Cooling Tower Improvement Study Using PEPSE

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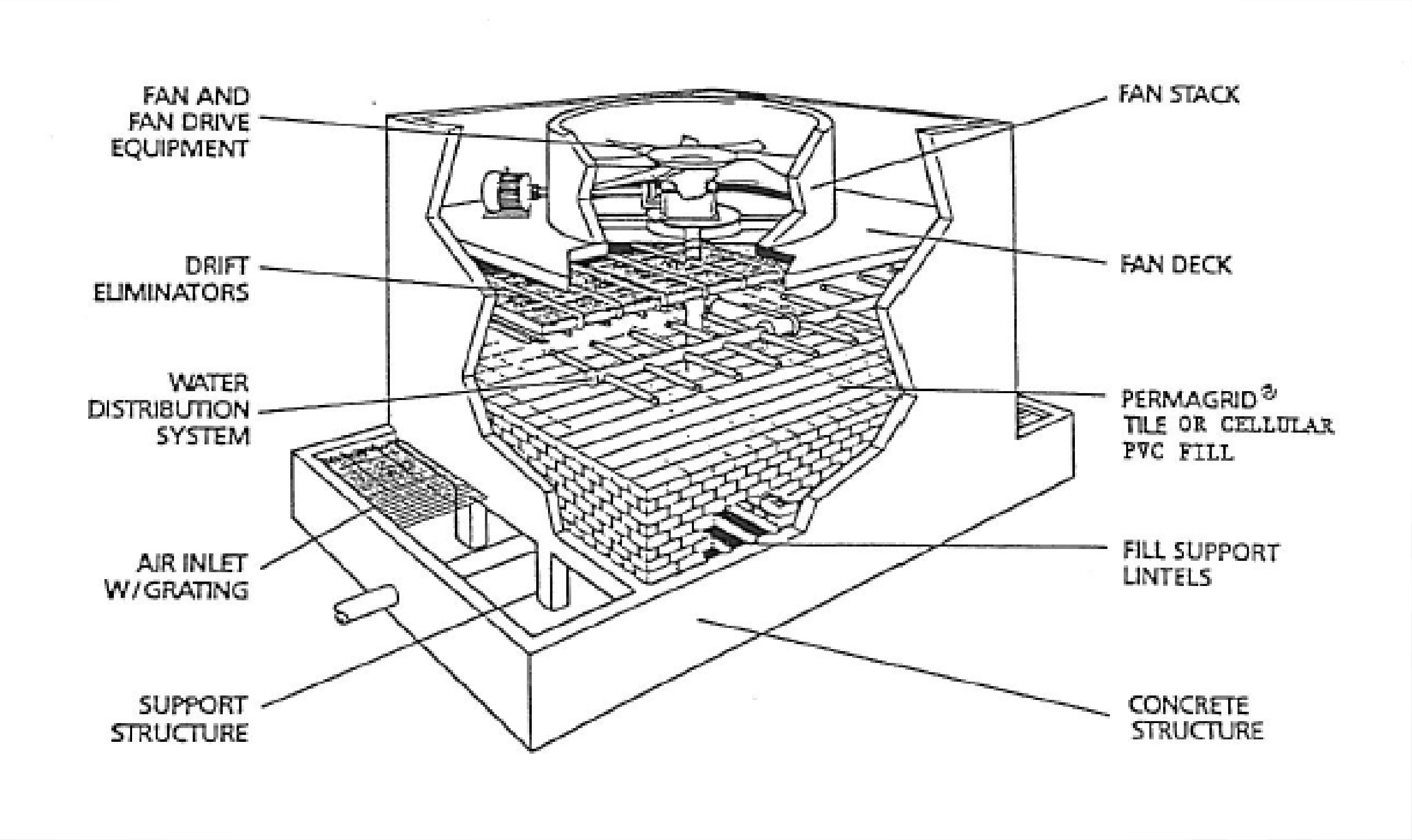
Shand Power Station

- Single-Unit Lignite Coal Plant
- Estevan, Saskatchewan, Canada
- Commissioned in 1992
- 305 MW Gross
- B&W Boiler
- Hitachi Steam Turbine

Cooling System

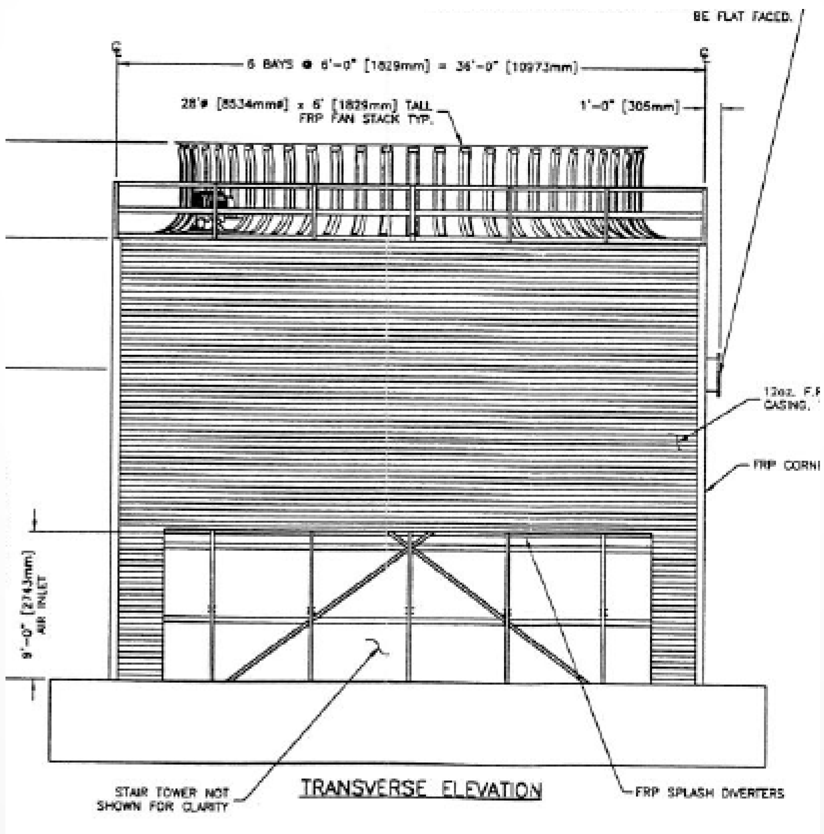
Main Cooling Towers

- OEM – Ceramic Cooling Tower, installed in 1992
- Induced Draft, Counterflow, Clay Tile Fill



