COMMUNITY-DRIVEN BIOMASS ENERGY OPPORTUNITIES

A NORTHERN MINNESOTA CASE STUDY

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Introduction

Figure 1. Project Area Map

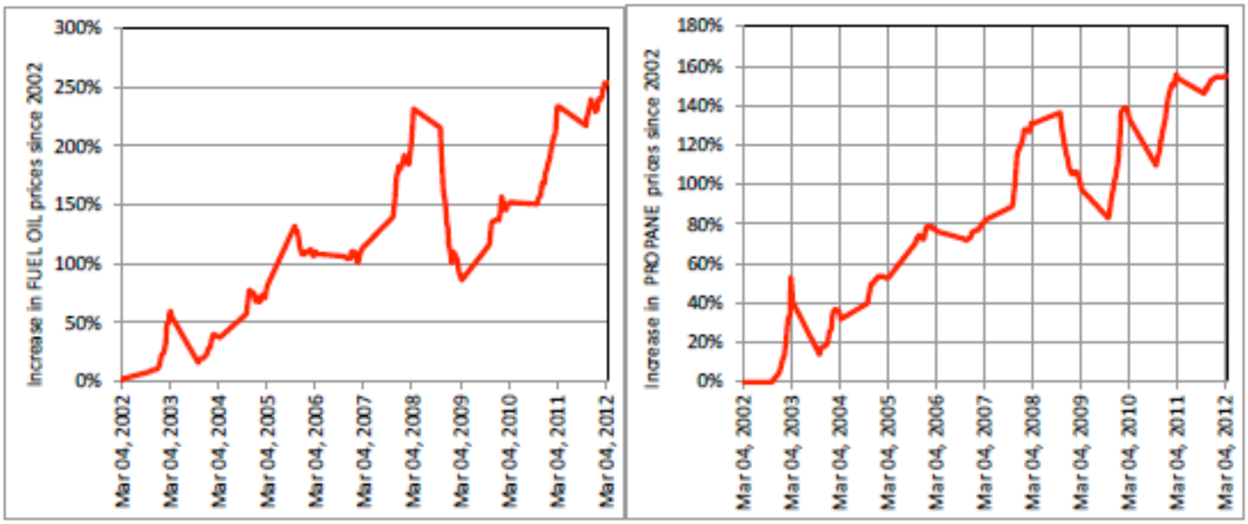
Many rural communities are interested in using locally-produced renewable energy sources to increase energy independence, lower costs, and reduce greenhouse gas emissions. This paper describes case studies of two communities in Minnesota's Arrowhead region (Figure 1) interested in using timber harvest residues, sub-merchantable timber, and waste wood to heat homes, businesses, and government buildings, in either stand-alone or district energy systems. Unlike imported energy, locally-sourced energy results in a significant proportion of the positive and negative impacts of energy consumption occurring locally. Having credible, objective information on the scale of these impacts and the tradeoffs they represent is crucial to communities considering new energy sources, particularly those that may require public investments. In the past decade, a great deal of attention has been given to large, industrial-scale bioenergy systems, and the positive and negative impacts they could have. Regarding the small cities and villages of the Arrowhead region and their more modest energy needs, questions arose as to whether an energy future built around woody biomass would be economically beneficial and environmentally sustainable at that scale. This collaborative study between two Minnesota communities – Ely and Grand Marais – and a team of experts investigates the options, tradeoffs, and social support for such a strategy.

Background

With energy costs rising and the search for alternative fuels expanding, one option stands out for many rural communities: producing renewable energy locally. This is certainly of interest in Minnesota's northern, end-of-the-pipeline counties, where energy options are few and costs have increased dramatically over the past decade (Figures 2 and 3). Resources like wind, solar, and geothermal are interesting possibilities, but interest in wood energy – using locally grown wood and well-known technology – is broad and deep in the region.[1]

[1] For examples of existing biomass energy use and experience in the region, see the case studies of "Using Biomass in Minnesota", available at: http://www.dovetailinc.org/content/using-biomass-minnesota

Figure 2. Fuel Oil Price History, 2002-2012 Figure 3. Propane Price History, 2002-2012



Fuel Oil and Propane Price Histories 2002-2012

Source: "Grand Marais Biomass District Heating System, Report #GM-13-001-0," by FVB Energy, Inc., Minneapolis MN.

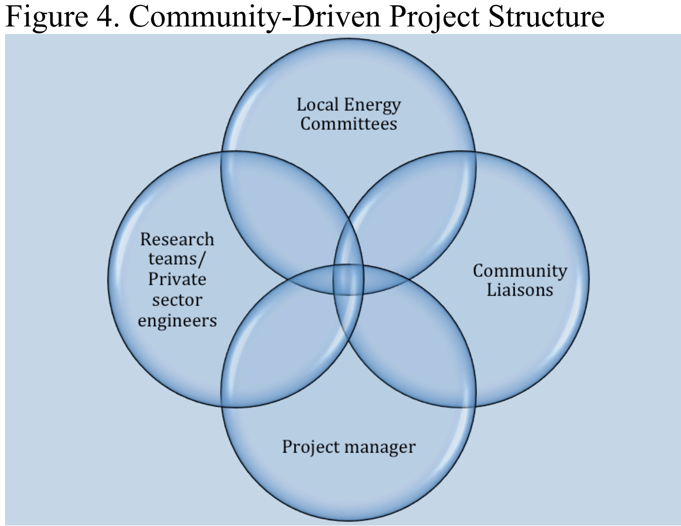
The modern era of using biomass to generate energy was launched by Middle Eastern oil embargos in the 1970s. In the United States, many schools and other large institutions adapted their boiler systems to burn wood, but the greatest advances were in the forest industry, where waste streams could easily and profitably be burned for energy. Over the decades, advances in technology have markedly improved the practicality, energy efficiency, and emissions control of burning biomass at all scales, from small wood- and pellet-burning stoves to biomass-fueled community district energy (DE) systems. This latter application, in which a central facility produces and delivers heat or a combination of heat and power (CHP) to a network of buildings, is being used successfully in communities across northern Europe and increasingly in western and northeastern regions of the United States. District energy presents an especially attractive option for capturing efficiencies and economies of scale unobtainable on a building-by-building basis. The City of Saint Paul's DE system, also initiated in response to 1970s energy crises, is a national model for its use of renewable energy sources and ability to provide heating to nearly 500 buildings and residences.

Biomass energy is also of interest in northeast Minnesota because of concern about its vast but aging forest resources. In the past, these forests were regularly renewed by fire and other disturbances, but a century of fire suppression and a reduction in other management practices have resulted in many forests that are no longer highly diverse or healthy, and increasingly characterized by highly flammable understories, brush, and blow-down timber. The 2007 Ham Lake fire in Cook County and the 2011 Pagami Creek fire near Ely - each burning over 100 square miles - make wildfire prevention and hazardous fuels management priority concerns in these areas and other parts of the region. Timber sales - the primary tool used to manage forests - have gone begging in recent years because of softening demand for pulp, saw logs, and other forest products. In the past five years, timber harvest near Ely has been 66% of 1990 harvest rates and 36% near Grand Marais, leaving public forest managers with forest stands aging out of the market and increasingly vulnerable to fire and insects (e.g., gypsy moth and emerald ash borer). The profitability of timber management might be improved if an underused component of harvest (residual treetops and limbs) currently lying in piles or open burned, and over-aged hardwoods could be converted into feedstocks for energy generation , thus providing the win-win solution that these forests, this industry, and these communities need.

Over the past several years, the cities of Ely and Grand Marais, and the larger area of surrounding Cook County, have completed energy plans calling for increased self-reliance and use of renewable fuels, and have appointed citizen committees to explore biomass energy. Unfortunately, both communities have also been confounded by the number and complexity of issues raised by a transition to a new energy source. One committee member expressed the frustration of many: "The myriad of questions we have encountered throughout the process of creating district heating has been mind-boggling. Our volunteer task force cannot answer these very technical questions." Key citizen questions include: Are sufficient fuel supplies available and sustainable, and how would biomass harvest affect nearby forests? Can the high upfront costs of converting to biomass energy be repaid by lower fuel costs? What air pollutants, including greenhouse gases, would be emitted? How would biomass energy affect loggers and existing forest markets?

