Cummins Energy Saving

Group Number 2

Daniel Baker, Warren Bell, Daniel Carnrike,
Kyle Fields, Marvin Fonseca

Cummins Advisor: Dr. Roger England, Dr. Michael Hays

Faculty Advisor: Dr. Juan Ordonez

Instructors: Dr. Shih, Dr. Gupta, Dr. Helzer

Overview

- **Updated Design Analysis:**
  - Chillers
  - Insulation
  - Engine Testing
    - Mechanical and Thermodynamic Power
- **Indiana Trip**
- **Additional Ideas**
- **Schedule**
- **Summary and Future Work**

Need Statement

- **"Cummins needs to reduce their energy usage in order to save money and reduce their environmental impact."**

Goal Statement

- **The goal of the project is to, "Review current Cummins Technical Center (CTC) electrical usage and devise a plan to decrease it by 10%."**

Primary Energy Consumption: the Energy used in the subsystem converted to primary energy in MMBTU		Ability to Influence: the level of opportunities for reductions in energy use and / or GHG emissions for that subsystem	
9	Greater than 30% of site total	9	High - Opportunities for improving efficiency and consumption will substantially decrease GHG
3	Greater than 5% but less than 30% of site total	3	Medium - Opportunities for improving efficiency and consumption may decrease GHG
1	Less than 5% of site total	1	Low - Opportunities for improving efficiency and consumption will have little or no decrease on GHG
Energy Cost: the cost of the energy in the subsystem in local currency		**Ability to Measure: the level of availability of accurate, reliable data**	
9	Greater than $1 million	9	High - Metered data available
3	Greater than $100,000 but less than $1 million	3	Medium - Some metered data available for calculating subsystem use
1	Less than $100,000	1	Low - No metered data available

Revision date: 8/18/2014		Significance threshold: 220						
Rating of Importance to EnMS		10	5	10	5	10	10	
Significance Category	**Important Energy Users** Energy subsystem / function	**Primary Energy Consumption** (MMBTU)	**Cost** (Currency)	**Greenhouse Gases** (MTCO2)	**Ability to Influence**	**Ability to Measure**	**Regulatory Requirements**	**Total**
1	Engine Testing (Diesel)	9	9	9	9	3	9	**390**
2	Facilties boilers (NG)	3	1	3	3	3	3	**140**
3	Test Cell Fans/Pumps (Electricity)	3	3	3	9	9	1	**220**
4	Test Cell, include Dynos (Electricity)	3	3	3	3	9	1	**190**
5	CVS Chillers & Chilled Water (Electricity)	3	3	3	9	9	1	**220**
6	Process water (Electricity)	3	3	3	3	9	3	**210**
7	Engine testing (NG)	1	1	1	3	3	9	**160**
8	Miscellaneous (Electricity)	1	3	1	0	9	0	**125**
9	Office (Electricity)	1	3	1	1	9	1	**140**
10	Compressors (Electricity)	1	3	1	1	9	1	**140**
11	Hybrid Test Cell, Cold Cell, Altitude Test Cell (Electricity)	1	3	1	1	9	1	**140**
12	Applied Lab (Electricity)	1	3	1	1	9	1	**140**
13	HTG Pump, Air Handlers-main aisle, Emergency Generator (Electricity)	1	3	1	3	9	1	**150**
14	Waste Heat Recovery Cells (NG)	1	1	1	1	1	3	**70**
15	Lighting (Electricity)	1	1	1	1	9	1	**130**
16	Walesboro Noise Facility (Electricity)	1	1	1	1	3	1	**70**

Chillers

VARS: Variable Absorption Refrigeration System
VCRS: Vapor Compression Refrigeration System

Table 1 – Annual Power Consumption

Annual Power Consumption(kWh/yr)		
	VARS	VCRS
Refrigerant Pump	13,140	N/A
Solution Pump	61,320	N/A
Compressor Power	N/A	2,938,980
Chilled Water Pump	324,120	324,120
Cooling Tower Fan	131,400	87,600
LT Hot Water Pump	43,800	N/A
HT Hot Water Pump	43,800	N/A
Cooling Water Pump	324,120	262,800
Total Annual Power Consumption	**941,700**	**3,613,500**

