Stabilizing Energy Costs for Communities Using Local Biomass: Economics of Community-Scale Wood Heating and CHP

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Summary. Municipalities and communities are negatively impacted not only by high fossil fuel costs, but also by volatility in fuel pricing – particularly for heating oil. When prices rise sharply and unpredictably, budget impacts can be difficult to manage. There is a growing body of experience, accumulated over the last twenty years, indicating that use of local biomass – principally woodchips – delivers significant, reliable cost savings with little fuel price volatility. Communities in rural forested areas are beginning to think about new models for community energy based on the large-scale replacement of fossil fuels with local renewable fuels provided on a sustainable basis. There is a growing interest and demand for woodchip and pellet fuel systems to be used in municipal, institutional and commercial buildings, and in downtown district energy systems. While the economics of heating single buildings with biomass fuels are well understood, that is not true of district energy systems or the community-wide economic impact of replacing fossil fuels with local biomass fuels in many individual buildings. This paper discusses both the micro and macro scales of economic impact from substituting local biomass fuel for fossil fuels in heating and medium-scale CHP applications.

Keywords. *Community heating, biomass heating, community-scale biomass, district heating, community energy economics.*

Introduction

Communities in rural forested areas are particularly threatened by increases in the cost of heating fuel, particularly in areas, like the Northeast, where fuel oil and propane (both unregulated on price) are the major fossil fuel sources. The Northern Forest Center found that, in 2006, fossil fuel purchases represented a $6 billion drain on the economies of the Northern Forest region of New York, Vermont, New Hampshire and Maine.[1] While fossil fuel purchases for heat represent a very large one-way dollar outflow from regions with no fossil fuel resources, this drain hits all members of all sectors of the economy, including building owners, large and small businesses, municipalities, state government, institutions, non-profits, home owners and renters. These exported fossil fuel dollars come entirely out of the earnings and wealth of all members of the affected regions, whether rich or poor, profitable or non-profit, municipality or state.

When fossil heating fuels dramatically increase in price, it is effectively an automatic pay cut and loss of business profitability impacting everyone across the region's economy, threatening businesses and individuals alike and leading to serious reductions in state and municipal tax revenues–and with an inevitable negative impact on public budgets and services.

Such an increase in fossil fuel prices took place in the mid-2008, with heating oil prices reaching as high as $4.50 per gallon in the summer. Homeowners and businesses who depended on oil had

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to decide whether to lock in that price as a hedge against the possibility of further price increases during the winter, or whether to bet that oil price would go down by waiting to see what the spot market had to offer. As it turned out, prices had dropped dramatically by the beginning of the heating season and those who locked in oil contracts lost out. For the heating season, homeowners who made this bet one way or the other had $1000 to $2000 to gain or lose for the winter–a big impact for anyone, but particularly for the poor. Public schools, with taxpayer-approved budgets in place, had to make a bet in the summer that might swing the spending impact $100,000 one way or the other.

While extreme volatility in fossil fuel prices is very difficult to deal with on a budgetary basis, sustained escalation in fossil fuel price represents economic un-development: loss of jobs, less money in the economies of affected regions, less spending, and loss of those businesses whose profits are eroded beyond the breaking point.

What is the likelihood that fossil fuels will exhibit long-term manageable increases in price over the coming years and decades? The answer to this question lies in assessment of domestic and global oil production and demand. US oil domestic oil production peaked in 1970. Since then, over the last 40 years, not even the development of the large oil fields in Alaska has made it possible to pump more oil out of the ground in the US than we did in 1970. During that time the increased US demand for oil has been met largely by increasing the level of imports. But what happens when global production oil peaks? Projections by governments around the world and by reputable analysts put the inevitable global peak anywhere along a time scale starting with "now" out 30 years into the future (world-wide production has never been as high as it was in the middle of 2006, leading some to suggest that the global peak may have already passed).

With global oil demand on the rise, fueled by the increasing oil appetites of China, India, Indonesia and other rapidly developing countries, when the planet passes its production peak, supply and demand will diverge with the inevitable results of rapidly increasing price for oil and increased competition for the diminishing resource.

