

Renewable Energy Systems

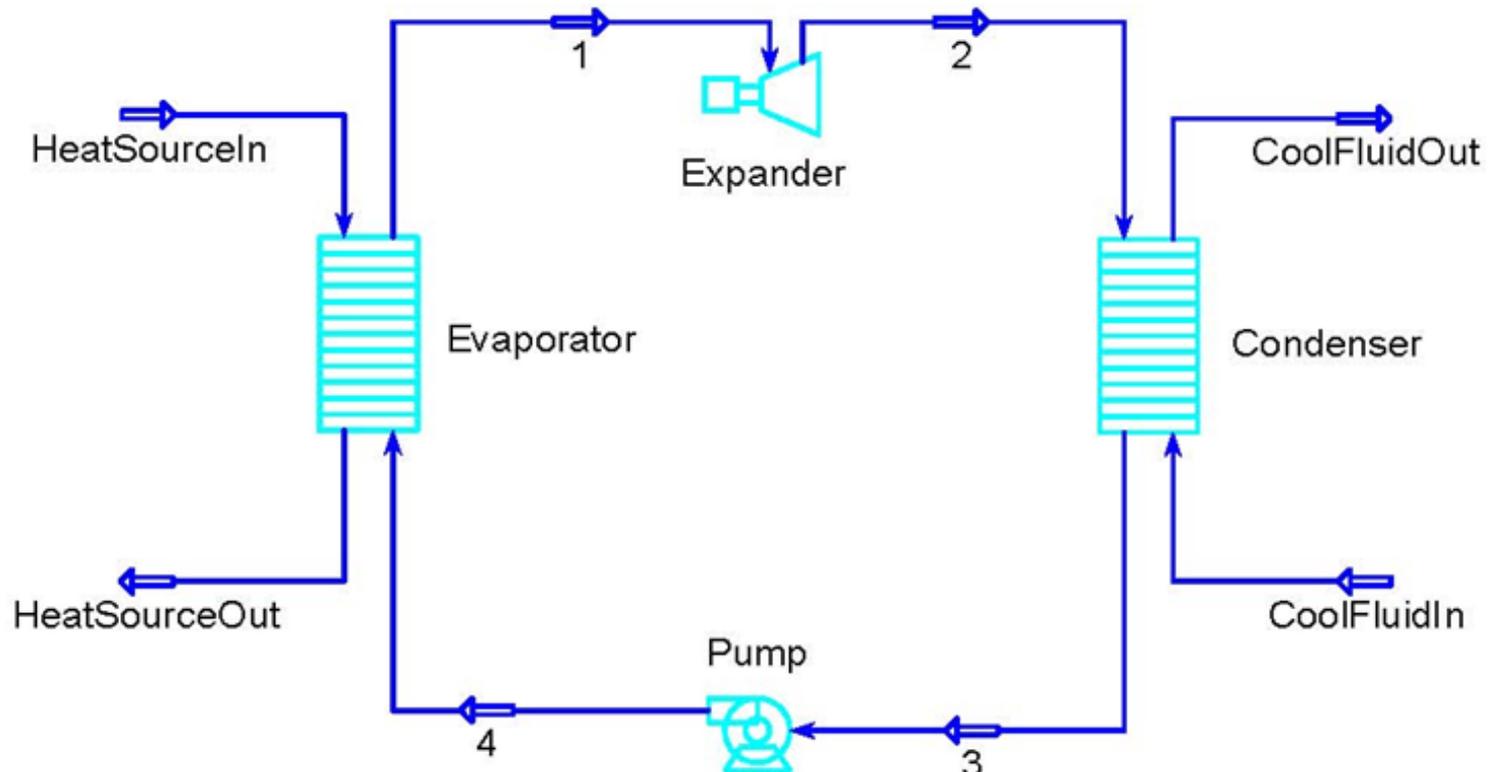
Designing and Achieving Geothermal Power Plant Performance with Confidence

Guofu Chen, TAS Energy Inc.



- Introduction to Organic Rankine Cycle (ORC)
- The benefits of a supercritical R134a ORC
- The **PROBLEM**: over or under estimate the performance
- The **SOLUTION**: design and achieve the performance
 - The tools being used
 - Model 1, build a “Virtual Plant”
 - With real geometries, but not site process data
 - Model 2, model heat and mass balance of an operating plant
 - Reflects plant operation on site
 - With site process data, but no geometries included
 - Model 3, combine model 1 and model 2 to predict reality
 - Site data, real geometries, really predicts the reality

- Based on Rankine cycle principle, use an organic working fluid to turn geothermal fluid energy or waste heat into electricity.



