COMMUNITY-BASED BIOENERGY AND DISTRICT HEATING

BENEFITS, CHALLENGES, OPPORTUNITIES AND RECOMMENDATIONS FOR WOODY BIOMASS

DR. STEVE BRATKOVICH

DR. JIM BOWYER
DR. JEFF HOWE
KATHRYN FERNHOLZ
ALISON LINDBURG

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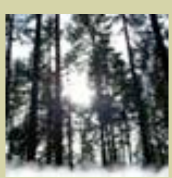

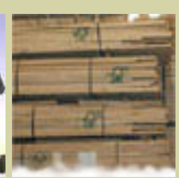
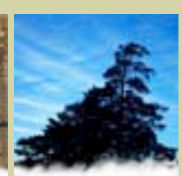

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Benefits, Challenges, Opportunities and Recommendations for Woody Biomass

Introduction

With oil prices peaking at an all-time high of $145 per barrel in July 2008, there is a renewed focus on using wood for energy. Woody biomass is a renewable fuel that holds promise to help the U.S. become more energy independent.

Using wood for energy in the United States is not a recent development. Up until the 1880s, wood generated more energy for our nation than coal. However, beginning more than a century ago fossil fuels replaced wood as "energy king". Alternatives to fossil fuels have been promoted in the U.S. since the oil embargo of 1973. Today, renewable energy sources (biomass, solar, wind, hydroelectric, and geothermal) supply about 7% of U.S. energy consumption. Wood and other forms of biomass provide approximately 50% of the total renewable energy consumed in the country.[1]

Wood's abundance, renewability, versatility, and carbon-neutrality make it well suited as a feedstock for energy applications, and as an alternative to fossil fuels. Wood can be used to produce thermal energy, electricity, and transportation fuels. The technologies for transforming woody biomass into energy include direct burning in boilers or other combustion devices and pyrolysis 'action' that results in a range of 'energy products' such as liquid fuels, char, and gas.

Applications that include the generation of thermal energy range from direct combustion for home heating (residential wood stoves burning firewood and wood pellets) to large-scale industrial uses (forest products manufacturing plants drying lumber). Wood-based electrical generation includes stand-

Combined Heat and Power in St. Paul, MN

District Energy St. Paul uses wood chips (up to 1,000 tons per day) and other fuels (natural gas, oil, coal) to fuel its district heating and cooling systems. With the 2003 startup of an adjacent wood waste-fired combined heat and power plant, District Energy has reduced its reliance on coal and oil by 70%. Using a renewable fuel produces significant environmental benefits (soot emissions are down 50% as well as greenhouse gas emissions) and helps the community solve a local wood waste disposal problem. Customers benefit from reduced costs, an alternative fuel source, and the knowledge that they are using an environmentally sustainable source of 'green energy' for heating and cooling.

District energy produces hot water, steam or chilled water at a central point and distributes the energy through underground pipes to buildings. Customers use the hot and chilled water to meet their space heating, water heating, processing and air conditioning needs. The water then returns to the central plant for re-use.

Currently, heating service is provided to more than 185 buildings and 300 single-family homes, representing over 31.1 million sq. ft. of building space, or 80% of St. Paul's central business district and adjacent areas. Cooling (air-conditioning) is provided to more than 95 downtown buildings, representing 18.8 million sq. ft. of space.

Additional benefits include the elimination of more than 150 smokestacks and 50 cooling towers on downtown buildings. Also, more than 300 chimneys have been eliminated on nearby homes.

(http://www.districtenergy.com/services/index.html)

[1] See Energy Information Administration Statistics at http://tonto.eia.doe.gov/energy_in_brief/renewable_energy.cfm.

alone power plants as well as cogeneration facilities where both heat and power are produced (paper mills for example). Transportation fuels that can be derived from wood include ethanol, methanol, gasoline, and diesel.[2]

District heating, employed as a wood-fired system to distribute thermal energy to institutions, industries, and individual homeowners, is a proven and efficient technology that has been widely adopted in European countries and selected U.S. locations. District heating can be cost-effective, provide economic benefits and stimulate the local economy, while offering new and expanded markets for woody biomass. A coordinated series of actions is needed at the federal, state, and local community level to expand the adoption rate of woody biomass as a heating fuel in the U.S., and the ability to transform our nation into an energy independent country should be enough incentive to move us boldly in this new direction.

This report is part of the *Seeing the Forest AND the Trees* project of the Blandin Foundation's Vital Forests/Vital Communities initiative.[3] This report specifically focuses on the thermal uses for wood as it applies to (1) district (community) heating and (2) combined heat and power (electricity) applications (cogeneration or Combined Heat and Power, CHP). District heating and CHP have enormous potential in the upper Midwest, including Minnesota. The opportunities and challenges of expanding district heating projects in the region are explored in this report. Lessons learned from around the U.S. and from other parts of the world are presented, as well as recommendations for further domestic development.

