Evaluating an HP/IP Turbine Replacement

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Background

This paper is a result of work done by Scientech for a utility in 2007. This utility prefers to remain anonymous. This paper appears as an article in the August, 2008 issue of *Power Engineering.*

The Utility

- Large US-based Electric Utility
- Mix of Fossil and Nuclear
- Fossil Fuel is Primarily Coal
- Utility Operates in 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, cross compound
- On-line in early 1970’s

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The Situation

- Evaluate an HP Turbine and IP Turbine Replacement
- Questions:
  - Will the 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 (OEM-1)
  - Vendor Y (OEM-2)
- As an Option, Also Look at Overhaul Instead of Replacement
- Analysis using **PEPSE® -** Turbine and Boiler Models

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

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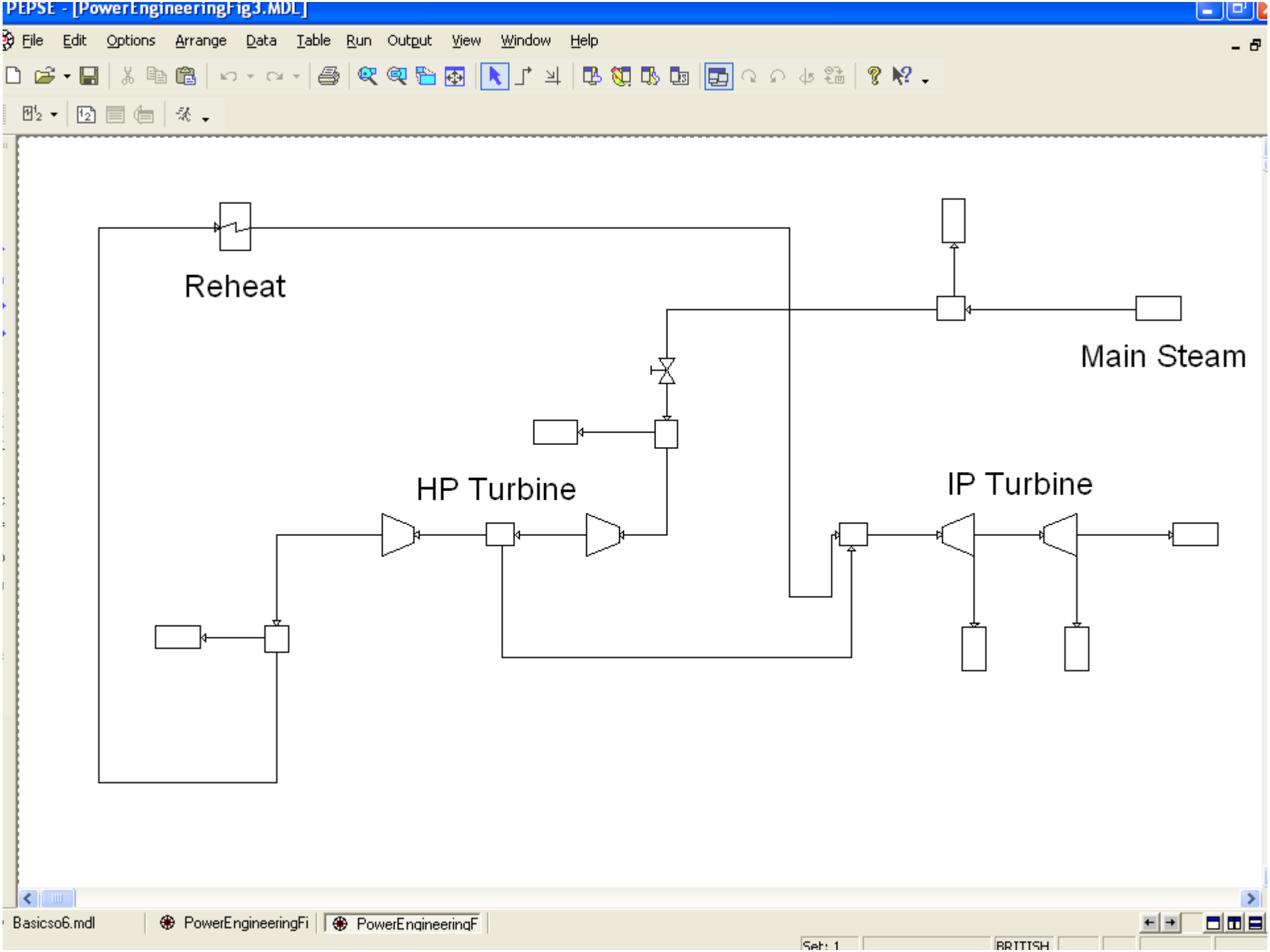
Solution Method

