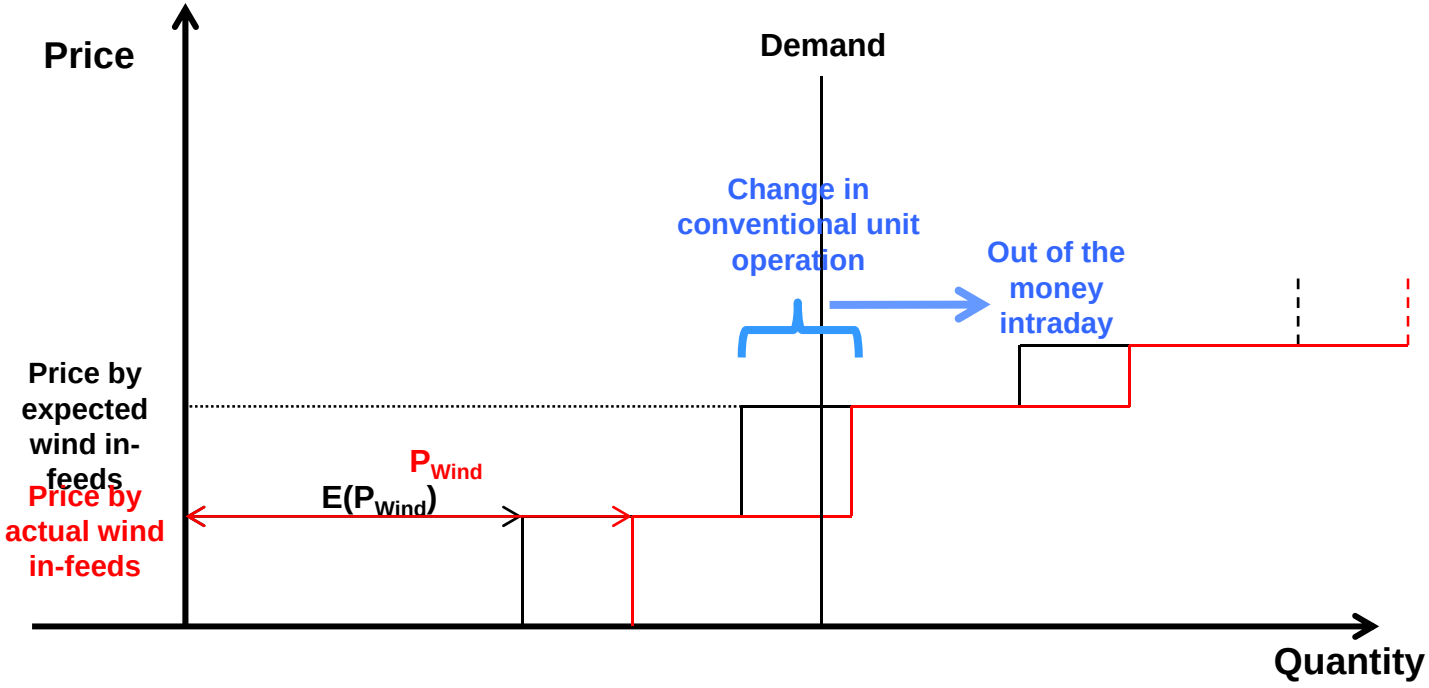
Key Issue: Forecasts for intraday trade

- **Approach:**
  - Merit-order model that incorporates the stochastic behavior of renewable energy in-feeds in order to anticipate future trades
  - Operational restrictions should be considered as well



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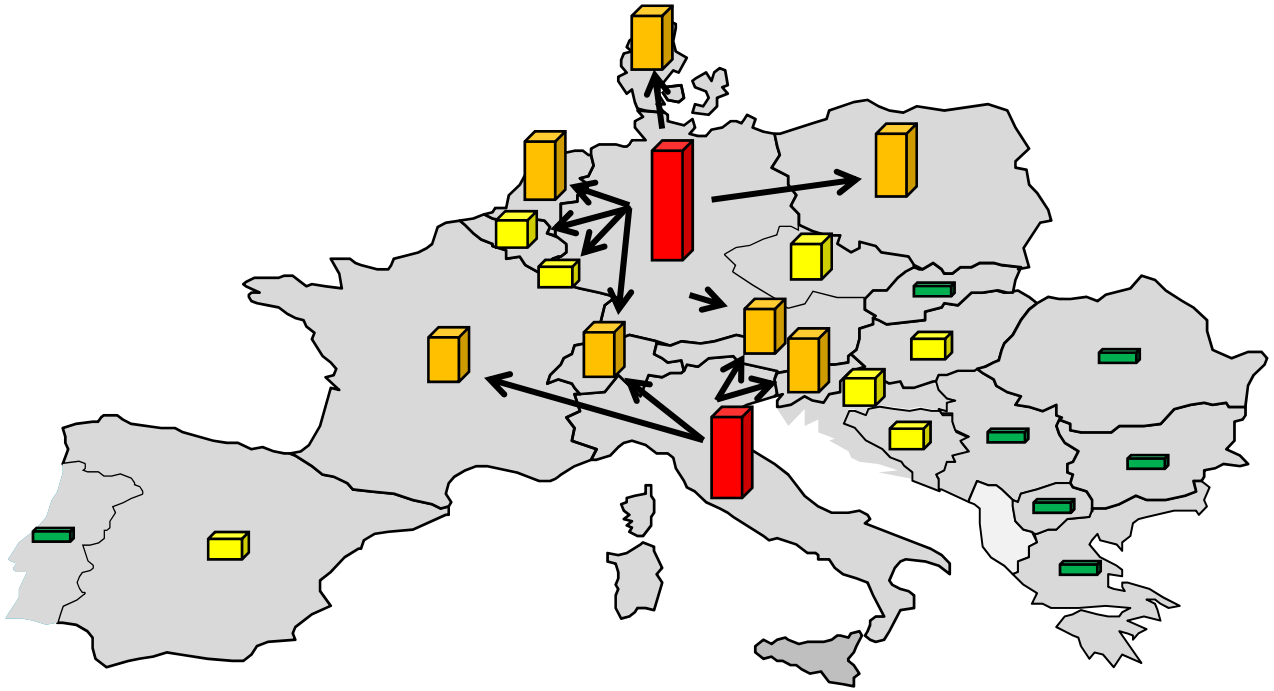
Key Issue: Forecasts of critical system states