Background

District heating can be defined as space and water heating for a number of buildings by a central plant or other shared heat source. The heat produced in the central plant is typically delivered as hot water or steam through an insulated, double pipeline system. Once the heated water travels to its destination and "gives up its heat", the cooler water is returned via pipeline to the plant for reheating. Any fuel (such as wood) or source of surplus thermal energy that has the capacity to heat water to approximately boiling temperature (212 degrees F) can be used in a district heating system.[4]

District heating provides thermal energy needs to institutions, industries and individual homeowners. Thermal energy needs include space heating for maintaining human comfort, domestic hot water requirements, and process heating for manufacturing plants. When district heating is combined with electricity (power) generation, the system is often referred to as Combined Heat and Power (CHP), and a more efficient energy system is created.

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[2] See Zerbe (2006) for a more complete description of the use of wood in thermal, electrical, and transportation fuels applications.

[3] For more information about this project and the initiative, see www.blandinfoundation.org

[4] This definition adapted from "Environmental Benefits from District Heating in the Nordic Capitals". Available at: http://www.energy.rochester.edu/nordvarm/env/.

Nordvarme, an association for cooperation between district heating associations in the five Nordic countries[5], offers this simple descriptor of the difference in fuel efficiency between CHP plants and traditional power plants:

For each eight "barrels of energy" consumed in a combustion plant:

- One "barrel of energy" is lost through the chimney or in the plant;
- Three "barrels of energy" are converted to useful electricity;
- Four "barrels of energy" are wasted in cooling systems OR Four "barrels of energy" are converted to useful district heating.

Although district heating (especially using woody biomass) is not widespread in the United States, it is increasingly employed in several regions of the country and within specific sectors.[6] In Vermont, 20 percent of students attend public schools that are heated by wood energy. A similar "Fuels for Schools" program is currently being promoted in the western U.S., and hospitals in many states have replaced traditional fuels with wood energy district heating and cooling. One of the best known district heating systems in the U.S. is that of the city of St. Paul, Minnesota which uses primarily urban wood wastes for district heating and cooling plus power generation.

Güssing, Austria

Leaders in Güssing (pop. 3,811) evaluated their local economy and realized their annual energy costs were 6 million euros. All of the energy was imported, while local farm and forest resources were underutilized. A plan was implemented to convert from fossil fuels to renewable energy.

Güssing became the first European town to produce its energy needs from local renewable sources. Solar, biomass, bio-diesel, and bio-gas are a 13.6 million euro industry. Almost all (99%) of Güssing's 1,500 households, schools, hospital, businesses and industrial park are heated and cooled with biomass. Fifty farmers have contracts to supply fuel to the systems, and electricity generation is 150% of local needs. Güssing now has over 1,000 jobs relating to energy and the mayor estimates that over 18 million euros now stays in the region due to the use of local renewables.

http://www.energyagency.at/index.htm

District Heating Examples from Europe

Many European countries have long traditions of district heating.[7] Over 100 years ago Denmark commissioned its first CHP plant using household waste to generate electricity with the surplus heat used for district heating. In 2005, Denmark had 430 city-wide (public) district heating systems with 300 CHP units and 130 heat-only boilers. All the heat-only boilers and 15 of the CHPs are fueled by wood or straw. In addition, there are about 480 private (small) CHP and heat-only plants (for greenhouses, schools, etc.). Also, 60% of all houses and residential units in Denmark are supplied with district heating; 25% (or more than 600,000 houses) are heated by biomass-based district heating (Larsen 2005). For many decades,

[5] The Nordic countries represented by Nordvarme include Denmark, Finland, Iceland, Norway and Sweden.
[6] District heating has been used in the U.S. since the late 1880s. However, the use of woody biomass in these systems has not experienced wide-spread adoption.
[7] The practice (and discussion of) district heating in Europe typically includes district/community heating as well as combined heat and power and district cooling.

oil was the primary fuel as district heating spread throughout the country. Renewable energy sources—wood, straw and biogas—became important fuels during the oil crises of the mid- and late-1970s. Climate policies became the key driver for renewables in the 1990s.

Helsinki, Finland established its district heating system in 1952 to supplant expensive and scarce fuel after World War II. District heating is now distributed to almost the entire city. On a countrywide basis, district heating accounts for almost 50% of the total heating market.[8] Finland boasts that it is number one in the world in bioenergy use with 25% of the nation's total energy consumption in 2004 coming from renewable sources. Woody biomass accounted for over 73% of all biomass and peat fuel use in 2003.[9]

Sweden has over 400 wood-fired district heating plants each with a capacity of over 5 MW.[10] Wood fuel in district heating has increased six-fold since 1990 and in 2007 contributed nearly one-half of the feedstock for district heating. In 2007, district heating (as an "energy carrier") contributed about 12% of the total supply in Sweden. At the same time, district heating made up approximately 29% of the energy delivered to the residential and service sectors throughout the country (non-industrial).[11] Renewable energy, as a share of total energy generation in Sweden, was nearly 44% in 2007.[12]

A recent article in Science magazine[13] highlights the fact that it's not only the Scandinavian countries that are seriously moving forward with district heating systems. In Austria, for example, more than 1,000 advanced wood combustion (AWC)[14] systems (i.e., district heating systems) have been constructed that provide a total of over 1,000 MW of thermal energy. Nearly all are community-based and locally operated. Additionally, there are more than 100 biomass-fired combined heat and power plants (CHPs) in Austria. Austrian officials hope that biomass and hydropower will account for 45% of their energy needs by 2020.

