

History of Combined Cycle Modeling in PJM

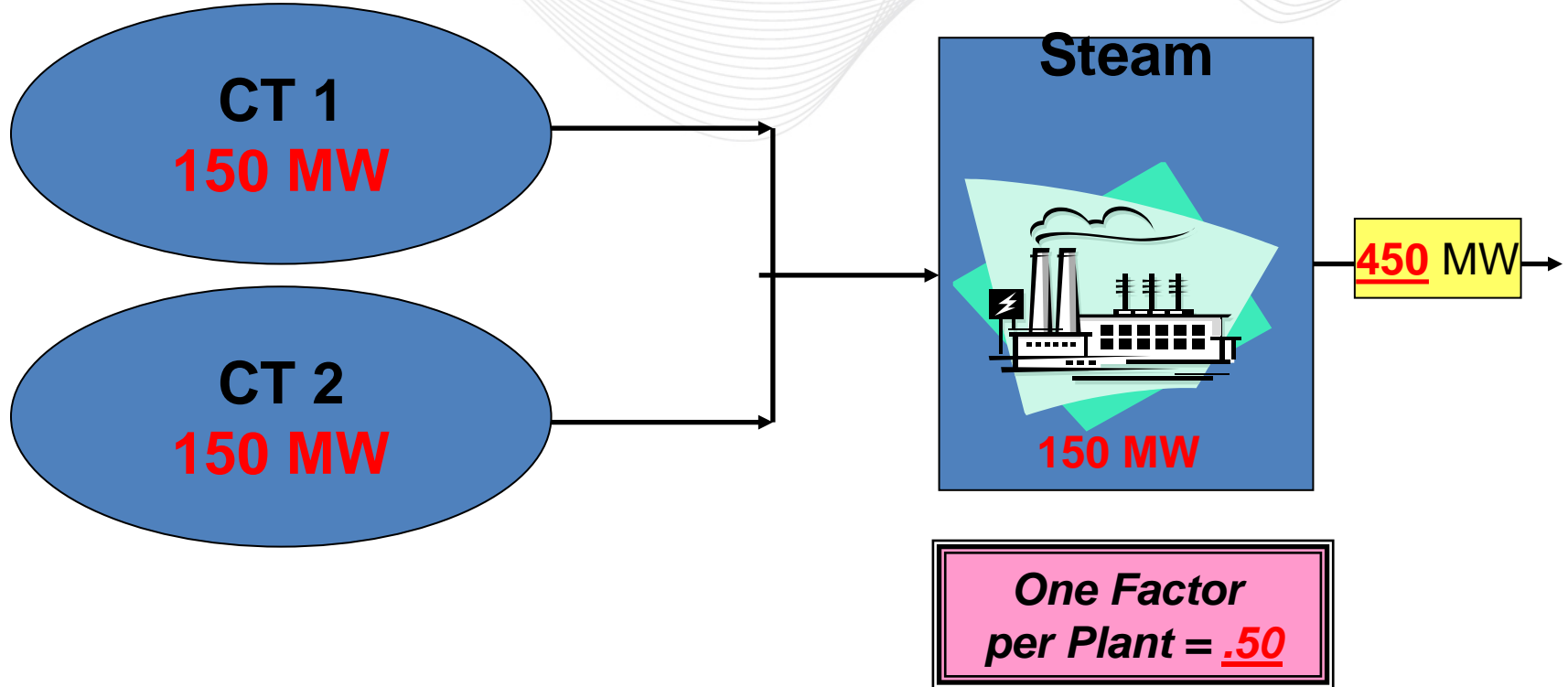


Thomas Hauske
Senior Lead Engineer, Performance Compliance
Modeling Generation Senior Task Force
January 27, 2017

- PJM developed a Combined Cycle Model in 2005 that could be used to model CC units as
 - A single composite unit
 - Or multiple individual units.
- Use of the model and the associated eMKT Screens were only available upon request
- This model was not used and is not currently available

- Each Physical component of the plant was modeled and had all the normal unit constraints
- Individual availability could be assigned for each component in the combined cycle group
- Each Combustion turbine and each Steam turbine could have its own startup cost, minimum up/down time, cost curves etc.

- Optional field enforced a minimum time between startups for all the CTs in the plant
- The Steam output was a function of the CT output
- There was a field to indicate if unit should be modeled as simple cycle.
- The Steam Unit could only be committed if at least one CT is committed