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Benefits of supercritical R134a ORC

- Supercritical Organic Rankine Cycle outperforms sub-critical cycle, from the gross and net kW generated point of view.
- Non-flammable working fluid, eliminates the risk of fires.
- Simpler to design and easier to operate than sub-critical cycle

Super-critical

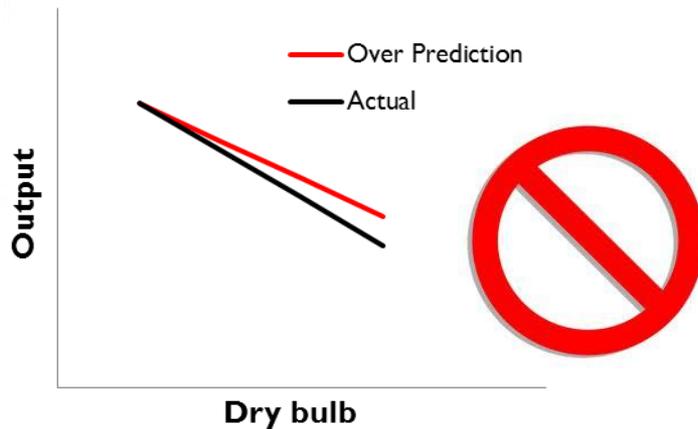
Sub-critical



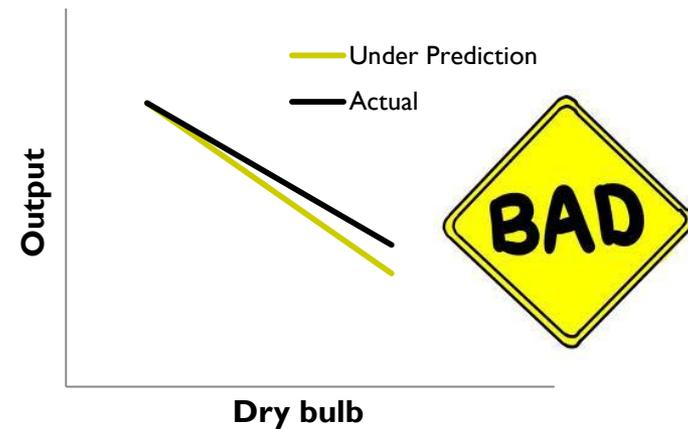
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The PROBLEM

- Over prediction



- Under prediction



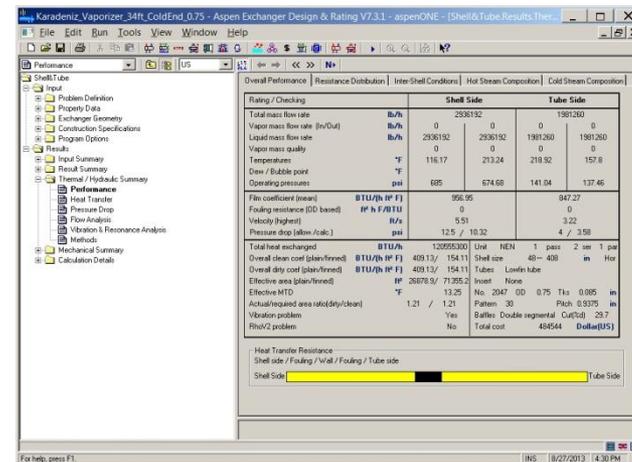
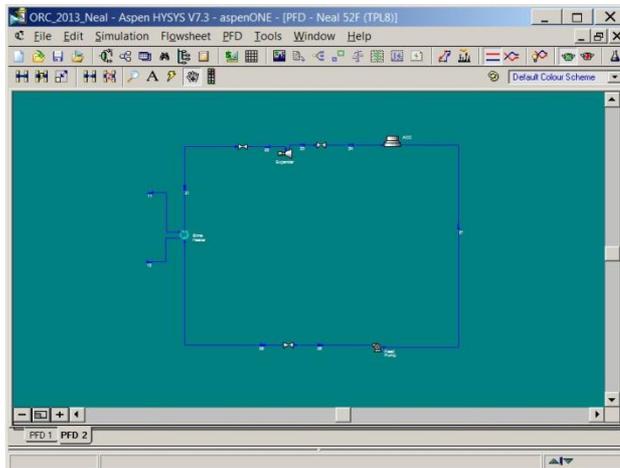
- Guaranteed performance not met

- Performance does not support further development

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The tools

- AspenTech HYSYS simulation program
- AspenTech Exchanger Design and Rating (EDR) program
- Proprietary knowledge and software developed by TAS