This eventuality will pose serious problems for rural communities, particularly in oil-dependent parts of the country. Not only will the price of oil rise, draining wealth out of these economies, but all fossil fuel users will find themselves in competition for the diminishing resource. Rural areas will compete against cities, states will compete against each other, nations will be under increasing pressure to secure oil militarily, and different uses of petroleum (energy, fertilizer, plastics, transportation, pharmaceuticals, chemicals, etc.) will compete on price for the scarce resource. Rural communities in the US and their inhabitants will not be positioned to fare well in this global competition.

There are conventional resources for buffering these impacts, notably increased efficiency and switching to non-oil fossil fuels (natural gas and coal). There is no question that the best way to address building heating energy is to dramatically improve the energy-efficiency of existing buildings and to create more efficient new buildings. However, to make a big difference across society will take a very capital intensive approach, whether to massively retrofit old buildings or

to replace old buildings with new ones, and neither approach will eliminate the need for heating fuel. Areas of the county already served with natural gas infrastructure will be in a better place than those without. However, it is not a foregone conclusion that natural gas pipes will ever be brought to all or most of the regions that now lack this infrastructure. Furthermore, analysts believe that just as there is an inevitability of a global oil peak there will follow a global natural gas peak. Both resources are finite and non-renewable. Abundant coal resources may be tapped for power production and conversion to liquid transportation fuels, but will not likely become widely used as heating fuels in areas that do not now produce or use coal.

Heating Buildings with Biomass

The logical answer to the heating problem discussed above (assuming an ongoing commitment to making buildings more energy efficient) is to find renewable alternatives to heating with oil, propane, natural gas and coal–alternatives available in sufficient quantity to replace fossil fuels completely over the coming decades. The wind and hydro resources are uniquely matched with power production and are unlikely to be developed to a level where wind and new hydro-generated electricity could take over as a major way to heat buildings. Solar energy is an integral part of advanced, energy-efficient building design and is key to the creation of a new generation of zero-energy buildings. However, it will be very difficult–if not practically impossible–to retrofit the majority of existing buildings to the extent that solar space heating will be able to substantially replace fossil fuels for heating. The two renewable resources that hold promise to meet the need to supplant fossil fuels for heating buildings are geothermal and biomass. The remainder of this paper will focus on the opportunity for using biomass to displace fossil fuels.

Biomass Heating Fuels

Biomass that can be used for fuel can come from a variety of sources. Woody biomass is available as a waste (or a low-value byproduct) from the wood manufacturing industry and as a low-grade byproduct from forest harvesting, logging or thinning operations. It can also be extracted from the municipal solid waste (MSW) stream. Another potential source of woody biomass fuel is plantation forestry, in which fast-growing trees are planted and harvested like an agricultural crop, then chipped into useable form. Biomass is also available for fuel coming from agriculture, either as a crop residue (such as corn stover, rice husks or wheat stalks) or as a dedicated energy crop (such as switchgrass or other grasses).

All of the forms of biomass mentioned can be made available with minimal processing for use as a direct combustion fuel for heating. Wood wastes, for example, are typically chipped or ground at the source (in the forest or in the mill) to make them more readily transportable. Low-value trees are cut to length and split for use as residential firewood. It is rarely cost-effective to dry biomass fuels, although some drying may happen naturally before the fuel reaches the point of use. While agriculturally-derived biomass can be directly used as heating fuels, there are currently very limited technology options for combusting these energy resources, even at large scale. The direct combustion options for biomass heating are limited, at this time, to a variety of forms of minimally-processed low-grade wood: woodchips, firewood, sawdust, ground-up MSW wood, and hog fuel (mixed ground residues from the forest products industry). Outside of the

forest products industry, only two of these are widely available and used as heating fuel: woodchips and firewood. The use of these two direct-combustion biomass fuel is largely determined by the type and scale of combustion technology available on the market. Firewood, because of the labor involved in handling it, is almost entirely constrained to use as a home heating fuel, either in wood stoves (which are space heaters) or in small boilers and furnaces for central whole-house heating. Woodchips, as discussed below, can be used to fuel a variety of heating applications starting at small commercial buildings and extending up to campus and municipal district heating systems.

