

# Forest Biomass Heating and Electricity in Cook County, MN

Phase I Report  
*September 20, 2011*



# Project Partners

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**COOK COUNTY LOCAL ENERGY PROJECT**

# Project Goal

*Provide objective information to Cook County on feasibility, impacts, potential benefits, and tradeoffs associated with woody biomass harvest, processing, and energy production in order for the community to make informed decisions about moving forward with biomass energy program(s).*

# Timeline

<b>Fall 2010</b>	<ul style="list-style-type: none"><li>✓ Initial community meetings</li><li>✓ Review existing data; identify and fill gaps in information</li><li>✓ Hire study team staff</li></ul>
<b>Winter – Spring 2011</b>	<ul style="list-style-type: none"><li>✓ Survey energy demand</li><li>✓ Assess current and potential biomass supply</li><li>✓ Evaluate energy production alternatives at different scales of operation</li></ul>
<b>Summer 2011</b>	<ul style="list-style-type: none"><li>✓ Preliminary report on biomass availability and options</li><li>• LCCMR long-term projections begin</li></ul>
<b>Fall 2011 – Winter 2012</b>	<ul style="list-style-type: none"><li>• Community dialogue on options and tradeoffs</li><li>• Long-term economic forecasting</li><li>• Life cycle, environmental, CO2 impact assessment</li><li>• Evaluate financial options</li><li>• Develop recommendations</li><li>• Deliver final report</li></ul>

# Outline of Presentation

- Study approach
- Biomass availability for energy production
- Engineering options and financial comparisons
- Other considerations
- Next steps and Phase II
- Q/A and discussion

# Key Definitions

**Bolewood (roundwood)** – the main trunk of the tree

**Btu** – British thermal unit; standard unit of energy measurement

**Clean chips** – fiber processed into wood chips free of contaminants like bark and needles, and generally includes only the bolewood

**Harvest residues** – fiber generated from logging and generally includes branches, leaves, bark, and tree tops

**Hog (hogged) fuel** – generally is harvest residues

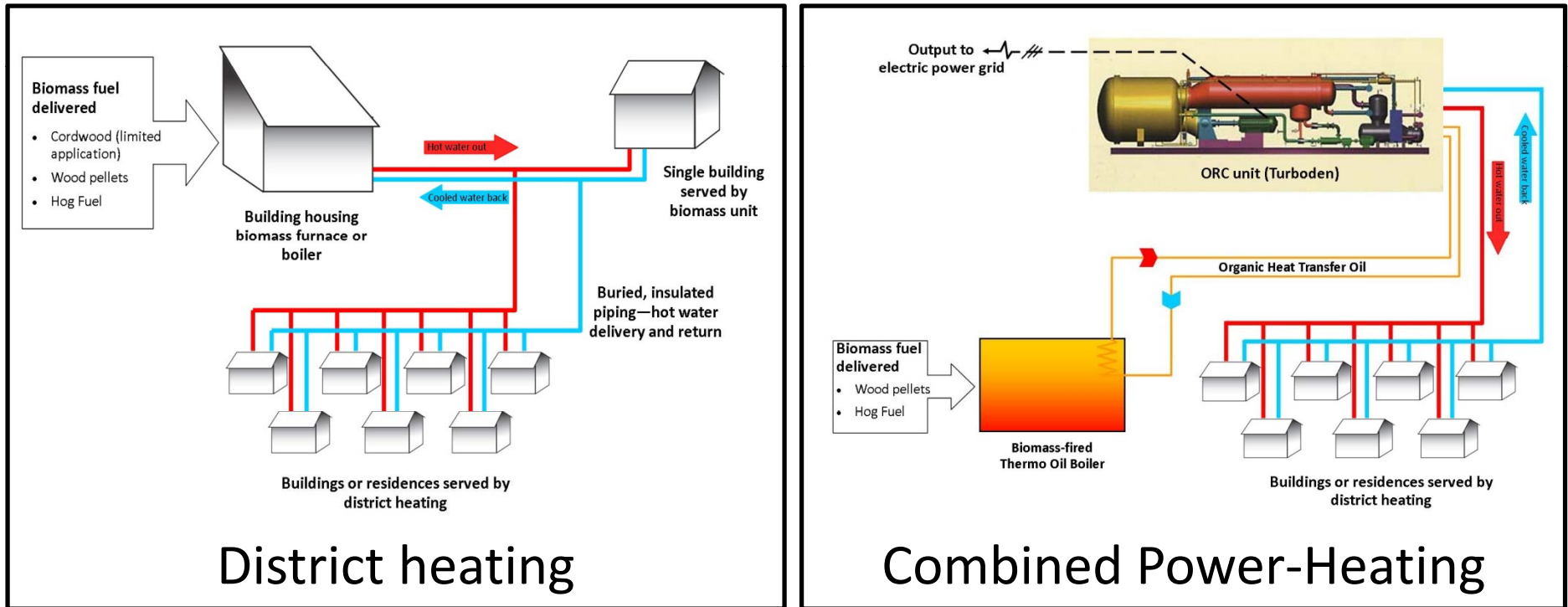
**Dry ton (oven dry ton)** – one ton of wood fiber at zero percent moisture content (~0.80 cords; 7,600-9,600 Btu/lb)

