Umbrella Project

Possible future concepts for optimized solutions for maximizing power transits

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Polskie Sieci Elektroenergetyczne Operator S.A.

amprion

swissgrid

APG AUSTRIAN POWER GRID WE KEEP IT GOING

FGH Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft e.V.

ČEPS, a.s.

TRANSNET BW

IAEW Institut für Elektrische Anlagen und Energiewirtschaft Univ.-Prof. Dr.-Ing. Albert Moser

RWTH AACHEN UNIVERSITY

EWL

TU Delft Delft University of Technology

ELES ELEKTRO-SLOVENIJA, d.o.o.

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

tennet Taking power further

TU Graz Graz University of Technology

Umbrella Project

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Umbrella – iTesla Workshop

Institut für Elektrische Anlagen
und Energiewirtschaft
Univ.-Prof. Dr.-Ing. Albert Moser

Background

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- 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
  - FACTS-devices
  - Phase shifting transformers
  - Redispatch
  - HVDC-terminals

➔Operational degrees of freedom become more powerful and important

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

➔Additional security margins required for real time grid operation

➔Potential for maximizing power transits in transmission grid operation

Steps to Maximize Transits

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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

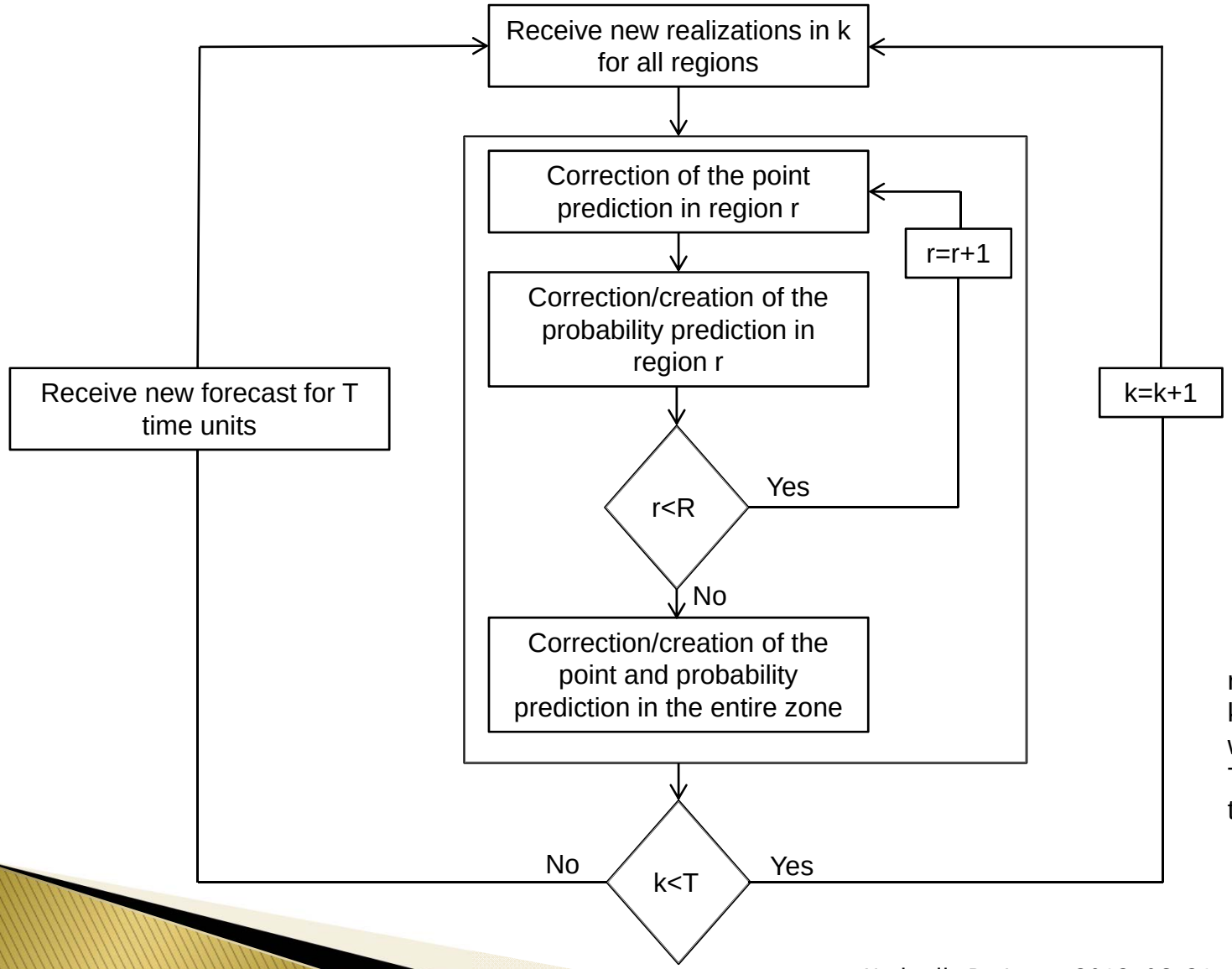
Considered Uncertainties

1. Feed-ins from renewable energy sources
   - Status quo: only strongly aggregated point predictions
2. Load
   - Status quo: only point predictions in DACF
3. Intraday trading
   - Status quo: forecast improvement desirable
4. Power plant outages
   - Status quo: forecast improvement desirable

Wind and solar power 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

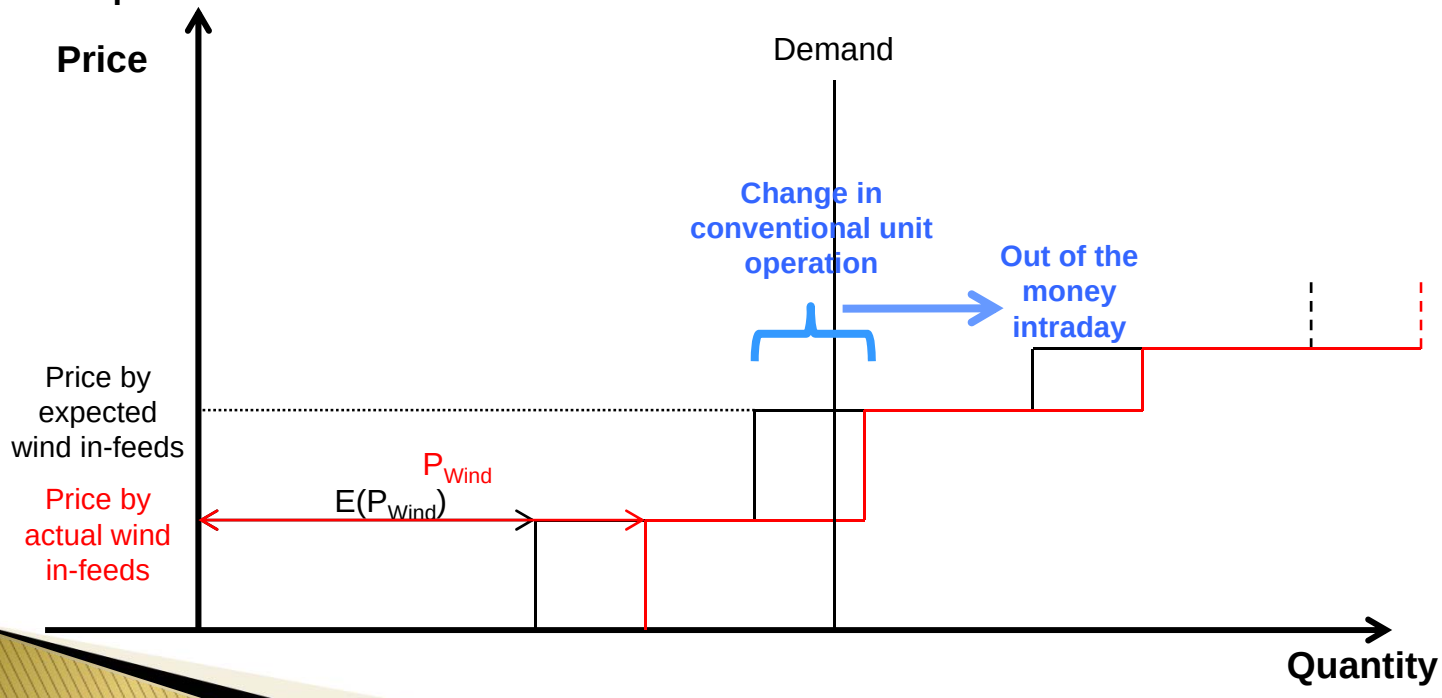
Wind and solar power forecasts



r … Region
k … Time step within time horizon
T … look-ahead time

Intraday trading

- **Objective:** prediction of intraday trades
- **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



Load forecasting and power plant outages

- **Approach:**
  - Analysis of state-of-the-art prediction tools
  - Evaluation and application

- **Challenge:**
  - Differences between the vertical grid load and total grid load are unobservable
  - Power plants are also connected to the subordinated grids, which causes important variations in the vertical grid load → proxies needed

