

Biomass Energy at Work

**Case Studies of Community-Scale
Systems in the US, Canada & Europe**

 **BERC**
Renewable • Reliable • Resourceful
Biomass Energy Resource Center



**Biomass Energy Resource Center
(BERC)**

BERC is an independent, national nonprofit that assists communities, colleges and universities, schools, state and local governments, businesses, utilities, and others in making the most of their local energy resources. Its mission is to achieve a healthier environment, strengthen local economies, and increase energy security across the United States by developing sustainable biomass energy systems at the community scale.

www.biomasscenter.org

**U.S. Endowment for Forestry and
Communities**

The U.S. Endowment for Forestry and Communities works collaboratively with partners in the public and private sectors to advance systemic, transformative and sustainable change for the health and vitality of the nation's working forests and forest-reliant communities.

www.usendowment.org

Biomass Energy at Work

Case Studies of Community-Scale Systems in the United States, Canada & Europe

This volume comprises a selection of exemplary community-scale biomass installations in the United States, Canada, and Europe. The goal of the initiative was to identify the “best in class” in biomass technology applications and highlight these successes in a case study series to be widely shared as a tool to grow the community-scale woody biomass industry in the United States and Canada.

During 2009, BEREC traveled to select biomass facilities in the United States, Canada, Austria, Italy, Germany, Switzerland, Denmark, Sweden, and Finland to identify, visit, and conduct assessments of applications and technologies in these countries that are excellent examples of heating and combined heat and power (CHP) using wood fuels. From this investigation, 53 of the best sites were selected for inclusion in this case study portfolio.

Funded by the US Endowment for Forestry and Communities with additional support from the US Department of Energy, the series illustrates the successful use of woodchips, wood pellets, cordwood, and other low-grade wood in community-scale systems that would otherwise be using fossil fuels.

Focus was put on replicable examples of technology that could be widely deployed elsewhere and that showcased the use of innovative, high-efficiency equipment (combustion and/or emissions control systems), cost-saving installation and operation, minimal maintenance with low staffing requirements, and technology types with particular promise to create a new national industry. Similar emphasis was given to systems using high standards of sustainably provided wood fuel (including harvesting practices), new and effective finance or project development processes, and broad community involvement and commitment.

Examples of community-scale applications include district energy (mini-grids for heat, downtowns, small communities, cities), schools, campuses, hospitals, prisons, public buildings, multi-family or senior housing, government buildings and complexes, heating for commercial or office buildings, farms and greenhouses, and small industrial parks.



Contents

Introduction i-ii

Schools 2

- Barre Town Elementary and Middle School, Barre, Vermont, US 3
- Christianshede Zoo School, Bording, Denmark 5
- Council, Idaho Schools, US 7
- Darby, Montana Schools, US 9
- Leavitt Area High School, Turner, Maine, US 11
- Mount Abraham Union High School, Bristol, Vermont, US 13
- Nakusp Secondary School, British Columbia, Canada 15
- Ponaganset High School and Ponaganset Middle School, N. Scituate, Rhode Island, US 17
- Townsend, Montana School District, US 19
- Verdersø Sports School and Husby Boarding School, Jutland, Denmark 21

Campus Settings 24

- Chadron State College, Chadron, Nebraska, US 25
- Middlebury College, Middlebury, Vermont, US 27
- Mount Wachusett Community College, Gardner, Massachusetts, US 29
- University of Idaho, Moscow, Idaho, US 31
- Nova Scotia Agricultural College, Truro, Nova Scotia, Canada 33

Institutional Settings 36

- Harney County District Hospital, Burns, Oregon, US 37
- Crotched Mountain Rehabilitation Center, Greenfield, New Hampshire, US 39
- South Dakota State Treatment and Rehabilitation Academy, Custer, South Dakota, US 41
- Kings County Memorial Hospital, Montague, Prince Edward Island, Canada 43

Housing Complexes 46

- Dartmouth College's Sachem Village, West Lebanon, New Hampshire, US 47
- Green Acres Public Housing Complex, Barre, Vermont, US 49
- Spring Valley Bruderhof, Farmington, Pennsylvania, US 51

Government Facilities 54

- Boulder County Parks and Open Space Department, Longmount, Colorado, US 55
- Quabbin Administrative Building, Belchertown, Massachusetts, US 57

Businesses and Industries 60

- Fronius International Factory, Wels, Austria 61
- Woodchip District Heating Business, Joutsa, Finland 63
- Mitter Transporte Fuel Company, Linz, Austria 65
- NRG Wind Systems, Hinesburg, Vermont, US 67
- A. Reponen Oy, Joutsa, Finland 69
- Xolar Group Headquarters/Manufacturing Plant, Eberstalzell, Upper Austria 71
- Chisholm Lumber, Tweed, Ontario, Canada 73
- Madsen's Custom Cabinets, Edmonton, Alberta, Canada 75
- Lathrop Forest Products, Bristol, Vermont, US 77

Community District Energy 80

- Cooperatively Owned System, Buchkirchen, Austria 81
- Town of Gjern Varmeværk, Denmark 83
- Town of Gleinstätten, Austria 85
- Hållanders Sawmill & Village of Dalstorp, Sweden 87
- Vølund Gasifier Plant and Town of Harbøre, Jutland, Denmark 89
- Village of Koivulahti, Finland 91
- Village of Hovmantorp, Lessebo Kommun, Sweden 93
- Lundsbrunns Bioenergi AB, Lundsbrunns, Sweden 95
- Community-Owned Pellet District Heating System, Mullsjø, Sweden 97
- Village of Oujé-Bougoumou, Quebec, Canada 99
- City of Revelstoke, British Columbia, Canada 101
- Towns of Toblach and Olang, South Tyrol, Italy 103
- City of Charlottetown, Prince Edward Island, Canada 105

Agricultural Facilities 108

- Nordstrom Greenhouses, Närpiö, Finland 109
- Stefan Nordmyr Family Farm and Greenhouses, Närpiö, Finland 111

Community Buildings 114

- All Souls Interfaith Gathering, Shelburne, Vermont, US 115
- Municipal Aquatic Center and City Schools, Craig, Alaska, US 117
- Lambach Abbey, Lambach, Austria 119
- Long Lake Conservation Center, Palisade, Minnesota, US 121
- Wolf Ridge Environmental Education Center, Finland, Minnesota, US 123





Introduction

As institutions, communities, and policymakers in northern regions where forests are a natural resource confront the insecurities of cost and supply that surround fossil fuels in the 21st century, more and more leaders and local champions are asking about those woods. Could we get at least some of the energy we need from there? Are there ways to do this that might boost the local economy and help build a sustainable, affordable energy supply, while avoiding negative environmental impacts?

The answer is yes. As the case studies in this book show, the use of woody biomass—fuel derived from low-grade wood, usually in the form of chips or pellets—to fuel clean-burning, efficient heating systems is already providing a wide range of benefits for hundreds of schools, colleges, other institutions, and even whole communities in the United States, Canada, and Europe. For example, for about two decades the City of Charlottetown, provincial capital of Canada’s Prince Edward Island, has been burning woodchips and municipal solid waste to meet 85 percent of the heating needs of its commercial center and large downtown buildings, also generating some electricity in the process (pp. 105-106). The district energy system works well, and the fuel supply is reliable; woodchips are culled from forest-thinning and land-clearing operations in the area.