The other approach to biomass heating is to process the biomass feedstocks into a variety of forms of bio-fuel, either solid or liquid. The most common of these is the wood pellet. Wood pellets are made from dried sawdust or from other forms of woody biomass dried and ground before pelletizing. In the US to date, wood pellets have been sold almost exclusively in 40 pound bags as a residential pellet stove fuel. Compared to woodchips, wood pellets are dry, uniform, manufactured to specifications, and flow well – making them a very desirable renewable fuel. As a manufactured product, wood pellets have always cost significantly more than woodchips or other forms of un-processed wood waste. The pellet industry is now starting to develop a different market approach for pellets: the bulk-fuel market that has been in use in Europe for years. Bulk pellet delivery requires specialized trucks, similar to oil and propane delivery trucks, with pneumatic systems to blow the pellets through a hose that fills the customer's pellet silo (which can be located in or adjacent to the building). To date all residential pellets on the market have been made from low-grade wood feedstocks, but work is under way to pelletize grass, paper, other burnable wastes, and blends of these forms of biomass.

There are also significant technology developments to use woody biomass feedstocks to create liquid fuels that could displace fuel oil, kerosene, and "diesel" heating fuel (as fuel oil is called in some western states). The leading form of such biomass fuels are the pyrolysis oils, which are now being produced commercially although at modest scale. Pyrolysis oil can be used as a direct replacement for fuel oil. However, it may be more valuable as a renewable feedstock to be blended in refineries to make a variety of energy and non-energy products. As a manufactured product, neither the per-gallon price of pyrolysis oil nor the conditions under which it will be an economic replacement for fuel oil is clear.

Applications and Technology for Biomass Heating

The applications where firewood makes sense as a heating fuel are well understood. It is primarily a stove fuel for residential use by homeowners who are willing to go through the work of handling wood to get the dollar savings. New water-storage and other clean-burning firewood boilers are now on the market and will extend the use of firewood to larger buildings and multi-building complexes where labor is available to handle the fuel. Wood pellets are also well understood as a residential stove fuel. Their use in central whole-building heating systems, mostly employing hot water boilers but also warm air furnaces, is likely to become common as oil prices rise over time.

Woodchip boilers are not widely understood, except in certain parts of rural America (notably the Northeast and the northern Rocky Mountain states) where they have been used for heating schools and other institutional buildings. Woodchip boilers produce hot water (or, in some cases, steam or warm air) using automated equipment to move the fuel from a large storage bin to the combustion chamber. The technology is fully mature, although there are new developments in emissions control and a heightened interest in European technology, which is widely perceived to be cleaner and more efficient than domestically manufactured equipment. The capital costs of automated woodchip boiler systems, including the cost of constructing the storage bin and boiler room, are significantly higher than the cost of an oil or gas system. For schools and other institutional uses, where a full-size backup oil or gas boiler system is usually kept in place to assure full 24/7 reliability, the high cost of the biomass system can only be afforded if there are enough fossil fuel savings to off-set the principal and interest payments on the woodchip system. This places a lower limit on the size of facility at which a woodchip system will be cost-effective. Generally, this threshold size is in the range of 1-2 million Btu/hour (1-2 MMBH) boiler capacity–about the size of a 40-50,000 square foot school that might have 200-300 students, for a cold climate in northern-tier states.

Below this size, wood pellet boiler systems are more likely to be cost-effective. Wood pellet systems are considerably less expensive to build because the fuel storage silos are much less expensive than woodchip bins and the fuel handling equipment is also more straightforward and less costly. In addition, pellet boilers are smaller than woodchip boilers and may not require the construction of a large dedicated boiler room. Pellet systems are more likely to be chosen by building owners where fuel storage and boiler room space are limited, where delivery truck access is more difficult, and where capital for system construction is limited, compared to woodchip systems. Pellet boiler systems are much more flexible in the types of applications where they fit in, both in terms of space and budget. There are many small commercial applications where pellet boilers will be a good choice. For larger facilities, where there is enough space to locate the system, woodchip systems are more likely to be chosen because the low fuel cost will outweigh other considerations.

The same technology that is used in schools and similar-sized buildings, is also available and in use in larger applications like hospitals, prisons, and campus central heating plants. Woodchip systems are also a good match for municipal district energy systems, which use one or more central plants to feed a hot-water distribution grid of buried, insulated piping to carry the heat from the plant to user buildings, as a form of municipal infrastructure. These systems are like a municipal water system, except that the product that is metered and sold is heat. Hot water district energy systems, many using biomass fuel, are common in Europe but have not caught on in the US, despite a current high level of interest. Until some good working models can be put in place, it will continue to be difficult to conceive, quantify, and organize biomass-fired district heating systems.

