Cummins Energy Saving

Group Number 2

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Instructors: Dr. Shih, Dr. Gupta

Background

- Cummins increased efforts to reduce energy consumption in 2009
- Energy audits used to reduce and reuse energy in industry
- An initial audit provides as much as a 20% energy savings

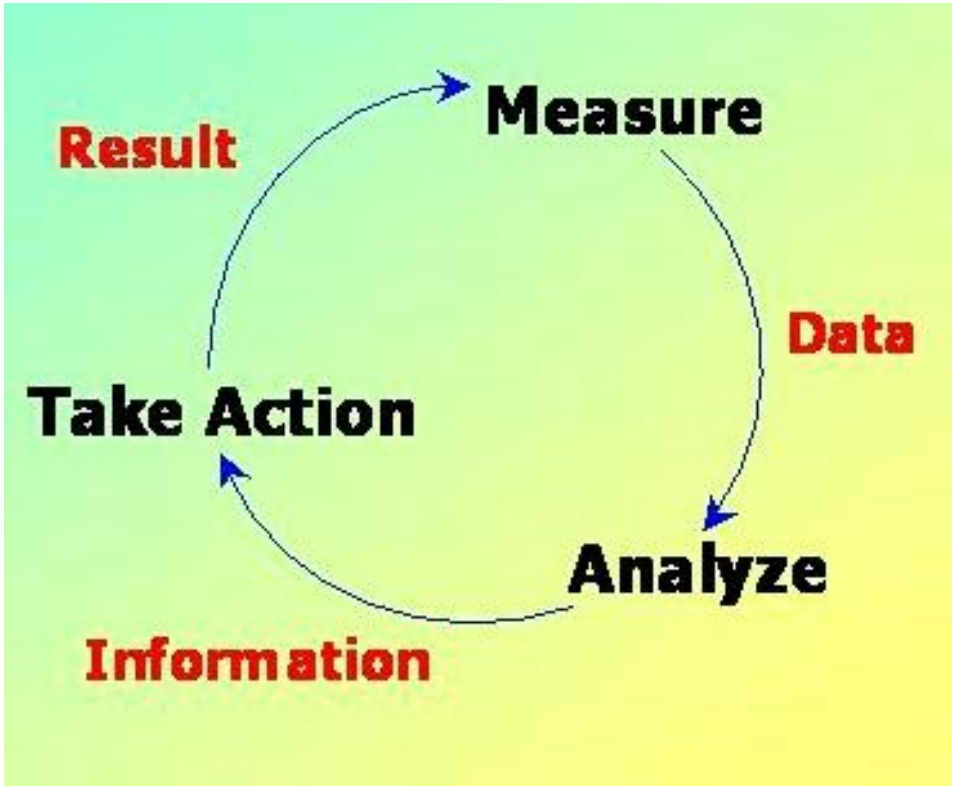


Figure 1 – Energy Audit Process