In just one province of Austria, called Styria, more than 300 biomass district energy systems are at work, including the one that heats the town of Gleinstätten (pp. 85-86). Two picturesque towns in the Italian Alps heat more than 900 buildings with woodchips, paying local farmers a premium for chips to strengthen the link between energy use and healthy forests (pp. 103-104). Similar systems are at work all over Denmark, Sweden, and Finland.

And in Vermont, USA, more than 45 public schools now heat with woodchips. So does prestigious Middlebury College, which has gained renown as a leader in the fight against climate change, in part by installing an \$11 million biomass plant that now meets most of its heating and cooling needs while cutting the college’s fuel-oil usage in half, saving an anticipated \$2 million each year on fuel costs, reducing its greenhouse gas emissions by 40 percent and replacing a distantly sourced fuel with one that comes from the surrounding forests (pp. 27-28).

Throughout this book, the brief case studies that profile these and other biomass facilities are intended to serve as a balanced information resource. They highlight key factual data, describe the challenges that some systems have worked through—most of those dealing with inconsistent fuel quality—and detail the benefits that users report having gained.

Often, as some case studies show, the advocates of biomass face initial skepticism. Some is often based on the relative newness of today’s biomass energy technology; there can also be concerns about the capital costs of building or converting to a biomass system, the sustainability of the fuel supply, and the fear that burning biomass will be cumbersome to operate, dirty, or air-polluting.

Here, in brief, are some responses to these concerns, based on present-day technology and the experiences of users such as those profiled in these pages:

■ **Biomass energy systems save money on fuel, and tend to repay their up-front costs in a short number of years.**

On a Btu basis, the cost of biomass fuel is generally less than half the cost of fuel oil—and over the past 20 years, the real price of wood energy has actually declined. In the future, however, in order to develop and sustain a reliable wood fuel supply infrastructure, suppliers will need to be paid prices at least matching the rate of general inflation over time.

■ **Biomass systems tend to be reliable.**

As the profiles here detail, these systems have been operating for years, sometimes decades, with high reliability in hundreds of community, school, and institutional settings. Some systems are more automated than others; most do require more regular cleaning than do fossil-fuel systems.

■ **The major challenge in operating biomass systems is fuel quality.**

This is mainly an issue for systems at the smaller end of community scale that burn woodchips, which can vary dramatically in size, cleanness, and moisture content. System operators have learned to set strict standards for chip quality. When they do that, operators report, their systems tend to work smoothly.

■ **Using biomass for energy improves the health of forests.**

Chip and pellet fuel is made from low-grade wood harvested as part of improvement thinnings—removing the low-quality trees to enhance the growth and vigor of the higher-quality trees. Without local, reliable markets for low-grade trees and smaller-diameter trees, improvement harvests are difficult to conduct.

Biomass plants are running on trimmings from logging operations, on residues from wood milling and processing, and on wood harvested in thinning procedures that improve forest health and—especially in dry areas like the American West—can sharply reduce the dangers of forest fires.

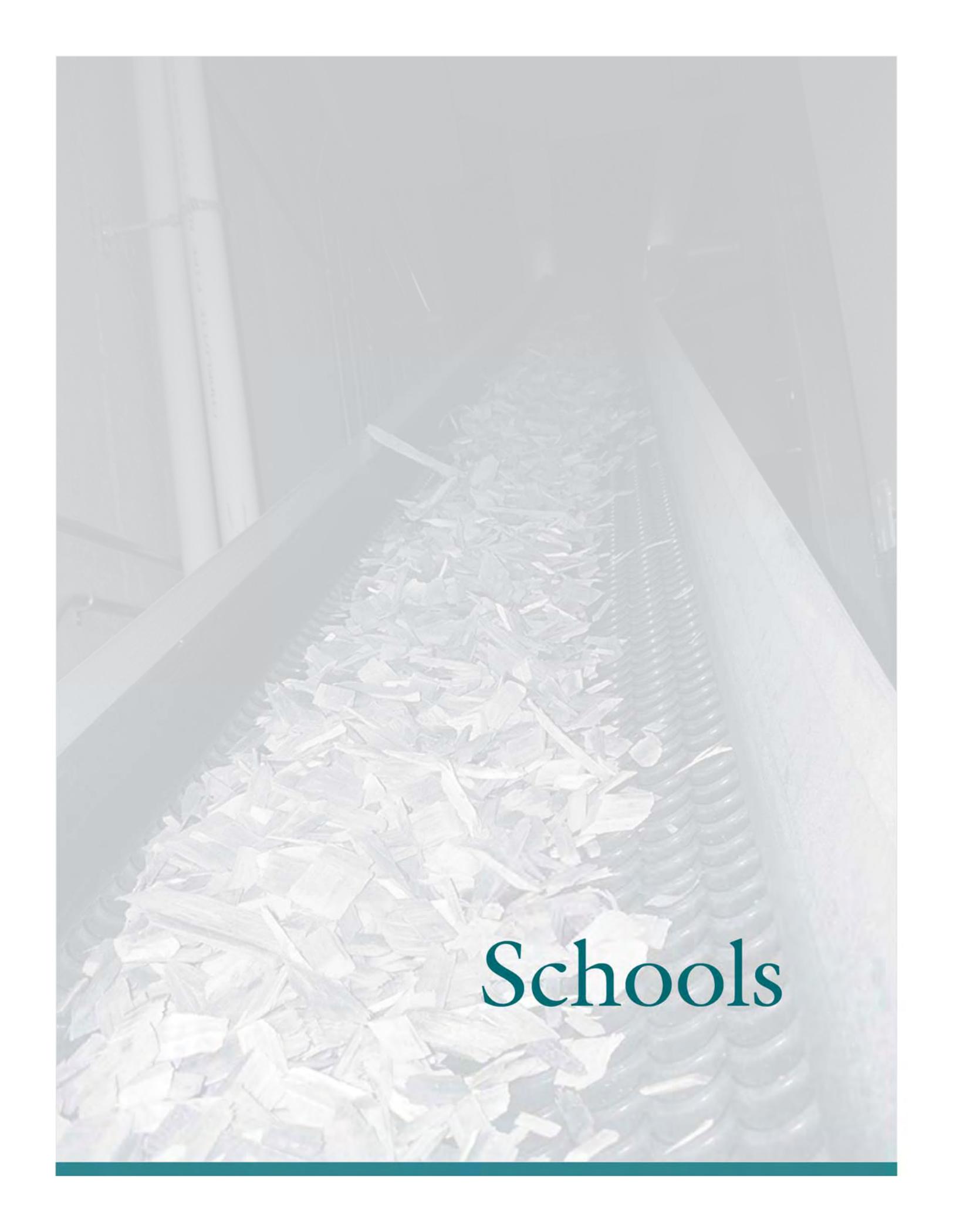
■ **Today's biomass energy systems are non-polluting, and combat climate change.**

Modern institutional biomass systems burn cleanly, with no visible emissions or odors, and emit far less particulate matter than do conventional wood stoves. And while the burning of fossil fuels takes carbon that has been locked away underground, as crude oil and gas, and releases it into the atmosphere as carbon dioxide, biomass energy systems recycle carbon that is already a part of the natural cycle between forests and the atmosphere. The net effect of using biomass for energy is that very little new CO₂ is added to the atmosphere.