The efficiency of using wood residues for heating is high, compared to the low efficiency of using wood fuel to make electricity. There is a real interest in wood-fired combined heat and power (CHP) systems, but little understanding of the available technology and its significant

limitations. Currently available wood CHP technology is limited to steam-cycle equipment, including high-pressure steam boilers, steam turbines and generators. These systems produce about 15 times as much heat as electricity, and so should rightly be used only in applications where the primary need is for heat. Electrical output is only 5-10 percent of input energy in systems where the heat and electrical output are used optimally. If the system is run to produce more power, efficiency drops sharply. These systems are most cost-justified in the forest products industry where the facilities can use their own residue streams for wood fuel, and in some campus and district energy applications where there is a very large winter thermal (heating) load and a significant summer thermal load (such as domestic hot water, or absorption cooling).

There are new wood CHP technology options on the near horizon, including engine-coupled gasifiers, direct and indirect combustion turbines, Stirling engines, and organic Rankine cycle (ORC) devices. Some of these are commercial in other countries, while some are still under development in the US and elsewhere.

Economics of Biomass Heating

Among the many compelling of reasons for installing biomass heating plants, the foremost for building owners are the low fuel costs and low operating costs of modern woodchip and pellet heating systems.

The following table, developed for the Maine Forest Service based on prices of fuels paid in the 2007/2008 heating season by Maine schools2, demonstrates the fuel cost advantage of biomass fuels compared to fuel oil.

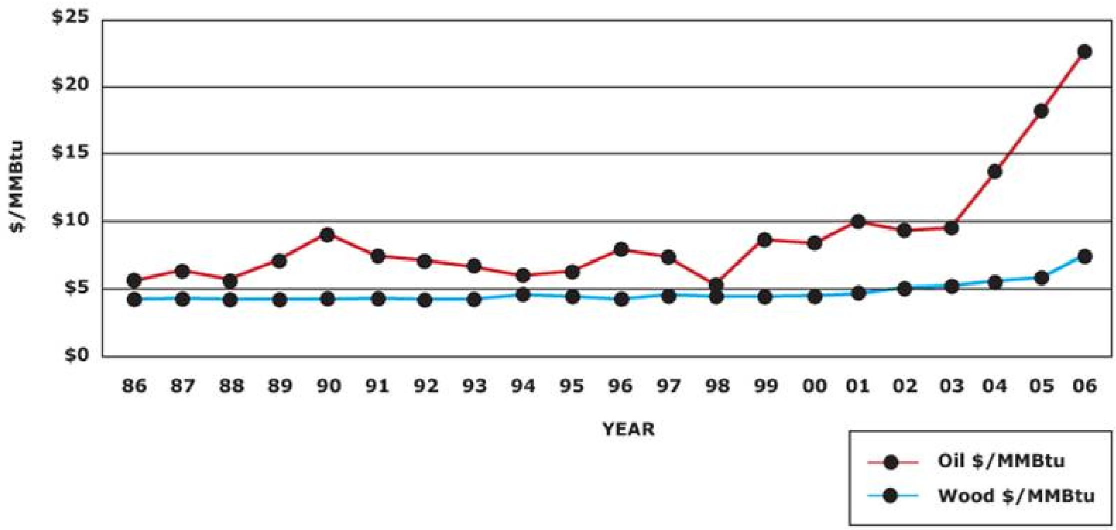
Fuel Type	Unit	Cost per Unit	BTU per Unit (dry)	Moisture Content	Average Seasonal Efficiency	Cost per MMBtu After Combustion
Oil	gallon	$2.30	138,000	0%	80%	**$20.83**
Wood Pellets	ton	$220	16,500,000	5%	75%	**$18.71**
Wood Chips	ton	$50	16,500,000	40%	65%	**$7.77**

The right-hand column shows the price paid for the equivalent amount of heat available to the building, for each of the three fuels. It can be seen that woodchips saved 63 percent and wood pellets saved 10 percent that year, compared to oil. The oil price is fairly typical of prices paid by schools and similar-sized facilities in northern New England before the sharp increase in mid-2008, when oil climbed up over $4 per gallon (and six months later retreated).