Auxiliary Cooling Towers

- OEM – Psychrometric Systems Inc, installed 2000
- Induced Draft, Counterflow, PVC Fill



Problem

- Since construction, Shand Power Station has had historically higher than design condenser backpressure
- Auxiliary towers were added in 2000 but the problem remained
- Causes
  - Cooling Water (CW) flow slightly lower than design
    - 92 – 95% design flow to condenser
  - Cooling Towers performing lower than design
    - 70 – 80% capability
  - Condenser cleanliness slightly lower than design
    - average 80% (design 90%)

Effects of Problem

- Forced Plant De-rates
  - In the summer, back pressure increases to a point near the maximum allowable for the turbine
  - MW output must be lowered to stay within the back pressure limits of the turbine
  - De-rates cost $800,000 per year in replacement energy costs
- Increased Heat Rate
  - As back pressure increases, the boiler must fire harder
  - Heat rate effect has not been quantified

Possible Improvement Areas

- Increase cooling water flow
- Increase air flow to the main cooling towers
- Additional cooling tower cells
- Upgrade water distribution system in main towers
- Upgrade fill in main towers

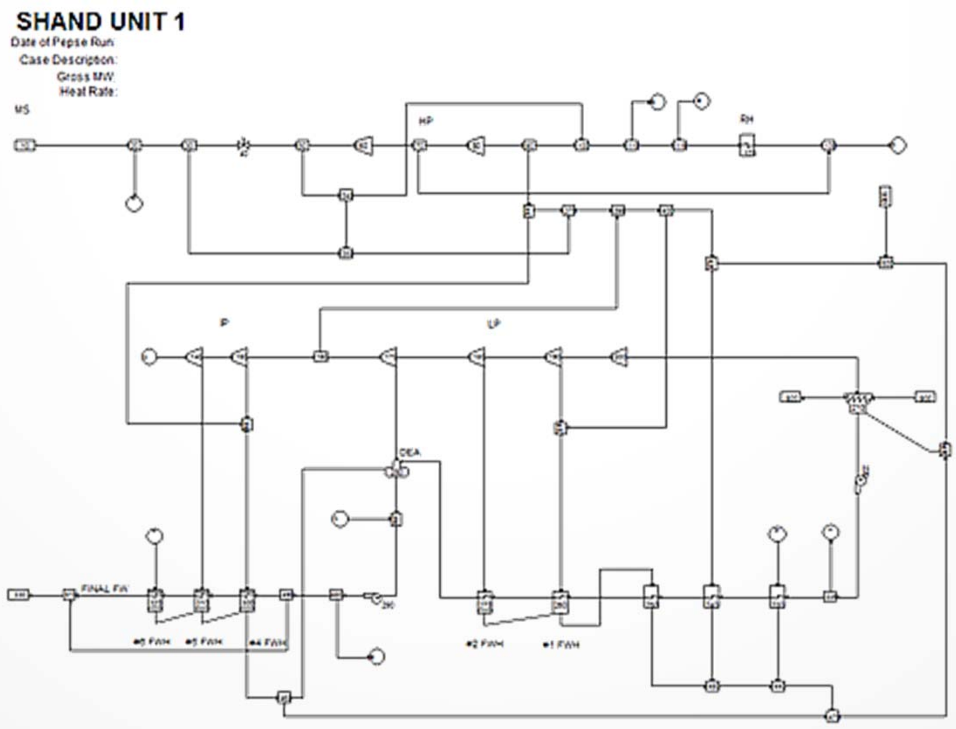
- First three can be modeled with PEPSE

Modeling of Possible Improvement Areas

- CW Flow
  - 15% under design flow
  - 30% over design flow
- Main Cooling Tower Air Flow
  - 15% under design flow
  - 25% over design flow
- Adding cooling tower cells
  - One cell to auxiliary cooling tower
  - Two cells to auxiliary cooling tower
  - One cell to main cooling tower
  - Two cells to main cooling tower