■ **Using biomass for energy contributes to the local economy, replaces distant fuel supplies with a local or regional one, and helps build a sustainable, renewable energy system.**

In addition, because biomass is a diffuse resource, growing over dispersed areas, its most efficient use is for generating heat and combined heat and power (CHP) at the community scale, where local wood resources are produced and can be used. That's why the profiles in this book focus on community-scale woody biomass systems that are at work today—in schools, campuses, hospitals, community centers, businesses, and industrial settings.



A photograph of a paper shredder's output tray filled with shredded paper. The shredded paper is piled up and appears to be falling or has just been shredded. The shredder's rollers and metal frame are visible on the right side. The word "Schools" is overlaid in a teal serif font in the lower right quadrant of the image.

Schools

Using Biomass for Energy in Schools

In an era of ever-tightening budgets, a growing number of public and private schools in the northern United States, Europe, and Canada are finding that biomass heat offers clear cost savings over systems that use fossil fuel. Several profiles in this first section detail the yearly budget benefits that schools are achieving, usually comparing biomass fuel costs to oil—from about \$50,000 saved at small-town schools in Idaho (pp. 7-8) and Maine (pp. 11-12), to \$205,000 saved during the 2008-09 heating season in the Darby, Montana schools (pp. 9-10).

But converting to a biomass system can be costly in the short term, and community members often raise legitimate questions—about air-quality impacts, system reliability, and the dependability of fuel supply. Skepticism can be stubborn, as advocates for a successful project in Rhode Island (pp. 17-18) found out. One Maine superintendent put local opinion-makers on the project committee; a Vermont student who spearheaded her school's conversion project as a ninth grader learned

that it's key to be prepared, to have solid answers, and to be candid about what you know (pp. 13-14).

Creative financing approaches—such as contracting with an energy services company, or partnering with a public agency like the US Forest Service—have helped projects succeed in Council, Idaho (pp. 7-8) and in Barre Town, Vermont (pp. 3-4). Schools such as Barre Town and Nakusp Secondary in British Columbia (pp. 15-16) are using their biomass systems as learning resources for students:

“It's a wonderful teaching tool for me,” says a Nakusp science teacher.

The lesson that smaller system operators most often cite: pay strict attention to fuel quality.

“The systems are designed to work perfectly with certain fuel specifications—and as long as you do that,” says a Fuels For Schools coordinator in Montana (pp. 9-10), “they will.”

After Twelve Years, School's Woodchip System 'Runs Like a Charm'

School Woodchip Heating System

Heating Capacity (output): 1.3 MW (4.5 MMBtu/hr)

Annual Woodchip Use: 650-725 tons

Year Installed: 1996

Thermal Output: Hot water

When the Barre Town, Vermont, Elementary and Middle (BTE) School was built in the mid-1960s, its all-electric heat and hot water system looked like a great investment. "It was a steal," says today's co-principal, Dr. Ted Riggen. But by the time the school was paying a \$180,000 annual power bill in the mid-90s, that notion of a steal had a different meaning.

The school had to do something—and it became one of the first in its home state, and in the US, to seriously investigate woodchip heat. The project would not be small—the baseboard system would have to be ripped out and a network of hot-water pipes installed, along with a boiler and its housing, chip bin, and installation ramp.

"There was trepidation," Dr. Riggen says. "It required reworking the whole way we heated this building." But the local school board was supportive, encouraged by a forecast that the new system would save \$100,000 per year, and would pay for itself in five years.

"Once you get by the normal, lethargic problem of change within an organization, then the idea that you could save \$100,000 a year from the beginning gets people's attention," the co-principal says. "Our board has been quite adventurous, even bold, in trying to think about BTE and energy usage."

During two years of research on system options in 1994-95, the school also considered geothermal heating, but woodchips won out. The school's new system was installed in 1996, and the forecasts of annual savings and pay-back time came true.

More than a decade later, Dr. Riggen and Steve Murray, the school's facilities and maintenance director, say they have given about 20 tours to interested people from around the US and even internationally—engineers, architects, foresters, school superintendents, and others.



"I always tell people, 'Do your research,'" says Murray. "That's what really helped us. We went out and got some good information."

'It's Very Low Key'

BTE's chip boiler operates nonstop about 215 days each year. The school installed two smaller oil burners as backups, but has never had to use them while the chip boiler is running. It uses the oil units only to provide hot water in the warm season, and occasionally for heat in the "shoulder" heating months during autumn and spring.

The chip boiler uses 650 to 725 tons of hardwood bole chips per year, with the adjacent 65-ton storage bin receiving weekly deliveries during the heating season. Murray's staff rakes out fine ash twice a week, shipping it off in small trash cans, then spends about 45 summer hours cleaning out the boiler and the tubes. In 12 years of operation, the school has had to replace two small motors, at a total cost of less than \$10,000.

“It’s very low key,” Murray says. “There’s no more maintenance than to the average oil boiler.” The school’s success with its chip boiler has helped encourage the BTE’s board and administration to try other ways of saving energy and/or costs while fighting global warming. For the last two years, the school has shipped its food waste—20 tons the first year—to the nearby Vermont Compost Company in Montpelier, instead of paying to landfill it.

An energy consulting firm, working with the school more than the first half of 2008, helped it save over \$10,000 in energy costs, trimming its bill by almost 14 percent—and cutting its production of carbon dioxide (CO₂) by 16 percent, or about 90,000 pounds, according to a June 29, 2008 article in the Barre-Montpelier Times Argus.

Barre Town owns an 88-acre forest, and the school recently was involved with the county forester in a project that saw the woodland logged, some of the culled wood chipped for the school’s bin, and a multi-year management plan developed.

“It takes a whole community, both people and professionals, to think these things through,” Dr. Rikken says. “The role of the school becomes to coordinate this. If you can get that kind of synergy going in an organization, to see things in a different way, you can achieve a great end.”

And, in a school setting, there is an educational benefit as well. Dr. Rikken, who has a forestry background, recently visited a fourth-grade class. Holding a large maple bole, with one small branch still on it, he was asked what that wood was made of.

“Well, it’s made of carbon,” he recalls saying.

“Where does

every bit of carbon come from? It only has one source. Every wood atom, and every woodchip, comes from CO₂—and CO₂ is the enemy, with regard to global warming. We’re promoting the growth of trees by finding a use for them, and the growth of trees reduces the CO₂ in the atmosphere. They capture the carbon.”

In the boiler house, Murray says the chip system has been “good for the school, and good for the community. I grew up on a farm, and to me it’s just another way of burning wood. But the impact ...”

He shrugs. The impact is still widening, like ripples on a very large pond.

“When people come here for a tour, I give it to ‘em straight,” Murray says. “This is not a chain around our neck. Nobody has complained about a smell, or anything like that. This thing runs like a charm.”



Opposite page: The Barre Town Elementary and Middle School woodchip plant.

Above left: Dr. Ted Rikken, co-principal of the Barre Town Elementary and Middle School, shows off a handful of the hardwood chips that the school burns for its heat and hot water.

Above right: Steve Murray, director of facilities and maintenance at the Barre Town School, with the facility’s chip boiler and feeder system.

Danish School's Pellet Heat Saves on Cost and Adds Comfort

Wood Pellet Heating System

Heating Capacity (output): One 40 kW (135,000 Btu/hr) boiler and one 25 kW (85,000 Btu/hr) boiler

Emissions Reduction and Combustion Control Equipment: O2 sensor control

Year Installed: 2005

Thermal Output: Hot water

At a boarding school in Denmark for troubled young people, switching from an electric heating system to one fueled by wood pellets has been one small part of a national movement away from fossil fuels.