The following graph shows the average price for heat from oil and woodchips paid by schools in Vermont over a 20 year period. The price shown for each fuel is per million Btus of heat delivered to the building, accounting for system efficiency. The graph shows that, over 20 years, the price of woodchip heat has always been below the price of oil heat, with the difference becoming dramatic since 2003. It also shows that the price of oil heat has been volatile and unpredictable, while the price of wood heat has increased slowly and steadily, on average at about the rate of general inflation over the 20 year period. While it uses data from Vermont schools, the

lessons learned from this graph apply equally to any large facilities buying wood in place of oil during the same time period.

Vermont Schools: Woodchip and Oil Energy Price History



Over the 20 years of Vermont school history of heating with wood (there are now 45 public biomass-heated schools in the state), the simple payback of woodchip heating system installations has ranged from about eight years (today) to 12 years (in the late 1980s). Schools have generally received at least 30 percent state-aid cost share. Because these districts have typically financed the school share of the capital cost over 20 year terms, in many cases they have achieved positive cash flow in the first year or two after installation–meaning that the oil-to-wood fuel cost savings were greater than the increased operating costs (finance payments plus increased operating, maintenance and repair costs), yielding a positive budget impact. Because oil prices have increased significantly faster than woodchip prices (twice the rate of general inflation over 20 years), school districts have seen the fuel cost savings easily outstrip the finance payments over time, resulting in better economics than those predicted in feasibility studies before system construction.

In 2008 the complete project cost of retrofit school woodchip systems (including the installed system, connection to the school's existing heating plant, controls, building construction, and design) was in the range of $800,000-$1 million. Wood pellet systems for smaller schools cost about $150-700,000. These costs apply equally to other settings where systems are designed by licensed architects and engineers and construction is carried out by general contractors selected on an open competitive bid basis.

For significantly larger systems where woodchips replace fuel oil for heating, as in college or university central heating plants, the economies of scale lead to more dramatic savings and faster payback times. A 2005 study of installing a 60 MMBH woodchip-fired steam boiler in a new state-of-the-art natural gas central campus energy plant at the University of Massachusetts Amherst showed a five to six-year payback on the $9-11 million wood system, even though the

displaced natural gas energy was based on the highest-efficiency equipment available and used natural gas under a very attractive long-term pricing contract.[3] First year savings to UMass were calculated at $1.9 million, including Renewable Energy Credits worth $0.5 million. The modeled wood boiler would provide 65-70% of all energy to the central steam plant, used for heating, cooling and power production. The price of woodchips available to the project at the time was $26 per ton delivered to the campus, and the price of natural gas was approximately $0.80 per therm.

New Biomass Based Energy Infrastructure For Communities

The descriptions above of community-scale woody biomass technology and its applications look at specific building uses of biomass, campus settings and downtown district energy systems. However, these descriptions do not paint a picture of how the energy economies of communities in rural forested areas (and the lives of community members) might be transformed if local wood resources were fully embraced as a substitute for fossil fuels.

Vision for Wood-Using Communities

At a meeting of the Northern Forest Biomass Energy Initiative in 2006, Mary Ann Hayes of Maine Rural Partners gave her vision of what these transformed communities, fully connected to their forest resources and disengaged from fossil fuels, would look like:

> People in the region will wake up in the morning living in communities with biomass central heating serving the downtowns and village centers, and with central wood pellet heating for smaller clusters of buildings. Individual homes not connected to these heat grids will have pellet boilers or advanced wood stoves. The wood residues to fuel the new community energy economy will come from nearby, sustainably-managed forests. Downtown district energy plants will use wood to make electricity simultaneously with heat, to complement wind, hydro and solar photovoltaic power generated across the region. The hospitals, schools, campuses and shopping malls will be models of energy efficiency and will all run on wood-fired combined heat and power systems. People will live in green-certified homes and drive cars that run on biodiesel and gasoline substitutes made form wood and farm residues. The many renewable energy businesses and manufacturers that have been attracted to the region and have prospered here will pay good wages because of their participation in the new, profitable green sector of the economy. These businesses will attract people from around the country to live in the Northern Forest's vibrant, historically grounded communities. The region will be known for its stewardship of natural resources and attention to air and water quality, and will have schools known nationwide as places where children learn about sustainable practices, forest management and the value and local economic benefits of the forest-based green economy.

