Evaluating Generation Considering All Plant Losses and Efficiencies

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Plant Issue

- Browns Ferry Unit 1 restarted in June 2007
- Steam path was optimized for 20% EPU
- Licensing approval of EPU has been delayed
- Unit currently operates at 105% OLTP
- Unit generating 14 MWe less than expected
- Need to make a full accounting of the difference

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Browns Ferry Nuclear

Background Info

- U1 started commercial operation in 1973
- Unit is an 1800-RPM tandem-compound design
- Double-flow HP section w/ six (6) stages
- Six-flow LP section w/ eight (8) stages (43” LSB)
- Five (5) stages of Feedwater Heating
- Cycle is non-reheat (moisture separators only)

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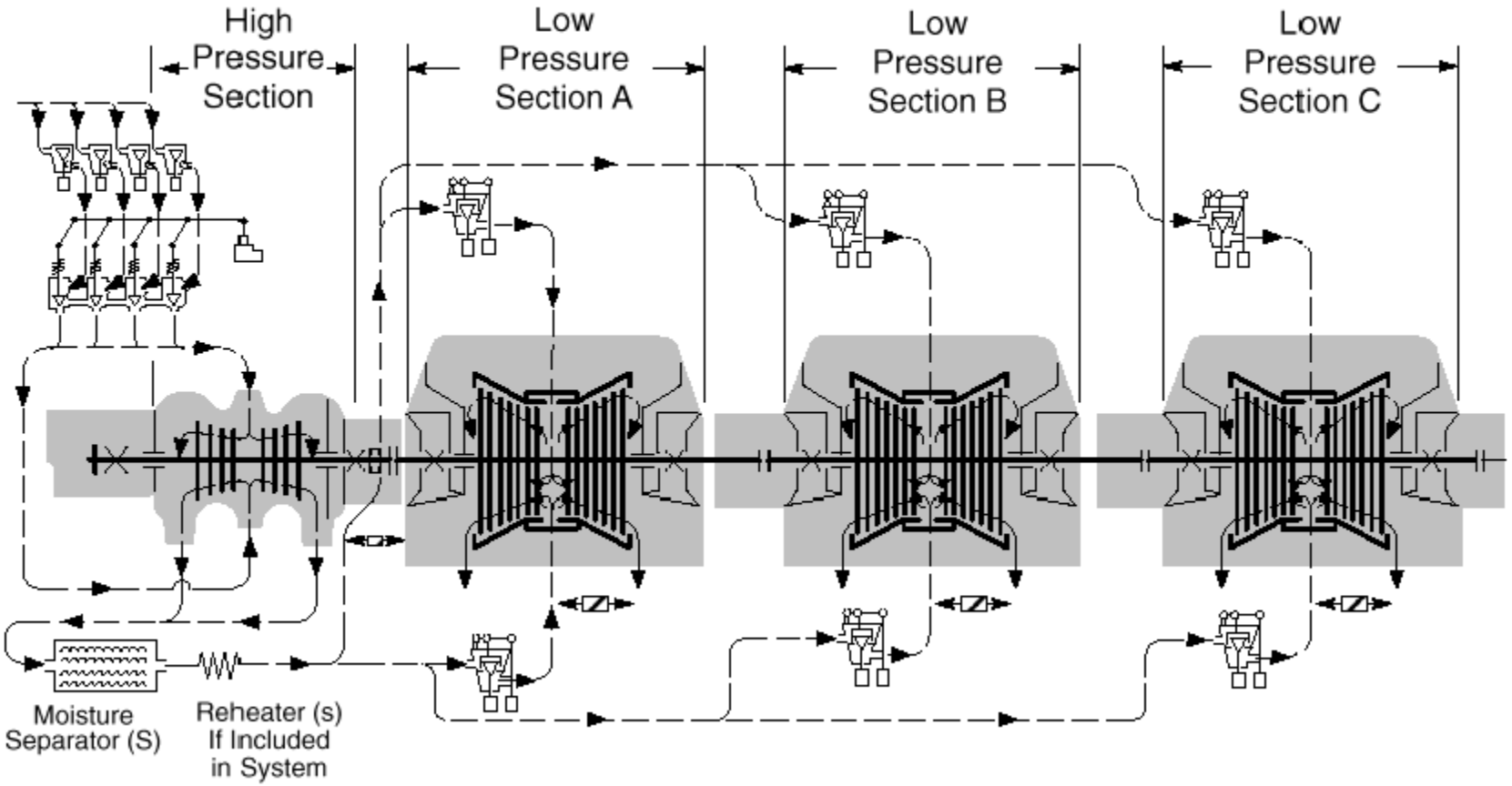
Background Info