# Study Approach

- Step 1:** Assess biomass energy technology options for surrogate small, medium, and large heating or electricity systems
- Step 2:** Estimate Cook County forest biomass feedstock availability
- Step 3:** Evaluate the financial performance of biomass energy systems vs. existing fossil fuel systems

# Step 1: Assess Bioenergy Technology Options

Annual heat demand, O&M costs, financial benchmarks with business-as-usual and high oil price scenarios of the cost of future energy



# Step 1: Assess Bioenergy Technology Options

## *Putting it into Perspective*

Configuration <sup>1</sup>	Annual heat demand (mmBtu)	Fuel type	Biomass needed (delivered, 40% MC) (green tons/yr)	Loaded truck weight (tons)	Trucks/yr
<b>S1-S4 and L1:</b> Heat for individual homes and small buildings	35 – 1,400	cordwood	7 – 73	18	0.4 – 4
		chips for pellets	3 – 147	22	0.1 – 7
		clean chips	178 – 220	22	8 – 10
<b>M1:</b> Heat for multiple buildings (medium-scale)	5,200	clean chips	850	22	39
		chips for pellets	570		26
<b>L2-6:</b> District heat for Grand Marais public buildings and business core	5,800 – 34,200	clean chips	935 – 1,963	22	43 – 89
		chips for pellets	627 – 2,833		29 – 129
		hog fuel	3,250 – 5,667		148 – 258
<b>L7:</b> District heat for Grand Marais homes, public buildings, and business core	45,000	hog fuel	7,667	22	349
		chips for pellets	5,167		235
<b>L8:</b> Combined heat and power (CHP) system for L7	45,000	hog fuel	14,583	22	663
		chips for pellets	11,417		519

<sup>1</sup>Small (S), medium (M), and large (L) system configurations assessed.

## Step 2: Biomass Availability Estimates

- Sufficient biomass is available above current utilization rates to provide feedstock (residuals or clean chips) for district heating in Cook County or Grand Marais.
- All slash generated from annual fuel reductions treatments could be utilized by district heating in Grand Marais.
- Clean chips and pellets from bolewood chipping could provide additional feedstock but could divert from existing markets.

## Step 2: Biomass Availability Estimates

- Future availability is dependent upon the level of roundwood harvest (*38,911 cords in 2010*)
- Current Cook County harvest level is about 75% below GEIS threshold for sustainable management (*~164,000 cords per year @ GEIS harvest rate; annual residual biomass increases to ~23,000 dry tons*)

## Step 2: Biomass Availability Estimates

Ownership	Current availability			Potential availability			
	2010 bolewood harvest (dry tons) <sup>1</sup>	2010 residual biomass (dry tons) <sup>2</sup>	2010 Firewise removals (dry tons) <sup>3</sup>	10% of 2010 bolewood (dry tons)	20% of 2010 bolewood (dry tons)	Future Firewise removals (dry tons) <sup>3</sup>	Residuals from GEIS harvest (dry tons) <sup>4</sup>
Federal forests	16,021	1,851	3,189	1,602	3,204	3,189	14,014
State, county, and local	19,009	2,344	--	1,901	3,802	--	3,790
Private <sup>5</sup>	8,889	1,034	--	889	1,778	--	5,505
<b>Total</b>	<b>43,919</b>	<b>5,229</b>	<b>3,189</b>	<b>4,392</b>	<b>8,784</b>	<b>3,189</b>	<b>23,309</b>

<sup>1</sup> A cord is equivalent to 1.2 dry tons. The total 2010 bolewood harvest is equivalent to 38,911 cords.

