Monte Carlo Simulation for Generation Adequacy Simulations

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Generation Adequacy

- The Generation Adequacy function of PowerFactory allows assessing the reliability of supply of a system.
- Typical reliability indices:
  - LOLP: Loss of load probability
  - LOLE: Loss of load expectancy
  - ENS (or END): Energy not supplied (or Energy not delivered)
- Generation Adequacy Assessment allows quantifying the required installed capacity of a system.
- The PowerFactory function “Generation Adequacy” makes special consideration of renewable energy sources and makes special provision for assessing the capacity credit of renewable generation.

Modelling of Dispatchable Generation

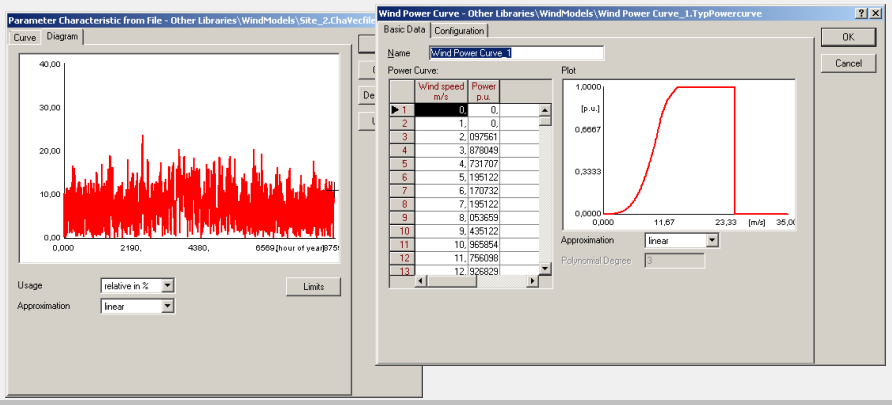
- Unplanned outages:
  - Multi-state Marcov-Model per generating unit.
  - Typically: two state models are used (unplanned outage rate)
- Planned outages:
  - Definition of a deterministic maintenance schedule.
  - Alternatively: Modelling of planned outages like unplanned outages

Modelling of Wind Generation

- Typically, wind farms are modelled rather than individual wind generators:
  - Rated power per individual wind generator
  - Number **n** of wind generators in wind farms
- Unplanned outages:
  - Two-state Marcov Model
  - Automatic consideration of the number **n** of wind generators
- Wind variation:
  - Probabilistic Approach: Weibull function
  - Time series approach

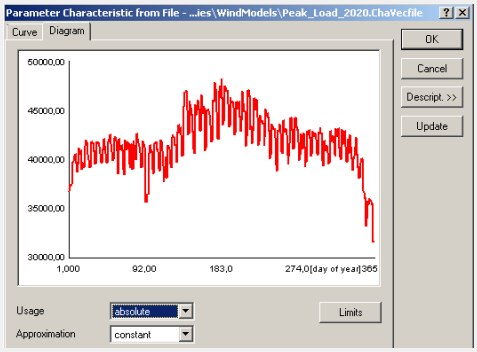
Modelling of Wind Generation – Time Series Approach

- Two types of time series definition:
  - Time series of power generation
  - Time series of wind speeds + power curve



Load Modelling

- Typical Approaches:
  - Constant load (e.g. yearly/seasonal peak load)
  - Peak load characteristic (e.g. daily peak loads)
  - Continuous load characteristic (e.g. with a 15min time resolution)
  - > usually depends on data availability



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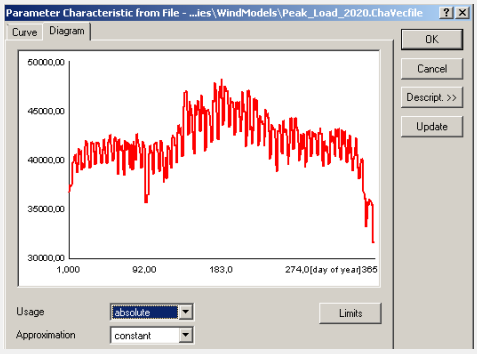
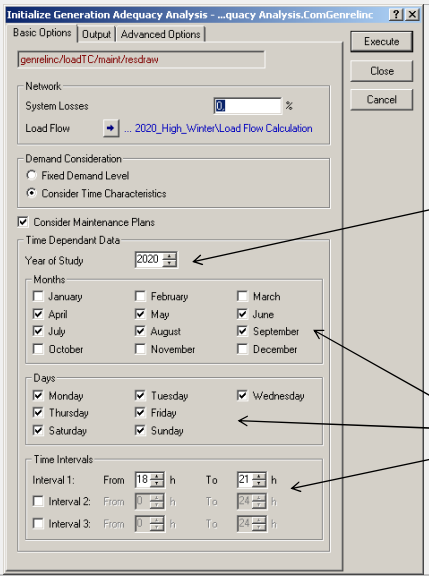