In 2011, Ely's Alternative Energy Task Force and the Cook County Local Energy Committee joined with a group of outside experts to answer these questions. Dovetail Partners, a non-profit organization in the Twin Cities, assembled a team of economists and natural resource scientists from the University of Minnesota, engineers from LHB, Inc (Duluth), and Wilson Engineering Services (Meadville, PA). Community liaisons were hired in each community to link the study group, local committees, and the public. Together, the local energy committees, researchers, community liaisons, and project manager provided the collaborative and community-driven project structure (Figure 4).

Figure 4. Community-Driven Project Structure



The importance of the collaborative structure used for this project cannot be overemphasized. To ensure a strong community-driven focus, it was essential to have local committees and a dedicated community liaison in place. This structure would be highly recommended for similar projects that desire a community-driven outcome. The functional elements made it possible to address evolving ideas and information needs, and allowed the study team to effectively support each community's decision-making process. The outcomes of this project can serve as a model for other communities to follow during exploratory stages of planning and provides information for state policymakers interested in the viability and impacts of locally-sourced community energy. A key statewide question is whether biomass energy could contribute to meeting Minnesota's target of 25% renewable energy consumption by 2025.

Initial funding for the project was provided by the Minnesota Natural Resources and Environment Trust Fund, as advised by the Legislative Citizen Committee on Minnesota Resources. Cook County Commissioners and the USDA Wood Education and Resource Center also contributed funds to substantially expand investigations and engineering analysis. Many community partners and public land managers provided input and assistance throughout the project. The Minnesota Department of Natural Resource, St. Louis County, Lake County, Cook County, the US Forest Service, particularly staff of Superior National Forest, local residents and property owners, business owners, loggers, and others provided important information and assistance.

Scope and Methods of Study

The goals of the study were to initiate constructive community dialogue, identify issues and options worthy of attention, and produce and communicate objective, third party information to community members and decision-makers. The study combined a pre-feasibility, or preliminary assessment of options, with a larger study of environmental impacts and supply chain issues related to harvesting, processing, and producing biomass energy locally. The work was divided into two phases, as described below and illustrated on the following page (Figure 5).

Phase I focused on developing technological options for biomass energy systems (also referred to as configurations) at different scales of operation. Preliminary assessments were made of biomass feedstock demand, system costs, and financial performance of alternative options. Options ranged from small, stand-alone residential wood-burning or pellet stoves, to medium- sized district heating systems for resorts or small business clusters, up to larger district heat or co-generation of heat and power (CHP) systems connecting government, business, and residential areas in each community. In Ely, several options developed prior to this project were also considered. At the conclusion of Phase I, community groups selected the most promising options for further study.

Phase II produced in-depth background reports on financial feasibility, biomass availability within 15-, 30-, and 60-mile supply zones around each community, environmental impacts of forest biomass harvest, and estimated air emissions of biomass combustion systems (both direct (smoke-stack) and life cycle (cradle-to-grave)). Slightly different financial analyses were conducted in each community. Implementation issues throughout the supply chain from forest to consumer were discussed with public lands representatives, loggers and timber industry representatives, major customers, and environmental stakeholders. A tour of several comparable biomass district heating systems in the region was organized. Fact sheets on study findings were disseminated at meetings with different interest groups and in larger public meetings. Phase II concluded with a final report of findings to each community.

Figure 5. Project Timeline and Milestones

Energy Policy

Public or private policy or initiative calling for investigation of renewable energy

Preliminary Assessment Scope and Methods							
Areas of Investigation	**Phase I**			**Phase II**			
Energy Production Options	Initial scoping + public outreach	Options identification and preliminary analysis	Community meeting to select preferred option(s)	Detailed financial performance of preferred options	Report to community on detailed analysis and impacts evaluation		Final report to community, and present background reports
Available Wood supply		Model-derived estimates in supply zones		Detailed supply analysis			
Environmental Impacts evaluation				Air quality & environmental impacts evaluation		Outreach to community (chamber of commerce, citizens, stakeholder groups, etc)	
Supply Chain Implementation issues						Interview potential customers Interviews and joint meetings with USFS, state, county forest managers Interviews with forest industry, loggers	

Feasibility Study of Preferred Option

- Obtain letters of interest
- Develop detailed project design and engineering specifications
- Develop business plan, including ownership/organizational structure and funding strategy
- Estimate costs-to-customer

Implementation Phase

- Secure necessary funds
- Construct and install systems
- Test to ensure performance meets expectation

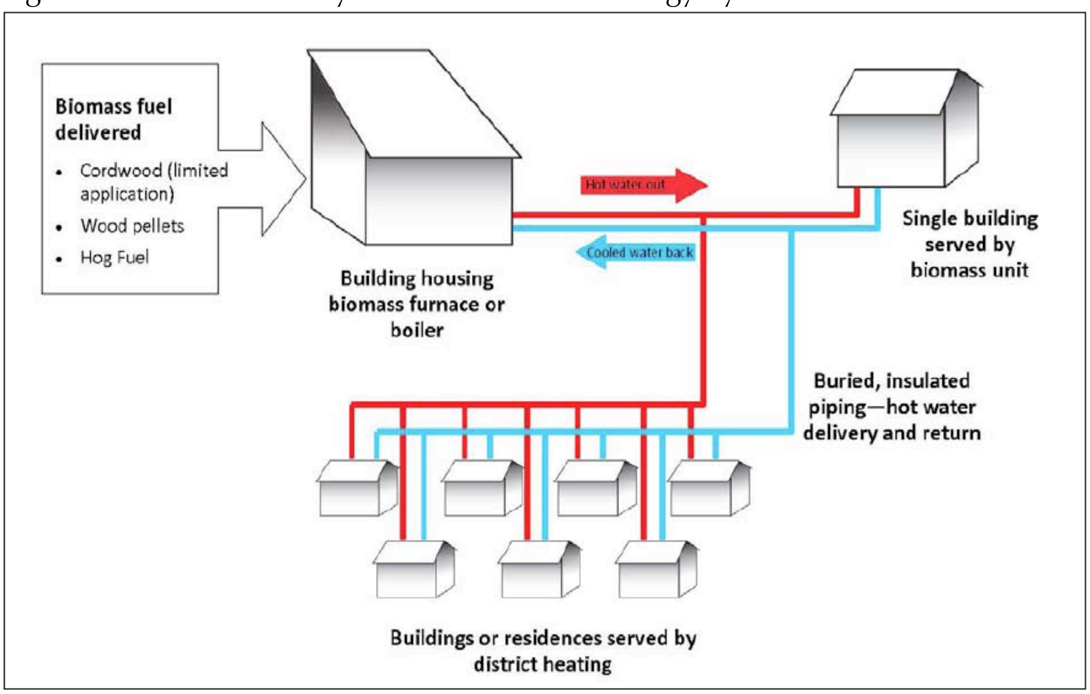
At the conclusion of the project, community and private decisions are made about whether to proceed to a more detailed analysis and development of a full technical concept, including detailed engineering, operating, and business plans. During this phase, details of ownership, siting of energy production and networks, and how much biomass energy will cost a specific customer are determined. Figure 5 and Table 1 on the following pages further illustrate the project design, methods, and results.

General observations and key definitions

Technological focus

- The major focus of this study was thermal energy generated by burning woody biomass fuels in a boiler to produce hot water and/or steam; circulating it to buildings via buried, insulated pipes; and then distributing it as hot water and space heat through radiant units or heat exchangers (Figure 6). Two approaches were taken in evaluating district energy for existing buildings: (1) design a piping configuration for a cluster of buildings with high heat loads; and (2) focus on the viability of initially serving 2 large buildings, with the potential for future extensions based on additional heat loads per foot of connecting pipe. Combined heat-and-power (CHP), which would add approximately 1 unit of electricity for every four units of heat, was evaluated for the largest options. Thermal energy is measured in British Thermal Units (Btus).

