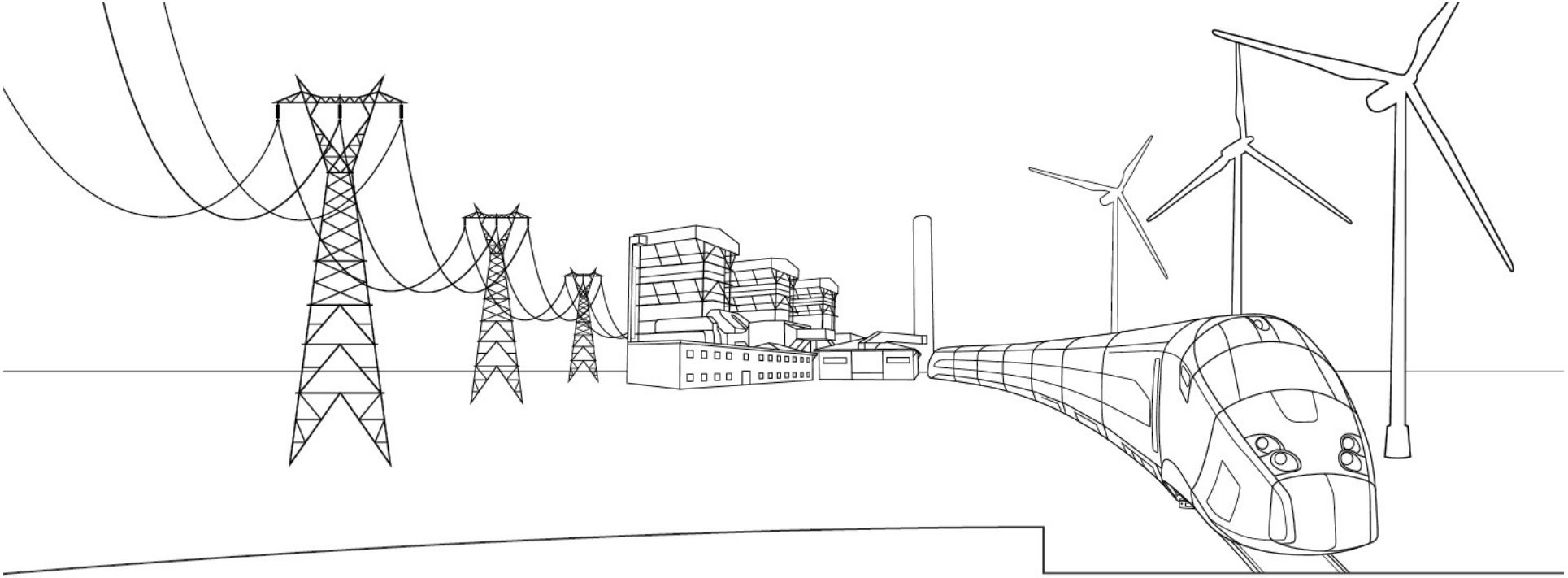

Reserve Requirement Calculator in SPP Integrated Market Place

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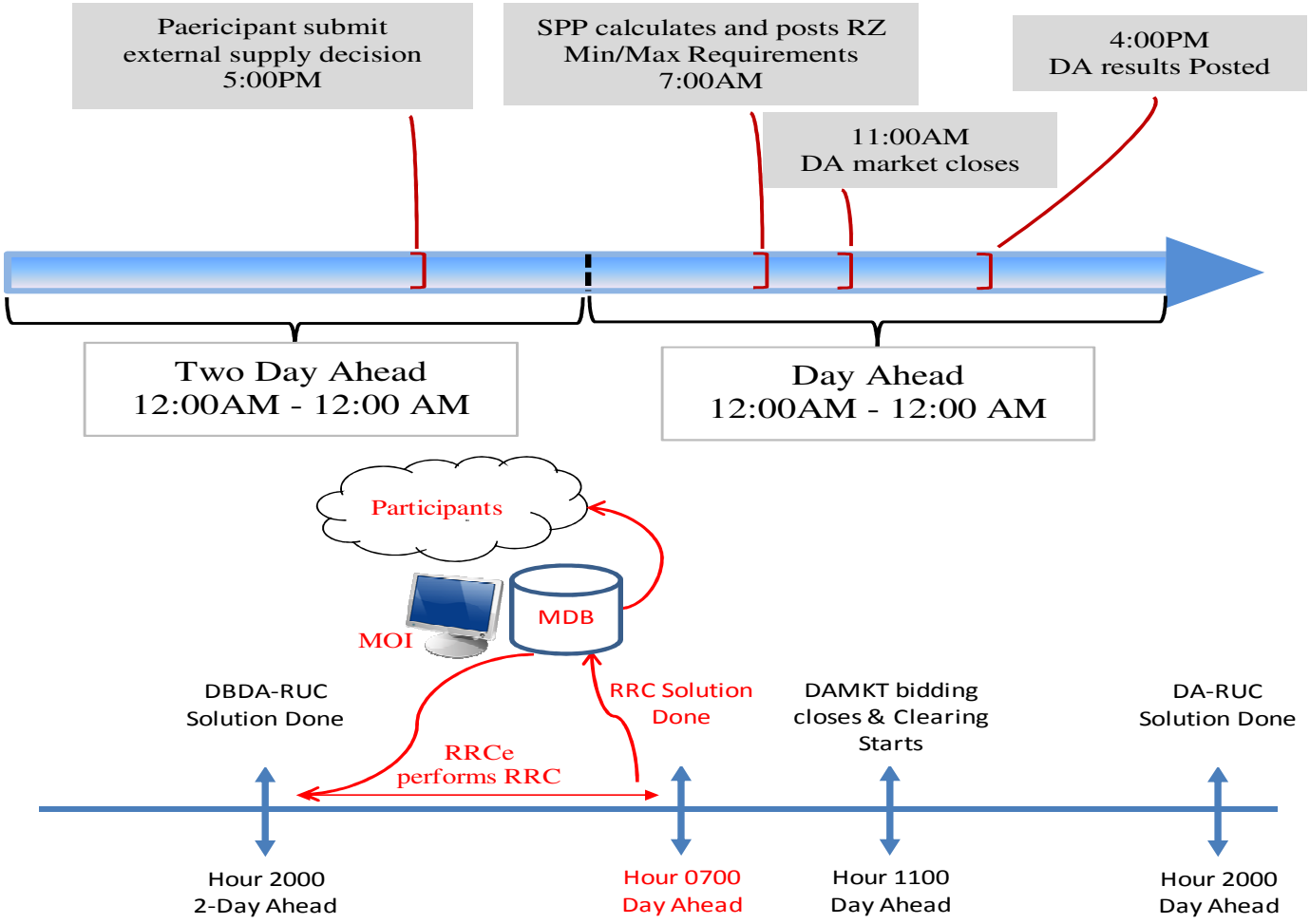
SPP Integrated Marketplace Project

- SPP Integrate Marketplace implemented March 1, 2014
- Market application components
  - Day-Ahead Market, Reliability Unit Commitment process, Real-Time Balancing Market
  - Security Constrained Unit Commitment (SCUC) and Security Constrained Economic Dispatch (SCED)
  - Co-optimization of 5 products: Energy, Regulation-Up, Regulation-Down, Spinning, and Supplemental
  - Hourly zonal contingency reserve (CR) minimum requirement and maximum requirement are calculated in a daily basis by Reserve Requirement Calculator(RRC)