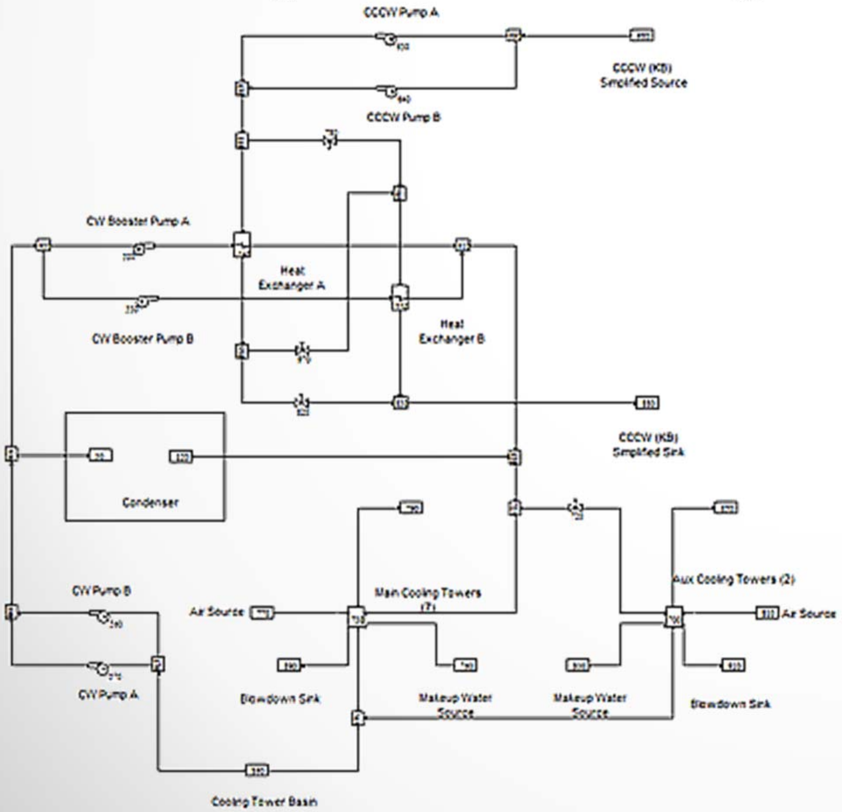
Turbine Cycle Modeling

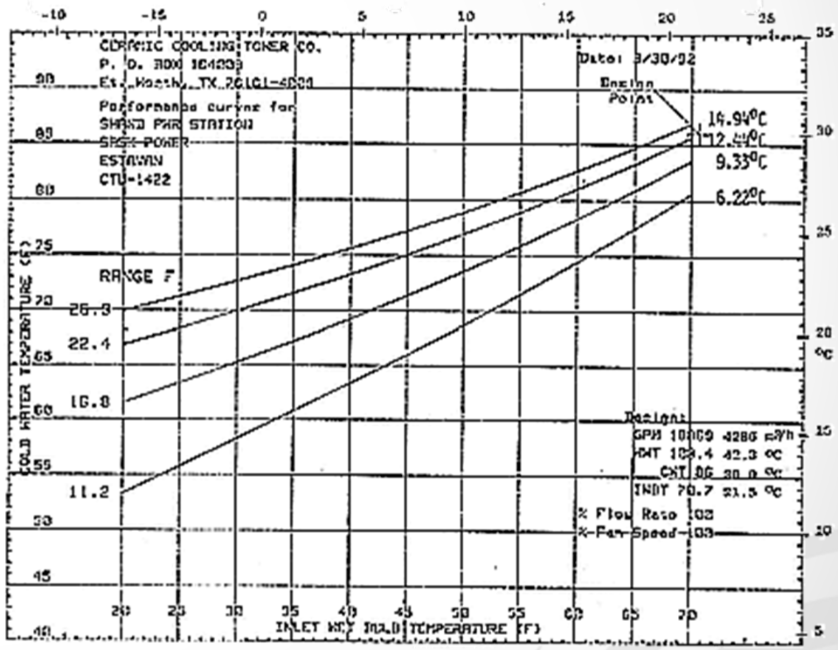
- Turbine Cycle
  - Heat Balance Tuned
  - Plant Data
  - Design mode Condenser



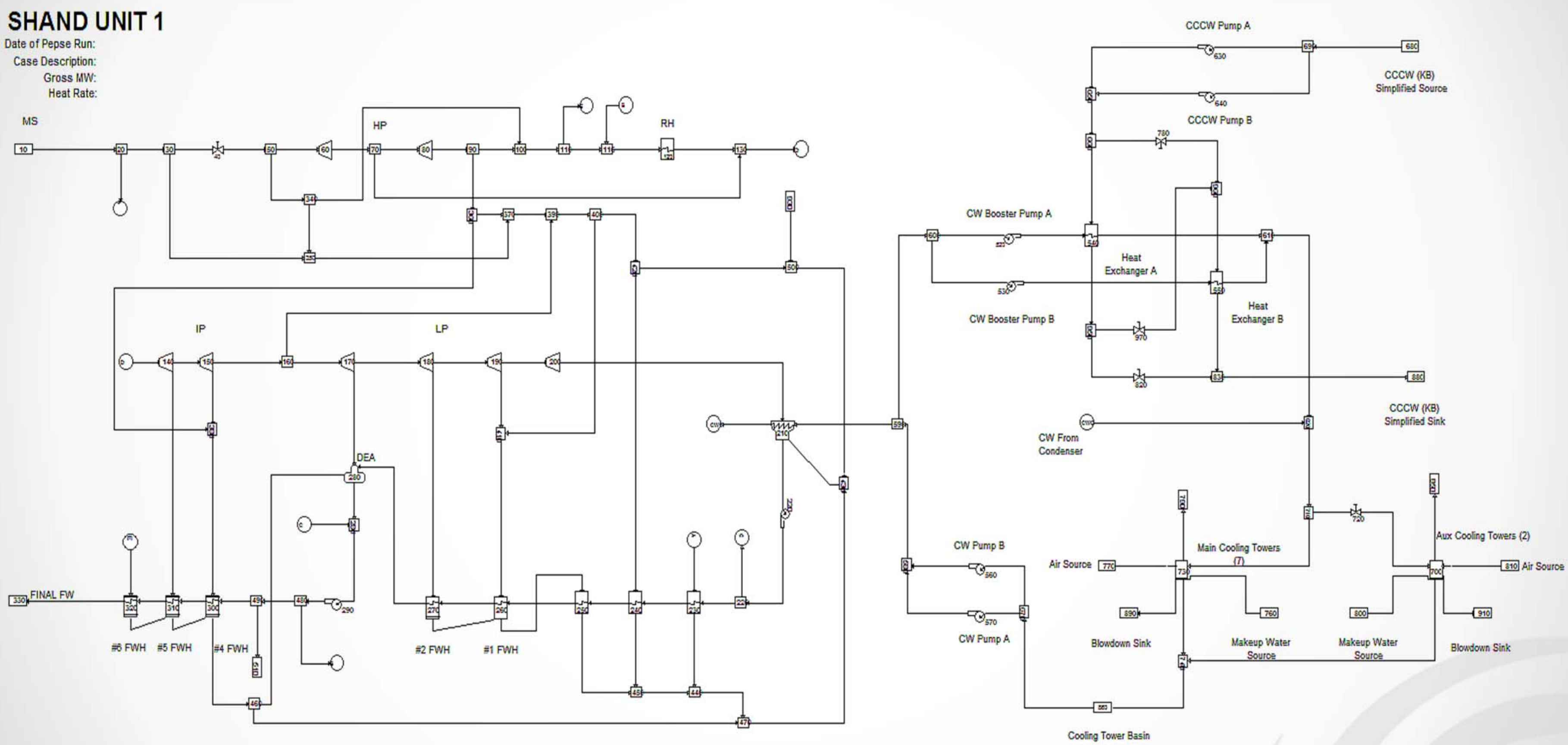
Cooling Tower Modeling

- Cooling Towers – Main and Auxiliary
- Cooling Tower Performance Curves
- Cooling Tower Tuning





Merged Model



Turbine Cycle Assumptions

- MCR Main Steam and Reheat Conditions
- Feedwater Heater TTD and DCA Constant
- Other Conditions
- Design Condenser Cleanliness Factor
- De-rate Conditions
  - LP Turbine Exhaust above 50°C
  - Main steam flow reduced