Fall 2014 Energy Saving Ideas

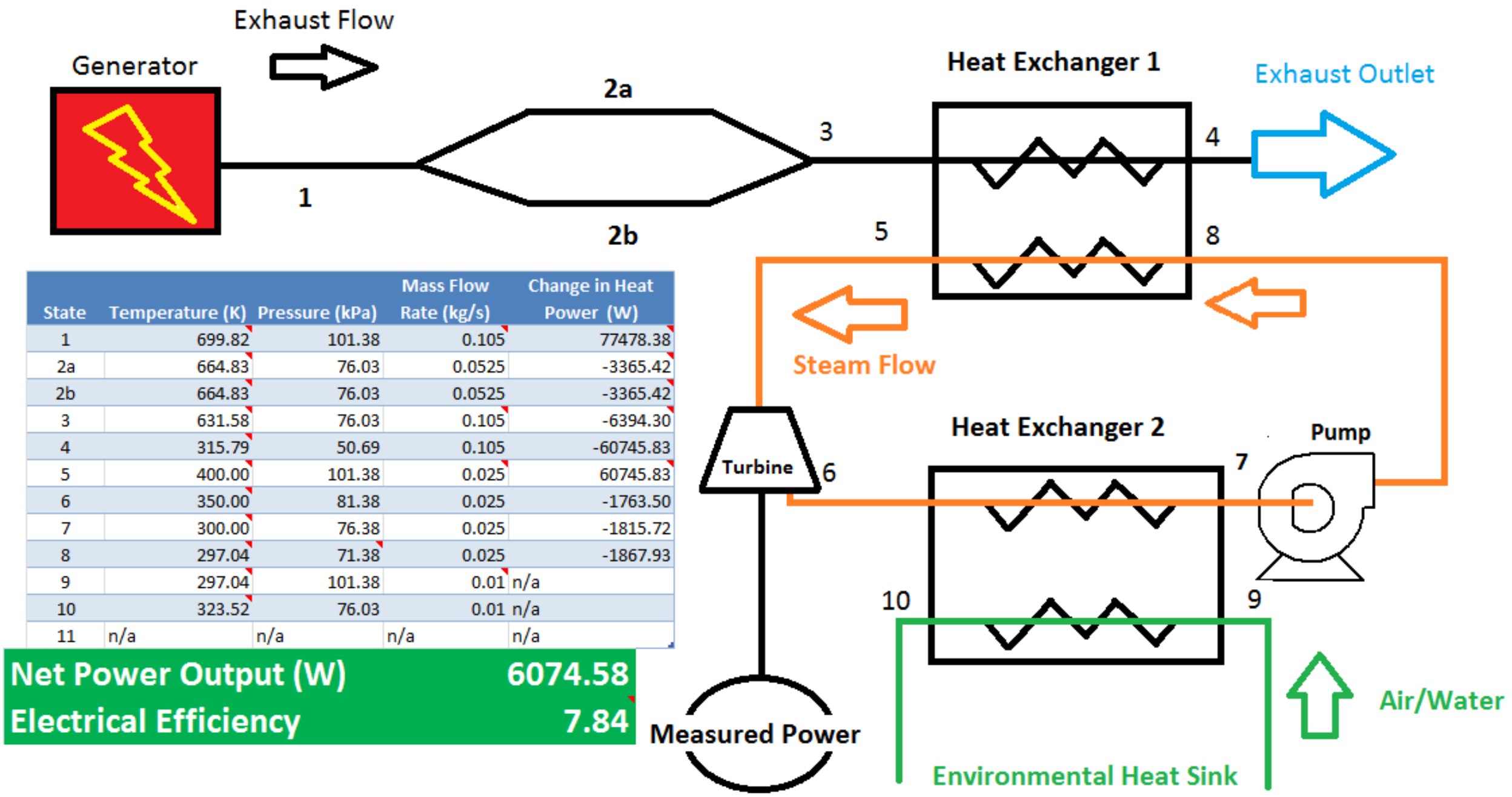
- **Chillers**
- **Insulation**
- **Dynamometers**
- **Exhaust Gases**
- **Solar Panels**
- Better appliances
- Solar light posts
- HVAC
- Wind Turbines
- Elevators

Fall 2014 Takeaways

- More Focused Goal
- Main Sources of Energy Consumption
- Improve Communication with Advisor and Professors
- Some Ideas Developed Already Implemented