This is an attractive picture, but what will it take to make this transformation of the economies of rural forested areas? How strong is the economic rationale? What are the barriers and how can they be overcome?

Economic Rationale for Transformation

A 1992 report of the Northeast Regional Biomass Program[4] quantified the economic development benefits of using wood fuel for energy. Updating its findings with current fuel prices, adjusting for inflation, and using the results for one typical northeastern state, it can be concluded that the direct benefits of using 100,000 tons of woody biomass as fuel would create the following direct economic benefits:

- Total income in the wood-using region increases by $9.7 million
- State and federal tax revenues increase by $1.8 million
- 132 jobs are created[5]

To give an idea of the overall impact for a typical northern state "downtown community" which fully substituted all of its fossil heating fuels with wood residues and pellets, it would take approximately 100,000 tons of green wood residues annually for a community with an approximate population of 20,000. In addition to the economic benefits to the region listed above, oil and propane imports into the community for heating might be reduced by 6 million gallons and 1 million gallons respectively, on an annual basis.

In addition to these direct economic benefits, the use of woody biomass as fuel creates monetizable carbon benefits, supports and stabilizes the forest products industry, reduces energy costs for users, and keeps energy dollars in local economy instead of exporting those dollars to other states, regions and countries.

Direct substitution–which can be defined as directly replacing fossil fuels with biomass fuels in community-scale applications–is most powerful in user economic terms when woodchips and other non-manufactured residues are used for heating, to replace expensive fossil fuels directly. By comparison, approaches where unprocessed biomass feedstocks are manufactured into value-added energy products–like wood pellets or cellulosic ethanol– will use the wood resources less efficiently and produce higher-priced biofuels, on a dollars-per-Btu basis. While the development of manufactured biofuels at industrial scale is a critically important part of moving to a renewable energy economy, there will always be an important role for direct substitution of wood for oil and gas as a heating fuel, particularly in rural areas where the biomass feedstocks originate.

Direct substitution of woody biomass in heating is also the most efficient and cost-effective way to use forest-based energy resources, as exemplified by the following hierarchy of uses:

1. Space heat, industrial process heat, and other thermal uses
2. Combined heat and power (CHP) – with applications limited by conventional technology
3. Power production (utility scale)

Space heating is approximately three times as efficient as using wood resources for stand-alone power production. Wood-fired power plants using today's steam-cycle technology convert only 15 to 30 percent of the energy in the wood fuel to electric output, with the remaining 70 to 85 percent of the energy vented to the atmosphere from cooling towers. The

smaller the power plant, the lower the efficiency–with plants smaller than 20 MW wasting over 80 percent of the input energy in the wood fuel. While it is important to support existing wood-fired power plants as sunk investments in renewable energy and as key players supporting the existing logging and forest harvesting industry, new stand-alone plants should not be supported or incentivized as a matter of public policy. The best way to support these plants is to make strategic investments to capture their wasted thermal energy and use it for district energy, agricultural production (e.g. large-scale greenhouse heating), or co-located biofuels or bio-products manufacturing. In this way, existing wood power plants would become CHP plants or multi-product bio-refinery sites.

Full-Spectrum Biomass Energy for Communities
While there is not enough low-grade woody biomass to meet all the nation's space heating needs, particularly for urban areas, there is enough to fuel many downtowns and small cities across the rural forested regions of the US. Communities which fully embrace the substitution of forest-based fuels for fossil fuels will require a full suite of technology solutions for buildings that can connect to new district energy systems as well as for buildings that are more distant from downtown centers and will therefore require single-building renewable heating solutions.

For single-family residences, the stand-alone biomass heating options will include wood pellet and cordwood boilers and furnaces as well as biomass space heaters–wood stoves and pellet stoves–which are less automated and require more homeowner attention. For small commercial buildings, pellet boilers will be the appropriate-scale biomass solution. Although domestically manufactured pellet boilers are not widely available at this time, the manufacture of advanced, high-efficiency, low-emissions pellet boilers is a well established industry in Europe and many US entrepreneurs are developing businesses based on importing European equipment.