Benefits of Wood-Fired District Heating Systems

High Efficiency with Existing Technology

District heating systems can achieve very high efficiencies; 85% to 90% efficiencies have been reported. The overall efficiency of a CHP is at least double that of a stand-alone power station.[15]

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[8] For additional information on district heating in numerous countries see http://www.absoluteastronomy.com/topics/District_heating.

[9] See Bioenergy in Finland at http://www.finbioenergy.fi/default.asp?init=true&InitID=398;0.

[10] See European Union On-Line report at http://ec.europa.eu/energy/atlas/html/body_biohint.html.

[11] See "Energy in Sweden, Facts and Figures, 2008". (See table for figure 7). http://www.swedishenergyagency.se/web/biblshop_eng.nsf/FilAtkomst/2054.pdf/$FILE/2054.pdf?OpenElement.

[12] Ibid. (See table for figure 11).

[13] Richter, D., et al. 2009. Wood Energy in America. Vol. 323, pp. 1432-1433 (March 13).

[14] Advanced wood combustion (AWC) is a wood energy system that includes temperature, combustion air, fuel feeding, and emission products monitoring technology interfaced with computer numeric controls.

[15] According to Maker (2005), "Generally, these systems [CHP] have higher efficiencies than do power-only systems, and so represent a more cost-effective way to produce electricity."

Future development of wood energy for electricity and transportation fuels relies heavily on new technologies. However, many of the solutions in the heating market do not require new technology to the same extent needed for electricity and transportation fuels. With 75% of total energy consumption in buildings used for space and water heating (Hillring 2008), wood-fired district heating systems can play a significant role in replacing fossil fuel dependent systems and greatly improving efficiencies while using existing state-of-the-art technologies.

Using Local Resources

Hauling distances for woody biomass district heating systems are usually kept to a local scale. The economic viability radius for transporting logging residues (without dependable rail service) is often 50 miles or less; urban waste wood transport areas can be slightly larger (e.g., up to 70 miles). Therefore, wood-fired district heating typically uses local wood resources and often provides an outlet for wood that otherwise might have little or no market value. In many urban situations, the wood has a *negative* value in that it is an economic burden to dispose of. Since district heating uses nearby biomass resources (purchased from local landowners and other suppliers), local labor is employed to cut, haul, chip, and deliver fuel. "Energy jobs" are generated in the local community and increase local economic activity. Increasing the use of local woody biomass supports the local tax base and builds tax revenues. The net impact is that more dollars remain in the local community with an accompanying positive economic multiplier effect.

An Advanced Wood Combustion (AWC) System in Spring Valley, Pennsylvania

AWC systems have increased dramatically in Europe since the oil crisis of the 1970s and '80s. Fuel shortages and national commitments to the reduction of greenhouse gases as a result of Kyoto Protocols have spurred technological advancements. AWC systems maximize fuel efficiency and minimize emissions via an automated heating system that requires a minimum of operator intervention. Unfortunately, such systems with UL approval and American Society of Mechanical Engineers certification were not available in the U.S. until 2008. Such certification is critical for installing AWC systems in public and commercial buildings due to insurance and building code requirements.

One such AWC system was recently installed in Spring Valley, PA at the Bruderhof Community. The system serves a 9 building district heating system that includes over 134,000 sq. ft. of two story buildings. These buildings include a kitchen/dining hall complex, apartment buildings, a laundry, and a school. The system includes a 2.4 million Btu per hour boiler, a 3,000 gallon thermal storage unit (insulated hot water tank), and over 2,400 feet of insulated hot water distribution/cold water return lines.

Dollars and Sense

In addition to wood, district heating systems typically are designed (especially in Europe) to burn other forms of biomass such as municipal trash and local agricultural residues.[16] Since "waste energy" is gathered from a variety of sources, the systems can respond to the availability and price of various fuels (including fossil fuels). Woody biomass fuel is often less expensive than competing fuels. In general, biomass prices have tended to be stable and are not directly linked to national or global energy markets. Maker (2005) used 2003 fuel prices and seasonal efficiencies of a heating plant to compare net

[16] Many district heating or CHP plants are designed as multi-fuel plants capable of burning renewables such as wood in addition to fossil fuels like coal and natural gas.

fuel costs for the following fuels: green hardwood chips, No. 2 and 6 fuel oil, electricity, LP gas, natural gas, and coal. In all instances, green hardwood chips were the least expensive fuel when comparing usable heat output (Btus).