RRC Business Process Timeline



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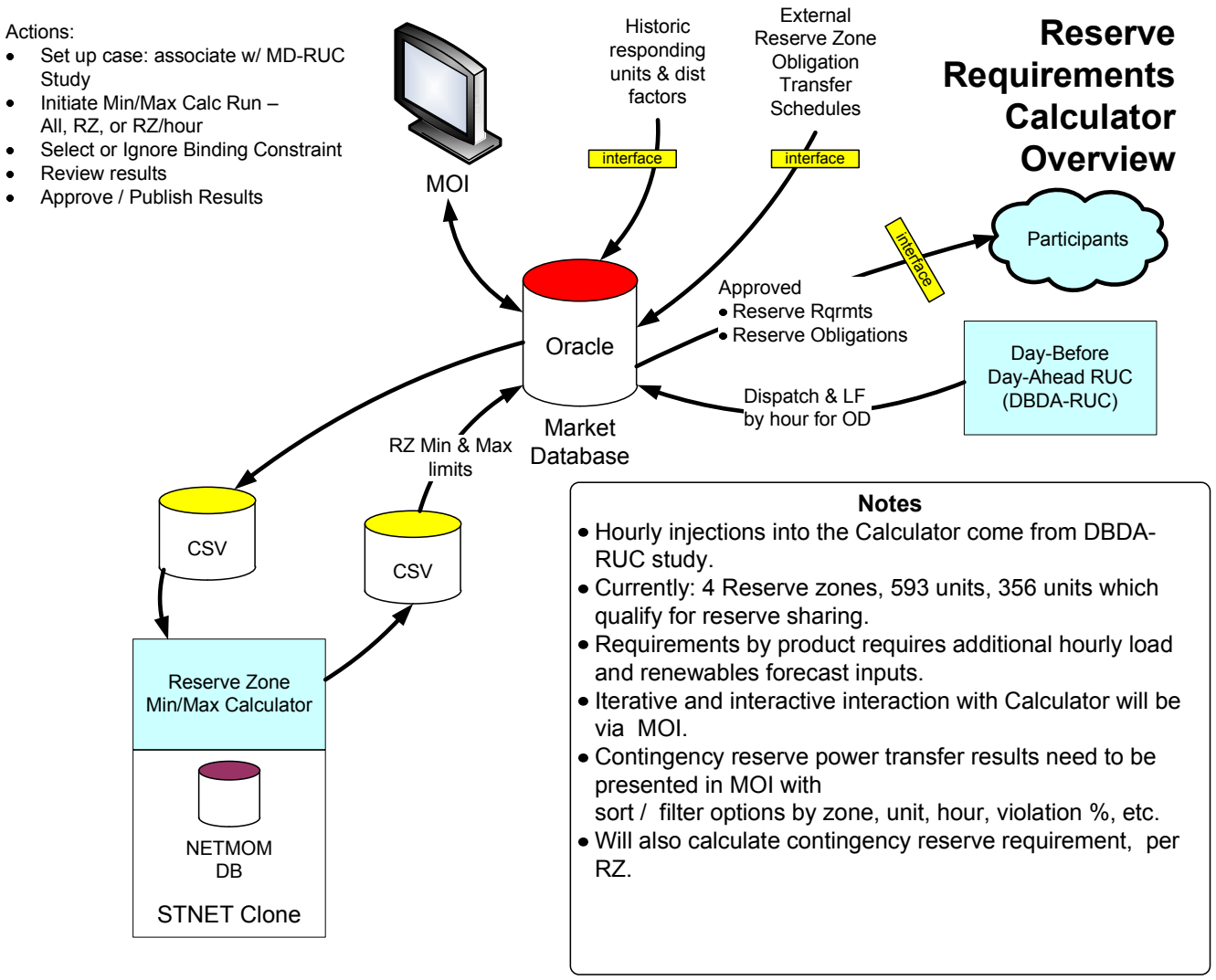
RRC Overview



Notes

- Hourly injections into the Calculator come from DBDA-RUC study.
- Currently: 4 Reserve zones, 593 units, 356 units which qualify for reserve sharing.
- Requirements by product requires additional hourly load and renewables forecast inputs.
- Iterative and interactive interaction with Calculator will be via MOI.
- Contingency reserve power transfer results need to be presented in MOI with sort / filter options by zone, unit, hour, violation %, etc.
- Will also calculate contingency reserve requirement, per RZ.

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RRC Features

- Provides
  - Hourly minimum zonal CR requirements
  - Hourly maximum zonal CR limits;
  - The list and loading levels of the transmission constraints/branches which determine the zonal requirements/limits
  - Asset owner reserve obligation
- Used a DC power flow and sensitivity based-method
- Integrated with Market Clearing Engine(MCE) for data and system modeling consistency between RRC and MCE.

Minimum CR Requirement and Maximum CR limit

- Zonal minimum CR requirement is defined as the minimum reserve capacity that must be available within a given reserve zone (due to transmission transfer limitations) in order to be able to survive the loss of the largest unit within the zone while also maintaining reliable operation of the power system.
- Zonal maximum CR limit is defined as the maximum MWs that the reserve zone could supply to the rest of the network (due to transmission transfer limitations) in the event of the most constrained CR event outside of the reserve zone.