Approach:

- The identification and forecasting of critical system states permits to organize remedial actions before an actual critical system state occurs
- Requires the definition of system state parameters and their impact on the system security
- System state parameters should ideally condense key information about the system



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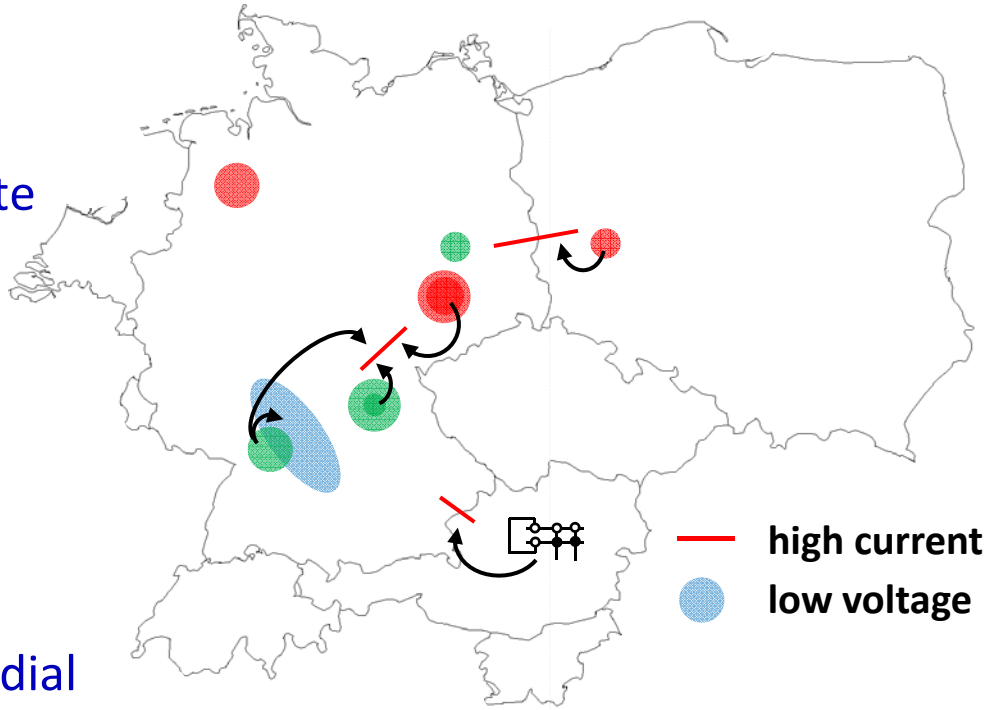
Expected outcomes

- Congestion forecast methods provide (DACF, IDCF, …)
  - Expected congestions
  - Critical faults
- Optimization algorithms estimate
  - Switching state
  - (Phase Shifting) Transformer tap position
  - Redispatch

  In base case & per outage
- Combined optimization of remedial measures for multiple congestions
- Assignment of congestions to remedial measure



4. Adequate means for TSOs

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Key Issue: Challenges in real time

- Unpredicted changes of RES infeeds and intraday trading influence load flow
- Adaption of remedial measures required

➔ Need for real time optimization methods

Additional Challenges	Simplifications compared to Step 1
❍ **Limited timeframe for optimization** ❍ **Reduced amount of remedial measures available**	❍ **Reduced amount of remedial measures available** ❍ **Reduced requirements regarding accuracy** ❍ **Initial solution available** ❍ **No uncertainties**

➔ Tradeoff between computational speed and accuracy required

- Real time optimization directly assists grid operator

➔ Advanced requirements regarding reliability and robustness