The Fuel Value Calculator, developed by the U.S. Forest Service, Forest Products Laboratory, can be used to compare unit costs of various fuels.[17] The user of the calculator can "set" the price of one fuel and compare the price of other fuels at the same heat content. For example, based on typical boiler efficiencies, fuel costs of $3/million Btu could be maintained by using green wood at 50% moisture content (MC) on a wet basis at $17.22/ton or natural gas at $2.46/1000 cubic feet or electricity at $0.010/kWh. All three approaches offer the same heat content and same final fuel cost on a Btu basis. In another example ($15/million Btu), green wood at 50% MC could be purchased at $86.10/ton and provide the same heat content as natural gas at $12.30/1000 cubic feet or electricity at $0.050/kWh.[18]

From a Danish perspective, the Danish District Heating Association reports that 98% of all district heating consumers pay less for their heat generated from biomass and other fuels as compared to heat from household-based oil boilers; and 92% pay less when compared to individual natural gas boilers (Larsen 2005).

Environmental Advantages

Burning wood in modern high-performance combustion units to generate thermal and electrical energy is considered a "green" technology. According to Zerbe (2006), air and water emissions are less problematic from burning wood than from burning or gasifying coal. Coal can produce sulfur (acid rain), mercury, and other heavy metal products. These emissions do not occur with wood, and the air emissions of particulates from burning wood can be controlled through the use of advanced combustion technologies to limit unburned hydrocarbons and by installing readily available emissions control technologies that clean exhaust gases. According to Spitzer and Graz[19], heat production from a combined cycle power plant operating on wood chips produced only 60 g CO_2 equivalent for each kilowatt-hour of energy produced, compared to 427 g from a similar plant using natural gas. Also, burning wood for energy (where the wood is derived from sustainable forestry practices) causes no net increase in the buildup of greenhouse gases. When wood replaces fossil fuels, there is a net reduction in greenhouse gas emissions. Wood is a renewable resource whereas fossil fuels are not. Wood also is an abundant resource. Growth exceeds harvests on U.S. timberlands by 33%, and the total acreage of U.S. forests has remained essentially unchanged for nearly 100 years.[20] Using low-value or "waste" wood for energy applications from fire and pest-prone forests can increase the overall health and vigor of the

[17] See Fuel Value Calculator at http://www.fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf.

[18] These values include typical boiler efficiencies but do not include handling, storage, maintenance, amortization, or other costs associated with the type of fuel.

[19] See "Greenhouse Gas Emissions of Bioenergy Systems" (slide 12) at: http://ec.europa.eu/research/energy/pdf/gp/gp_events/biorefinery/bs4_03_spitzer_en.pdf.

[20] For a detailed description of U.S. forest resources see Smith et al. 2004 at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=1987.

forest resource. Forest health management practices such as thinnings and fuel load treatments can help protect communities and reduce reliance on costly fossil fuels.

Challenges of Wood-Fired District Heating Systems

Despite the long history and continued success of district heating systems in Europe and other regions of the world, challenges to growth are evident in the U.S.

Investment and Operating Costs

Although district heating systems typically provide long-term energy and cost savings, the short-term start-up costs can be a disincentive. Depending on the type of district heating system, an individual, institution or industry might be required to make a considerable upfront investment, especially if converting from a traditional fuel system to woody biomass. For some, the concept of using woody biomass as a primary heat or power source conjures up the notion of “risky investment.” This notion can sway decision makers, even if the “numbers look good on paper.”

State-of-the-art biomass systems typically have similar maintenance costs and personnel needs as compared to facilities that burn oil or gas. However, there are some biomass systems (especially older installations) that report increased maintenance costs in the form of either operator time or parts replacement and repair.

Competition for Supply

Expanded bioenergy markets could (especially in the short-term) drive up the price of wood fiber, putting some existing wood businesses at a competitive disadvantage. This is a legitimate concern for select existing domestic industries, including industries located in Minnesota and the Midwest. For example, research in Minnesota found that current mill demand exceeds in-state supply and that this excess demand has been met in the past through imports from other states and Canada. The development of energy markets may make these suppliers less likely to ship to Minnesota, resulting in increased costs and greater reliance on locally produced materials. The challenge for industries in this position will be to see the expanding role of wood fiber for energy in a positive light. Industries that are threatened by more outlets for wood fiber will need to find opportunities to benefit from the expanding energy markets. Also, the current downturn in the forest products industry, coupled with a shrinking wood harvesting workforce, presents challenges to wood fuel production in the near-term.

Wood Pellet Fuels

Woody biomass comes in different sizes, shapes and moisture contents in the form of logging debris, sawmill residues, chips, urban trees, scrap lumber, etc. To be burned efficiently and economically, wood fuel needs to be appropriately sized for the specific wood combustion system. Pellet fuels are gaining in popularity because they are a renewable value-added energy product that are uniform in size and moisture content, easy to handle and store, provide a clean hot burn, and contain little dust and no bark.