Figure 6. Generic Woody Biomass Thermal Energy System



Wood fuels focus

Locally grown woody biomass was defined as being available within a 60-mile radius zone around each community. Four biomass fuel types were evaluated, each with unique characteristics in energy output or value (measured in BTUs per ton); air emissions (measured in tons per BTU); optimal use; and costs. The four fuel types included in the evaluation were:

- *cord wood*, or roundwood, used in conventional fireplaces, wood-burning stoves, and boilers for home heating;
- *clean chips*, processed from the main trunk (bolewood) of a tree and most suitable for residential and small industrial heating;
- *hog (hogged) fuel* generated by grinding or chipping wood and residues (bark, leaves, branches, tops of trees) resulting from timber harvest, brush clearing, hazardous fuels (fire) reduction programs, right of way clearings, storm debris, etc. Hog fuel has higher ash content and is used in industrial applications with larger boilers and higher combustion temperatures;
- *pellets* made from compacted sawdust, have high energy values and low emissions per BTU, however they are currently produced outside the local area.

The main focus of the biomass supply analysis began with timber harvest residues, driven by strong local interest in hazardous fuels reduction, and belief in long-term availability and price stability (estimated $1 per 100 cubic feet). The analysis used biomass harvest guidelines published by the Minnesota Forest Resources Council (MFRC) recommending that 30 – 50% of harvest residuals be left on the forest floor to aid forest regeneration, soil replenishment, habitat protection, and other ecological functions. Because biomass harvest is considered a by-product of timber harvest, it was evaluated using information about harvest impacts contained in the *Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota* (GEIS), and subsequent updates and guidelines. Removing harvest residues, and particularly whole tree harvest, does intensify the impacts of traditional bolewood harvest described in that study. For this reason, and because long-term effects of biomass harvest are poorly-understood, precautionary approaches, including recommendations for site evaluations and field surveys before harvesting, monitoring and evaluation over time are included in conclusions of this study. The analysis also quantified biomass volumes that would be available if a small amount (10%) of local bolewood harvest were used for energy fuels. Stakeholder groups expressed reluctance to divert bolewood from existing markets and concerns about increased harvest pressure on forests. As long as viable pulp and timber markets for roundwood exist in the region, chipping quality bolewood for biomass systems is believed unlikely.

Over the course of the study, public lands managers and local loggers identified over-aged (80+ years) paper birch and aspen stands as a source for clean chips. Although considered un-merchantable for other products, bolewood from this source may provide a more consistent, cleaner, and energy efficient biomass fuel. An enormous volume of this material, estimated over 1.6 million dry tons, exists within short distances of Ely and Grand Marais. On the other hand, price volatility of this material could be considerably higher than hog fuel. Further examination of this potential fuel supply is now underway. Other low quality or degraded roundwood, including wood salvaged from windstorm events, wildfire, or insect or disease outbreaks, may also be used for bioenergy system.

In addition to timber harvest sources of wood, wood debris from fuel reduction programs and from community and county collection yards would also be possible biomass energy fuels. Although not extensively quantified in this study, the counties of St. Louis, Lake and Cook generate sizeable quantities of wood every year as a result of invasive species removal and storm cleanup. Woody debris from utility line and easement clearings, highway construction, road widening projects, commercial land clearing, residential land clearing, dunnage recovery (pallets and crates), etc., is also generated.

Although in-depth assessment of local manufacturing of pellets was not a formal part of this study, available information suggests that there is insufficient local demand to make such an enterprise profitable. Pellet-burning options are included in this study but, because this type of fuel is currently produced outside the area, they do not fall into the category of locally sourced bioenergy that is the focus of this study.

A note about carbon dioxide: An important driver of the search for alternative energy is greenhouse gas emissions and climate change associated with carbon in the form of carbon dioxide, methane, and other compounds emitted when burning fossil fuels. The carbon cycle is the flow of carbon through plants, animals, oceans, and atmosphere. Centuries of land clearing and fossil fuel (coal, petroleum, and natural gas) burning have added more carbon to the atmosphere than is reabsorbed each year and set in motion climate and environmental changes. A related concern is carbon and other pollution emissions from forest fires.

Harvesting wood reduces carbon stocks in the forest and, depending on how wood is used, causes it to be re-emitted to the atmosphere, or stored in long-used construction material, furniture, and other products. When wood is burned for energy, it emits more (organic) carbon *per unit of energy* than fossil fuels because it is a less concentrated form of energy. However, in situations where bioenergy replaces the mining and burning of fossil fuels, its use avoids new additions of fossil carbon to the atmosphere. This is particularly the case when annual forest growth (and therefore carbon uptake from the atmosphere) exceeds annual removals, which is the case in Minnesota. For these reasons, carbon released from wood combustion is typically not considered as a net atmospheric increase in life cycle assessments of wood energy. This issue continues to be a subject of scientific debate. The EPA is studying the issue and is expected to issue rules about how to account for biogenic CO_2 emissions in energy combustion in 2014.

Table 1. Biomass energy community case study questions, methods, and key findings

Questions	Study methods	Findings
Wood supplies: How much woody biomass is available in local forests to supply bioenergy projects? What types of feedstocks exist, at what price?	• Estimate current and long-term biomass availability based on forest types, age classes, and recent timber harvest averages in supply zones • Assume 50% of harvest residuals retained at forest site. • Refine estimates based on forest plans, stewardship guidelines, projected timber sales, and other management activities • Estimate production and delivery costs of different feedstock types (bolewood chips, hog fuel, etc)	• Based on current and projected harvest rates in supply zones, sufficient locally grown biomass is available to supply multiple district heating facilities in Ely and Grand Marais. • Hog fuel availability is dependent on local timber harvests for higher-valued products (pulp or saw logs), which subsidize the removal of residuals to landing for processing. Currently, approximately 45,000 dry tons (DT) of hog fuel are available as a byproduct of harvesting within 60-mile radii of Ely; 11,450 DT are available near Grand Marais. Delivered cost of hog fuel is estimated at $37 - $56/DT based on transportation distance (0-60 miles). Cost of logging residue are considered very stable if included in fuel reduction or stewardship projects. • If 10% of current annual bolewood harvest were diverted to biomass market, it would add 34,300 DT of clean chips in Ely zone and 9,250 DT around Grand Marais. Delivered cost of clean chips is approximately $10/ton more than hog fuel. • USFS estimates that 1.65 million dry tons of overaged (80+ years) biomass from hardwoods, primarily birch and aspen, is available within 50 miles of Ely and Grand Marais. Although considered unmerchantable for other uses, bolewood from this source could produce a high-quality chip for energy production. • Additional material from wildfire mitigation, brush clearing, and other activities could be available for processing into fuels.
Technologies: What technological options exist for small, medium, and large facilities or clusters of buildings?	• Identify small, medium and large biomass energy applications for stand-alone and district heating systems • Alternatively, identify "central core" of 2 buildings, plus viable extensions • Quantify heat loads based on monthly fossil fuel and electricity bills of existing heat/cooling systems in each building • Quantify annual biomass fuel requirements to meet heat loads	• Numerous applications exist, ranging from small residential wood- and pellet-burning stoves; furnaces/boilers of large government or commercial buildings; small business clusters and resorts; and optional configurations for larger district energy (DE) for government and commercial districts. Financial analysis identifies the most viable options for futher study. • Thermal only (space heat and hot water) could work at many scales; CHP requires energy loads higher than most rural applications. • Annual heat loads and fuel demands range from residential stoves (35 MMBtu/annually using 3.6 DT cordwood) up to district heating for 75 government, commercial, and residential building (30,5000 MMBtu/annually using 2,450 DT chips/hog fuel).