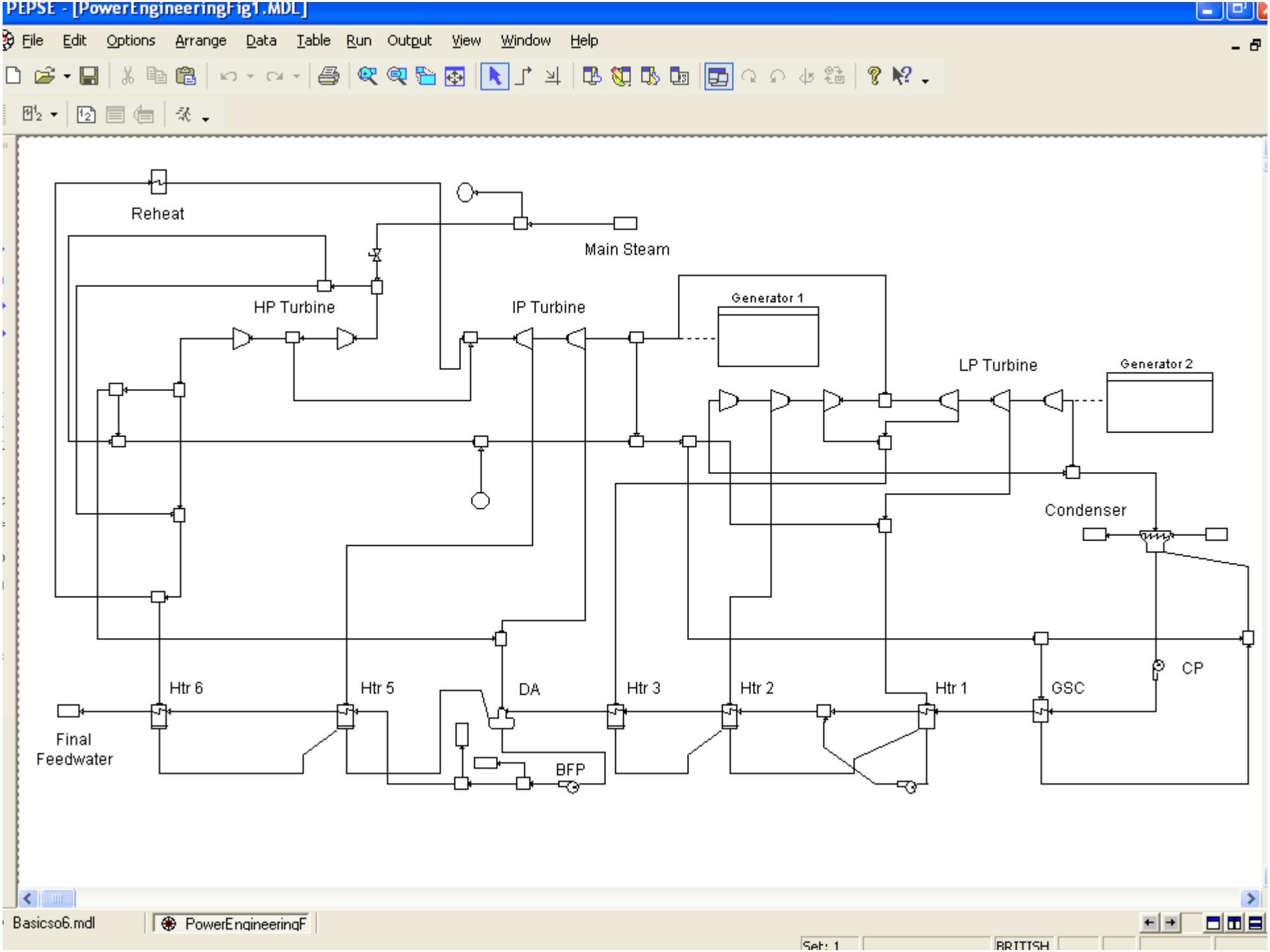
1. Use The Utility's Existing PEPSE Turbine and Boiler Models
2. Check (and Modify if Necessary) the Models Against Current Design
3. Tune the Models to Actual Plant Data
4. Using Vendor X's and Y's Proposed HP/IP Performance, Develop Submodels of HP and IP Turbines and Tune the Turbines