Global pellet production is about 9 million tons (mostly from wood). About 60% is estimated to be used in small- and medium-scale burning units (stoves, home boilers and small district heating plants). The remaining 40% is used for large-scale consumption, including district heating plants and power plants. (Hillring 2008)

The forecast for 2010 is that global pellet production will reach about 16 million tons with Europe expected to consume 12 million tons. Sweden is the world’s largest producer and consumer of wood pellets. (Hillring 2008)

Change in Forest Management Regimes

If wood for bioenergy use approaches the level of intensity as in some European countries, then the forest management regimes practiced in the northern locales of Minnesota and many parts of the United States will likely change. It may become economical to conduct more intermediate treatments and thinning operations. These changes could provide forest health and productivity benefits but could also result in a need for more forest roads and an increase in impacts to soil and water resources due to increased frequency of site disturbing activities. Biomass markets may also impact the utilization standards (and utilization techniques) with more material being removed from harvest sites. This change in practice could provide a reduction in fuel loading and help manage the risk of wildfire, but may also harm soil productivity and wildlife habitat by removing ecologically beneficial coarse woody debris from the forest. Land managers have recognized these concerns about biomass harvesting and several states, including Minnesota and Wisconsin, have developed biomass harvesting guidelines that address retention levels and other considerations that aid in minimizing the negative impacts.[21] These guidelines have been added to the existing guidelines that have been put in place to support forest management objectives related to soil and habitat protection, biodiversity and responsible harvesting practices.

Crotched Mountain Rehabilitation Center in Greenfield, New Hampshire

The Center includes a school, hospital, out-patient clinic, brain injury center, media center and athletic complex. In 2004, the managers and staff explored ways to reduce operating costs. The use of wood to provide energy was selected as part of the Center's strategy.

Today, this facility is an excellent example of community scale woodchip heating in action. The Center burns bole woodchips in two side-by-side boilers that deliver heat, cooling, and hot water throughout the 250,000 square foot multi-building campus via a network of underground supply and return pipes . A local logging contractor stores pulpwood at his yard just 10 miles away and chips it directly into trailers for periodic delivery to Crotched Mountain's heating plant.

During the 2007-08 heating season the system burned about 1,500 tons of wood chips, saving the Center about $250,000 in fuel costs (the equivalent of paying about $0.61 per gallon for fuel oil). When the system is implemented campus-wide, savings of over $1 million per year are expected.

For more information, see http://www.crotchedmountain.org/crotchedmountain/html/woodchipplant.ht

Public Concerns

The public, in many cases, views wood burning as "dirty" and discourages its use. For example, the construction of a proposed wood burner in the Phillips neighborhood of Minneapolis was cancelled in 2008 due to concerns that the community already had too much pollution.[22] Images of concern included whining wood chippers, rumbling wood delivery trucks, and unsightly piles of biomass invading the neighborhood. Some people undoubtedly believe that wood energy is old fashioned. For many, "green energy" means wind and solar - not trees, scrap lumber, wastepaper and wood chips. Proponents of bioenergy need to address these issues in an upfront manner through collaboration with stakeholders.

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[21] For more information about biomass harvesting guidelines, see the report prepared by the Forest Guild. Available at: http://www.forestguild.org/publications/research/2009/biomass_guidelines.pdf

[22] See http://www.neighborsagainsttheburner.org/files/NOEcoBurn.cwk%20(WP).pdf.

There are also public and social concerns about the cost of energy produced from district heating or CHP facilities. For decades, fossil fuels were relatively inexpensive. The idea of using a renewable fuel like wood in a different heating and power configuration represents a significant change in the status quo. Societal inertia must be overcome and long-term benefits explained to ease concerns and gain public support for the development of new systems incorporating "new" fuels like wood.

Climate Change Policy

Although the U.S. is beginning to take seriously the need to reduce greenhouse gas emissions, the effort falls short of the current situation in Europe. Policies in Europe are clearly driving the expansion of renewable energy. For example, recently established binding targets for the share of renewables in total energy for each European Union member range from 10% for Malta to 49% for Sweden (Hillring et al. 2008). It is reasonable to expect that heat and power projects in the U.S. will increasingly be expected to meet greenhouse gas emission targets and comply with evolving climate change policies.

Opportunities for Minnesota and the Midwest

Wood, along with solar, wind, and other renewables, is poised to play a key role in helping achieve local, regional and national renewable energy mandates. In 2007 Minnesota enacted a renewable portfolio standard (RPS) that requires that 25% of the state's electricity come from renewable power sources by 2025. Xcel Energy, the major electricity supplier in Minnesota, is required to achieve a 30% renewable benchmark by 2020. This mandate and other developments in the marketplace indicate that there may be opportunities for expanding and supporting wood-derived district heating systems in Minnesota and the Midwest.

Build on Success in Europe

The same technology used in Europe could be more widely adopted for use in the U.S. One of the distinguishing characteristics of European systems is that district heating comprises a network where heat can be obtained from various sources such as from waste generation, electricity generation via CHP, industrial exhaust heat, and heat from solar and geothermal sources. Secondly, numerous European systems have the flexibility to switch between fuels (renewable and non-renewable) to take advantage of price fluctuations and local resource availability. These factors have contributed to the growth of district heating in Europe by keeping down the costs to customers.[23] The numerous successful examples of district heating and CHP systems throughout Europe provide a basis for further developments domestically and in Minnesota.