Financial performance: Which options are feasible financially?	• Develop preliminary estimates of capital and operating expenses of optional configurations • Measure financial performance of options based on (1) cost of biomass heat ($/MMBtu); (2) net present value; (3) simple payback period; and (4) maximum annual outlay. • Project financial impacts of future changes in fuel costs and interest rates (e.g., sensitivity analysis) • Create model for use by other communities in estimating financial feasibility of biomass energy	. • Heat density is key to viability in district energy systems, because of the high capital cost of buried piping ($138 – 220 per foot). Linking two or more facilities with high heat loads and short transport distance improves metrics for energy efficiency, financial performance, and environmental impacts. • Construction and operating costs (including fuel) sometime run counter to one another. Pellet-based systems are less expensive to build, but (because of delivery costs) are more expensive than clean chips and hog fuel to operate. • Capital intensive DE systems have high initial costs but relatively low annual operating costs. The most promising options in each community have similar or lower costs per unit of energy ($/MMBtu) compared to existing systems. They have positive net present value (NPV), indicating long-term investment benefit, and short simple payback periods (i.e., time needed to have positive cash flow, not counting time value of money) because of low annual outlays. • A 50% increase in delivered biomass price, interest rate, or other annual expenses would weaken but not eliminate viable options for Ely and Grand Marais, requiring additional means for offsetting capital costs. • Combined-heat-and-power options have considerably higher capital costs than heating only. None of the CHP options in these communities appears to be financially viable at this time. • A mathematical model created to assess financial feasibility is being adapted for use by other communities and is expected to be available in mid-2013.
Air quality impacts: What changes in air emissions are associated with preferred options?	• Review published studies of life cycle and at-combustion site emissions of wood energy versus fossil fuels • Apply emission values to options being considered	• All options considered are 50-80% below State of Minnesota Option D emissions limits. • On-site emissions are determined by fuels used, production equipment, and pollution controls. Life cycle emissions increase with transportation distance. Reducing transportation distances and utilizing local sources of fuel can minimize carbon emissions associated with biomass energy. • Dry, clean, uniform fuels provide greater heating value, uniform burning, lower emissions, and less need for boiler maintenance. Clean mill chips have highest fuel quality, followed by chipped bole wood, whole tree chips, and hogged forest residues. • Automated district energy systems that are engineered to optimize energy use density and energy transport distance have lower emissions/MMBtu than stand-alone systems, and make pollution control (electrostatic precipitators) more affordable. • In the future, regulation of compounds emitted by biomass fuels could tighten, including particulate matter (PM) limits.

Environmental impacts: What are the potential positive and negative impacts of biomass harvest on forest ecosystems, water, and aesthetics?	• Identify community concerns about potential impacts • Review potential impacts of timber harvest as described in *Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota (GEIS*) • Consult with state and regional forest managers about forest plans and concerns in procurement zones	• Ample fuel supplies are available at current harvest levels, which are significantly below levels found biologically sustainable in the MN Forestry GEIS. Although the district heating options being considered demand relatively small volumes of fuel, they could alter forestry practices in supply zones. • Ecological impacts on soils, wildlife, fire regimes, and water quality of using biomass for bioenergy depends on existing forest conditions and the timing, methods, and amount of biomass removed at a site over a specific period. • Biomass harvest and whole tree harvesting (used to produce some types of wood chips) increase losses of essential soil minerals compared to traditional timber removals (i.e., bolewood harvest only). • State and federal forest plans restrict biomass removal in certain forest stands to protect sensitive soil types, biodiversity, water quality, and cultural resources. • Minnesota's use of third-party forest certification, biomass harvesting guidelines, logger training and certification programs, and other tools aid in addressing forest sustainability and biomass utilization concerns. • Long-term environmental impacts of woody biomass utilization are not well known. Regional foresters and ecologists advise precautionary approaches and monitoring and evaluation over time. • Regional foresters identified biofuel harvesting as an important tool for conducting riparian corridor restoration, habitat management, hazardous fuel reduction, and other conservation projects.
Supply chain: Does forest infrastructure exist to sustainably produce and deliver biomass for community DE system? If not, how can this capacity be obtained?	• Meet with public forest managers, logging operators, mill owners to discuss harvest and fuel production and delivery requirements of energy systems • Facilitate communication between all parties in supply chain to find mutually beneficial approaches	• The majority of the forestland in northern Minnesota is public land (state, county, federal), Biomass harvests on public forestland are governed by long- and short-term management plans, regulations, and guidelines. New federal forest plans are due in 2014. • In the past decade, dwindling demand for forest products has reduced forest management and the number of logging operators in the area. The existence of a healthy, active logging labor force is a critical factor in long-term viability of locally grown wood-based bioenergy. • Purchase agreements or other incentives may be necessary because of the high cost of equipment investment relative to the low demand for bioenergy feedstocks. The competitiveness of community bioenergy projects with other markets will be determined by haul distances (and diesel fuel costs) as much or more than harvest and processing costs. • Long-term stewardship contracting is a management tool that can help address forest conservation, biomass supply, and logger assurances. • Business models for how a municipal fuel operation can be developed are an important step to address harvest, transport, and processing infrastructure issues.

Findings for Each Community

The project included investigations in the City of Ely and for Grand Marais and Cook County. Although these two communities are less than 100 miles apart and located within a similar forest ecosystem, there are unique circumstances in each. These differences help illustrate a more complete spectrum of local renewable energy trade-offs and opportunities than would result from the review of a single community situation.

Cook County / Grand Marais

Cook County covers approximately 3,340 square miles, over half of which is publicly owned forestland. The current population of the county is 5,176, with projections of a 26% increase by 2030. Population density is low, estimated at 6.4 people per square mile. Grand Marais is the county seat and largest community; smaller communities are Lutsen, Hovland, Tofte, and Shroeder. Tourism and related services – which are both seasonal and located in remote areas - are the largest economic sectors. The most common form of owner-occupied home heating is propane, followed by electricity and equal amounts of #2 heating oil and wood.

In the past two years, the Cook County Commissioners have adopted a voluntary energy plan that calls for government entities, businesses, and residents to lower fossil fuel use and tap into renewable energy sources. A local non-profit organization, the Cook County Local Energy Project (CCLEP), formed a biomass working group to investigate potential projects and address community concerns. An initial analysis by LHB, Inc resulted in a proposal for an extensive system linking government, commercial, and residential buildings in Grand Marais. The project stalled because of funding issues, whereupon CCLEP elected to participate in the pre-feasibility study to re-consider a broader set of biomass energy options in the county.

Surveys of public opinion in Cook County reveal a variety of concerns driving interest in alternatives to existing home heating options:

- Volatile and rising prices for propane and heating oil, which are a significant portion of monthly household expenditures;
- Utilization of waste wood and slash generated by wildfire hazardous fuels reduction projects around structures and communities. Developing markets for under-utilized biomass could pay for increased forest management and forest restoration activities;
- Reducing greenhouse gases generated from burning of fossil fuels;
- Local economic development and job opportunities in forest management, harvesting, processing, and energy operations;
- Retention of money spent on energy within the county.

Public surveys also identified concerns about potential negative impacts of conversion to bioenergy that need careful analysis.

- Negative impacts from rising demand for and over-harvest of forest biomass, including increased forest harvest to meet demands, extension of forest roads to access biomass, and the environmental impacts of biomass removal;
- Impacts on air quality from biomass combustion, including changes in emissions of particulate matter (PM), NOx, sulfur dioxide (SO_2), carbon (CO), and volatile organic compounds (VOC).

A. Wood supply

In the 60-mile supply zone surrounding Grand Marais, the dominant forest types are aspen-birch (415,659 acres) and spruce-fir (200,027 acres). Of those acres, 53% and 42% respectively, are greater than 60-years and are either at or beyond their target harvest rotation age. The available supply analysis is based on estimates of 2006-2010 harvest rates in the zone, which are low by historic standards. For comparative purposes, estimates used in the 1990 GEIS to study timber harvest impacts are also shown (Table 2). Designated wilderness areas, old-growth reserves, wildlife management areas, state parks, and towns are not included in this analysis.

In addition, the USFS estimates that within 50 miles of Grand Marais, over 25,000 acres of hardwoods, containing approximately 334,360 biomass tons, are over 80 years old and not merchantable for sawlog and pulpwood markets. Removing over-aged stands and replacing them with more vigorous and diverse forests is included in Superior National Forest forest plans to reduce fire hazards and improve forest health.