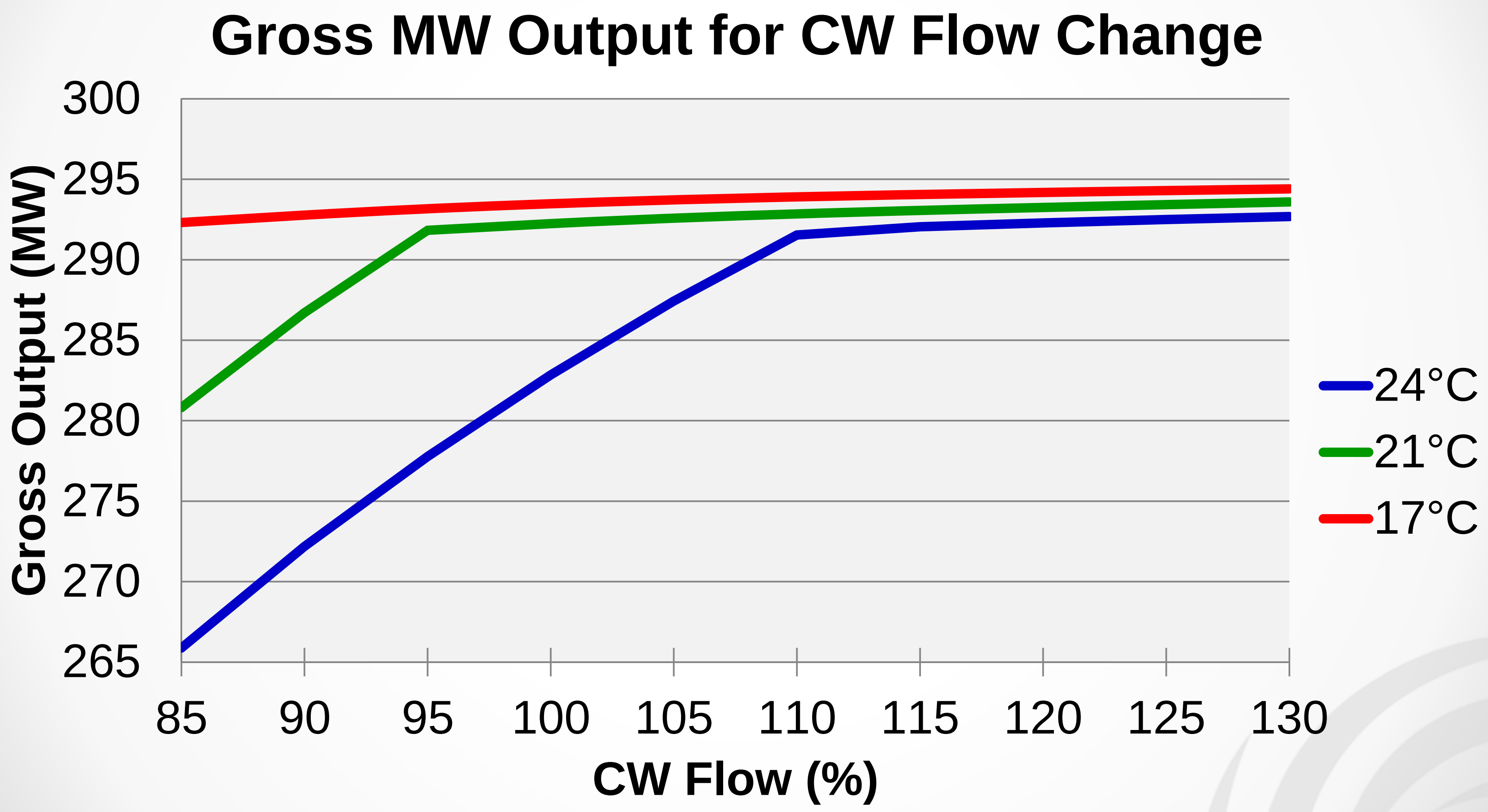
Cooling Tower Assumptions

- Five wet-bulb temperatures – 24°C, 23°C, 21°C, 18°C, and 17°C
  - 50% Humidity
  - 94.5 kPa Pressure
- Cooling Tower Conditions
- CCCW System

