Cummins Energy Saving

Group Number 2

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Need Statement

- **Cummins Technical Center is consuming too much energy**
- Feasibility of installing solar panels
- Determine alternative power saving options
- Decision matrix

Decision Matrix for Important Energy Users

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**

Table 1 – Decision Matrix

Measurements of Energy Users

Energy Source	Energy User/User Group	Estimated/ Measured	Monitoring System?	How often Measured?	Utility Provider	Data Analyzed
Electricity (kWhr)	Test Cell Fans/Pumps	Measured	On Site Meters	Continous	Duke Energy	Monthly
Electricity (kWhr)	CTC Electricity	Measured	On Site Meters	Continous	Duke Energy	Monthly
Electricity (kWhr)	Chillers	Measured	On Site Meters	Continous	Duke Energy	Monthly
Natural Gas(ccf)	Engine Testing(Diesel)	Estimated	Estimated	Monlthy	Bectren	Monthly

Table 2 – Decision Matrix

Ideas to improve energy efficiency

- Adjustable speed driver
- Hot gas recovery
- Insulation
- Solar panels

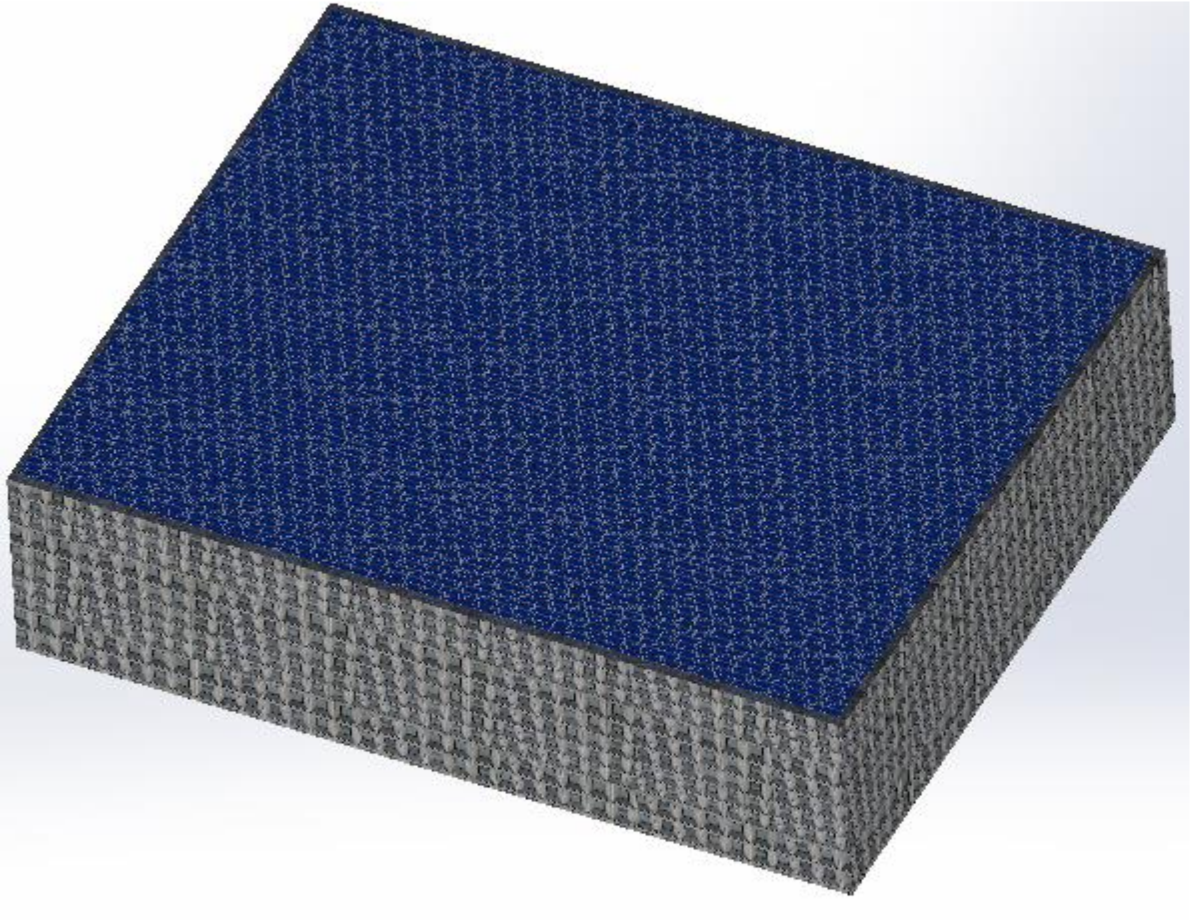


Fig. 1 - Solar Panel Ideal Case

Insulation

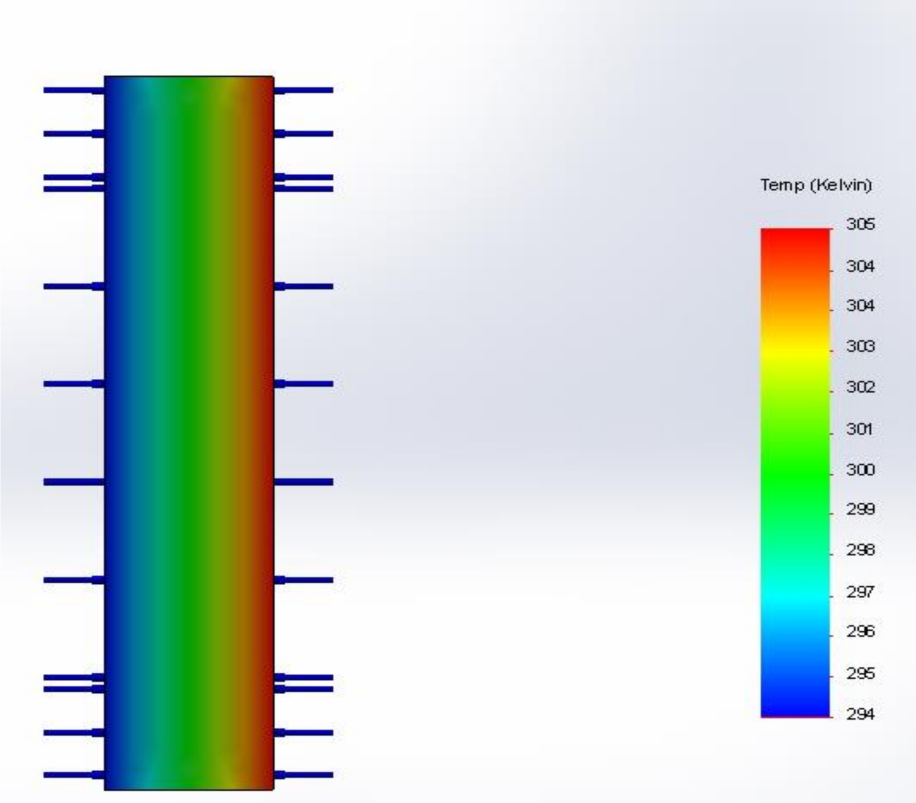


Fig. 2 - High density foam thermal analysis

Variable Speed Driver

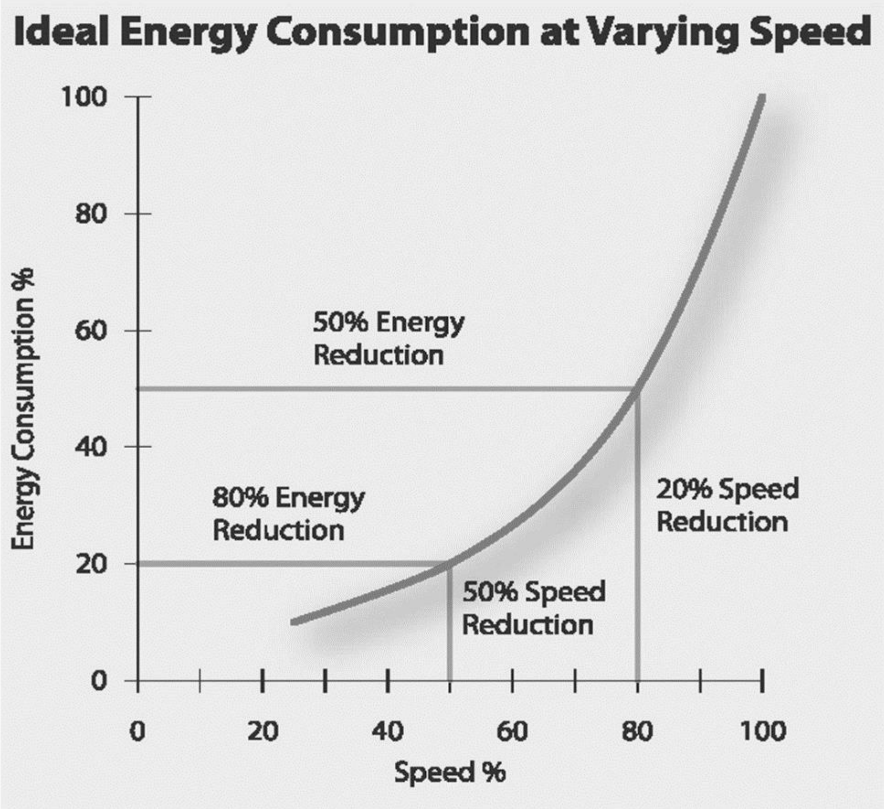


Fig. 3 - Variable speed driver consumption

Solar Panel: Equations

Hour Angle

$$\alpha = \frac{360}{24}(t_{solar} - 12)$$

Declination Angle

$$\delta = 23.44 \sin\left[360\left(\frac{d - 80}{365.25}\right)\right]$$

Solar Zenith Angle

$$\cos(\chi) = \sin\delta \sin\lambda + \cos\delta \cos\lambda \cos\alpha$$

Solar azimuth Angle

$$\tan\xi = \frac{\sin\alpha}{\sin\lambda \cos\alpha - \cos\lambda \tan\delta}$$

Another way to calculate azimuth

$$\cos(180° - \xi) = -\frac{\sin\lambda \cos\chi - \sin\delta}{\cos\lambda \sin\chi}$$