By improving comfort at the school, biomass heat may also be helping to improve student behavior.

“When we were on oil and electric heat it was really expensive heat, so we kept the buildings cooler,” says Bue Grunnet, head of maintenance at the Christianshede Zoo School in Bording, Denmark. “Now, with pellets, we keep the buildings warm. These kids have a lot of issues, and they do much better now that we have a higher level of comfort from pellets.”

The Christianshede School is on the site of a former zoo and still houses a number of zoo animals, which the students care for as part of their therapy. Twenty-two resident students here are served by about the same number of teachers and staff. The school's two pellet boilers—with heating capacities of 25 thermal kW (85,000 Btu/hour) and 40 kW (135,000 Btu/hour)—use about 40 tonnes (35 US tons) of pellet fuel per year, at the equivalent of \$325 US per US ton.



In a country where the price of oil is the equivalent of \$5.75 US per gallon, pellet fuel's relatively low cost has made it a natural alternative.

“In areas where there is wood, there is no reason not to heat with pellets, woodchips, or logs,” Grunnet says. “I like the idea of pellets being cheaper than oil, but I know I have to spend a little time on cleaning the pellet boilers.”

Otherwise, he adds, “this pellet system is really automatic!” It has automated boiler controls, based on oxygen sensing using a lambda sensor, and has automatic ash removal.

There's not much to show off with the heating plant for the school. Call it hidden infrastructure: You can't see the buried pipes that are the arteries of the system. Compared to the size and number of buildings on the school campus, the boiler plant is tiny.

The unassuming, closet-sized concrete block boiler house sits off behind one of the dormitory buildings—but its function is big.

It connects to all the buildings using insulated pipe, just like larger plants that heat university campuses or whole towns. The two residential-size pellet boilers put out enough heat to keep the entire campus warm.

Biomass Market ‘a Good Place to Be’

The Zoo School bought its pellet system from the Danish boiler manufacturer Baxi, which 15 years ago purchased TARM, a pioneering line of pellet-heating products.

“The TARM name is known in a lot of countries,” notes Baxi representative Hans-Jørn Rasmussen. “We sell small pellet boilers, residential and light commercial up to 40 kW thermal (135,000 Btu/hour)—but they can burn lots of biomass fuels, like grain, chips, and mustard seed.

“Being in the biomass market is a good place to be. We sell a lot of boilers in Denmark, Sweden, Germany, Austria, Italy, and Ireland as well as in the United States and Canada.

“Here in Europe we are very worried about relying on the Russians for natural gas. One year they may treat you well and sell gas at reasonable prices, but the next they may chase the Chinese market and leave us high and dry. Our government used to say that we had 20 years of our own natural gas, but now there’s not much left. Using local biomass fuel is much better than relying on gas.”

“As a country,” Rasmussen concludes, “Denmark has committed to get off imported fossil fuels like oil, gas and coal in all sectors—including gasoline for transportation—within 10 years, so we don’t have to rely on Russia or the Arab states.”



Opposite page: This small pellet boiler plant heats all the buildings of the Zoo School.

Above: Baxi pellet boiler representative Hans-Jørn Rasmussen (on right) discusses combustion questions with the school’s head of maintenance, Bue Grunnet.

Building Support and Partnerships for a Local Project

School Woodchip Heating System

Heating Capacity (output): 440 kW (1.5 MMBtu/hr)

Annual Woodchip Use: 350-450 tons

Emissions Reduction and Combustion Control Equipment: O₂ sensor control

Year Installed: 2005

Thermal Output: Hot water

In the autumn of 2004, the superintendent and school board in Council, Idaho, population 900, circulated a brochure.

Infrastructure Revitalization Project, it declared. *Imagination & Innovations ... PLEASE VOTE.*

The community's school system was in a bind. Its high school's electric heating system cost around \$10,000 per month in winter. Its elementary school had a half-century-old diesel boiler that was burning 8,000 gallons a year and costing \$500 a month in maintenance just to keep it going.

For a system with just 240 students, in a community still struggling to rebound from the 1995 closing of its Boise Cascade lumber mill, these costs were crippling the budget. In response, school leaders were floating a \$2.2 million bond issue that would, if approved, provide the main funding for a new biomass heating system that would run on "slash"—woodchips from downed trees and forest debris.

"We're the OPEC of woody biomass, with a thousand years worth of fuel," Superintendent Murray Dagleish boldly declared. Sixty percent of Council's home county lies in the Payette National Forest; the biomass system could use wood that was culled from the forest.

The bond-funded project would also include efficiency work at the school to install power-thrifty lighting, water-conservation measures, and better system controls. "Our proposed improvements will save us energy costs of close to \$1 million over the next several years," the brochure declared. In bold type, it added: "These savings are guaranteed through our performance contractor."

The key was to convince local voters. The brochure told them the project had received \$510,000 in grants; the largest was from Fuels For Schools, a US Forest Service (USFS) program that promotes the use of biomass at schools in Idaho, Montana, Nevada, North Dakota, and Utah.



The case was strong. But the superintendent wasn't just going to rely on a brochure.

"I went to the Lions Club," Dagleish recalls. "I went to the coffee shop ... I pulled up a chair and I said, 'Can I answer any questions about the bond we're trying to pass?'"

The system would need such a small amount of woodchips that "we shouldn't have a problem with supply," he told anyone who would listen. People said the technology seemed new. Dagleish would ask, "How many of you heat with wood?" Nearly all did.

"It's cheap," he notes. "It's available."

When voters asked why not install a propane system, he adds, "we had the charts to show that the costs of this in the long run are just going to be prohibitive. And that's money taken away from your kids' education."

But the first bond vote fell 10 votes shy of the needed two-thirds majority. Supporters went back to work—and six months later, the proposal passed. In 2005, the biomass system was installed to provide heat and ventilation to the Council schools.

“The way we put the project together is kind of a model for smaller systems that think they can’t afford to do this,” Dalglish says. “If they can get creative, they can have a nice little project. We created some really strong partnerships between the Forest Service, the county and the schools, and the contractor, with everybody pushing together to make this happen.”

‘Do a Performance Contract’

The process hasn’t been bump-free. Three years after the new system went online, “we’re still only 80 percent done,” the superintendent says. “We’ve been scrambling to get them”—the nationally prominent energy-services contractor, or ESCO, that installed the system—“to finish. Eventually, we had to sue and go after their performance bond.

“The biggest lesson we learned was: Do a performance contract. We have such a great contract because it’s so detailed. It protects us in so many ways.”

But although the ESCO that Dalglish chose was federally approved, he now feels that it did not have a strong track record of working with small facilities like schools. In particular, the company has been unresponsive on fixing system problems that derive from rougher-grade fuel. Council specified that its biomass system should be capable of handling such fuel, but that has not been the case. Dalglish has been pressing the ESCO to make the fix through the system supplier, Messersmith Manufacturing.

“Lesson two: Know exactly what kind of fuel your system is designed to burn,” he says. Council’s is intended to burn ‘hogfuel’, non-merchantable chips that can’t be used in a pulp mill or for other purposes.

“This is the roughest stuff that comes out of the woods,” says Dalglish. “You don’t want to compete against pulp mills—you’re going to pay too much, and the system will not pay off.”

Council has been using storm-damaged wood that the USFS has logged and chipped. The school system has enough of that on hand to last through the 2009-10 heating season.