RRC Modeling

- Resource Modeling
  - Use resource commitment/dispatch, phase-shifter setting and transactions from DBDA RUC solution
  - Use real time offers including capacity limits, commit status/outage status, ramp rate Limit, reserve qualification and dispatch status
  - Treat Jointly-Own Units (JOU) /Plant units/combined Cycle units modeled as a whole in a lost-of-generation event
  - Use resource historical reserve sharing capability to indicate whether a resource is capable of providing CR response to a loss-of-generation event

RRC Modeling

- Transmission network modeling
  - Transmission outage schedules for each hour of the Operating Day(OD)
  - User configurable network branches, generic transmission security constraints represented with aggregate and proxy PTDF flowgates
  - Constraint limits used in RRC evaluation consider transmission capability set aside to protect against instability, uncontrolled separation, or cascading outages where needed
  - Linear DC power flow model and sensitivity based generic transmission constraint model

RRC Modeling

- Load and Loss Modeling
  - Hourly mid-term load forecast by load forecast zone are allocated to the energized electrical nodes based on hourly load distribution factors.
  - No Marginal loss model is in the RRC since load forecast include loss
- Contingency Event Modeling/Assumption
  - Simulates loss-of-generation event
  - Calculates the system base power flow based on Mw output from DBDA RUC
  - Resource commitment and dispatch carried from the DBDA RUC solution to the RRC is already a secure solution taking into account the likely contingencies.

Methodology

- Calculate the base power flow using DBDA RUC commitment and dispatch
- Evaluate each loss-of-generation
  - Re-balance the lost generation Mw among available contingency reserve sharing resources
  - Calculate the incremental power flow
  - Calculate the PTDF based the power flow difference
  - Evaluate maximum transferable contingency reserve capacity
- Determine the minimum CR requirement and maximum CR limit for each zone based on the PTDF over all constraints/branches and loss-of-generation events.

Incremental Power Flow for Loss-of-Generation Events

- Incremental Power Flow for Min CR Requirement
  - the lost mw in a reserve zone is re-balanced by the reserve sharing capable resources outside the reserve zone in proportion to their CR sharing MW-capabilities
- Incremental Power Flow for Max CR Limit
  - the lost generation of a contingency resource outside a reserve zone is re-balanced by the reserve sharing capable resources inside the reserve zone in proportion to their CR sharing MW-capabilities.
- Resource CR Sharing Capacity:
  - Operating reserve qualification
  - DBDA RUC dispatch
  - Capacity limits
  - Offline supplement Maximum limit
  - Ramp rate limits
  - Contingency reserve response time

PTDF and Maximum Import/Export MW Calculation

- PTDF is defined as the sensitivity of the flow on a transmission constraint/branch with respect to the loss-of-generation event and the corresponding allocation of the lost generation among the reserve sharing resources.
- Hourly PTDFs for min CR requirements and max CR limits are calculated over
  - transmission constraints/branches
  - reserve zones
  - loss-of-generation events
- The maximum deliverable import/export Mw is computed based on the remaining amount of the transmission transfer capability and PTDFs

Min CR requirement and Max CR limits Calculation

- The minimum CR requirement for a reserve zone is the maximum of the differences between the lost MW in a loss-of-generation event and the maximum deliverable import Mw that can be carried into the reserve zone without exceeding the remaining amount of the transmission transfer capability of a constraint over all transmission constraints, branches and all loss-of-generation candidates
- The maximum CR for a reserve zone is the minimum of the maximum deliverable export Mw from the zone in a loss-of-generation event outside the reserve zone e over all transmission constraints/branches and all loss-of-generation candidates.