Rating / Checking		Shell Side		Tube Side	
Total mass flow rate	lb/h	0	2936192	0	1981260
Vapor mass flow rate (in/Out)	lb/h	2936192	2936192	1981260	1981260
Liquid mass flow rate	lb/h	0	0	0	0
Vapor mass quality		0	0	0	0
Temperature	°F	116.17	213.24	218.92	157.8
Dew / Bubble point	°F				
Operating pressure	psi	695	674.69	141.04	137.46
Film coefficient (mean)	BTU/(h·ft ² ·°F)	596.95		847.27	
Fouling resistance (DD based)	ft ² ·h/BTU	0		0	
Velocity (light)	ft/s	5.51		3.22	
Pressure drop (allow/calc.)	psi	12.5 / 10.32		4 / 3.98	
Total heat exchanged	BTU/h	12095300			
Overall clean coef (plate/finned)	BTU/(h·ft ² ·°F)	489.13 / 154.11			
Overall dirty coef (plate/finned)	BTU/(h·ft ² ·°F)	489.13 / 154.11			
Effective area (plate/finned)	ft ²	26876.9 / 71395.2			
Effective MTD	°F	13.25		No. 2047	OD 0.75
Actual/required area ratio(dty/clean)		1.21 / 1.21		Pattern: 30	Pitch: 0.5375
Vibration problem	Yes			Baffles: Double segmental	Cut: 50 / 29.7
RN42 problem	No			Total cost	484544 Dollars[US]

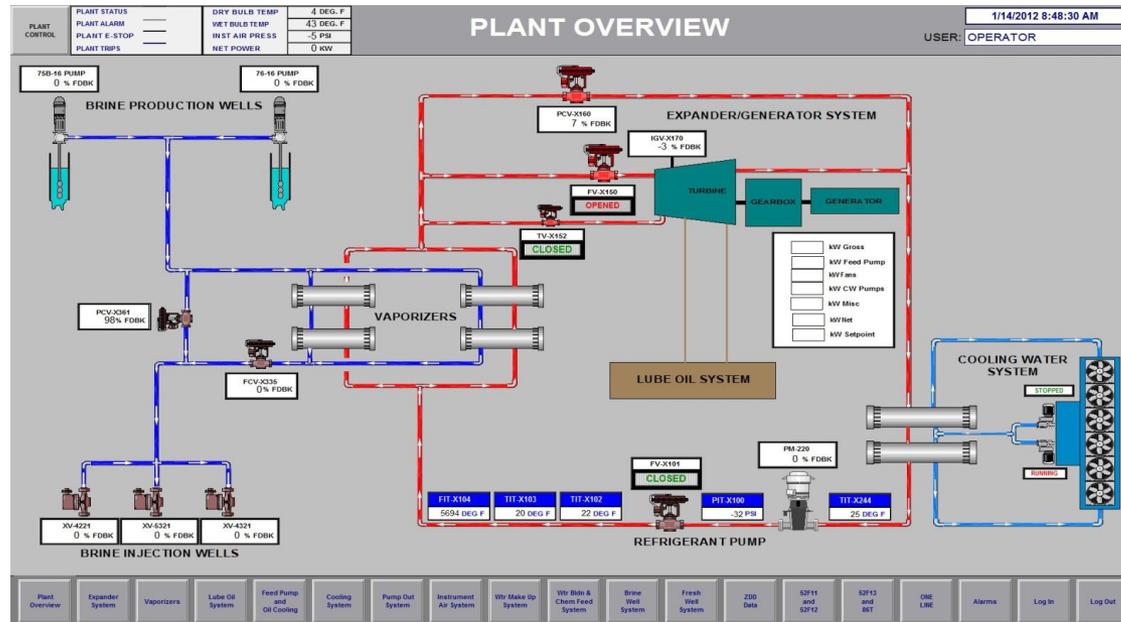
Model 1, Virtual Plant at design phase

- Create a thermal model, using sound engineering practice
- Size exchangers, select # of ACC, expanders and pumps
- Integrate the geometries and build the true simulation model that allows you to do virtual experiment
- Optimize output and commit to customers with confidence



Model 2, reflects actual operation

- The plant is successfully commissioned
- Measure the flow rate, temperature and pressure
- Build a plant reality thermal model to reflect the plant operation conditions at site. No geometries in Model 2