As for costs, “Let’s do a little math,”

Dalglish says. With the old electric and diesel oil systems, “we were looking at \$56,000 to heat our buildings. Last year, I spent \$6,000 on fuel—300 tons at \$20 per ton. I would say we’re saving \$50,000 a year—and I may be underestimating the savings on electricity.”

Environmentally, “the town typically gets ‘smoked out’ for weeks at a time from the nearby burning of slash piles” in the forest, says a USFS report on the Council project. “It made more sense to everyone to burn this slash in a highly efficient boiler.” Overall, carbon dioxide (CO₂) emissions from the wood boiler are essentially zero, while the oil boiler is a big CO₂ emitter.

Now, thanks to another USFS grant, Council’s high school is building a new greenhouse, to be radiant-floor-heated with hot water from its chip system. Students will raise native plants that they will then plant in the national forest, for example, to repopulate flood-damaged riverbanks.

“We hope for the next 40-50 years, we’re going to have this relationship between our kids and the Forest Service,” the superintendent says.



Opposite page: Council, Idaho Superintendent of Schools Murray Dalglish stands by the school’s wood fuel bin.

Above: Oversized fuel is being rejected from the metering bin.

From a Montana Project, a Key Lesson Learned

School Woodchip Heating System

Heating Capacity (output): 900 kW (3 MMBtu/hr)

Annual Woodchip Use: 850 tons

Year Installed: 2003

Thermal Output: Steam

Because its three million Btu per hour woodchip-fired biomass heating plant was the first demonstration project installed through the federal Fuels For Schools and Beyond Program in Big Sky country, the system that heats the Darby, Montana schools has become a model for others—and a learning experience.

The Darby school district's biomass boiler was commissioned in late 2003. Since then, its biggest lesson learned hasn't been about the boiler, but about the fuel.

"The most important thing to pass on to people who are putting [biomass systems] in is, 'Pay attention to fuel quality,'" advises Tom Coston, Fuels For Schools coordinator at the nonprofit Bitter Root Resource Conservation and Development program, a Darby project partner in Hamilton, Montana.

"There are 14 systems operating now in the five-state [Montana, North Dakota, Idaho, Nevada, and Utah] Fuels For Schools area. Ninety-five percent of the operational problems they've had have been because of poor-quality fuels.

"The systems are designed to work perfectly with certain fuel specifications—and as long as you do that, they will," he explains. "But if you buy dirty fuel or oversized fuel, that becomes a headache."

'A Win-Win Situation'

The US Forest Service (USFS) created Fuels For Schools after a very severe forest wildfire season hit the Bitterroot Valley of Montana in 2000. When logging is carried out to reduce wildfire hazard by thinning the forest, biomass system users can purchase and burn the otherwise noncommercial wood that those operations harvest. This new market boosts the region's struggling wood-products industry, and it can sharply reduce fuel costs for schools.

For all these reasons, "using hazardous fuels for heating public facilities like schools was a win-win situation," said a 2007 report on the Darby Project by Fuels For Schools.



"The Forest Service estimates that 70 million acres of federal land need immediate hazardous fuel reduction, and 140 million acres nationwide will soon need treatment," said the report. "Developing ways of using forest residues from these treatments is vital for rural communities."

Darby is one such community. With a population of less than 1,000, the town has three school buildings and 365 students. Each school previously had its own oil-fired steam-heating plant. In 2002, oil use averaged 47,600 gallons and cost \$44,000 for all three schools combined.

"The three Darby schools are fairly typical for western Montana in age and condition," said Fuels For Schools. "Insulation levels are far below those of new school construction." One of the schools' three oil boilers was 40 years old; the other two were installed in 1990 and 1992.

The partners who put the biomass project together included the Bitterroot National Forest, the Bitter Root RC&D, and the USFS. The USFS's Technology Marketing Unit recruited the nonprofit Biomass Energy Resource Center (BERC) of Vermont to conduct feasibility studies for several school districts in the Bitterroot Valley—and BERC identified Darby as the best location for a biomass demonstration project. The USFS funded all of the \$885,000 capital costs for the Darby project. Subsequent projects through Fuels For Schools have competed for up to 50 percent federal funding.

Saving Almost 80 Percent on Fuel Costs

Even though the Darby schools retained two backup oil boilers, the new biomass system met all the schools' heating needs, even on the coldest days, through the 2003-04 and 2004-05 heating systems, said the 2007 Fuels For Schools report.

The system continues to work that well, says Rick Scheele, who is facilities manager for the Darby schools and also the town mayor. The cost savings, he adds, are dramatic. "Last year, we burned right at 1,000 tons," Scheele says. "We spent \$40 per ton—right around \$40,000," to heat all three schools for the full year. Had Darby kept its oil-fired system, "We'd have spent right around \$245,000" on fuel, Scheele estimates.

The Darby system was built with a projected payback time of 18.5 years, based on oil prices at 2003-04 levels. At today's oil prices, "it'd take less than 10 years" for payback, Scheele figures. Darby's system reduced its fuel costs by half in the first season, 75 percent in the second—and, according to Scheele's calculation, nearly 80 percent in 2008-09.

When representatives from other communities interested in biomass systems visit the Darby facility, they often ask about air quality. "As far as smoke or emissions, no—we haven't had any," Scheele reports.

As a small-scale system, Darby's boiler has no emission controls. Yet from an emissions perspective, it "performs much better than many of the older generation of much larger industrial wood boilers," said the Fuels For Schools study. Testing showed particulate-matter emissions of about 1.25 pounds per green ton of chips burned, 1.22 pounds of nitrogen oxides, and 1.67 pounds of carbon dioxide, all well within USEPA standards.

"Virtually no odor or visible smoke is produced by modern school wood heating systems," the report affirms. "The ash, removed from the boiler on a regular basis, is nontoxic and can either be landfilled or used as a soil amendment on lawns or fields."

'Proper Fuel, No Problems'

Overall, fuel quality remains "the biggest problem we have" at operating biomass systems in Big Sky country, says Coston, looking back on the experience at Darby and other school systems since installed through Fuels For Schools. Hog fuel, an unscreened mix of coarse, ground-up wood bark from logging waste, works fine in a pulp and paper mill's cogeneration facility near Darby. But in the smaller school biomass units, it doesn't.

"Chips are chips—but hog fuel comes from a grinder and is subject to large pieces, and they can't seem to avoid having some dirt in it," Coston says.

Darby's system uses chips from small-diameter trees, treetops, and logging debris. It's more expensive than hog fuel, but runs reliably in school systems.

"If you use the product of a chipper, not only is the stuff more uniform, but the guy who owns the chipper doesn't want to run dirt or rocks through it—so you get a better product all around," Coston concludes.

"Basically, if you use the proper fuel, you have no problems."



Opposite page: The woodchip-fired biomass heating plant at the Darby school system.

Above: Testing of Darby's three MMBtu/hour boiler system has shown that particulate matter, nitrogen oxides, and carbon dioxide emissions are all well within USEPA standards.

At a Pioneering Maine School, Skeptics Have Become Believers

School Woodchip Heating System

Heating Capacity (output): 1.3 MW (4.5 MMBtu/hr)

Year Installed: 1999

Thermal Output: Hot water

When Leavitt Area High School in rural Turner, Maine proposed installing a woodchip boiler as part of a reconstruction project in the late 1990s, one key early supporter was Ralph Caldwell. Well known and plain spoken, the local farmer and businessman was already using chip boilers in several houses he owned. Leavitt High had been using electric heat, and was looking to become the first school in Maine to go with a chip system.