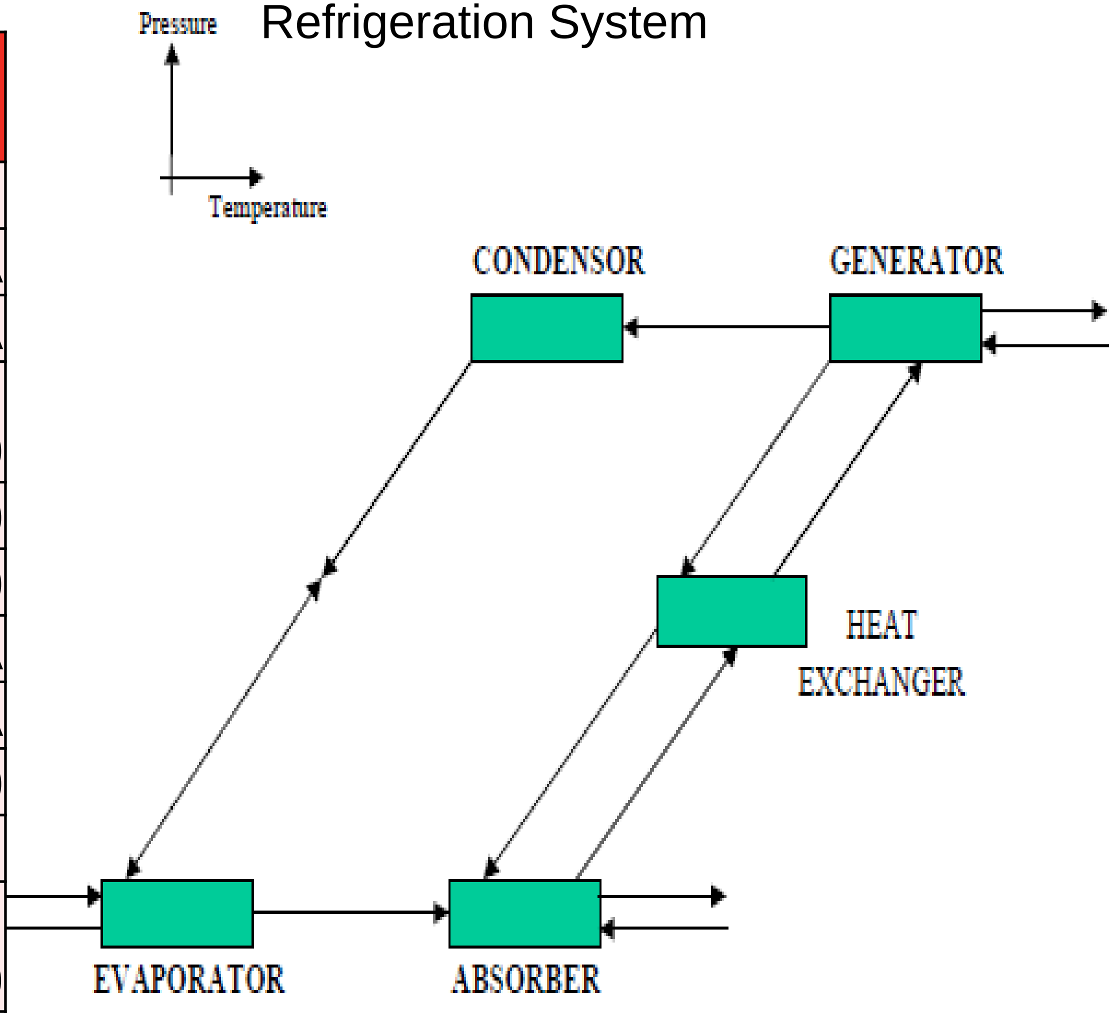


Figure 1. Absorption Cycle

Chillers

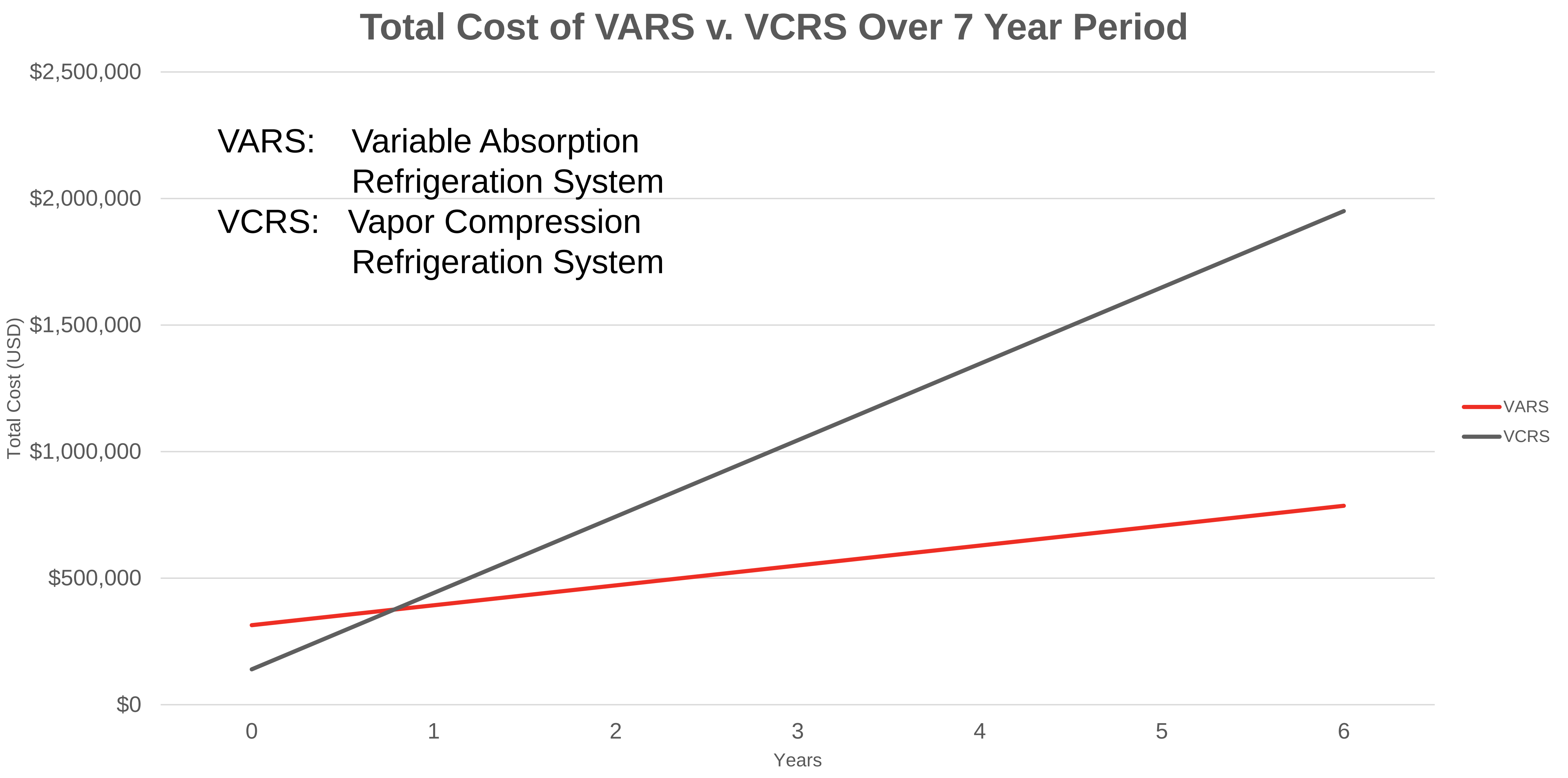
Table 2 – Annual Cost Comparison

Annual Operating Costs (USD)		
	VARS	VCRS
Refrigerant Pump	$ 1,097.19	N/A
Solution Pump	$ 5,120.22	N/A
Compressor Power	N/A	$ 245,404.83
Chilled Water Pump	$ 27,064.02	$ 27,064.02
Cooling Tower Fan	$ 10,971.90	$ 7,314.60
LT Hot Water Pump	$ 3,657.30	N/A
HT Hot Water Pump	$ 3,657.30	N/A
Cooling Water Pump	$ 27,064.02	$ 21,943.80
Total Annual Operating Cost	**$ 78,631.95**	**$ 301,727.25**

Table 3 – Initial Cost Comparison

Initial Cost (USD)		
	VARS	VCRS
Machine Cost	$ 278,478	$ 112,041
Cooling Tower	$ 22,826	$ 19,565
Cooling Water Pump	$ 5,435	$ 4,348
Chilled Water Pump	$ 3,913	$ 3,913
LT Hot Water Pump	$ 1,848	N/A
HT Hot Water Pump	$ 1,848	N/A
Total Initial Cost	**$ 314,348**	**$ 139,868**