<sup>2</sup> Residual biomass is tops, limbs, branches and needles as defined by the USDA Forest Service FIA biomass attributes, and is in addition to the reported 2010 roundwood harvest rate for Cook County. Availability assumes 50% retention on-site.

<sup>3</sup> Firewise removals are estimated for Superior National Forest removals only of slash from fuels reductions efforts based on an estimated 12,599 cu. yards of slash generated in 2010. Future removals assumed equal to 2010 and not constrained by future budget allocations.

<sup>4</sup> The highest level of sustainable biomass removal based upon the proportion of a statewide timber harvest level of 4.0 million cords as estimated in the Final Generic Environmental Impact Statement (GEIS) for Minnesota. This amount is residual biomass only assuming 50% retention on-site, and does not include bolewood potential.

<sup>5</sup> Includes corporate, non-governmental conservation/natural resources organizations, unincorporated local partnerships/associations/clubs, and tribal timberlands; also includes non-industrial private woodlands.

## Step 3: Evaluate Financial Performance

- All options have lower annual fuel and O&M costs than the existing fossil fuel heating systems.
- New capital investment is needed to convert to biomass; replacement of old fossil fuel boilers will also eventually require new investment.
- Financial advantages of biomass energy depend upon assumptions about biomass fuel type, future fossil fuel prices, and/or taxes.

# Small Biomass Energy Systems

	<b>S1</b>		<b>S2</b>		<b>S3</b>	<b>S4</b>	
<b>Location: Bearskin Lodge</b>	<b>Supplemental heat stove single-family residence</b>		<b>Biomass furnace for single-family residence</b>		<b>Heat for main lodge</b>	<b>Heat for multiple cabins and lodge</b>	
<b>Thermal demand</b>	35 mmBtu/yr		70 mmBtu/yr		500 mmBtu/yr	1,100 mmBtu/yr	
<b>20-yr effective fossil fuel price<sup>2</sup></b>	\$29.50/mmBtu		\$29.50/mmBtu		\$22.50/mmBtu	\$24.00/mmBtu	
<b>Fuel type</b>	Cordwood	Pellets	Cordwood	Pellets	Cordwood	Clean chips	Pellets
<b>Capital construction costs</b>							
TOTAL	\$4,000	\$3,500	\$15,000	\$15,000	\$162,000	\$649,000	\$575,000
<b>Annual operating costs (20 yrs)</b>							
TOTAL Reference	\$800	\$600	\$1,500	\$1,100	\$10,600	\$17,000	\$20,600
TOTAL High Oil Price	\$800	\$600	\$1,500	\$1,100	\$10,700	\$17,000	\$20,700
<b>Reference scenario</b>							
Cost of heat (\$/mmBtu) <sup>2</sup>	\$32.00	\$24.70	\$40.80	\$34.80	\$55.90	\$69.30	\$66.70
Simple payback period	9 years	6 years	16 years	11 years	>20 years	>20 years	>20 years
Return on investment <sup>3</sup>	147%	310%	32%	91%	-109%	-71%	-81%
Outstanding capital needed <sup>4</sup>	\$0	\$0	\$4,900	\$100	\$170,200	\$548,900	\$517,700
<b>High oil price scenario</b>							
Cost of heat (\$/mmBtu) <sup>2</sup>	\$33.60	\$25.70	\$42.40	\$35.80	\$57.40	\$69.80	\$67.60
Simple payback period	8 years	5 years	12 years	9 years	>20 years	>20 years	>20 years
Return on investment <sup>3</sup>	312%	514%	120%	186%	-105%	-61%	-72%
Outstanding capital needed <sup>4</sup>	\$0	\$0	\$0	\$0	\$166,800	\$519,300	\$494,500

<sup>1</sup> Other miscellaneous costs include taxes, insurance, freight, engineering services, and construction management.

<sup>2</sup> The levelized cost of fuel over the next 20 years, which is the capital and operating costs divided by the total units of energy produced (mmBtu) over that time period adjusted for furnace efficiency. Cost of heat does not include the replacement cost of existing boiler(s).

<sup>3</sup> Total revenue divided by total expenses over 20-years (non-discounted rate, before taxes).

<sup>4</sup> Amount of investment needed in addition to the fuel cost savings achieved over 20 years; includes all costs amortized over 20 years.

