

# Security Constraint Unit Commitment

## SCUC for Creating Active Power Time Series

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### DC Load Flow Calculations

For grid analysis

- The Kopernikus project ENSURE provides data for prospective active power ranges of the german power system while dynamic modelling requires exact operating points
- Based on the calculation of the incidence matrix **A**, the susceptance matrix **B** and the diagonal matrix **b**, Linear Sensitivity Factors (LSF) can be computed for grid analysis (PTDF, LODF)

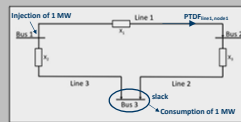
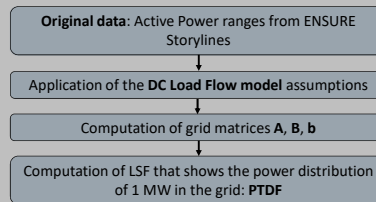
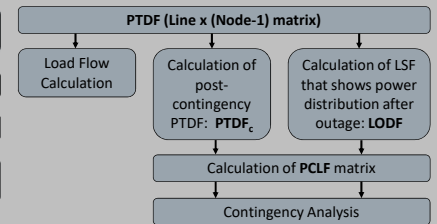


Figure 1: Illustration of one element of the Power Transfer Distribution Factor: Injection of 1 MW on node 1 and consumption of 1 MW on the slack



PCLF	Line 1	Line 2	Line 3
Line 1	0	line loading in %	line loading in %
Line 2	line loading in %	0	line loading in %
Line 3	line loading in %	line loading in %	0

Figure 2: Illustration of the Post Contingency Load Flow matrix: each row corresponds to a monitored line, each column corresponds to an outaged line

### Optimization Functions

With the Gurobi Optimizer

- Implementation of two optimization functions regarding grid security ((N-1) criterion) and one economic efficiency optimization

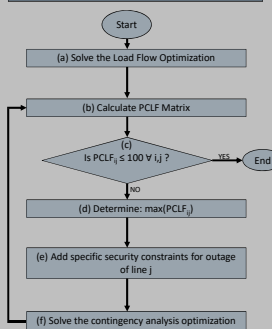
#### Load Flow Optimization:

- **Objective function:** maximization of all power flows in the grid
- **Constraints:** no loadings > 100 %
- Prefixed optimization for solution of SCUC model

#### Contingency Analysis Optimization:

- **Objective function:** maximization of all power flows in the grid
- **Constraints:** no loadings > 100 % in contingency load flow/ PCLF matrix
- Iterative approach to reduce computation time of the SCUC model

#### Iterative Contingency Analysis Optimization:



#### Economic Efficiency Optimization:

- Determination of the economically most efficient distribution of active power injection on one node between the different power plant types

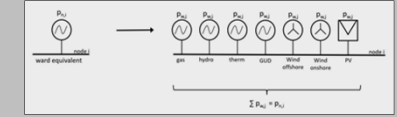


Figure 3: Economic Efficiency Optimization: Distribution of active power injections on the different plant types while minimizing the power generation costs on each node

- Adjustable composition of power plant types per node, power generation costs and power injection ranges
- Optional prioritization of specific plant types

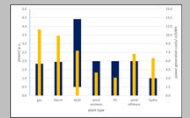


Figure 4: Illustration of active power ranges and power generation costs per power plant type (paradigmatic values for economic efficiency optimization)

### Iterative Optimization Results

For the IEEE 39-bus-system

- Upper operational limit of the synchronous machines is often reached

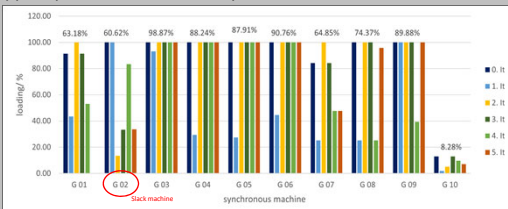


Figure 7: Illustration of utilization of the synchronous machines in the grid after each iteration step, slack machine shows lowest average utilization

- IEEE 39-bus-system does provide (N-1) security for an upper loading limit of 120%
- By application of iterative approach 10.6 % of the possible constraints for the complete SCUC model were sufficient to receive a result

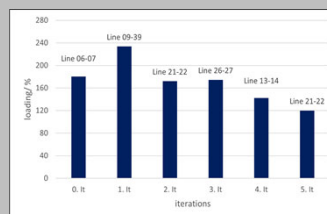


Figure 5: Illustration of the maximum of the PCLF matrix throughout the iterations, after six iteration steps all utilizations are ≤ 120% and the SCUC model is solved

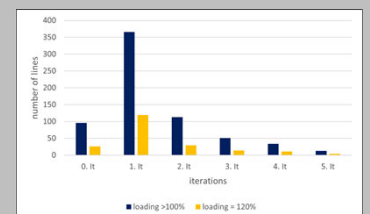


Figure 6: Illustration of the number of congestions throughout the iterations, final result contains 4 connections with a loading of 120% and 13 connections with a loading of >100%

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