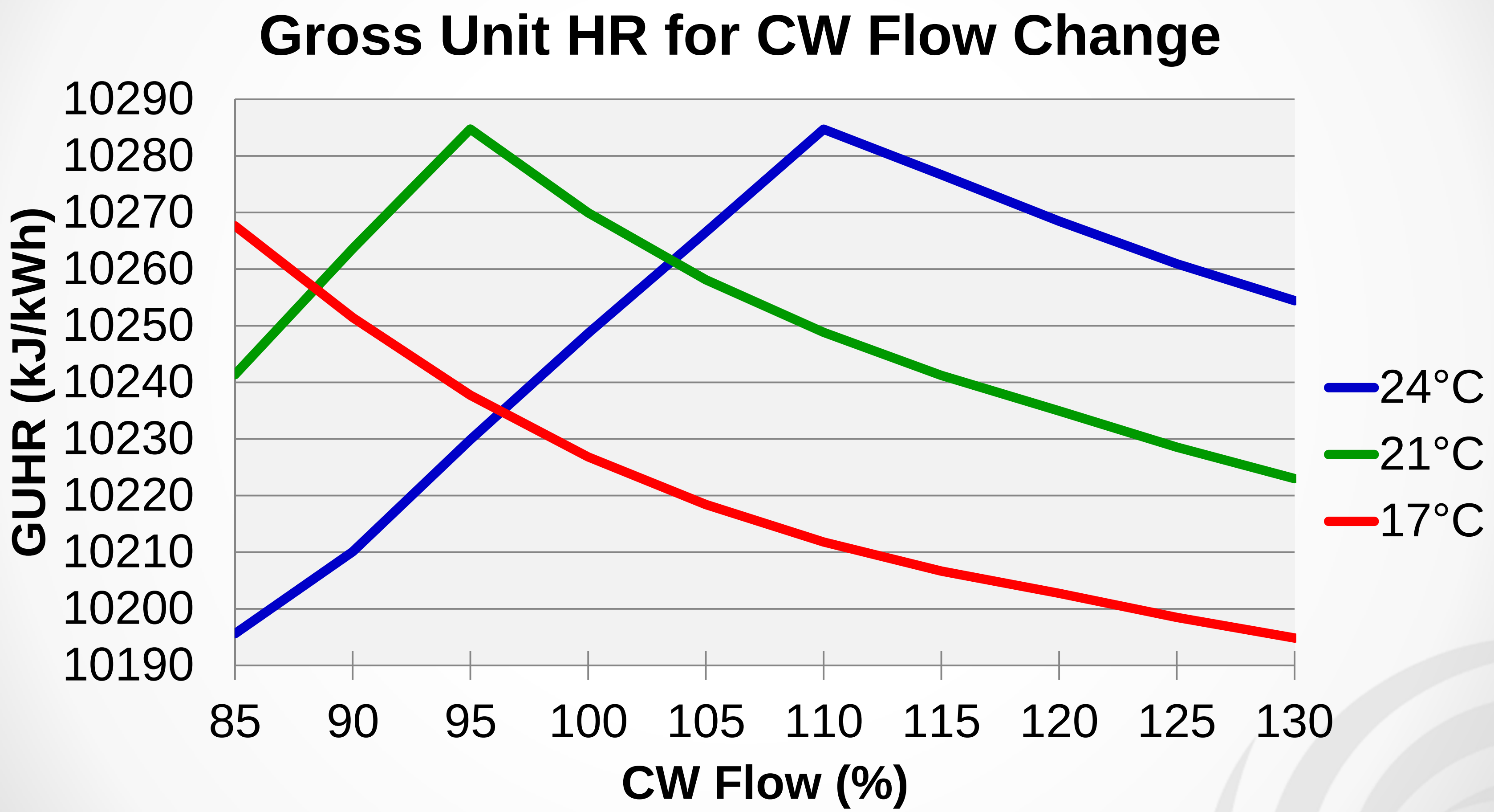
CW Flow Calculations

- Change the CW flow from 85% to 130% of design CW Flow

CW Flow Results - MW



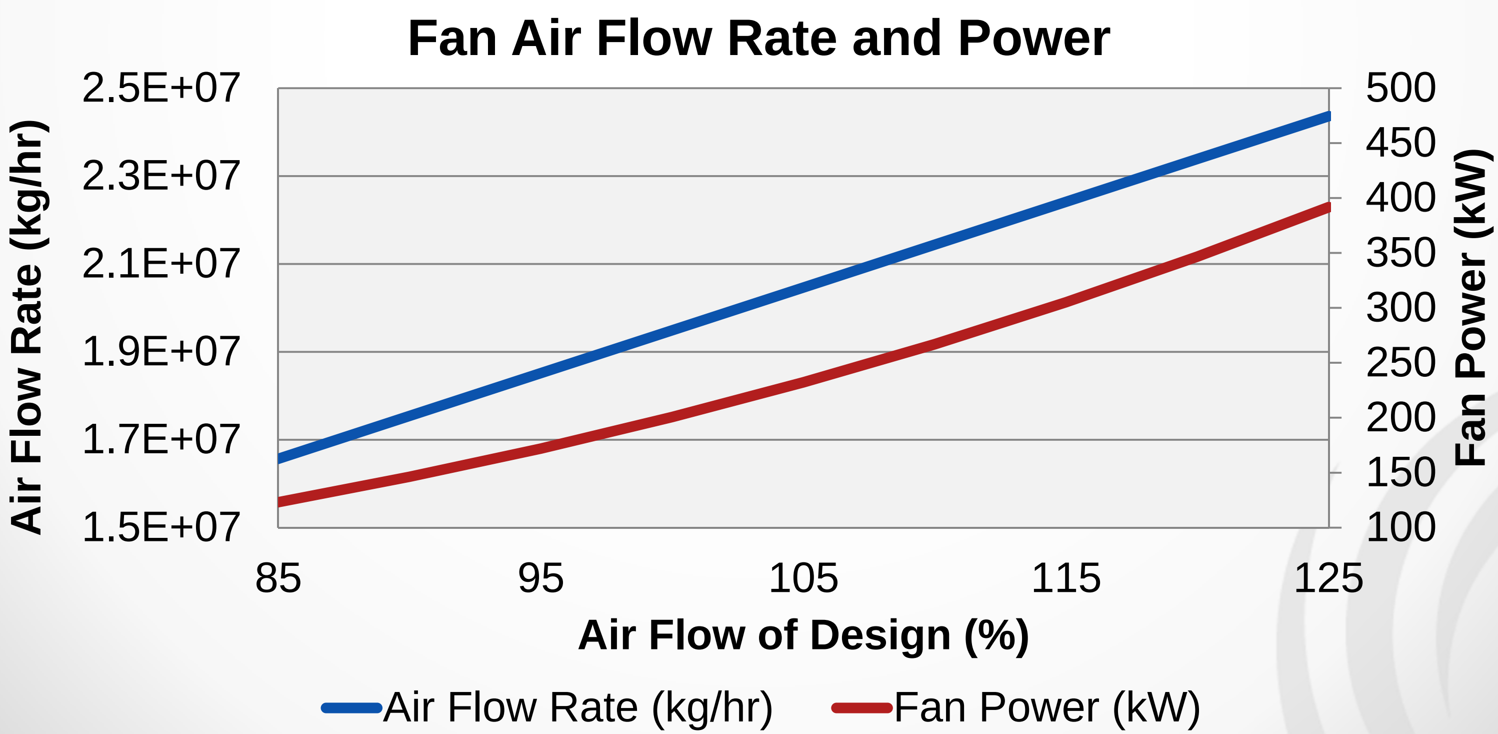
CW Flow Results - HR



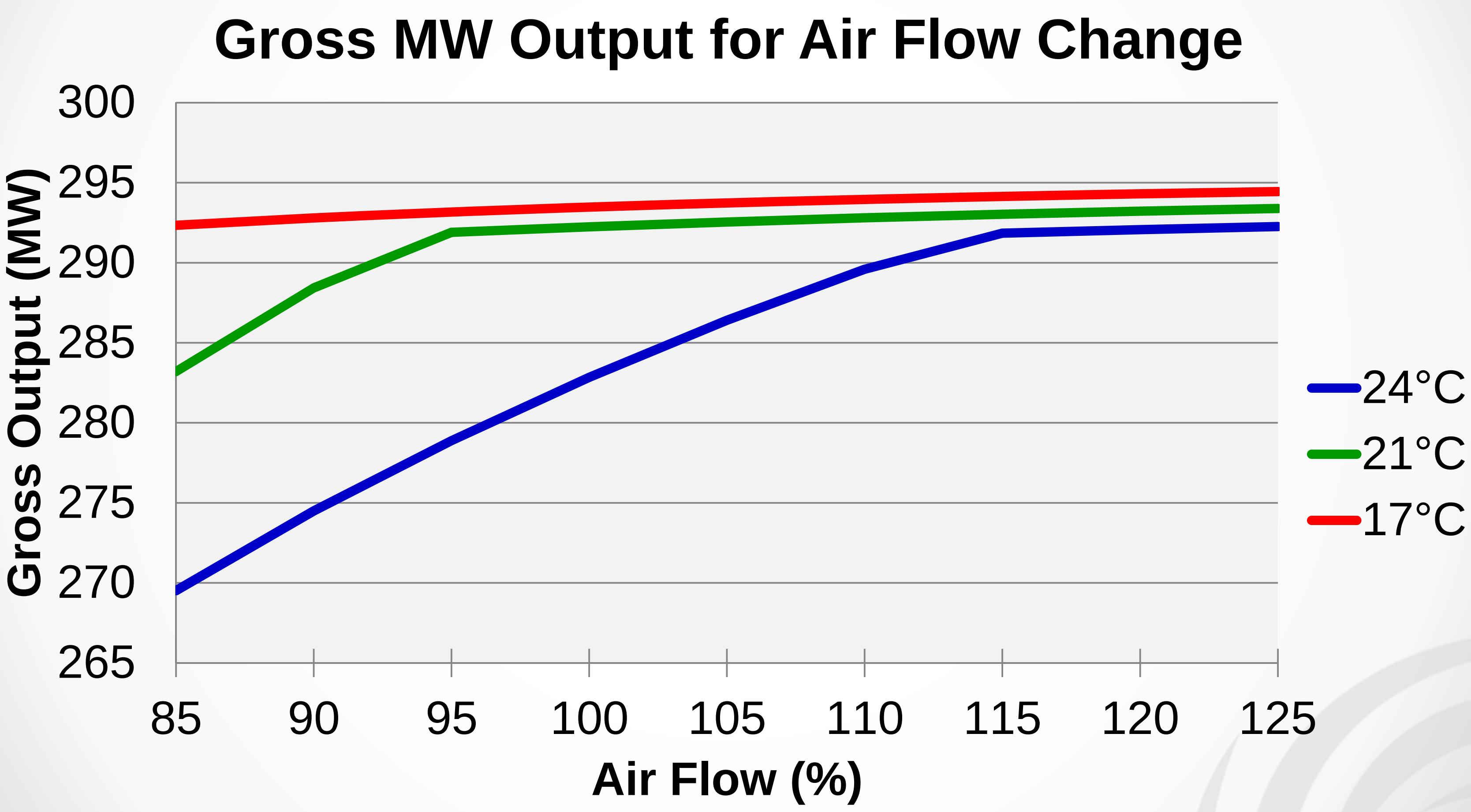
