

Configuration Based Combined Cycle Group Model

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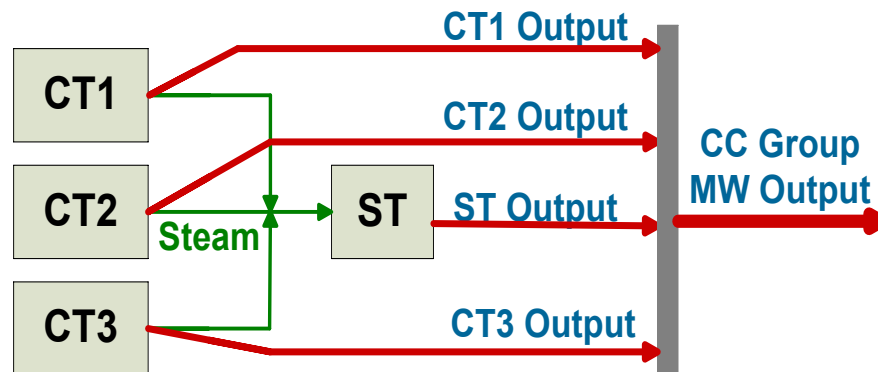
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Combined Cycle Group

- A Combined Cycle (CC) Group generally consists of:
 - one or more combustion turbine generators (CTs) and
 - one steam turbine generator (ST).

CTs generate electricity and waste heat is used to make steam to produce power via ST.

- A CC group can be operated with various configurations (CFGs) of CTs and STs.



Combined Cycle Group Model Overview

- **Aggregation Model:**

Treat whole CC group as one generator.

- **Composite Model:**

Each generator is modeled as a conventional unit. Output of ST is function of output of CTs.

- **Configuration based Model:**

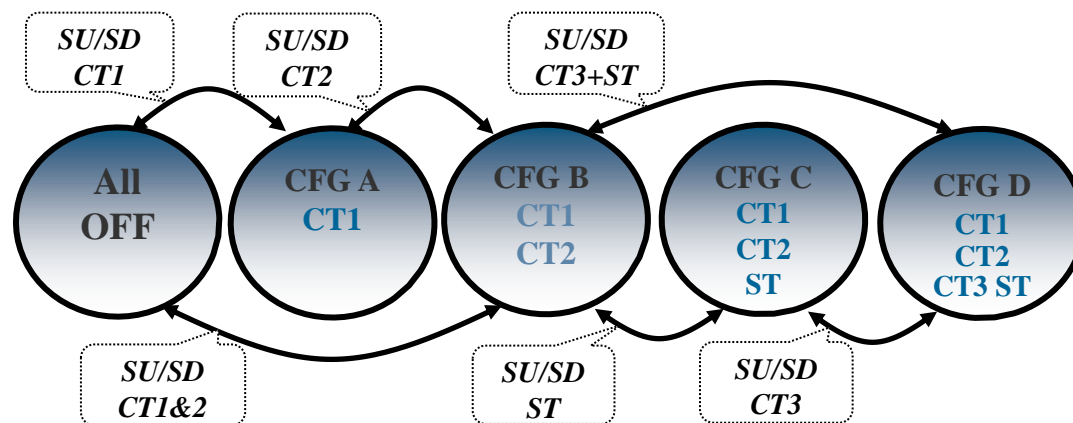
CFGs transfer following transition matrix.

Project Updates of Configuration Based CC Group Model

- *The configuration based CC model will be used in SPP DA market and RUC (Reliability Unit Commitment);*
- *MISO and Alstom Grid start working on a research project for proof-of-concept and to study the performance impact of CC model on MISO MCE execution in DA/IRAC/LAC time frames.*

Functional Requirements of Configuration Based CC Group Model

- For a CC group at an interval, only one configuration can be selected for energy and online reserves.
- Transitions between configurations shall follow given transition matrix, which reflects operational rules.
- Transition costs:
 - Costs for startup transitions: *“to-CFG” SU costs - “from-CFG” SU costs.*
 - Warmth state of the “to configuration” shall be considered.
 - Costs for shutdown transition are zero.