Background Info

- Steam supplied by Boiling Water Reactor (BWR)
- Operates with four (four control valves (full arc)
- No precision testing performed following Restart
- No vendor balances at current 105% OLTP
- U1 generating 38 MWe less than U2 & U3
- EPU delays - TVA exploring recovery options

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Theories

- Feedwater flowrate reading higher than reality
- HP turbine was less efficient than thermal kit data
- Excessive control valve throttling as a result of:
  - Significant flow margin at this power level

    and/or
  - Physical configuration (poor manufacturing)
- Other possible plant losses (e.g., cycle isolation)

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Evaluation

- PMAX was used to gather plant and calculated data from its own historian
- PEPSE was used to validate the generation based on this data.

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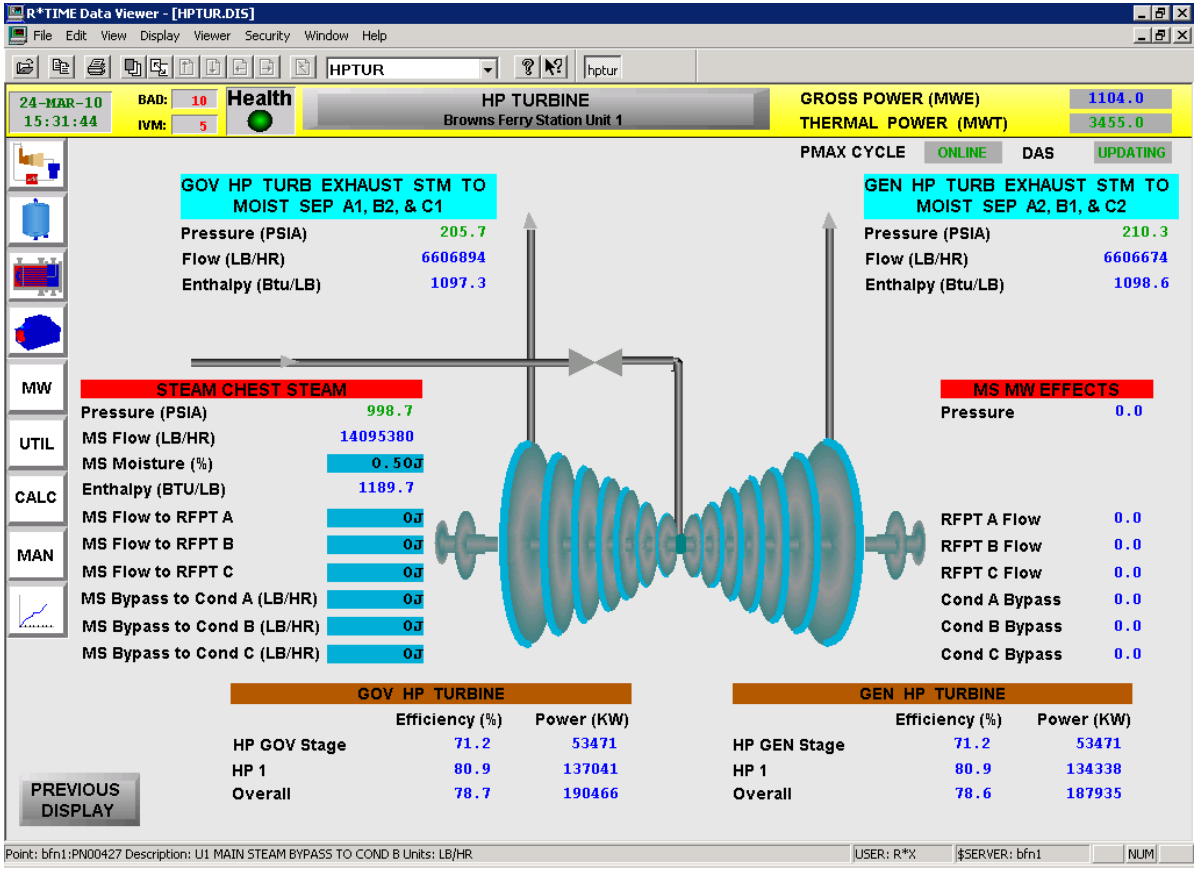
Evaluation - PMAX