“Our superintendent then, he’s moved along now, but he’d pick out some of us who are sort of movers and shakers, the people who can give you grief—and he’d get you on the committee,” Caldwell recalls with a chuckle. “If you get the people who are going to give you a hard time on board, it goes a lot calmer. Once you’ve committed them, the rest isn’t a problem.”

Not that there wasn’t skepticism. The state of Maine was putting up 80 percent of the funding for the construction budget, and officials were leery enough of the chip system—it would be the first in a Maine school—to insist that its oil-fired backup burner be big enough to meet 100 percent of the need. The maintenance staff was also a bit concerned that the chip system would be an operation and maintenance headache at Leavitt High, which serves about 750 students from the towns of Turner, Leeds, and Greene in south central Maine.

Townpeople approved the project in a local vote—and a 4.5 MMBtu/hour chip system, with a 6 MMBtu oil backup boiler, was installed during summer and fall 1999.



“I was very involved that first winter that it went in, and then I got busy with other things,” Caldwell remembers. “During April vacation, I happened to meet the guy who was seeing to maintenance, so I asked him how the winter had gone. He didn’t say anything. I said, ‘Geez, was it that bad?’ He said, ‘Geez, the damn thing worked pretty good—and I’d damn well tell you if it didn’t!’”

‘It Tells Us What It Wants’

In its first years of operation, the chip system proved itself nicely. From 2002-03 through the 2006-07 school year, the wood-fired boiler met 84 percent of the school’s heat and hot water needs—and it saved an estimated total of \$214,000 in energy costs compared to using all oil, says an independent study of the system’s costs and performance.

Commissioned in 2007 by the Maine Department of Education in response to growing interest among other schools in chip systems, the study by CCI, Inc., of Augusta found that the fuel-cost savings generated by Leavitt’s chip system were rising dramatically along with oil prices. In 2002-03, Leavitt’s total energy-cost savings, projected against current fuel-oil prices, was \$20,582. In 2006-07, it was \$53,113.

The chip system had so far required only one repair, a \$1,200 patching of the firebox lining. Operation requirements, while slightly greater than for an oil burner, are not a burden, says Gene Jordan, a member of the school's maintenance staff who has been involved with the system since it was installed.

"It's been pretty decent to us," Jordan says. "It's got a lot of moving parts, so a guy spends about an hour a day, keeping it clean. We've learned that if you keep it dusted down, it runs better. It tells us pretty well what it wants."

Jordan says the oil burner is used mainly during the off-peak heating months, and is fired to full capacity only about three percent of the time. Even that may lessen as the school moves to use the chip burner to provide hot water during autumn and spring.

"This last year, we ran chips right up till June, just for hot water," Jordan says. "We also have a gas hot-water heater, to use in summer."

'Take Lots of Pictures'

These days, Leavitt High School draws a fair amount of interest from other Maine schools that are considering woodchip boilers. "Oh, they promote it, now," Ralph Caldwell quips.

Gene Jordan says that when visitors ask about chip systems, he advises them to make sure they get a good supply of uniform-quality chips. Leavitt uses green hardwood mill chips, supplied by an area broker and mainly generated by Maine Wood Turning in New Vineyard. A consultant for another school project found that chip availability in forest-rich Maine shouldn't be an issue.

Leavitt's 60-ton chip bin takes delivery of a 33-ton load about once a week during heating season—and the bin's design requires some shoveling to spread the load. If he were planning a new system, Jordan said he would design a bin that would spread its load evenly without extra labor.

Other than that, he advises only to go look at a working system, just as the Leavitt folks did.

"Take a digital camera, and take lots of pictures—because when you get back, somebody's always asking you things. If you've got it in color so they can see it, see what you've been looking at, that's really helpful."

"I got no complaints, no problems," adds Ralph Caldwell. "Delighted we did it. But gasification is the next step up."



Opposite page: Leavitt Area High School.

Above: Leavitt's biomass plant. Since its installation in 1999, the chip system at the school has so far required only one repair, a \$1,200 patching of the firebox lining.

When a Biomass Project's "Champions" Are Teenagers

School Woodchip Heating System

Heating Capacity (output): 1.8 MW (6 MMBtu/hr)

Annual Woodchip Use: 900 tons

Emissions Reduction and Combustion Control Equipment: Multi-cyclone

Year Installed: 2006

Thermal Output: Hot water

Vermont wood-energy consultant Jeff Forward has been involved in community-scale biomass projects since 1992. "The common thread in all of the projects that I've worked on is that there has been a strong community champion," he says. "In just about every case, somebody plays the role of keeping the idea in front of community decision-makers—and keeps saying, 'Let's think about this.'"

When a \$1.5 million system went online at Mount Abraham Union High School in Bristol, Vermont in 2006, the technology wasn't new—it was the 29th installed in a Vermont public school—but its champions were. Two Mount Abe 9th graders persuaded their school board to move forward, then served on the project committee, then helped convince local voters to approve the bond that provided key funding. One of the two students has gone on to help lead a new youth-driven project, the Vermont Sustainable Heating Initiative, that is promoting residential pellet stoves, along with the growing use of local grass crops for heat.

"As you get older, you gain an idea of what sustainability is," reflects that student, Jessie-Ruth Corkins, who last year was among six environmental leaders selected by the Earth Island Institute for the 2008 Brower Youth Award. "Ninth grade was just the tip of the iceberg."

Corkins and Christi Kroll were in Tom Tailer's Earth Science class when the teacher challenged his students. "If they could get the school board to agree to an energy-saving option in the school, I would offer them \$100," Tailer recounts. "As a teacher, my role is to use real-world problem-solving to facilitate education."

Corkins and Kroll teamed up. Tailer suggested they work on alternate ways to heat the school, which was then burning 47,000 gallons of fuel oil during the school year. The two began to learn about biomass.

"Within a month and a half," Tailer says, "they were communicating with engineers and several different providers of biomass technology."



MOUNT ABRAHAM UNION High School eighth-graders Christi Kroll, left, and Jessie Ruth Corkins, and science teacher Tom Tailer each hold a handful of wood shavings to represent the fuel source they hope their school will adopt to replace oil. The two students, supervised by Tailer, have spearheaded a proposal for a wood chip-powered boiler that district voters may be asked to endorse on Town Meeting Day.

'You Present Decisions to Them'

With help from their teacher and from Forward, who was then interim director for the Vermont Superintendents Association's School Energy Management Program, the students prepared an analysis for their school board. They met with the board several times. In 10th grade they put together a formal proposal. Forward's program had provided a free, preliminary feasibility study. The students were now set to argue that the school board should go forward on a biomass heating project.

"What you need to do with community decision makers is to present decisions to them: yes or no," Forward advises. "If you just present information, they'll say, 'Yes, this is very interesting'—but that decision point forces them to make a decision."

At the time, the State of Vermont was offering 90 percent aid for school renewable energy construction projects. At a well-attended school board meeting, the students made their presentation and offered a decision point: move forward with a renewable energy project, or not? The school board voted that night to go forward.

Corkins and Kroll were named voting members of the project committee, with their teacher and the head custodian. The group oversaw a feasibility study and selected a system vendor—the one, says Tailer, who "talked directly to everyone on the panel, including the young women."

When the Mount Abe school board put a bond issue before voters to cover its share of the project's cost, Corkins created a brochure and prepared a speech.