Insolation on a stationary surface

$$P = P_s[\cos\epsilon \cos\chi + \sin\epsilon \sin\chi \cos(\xi - \zeta)]$$

Fig. 4 - Equations For Solar Panel Calculations

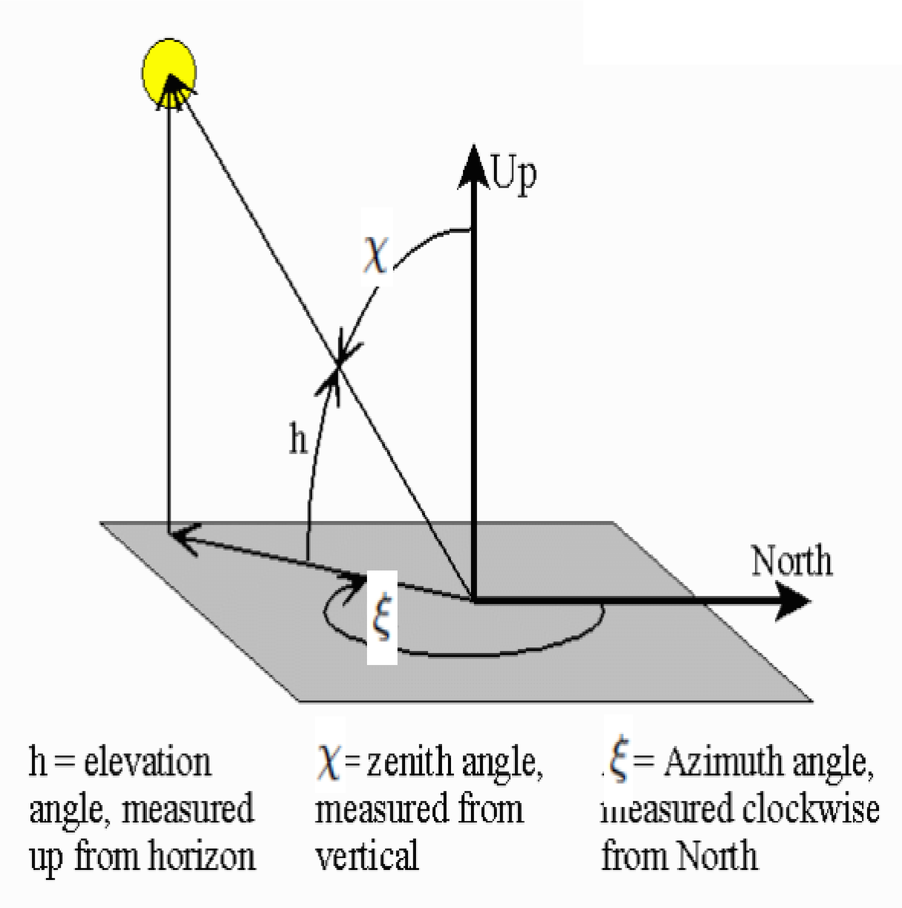


Fig. 5 - Angle References

Solar Panel: Power

Table 3. Average Insolation

Date	**Average Insolation**
December 21st	612.05 W/m^2
March 21st	546.56 W/m^2
June 21st	515.02 W/m^2
September 21st	549.38 W/m^2
Total Average	**~556 W/m^2**

- Average of 4.21 Sunshine hr/day