Revised Project Scope

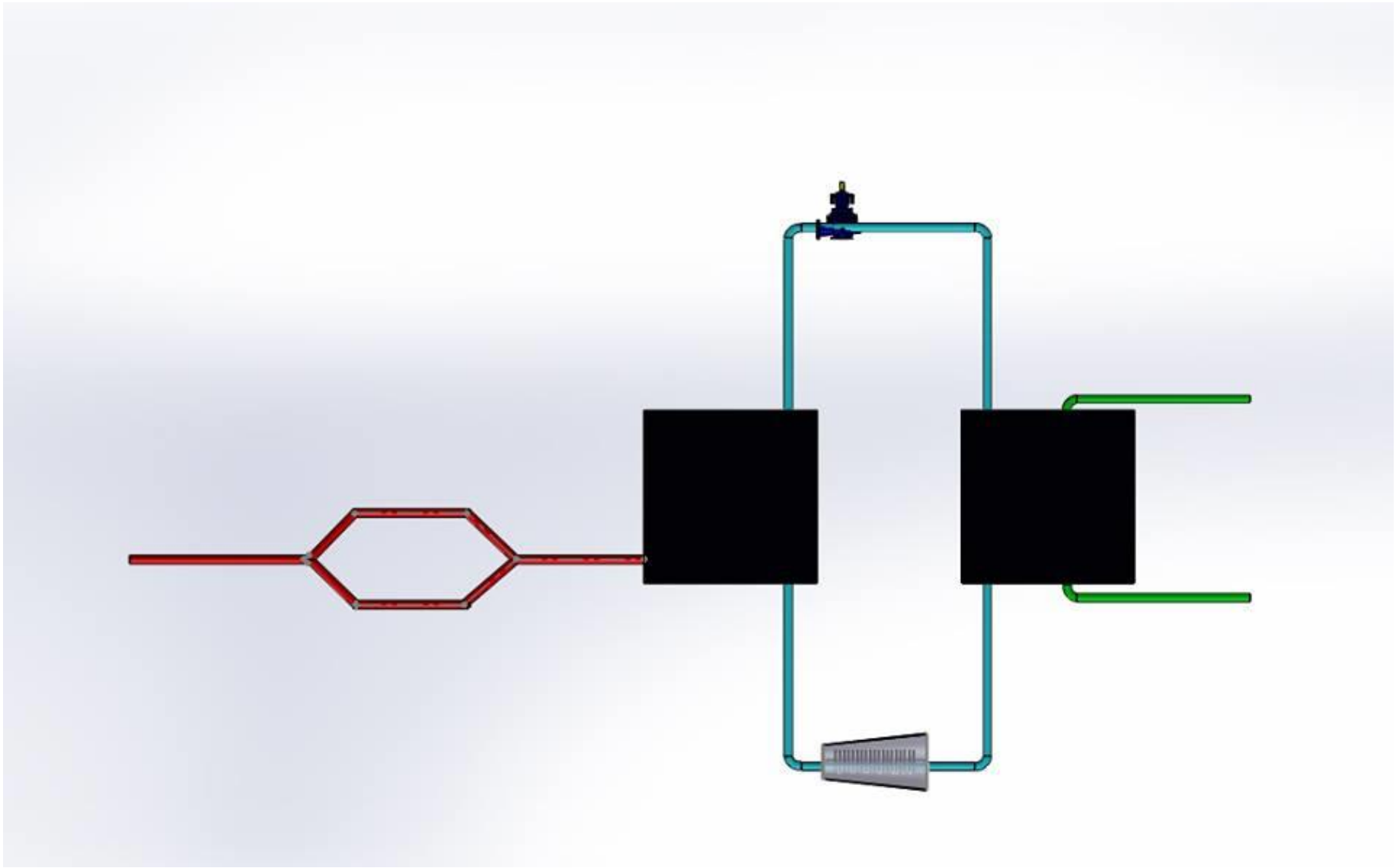
"*Provide an engine exhaust capture system design supplemented with other energy saving ideas that will assist in decreasing the overall energy usage at the Cummins Technical Center.*"



State	Temperature (K)	Pressure (kPa)	Mass Flow Rate (kg/s)	Change in Heat Power (W)
1	699.82	101.38	0.105	77478.38
2a	664.83	76.03	0.0525	-3365.42
2b	664.83	76.03	0.0525	-3365.42
3	631.58	76.03	0.105	-6394.30
4	315.79	50.69	0.105	-60745.83
5	400.00	101.38	0.025	60745.83
6	350.00	81.38	0.025	-1763.50
7	300.00	76.38	0.025	-1815.72
8	297.04	71.38	0.025	-1867.93
9	297.04	101.38	0.01	n/a
10	323.52	76.03	0.01	n/a
11	n/a	n/a	n/a	n/a

