InnoGrid2020+

The European Research & Development Dissemination Seminar

20 - 21 February 2013

Umbrella Project

SEVENTH FRAMEWORK PROGRAMME

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UMBRELLA

Innovative tools for the future coordinated and stable operation of the pan-European electricity transmission system

Researchers: EU Top Quality Collaboration TSOs—Universities—Institute

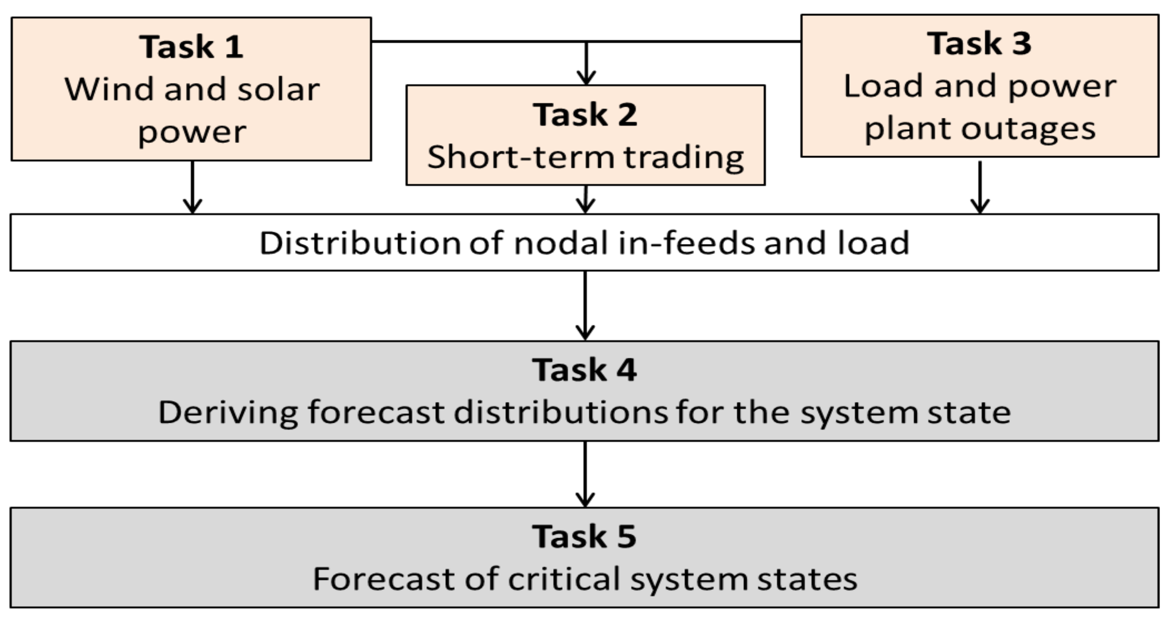
Project Coordinator: TenneT TSO GmbH (TTG)

WP2: Forecasting

Overview

Two major topics:

1. Estimation of relevant uncertainties (task 1-3)
2. Determination and forecasting of critical system states (task 4-5)

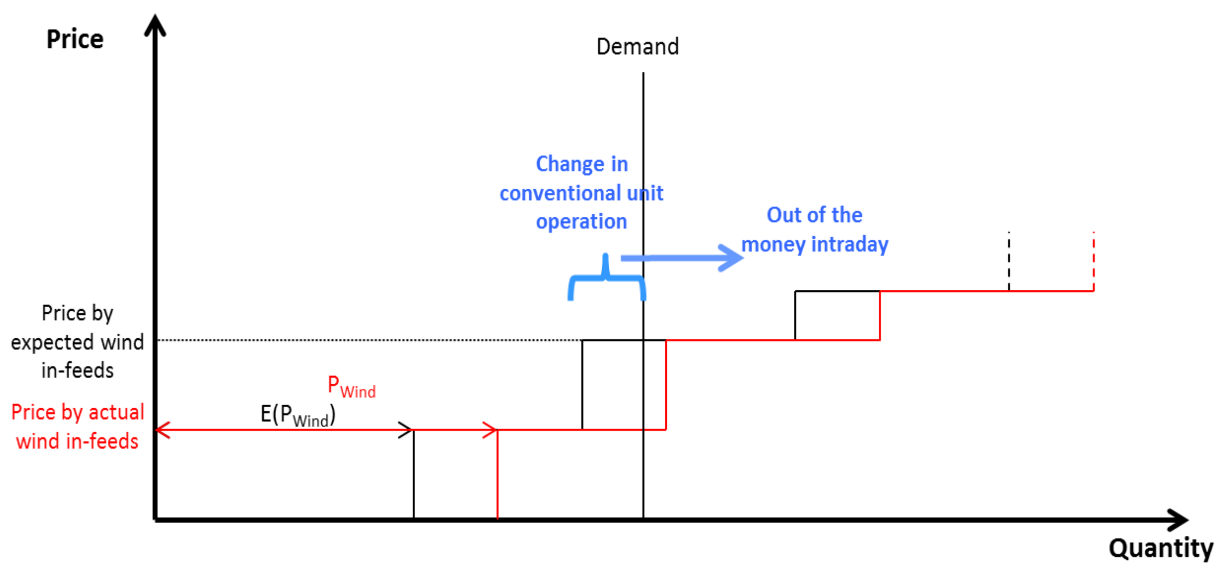


Task 1: Wind and solar power forecast uncertainty

- Conditional kernel density estimation used to estimate the uncertainty of RES in-feeds in order to assess potential risks adequately
- The uncertainty of the forecast error is conditional on the point forecast

