

Grand Marais DH & CHP Excel Spreadsheet Narrative

Work/Expenditure Breakdown Structure: This worksheet summarizes required data onto a single, albeit 11x17, page. Starting from the left, tasks are broken down per the FOA Attachment A, Statement of Project Objectives. Start and end dates are next, followed by expenditure breakdown, first by month and then by quarter beginning April, 2010. Total \$ are given per line item and per month, with the 50% Grant Award at the top and in bold. The Milestone Log is the far right hand column. At the bottom of the spreadsheet, we have included, Manufacturing/Construction/Engineering jobs created/preserved as a result of the project.

Full Build-out Financials: The Full Load Electric Output is the electrical generation from the ORC units, 1700 kW. Converting to mmBtu/hr, yields 5.8 mmBtu/hr. The electrical conversion at 175°F DH water is 14.5%. Parasitic load is the amount of electricity required to run the TO & CHP plants. Net generation is gross minus parasitic. The thermal oil fuel requirement is the heat needed in the process divided by the thermal efficiency of the TO heater, 75% (lower than fossil fuel units due to having to evaporate the moisture from the wood). The TO heater fuel requirement is a function of the amount of waste heat from the ORC process, 60.5%

We separate heating costs from fuel costs and factor the operating costs (fuel, O&M, etc.) based on a cost split to generate a unit cost. We compare the unit cost to purchased fuel unit cost and then multiply the difference by the number of units to generate the savings.

Low Load Financials: Essentially the same as full build-out, but at the lower load.

Heating Load: At the top of this worksheet is an estimate of annual tons of CO₂ avoided, based on displaced fossil fuel and displaced coal based electricity. The lower part of the sheet walks through the loads of the major buildings that will be served by the DH system. Using fuel data and unit efficiencies, we calculate heating load. Excess heating is available for distribution to homes and commercial buildings.

Dept. of Energy EIA Energy Prices: We used the 2010 reference projections for Natural Gas (NG) and electricity. For natural gas, we used the Commercial number as more than 2/3rds of the heating load is major buildings with access to unbundled NG. We also used the Commercial electric number, converted to \$/kWh and added \$0.015 per kWh, a rounded and simplified average of the EPA's estimate of \$13 to \$17 per metric ton of CO₂.

Wind Alternative: Calculation of equivalent CO₂ reduction from wind.

Emissions: Estimated emissions using EPA's AP-42 data, the TO heater manufacturer's (VAS) guarantees and some emission rates from MN Power's website for coal based electricity. We know that GM gets its electricity from SMMPA, but believe that this data is probably very similar.

AP 42 is a compilation of studies of emission tests for various emission sources with a variety of control equipment. The TO heater guaranteed emission rates are based on actual equipment with a similar or identical design.

**Grand Marais DH & CHP: Work/Expenditure Breakdown Structure
Project Funding & Costing Profiles & Timeline/Milestone Log**