Command Settings



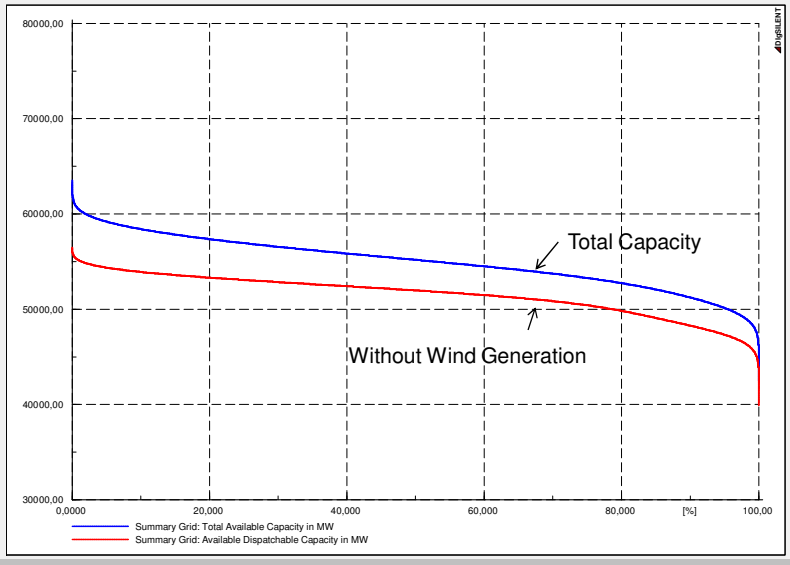
Year of study:
- For system model (Expansion Stages)
- Maintenance Plan

Considered periods
- Months
- Days
- Hours
-> e.g. In case of known full load hours or full load season

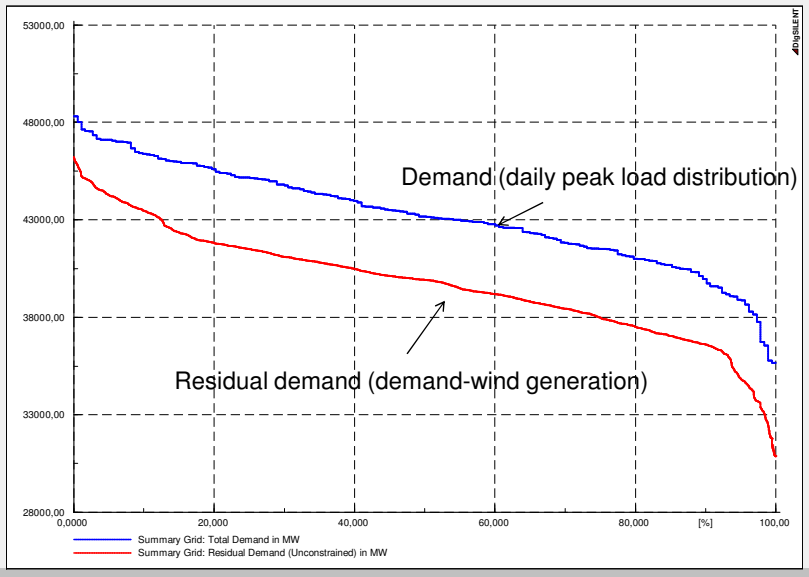
Results

- Reliability Indices (LOLP, LOLE)
- Cumulative probability curves:
  - Total available capacity
  - Available capacity of dispatchable generation
  - Available capacity of non-dispatchable generation
  - Reserve (Total, dipatchable, non-dispatchable)
  - Total demand (load duration curve)
  - Demand supplied
  - Demand not supplied
  - Residual demand (Demand – non-dispatchable generation)