For larger buildings that are not located near downtowns or in other built-up areas, such as rurally-sited regional high schools, woodchip boiler systems will be the best biomass option. This technology is well developed. Vermont now has about 45 woodchip heated public schools, serving over 20 percent of the state's school population. A recent study by BERC[6] found that if all of Maine's public schools were converted to woodchip boiler systems (and pellet boilers for the smaller schools), fuel cost savings to school districts would total $20 million per year. It would take 250,000 tons of woodchips annually to heat all the state's schools. Total fuel cost savings over 20 years would be $1.0 billion (not adjusted for inflation).

While the technology and project know-how for heating buildings with woodchips and wood pellets is fully mature and accessible, the technologies for CHP and district energy are not.

Currently, the only thermal energy grids in any significant numbers in the US are large urban steam systems and campus central heating systems, both of which have been well-developed for 100 years. Modern, European-style hot water grids, for distributing heat to multiple

buildings in municipal settings, are almost unknown and virtually unsupported by public policy in the US. Such systems are essentially a new kind of municipal infrastructure. Unlike public water and sewer systems, that are universal, well-understood, mandated and highly subsidized by federal and state funding over the years, there are virtually no models for modern municipal district energy systems in the US. The one prominent exception is District Energy St. Paul, which serves all of downtown St. Paul, Minnesota with hot water (for heating) chilled water (for air conditioning), and supplies 25 MW of renewable power, all fueled with wood.

The greatest barrier to the creation of municipal district energy and heat distribution grids is simple unfamiliarity with how to think about these systems, how to do straightforward studies of their economic viability, how to finance them, and how to organize their construction, ownership and operation.

There is a high level of interest in the use of biomass for CHP and an assumption by many not intimately involved in the field, that biomass CHP is just like fossil fuel CHP. Nothing could be further from the truth. Fossil CHP (mostly using natural gas as fuel, but also diesel) is generally accomplished at high combined efficiency using gas engines linked to generators to convert fuel Btus into electricity and heat. With wood fuels, the only CHP technology commercially available today is to combust the wood in a high-pressure steam boiler and use the steam to run a steam turbine and generator–a technology that goes back over a hundred years. Steam-cycle CHP is inherently much less efficient than engine-based CHP, particularly when the wood fuel (unlike fossil fuel) has a high moisture content. While there are reasonable large-scale CHP systems using steam-cycle technology (such as District Energy St. Paul and some college and university campus systems), it does not scale down well to the size that would find wide applicability in rural areas (less than 1 MW electrical generating capacity). Wood-fired CHP systems are primarily heat producers, with electricity production being a minor percentage of the input energy.

The use of steam-cycle equipment for generating power from wood reaches its fullest potential at large scale where it is co-located with a large, year-round demand for thermal energy that can absorb all the heat that is produced when making power from wood. This can happen in industrial settings (breweries, food processing plants, brick kilns, etc.) where there is a steady, day-to-day, year-round demand for large amounts of process heat. It can also happen when there are well-developed heat grids, such as the ones found in Denmark and exemplified by the Copenhagen district energy system. This system is comprised of a massive grid of buried hot water piping throughout the city. 95 percent of all space heating and domestic hot water in the city is provided from this grid; individual buildings do not have heating plants. The Copenhagen district heating grid operates year-round and serves many 12-month thermal loads as well as heating season loads. The system is designed to capture all waste heat from industry, power plants and waste-to-energy plants throughout the urban area. With this ability to use all the thermal energy from power plants, their net efficiency can be optimized because no heat is wasted.

This level of optimization of all the energy from wood-fired power plants is not available to US municipalities because there are no district heating networks to use the thermal energy. A system of this type has been long studied for the city of Burlington, Vermont, where there is a municipally-owned and operated 50 MW wood power plant. Plans to create the district energy system that would optimize the power plant have recently been revived in Burlington.

There is a new generation of wood-fired CHP equipment that is expected to come to the US market within the next few years, which will operate more efficiently and with better emissions characteristics, compared to steam boiler based systems. This includes wood gasifiers linked to engines, wood combustion turbine systems, organic Rankine cycle systems, and Stirling engines linked to generators. However, none of these technologies (some of which are commercial in other countries) are sold commercially and fully supported with warranties and service capability in the US at this time. Currently there are no broad state or federal government programs supporting the development of this technology at the scale up to 1 MW.

When wood-fired CHP using advanced technology becomes commercially available in the US it will open up a large new market for the efficient use of wood residues for energy. The maturation of these technologies will also help to realize the potential of biomass energy to fully penetrate the energy economies of rural, forested areas.