7/12/09 ceh

	Start Date	End Date	Oct-09 \$1000's	Nov-09 \$1000's	Dec-09 \$1000's	Jan-10 \$1000's	Feb-10 \$1000's	Mar-10 \$1000's	Q2 10 \$1000's	Q3 10 \$1000's	Q4 10 \$1000's	Q1 11 \$1000's	Q2 11 \$1000's	Total \$1000's	Milestone Log
Task 1.0 Project Management and Planning															
1.1 – Maintain Project Management Plan															
Grant Award (assumed to be 10/15/09)			31.5	75.5	342.5	95	117.5	395.5	763	1150.5	1524	880.5	399.5	5775	10/15/2009
Engineering	10/15/09	03/31/11	40	80	80	70	60	40	30	25	15	5	5	450	12/15/2009
Survey & Architecture	10/15/09	03/15/11	5	13	20	15	10	5	5	5	2			80	
Construction Management	11/01/09	05/15/11	3	3	4	5	5	5	10	10	10	10	5	70	6/30/2011
Training, Procedures & Commissioning	08/01/10	05/15/11								5	10	10	5	30	
Equipment Procured (major equip ordered)	12/01/09	01/01/10													1/1/2010
150 Day Go/No Go Decision Point	10/15/09	03/14/10													3/14/2010
Equipment Delivered to site	04/15/10	11/01/10													11/1/2010
System Installation Complete	04/15/10	01/15/11													1/15/2011
Installed System Shakedown Complete	01/15/11	02/15/11													2/15/2011
Full Scale System Verif. Complete (min 160 hrs)	02/15/11	03/01/11													3/1/2011
Project Complete	10/15/09	05/01/11													5/1/2011
1.2 Environmental and Regulatory Compliance	10/15/09	04/15/11											5	5	4/15/2011
1.3 Execution of Required Financing Agreements															10/1/2009
1.4 – Prepare Reports and Briefings (DOE & ARRA)	11/01/09	06/30/11			1			1	1	1	1	1	1	7	Final 6/30/11
Task 2.0 Procurement of Equip, Cntrls & Ancillaries															
Order ORC Units	12/01/09	11/01/10			140			140	140	140	400	250	150	1400	12/1/2009
Order TO Heaters (incl fuel & ash hndlg)	12/01/09	11/02/10			220			220	220	250	500	500	490	2400	12/1/2009
Order Biomass HW Boilers (incl fuel & ash hndlg)	01/01/10	08/01/10			130			130	130	140	240	220		1000	1/1/2010
Order Fossil Fuel HW Boilers	01/02/10	08/02/10			15			15	15	50	5			100	1/1/2010
Construction Documents	10/15/09	03/31/11	10	30	50	10	5	5	20	20	20	10	10	190	12/15/2009
Order Building Steel, Panels, etc & concrete	02/01/10	01/15/11				90	45	45	200	190	190	50		810	2/2/2010
Let Construction Contracts	11/01/09	02/15/10													1/15/2010
Final Piping Ordered	11/02/09	05/03/10													4/15/2009
Task 3.0 Installation and integration															
Site Prep & Misc Civil	11/04/09	04/15/11	5	25	25			25	25	25	25	25	10	190	11/1/2009
Building Labor	11/05/09	04/15/11							140	300	300	160		900	
Piping	11/06/09	12/15/10					110	140	500	900	800	50		2500	
Major Mechanical	07/01/10	03/15/11							50	190	380	280	50	950	
Electrical & Instrumentation	03/15/10	04/15/11						20	40	50	150	190	50	500	
Task 4.0 Commissioning, Shakedown & Startup															
Mechanical Completion Inspection: Verify Project Spec's	01/01/11	1/15/11													1/15/2011
Cntrl system CO & Doc Verification	02/01/11	2/15/11													2/15/2011
First Biomass TO Heater Fire	02/15/11	2/15/11													2/15/2011
Perf. Testing, Independent Confirm subsystem op's	04/01/11	4/15/11											8	8	4/15/2011
Task 5.0 Operational Data Collection															
Complete Data Collection & Report	05/01/11	06/15/11											10	10	6/15/2011
Total Project			63	151	685	190	235	791	1526	2301	3048	1761	799	11600	Total Project
Grant Award to Grand Marais	700 kWe		31.5	75.5	342.5	95.0	117.5	395.5	763.0	1150.5	1524.0	880.5	399.5	5775	Grant Award to Grand Marais
Total Grant Award	700 kWe														
FTE Jobs Created/Preserved															Peak
Engineering			3	6	7	5	4	3	7	3	2	2	2		7
Mfg (blr, pipe, bldg), then misc. (paving, LS, painters)						5	7	9			2	5	5		9
Construction - Mech										1	20	2			20
Construction - Civil			1	2	1				1	22	3	2	1		22
Construction - Piping							12	12	12	8	4				12
Construction - Elec									1	3	6	4	1		6
Total			4	8	8	10	23	25	42	37	37	15	9		

Grand Marais DH & CHP Summary Financials

Full Build-out

Full Load Electric Output (kW)	700			
Conversion factor (Btu/kW)	3413			
Electric Production (mmBtu/hr)	2.4			
Fuel Efficiency	75.0%	Thermal Oil (TO) Heaters		70% Hot Water Boiler
Electrical Conversion from Fuel	14.5%			
Electrical Operating Hours	8300	346 days		
Annual Electric Production (kWh)	5810000		19830 mmBtu/yr electricity	
Parstitic Load	25%		36% Utility electric eff from coal	
Net Generation (kWh)	4357500		55082 mmBtu/yr of coal displaced	
TO Htr Fuel Req'd (mmBtu/hr, 5.8/.145)	16.5		57710 mmBtu/yr of Net DH distributed	
Wood Waste Fuel Value (mmBtu/ton)	9		0.11 trillion Btu/yr	
TO Hourly Fuel Use (tph)	1.83			
TO Heater Annual Fuel Use (tons)	15195	12257	2938	
Biomass HW Blr Annual Fuel Use (tons)	1181	3 mmBtu/hr,		90 days
Total Fuel Use	16376	2 mmBtu/hr,		20 days
Average Wood Fuel Cost	\$21	Heating	Elec	
Total Fuel Cost	\$343,896	\$282,204	\$61,692	
District Heat (DH) Fuel Conversion Eff.	60.5%			
District Heat per hour (mmBtu)	10.0			
ORC District Heat Peak Operating Hrs	4450			185 days
ORC District non-Peak Operating Hrs	3850			160 days
ORC District non-Peak load	25%			
ORC District Heat Supplied (mmBtu/yr)	53953			
Biomass Hot Water DH (mmBtu/yr)	7440			
Total DH Distributed (mmBtu/yr)	61393			
Piping Losses & Facility Heat	6.0%			
Net DH Distributed (mmBtu/yr)	57710	Heating	Elec	
Annual TO & HW Blr's Maintenance	\$125,000	\$67,018	\$57,982	
Annual ORC Maintenance	\$40,000		\$40,000	
Annual Op Labor (1 FTE, each site)	\$70,000	\$37,530	\$32,470	
Insurance	\$30,000	\$16,084	\$13,916	
Misc. (Service Eng, Fuel Oil, etc.)	\$40,000	\$21,446	\$18,554	
	\$648,896	\$424,282	\$224,614	Total Annual Operating
Net Unit Cost (per mmBtu)		\$7.35	\$0.0387	per kWh
EIA 2010 estimate (per mmBtu)		\$20.75	\$0.1099	per kWh
Fossil Fuel Efficiency		82%		
EIA 2010 adjusted for Fossil Fuel Eff. (per mmBtu)		\$25.31		
Unit Cost Savings (per delivered mmBtu)		-\$17.96	-\$0.07	per kWh
		-\$1,102,416	-\$310,645	-\$1,413,061 Total Savings