# Medium Biomass Energy Systems

	<b>M1</b>	
<b>Location: Lutsen Resort</b>	<b>Heat for multiple buildings</b>	
<b>Thermal demand</b>	5,200 mmBtu/yr	
<b>20-yr effective fossil fuel price<sup>2</sup></b>	\$31.50/mmBtu	
<b>Fuel type</b>	Clean chips	Pellets
<b>Capital construction costs</b>		
TOTAL	\$995,000	\$909,000
<b>Annual operating costs (20 yrs)</b>		
TOTAL Reference	\$53,800	\$87,100
TOTAL High Oil Price	\$54,000	\$87,600
<b>Reference scenario</b>		
Cost of heat (\$/mmBtu) <sup>2</sup>	\$27.80	\$32.90
Simple payback period	9 years	12 years
Return on investment <sup>3</sup>	134%	78%
Outstanding capital needed <sup>4</sup>	\$0	\$76,100
<b>High oil price scenario</b>		
Cost of heat (\$/mmBtu) <sup>2</sup>	\$28.30	\$33.90
Simple payback period	8 years	10 years
Return on investment <sup>3</sup>	234%	181%
Outstanding capital needed <sup>4</sup>	\$0	\$0

<sup>1</sup> Other miscellaneous costs include taxes, insurance, freight, engineering services, and construction management.

<sup>2</sup> The levelized cost of fuel over the next 20 years, which is the capital and operating costs divided by the total units of energy produced (mmBtu) over that time period adjusted for furnace efficiency. Cost of heat does not include the replacement cost of existing boiler(s).

<sup>3</sup> Total revenue divided by total expenses over 20-years (non-discounted rate, before taxes).

<sup>4</sup> Amount of investment needed in addition to the fuel cost savings achieved over 20 years; includes all costs amortized over 20 years.

# Large Biomass Energy Systems

	<b>L1</b>		<b>L2</b>		<b>L3</b>	
<b>Location: Grand Marais</b>	<b>Heat for Cook County Courthouse</b>		<b>Public buildings north of 5<sup>th</sup> St N (no hospital)</b>		<b>Public buildings north of 5<sup>th</sup> St N (hospital)</b>	
<b>Thermal demand</b>	1,400 mmBtu/yr		5,800 mmBtu/yr		12,100 mmBtu/yr	
<b>20-yr effective fossil fuel price<sup>2</sup></b>	\$35.90/mmBtu		\$34.90/mmBtu		\$32.60/mmBtu	
<b>Fuel type</b>	Clean chips Pellets		Clean chips Pellets		Clean chips Pellets	
<b>Capital construction costs</b>						
TOTAL	\$336,000	\$269,000	\$1,443,000	\$1,354,000	\$2,137,000	\$1,964,000
<b>Annual operating costs (20 yrs)</b>						
TOTAL Reference	\$13,200	\$22,900	\$21,000	\$90,000	\$45,000	\$188,500
TOTAL High Oil Price	\$13,200	\$22,900	\$21,000	\$92,000	\$45,000	\$192,500
<b>Reference scenario</b>						
Cost of heat (\$/mmBtu) <sup>2</sup>	\$32.80	\$35.50	\$26.60	\$37.60	\$19.80	\$31.00
Simple payback period	10 yrs	11 yrs	8 yrs	13 yrs	6 yrs	10 yrs
Return on investment <sup>3</sup>	117%	98%	157%	68%	236%	111%
Outstanding capital needed <sup>4</sup>	\$0	\$0	\$0	\$170,000	\$0	\$0
<b>High oil price scenario</b>						
Cost of heat (\$/mmBtu) <sup>2</sup>	\$33.20	\$36.50	\$27.10	\$40.80	\$20.30	\$34.10
Simple payback period	9 yrs	9 yrs	7 yrs	11 yrs	6 yrs	9 yrs
Return on investment <sup>3</sup>	205%	201%	239%	126%	331%	172%
Outstanding capital needed <sup>4</sup>	\$0	\$0	\$0	\$0	\$0	\$0

<sup>1</sup> Other miscellaneous costs include taxes, insurance, freight, engineering services, and construction management.

<sup>2</sup> The levelized cost of fuel over the next 20 years, which is the capital and operating costs divided by the total units of energy produced (mmBtu) over that time period adjusted for furnace efficiency. Cost of heat does not include the replacement cost of existing boiler(s).

<sup>3</sup> Total revenue divided by total expenses over 20-years (non-discounted rate, before taxes).