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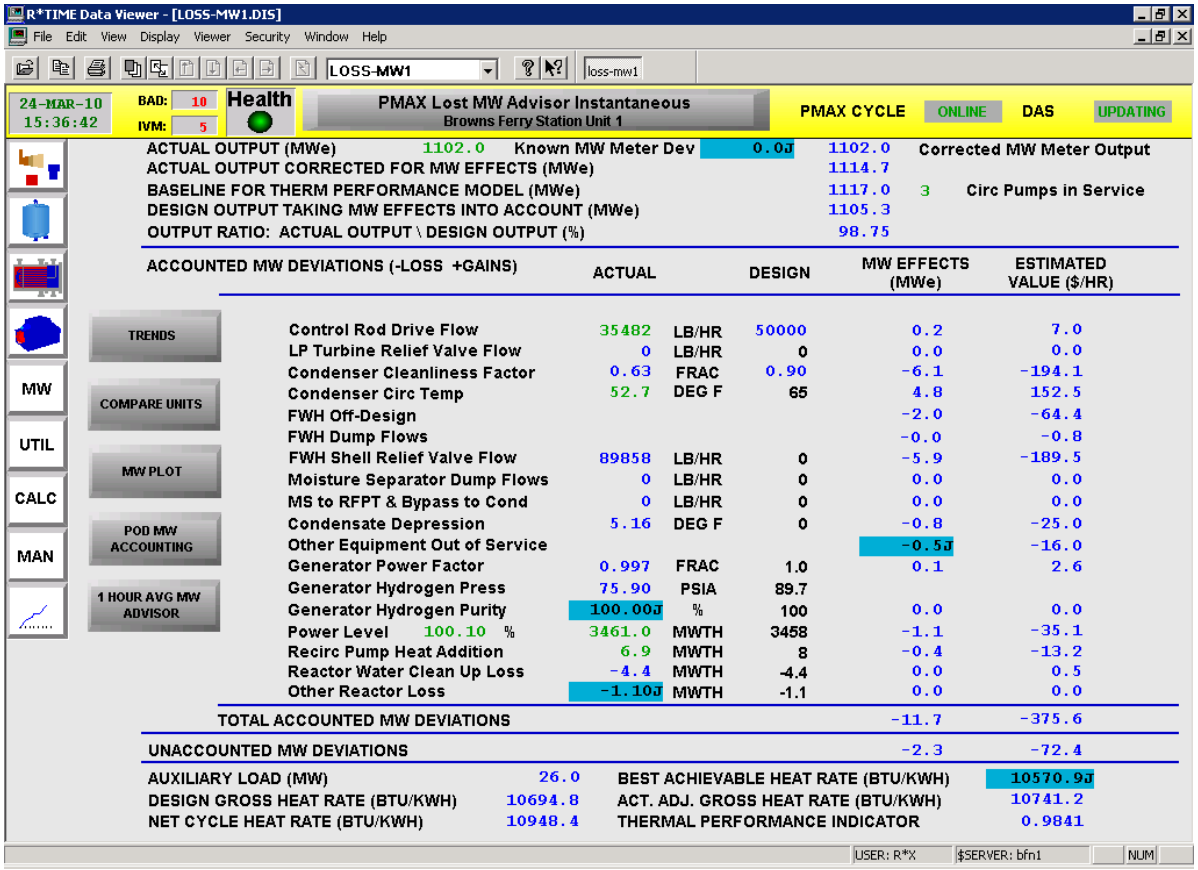
Evaluation - PMAX