[23] See "Community Heating – The European Success Story" at http://www.energy.rochester.edu/uk/chpa/commheat/eursuccess.htm.

Build on the St. Paul Example

The district energy system in St. Paul, Minnesota, is the largest wood-fired CHP plant in the nation. It simultaneously produces about 65 megawatts of thermal energy for its nearby customers and 25 megawatts of electricity for the grid (Xcel Energy).

The St. Paul system is an example of adopting a European model in the U.S., including both of the key elements of successful European systems – using "waste" heat in a CHP plant and the flexibility to burn multiple fuels. The system generates power while also heating and cooling buildings and homes in downtown St. Paul. The Minnesota State Capitol is one of the buildings served by the system. In addition, the St. Paul system utilizes a seemingly "waste" resource in the form of urban wood and tree removals as a primary fuel source, demonstrating that urban wood utilization can be done efficiently and economically. The St. Paul system is particularly attractive for replication in other high-density communities where distribution costs (pipelines, for example) can be minimized while still serving a large number of customers.

District Heating/CHP in Rural Areas

The Laurentian Energy Authority (LEA) recently converted two existing public district energy cogeneration plants in Hibbing and Virginia, Minnesota from coal to biomass.[24] The biomass fuel includes local logging debris (waste wood, limbs, tops, underutilized species, etc.), agricultural residues, "closed loop" dedicated energy crops (hybrid poplar, willows) and brush, and right of way clearings. LEA has a 20-year contract to sell 35 MW of biomass electricity to Xcel Energy. The LEA provides steam and heat for 3,600 residential and commercial customers.[25] One of the key elements in the LEA example is that existing cogeneration plants fired by coal (or other non-renewables) are potential targets for conversion to woody biomass systems since much of the infrastructure to transport the heat and power is already in place As of 2006, there were 176 cogeneration plants in Minnesota, Wisconsin and Michigan.[26] As these plants age and need to be updated, there are opportunities for conversion to biomass combustion systems.

One method of expanding district heating (and CHP where appropriate) in rural areas is to investigate small-scale opportunities with schools, hospitals, prisons, industrial sites, municipal buildings and other potential heat and power customers. For example, in Vermont the first school conversion was in the mid-1980s and focused on electrically heated schools. More recent conversions resulted from the need to replace 30+-year-old oil boilers or were done in conjunction with major renovations or construction. Currently, 41 Vermont schools are heated with wood-fired systems and more are in the design phase; schools range in size between 23,000 and 390,000 sq. ft. All of the wood-heated Vermont schools combined use only 20,000 tons of

[24] For an overview of the LEA project see http:/www.hpuc.com/web-content/biomass/Renewable%20Energy%20Devel%20.ppt.

[25] The gross revenues to Hibbing and Virginia over 20 years is projected to be greater than $700 million with a total of $1.2 billion of impact when economic multipliers are applied.

[26] See Midwest Cogeneration Association's CHP Application Center at: http://www.chpcentermw.org/home.html.

green wood chips per year. Annual fuel cost savings average nearly $61,000 per school (with a range of $8,000 to $171,000) which is an average savings of about 53%.[27 28]

A Fuels for Schools project in six western states (Nevada, Utah, Idaho, Montana, Wyoming, and North Dakota) has supported the construction of 14 wood heat systems since 2003 with two additional ones in the design/construction phase. Annual fuel savings at the 14 facilities is estimated at over $1.8 million. The costs of the projects ranged from $200,000 to $8.2 million.[29] In Pennsylvania, a "Fuels for Schools and Beyond" project has supported biomass heating projects in public schools, a private greenhouse and a hospital.[30]

A recent study in Wisconsin (P Squared 2008) found that 11 schools currently heat with biomass but up to 300 could potentially save money by switching from natural gas to wood. The Wisconsin Secretary of Agriculture has set a goal of having 100 schools utilize wood heat by 2015. Schools needing to replace existing boilers present some of the best opportunities for conversion to biomass heating.

Build on Existing Forest Industry Infrastructure

Many wood-based businesses in Minnesota and the Midwest utilize their own wood residues for heat and, to a lesser degree, to generate power. For facilities not completely energy self-sufficient, there are opportunities (perhaps by acquiring additional wood) to become energy independent. In other instances, existing wood-based firms could become net producers of energy for other uses, especially where power grid or heat transfer infrastructure exists nearby or could be easily capitalized.

School Examples Across the U.S.

Mountain View School District – This district in Pennsylvania installed a wood-biomass boiler system in 1991. School buildings totaled 200,000 sq. ft. Fuel (wood chips) is supplied under contract with a local firm. In 2006, the school district saved over $114,000 by heating with wood chips versus fuel oil. With the addition of a cyclone exhaust cleaning system, much of the particulate material is removed and there have been no difficulties meeting or exceeding state air quality requirements.

Barron (Wisc.) Area School District - A wood boiler system was installed in 1980 to provide steam for the town's schools plus a hospital/medical center and senior home. During the 2002-03 heating system, 2,570 tons of wood chips were used at an average cost of $28.37 per ton or $0.323/therm (compared to natural gas at $0.776/therm). Total annuals savings are $100,000. In 2004, Johnson Controls, Inc. installed an upgraded monitoring and heat control system saving an additional 75,000 therms per year. At current gas prices of $1.07/therm, additional savings of $82,260 are achieved.