Chillers


Total Cost of VARS v. VCRS Over 7 Year Period
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0
Total Cost (USD)
VARS: Variable Absorption Refrigeration System
VCRS: Vapor Compression Refrigeration System
0
1
2
3
4
5
6
Years
VARS
VCRS

Insulation

Table 4 – Material Cost Comparison

Material	Cost (per ft^2)	Total Material Cost	Total Savings per year
Fiber Glass	0.42	$9,606.66	$18,331.76
Mineral Wool	0.625	$14,295.62	$18,352.97
Cellulose	1.25	$28,591.25	$18,448.09
Plastic Fiber	1.5	$34,309.50	$18,596.58
Closed Cell Foam	2.2	$50,320.60	$18,955.43
Closed Cell Foam modified	2.3	$52,607.90	$19,068.17

Table 5 – Material Properties

Material	Thermal Resistance	Types	Green	Fire Resistant
Fiber Glass	2.2 to 2.7	High, Medium, Low Density	20% to 30% Recycled	Yes
Mineral Wool	3.7	Blanket and loose fill	75% post-industrial recycled	Yes
Cellulose	3.2 to 3.8	loose fill or spray	82% to 85% recycled	No
Plastic Fiber	3.8 to 4.3	High, Low Density	----	Yes
Closed Cell Foam	5.6 to 8	Spray, Foam board	-----	No
Closed Cell Foam modified	9	Foil	----	Yes

Engine Testing – Dynamometers

88 main Test Cells with 8 auxiliary Test Cells.

Cummins ISX15 600 used for analysis.

Table 6 – Dynamometers Properties

Variable	Value
Test Power	268.2 kW
Power Generation	7,878,643 kWh
Power Lost	1,390,348 kWh
Annual Savings	$5,866,437,727
Annual Savings Lost (inefficiency)	$1,035,253,716

Engine Testing – Exhaust gasses

88 main Test Cells with 8 auxiliary Test Cells

Cummins ISX15 600 used for analysis

Q = n * m_dot_exhaust * C_v (T_out – T_amb.)

Pollutants

Table 7 – Exhaust Properties

Fuel Consumption	11.67 Gallons / Hour
Mass Flow Fuel In	10.21 g/s
Mass Flow In Air	10.58 g/s
Mass Flow In Total	20.79 g/s
Mass Flow Refuel	1.021 g/s
Mass Flow Exhaust	19.77 g/s
Specific Heat Fuel	1.832 kJ / kg*K
Heat Generated	354.1 kW
Heat Available to Convert	318.7 kW
Heat Available	1,147,294 kWh

Engine Testing – Noble Energy Conversion

Table 8 – Energy Conversion Systems Comparison

	Theoretical eff.	Actual eff.	Initial cost	Annual maintenance cost
Thermionic Generator	40%	10%	low	low
Generation Thermocoupler	10%	(5% - 8%)	low	low
Rankine Cycle	42%	40%	med	med
Single Reheat Rankine	46%	44%	med-high	med-high
Double Reheat Rankine	48%	46%	high	high
Regeneration Rankine (open)	45%	43%	high	med-high
Regen. Rankine (closed)	47%	44%	high	high
Steam Turbine Cogeneration	100%	80%	high	high

Heat Energy (degraded) → Electrical Energy (noble)