The Role of Public Education

Public education will have to play a major role in empowering a re-structuring of the energy economies of communities in the nation's forested regions.

It is safe to say that few Americans, when they do contemplate their energy future, even consider that wood energy might be an important part of that future. If asked, many would respond, aghast, "You certainly aren't suggesting that we cut down trees to provide energy, are you?" The idea that harvesting low-grade wood as a fuel could improve the health of the forest is inconceivable to many. This is perhaps the greatest barrier to significantly increasing the role of wood-based energy: that it is so far from mainstream thinking that few will take it seriously. If the general public has no understanding what "biomass" means, how can it be expected that members of Congress and state legislatures will act to allocate an important role in public policy to wood energy?

On the positive side, however, rural people in areas where there is or was an active forest products industry have little trouble grasping the idea of wood for energy. Whenever there is a rapid increase in the price of fuel oil, the use of wood stoves surges. Wood heating is a familiar idea in much of rural America. When taxpayers in Calais, Vermont, at the annual Town Meeting in 1986, were asked to vote funds for a woodchip heating plant for the elementary school–the first modern, automated wood system in a Vermont school–the voice vote was unanimous, without a single "no" vote.

The concept of community-scale wood energy, using woodchip and wood pellet fuels, is beginning to get attention in the Northeast, in the upper Midwest, in the Rocky Mountain states from Montana to New Mexico, and in the Pacific Northwest. The leadership for this slow realization of the potential for community benefit has come largely from the non-profit sector and state and federal forestry and land-management agencies. The idea is just beginning to get traction in Congress and from some state energy offices, but not from the US Department of Energy. The potential of woody biomass use at community scale will only be realized when there is national leadership from US DOE and Congress, to raise the visibility of this attractive form of renewable energy and to educate the broader public in its benefits.

Growing the Industry

The nascent community-scale biomass energy industry is in a classic chicken-and-egg situation. The "industry" consists of: woodchip system manufacturers, wood pellet boiler sellers, wood pellet manufacturers, loggers, woodchip sellers and brokers, consultants, NGO advocates and policy interests, and supportive public agency players. The businesses that supply system hardware do not have a big enough market, with enough accessible capital, to increase sales, and without that demand it has been difficult for these businesses to ramp up production to the point where they can mass produce and bring down product cost.

The industry needs to move beyond a "project" mentality–where each installation needs to be studied, then creatively financed, then each project is separately managed by an architect, then a system vendor is selected through a bidding process and custom-builds the system before installing it–to a place where uniform system packages with established pricing are manufactured and sold, to be installed in sites in the same way a new gas boiler is selected and installed. This will bring down the total installed cost of systems and greatly increase the number of applications where wood energy is cost-effective.

It is worth noting that there is no unified voice speaking for all these stakeholders and so they have a limited role in affecting public policy. It is also worth noting that, with the possible exception of the pellet manufacturers, none of these entities are well-capitalized in a way that would allow for significant rapid growth. It could be said that community-scale biomass is not really an industry, at least according to the definition under which the other major renewables–solar and wind–have become industries. The manufacturers who produce and install woodchip heating systems, for example, have annual sales volumes that might qualify them as "mom and pop" businesses, not the kind of businesses that are on a rapid-growth trajectory.

Public sector players and NGOs can help by lobbying for and creating funded programs with ambitious targets for number of installations, to create a bigger demand than has been seen when projects have been installed at an incremental rate, a few a year over many years. One example is the partnership between the Wisconsin Energy Conservation Corporation's Focus on Energy Program, a number of state agencies and BERC, to build the "First 10" new school wood energy systems in one year, to be followed by a program ramp-up that would achieve a significant penetration of biomass heating in the public school market in Wisconsin. Another

is BERC's partnership with the Maine Forest Service to design and implement an ambitious program targeting all schools in the state for woodchip or wood pellet heating. Another is the US Forest Service's efforts to get significant federal funding to expand its effective "Fuels For Schools and Beyond" initiative from its base in Montana other western states to become a national initiative.

End Notes

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[1] NFC SEI plan
[2] Maine Fuels For Schools Development Concepts
[3] BERC, UMA Study
[4] NRBP, etc.
[5] Can-Bio Annual Conference presentation by Tim Maker, October 7, 2008
[6] Maine Fuels For Schools Development Concepts