Fan Air Flow Calculations

- Main Cooling Tower Only
- Fan Affinity Law

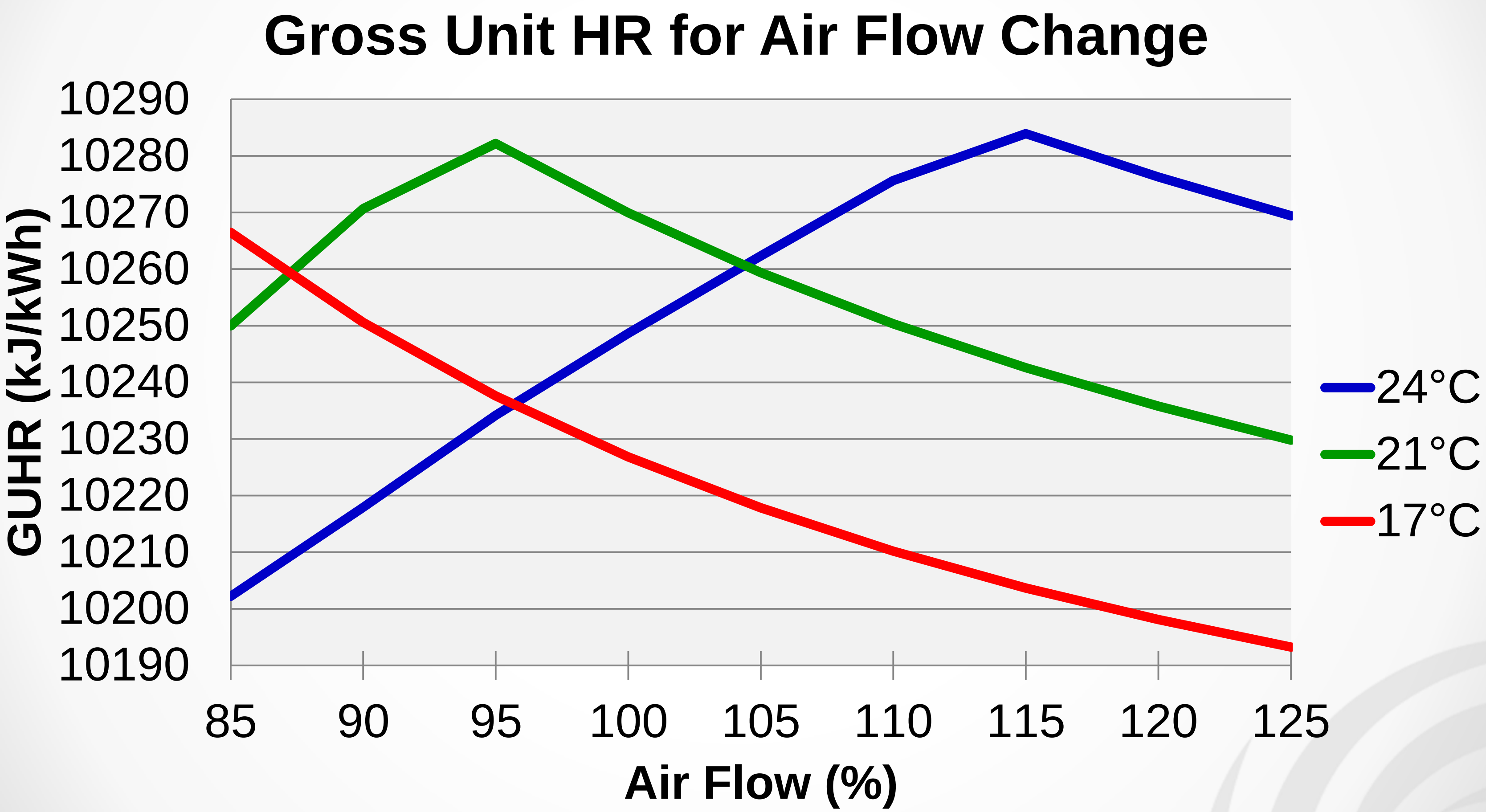
$$\frac{Fan\ Power_{Load}}{Fan\ Power_{Design}} = \left(\frac{Fan\ Air\ Flow_{Load}}{Fan\ Air\ Flow_{Design}}\right)^3$$



