HP/IP Turbine Replacement Analysis Using PEPSE

Update 1

Bill Kettenacker, PE
Scientech

2009 Scientech Symposium
Managing and Improving Plant Performance
January 14-16, 2009

CURTISS WRIGHT Flow Control Company
SCIENTECH

Update

This paper is an update to the one given at the last Symposium in 2007. It has been updated to reflect new analyses that were performed subsequent to the last paper. This updated paper appears as an article in the August, 2008 issue of *Power Engineering.*

The Company

- Large US-based Electric Utility
- Mix of Fossil and Nuclear
- Fossil is Primarily Coal
- Spread Over Several States

The Station

- Multi-Unit Station
- Unit “X” – 310 MW
- Sub-critical, coal-fired
- 2415 psi, 1050^{o}F/1000^{o}F, 1.9x10^{6} lb/hr
- Original GE turbines
- On-line in early 1970’s

The Problem

- Considering HP Turbine and IP Turbine Replacement
- Will Turbines Perform as Proposed?
- What Will the Real Plant Performance Be after Replacement?
- Will the Turbine Replacement Pay for Itself in a Reasonable Time?

Considerations

- What does the utility get from the vendor?
  - A heat balance diagram
  - A guarantee
- Utility must prove non-guarantee.
- What if the turbines fail guarantee?
  - Utility gets a penalty payment
  - Utility must live with it

The Solution

- Proposals from 2 Vendors
  - Vendor X
  - Vendor Y
- Also Look at Overhaul Instead of Replacement
- Analysis using **PEPSE®**
  - Turbine and boiler models
  - Special Option 11 application

PEPSE®

- Steady-state energy balance program
- Simulation model built from comp library
- Windows®-based drag and drop
- Fossil, nuclear, gas turbines, combined cycles, any fluid system
- 100's of PEPSE® customers representing 1000's of users world-wide