Darby, Montana School District- Three oil-fired systems were replaced by a wood-fired system that served three buildings totaling 82,000 sq. ft. Total costs for combustion and fuel handling systems plus heat transmission lines was $885,000. During 2003-04 the district saved $24,500 in fuel costs with savings increasing to $61,500 in 2004-05. Fuel costs were reduced from $0.63 per sq. ft. (oil) to $0.35 per sq. ft. (wood).

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[27] For more information on wood heating systems in Vermont schools see http:/www.nhrcd.net/WoodEnergyppts/NH%20Wood%20Heating%20Penacook.ppt.

[28] Personal communication with Lew McCreery, USDA Forest Service.

[29] For more information on Fuels for Schools see http://www.fuelsforschools.info/projects.html.

[30] For additional information on the Pennsylvania Fuels for Schools and Beyond project see http://www.pafuelsforschools.psu.edu/case_studies/elk.asp.

The central point with existing forest industries is that they have a strategic advantage since they have the know-how and infrastructure to purchase and handle wood. These companies also have a built-in option for value-added processing and knowledge of other value-added markets as a way to facilitate sorting and obtaining the highest possible value for forest resources.[31]

Forestry and Agricultural Partnerships

Many biomass energy systems are designed to burn multiple fuels, including wood *and* agricultural residues. Too often the forestry community focuses exclusively on forests and wood residues and the agricultural community zeros in on crops such as wheat straw, corn stover, and switchgrass. There would appear to be opportunities for greater cross sector collaboration on the development of biomass energy systems, and the absence of forestry and agricultural partnerships can be a limiting factor for some projects. For example, switchgrass is a highly touted bioenergy feedstock. However, switchgrass has a limited harvest window and storage of bulk bales can pose a challenge due to degradation. While wood in some forms also has drawbacks (i.e., size and moisture content of chips), a biomass energy system that utilizes the best characteristics of both fuel sources could provide maximum efficiencies and minimum costs. Switchgrass (or other agricultural products) could be utilized at the appropriate time of year to take advantage of their maximum heat output, and the less-perishable woody biomass could be used during the agricultural off-season. Thoughtfully combining the use of both agricultural and woody biomass might prove advantageous to certain projects. Multiple biomass feedstocks could diversify supply options across ownerships and resource categories.

New and Expanded Markets

Bioenergy in the form of woody biomass creates new and expanded markets for loggers, forest landowners, land managers, forest product brokers, selected wood manufacturers such as sawmills, and others. Bioenergy provides these entities with another option for marketing logging residues, underutilized species, dead or pest-infested trees and mill manufacturing residues. In addition, urban wood waste including trees, pallets, other forms of scrap wood, and construction and demolition waste could experience an increase in demand. In some instances, these new and expanded market opportunities will be continuous markets, providing a reliable stream of income for landowners and others. Landowners with a dominant objective of maximizing economic returns, including Timberland Investment Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs), may have particularly strong interest in the biomass markets if it provides sufficient return.

[31] Personal communication with Keith Jacobson, Minnesota Department of Natural Resources, Forestry Division.

Recommendations

The following is a short list of recommendations to help guide decision-makers in their quest to better understand and promote the development of district heating systems utilizing woody biomass (including CHP).

- *Use a collaborative approach when evaluating district heating opportunities.*[32]
  All projects have legitimate pros and cons; consequently, all stakeholders should be engaged from the beginning including wood suppliers, existing wood industries, consumers, utility officials, environmental groups, systems engineers, neighbors, etc.

- *Provide education and technology transfer resources to all stakeholders.*
  There is a learning curve associated with district heating systems and their development. Providing education and technology transfer resources to project partners and other stakeholders can increase understanding and address key concerns and questions that may otherwise negatively impact the project.

- *Work with Small Business Administration, Small Business Development Centers, and other economic development organizations to foster entrepreneurship in the area of wood energy*[33]. It is important to develop and nurture the right *mind-set* for localized wood energy projects. Champions for district heating systems can come from all backgrounds and experiences. The more district heating is discussed and evaluated, the more likely opportunities will be discovered to implement a system.

- *Develop appropriately scaled biomass energy projects.* Caution needs to be exercised to build facilities that do not lead to long-term problems like unsustainable forest management or negligible community benefit. For example, biomass projects should be part of an integrated wood utilization program that sorts wood to its highest and best use. A biomass energy system should not "steal wood" from an existing industry that has a higher/better use for the wood.

- *Promote thermal energy applications of woody biomass (and CHP where appropriate).* New start-up stand-alone power plants fired by wood should be a much lower priority due to their inefficiencies.