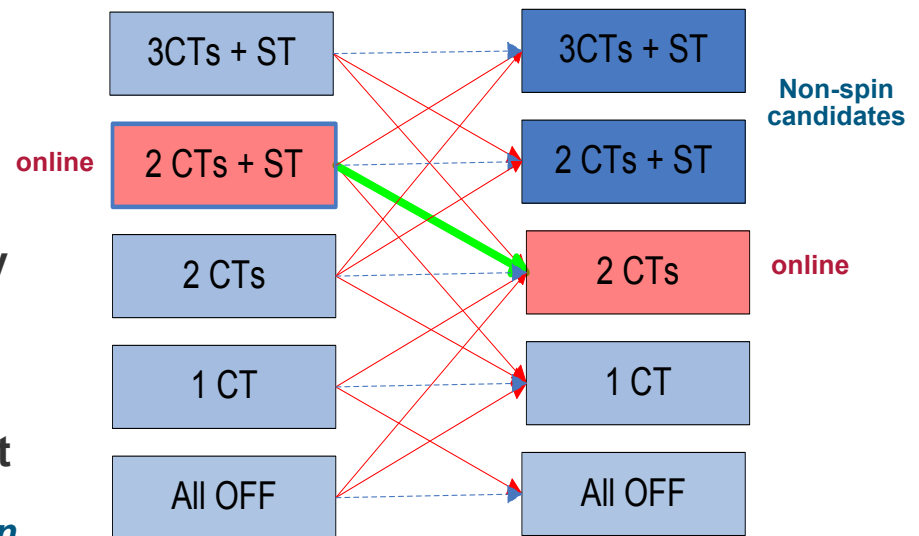


Configuration Based CC Group Model in MCE

- **Each configuration is completed modeled as a conventional generator.**
 - Energy dispatch ranges
 - AS eligibility/dispatch ranges
 - Energy/AS offer prices
 - Min up/down time limits
 - Impact on Transmission Constraints
 - SU/SD/dispatch ramp rate
 - Self-scheduled configuration
 - Max Startup limits
 - Max Energy limits
- **Transition matrix**
- **Warmth state based transition costs**
 - Hot/Cold/Intermediate Transition Costs are modeled based on the down time of configuration.
 - Hot(/Cold/Intermediate) Transition Costs are calculated as:
Hot(/Cold/Intermediate) “to-CFG” SU cost– Cold “from-CFG” SU cost.

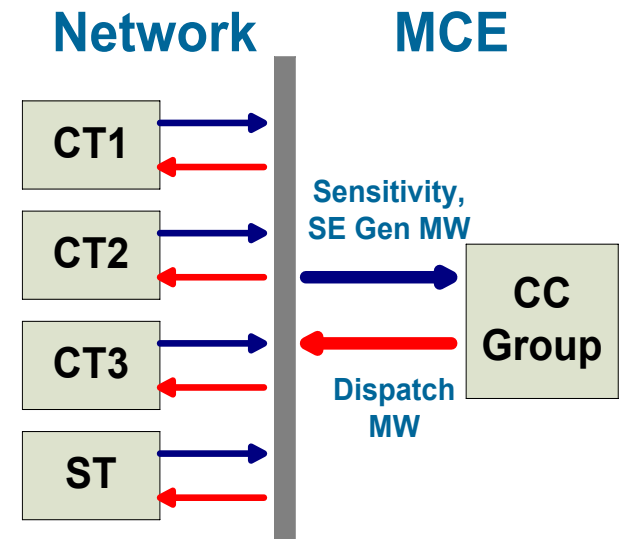
Configuration Based CC Group Model in MCE (Cont'd)

- Online reserves can be provided from online configurations.
- For non-spinning reserve, special logics are needed to ensure:
 - No more than one offline CFG to be selected for non-spinning;
 - The offline CFG should be transferable from previous interval's online CFG;
 - Capacity of offline CFG > capacity of selected online CFG at the interval.
 - Max non-spinning reserve amount is:
Capacity of offline CFG for non-spin
- Capacity of current online CFG.



