Configuration Based
Combined Cycle Group Model

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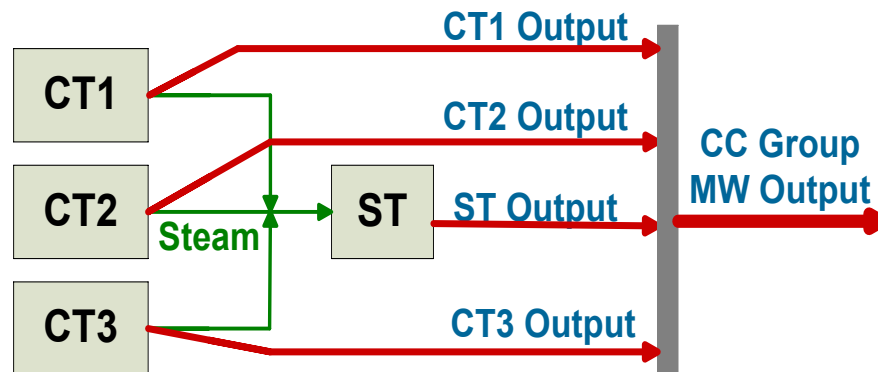
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Combined Cycle Group

- **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.
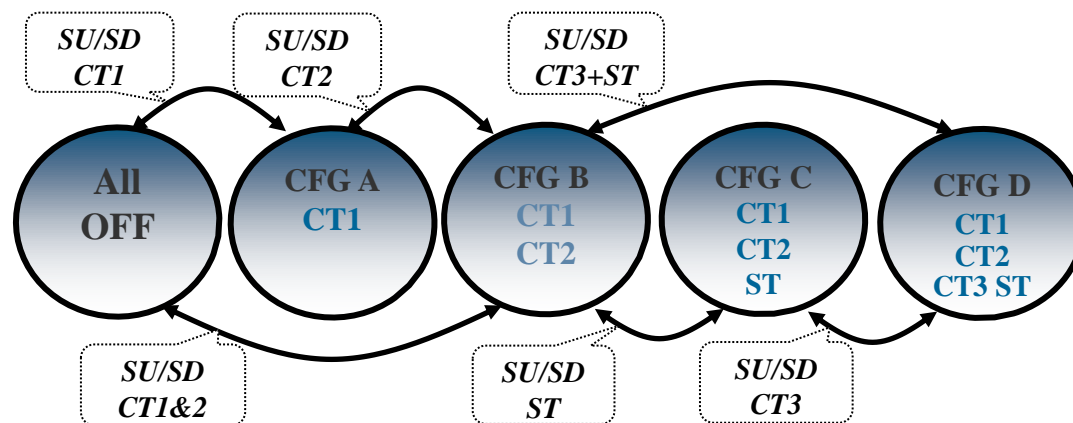
- **Configuration based Model:**

  CFGs transfer following transition matrix.

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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.*

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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.**


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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.