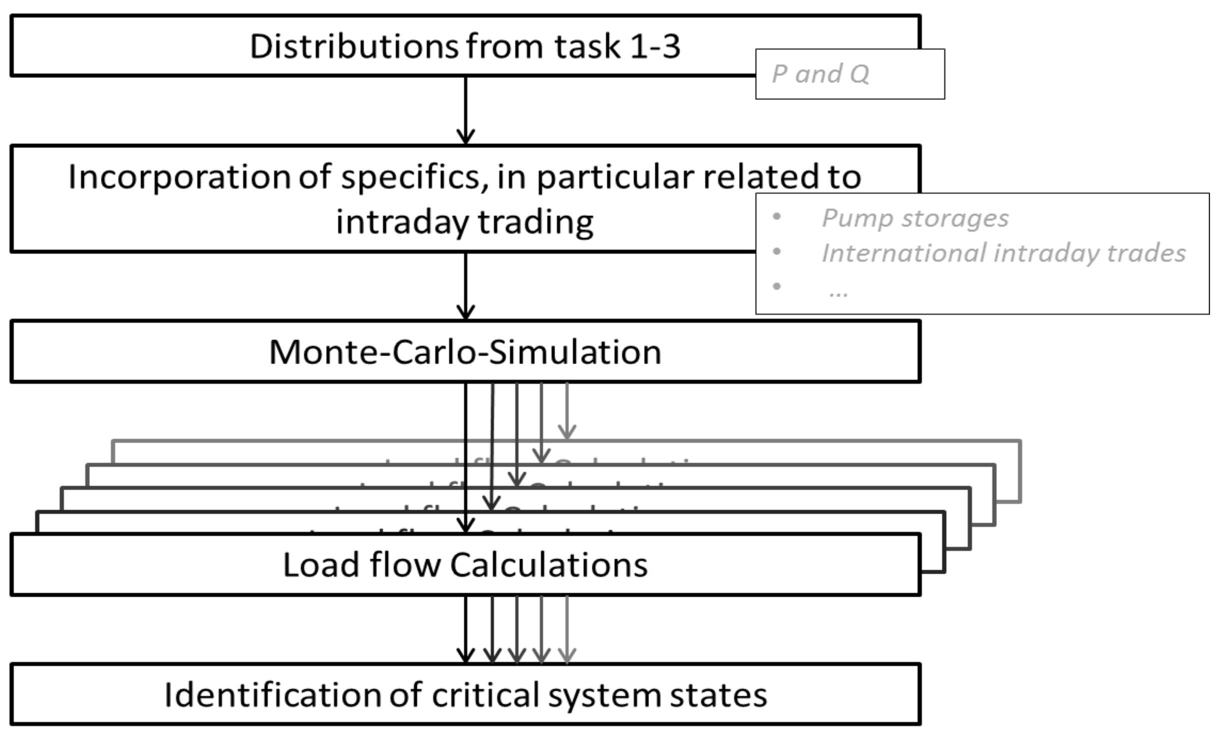
Task 2: Short-term trading uncertainty

Combination of uncertainties used to anticipate changes in conventional power production at each grid node and, thus, changes of trades as well as power flows



Task 4 and 5: System state distributions and their forecasts

Estimated uncertainties combined with a load flow calculation and a Monte Carlo Simulation can be utilized to identify critical system states in advance



WP3: Optimization

Objectives

- Optimization of transmission grid state can aim at multiple objectives
  - Minimizing amount & costs of applied remedial measures while only fulfilling technical constraints
  - Optimizing secure states by e.g. minimizing active power losses
- Amount of measures proposed by the optimization tools should be minimal to keep results comprehensible and viable for grid operators

➔ Minimizing only amount of cost of remedial measures

➔ No application of measures to secure grid states

Basic concept of optimization algorithms

- Previous work shows problems in computational feasibility of one single optimization problem taking into account
  - Topology optimization
  - Continuous optimization
  - Preventive and curative application of remedial measures
  - Large number of constraints

➔ Formulation of adequate optimization tools for all sub-problems and intelligent heuristic coordination intended

Real time optimization tool

Post contingency application of remedial measures

- Thermal time constants of electric equipment allow reaction on congestions after their actual occurrence
- Curative implementation of remedial measures reduces amount of required preventive remedials and therefore helps saving money

➔ Interaction between preventively and curatively applied remedials needs to be considered in all subproblems

Continuous optimization

- Joint optimization of (quasi-)continuous remedial measures
- Integrated consideration of multiple pre and post contingency timestamps
- Contingency filtering based on initial (n-1)-simulation

Topology optimization

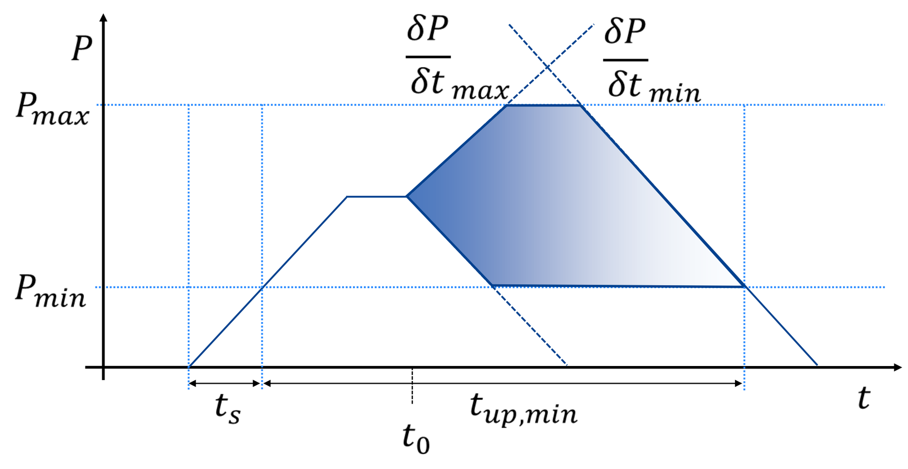
- Corrective switching actions provide huge amount of possible solutions
- Technical feasibility of special switching states cannot be assessed using current congestion forecast datasets