$$\left(556\frac{W}{m^2}\right)(2{,}125m^2)\left(4.21\frac{hr}{day}\right)\left(365\frac{day}{year}\right)(.19)$$

- ~345,000,000 kWhr/year Generated

- SolarWorld SW 265~ 19%

Solar Panel: Levelized Cost of Energy

- KI = $950,000
- KOM = $10,000
- E = 345,000,000 KWhr
- n = 25 Years
- Kd = 10%

$$LCOE = \frac{CRF \times K_I + K_{OM} + K_F}{E}$$

$$CRF = \frac{k_d(1+k_d)^n}{(1+k_d)^n - 1}$$

Solar Panel: Savings

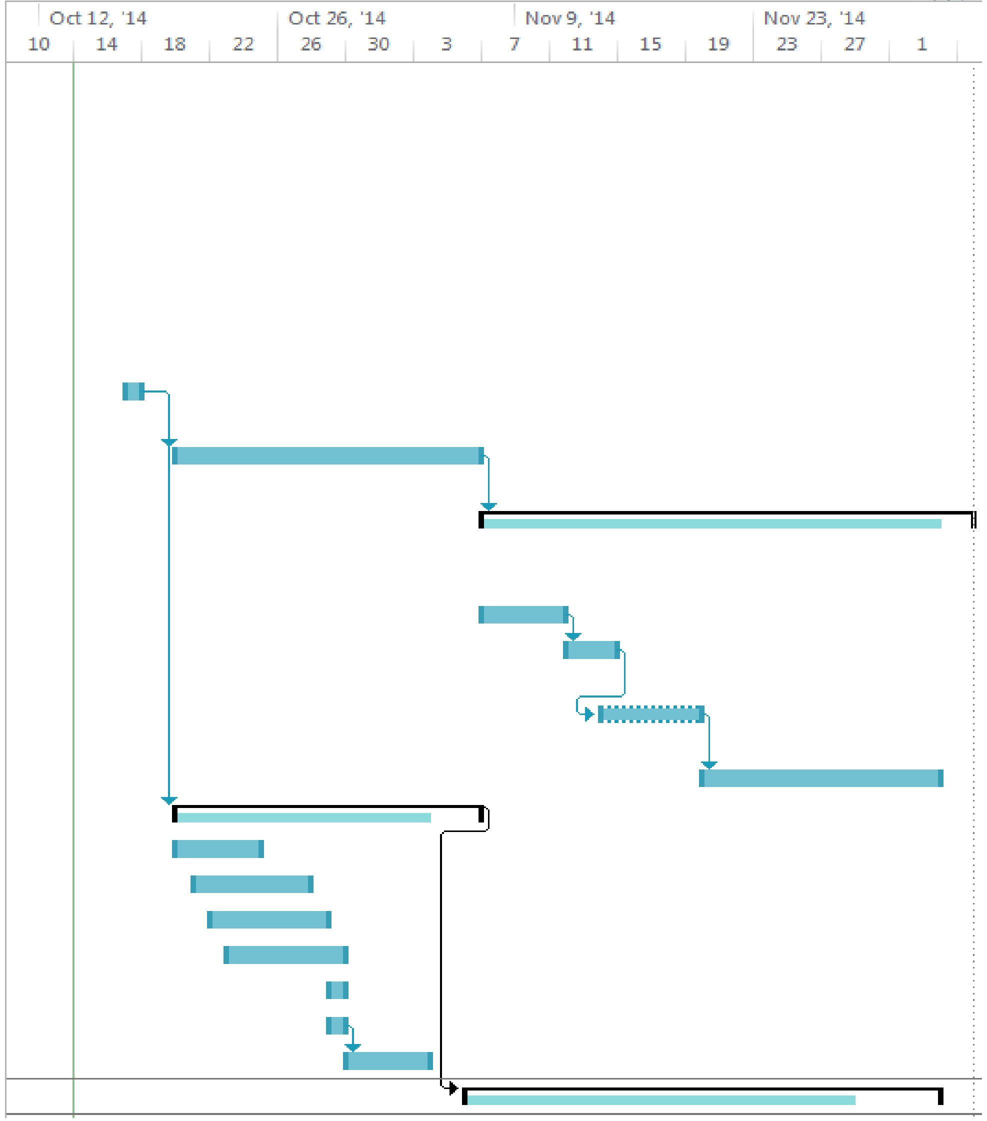
- A.C.O.E - Industrial
  - ~ ¢6.95/kWhr
- Cost ~ $23,400,000
- L.C.O.E - Solar Panels
  - ~¢0.033/kWhr