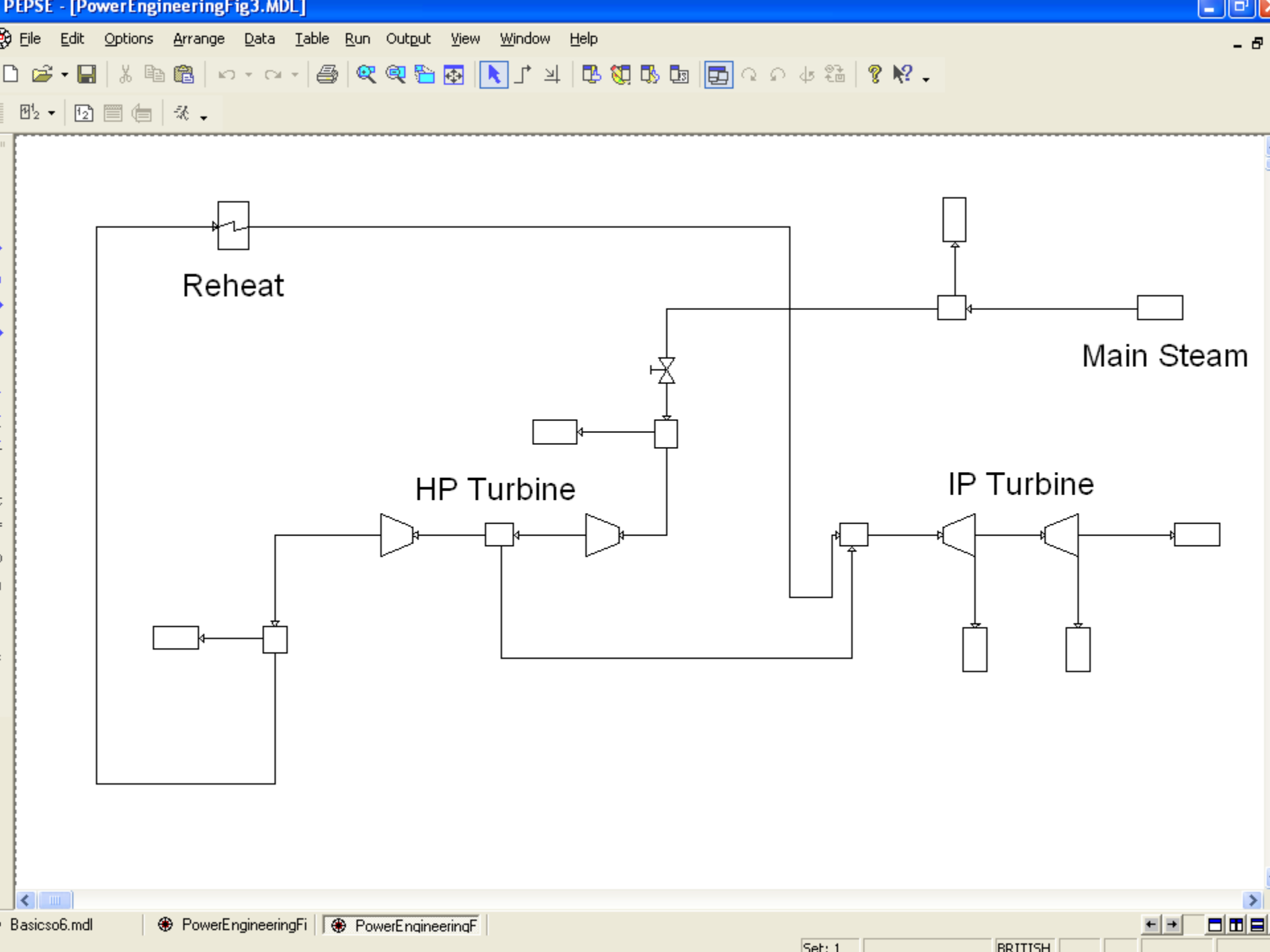
Solution Method

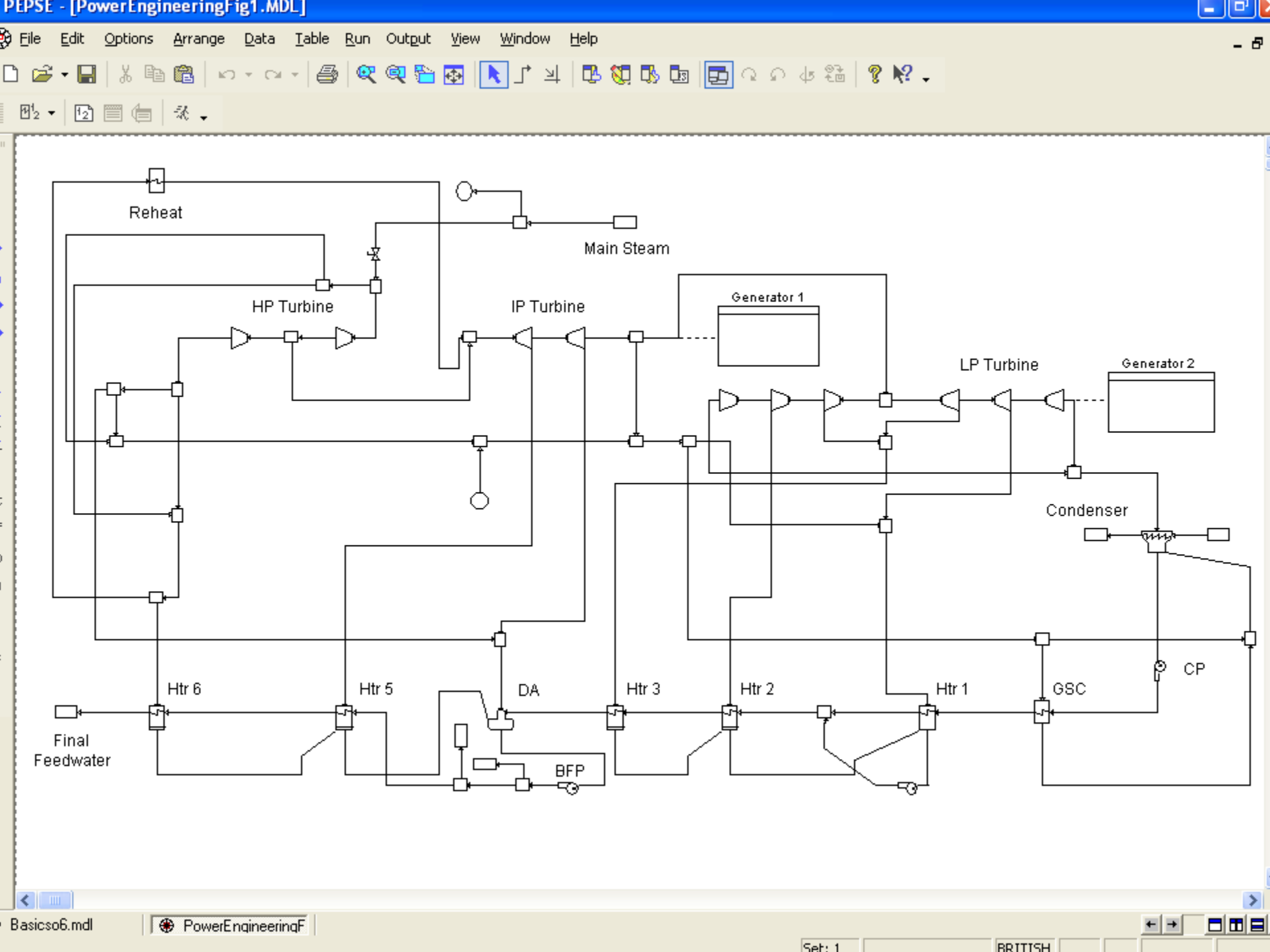
1. Use The Utility's Existing PEPSE Turbine and Boiler Models
2. Check (and Modify if Necessary) the Models Against Current Design
3. Tune the Models to Actual Plant Data
4. Using Vendor X's and Y's Proposed HP/IP Turbine Replacement Heat Balances, Develop Submodels of HP and IP Turbines and Tune the Turbines