Operating Cost Split

District Heat	53.6%	Based on percent time at full load
ORC/Elec	46.4%	

Grand Marais DH & CHP Summary Financials

Low Load

Full Load Electric Output (kW)	700			
Conversion factor (Btu/kW)	3413			
Electric Production (mmBtu/hr)	2.4			
Fuel Efficiency	75.0%	Thermal Oil (TO) Heaters		70% Hot Water Boiler
Electrical Conversion from Fuel	16.5%			
Electrical Operating Hours	8300	346 days		
Annual Electric Production (kWh)	5810000		19830 mmBtu/yr electricity	
Parstitic Load	25%		36% Utility electric eff from coal	
Net Generation (kWh)	4357500		55082 mmBtu/yr of coal displaced	
TO Htr Fuel Req'd (mmBtu/hr, 5.8/.145)	14.5		14000 mmBtu/yr of Net DH distributed	
Wood Waste Fuel Value (mmBtu/ton)	9		0.07 trillion Btu/yr	
TO Hourly Fuel Use (tph)	1.61			
TO Heater Annual Fuel Use (tons)	13353	10416	2938	
Biomass HW Blr Annual Fuel Use (tons)	0	0 mmBtu/hr,		90 days
Total Fuel Use	13353	0 mmBtu/hr,		20 days
Average Wood Fuel Cost	\$18	Heating	Elec	
Total Fuel Cost	\$240,358	\$187,479	\$52,879	
District Heat (DH) Fuel Conversion Eff.	58.5%			
District Heat per hour (mmBtu)	8.5			
ORC District Heat Peak Operating Hrs	500			21 days
ORC District non-Peak Operating Hrs	7800			325 days
ORC District non-Peak load	15%			
ORC District Heat Supplied (mmBtu/yr)	14146			
Biomass Hot Water DH (mmBtu/yr)	0			
Total DH Distributed (mmBtu/yr)	14146			
Piping Losses & Facility Heat	6.0%			
Net DH Distributed (mmBtu/yr)	14000	Heating	Elec	
Annual TO & HW Blr's Maintenance	\$95,000	\$5,723	\$89,277	
Annual ORC Maintenance	\$40,000		\$40,000	
Annual Op Labor (1 FTE, each site)	\$70,000	\$4,217	\$65,783	
Insurance	\$30,000	\$1,807	\$28,193	
Misc. (Service Eng, Fuel Oil, etc.)	\$30,000	\$1,807	\$28,193	
	\$505,358	\$201,033	\$304,325	Total Annual Operating
Net Unit Cost (per mmBtu)		\$14.36	\$0.0524	per kWh
EIA 2010 estimate (per mmBtu)		\$20.75	\$0.1099	per kWh
Fossil Fuel Efficiency		82%		
EIA 2010 adjusted for Fossil Fuel Eff. (per mmBtu)		\$25.31		
Unit Cost Savings (per delivered mmBtu)		-\$10.95	-\$0.06	per kWh
		-\$154,881	-\$250,862	-\$405,743 Total Savings