Problems

- Electrical layout
- Visit postpone to January
- Communication
- Energy assessment done previously
- Grid monitoring system done

Future Work – Gantt Chart

	Info	Task Mode	Task Name	Duration	Start	Finish
1			BackGround Research	10 days	Mon 9/8/14	Fri 9/19/14
2	✓		Solar Panels	6 days	Mon 9/8/14	Mon 9/15/14
3	✓		Insolation	2 days	Wed 9/10/14	Thu 9/11/14
4	✓		Power Output	2 days	Fri 9/12/14	Mon 9/15/14
5	✓		Power Output	2 days	Fri 9/12/14	Mon 9/15/14
6			Energy Audits	6 days	Thu 9/11/14	Thu 9/18/14
7	✓		Grid Monitoring	1 day	Mon 9/8/14	Mon 9/15/14
8			Web Design	13 days	Mon 9/15/14	Wed 10/1/14
13			Zero House Emissions	1 day	Fri 10/17/14	Fri 10/17/14
14			Grid Monitoring Design	14 days	Mon 10/20/14	Thu 11/6/14
15			Grid Monitoring System Development	21 days	Fri 11/7/14	Fri 12/5/14
16			Meter Readers	3 days	Fri 11/7/14	Tue 11/11/14
17			Current Development	3 days	Wed 11/12/14	Fri 11/14/14
18			Voltage Development	4 days	Fri 11/14/14	Wed 11/19/14
19			Fabrication	10 days	Thu 11/20/14	Wed 12/3/14
20			Solar Panel Design	14 days	Mon 10/20/14	Thu 11/6/14
21			Cost Anaylsis	5 days	Mon 10/20/14	Fri 10/24/14
22			Area Covered	5 days	Tue 10/21/14	Mon 10/27/14
23			Insolation	5 days	Wed 10/22/14	Tue 10/28/14
24			Power Generated	5 days	Thu 10/23/14	Wed 10/29/14
25			Review Designs	1 day	Wed 10/29/14	Wed 10/29/14
26			Pick Design	1 day	Wed 10/29/14	Wed 10/29/14
27			Edit Design	3 days	Thu 10/30/14	Mon 11/3/14
28			Cummins Visit	20 days	Thu 11/6/14	Wed 12/3/14



Summary

- Major energy users identified
- General power saving options discussed
- Solar panels are feasible

Questions?

References

1. http://sunbridgesolar.com/solar-energy-blog/how-long-do-solar-panels-really-last/
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3. http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a
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