Net Power Output (W)	6074.58
Electrical Efficiency	7.84

Prototype



Pipe Material Selection

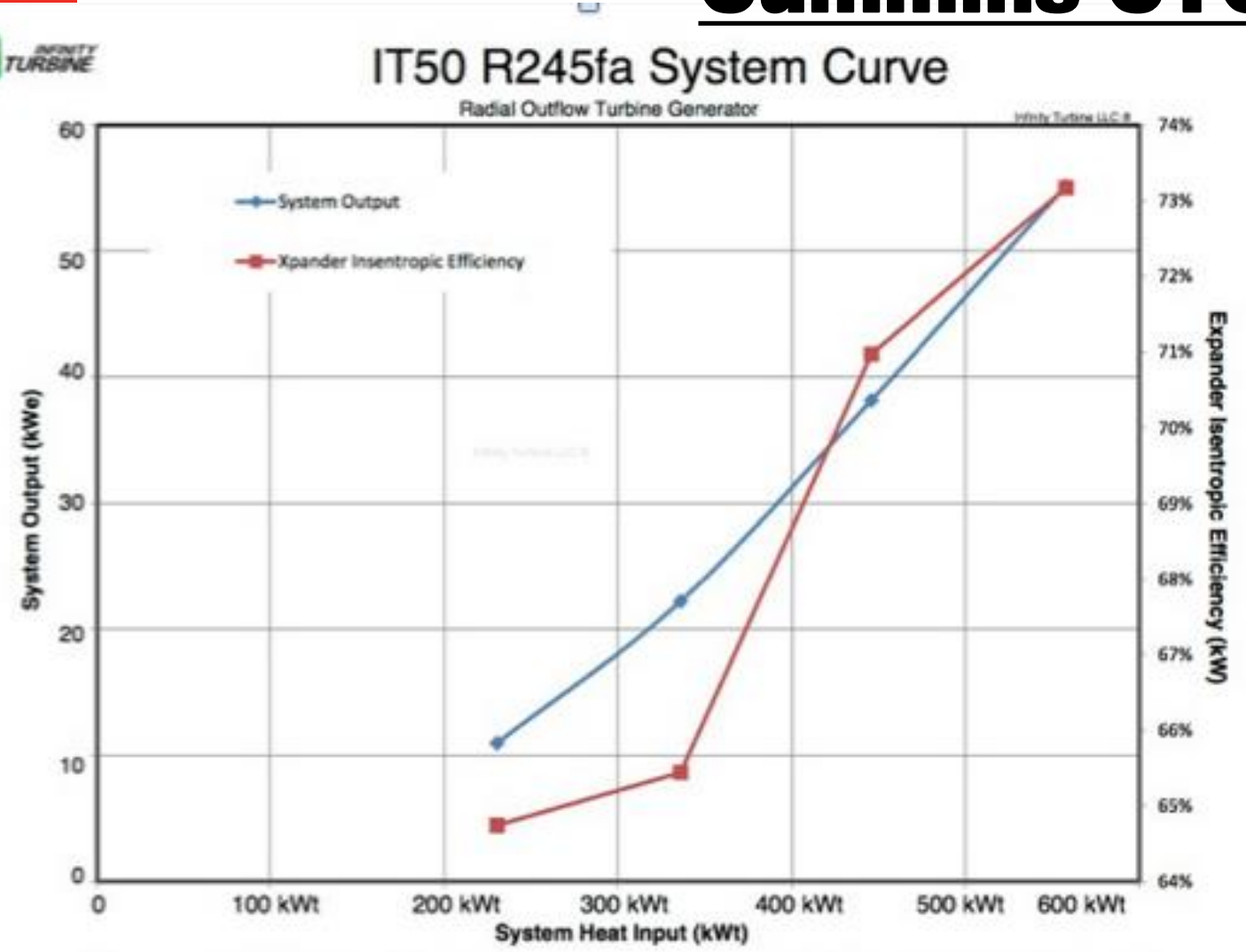
Material	Therm. Cond. k (W/m*K)	Melting T (F)	Approx. $/ft
Black steel	43	2600	2
304 SS	16	2750	6.25
Brass	109	1700	20
Copper	401	1983	5.6
Cadmium	92	610	n/a