➔ Manual TSO approval of selected switching states required

- Offline estimation of beneficial switching states by optimization algorithm & feasibility assessment by TSO
- Online topology optimization based on list of approved switching states

➔ Assured technical feasibility & optimized computational effort

Operational planning optimization tool



Timeframe optimization

- Flexibility of thermal power plants limits immediately available redispatch measures

➔ Timeframe optimization allows consideration of intertemporal constraints and therefore extends amount of available redispatch measures

Uncertainty accounting optimization tool

Uncertainty accounting during operational planning

- Physical realization of expected in-feed and load uncertainty

➔ Assessment of uncertainties in WP2

- Physical risk not directly correlated to violated constraints

➔ Estimation of risk in WP4

➔ Optimization of operational planning under consideration of uncertain input data and risk based security assessment

WP4: Risk-based security assessment

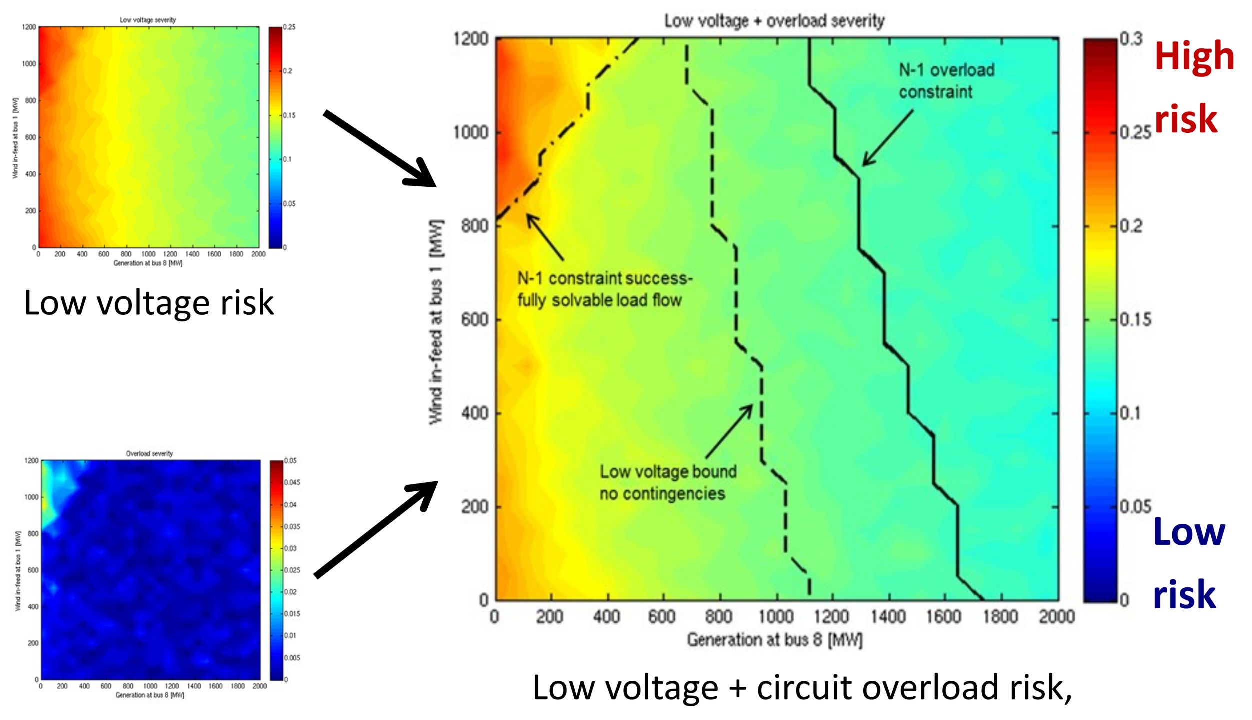
Objective:

Develop strategies to retain system security while facilitating market operation and integration of renewable energy.

Additional information about risk level, based on [1], [2]:

Evaluation of risk: **Risk = Probability · Severity**

- Monte Carlo simulations to determine risk levels for a range of different operating conditions
- Total risk = weighted sum of risk from different sources.