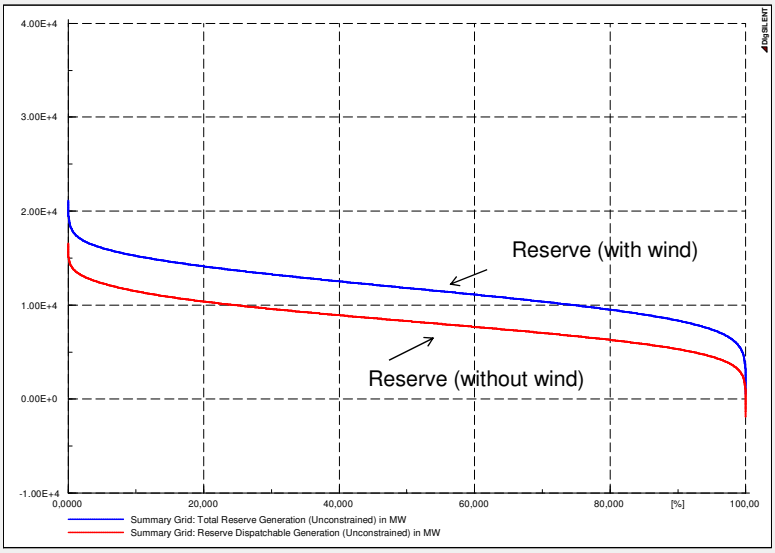
Example – Available Generation



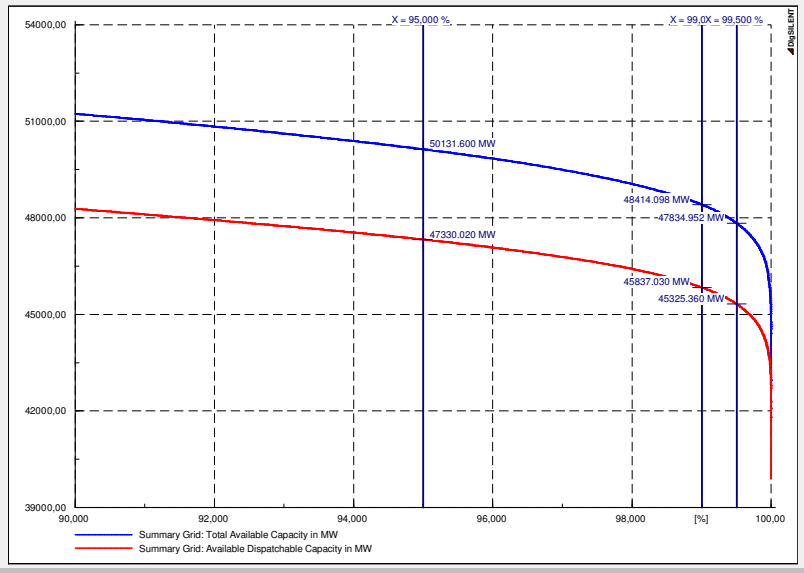
Example – Demand



Example – Reserve



Definition of Capacity Credit based on Generation Availability

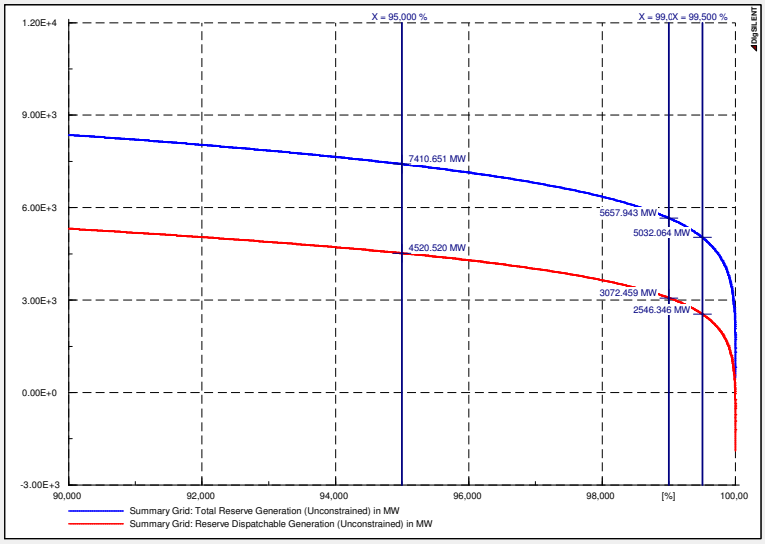


Definition of Capacity Credit based on Generation Availability

Capacity Credit of variable generation can be defined on basis of the available generation at a specified confidence level (or loss of load probability level)

- Advantages:
  - Clear criterion, easy to understand.
  - Low data requirements
- Disadvantages:
  - Ignores correlation between load and generation.
  - Consideration of maintenance plans difficult

Definition of Capacity Credit based on Reserve



Definition of Capacity Credit based on Available Reserve

Capacity Credit of variable generation can be defined on basis of the available Reserve at a specified confidence level (or loss of load probability level)

- Advantages:
  - Clear criterion, easy to understand.
  - Correlation of load and maintenance plans can be considered easily.
  - Seasonal correlation between wind generation and load can be considered easily
- Disadvantages:
  - More data required (especially load data)

Generation Adequacy Function in PowerFactory

- The new PowerFactory function “Generation Adequacy” provides probabilistic models for generator outages and wind speed variations.
- Studies about the reliability of supply of a system are supported by the built-in Monte Carlo Analysis (non time sequential).
- Studies about the capacity credit of renewable generation directly supported by the new Monte Carlo Analysis function.
- DPL functions give easy access to the new probabilistic models and allow for additional functionality related to the variable nature of renewable generation, such as:
  - Probabilistic load flow
  - Time series studies relating to load variations, ramp rates etc.

Thank You

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