Engine Testing – Cogeneration

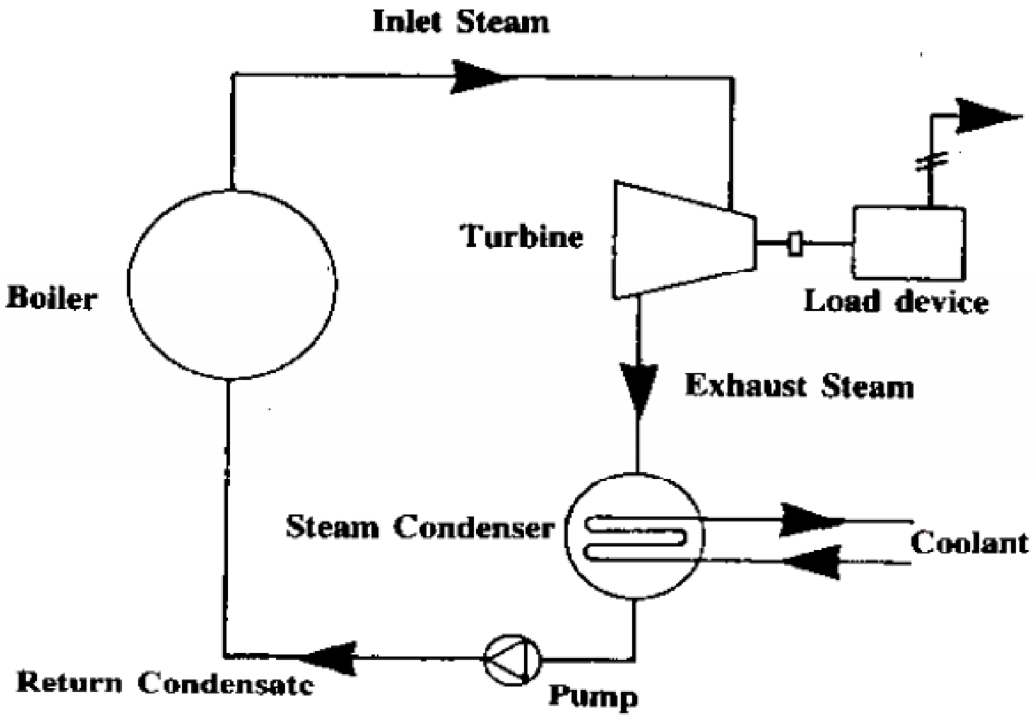


Figure 2. Cogeneration (Condensing) Cycle

Indiana Trip

- Key Takeaways:
  - Cummins has already implemented closed cell foam insulation in the roof.
  - Absorption chillers can potentially be combined with the exhaust gases as the energy source.
  - The exhaust gases (post analysis) are being neglected as a potential energy source.

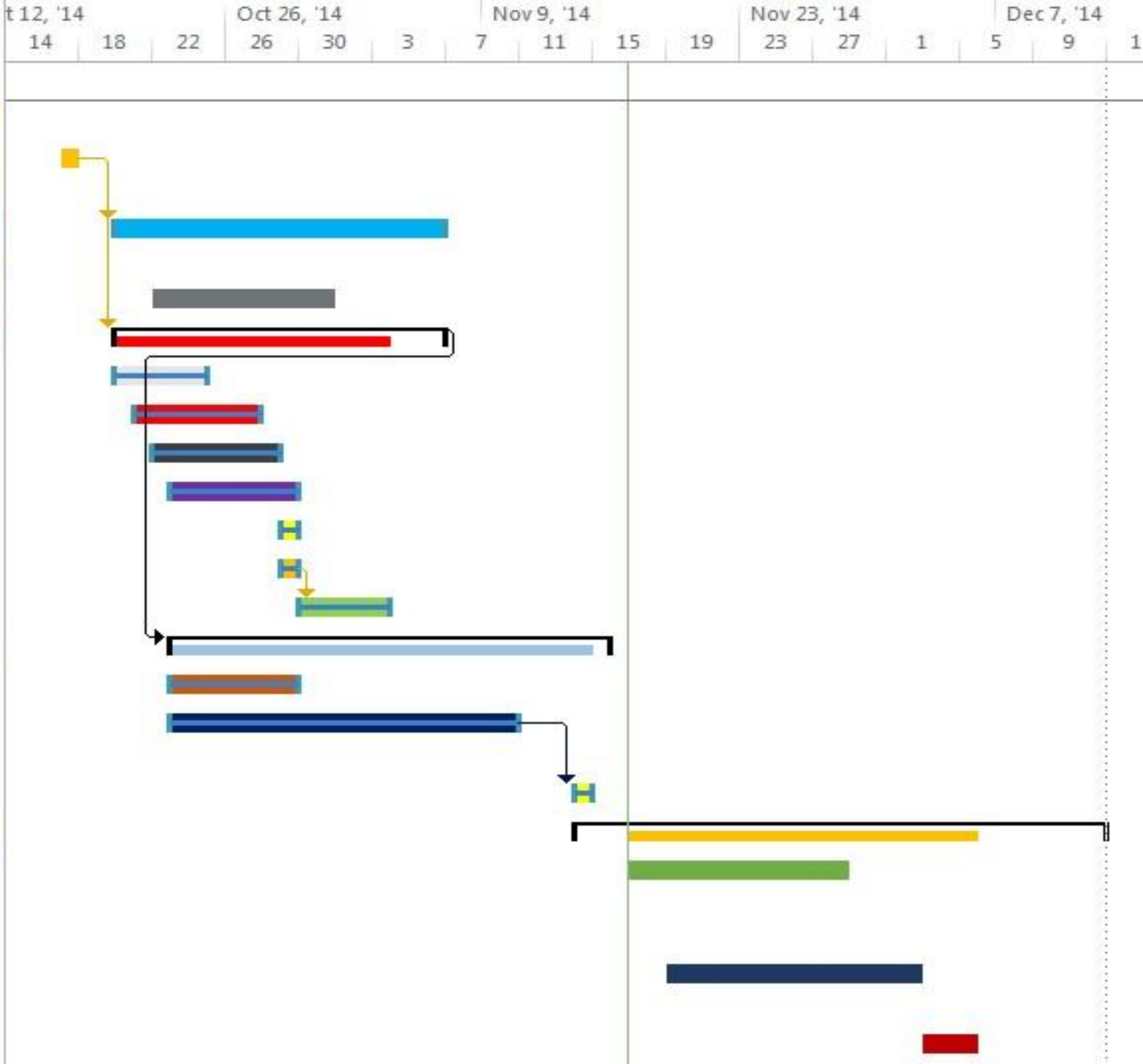
Cummins wants us to focus resources on designing a system for the exhaust gases along with our other design analyses.