"Jessie-Ruth stood in front of a very hostile audience from the town," Tailer says. "You know, 'Why should we spend our tax dollars on this? Oil is cheap.'"

On polling day, "she spoke to hundreds of people," the teacher recalls. "She went out and did the politics, and convinced enough people that it passed."

"Kids do not know how powerful they can be," Jeff Forward reflects. "If they become empowered, if they're passionate and they're accurate, it's an amazing thing to see."

If they were to win the teacher's \$100 prize, Corkin and Kroll's original plan was to buy \$100 worth of penny candy. They did win. They wound up purchasing a house in Rwanda for HIV-positive children there, through an organization with which Kroll had a contact.

Keys for a Convincing Presentation

During the 2008-09 heating season, the school's Messersmith Manufacturing wood boiler used almost 900 tons of woodchips, provided by a local supplier. "I'm paying \$36 a ton," says District Business Manager Greg Burdick. "If I go back to the last major oil year," when Mount Abe was heating entirely with fuel oil, "we used 47,000 gallons. In today's dollars, that usage would have cost \$141,000."

The district's total bill for heat in 2008-09, including 900 tons of woodchips and about 9,000 gallons of oil, was \$53,750. Mount Abe used its backup oil boiler mainly during the fall and spring "shoulder seasons," when the biomass system would not burn at peak efficiency.

Overall, Burdick says, the chip system has been virtually trouble free.

Corkins has meanwhile joined her former teacher and a core group of about 20 other young Vermonters in creating the Vermont Sustainable Heating Initiative. The group "wrote a persuasive statewide plan to develop Vermont's 100,000 acres of under-utilized land to grow prairie grass that could be pelletized and provide all of Vermont's home heating needs," said the Earth Island Institute in citing Jessie-Ruth for the Brower Youth Award.

As its pilot project, the Vermont Sustainable Heating Initiative is currently working with a \$20,000 state grant, plus other fundraising, to install pellet-burning stoves into selected low-income households. The group's goal is to do 15 installations; by June 2009, it had completed nine.

In making presentations for these sustainable energy projects, Corkins said she and Kroll followed a few key guidelines. One was preparation. "We worked hard to practice the main elements, and to have them in good organization." Another was candor. "At the end, a lot of questions would be thrown at us. If we didn't know the answer, we said we didn't have that information."

There are people today in Bristol who remember what Corkins and Kroll did.

"Last summer, one man walked up to me," Corkins says. "I didn't know who he was. He said, 'When I look at you, I think about all the money you're saving me.'"



Opposite page: Newspaper photo of students Christi Kroll and Jessie-Ruth Corkins with teacher Tom Tailer in the months before helping to secure a yes vote from the town to install a woodchip system at their school.

Above: The woodchip plant at Mount Abraham Union High School.

Starting up a Modular, High-Tech Wood/Solar System Hasn't Been So Simple

Wood Pellet Heating System

Heating Capacity (output): 180 kW (600,000 Btu/hr)

Emissions Reduction and Combustion Control Equipment: Cyclone

Year Installed: 2007

Thermal Output: Hot water

Out back of a small secondary school that serves a very rural district, in the West Kootenay Mountains of British Columbia, is a big, windowless metal box with solar panels on top. When you look closer, the box turns out to be three shipping containers bolted together, with a sign on the side that says, “Renewable Energy Heating System.”

This is the Nakusp Energy Corporation’s (NEC’s) combined wood and solar heating plant. Serving the Nakusp Secondary School, this system has been a focus of much more attention than its modest appearance and heating capacity would suggest.

The players in developing the project have been NEC, the Arrow Lakes School District 10, and Natural Resources Canada. NEC was formed in 2004 as a locally owned, private energy supply company that could offer significant cost savings to the school district by installing a system that would both burn wood and meet the province’s air emissions standards.

NEC put its project out to bid in 2006 and selected Energy Cabin, one of four bidders. Energy Cabin is an Austrian company that specializes in “modular and mobile heating and cooling systems based on renewable biomass and solar energy sources,” according to its website. Energy Cabin brought with it some of the project financing, from the European Union through the Austrian Export bank.

The Energy Cabin equipment, mostly pre-assembled in the containers, arrived in January 2007—and then the fun began.

“We had to change over some parts and pieces to make the unit conform to our safety regulations,” says Ray Greene, CEO of Nakusp Energy.



Nakusp is a village in a heavily timbered area, and its school district was then heating the well-maintained, 100,000 square-foot secondary school with 96,000 liters (25,000 gallons) of liquid propane (LP) gas per year. At an LP price of \$0.40 CAD per liter, the total annual cost was \$38,000 CAD.

When the renewable energy system was installed, it combined a wood-heat capacity of 180 thermal kW (600,000 Btu/hour) with a solar hot-water-panel array that covered 24 square meters (260 square feet). The modular plant can burn woodchips, wood pellets, or wood “pucks,” another manufactured form of densified wood. It has a fuel storage bin that can hold 30 tonnes (33 US tons).

The system would use wood pellets as fuel, although it can also burn chips, the fuel that Greene said he and others would have preferred. But even though Nakusp is in a heavily forested region, the area does not have enough market demand for suppliers to deliver woodchips in such small amounts. Nakusp Energy contracted instead for pellets, delivered from 135 miles away at \$120 CAD per tonne (\$100 US per US ton).

There was some support for the project within the school. “Our school has a growth plan to move toward sustainability,” says Elaine Tupper, science teacher at Nakusp Secondary. “This project has been an important part of that plan.

“As a science teacher,” she adds, “I love this system, the combination of local biomass and solar. It is a wonderful teaching tool for me.”

‘A Lot of Government Players’

The system was in place for the 2007-08 and 2008-09 school years, but did not operate to capacity—primarily because the local people were having difficulty figuring out the software and controls, with little support from outside.

“We really had to push the protocols on this project,” says Greene, “because there were a lot of government players involved—local, provincial, and federal. We had to make sure everything followed all the codes and regulations. We couldn’t take any shortcuts.”

In its first two years, the plant burned just a fraction of its fuel capacity—15 tonnes of pellets in year one, then 29 in year two.

There was a particularly high level of back-and-forth and scrutiny over the national engineering standards for certifying a pressure vessel of this type. “We lost a whole heating season of operation,” Greene recalls, “because of confusion around the pressure-vessel rules for the wood boiler, how they applied and how they didn’t.”

Another issue was difficulty integrating the heating plant’s operating system with the school’s own controls. “Everyone here in Nakusp knew there would be issues in operating a new kind of system—but so far it has turned out to be a steeper learning curve than we expected,” Greene says. “The real problem has been the interface between the wood boiler controls and the school’s own control systems.”

Another challenge: the Austrian-designed modular “box” used for fuel storage was set up to be filled from a truck that would blow fuel horizontally into the bin through the side door—but such a truck did not exist in this part of British Columbia. So NEC installed a water-tight hatch in the roof to accept delivery of pellets from a grain truck, with an auger used to deliver the fuel.

The system was finally de-bugged for full-scale operation in spring 2009, two years after it was installed.

One bright side: The system’s solar array pleased not just local teachers but other environmentally concerned Nakusp residents as well.

“I think the solar component did a lot to make local environmentalists comfortable with the project,” Greene says.



Opposite page: The modular Energy Cabin system integrates biomass heating and solar hot water in a single package.

Above: Nakusp’s Secondary School is in the spectacular West Kootenay Mountains of British Columbia, surrounded by vast forests and ranges of rugged peaks.