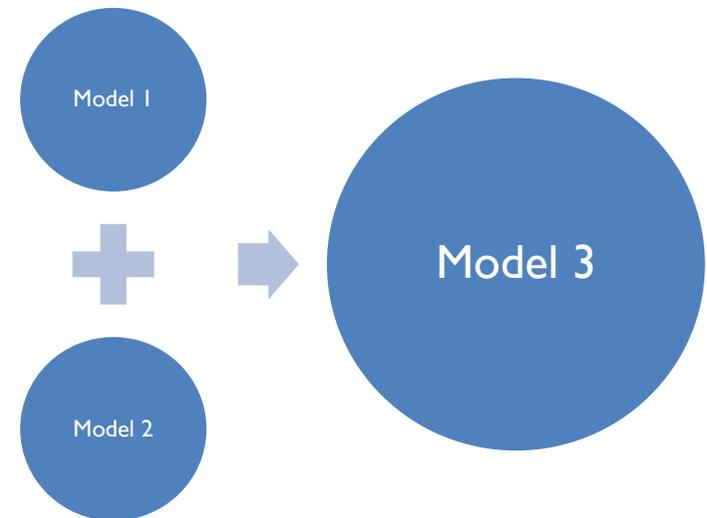


Model 3, predict the reality

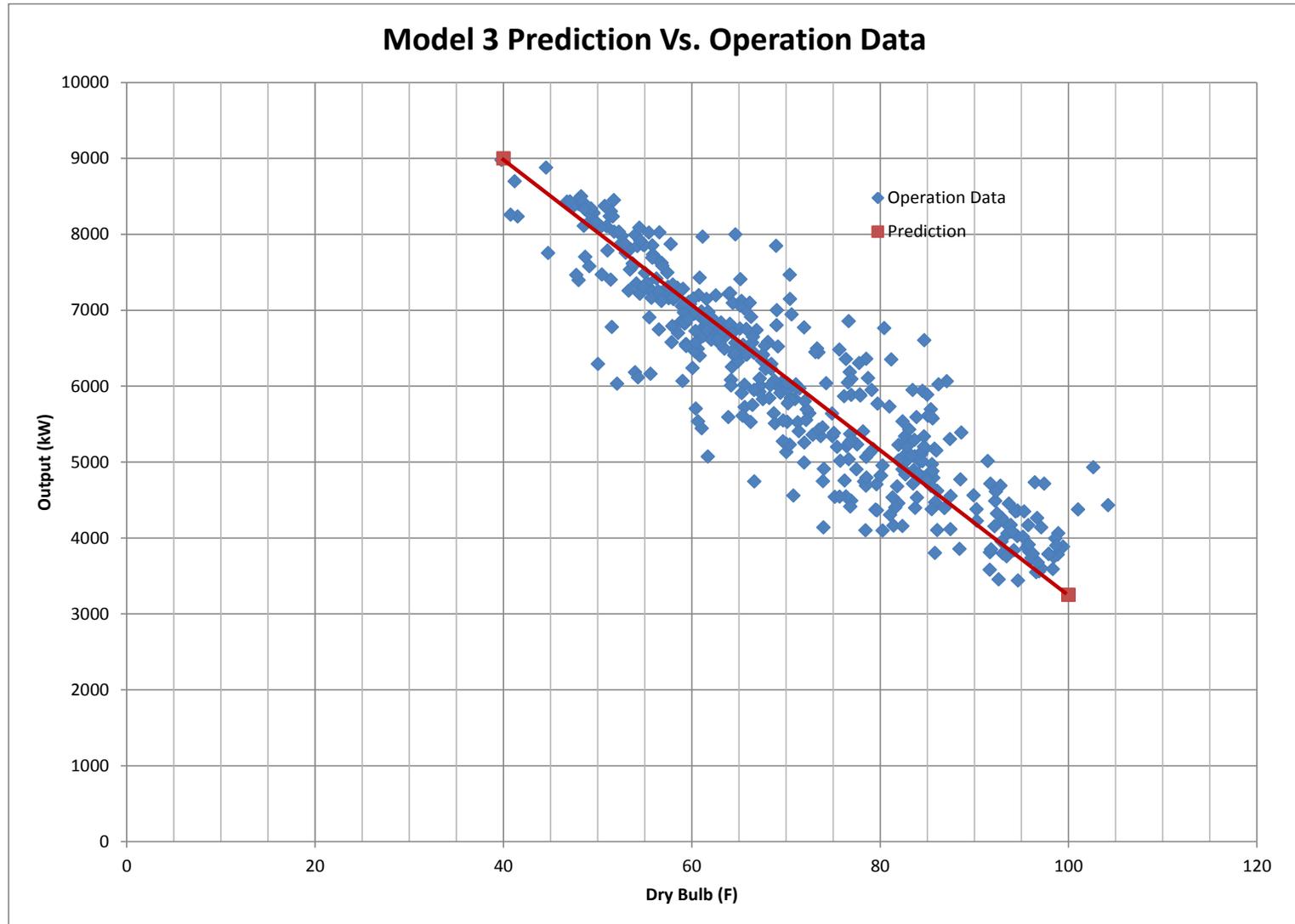
- Extract Model 2 process conditions
- Input Model 2 conditions to Model 1

- Model 3 now has the site process conditions and real geometries.

- Model 2 is the reality, while Model 3 is used to predict the reality with site process conditions and actual equipment selection.



Model 3: how good we are?



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Questions



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Thank you for your attention

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