Solution Method

(continued)

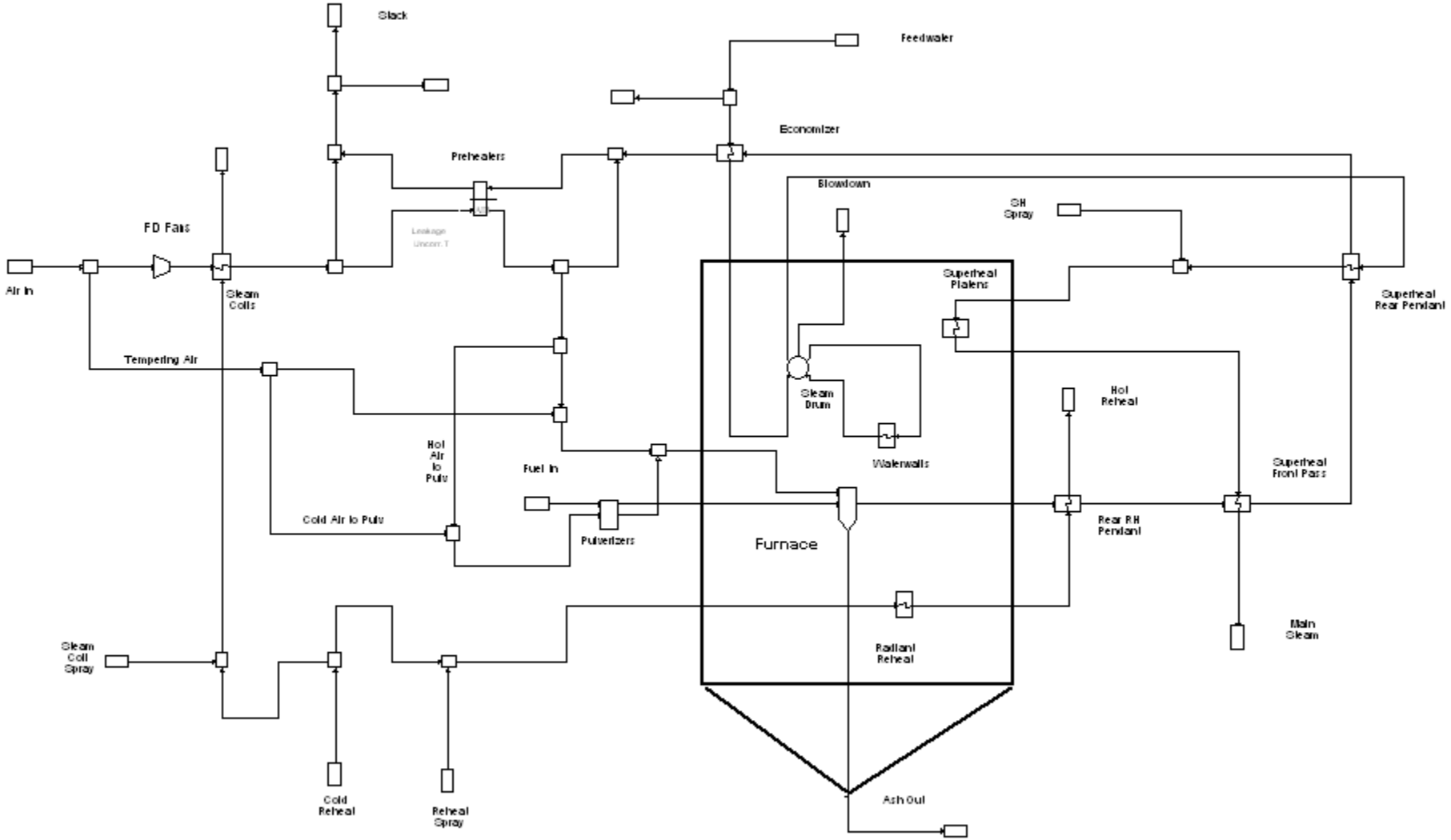
5. Put Tuned Results Back into Main Model
6. Run “New” Turbine Model and Boiler Model Together Using Special Option 11
7. Repeat Step(6) Using “Re-Built” HP and IP Turbines by Assuming an Efficiency