Table 2. Annual average biomass volume and delivered cost in 60 mile supply zone surrounding Grand Marais, MN

Supply Zone	Annual harvest, *(cords)*[2]	Hog Fuel[3]		Bolewood chips[4]	
		Green tons[5]	*Dry tons*	*Green tons*	*Dry tons*
Average Annual harvest (2006-2010) and delivered cost[6]	79,572	19,083 $22 – 33/GT	11,450 $36 – 55/DT	15,410 $29 – 41/GT	9,246 $48 – 68/DT
GEIS/baseline scenario[7]	219,710	51,823	31,094	42,347	25,408

[2] Assumes average 1.2 dry tons per cord, actual conversion varies by species.
[3] Hog fuel is tops, limbs, branches, small trees, and needles. A conservative estimate of 50% is retained on site to meet MFRC Biomass Harvest Guidelines.
[4] Bolewood is main stem of tree. Analysis assumes 10% of harvest devoted to biomass.
[5] Assumes 40% moisture content at time of transport
[6] Delivered cost of biomass reflects a hypothetical market price with assumed transportation cost of $4.25 per mile (25-green ton load at 40%moisture content with return trip) with in-woods processing costs of $11.47/dry ton (hog fuel) and $23.17/dry ton (clean chips). Table shows prices for haul distances from 0 – 60 miles.
[7] Biomass removal estimates based upon the proportion of a statewide timber harvest rate of 4.0 million cords as estimated in the 1990 Base Scenario analyzed in the Final Generic Environmental Impact Statement (GEIS) for Minnesota.

B. Technological options and financial feasibilities

In Phase I, eight options were identified for biomass heating for private homes, large public or commercial buildings, resorts and business clusters in rural areas, and groups of public buildings and the downtown areas of Grand Marais. Co-generation (CHP) was included in the largest community-scale options. Costs for fuel, construction, operation & management, and financing were assessed. In Phase II, four "preferred" options were identified and became the focus for further study (Table 3). The largest potential commercial customers of district heating in the downtown area were interviewed to determine (1) if they expected to make changes in heating systems in coming 5 years and (2) if they were interested in district heating. The input received from these interviews informed the design of district heating options. All options are distributed hot water for heating. The options are:

1) Resorts or small business clusters (Lutsen Resort main lodge and guest cabins, a total of 12 buildings, served as proxy for the analysis).

2) Public buildings cluster north of 5th Street N in Grand Marais plus Cook County Courthouse and a large nearby Laundromat. Buildings included are: Cook County Hospital and Care Center, Sawtooth Mountain Clinic, Cook County Law Enforcement Center, Cook County Schools, total of 10 buildings.

3) Most extensive system, connecting public building cluster (see #2, above), downtown businesses, and adjacent residential properties for a total of 75 buildings.

4) Hybrid option for public buildings (see #2, above) and 21 largest customers in Grand Marais business district for a total of 31 buildings.

Table 3. Analysis of preferred options for Cook County and Grand Marais, MN				
	Option 1	Option 2	Option 3	Option 4
Total number of buildings	12	10	75	31
Annual heat demand	5,200 MMBtu	11,796 MMBtu	30,562 MMBtu	24,186 MMBtu
Boiler capacity	4.4MMBtu/hr	3.4MMBtu/hr	8.5MMBtu/hr	6.8MMBtu/hr
Piping, in linear feet	1,100	6,750	28,745	12,425
Biomass type	Clean chips	Clean chips Hog fuel	Clean chips Hog fuel	Clean chips Hog fuel
Annual biomass demand	390 DT	940 DT	2,450 DT	1,940 DT
Capital costs + hookups	$ 995,000	$ 4,040,000	$ 11,800,000	$ 7,330,000
Annual operating costs	$ 51,500	$ 178,950	$ 528,273	$360,019
Net present value* (20 year)	$ 1,012,158	$208,098	($ 2,828,098)	$ 1,306,862
Biomass cost of heat ($/MMBtu)	$23	$36	$44	$33

* Net present value is the current worth of future cash flows or savings, minus its current cost, at a 4.5% discount rate.

Source: Becker, Dennis R., Steve Taff, and David Wilson. 2012. *Pre-Feasibility Financial and Woody Supply Analysis for Biomass District Heating in Ely and Cook County, MN: University of Minnesota Report to Dovetail Partners, Inc."*

C. Emissions

Based on life cycle evaluations conducted as part of this project, the largest district energy systems considered in Grand Marais have combustion emissions 50 – 80% below Minnesota's Option D regulatory limits. When compared with similarly sized equipment using heating oil and natural gas, wood fuels produce higher emissions of several important air pollutants: particulates (PM), carbon monoxide (CO), methane (CH_4), volatile organic compounds (VOCs). Emissions limits could tighten in the future.

State of the art pollution control equipment would add to capital costs, but may have stong local support. Research indicates that use of an electrostatic precipitator would reduce particulate emissions for wood chips and hog fuel to 13 percent of uncontrolled emissions.

As stated above, critical factors in energy efficiency (and therefore, emissions per MMBtu) are high energy density and low transportation distances. When transport distances are great and heating density low, a stand-alone latest technology wood stove or boiler is a more attractive option than linking buildings via a district heating system.

The Cook County Local Energy Project committee has been interested in emissions associated with expanded use of residential wood-burning stoves. A campaign to install 500 residential cordwood stoves, even in a best case scenario (i.e., all stoves are EPA-certified), would collectively have much higher emissions compared to propane, heating oil, and natural gas for criteria pollutants. Incomplete combustion, intermittent operation, and lack of emissions controls are factors in the higher emissions, and would likely become problematic if use of wood-burning stoves were to increase significantly in the future. Pellet stoves have a large advantage over cordwood stoves in terms of emissions, emitting only 20% of many important air pollutants compared to similarly sized cordwood stoves.

In addition to direct, on-site emissions, logging and hauling would increase emissions of compounds by very small amounts with the exception of greenhouse gases. Depending on hauling distance, these gases could increase by as much as 30%. Life cycle impacts for the wood pellet and fossil fuel options occur outside the local area. The magnitude of these depends on hauling distance and the type of fuel used in drying wood in the pellet manufacturing process. Overall impacts may be 30-50% greater than reflected in local impact figures.

D. Environmental impacts

Cook County's geography and ecology range from gently rolling to steep terrain, with shallow soils, bedrock outcrops, and extensive peatlands. The county is dominated by forests 50 years and older. In the 60-mile supply zone around Grand Marais, the aspen-birch forest type occupies 415,659 acres (51% of timberland) and spruce-fir occupies 200,027 acres (25% of timberland). Of those acres, 53% and 42%, respectively, are greater than 60 years old and are either at or beyond their target harvest rotation age and are experiencing health declines.

Wildfire prevention and hazardous fuel reduction are priority concerns in Cook County and the area around Grand Marais. Currently, much of the woody debris from FireWise and similar programs is unmarketable and is piled and open burned. Using this material for bioenergy systems would reduce uncontrolled emissions and could help fund on-going wildfire mitigation work. Biomass harvesting may include some additional collection of understory and smaller-diameter materials, including balsam fir and species that create ladder fuels and increase wildfire risk. Other key conservation concerns that could be positively or negatively affected by biomass harvest are:

- *Water quality and fisheries*. The Lake Superior North Shore Highlands is an ecological region that includes Cook County and contain the state's highest density of designated trout streams, fed by surface runoff. Depending on the scale of operation, timber harvest and road building could change the quantity and rate of runoff, and increase sedimentation and water temperatures in streams. Forest management guidelines that are mandatory on public lands in Minnesota include practices related to riparian areas, buffer strips, and soil erosion from access roads and skid trails (Table 4). Some stakeholders believe that site plans should include water quality assessment at the sub-watershed scale to better protect water quality downstream.