SPP Production Results

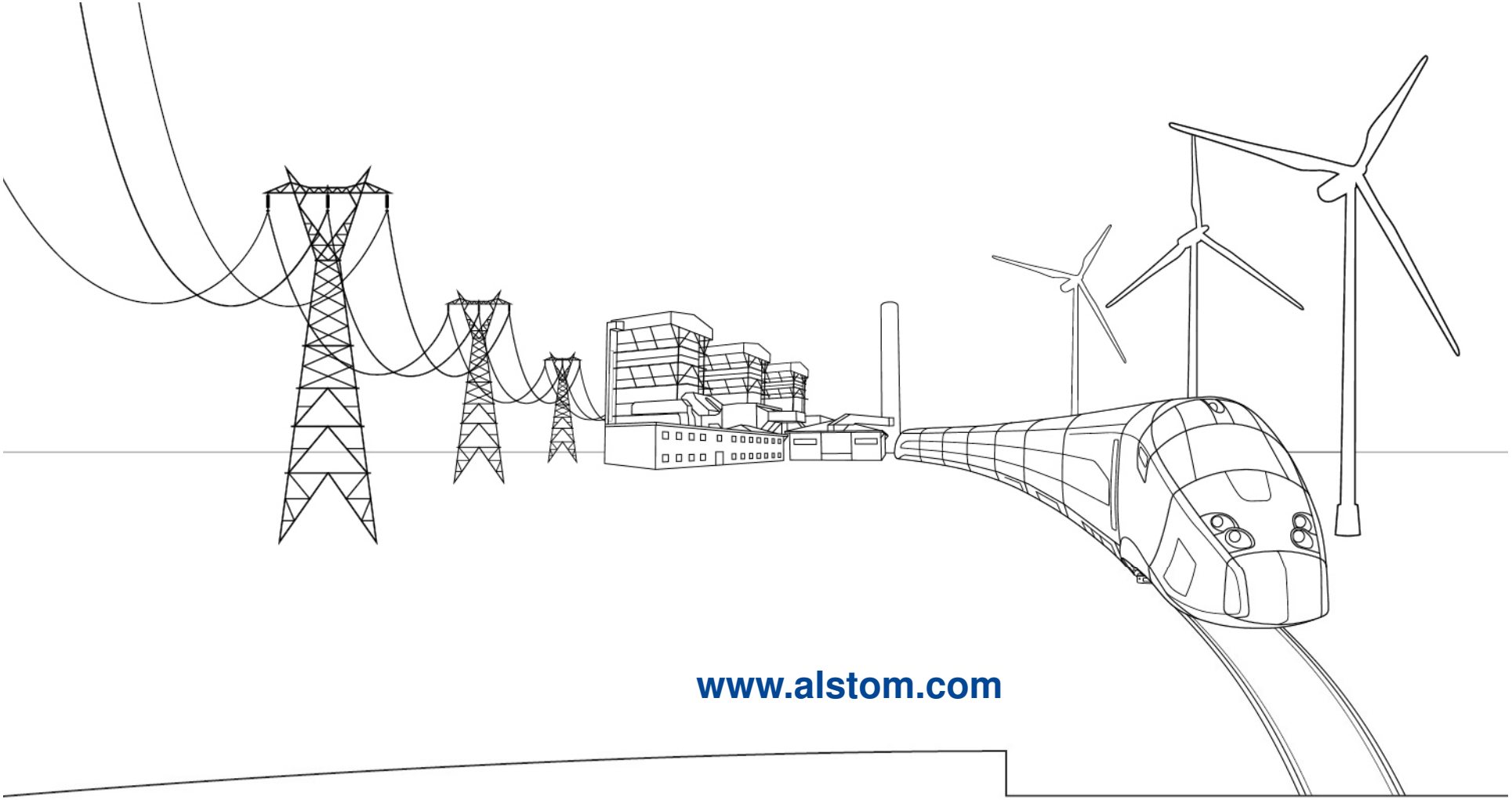
# of Units	593
# of Buses	15710
# of Branches	20727
# of Reserve zones	4
# of loss-of-gen events	10
# of Constraints	5

ReserveZone	MinCRReq	MaxCRReq
1		308.76
2		
3		
4	493.425	

- Solution time:
  - About 6 minutes per hour
  - with 4 hour being executed in parallel
  - About 50 minutes for 24 hours

Challenges

- Use pre-selected transmission constraints instead of full branch evaluation
  - Need better constraint management and study
- Dependency with DBDA RUC results
  - Need good coordination between DBDA RUC, RRC and DA and RUC study
- Not accurate for RTBM study due to the changes of the system condition and constraint enforcement
- Will consider the impact of possible reserve deployment in transmission constraint evaluation in DA , RUC and RTBM in the future



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