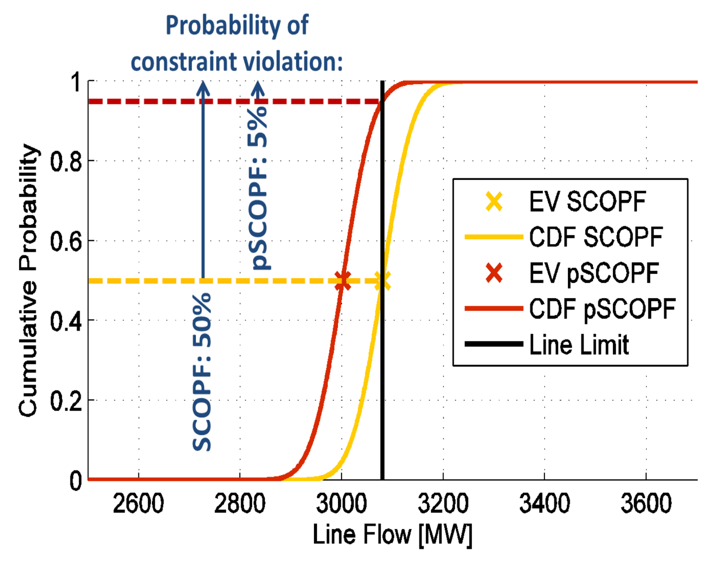
Low voltage risk

Circuit overload risk

Low voltage + circuit overload risk, and comparison with deterministic bounds

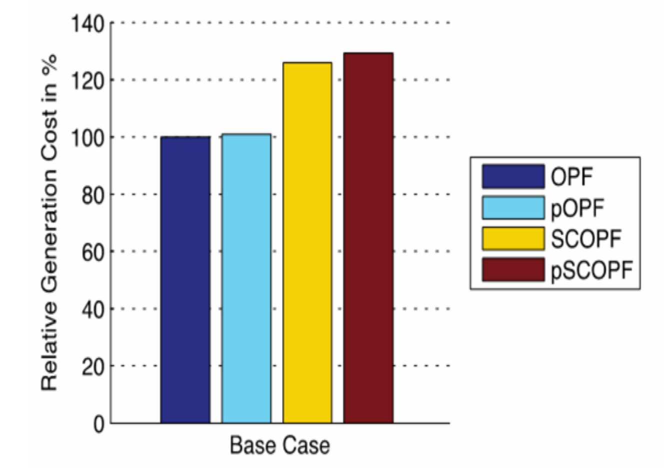
Optimization of power transits accounting for uncertainty and risk [3]:

- Account for **uncertainty of RES in-feed**
- Security-Constrained Optimal Power Flow (SCOPF) formulation for which the system remains N-1 secure with given probability



I. Constraint tightening:

Expected value (EV) and cumulative distribution (CDF) of power flow on a line after an outage, computed with a deterministic SCOPF and a probabilistic SCOPF (pSCOPF). Because of the constraint tightening in the pSCOPF, the **probability of a post-contingency overload is reduced from 50% to 5% !**



II. Cost of uncertainty/security:

The cost of securing the system against fluctuations of RES (**cost of uncertainty**) and against contingencies (**cost of security**) can be estimated by comparing results from the different OPF solutions.

[1] D. Kirschen and D. Jayaweera, "Comparison of risk-based and deterministic security assessments", IET Generation Transmission and Distribution, 1 (4):527-533, 2007

[2] M. Ni, J. McCalley, V. Vittal, and T. Tayyib, "Online risk-based security assessment", IEEE Transactions on Power Systems, 18(1):258–265, 2003

[3] L. Roald, F. Oldewurtel, T. Krause and G. Andersson, "Analytical Reformulation of Security Constrained Optimal Power Flow with Probabilistic Constraints", submitted to IEEE PowerTech Conference, Grenoble, France, 2013