- *Soil productivity*. Full tree harvesting (used to produce some types of wood chips) can increase losses of essential soil nutrients compared to traditional timber removals (i.e., bolewood harvest only). On sites with sandy or peaty soils, increasing the frequency and volume of biomass removal during timber harvest could damage and further reduce productivity. State and federal land managers restrict or prohibit biomass harvesting on sites with low nutrient (poorer) soils.

- *Wildlife*. The eastern Arrowhead region of Minnesota is important habitat for species listed as endangered, threatened, or special concern.[8] USFS management plans have been developed for some of these species to ensure that the impacts to their habitat needs are considered in harvesting restrictions and the biomass limits. Biomass harvest, if poorly implemented, could have negative impacts on Canada lynx, moose, snowshoe hare, timber wolf, and numerous bird species. The less sensitive populations of game and non-game wildlife are unlikely to be significantly affected either positively or negatively at the baseline level of harvest, as this level of activity does not significantly alter the overall distribution of habitat types. Long-term impacts are not well-understood and should be monitored and evaluated over time.

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[8] For more information about Species of Greatest Conservation Need for the North Shore Highlands Subsection, see: http://files.dnr.state.mn.us/assistance/nrplanning/bigpicture/cwcs/profiles/north_shore_highlands.pdf

- *Forest Restoration.* Forest management goals in the region include protection and restoration of pine forests (including in riparian areas), management for uneven-aged forests, preservation of sensitive ecological areas, and other goals that could be affected positively or negatively by biomass harvest.

Table 4. Summary of Minnesota's Biomass Harvesting Guidelines	
DO'S	DON'TS
During Biomass Harvesting:	***Avoid Biomass Harvesting:***
• Plan roads, landings and stockpiles to occupy a minimized amount of the site • Ensure that landings are in a condition to regenerate native vegetation after use, including tree regeneration • Avoid site re-entry to collect biomass after harvesting *(this reduces potential for soil compaction and damage to regeneration)* • Install erosion control devices where appropriate to reduce sedimentation of stream, lakes and wetlands • Retain and scatter at least one third of the fine woody debris on the site • Encourage native seed mixes and avoid introduction of invasive species • Retain slash piles that show evidence of use by wildlife • Leave all snags, retain stumps and limit disturbance of pre-existing coarse woody debris	• Within 25 feet of a dry wash bank, except for tops and limbs of trees • On nutrient-poor organic soils deeper than 24 inches *(These sites typically have sparse (25-75%) cover that is predominantly (>90%) black spruce and stunted (<30 feet high).)* • On aspen or hardwood cover types on shallow soils (8 inches or less) over bedrock • On erosion-prone sites (e.g. steep slopes of 35% or more) • In areas that impact sensitive native plant communities and where rare species are present • In riparian areas or leave tree retention clumps • In a manner that removes the forest floor, litter layer or root systems; these resources must be left within the forest

E. Supply chain implementation issues

A robust discussion about the logistics of harvesting, handling, processing, and transporting biomass was part of this study. Initial meetings with groups of federal, state, and county lands managers and loggers were followed by interviews with individual operators and fuel providers. In Cook County, key considerations are:

- *Public land manager support.* Active engagement by USFS Fuels Reduction Program is important given the dominance of federal land ownership around Grand Marais and in Cook County. Biomass utilization is believed to be critically needed to support wildfire reduction efforts and other conservation objectives. Revisions to forest plans will occur in 2014, and may provide more specific guidance on biomass harvest. There is openness on the part of federal forest managers to use approaches other than commercial timber harvest to manage forests, including long-term contracts for services;

- *Win-win strategies*. Identifying fuel procurement systems that meet the efficiency requirements of an energy plant and standards for sustainable biomass harvest and forest management are an important focus of continuing supply chain discussion. Coordination with forest management plan revision in coming year could set stage for addressing overage stands, forest restoration, and regional fuel supply issues.
- *Viability of the logging labor force*. Labor force capacity – the physical ability to get the work done on the ground – may be a more critical issue to bioenergy than supply issues in this county. The logging work force in Cook County is small, with few young people replacing retirees or those departing for better-paying jobs;
- *Fuel business viability*. The low volume of biomass used by small district heating projects in Grand Marais (under 2,500 DT per year) could make this a tough business venture for fuel producers and harvesting operations, particularly if specialized harvest or processing equipment needs to be purchased. Contracts for a guaranteed annual purchase and processing at central chipping facility (public or private) could improve business opportunities.

City of Ely

Ely, Minnesota is a community of 3,460 in St. Louis County. Ely is surrounded by Superior National Forest and is in close proximity to the Boundary Waters Canoe Area Wilderness. Tourism, pulpwood production, and mining are the largest economic sectors in the county. Ely is also home to Vermillion Community College. Drought and dry conditions in the area have increased fire danger in Ely, including the 2011 Pagami Creek Fire, which started following a lightning strike 13 miles from town and burned nearly 100,000 acres.

In 2010, the Ely City Council adopted an energy action plan that called for maximizing energy efficiency and renewable (wind, solar, and biomass) energy in the community. A strategy of interest is biomass district heating. An engineering study was completed for a biomass-fired district heat and co-generation (CHP) system linking the college, public schools, hospital, city hall and other large energy users. The city-sponsored Alternative Energy Task Force (AETF) elected to join this study to consider numerous issues not covered in the engineering study. Subsequently, at the request of the AETF, the US Forest Service and the Wood Education and Resource Center (WERC) funded technical studies of additional biomass energy options.

In an initial survey, community members:

- Expressed strong interest in obtaining more information on economic affordability and environmental impacts of biomass energy;
- Surfaced concerns that district energy would not be financially viable over the long-term; and
- Indicated a desire to see other options or alternatives to a large district energy system.

A. Wood supply

The 60-mile zone surrounding Ely includes timberland managed by federal, state, county, and private landowners, each with different management objectives, harvest rates, and restrictions. Across ownerships, aspen-birch forest types occupy 646,730 acres (40% of timberland) and spruce-fir occupies 560,647 acres (35% of timberland). Of those acres, 37% and 62% respectively, are greater than 60 years old and are either at or beyond their target harvest rotation age. The current available supply analysis is based on estimates of 2006-2010 harvest rates in the zone (Table 5). For comparative purposes, estimates used in the 1990 GEIS to study timber harvest impacts are also shown.

Table 5. Annual average biomass volume and delivered cost in 60 mile supply zone surrounding Ely, MN

Supply Zone	Annual harvest, *cords*[9]	Hog Fuel[10i]		Bolewood chips[11]	
		Green tons[12]	*Dry tons*	*Green tons*	*Dry tons*
Average Annual harvest (2006-2010, delivered cost[13]	291,298	74,465 $22 – 34/GT	44,679 $36 – 57/DT	57,182 $29 – 41/GT	34,309 $48 – 68/DT
GEIS/baseline scenario[14]	436,814	97,448	58,469	83,683	50,210

9 Assumes average 1.2 dry tons per cord, actual conversion vary by species.

10 Hog fuel is tops, limbs, branches, small trees, and needles. A conservative estimate of 50% is retained on site to meet MFRC Biomass Harvest Guidelines.

11 Bolewood is main stem of tree. Analysis assumes 10% of harvest devoted to biomass.

12 Assumes 40% moisture content at time of transport

13 Delivered cost of biomass reflects a hypothetical market price with assumed transportation cost of $4.25 per mile (25-green ton load at 40%moisture content with return trip) with in-woods processing costs of $11.47/dry ton (hog fuel) and $23.17/dry ton (clean chips). Table shows prices for haul distances from 0 – 60 miles.

14 Biomass removal estimates based upon the proportion of a statewide timber harvest rate of 4.0 million cords as estimated in the 1990 BaseScenario analyzed in the Final Generic Environmental Impact Statement (GEIS) for Minnesota.

In the area around Ely, an estimated 37,500 acres of over-aged (80+ years) Birch-Aspen forests, containing approximately 487,643 tons of biomass, could provide bolewood otherwise not merchantable for sawlogs and pulp mills. Bolewood chips are considered superior to hog fuel for most energy applications. Removing over-aged stands and replacing them with more vigorous and diverse forests is included in Superior National Forest forest plans to reduce fire hazards and improve forest health.