Additional Ideas

- Wind Turbine/High Altitude wind turbines
- Heat treat facilities/components
- More efficient Air Conditioning Units/HVAC
- Making the building more green
  - Check 179D federal tax reduction
  - What are some Go Green building regulations

GANTT CHART

	Task Name	Duration	Start
1	**BackGround Research**	**10 days**	**Mon 9/8/14**
8	**Web Design**	**13 days**	**Mon 9/15/14**
13	Zero House Emissions	1 day	Fri 10/17/14
14	Grid Monitoring Design	14 days	Mon 10/20/14
15	Brain Storming	8 days	Wed 10/22/14
16	**Solar Panel Design**	**14 days**	**Mon 10/20/14**
17	Cost Anaylsis	5 days	Mon 10/20/14
18	Area Covered	5 days	Tue 10/21/14
19	Insolation	5 days	Wed 10/22/14
20	Power Generated	5 days	Thu 10/23/14
21	Review Designs	1 day	Wed 10/29/14
22	Pick Design	1 day	Wed 10/29/14
23	Edit Design	3 days	Thu 10/30/14
24	**Cummins Visit**	**18 days**	**Thu 10/23/14**
25	Cost Anaylsis	5 days	Thu 10/23/14
26	Question Development	13 days	Thu 10/23/14
27	Building Tour	1 day	Fri 11/14/14
28	**ReRouting Design**	**21 days**	**Fri 11/14/14**
29	Power Generation Cycle Research	10 days	Mon 11/17/14
30	Analysis on Exhaust Gases	10 days	Wed 11/19/14
31	Initial Pipe Design	3 days	Wed 12/3/14



Summary

Major energy users identified, costs estimated for the current facility use.

Conceptualized ideas have been estimated in terms of energy use and cost.

In addition to the main areas of improvement, several other ideas will be pursued in the following semester.

Primary focus for implementing changes at the facility will be harnessing the exhaust gases from the facility.

References

1. “Electric Power Monthly with Date for August 2014” *Independent Statistics & Analysis; U.S Energy Information Administration*. Web. 24 Oct 2014. http://www.eia.gov/electricity/monthly/pdf/epm.pdf
2. Murugavel, V., and R. Saravanan. "LIFE CYCLE COST ANALYSIS OF WASTE HEAT OPERATED ABSORPTION COOLING SYSTEMS FOR BUILDING HVAC APPLICATIONS." *Department of Mechanical Engineering, Anna University* (2010): 1-9. http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a
3. “Dynamometer Review.” *Engineers EDGE*. Web. 17 Oct 2014. http://www.engineersedge.com/industrial-equipment/dynamometer-review.htm
4. “Insulation. – Department of Energy” Web. 30 October 2014. http://energy.gov/energysaver/articles/insulation http://energy.gov/energysaver/articles/insulation-materials


BANKERS LIFE FIELDHOUSE
Terry Lee
Honda
REPLAY
INDIANA PACERS
INDIANA PACERS

Questions?