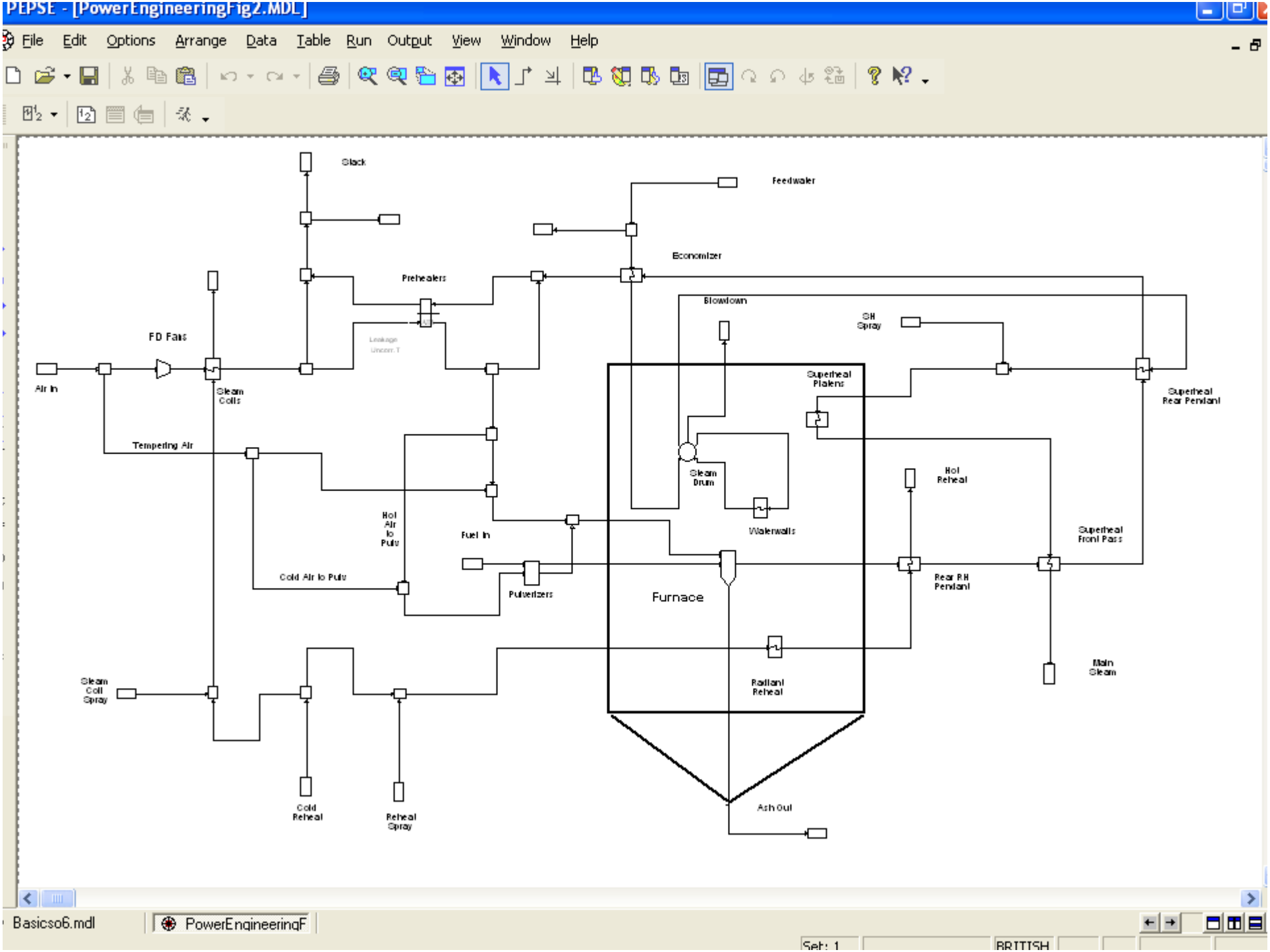
Solution Method

(continued)

5. Put Tuned Results Back into Main Model
6. Run “New” Turbine Model and Boiler Model Together
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
GSC
Htr 6
Htr 5
DA
Htr 3
Htr 2
Htr 1
Final Feedwater
BFP
Basicso6.mdl
PowerEngineeringF


PEPSE - [PowerEngineeringFig2.MDL]
File Edit Options Arrange Data Table Run Output View Window Help
Stack
Feedwater
Economizer
Preheaters
Blowdown
SH Spray
FD Fans
Air In
Steam Coils
Superheat Platens
Superheat Rear Pendant
Tempering Air
Steam Drum
Hot Reheat
Hot Air to Pulv
Fuel In
Waterwalls
Superheat Front Pass
Cold Air to Pulv
Pulverizers
Furnace
Rear RH Pendant
Steam Coil Spray
Radiant Reheat
Main Steam
Cold Reheat
Reheat Spray
Ash Out
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

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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

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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**

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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

Questions?

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FAMOS: Fleet Asset Management and Optimization Solutions

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