Bill of Materials

BOM prototype	quantity	price	total	reference
Pump	2	$199.00	$398.00	lowes
Heat Exchanger	2	$66.00	$132.00	amazon
Piping	10	$2.03	$20.25	home depot
Valves	2	$154.86	$309.72	discover valve
Generator	1	$0.00	$0.00	Dr. Gupta
Turbine	1	$0.00	$0.00	Dr. Ordonez
		Total:	**$859.97**	

- Current Budget: $600
- Requesting: $300 more

Cummins CTC Design



Organic Rankine Cycle		
infinity turbine	IT100 R245fa ORC	IT50 R245fa ORC
	at 500 kWt	at 500 kWt
	30 kWe at 65% efficiency	50 kWe at 72% efficiency
	system price is $120,000	
Annual kWh	262,800	438,000
Installation	*$100,000*	*$80,000*
Annual revenue	$22,338	$37,230
Maintenance	*$10,000*	*$10,000*
Total initial	$220,000	$150,000
	18 year Return on investment	6 year Return on investment

Cummins CTC Design

- 500 kWt from exhaust gasses

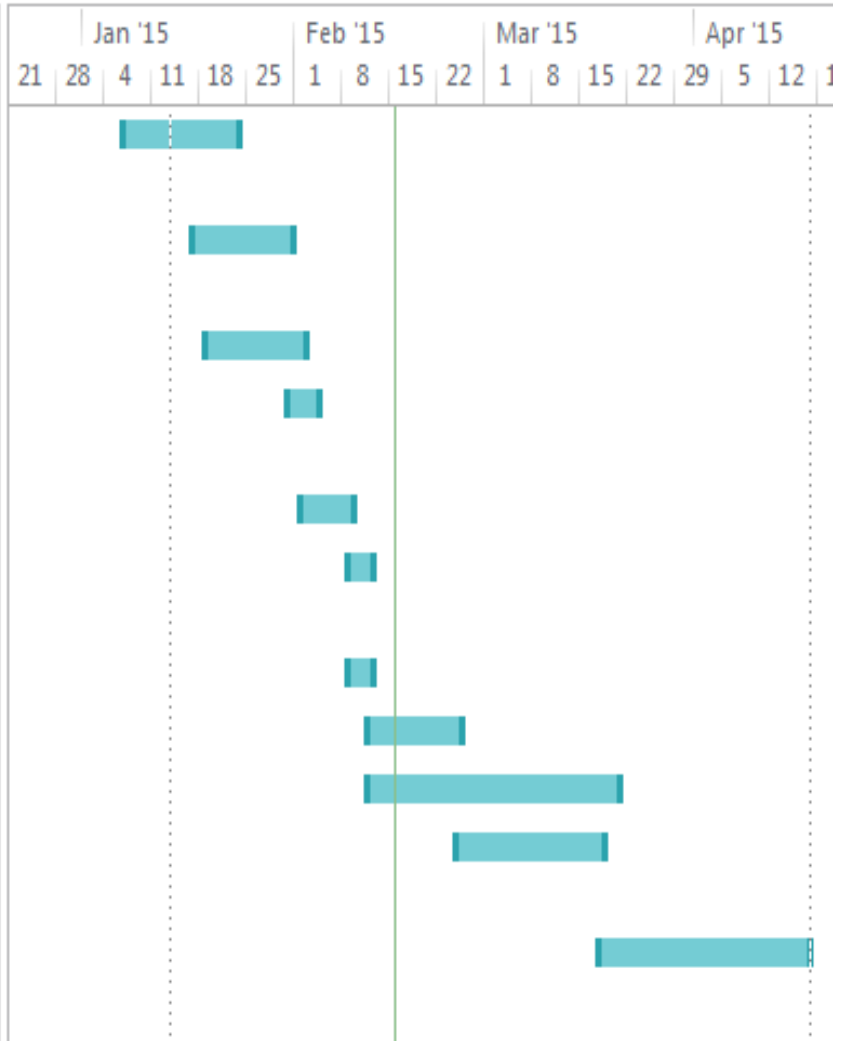
Mech. E to Elect. E	theoretical eff.	initial cost	installation	annual maitenance	elec. Effic.	Annual kWh	Annual revenue	25 year profit	ROI
Thermionic Gernerator	40%	N/A	N/A	N/A					
Generation Thermocoupler	10%	N/A	low	N/A					
RTG	40%	high	high	high	10%				
ORC 100	42%	120,000	100,000	10,000	10%	262,800	$22,338	88,450	18
ORC 50	41%	70,000	80,000	10,000	10%	438,000	$37,230	530,750	6
Single Reheat Rankine	51%	180,000	110,000	15,000	13%	569,400	$48,399	544,975	9
Double Reheat Rankine	58%	240,000	120,000	16,000	15%	657,000	$55,845	636,125	10
Regeneration Rankine (open)	48%	210,000	115,000	17,000	14%	613,200	$52,122	553,050	10
Regen. Rankine (closed)	47%	210,000	120,000	18,000	14%	613,200	$52,122	523,050	10