In addition to traditional timber harvest, both the City of Ely and St. Louis County operate brush pile collection sites that could be used for bioenergy. Ely collects 300 - 450 green tons of tree debris per year. St. Louis County handles a sizable portion of woody material at 10 free transfer sites (collection yards) in the county. An estimated 1,200 – 1,500 green tons comes from buckthorn removal projects, storm damage reclamation, landscape operations, and other sources per year. Seven of the 10 transfer sites are within 60 miles of Ely.

B. Technological options and financial feasibilities

Prior to the beginning of this study, LHB, Inc examined the feasibility of district heat and CHP for the residential and business districts of the community. Additional options for two smaller sites – the community college and a hospital school complex - were examined by Wilson Engineering in coordination with this study. A hybrid option, extending the hospital complex into the downtown area, was also assessed. Fifteen potential commercial customers of district heating in the downtown area were interviewed to determine (1) if they expected to make changes in heating systems in coming 5 years and (2) if they were interested in district heating. The input received through these interviewed informed the development of the district hearing options. Financial analysis included capital costs, annual operating costs & net savings, and 25-year Net Present Value. The three options of greatest interest (Table 6, following page) were:

1) Vermilion Community College, stand-alone hot water boiler for space heat and domestic hot water for 10 academic, administrative, and residential buildings. Pipes for district heating already exist;

2) Ely-Bloomenson Community Hospital and Sibley Nursing Home, and Independent School District 696, district heating using hot water boiler for space heating and domestic hot water;

3) Extension of Option 2 above plus 15 commercial buildings along Sheridan Street, Ely's core business district, a total of 18 buildings.

Table 6. Analysis of preferred options / City of Ely, Minnesota

	Option 1	Option 2	Option 3
Number of buildings	10	3	18
Annual heat demand (non peak)	7,680 MMBtu	16,235 MMBtu	21,381 MMBtu
Boiler capacity	3.3 MMBtu/hr	5.0 MMBtu/hr	7.0 MMBtu/hr
Piping, in linear feet	0 (already exists)	3,200	7,300
Biomass type	Clean chips Hog fuel	Clean chips Hog fuel	Clean chips Hog fuel
Annual biomass demand	527 DT	1,754 DT	2,559 DT
Capital costs + hookups	$ 1,934,318	$ 3,765,866	$ 5,459,348
Annual operating costs	$ 68,132	$ 126,607	$ 181,185
Annual operating savings	$ 139,873	$ 306,854	$ 405,833
Net present value (25 year)	$ 1,484,642	$ 3,877,825	$ 4,560,259

Source: Wilson Engineering Service and USDA Forest Service Wood Education and Resource Center. 2012. *Preliminary Feasibility Report, Ely Minnesota Biomass District Energy System and Addendum.*

C. Emissions

Direct on-site emissions for each of the preferred options are well below state and federal clean air regulations. Combustion emissions for the largest district heating option (hospital-school complex extended into downtown business district) are at least 80% below Minnesota's Option D regulatory thresholds. When compared with similarly sized equipment using propane, wood fuels produce higher emissions of several important air pollutants. Emissions limits could tighten in the future.

Standard emission control technology (multi-cyclone) is included in cost estimates. An electrostatic precipitator (ESP) could be added, costing approximately $250,000 – 300,000 more than estimates above. Research indicates that use of an ESP would reduce particulate emissions for wood chips and hog fuel to 13 percent of uncontrolled emissions. For instance, space heat and hot water for Option 2 (hospital-school complex) would generate emissions equivalent to 40 cords of wood burned in a fireplace if multi-cyclone technology is used, or 6 cords of wood with use of ESP technology.

Options 1 and 2 were identified based on high energy density and low transportation distances, the critical factors in energy efficiency (and therefore, emissions per MMBtu). Option 3, which extends Option 2 along Sheridan Street, more than doubles linear feet of piping without a commensurate increase in heat load, thereby reducing energy density and efficiency.

In addition to direct, on-site emissions, logging and hauling would increase emissions of compounds by very small amounts with the exception of greenhouse gases. Depending on hauling distance, these could increase by as much as 30%. When considering life cycle impacts for the wood pellet and fossil fuel options, significant impacts would occur outside the local area. The magnitude of these would depend hauling distance and the type of fuel used in drying wood in the pellet manufacturing process. Overall impacts may be 30-50% greater than reflected in local impact figures.

D. Environmental impacts

The Border Lakes is an ecologically-defined region of rolling hills, pine forests, exposed bedrock, and an extensive and connected network of lakes, streams, marshes, and peatlands. Prized remnants of virgin pine forests - jack pine, white pine-red pine, and hardwood-conifer – still survive in the Boundary Water Canoe Area Wilderness (BWCAW) and Superior National Forest. The 60-mile radii zone around Ely is dominated by the aspen-birch forest type, occupying 646,730 acres (40% of timberland), and spruce-fir occupying 560,647 acres (35% of timberland). Of those acres, 37% and 62%, respectively, are greater than 60 years old and are either at or beyond their target harvest rotation age. Wildfire prevention and hazardous fuels management are priority concerns. The Pagami Creek fire threatened homes, businesses, and cabins as it expanded outside of the BWCAW and into the vicinity of nearby Isabella. Other key conservation concerns that could be positively or negatively affected by biomass harvest are:

- *Water quality and fisheries*. Biomass harvesting in close proximity to streams, lakes, and wetlands could impact the highly prized water quality and fisheries in this region. Riparian zones and corridors connect and buffer isolated patches and promote biodiversity. Forest management guidelines (Table 4) that are mandatory on public lands in Minnesota include practices related to riparian areas. Site plans could include water quality assessment at the sub-watershed scale to better protect water quality downstream.

- *Sensitive plants*. Rare native plant communities, particularly where threatened or endangered species are known to occur need to be protected. The Minnesota County Biological Survey lists lands having populations of rare species and it is important to use the best available information in harvest planning. Biomass harvests could potentially impact native plant communities and rare species if sensitive sites and important habitats are not adequately identified and protected.

- *Soil productivity*. Inevitably, biomass harvest removes more nutrients than conventional bolewood harvest. Mineral soils are believed to tolerate such harvest rotations with little effect, but deep organic soils and very shallow to bedrock soils are susceptible to nutrient loss. Approximately one-third of 2012 timber sales on state land and administered by the Tower office of DNR-Forestry (Orr, Cook, Tower, Ely area) did not allow biomass harvest due to soil sensitivity.

- *Wildlife*. The Border Lakes region provides habitat for bear, bobcats, beaver, moose, owls and many other species of birds, amphibians, and small mammals. Fifteen species on federal or state endangered, threatened, or special concern lists are known to occur in the region, including Canada lynx and gray wolves.[15] The U.S. Fish and Wildlife Service has determined that the critical habitat for the lynx includes most of the Superior National Forest and other lands in northeastern Minnesota. Management plans for listed species may include harvesting restrictions, including for biomass. The less sensitive populations of game and non-game wildlife are unlikely to be significantly affected either positively or negatively at the baseline level of harvest, as this level of activity does not significantly alter the overall distribution of habitat types. Long-term impacts are not well-understood and should be monitored and evaluated over time.
- *Noise pollution*. The BWCAW is the largest un-roaded forest area east of the Rocky Mountains and one of the most popular in the Wilderness Preservation System. People travel here seeking solitude and a natural, untrammeled environment. Noise from logging and road building activities is not compatible with these experiences and can create conflicts, including with the region's important tourism economy. The majority of the forestland in the vicinity of the BWCAW is managed by the US Forest Service, MN DNR, and the St. Louis County land department. On public lands, winter is the predominant season for timber harvesting (and associated biomass harvesting), which corresponds with lower recreational use in the BWCAW.
- *Forest Restoration*. USFS forest restoration initiatives, including within the Fernberg Corridor, aim to manage areas currently dominated by non-native invasive plants and declining aspen and Jack pine forests and restore them to more diverse and long-lived conifer species. Biomass harvested during vegetation restoration work could help pay for this work, but – at present - area loggers are unwilling to bid on sites with such low merchantable material. Without biomass markets, these sites are expensive to manage, and require other funding sources. A number of wildlife habitat initiatives by private conservation groups could be partners in this work.