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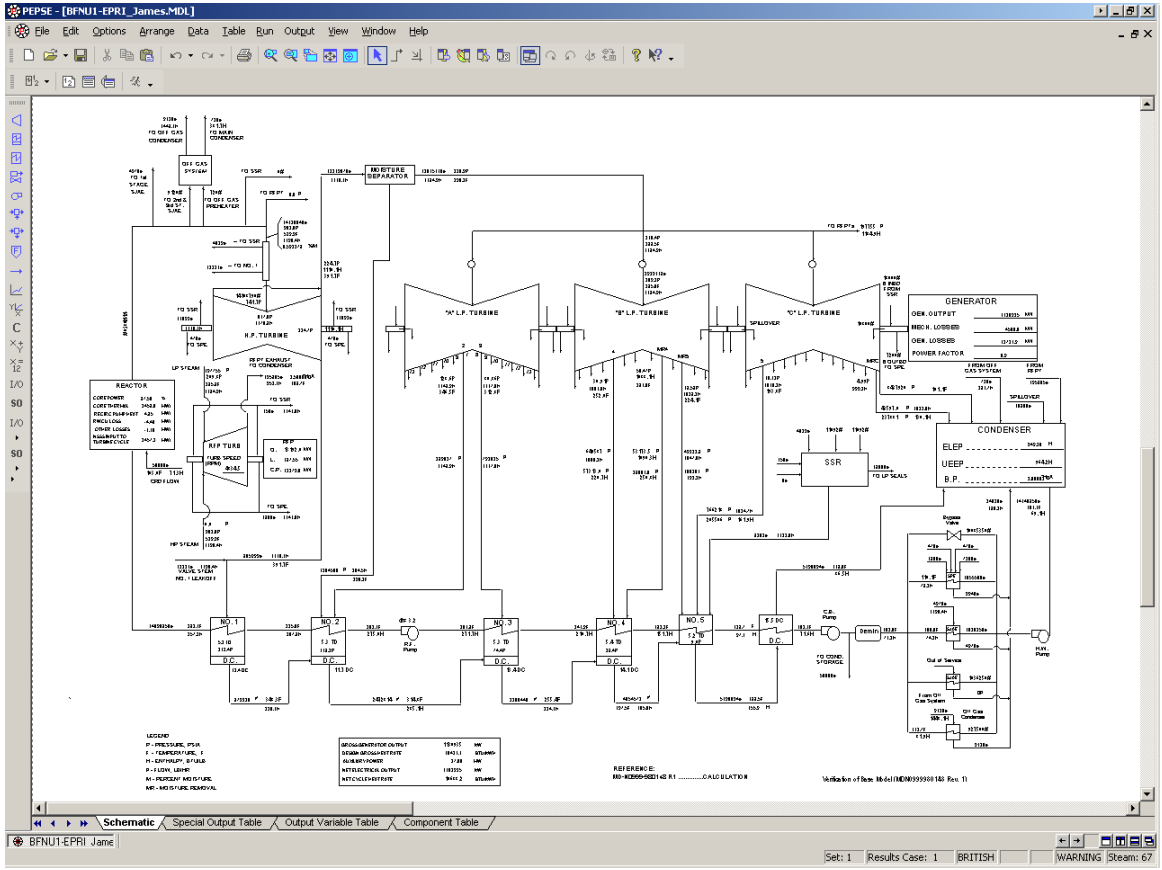
Evaluation - Data

- An hour of data was collected on 3/24/2010 from 15:00:00 to 16:00:00
- An average of this data was then used in the predictive heat balance software.

Evaluation - PEPSE



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Results – Case Studies

CASE	DESCRIPTION	GENERATION (MW)
1	BASE MODEL	1130.935
2	3/24/2010 ACTUAL PLANT DATA BOUNDARY CONDITIONS	1130.786
3	ALL ACTUAL CONDITIONS W/O TURBINE EFFICIENCIES	1133.428
4	LP TURBINE EFFICIENCIES INCLUDED	1120.019
5	ACTUAL THROTTLE VALVE OUTLET PRESSURE INCLUDED	1111.576
6	HP TURBINE EFFICIENCIES INCLUDED	1107.888
7	HP TURBINE DEGRADED TO MATCH GENERATION	1103.024
8	NEW HP TURBINE & THROTTLING CONDITIONS INCLUDED	1157.679
9	NEW HP TURBINE WITH 4.15% THROTTLED PRESS DIFF	1150.361

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Results - MW Losses

- With the plant data from 3/24/2010 without turbine efficiencies, the generation should be 2.642 MWe higher than design conditions
- With LP Efficiencies - 13.409 MWe drop
- With throttle valve pressure reduced to 704.5 from 738.9 psia (4.15% drop) – 8.443 MWe drop
- With HP Efficiencies based on design expansion line and actual plant pressures – 3.688 MWe