Operating Cost Split

District Heat	6.0%	Based on percent time at full load
ORC/Elec	94.0%	

Grand Marais DH & CHP Heating Load

			Electric
CO2 (lbs per mmBtu)	161	139	1.1 ton per MWh
	62.5%	37.5%	5810 gross MWh
	3540	1835	6391 11766 total CO2 avoided
	Fuel Oil	Propane	
	gallons	gallons	
Heating values per unit	135000	91600	
Grand Marais	gallons	gallons	
Hospital	63000		
Clinic	15000		
Courthouse		18000	
School		25000	
Community Center		20000	
Laundromat		6000	
Total	78000	69000	1287 Major Bldg fuel CO2
Total mmBtu/yr fuel	10530	6320	16850 mmBtu/yr Fuel
Fuel Efficiency	0.82	0.82	57710 mmBtu total available
Major User Heating Load	8635	5183	13817 mmBtu/yr heating load
Fuel Mix	62.5%	37.5%	43893 available for post start-up load growth
100 mmBtu/yr Homes	100	345	34500
250 mmBtu/yr Businesses	250	15	3750
Domestic Hot Water	15	360	5400
			243 Left Over
			16850 mmBtu/yr
			\$20.75 per mmBtu DOE EIA
			\$349,696
			375 kW Load 3614 ton CO2
			\$0.110 per kWh
			\$361,185
			4900 Major Bldg CO2
Full Build-out Fuel Displaced	267137	236314	

Table B3. Energy Prices by Sector and Source (Nominal Dollars per Million Btu)
From DOE/EIA March 2009 Annual Energy Outlook

	2007	2010	Projections		2020/2010	2030/2010
			2020	2030		
LPG	\$18.53	\$22.07	\$35.61	\$43.16	161%	196%
Fuel Oil	\$19.94	\$19.99	\$32.65	\$40.51	163%	203%
Electricity	\$26.70	\$27.82	\$35.62	\$44.31	128%	159%

Fuel Mix

LPG	36.7%	\$8.10
Fuel Oil	63.3%	\$12.66
		\$20.75 Weighted Average Fuel Cost

Electricity

\$0.0949 DOE/EIA
\$0.015 add EPA Cap & Trade Estimate
<hr/>
\$0.1099

Wind Alternative Calculations

CO2 Reduction by ORC project	11766 tpy
Wind Equivalent	1.1 ton CO2/
Coal Based Electricity displaced	10696 MW
Wind Load Factor	30%
Annual Wind Capacity	35655
Wind Potential Operating Hours	8760
Wind Installed Capacity (MW)	4.1
Wind Installed Cost	\$2,600
Wind Project Total Cost	\$10,582

Grand Marais Emissions

			PM (lbs/ mmBtu)		N0x (lbs/ mmBtu)		SO2 (lbs/ mmBtu)		CO (lbs/ mmBtu)		
AP 42 Wood Emission Rates			0.56		0.36		0.025		0.6		
DH/ORC Project Emissions											
	Size mmBtu/ hr	Planned Full Load Op Hrs	PM (lbs/ mmBtu)	PM tpy	N0x (lbs/ mmBtu)	N0x tpy	SO2 (lbs/ mmBtu)	SO2 tpy	CO (lbs/ mmBtu)	CO tpy	Total tpy
Thermal Oil Heater	24	8300	0.04	4.0	0.2	19.9	0.025	2.5	0.08	8.0	34.4
Biomass HW Boiler	19.1	500	0.05	0.2	0.36	1.7	0.025	0.1	0.6	2.9	4.9
		Planned Firing (gal)	PM (lbs/ 1000 gal)	PM tpy	N0x (lbs/ 1000 gal)	N0x tpy	SO2 (lbs/1k gal %S)	SO3 tpy	CO (lbs/ 1000 gal)	CO tpy	Total tpy
FO Back-up Blr (AP 42 Emiss Rates)	16.8	2000	2	0.002	20	0.020	142	0.007	5	0.005	0.0
% S	0.05										
Total Project				4.2		21.7		2.6		10.8	39.3
	% S										
Existing FO emissions	0.05	267137	0.4	0.053	18	2.40	142	0.948	5	0.7	4.1
			PM (lbs/ 1000 gal)		N0x (lbs/ 1000 gal)		SO2 (lbs/ %S)		CO (lbs/ 1000 gal)		
AP 42 LP Emission Rates			0.7		13		0.1		7.5		
	0.00	236314	0.7	0.083	13	1.54	0.1	0.00	7.5	0.89	2.5
		MWh							Estimated		
MP Website Emis. Rates (per MWh)		5810	0.739	2.1	5.141	14.9	6.209	18.0	0.823	2.4	37.5
Total Existing				2.3		18.9		19.0		3.9	44.1
										Difference	-4.7
Notes:											-10.8%

For the TO Heater, using planned full load operating hours and at emission rate guarantees is conservative

For FO Back-up Blr, 2000 gallons of FO corresponds to about 26 hours at 50% load.

Total existing assumes no emissions from wood stoves, outside wood boilers. Existing emissions would be much higher if they were included.