<sup>4</sup> Amount of investment needed in addition to the fuel cost savings achieved over 20 years; includes all costs amortized over 20 years.

# Large Biomass Energy Systems

	L4 District heat for Grand Marais business district		L5 Business district + public buildings (no hospital)		L6 Business district + public buildings (hospital)	
<b>Location:</b> Grand Marais						
<b>Thermal demand</b>	19,700 mmBtu/yr		25,500 mmBtu/yr		34,200 mmBtu/yr	
<b>20-yr effective fossil fuel price<sup>2</sup></b>	\$33.30/mmBtu		\$33.60/mmBtu		\$32.60/mmBtu	
<b>Fuel type</b>	Hog fuel	Pellets	Hog fuel	Pellets	Hog fuel	Pellets
<b>Capital construction costs</b>						
TOTAL	\$7,058,000	\$6,679,000	\$8,405,000	\$7,992,000	\$8,955,000	\$8,520,000
<b>Annual operating costs (20 yrs)</b>						
TOTAL Reference	\$210,000	\$388,000	\$253,000	\$494,000	\$304,000	\$645,000
TOTAL High Oil Price	\$211,000	\$395,000	\$254,000	\$502,000	\$306,000	\$656,000
<b>Reference scenario</b>						
Cost of heat (\$/mmBtu) <sup>2</sup>	\$43.50	\$51.20	\$40.20	\$48.50	\$32.90	\$42.10
Simple payback period	16 yrs	>20 yrs	14 yrs	>20 yrs	11 yrs	18 yrs
Return on investment <sup>3</sup>	30%	-19%	48%	-7%	86%	12%
Outstanding capital needed <sup>4</sup>	\$2,217,000	\$3,879,000	\$1,837,000	\$4,171,000	\$113,000	\$3,561,000
<b>High oil price scenario</b>						
Cost of heat (\$/mmBtu) <sup>2</sup>	\$44.00	\$54.50	\$40.60	\$51.80	\$33.40	\$45.40
Simple payback period	13 yrs	18 yrs	12 yrs	17 yrs	10 yrs	15 yrs
Return on investment <sup>3</sup>	80%	13%	104%	29%	151%	51%
Outstanding capital needed <sup>4</sup>	\$701,000	\$2,981,000	\$0	\$2,956,000	\$0	\$2,142,000

<sup>1</sup> Other miscellaneous costs include taxes, insurance, freight, engineering services, and construction management.

<sup>2</sup> The levelized cost of fuel over the next 20 years, which is the capital and operating costs divided by the total units of energy produced (mmBtu) over that time period adjusted for furnace efficiency. Cost of heat does not include the replacement cost of existing boiler(s).

<sup>3</sup> Total revenue divided by total expenses over 20-years (non-discounted rate, before taxes).

<sup>4</sup> Amount of investment needed in addition to the fuel cost savings achieved over 20 years; includes all costs amortized over 20 years.

# Large Biomass Energy Systems

	L7 Grand Marais homes and businesses		L8 CHP system for Grand Marais	
<b>Location:</b> Grand Marais				
<b>Thermal demand</b>	45,000 mmBtu/yr		45,000 mmBtu/yr	
<b>20-yr effective fossil fuel price<sup>2</sup></b>	\$33.20/mmBtu		\$33.20/mmBtu	
<b>Fuel type</b>	Hog fuel	Pellets	Hog fuel	Pellets
<b>Capital construction costs</b>				
TOTAL	\$13,227,000	\$12,709,000	\$18,337,000	\$17,819,000
<b>Annual operating costs (20 yrs)</b>				
TOTAL Reference	\$437,000	\$867,000	\$563,000	\$1,758,000
TOTAL High Oil Price	\$439,000	\$881,000	\$567,000	\$1,791,000
<b>Reference scenario</b>				
Cost of heat (\$/mmBtu) <sup>2</sup>	\$37.20	\$46.10	\$51.30	\$77.70
Simple payback period	13 yrs	>20 yrs	15 yrs	>20 yrs
Return on investment <sup>3</sup>	59%	-5%	30%	-106%
Outstanding capital needed <sup>4</sup>	\$1,996,000	\$6,381,000	\$8,972,000	\$22,056,000
<b>High oil price scenario</b>				
Cost of heat (\$/mmBtu) <sup>2</sup>	\$37.80	\$49.50	\$52.50	\$85.50
Simple payback period	11 yrs	17 yrs	13 yrs	>20 yrs
Return on investment <sup>3</sup>	112%	24%	65%	-113%
Outstanding capital needed <sup>4</sup>	\$0	\$4,809,000	\$6,283,000	\$22,618,000

<sup>1</sup> Other miscellaneous costs include taxes, insurance, freight, engineering services, and construction management.