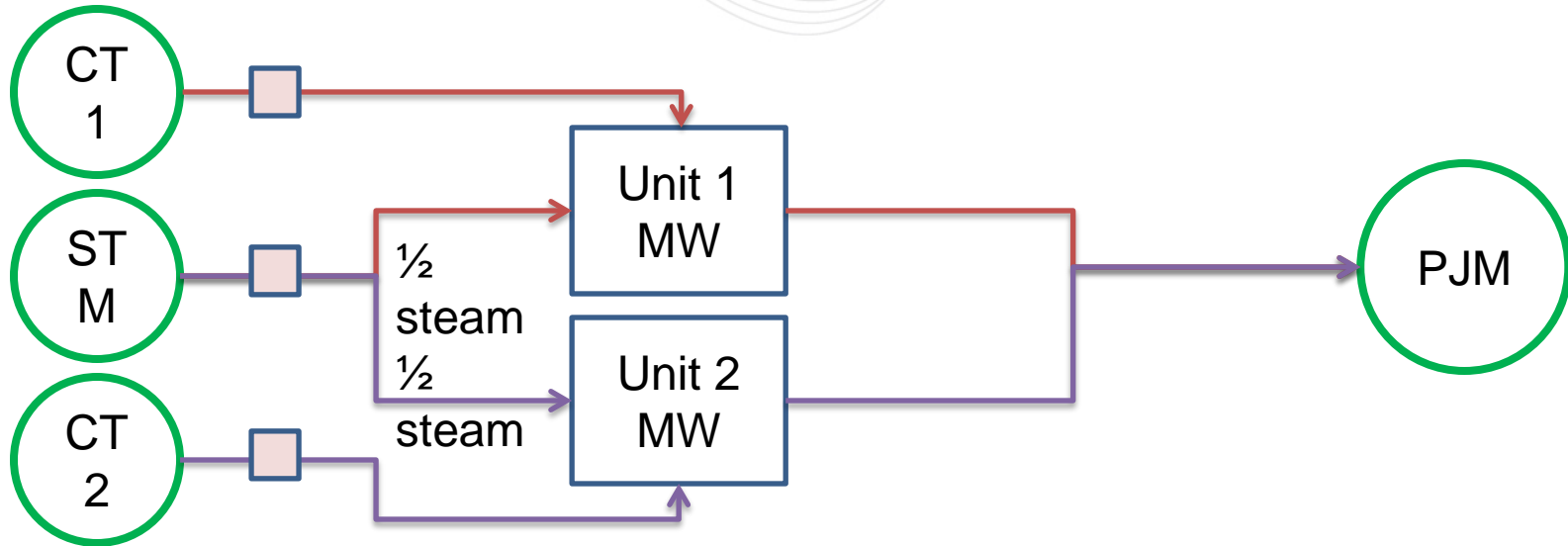
Data Elements	CT 1		CT 2		Steam	
Hot Start Price						
Inter Start Price						
Cold Start Price	\$4,000		\$4,000			
Hourly No-Load	*****CT'S CANNOT SUBMIT NO-LOAD COSTS*****					
CT Factor					.50	
Offer Curve (max 10 points)	MW	Price	MW	Price	MW	Price
segment 1	100	\$ 55	100	\$ 70	0	\$0
segment 2	150	\$ 80	150	\$ 90	0	\$0
Eco Min MW	100		100		100	
Eco Max MW	150		150		150	
Min Run Time	4 hours		4 hours		8 hours	
Use Start Up No Load	Yes		Yes		Yes	
Use Offer Slope	No		No		No	

- IMM brought seven (7) Problem Statements to CDS in January 2011 which included Combined Cycling Modeling
- CDS provided education on Combined Cycle Modeling in January 2012. CDS forwarded the Problem Statement to the MRC, since it would impact more than cost offers.
- MRC endorsed the Combined Cycle Modeling Problem Statement in March 2012 and forwarded it to the Operating Committee for action.

- OC initially evaluated three (3) different potential solutions
 - Additive (Pseudo) Model
 - Alstom Configuration Model
 - Enhancements to the current Combustion Turbine or Steam models
- OC ultimately reduced its efforts to evaluating just the Additive Model and the Alstom Configuration Model

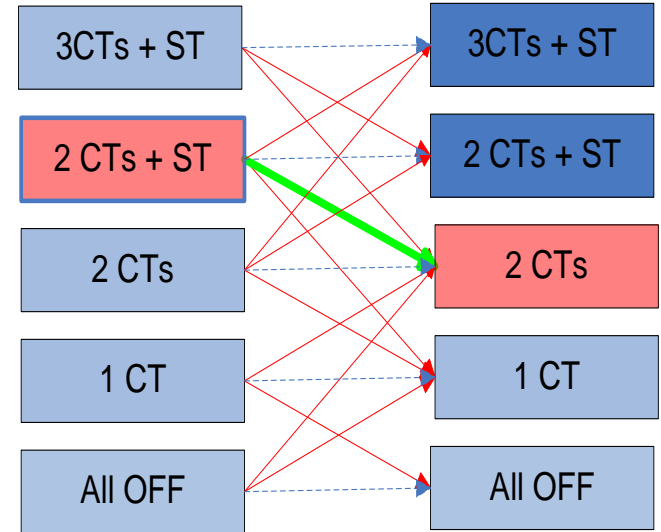
- Additive (Pseudo) model
 - Combustion Turbines can be modeled as separate Market units. Steam Turbine is split evenly and modeled as part of the Combustion Turbine
- Alstom Configuration Model
 - Existing Add-On Combined Cycle Module which has the ability to model Combined Cycle units as single Market Unit with many configurations.
- OC endorsed the Alstom Configuration Model in April 2013

Additive (Pseudo) Model



Alstom Configuration Model

- Each configuration modeled as a conventional generator
- Transition matrix
- Warmth based transition states



- PJM performed a detail review of the Alstom Configuration Model with Day Ahead, Real Time, Dispatch, Real Time Data Management, and Settlements.
- PJM also had discussions with Alstom, MISO, and SPP.
- Due to estimated implementation cost of \$1M along with many more system being impacted than expected, PJM decided to perform cost benefit analysis in October 2013

- PJM and the IMM were unable to accurately quantify the cost benefit savings from implementation of the Alstom Configuration CC model.
- SPP delayed their implementation of the model due to performance issues and estimated implementation cost increase (\$7M) to perform a cost benefit
- PJM placed implementation of the model on hold in August 2014 with plans to monitor SPP's experiences.

- The Combined Cycle Owners User Group was created in May 2016.
- The Users Group reviewed CC models in various RTOs
 - ERCOT's Combined Cycle Train Model
 - CAISO's Multi-Stage Generation Model
 - SPP's Configuration Model
- The CCOUG developed a Problem Statement which was approved at the November MRC creating the Modeling Generation Senior Task Force.