Interaction between MCE and Network Model

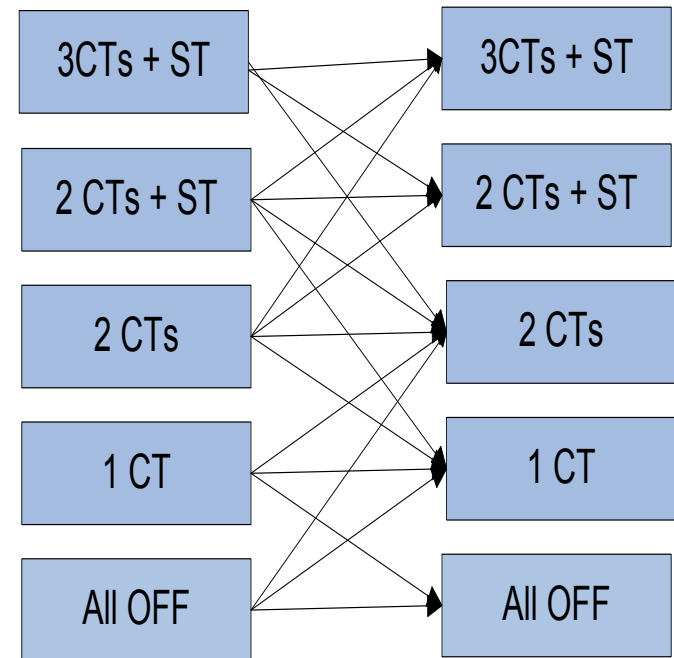
- Network models individual physical units.
- MCE sees both individual units and configurations of CC group.
- Network provides sensitivities of CTs and ST. Based on sensitivities and telemetry output of physical units, sensitivity of a configuration can be estimated.
- CC group's SE gen value is the total of SE gen MW of CTs/ST.
- For physical unit power injections, configuration level dispatch MW will be disaggregated based on capacity of individual physical units.
- Minimum initial on (off) time of all physical units is considered as configuration Initial on (off) time.



Potential Performance Issue

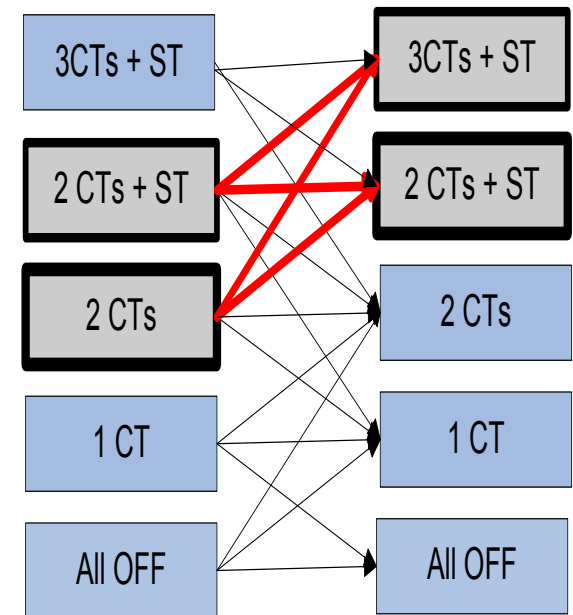
- Performance issues may be caused by additional integer variables and constraints:

- Number of CC groups.
- Number of CTs in CC group.
- Density of transition matrix



Performance Improvement

- Performance can be improved by using two-round solves
 - 1st round solve with Aggregation CC model to calculate total MW dispatch of whole CC group at each interval
 - Based on total MW dispatch, reduce configurations and prune transition matrix
 - 2nd round solve with configuration based CC model



Conclusions

- A configuration based Combined Cycle model has been described, where configuration transfers following specified transition matrix.
- Compared with existing models, this model can better support operational rules of CC groups in power industry.
- Potential performance issue can be handled by two-round solves.

Questions?