<sup>2</sup> The levelized cost of fuel over the next 20 years, which is the capital and operating costs divided by the total units of energy produced (mmBtu) over that time period adjusted for furnace efficiency. Cost of heat does not include the replacement cost of existing boiler(s).

<sup>3</sup> Total revenue divided by total expenses over 20-years (non-discounted rate, before taxes).

<sup>4</sup> Amount of investment needed in addition to the fuel cost savings achieved over 20 years; includes all costs amortized over 20 years.

# Other Considerations

- Money spent on fossil fuels is largely re-spent outside the region (leakage).
- In other communities, \$0.26 – \$0.86 re-spent locally for every dollar spent on local bioenergy fuels.
- Emissions for all configurations are below allowable state and federal thresholds; larger configurations may require minimal air quality permits and/or emissions tracking.

## Criteria pollutants from biomass burning (tons/yr)

	PM	PM10	NO <sub>x</sub>	SO <sub>2</sub>	CO	VOC	Total emissions	Single HAP	Total HAP
<b>Option D permit thresholds</b>									
Standard threshold	50	50 <sup>1</sup>	50	50	50	50	250	5	12.5
Reduced record keeping	25	25	25	25	25	25	125	2.5	6.25
<b>Configurations</b>									
<b>S1:</b> single-family residence heating	0.01	0.01	--	0.01	0.04	0.01	0.06	0.01	0.01
<b>S2:</b> Single-family heating and water	0.01	0.01	0.02	0.01	0.03	0.01	0.05	0.01	0.01
<b>S3:</b> Main lodge heating	0.03	0.02	--	0.01	0.13	0.01	0.16	0.01	0.01
<b>S4:</b> Main lodge heating and cabins	0.04	0.04	0.07	0.01	0.30	0.01	0.42	0.01	0.02
<b>M1:</b> Heat multiple buildings	0.37	0.34	0.62	0.03	2.73	0.064	3.82	0.07	0.22
<b>L1:</b> Cook County Courthouse	0.10	0.09	0.16	0.01	0.71	0.02	0.99	0.02	0.06
<b>L2:</b> Public buildings (no hospital)	0.41	0.37	0.68	0.034	3.00	0.07	4.20	0.08	0.24
<b>L3:</b> Public buildings (with hospital)	3.11	2.80	1.96	0.22	5.33	0.15	10.77	0.17	0.52
<b>L4:</b> Grand Marais business district	6.90	6.21	4.34	0.49	11.83	0.34	23.89	0.34	1.15
<b>L5:</b> Business district (L4) and public buildings (L2)(no hospital)	6.51	5.86	4.09	0.47	11.16	0.32	22.55	0.36	1.09
<b>L6:</b> Business district (L4) and public buildings (L3)(with hospital)	8.14	7.33	5.12	0.58	13.95	0.40	28.19	0.44	1.36
<b>L7:</b> Whole community district heat	11.57	10.42	7.27	0.83	19.84	0.56	40.08	0.63	1.93
<b>L8:</b> Whole community combined heat and power (CHP)	2.80	2.52	14.02	1.75	5.61	1.19	25.37	1.34	4.10
<b>Non-biomass burning references</b>									
Oil boiler	0.0031	0.0028	0.0313	0.1095	0.0077	--	--	--	--
Propane boiler	0.0009	0.0008	0.0337	0.0035	0.0046	--	--	--	--
Taconite Harbor facility (2008)		744	2351	4720	230	28	7328	--	--

## Next steps and Phase II

- LCCMR-funding for biomass procurement by area, life-cycle analysis, and environmental impacts
- Financing considerations
- Extensive community and stakeholder outreach and education for selected configuration(s)
- Develop decision support tools for deployment in other communities

# Building public dialogue

- Step 1:** Using the Phase I report as a foundation, increase community understanding and knowledge regarding biomass energy and related issues
- Step 2:** Obtain focused community input on the short and long-term impacts, implications and trade-offs of biomass energy (forest management practices, environmental, economic, and social)
- Step 3:** Town hall meeting(s) with panel discussions to promote community dialogue and build consensus (Spring 2012)