PEPSE - [PowerEngineeringFig3.MDL]
File Edit Options Arrange Data Table Run Output View Window Help
Reheat
Main Steam
HP Turbine
IP Turbine
Basicso6.mdl
PowerEngineeringFi
PowerEngineeringF


PEPSE - [PowerEngineeringFig1.MDL]
File Edit Options Arrange Data Table Run Output View Window Help
Reheat
Main Steam
HP Turbine
IP Turbine
Generator 1
LP Turbine
Generator 2
Condenser
CP
Htr 6
Htr 5
DA
Htr 3
Htr 2
Htr 1
GSC
Final Feedwater
BFP
Basicso6.mdl
PowerEngineeringF

PEPSE - [PowerEngineeringFig2.MDL]

File Edit Options Arrange Data Table Run Output View Window Help



Basicso6.mdl PowerEngineeringF

Set: 1 BRITISH

Results – Turbine Changes Only

	Current Operation	OEM 1	OEM 2	Rebuilt HP/IP
HP Turbine Power, MW	86.2	92.6	93.8	89.3
IP Turbine Power, MW	78.8	82.8	82.3	79.8
LP turbine Power, MW	146.0	141.5	141.0	144.1
Total Gross Generation, MW	306.5	312.4	312.6	308.7
Plant Heat Rate, BTU/kW-hr	9104	8935	8930	9042

Results

- Both Vendor's Results Almost Identical for New HP and IP Performance
- LP Turbine "Energy-Starved"
- Results Show Little Overall Improvement with New Turbines
- Inconclusive

What To Do Next?

- Keep the Project Alive
- What is Needed?
  - Net ~7-8 MW
  - Net ~200-225 BTU/kW-hr
- What to Do?

Solution Method - New

Add Boiler Surface Area (5% - 25%) to Increase Heat to Turbine Cycle

- Superheat
- Reheat
- Economizer

Results – Turbine + Boiler Changes, OEM-1

	Turb Only	RH +10%	SSH +10%	PSH +10%	Econ +10%
HP Turbine Power, MW	92.6	91.8	92.8	93.3	93.0
IP Turbine Power, MW	82.8	83.0	82.7	82.9	83.0
LP turbine Power, MW	141.5	141.9	141.4	141.7	141.9
Total Gross Generation, MW	312.4	312.1	312.4	313.2	313.3
Plant Heat Rate, BTU/kW-hr	8935	8941	8934	8911	8907

Results – Turbine + Boiler Changes, OEM-2

	Turb Only	RH +10%	SSH +10%	PSH +10%	Econ +10%
HP Turbine Power, MW	93.8	93.0	94.0	94.5	94.2
IP Turbine Power, MW	82.3	82.6	82.3	82.5	82.6
LP turbine Power, MW	141.0	141.5	141.0	141.3	141.5
Total Gross Generation, MW	312.6	312.6	312.8	313.7	313.7
Plant Heat Rate, BTU/kW-hr	8930	8929	8921	8900	8896

Results – Turbine + Boiler Changes, OEM-1

Temp Control	Turb Only	RH +10%	SSH +10%	PSH +10%	Econ +10%
HP Turbine Power, MW	93.4	93.5	93.8	93.5	93.8
IP Turbine Power, MW	84.1	84.3	84.1	84.1	84.1
LP turbine Power, MW	143.6	143.9	143.6	143.7	143.7
Total Gross Generation, MW	316.4	317.0	316.8	316.7	316.9
Plant Heat Rate, BTU/kW-hr	8910	8897	8897	8898	8890

Results

- Additional Boiler Surface Area Did Not Sway the Results
- Rebuilt HP/IP ~$1.5M
- New Turbines ~$12M
- Rebuild Instead of New
- No New Boiler Surface

Conclusions

- **PEPSE®** Is An Efficient Tool for Power Plant Analysis Studies
- Spending a Little Up-Front Can Save a Bundle Down the Road

FAMOS: Fleet Asset Management and Optimization Solutions

CURTISS WRIGHT
Flow Control Company
SCIENTECH