Steam Turbine Cogeneration	82%	300,000	140,000	50,000	36%	1,576,800	$134,028	1,660,700	7
trigeneration (VCRS chiller)	100%	300,000	140,000	180,000	44%	1,971,000	$167,535	-751,625	innefficient
trigeneration (VARS chiller)	100%	600,000	180,000	60,000	45%	1,971,000	$167,535	1,908,375	8

Future Work and Challenges Faced

- Fabrication of Prototype
- Simulation does not require accurate dimensions for CTC
- Large Scale Simulation
  - Assumed values must be accurate

Project Breakdown

Task Name	Duration	Start	Finish
Background/Component Research	13 days	Wed 1/7/15	Fri 1/23/15
Exhaust Gas Capture Design	12 days	Sat 1/17/15	Sat 1/31/15
Piping Design	11 days	Mon 1/19/15	Mon 2/2/15
Piping Material Selection	4 days	Sat 1/31/15	Wed 2/4/15
Component Selection	6 days	Mon 2/2/15	Mon 2/9/15
Revise/Edit Material and Design	4 days	Mon 2/9/15	Thu 2/12/15
Cost Analysis	4 days	Mon 2/9/15	Thu 2/12/15
Order Material	10 days	Thu 2/12/15	Wed 2/25/15
Simulation Work	27 days	Thu 2/12/15	Fri 3/20/15
Capture Design Construction	16 days	Wed 2/25/15	Wed 3/18/15
Testing / Simulation Finalized	23 days	Wed 3/18/15	Fri 4/17/15



Summary

- Prototype calculations completed
- Request more for budget
- Begin Fabrication
- Ensure feasibility for CTC

Questions

References

- http://energy.gov/public-services/homes/home-weatherization/home-energy-audits
- http://cumminsengines.com/isx15-heavy-duty-truck-2013#specifications
- http://www.maine.gov/mdot/ofbs/documents/pdf/atrimainereport.pdf
- http://infinityturbine.com/ORC/IT100_ORC_System.html
- http://mars.jpl.nasa.gov/msl/files/mep/MMRTG_Jan2008.pdf