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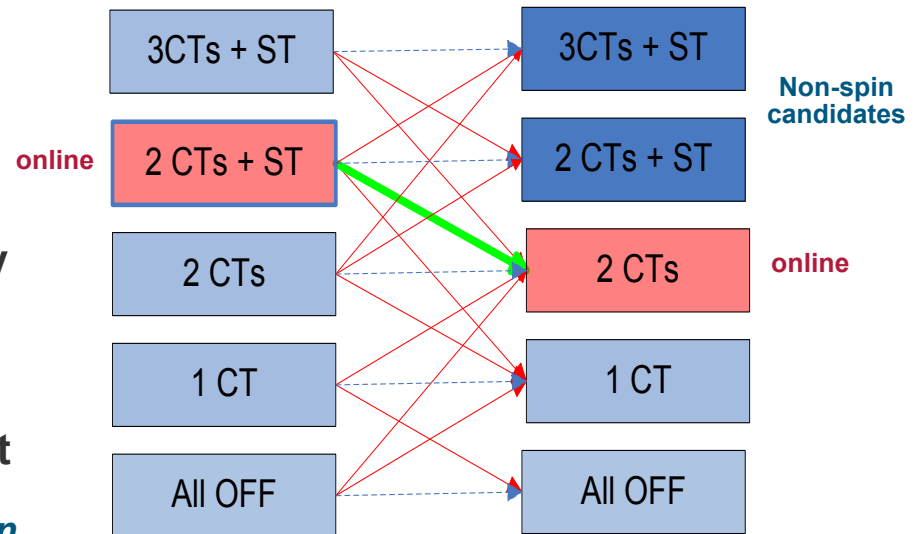
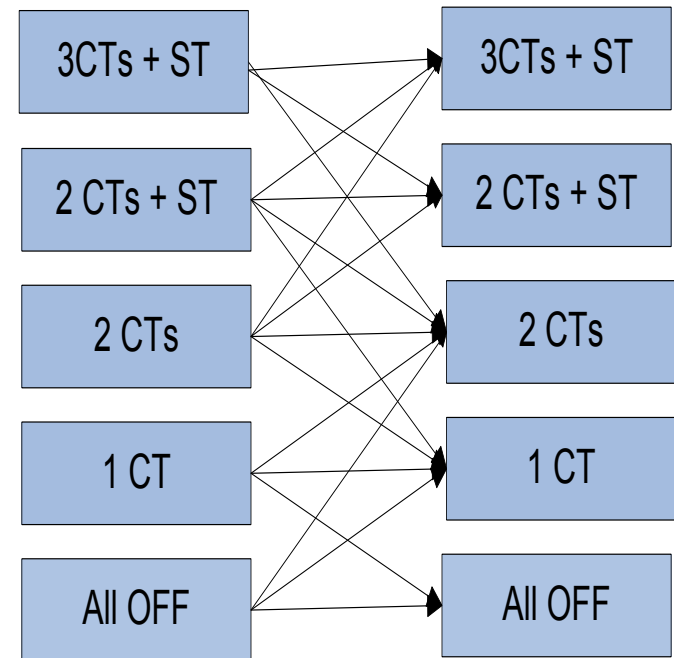# Interaction between MCE and Network Model

- **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.**

Network   **MCE**

CT1

Sensitivity, SE Gen MW

CT2

CC Group

CT3

Dispatch MW

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.**

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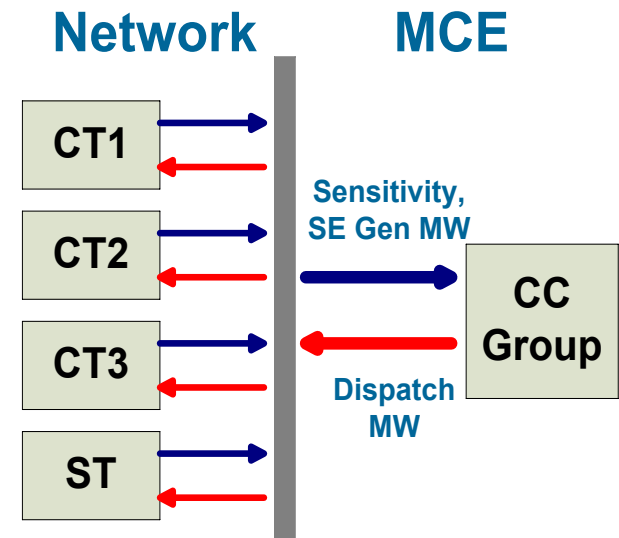
Potential Performance Issue

- **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**

3CTs + ST	3CTs + ST
2 CTs + ST	2 CTs + ST
2 CTs	2 CTs
1 CT	1 CT
All OFF	All OFF

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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

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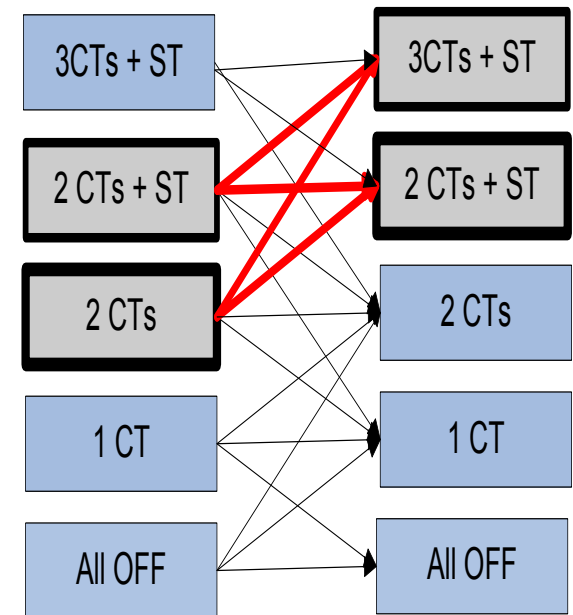
Conclusions

- 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?

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