Fan Air Flow Results - MW

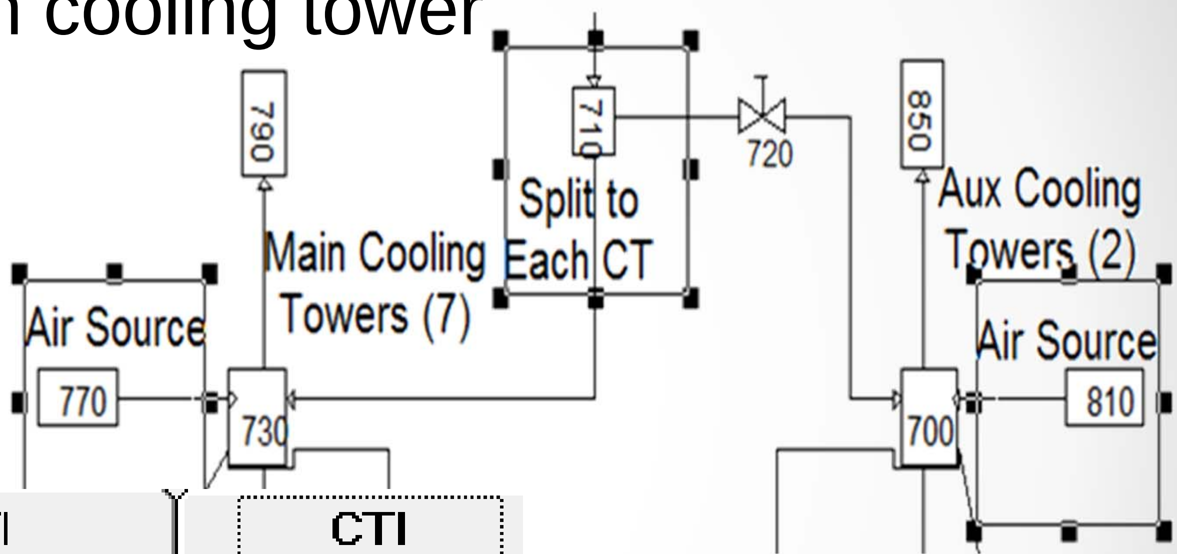


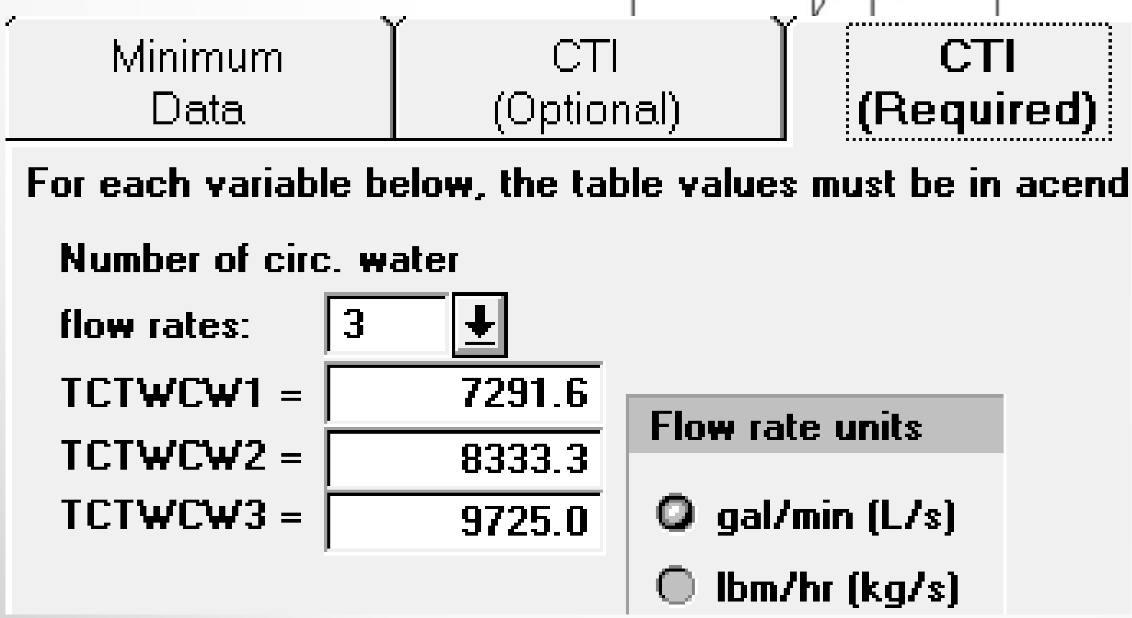
Fan Air Flow Results - HR



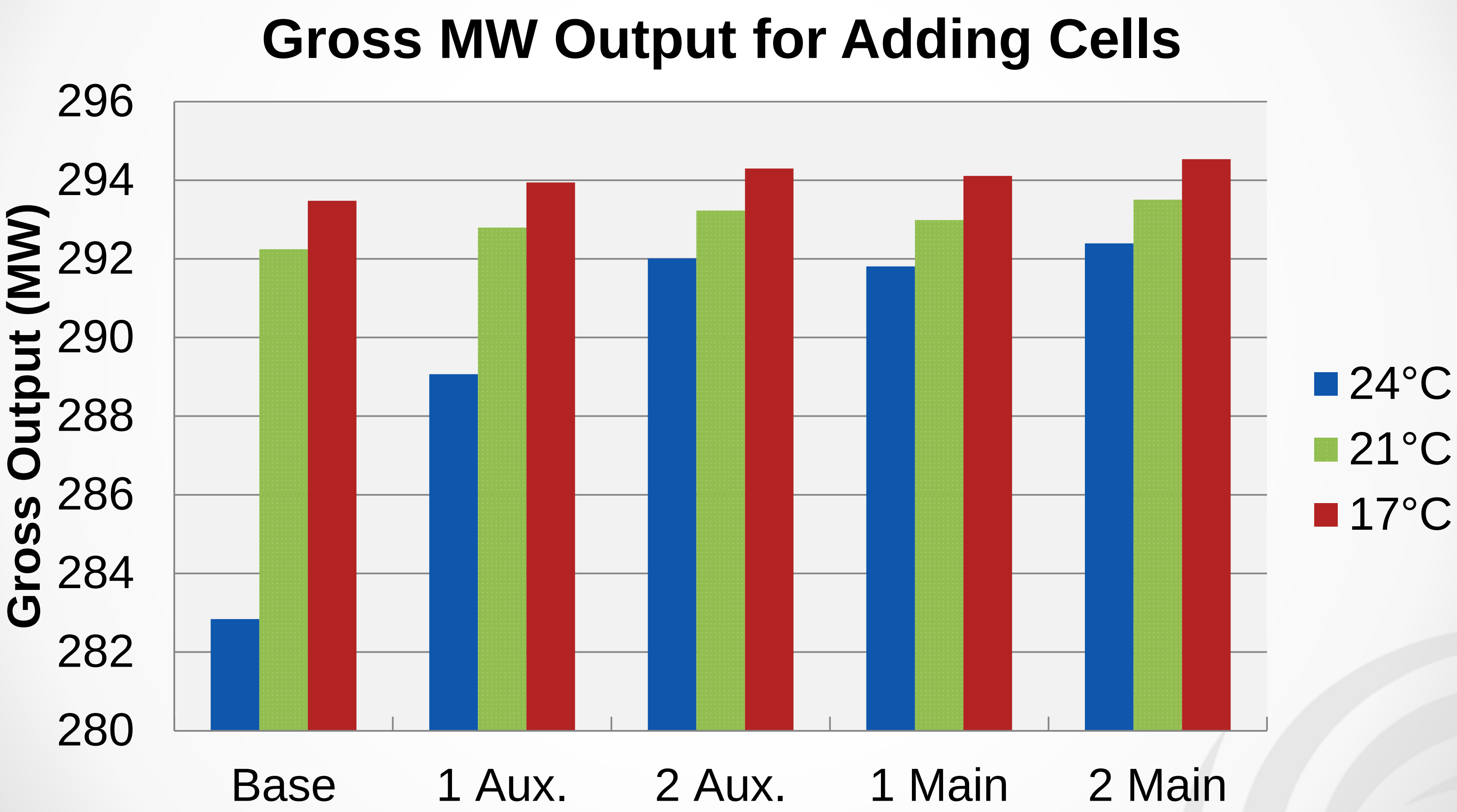
Additional Cells Calculations

- Flow Split to each cooling tower
- Number of Cells
- Source Air Flow
- CTI CW Flows

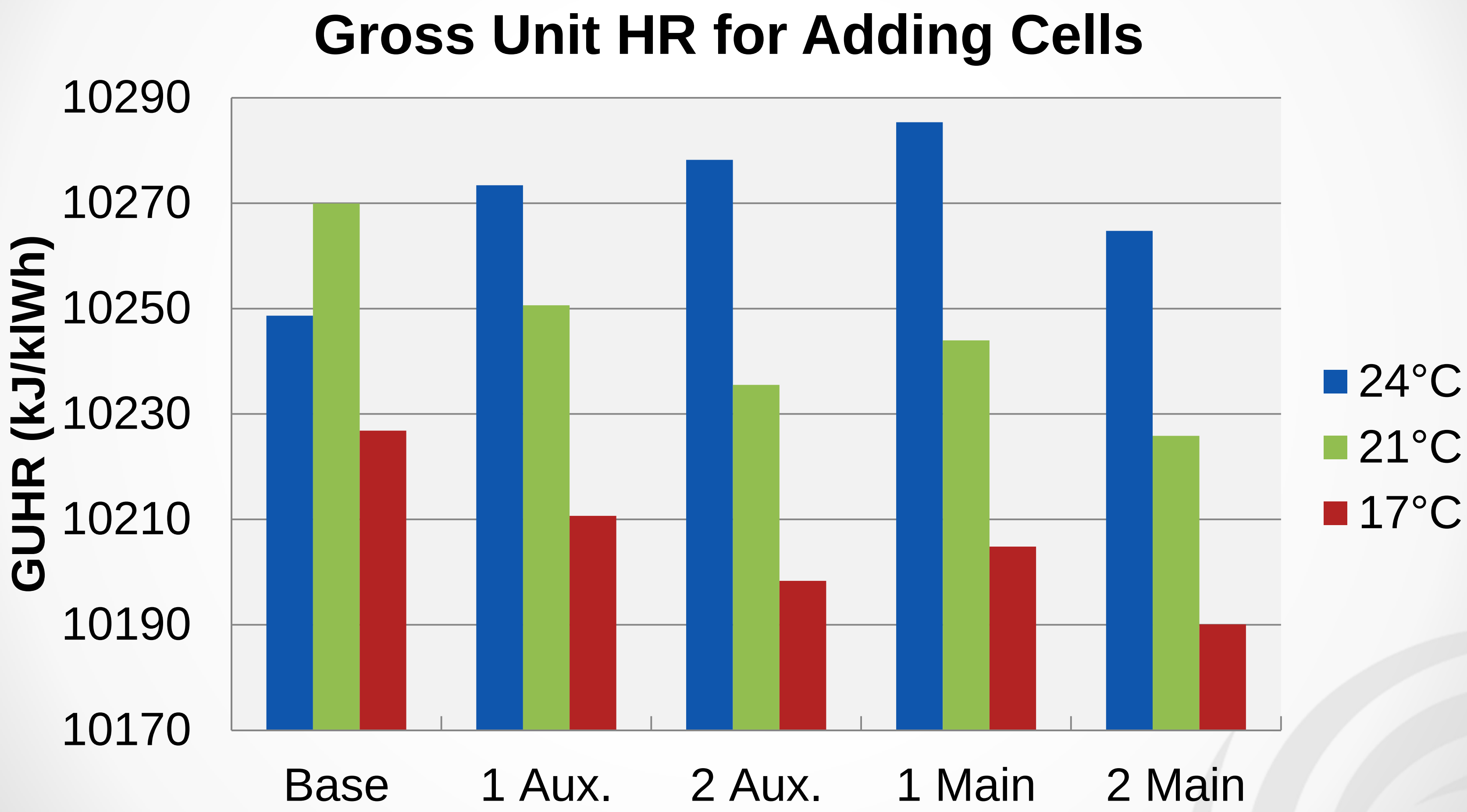




Adding Cooling Tower Cells Results - MW



Adding Cooling Tower Cells Results - HR



The use of the PEPSE Data

- Review which options were worth exploring further:
  - Feasibility of implementation
  - Cost of implementation
  - Effects on other parts of the system

- Provide benefits found to the second part of the study:
  - Potential benefits
  - Cost justification

Conclusion

- Study to choose best improvement option(s) is still ongoing
- So far, indications are that a distribution system / fill upgrade in the main towers will offer the greatest improvement
- Study will provide which option or combination of options is best suited to improve the back pressure issue

Questions?