E. Supply chain implementation issues

The project included consideration of practical aspects of forest management, biomass and timber harvests, and the handling, processing, and transporting of biomass to an energy plant. Initial meetings with groups of federal, state, and county lands managers and loggers were followed by interviews with individual operators and fuel providers. In the Ely area, areas of interest include:

- *Biomass restrictions vary under different land ownerships*. Large blocks of forestland north of Ely are included in the BWCAW and off-limits to timber and biomass harvest, as are many other sites in Superior National Forest that contain sensitive plants, soils, habitat, and other ecological values. Biomass from pre-commercial thinnings, stewardship contracts, and fuels reduction projects on federal land is often not available to logging operators. On the other hand, St. Louis County forests have fewer such restrictions and, in general, land available for timber harvest is available for biomass removal.

[15] For more information about Species in Greatest Conservation Need for the Border Lakes Subsection, see: http://files.dnr.state.mn.us/assistance/nrplanning/bigpicture/cwcs/profiles/border_lakes.pdf

- *Public land manager support*. There is strong active engagement among county, state, and federal land managers in potential of biomass energy to assist in forest management in the area. As forest plans are revised in coming years, additional strategies for increasing biomass removal or addressing considerations on some federal lands may be included.
- *Logging labor force*. A number of operators in the area have the necessary equipment to harvest and supply biomass fuel, although better-paying jobs in mining and oil fields have reduced the local work force. Capturing logger attitudes and ideas about business models, cost assurances, profit margins, and other incentives could help enable the long-term sustainability of supplying bioenergy fuelstocks;
- *Interest in stewardship contracting*. There is openness on the part of the USFS to use approaches other than commercial timber harvest to manage forests, including long-term stewardship contracts;
- *Competition*. It is uncertain how competitive Ely will be with other nearby biomass (or roundwood) markets, including the Laurentian Energy Authority in Hibbing and Virginia. If a viable core of operators remains in Ely, and processing costs are the same, transportation costs (i.e., price of diesel fuel) will determine which markets have the competitive advantage.

Conclusions and Recommendations:

Transitioning to local, renewable energy is of great interest and offers important benefits to many rural communities and to the State of Minnesota. This project was a preliminary, or pre-feasibility, investigation of biomass energy options, impacts and trade-offs in two Northern Minnesota communities, Ely and Grand Marais. Based upon the outcomes of the project, the following conclusions and recommendations are provided.

1) A wide range of biomass energy approaches are available, including small to large system designs, different fuel types, with various potential environmental impacts and mitigations. Community members expressed strong interest in objective assessments of the economic viability of a range of options, before incurring the expense of a more in-depth feasibility study of a specific project.

2) Although the biomass projects being considered in Ely and Grand Marais are relatively small, locally-produced energy means that both positive and negative impacts occur locally. This is not the case with imported fossil fuels, in which most impacts (mining, processing, production, transportation, etc.) occur elsewhere. Emphasizing multiple-benefit projects - increased energy self-sufficiency, improved forest management and wildfire protection, additional job opportunities, and retaining local energy dollars locally – is strategically important when district energy systems requiring public support are being considered.

3) When considering district energy options, high heat density (heat load per linear foot of piping) is critical to energy efficiency, financially feasibility, and environmental protection. Building a relatively small, high-density system that can be expanded over time could both meet these criteria and bring benefits of experience to development of more expansive systems in the future.

4) Fuel types have important tradeoffs in terms of costs, emissions, equipment requirements, ability to reduce fire prone materials, harvest practicalities, and other issues that must be carefully considered in the design of a biomass energy system. Hog fuel (i.e., timber harvest residue) is abundant, stable in price, and would reduce buildup of this material in area forests, but it produces higher levels of air pollutants than drier, more uniform fuels made of bolewood. Producing fuels from bolewood from overaged and un-merchantable trees and other waste wood supplies could increase energy efficiency and lower emissions without increasing market competition and forest harvest rates. Careful consideration of tradeoffs between forest management objectives, energy production needs, and environmental impacts is crucial to community plans for renewable energy conversion.

5) Removing harvest residues intensifies the impacts of traditional bolewood harvest. For this reason, and because long-term effects of biomass harvest are poorly-understood, use of precautionary approaches (as detailed in MFRC Biomass Harvesting Guidelines), site evaluations and field surveys before harvesting, monitoring and evaluation over time are important components of community biomass energy systems.

6) Community-driven initiatives require strong community participation and input throughout all aspects of the project. It is important to structure a project design to accommodate and prioritize direct community engagement (e.g., via the inclusion of a community liaison study team member). Successful community-driven project design and involvement by key supply chain participants, responsible governments, potential customers, and community groups results in shared responsibility and decision-making authority in transitioning to renewable energy systems.

7) Future community-driven biomass energy projects in the region can utilize the findings from this study to reduce or avoid time and costs associated with some components of biomass feasibility evaluations. This summary report and the other products from the project (see list on the following page) provide a significant amount of information about various biomass options, financial comparisons, and environmental considerations that can help other communities more quickly identify viable alternatives for utilizing this form of renewable energy.

Many rural communities are interested in using locally-produced renewable energy sources to increase energy independence, lower costs, and reduce greenhouse gas emissions. Having credible, objective information on the scale of these impacts and the tradeoffs they represent is crucial to communities considering new energy sources. The design and outcomes of this project can help inform other communities that share similar interests and concerns.

Publications

Background research reports and final executive summary, presented to local project partners and public officials. All titles available from Dovetail Partners or online at http://www.dovetailinc.org/content/lccmr-supporting-community-driven-sustainable-bioenergy-projects

Becker, Dennis R., Steve Taff, and David Wilson. 2012. *Pre-Feasibility Financial and Woody Supply Analysis for Biomass District Heating in Ely and Cook County, MN: University of Minnesota Report to Dovetail Partners, Inc."* contains the full analysis of the biomass system options and the modeling of financial performance, including a discussion of assumptions and key metrics.

Bratkovich, Steve. 2012. *Local Environmental Considerations Associated with Potential Biomass Energy Projects in Cook County and Ely, Minnesota* uses GEIS and consultation with local experts to assess affects of biomass harvest in supply zones.

Bowyer, Jim. 2012. *Life Cycle Impacts of Heating with Wood in Scenarios Ranging from Home and Institutional Heating to Community Scale District Heating Systems* contains data from wood energy research and applies this information to options considered.

Fernholz, Kathryn and Cheryl Miller. 2012. *Supporting Community-Driven Sustainable Bioenergy Projects, Final Report, Executive Summary* highlights key findings of all background research reports.

Miller, Cheryl A., and Kathryn Fernholz. 2013. *Community-Driven Biomass Energy Opportunities: A Northern Minnesota Case Study* is final and comprehensive report on study.

Miller, Cheryl A., Gary Atwood, and Gloria Erickson. 2012. *Supply Chain Logistics and Concerns" is available from the project website or by contacting Dovetail Partners.*

Wilson Engineering Service and USDA Forest Service Wood Education and Resource Center. 2012. *Preliminary Feasibility Report, Ely Minnesota Biomass District Energy System and Addendum.*

Fact sheets for community members in Ely and Cook County

- "Emissions and biomass energy in Northeast Minnesota" (separate versions for each community)
- "Environmental Impacts of Biomass Harvesting and Wood Energy Production in Northeastern Minnesota"
- "Forestry and biomass energy in Northeast Minnesota"

Other publications produced by Dovetail Partners to support this project

- "Heating With Wood: Using wood to heat your Northern Minnesota Home"
- "Protecting Minnesota's Forests While Utilizing Biomass Resources: *An Overview of the Minnesota Forest Resources Council's Forest Biomass Harvesting Guidelines"*
- "Using Biomass in Minnesota (5 case studies)"

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