- *Think community scale—distributed and decentralized energy production.* Using the wood resource close to the stump delivers high conversion efficiency, creates local "green" jobs, and recirculates money in the local economy. Priority for district heating projects at the community level should be given to municipalities with their own municipal utility. This can provide an operational home for the project plus

[32] A good guide for collaboration on the topic of wood energy is "Harnessing the Power of Local Wood Energy: Ensuring a sustainable supply of woodchips for your school (A community resource guide)" by Caitlin Cusack, 2008 at http://www.forestguild.org/publications/research/2008/Local_Wood_Energy.pdf.
[33] Opportunities for cost-share assistance should also be explored with the USDA's Rural Energy for America Program (REAP). See http://www.rurdev.usda.gov/rbs/farmbill/.

access to credit and grants. It is also important to look for areas where homes and businesses are clustered tightly together and nearby source of reasonably priced fuel exists.

- *Encourage biomass energy projects that link multiple buildings.* Such projects provide larger and more stable markets for biomass fuel products and make installation of emission control technologies more cost effective. This eliminates the need for multiple combustion units thereby improving overall air quality.

- *Focus on efficiency in modern biomass combustion systems. Such systems combine computer controlled state-of-the-art combustion and emissions control technologies with automated fuel-feeding systems.* A good model to follow is that of the Advanced Wood Combustion Systems (AWCs) currently being deployed across Europe. These systems are computer controlled, use thermal storage technology to maximize combustion efficiency, and reduce fuel use.

- *Develop tax incentives for biomass thermal energy systems and enhance woody biomass production tax credits and other financial incentives for renewable biomass.* Tax policy can significantly help or hinder biomass energy development. In Vermont, for example, state cost-share assistance for construction of school heating systems using renewable energy was critical to success.[34] However, subsidies or other government incentives should not be used in a manner that unduly tilts the playing field in favor of one form of renewable energy over another. It is important that incentive programs reward renewable energy systems in general without picking specific winners and losers.

- *Encourage light-on-the-land harvesting, handling, and processing technologies for woody biomass to energy projects.* Several states have established biomass-harvesting guidelines and conduct logger training workshops to deliver information about responsible harvesting practices.

- *Support cost-effective programs that build capacity and provide technical assistance to communities and others who are exploring wood energy options.* For example, federal programs that once delivered direct technical support to communities (like the U.S. Forest Service's Economic Action Program) were discontinued in recent years. Many University Extension and State forestry agency programs also have been downsized in the areas of technical support to wood-based industries and related natural resources programs. These and similar programs will need renewed support if communities are going to have the necessary resources for engaging in district heating development.

[34] In 2001 Vermont raised the reimbursement rate for construction of school heating systems using renewable energy to 50% (up from 30%). In 2003 the State legislature raised the reimbursement rate to 90%. In 2007 the rate was rolled back to 75%. Currently, there is a moratorium on state funding of school construction. See (http://www.biomasscenter.org/berc-in-the-news/130-reading-writing-and-renewables.html.

- *Support legislation to change the definition of renewable fuels to include woody biomass materials from public lands and private non-plantation forests.* As the Energy Independence and Security Act of 2007 is currently written, woody biomass from National Forests and other public lands, plus most private forestland, is excluded. The upshot is that cellulosic ethanol derived from this "excluded" feedstock does not count toward the expanded Renewable Fuels Standard (RFS), resulting in blenders and refiners having no incentive or requirement to purchase biofuels produced from these sources. The RFS requires that 36 billion gallons of renewable fuel to be in use by 2022.[35] The significance to wood-based district heating is that future legislation written to encourage thermal energy systems could use the same definition of woody biomass, thus excluding the majority of forestland in the U.S. and suppressing future development of this industry.

- *Recognize thermal energy applications in Renewable Portfolio Standards.* The use of fossil fuels for heating and cooling must be reduced. Providing RPS status for thermal applications would increase the use of renewable in these applications and be an incentive for biomass CHP projects.

Bottom Line

District heating, employed as a wood-fired system to distribute thermal energy to institutions, industries, and individual homeowners, is a proven and efficient technology that has been widely adopted in European countries and selected U.S. locations. District heating can be cost-effective at different scales (from public schools to large cities), provide economic benefits in the form of jobs and stimulation of the local economy, and offer new and expanded markets for woody biomass. When combined with electricity generation, the combined heat and power plant (CHP) provides important operational efficiency improvements over stand-alone power generation stations.

For the U.S. to significantly move forward with district heating systems and expand the adoption rate of woody biomass (and other forms of biomass) as a fuel, a coordinated series of actions is needed at the federal, state, and local community level. Chief among these actions is a commitment and dedicated long-term effort to vigorously pursue biomass-based district heating. The ability to transform our nation into an energy independent country should be enough incentive to move us boldly in this new direction.

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[35] Legislation was reintroduced on March 18, 2009 by Senators Thune (South Dakota), Tester (Montana), and Chambliss (Georgia) to correct the definition of woody biomass to more closely conform with earlier versions of the RFS and the 2008 Farm Bill.

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612-333-0430

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DOVETAIL PARTNERS, INC.
528 Hennepin Ave, Suite 202
Minneapolis, MN 55403
Phone: 612-333-0430
Fax: 612-333-0432
www.dovetailinc.org