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Results – MW Losses

- About 5 MWe short of actual measured output
  - Instrument Error (HP exhaust 11 psia low; worth 3 MWe)
  - Other cycle losses (valve leaks, feed flow error, etc.)
  - HP turbine not expanding on design expansion line
- New HP efficiencies if the 5 MWe due to HP turbine

HP Stage	Case 6	Case 7	Delta
Governing	85.10%	84.41%	0.69%
1st Stage	82.20%	80.30%	1.90%

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Results – New HP Turbine

- New HP turbine and throttling conditions – 1157.679 MWe – 54.655 MWe gain
- If 5 MWe of unaccounted is not HP turbine related – 49.791 MWe
- If the throttle valve outlet pressure is 4.15% less as it is currently, the gain is only 42.473 MWe
- The vendor suggests that the gain will be at least 27.5 MWe

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Conclusion

- Throttling loss is a large contributor to underproduction
- Turbine efficiency contributes a large portion of loss as well
- The HP turbine modifications have the ability to supply the vendor suggested 27.5 MWe to as much as 50 MWe.

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Future Plans

- Continue to operate at 105% OLTP
- Replace first 4 stages of HP Turbine (Fall 2010)
- 1st Stage P Tap being reinstalled (Fall 2010)
- Pre and Post Test Evaluation will be performed
- Recover Minimum 27.5 MWe (Vendor Predicted) up to Maximum 50 MWe (Based on Analysis)

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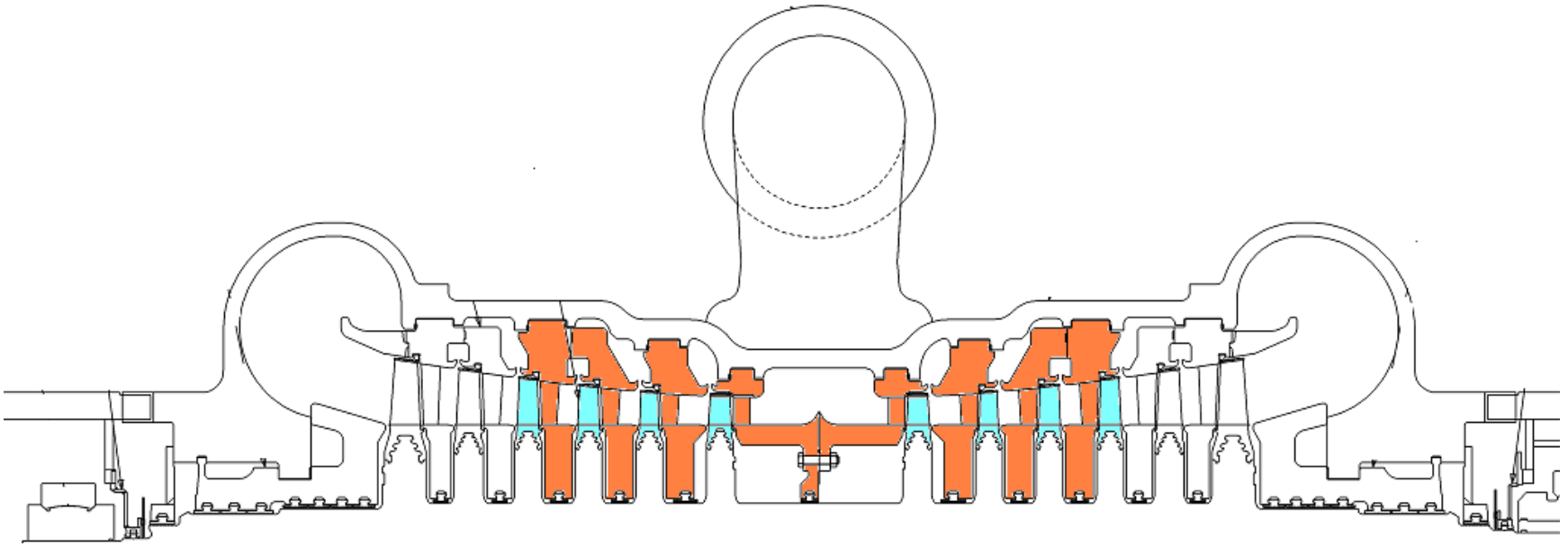
Future Plans



Highlighted First 4 Stages Buckets/Diaphragms To Be Replaced

Questions or Comments