Forecast of critical system states

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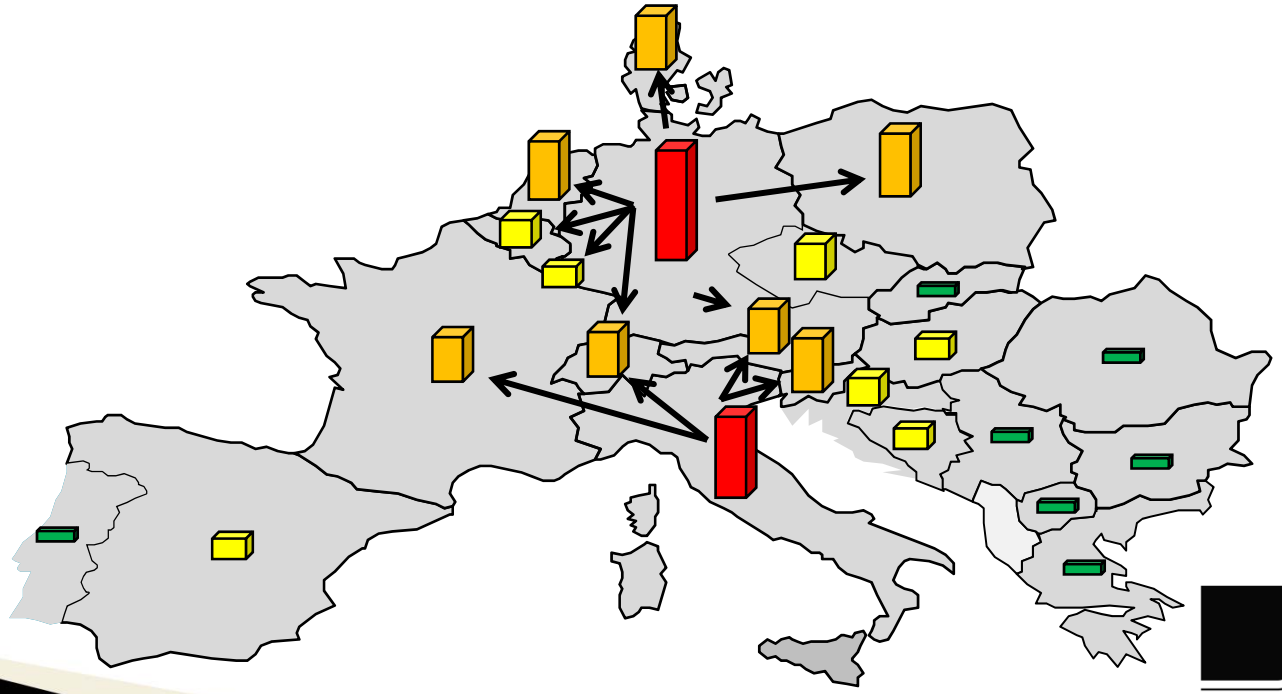
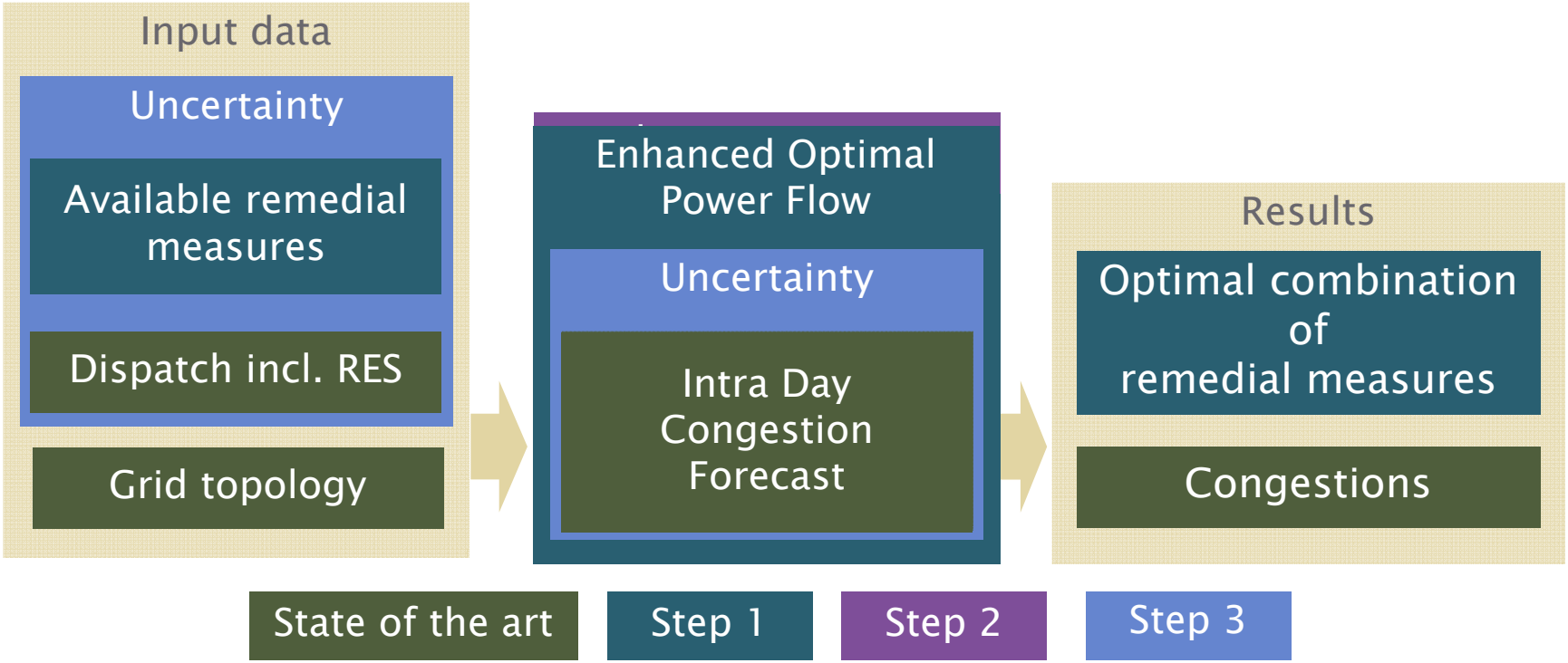
Approach:

- 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

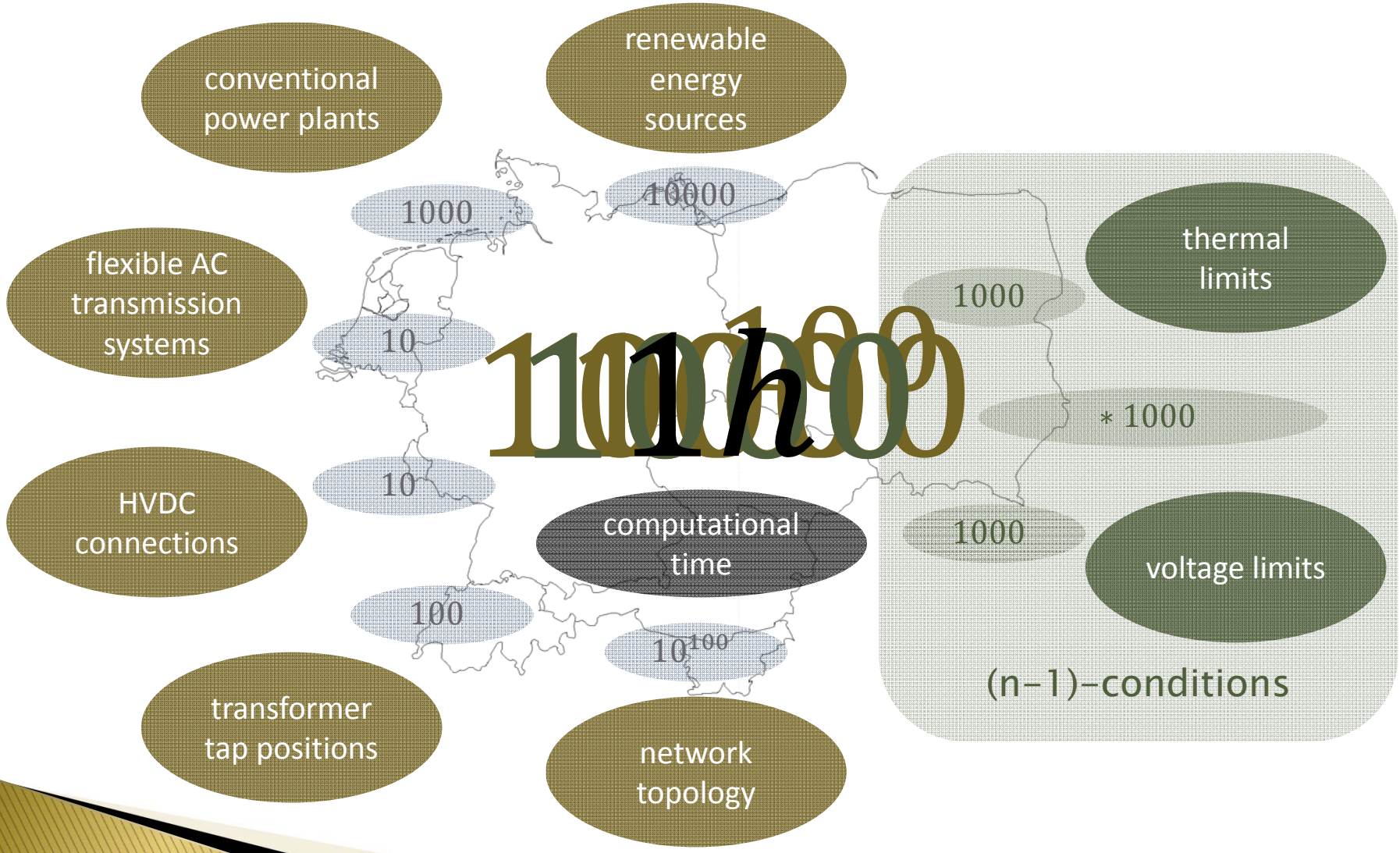


Concept



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

Orders of Magnitude



Possible Approaches

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Modeling of Remedial Measures

- Considering electrical and physical distances
  - Impact of remedial measures limited to surrounding region
  - Neglecting measures with little effect on observed congestions (cf. observability area)
- Reducing model complexity
  - Linear approximation in operating point
  - Limiting the amount of simultaneously applied remedial measures

Handling of Constraints

- Critical situations known from congestion forecast
  - Identification of relevant technical restrictions
  - Neglecting dispensable constraints
- Alternative methods for outage calculation
  - Simplified approximation of load flow in (n-1) situations

Intended Outcomes

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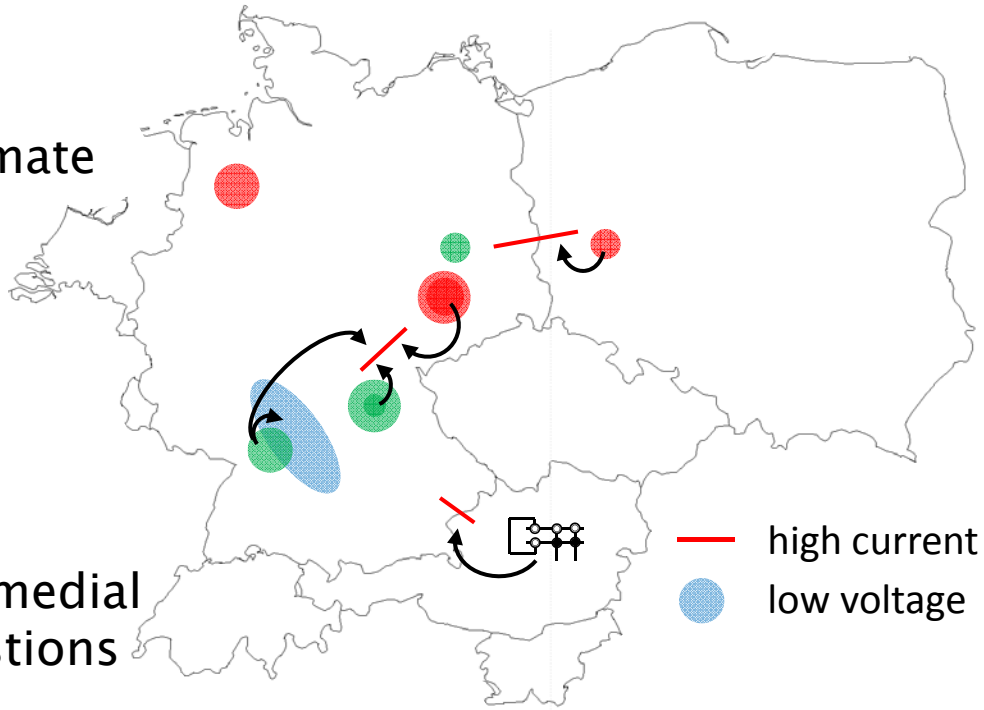
- Congestion forecast methods provide (DACF, IDCF, …)
  - Expected congestions
  - Critical faults
- Optimization algorithms estimate
  - Switching state
  - (Phase Shifting) Transformer tap position
  - Redispatch

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



Challenges in Real Time

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- 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

Summary

Umbrella Project

- Growing uncertainties in transmission grid operation

➔Quantification of uncertainties

➔Uncertainty estimation tailored for transmission grid operation

- Increasing degrees of freedom (HVDC, PST, …)

➔Maximizing power transits by

  ➔Optimization in operational planning considering uncertainties

  ➔Short term optimization for real time grid operation

- Dependency between system utilization and system security

➔System security needs to be considered in grid operation

➔Possible future strategies to limit extend and impact of major system disturbances