How Rhode Island's Pioneering Project Overcame Local Resistance

School Woodchip Heating System

Heating Capacity (output): One 1.9MW (6.4 MMBtu/hr) boiler and One 0.9 MW (3.2 MMBtu/hr) boiler

Year Installed: 2008

There's a saying that new ideas are first ridiculed, then attacked, and finally accepted as obvious. That pretty much covers what a group of community volunteers experienced when they sought to convince their western Rhode Island school district to install the first biomass heating systems to go into a public facility in that state.

In 2005, the school district serving the two towns of Foster and Glocester had won voter approval for the bond issue that would finance a \$46 million project to both build a new middle school and renovate the high school. The project's building committee created an energy committee to work on how to heat the schools. Foster resident Rick Sparks decided he would volunteer.

Sparks thought the group should look at biomass. Nobody wanted to hear about it.

"I would bring up biomass, and people would look down at the floor," Sparks says. "I think they thought it was a dirty fuel. Nobody was interested. So at my third or fourth meeting, I was giving my throw-in-the-towel speech. I said, 'If no one's interested in biomass, I'm not going to bring it up again.'

"It just so happened that a woman attended that meeting who works for the Governor's Energy Office. She said, 'Well, I love biomass—and I have money!'"

"I said to the group, 'We could fund a feasibility study,'" recalls Julie Capobianco, renewables program manager for the Energy Office.

Fast-forward to late summer 2008. As new woodchip-fueled heating systems were installed—a 6.4 MMBtu/hour boiler at the Ponaganset High School, and a 3.2 MMBtu/hour system at the Ponaganset Middle School—the building committee had a contract to buy chips from a nearby supplier for a price equivalent to \$.74 per gallon for heating oil.



When oil was \$2.69, the project's energy-services consultant had estimated the district would save about three quarters of a million dollars, per year, using biomass heat. Since then, oil had risen to more than \$4 per gallon.

With economics like that, it's easy to assume that the path was smooth from Rick Sparks' idea to the biomass installation. But this was not such an easy process. Skeptics in influential positions on town and school committees provided stubborn opposition—even when the favorable numbers became clear.

'We Kept Pushing and Pushing'

"The evidence was so strong and clear, we thought it was a slam dunk," says Greg Laramie of Glocester, who chairs the building committee.

The committee accepted Capobianco's offer to fund a feasibility study. The analysis, done by Biomass Energy Resource Center in late 2005, found it made both mechanical and economic sense to consider automated chip systems at the new middle school and the high school, which was being expanded to absorb the old middle school.

Volunteers visited nearby Mt. Wachusett Community College in Massachusetts, which has heated with biomass since 2001. They developed a Powerpoint presentation on what they'd learned.

"We were rapidly brought up to speed," says Laramie. "The feasibility study proved that it could be done. Then it just became a question of, 'How do we finance it?'"

An "ESCO" contract, signed by the district with energy services company ConEdison Solutions, generated primary funding for the \$11.4 million energy project, to be repaid out of energy-cost savings. About half those savings are projected to come from the chip systems. The other half will come from a wide range of energy-saving measures and technologies installed in the schools through the energy services company's design guidance.

But as proponents made their presentations to the school committee and the two town councils, some folks were stubbornly opposed. Skeptics believed that biomass would be dirty, that the systems would require specialized operators, that there would not be a reliable supply of chips.

Volunteers provided information, explained, answered questions, and kept doing that. An air-quality analysis found that the systems would meet even tough new anti-pollution standards. Local resident Bruce Payton, who is supervising forester for the state Division of Forest Environment visited Vermont schools that had chip systems. He reported that they were maintained, virtually trouble-free, by the schools' regular maintenance staff.

Payton told skeptics that Rhode Island is 56 percent forested, and that the supply of chips was far more than ample. Still, "they sort of balked for a while," he says.

"We just kept pushing and pushing and pushing it, until finally they sort of gave in to us. Number one, we had enough information so they could see it was going to work—and two, we had some funding."

The biomass proponents were indeed ridiculed, at times, and they were bewildered by some failed efforts to undercut and block their project.

Asked for lessons learned, Laramie says: "Assume the skepticism, and be prepared immediately with the answer." Now, with current oil prices, there is new interest in Foster-Glocester's project from others at the state and local levels in Rhode Island.

Locally, "I think people are reluctantly beginning to understand," Laramie says. "Of course, they're not going to come out and applaud it the way they opposed it. But that's all right. It's going to get done anyway."

"You just keep plugging away at it," Payton adds.



Opposite page: Ponaganset High School.

Above: Early construction of the Ponaganset Middle School in 2005.

Pellets: A Rural School District's Compact Solution

School Wood Pellet Heating System

Heating Capacity (output): 199 kW (0.68 MMBtu/hr)

Annual Wood Pellet Use: 200-300 tons

Year Installed: 2007

Thermal Output: Hot water

When a very small school district serving a low-income community was looking for ways to save on costs, its superintendent looked into wood pellets. The numbers made sense.

“Our existing fuel oil system, from the early 1990s, was working fine,” says Brian Patrick, the superintendent, whose Townsend, Montana district serves about 730 students grades K-12 in two school buildings. Yet when Patrick attended a December 2003 US Forest Service (USFS) workshop on heating system options, he thought wood pellets seemed worth investigating.

Back then, he notes, no one was predicting that fuel oil prices would rise as steeply as they have.

In 2004, the Montana Fuels For Schools and Beyond program, a USFS initiative, paid for an engineer’s pre-feasibility study on Townsend’s existing system. Townsend next sought and received a Fuels For Schools grant to install a pellet system to heat its elementary school.

After installing its system in 2007, Townsend, one of Montana’s first schools to use wood pellets, also became the first Fuels For Schools project to sell carbon offsets. The district has received \$12,420 from The Climate Trust for selling more than 130 metric tons per year of carbon dioxide emission offsets.

“We make an annual report to them, on total energy costs involved in delivering the pellets here and burning them, along with use and consumption here,” Patrick says.

Those welcome funds complement a package of financing that Townsend put together to meet the pellet system’s \$432,000 design, engineering, and construction costs. Along with more than \$46,000 of its own funds, the school district brought in the \$190,080 Fuels For Schools construction grant, a \$15,000 grant from the local conservation district, and a \$14,000 grant plus a \$140,000 low-interest loan from the USDA Rural Development Community Facilities Grant and Loan Program.



The pellet system was retrofitted into two existing oil boilers that heated the elementary school only, with the oil burners in those boilers left in place and fully functional for backup. The high school has a separate propane boiler system.

Patrick is also now president of the School Administrators of Montana—and in January 2009, he organized an “Energy Summit” for schools across the state that covered, among other options, woodchip and pellet systems.

“In Montana,” he says, “we do a good job of sharing what works.”

First-Winter Lessons Learned

The Townsend project has had its learning curve. The Fuels For Schools grant required it to use fuel drawn at least half from forest-management practices—such as slash from timber harvests or forest thinnings to reduce fire hazards. So, although the pellet system was designed for standard, residential-grade pellets, the district began fueling it with whole-tree pellets. These include bark, needles, and branches, along with bolewood, while standard pellets are pressed entirely from bolewood.

“If you bought a new Mercedes Benz and put bad fuel in it, you’d wonder why it didn’t work so well,” Patrick quips. This is roughly what happened during the Townsend system’s first winter.

For Townsend, Eureka Pellet Mills developed a pellet that is half forest-management slash and half wood material from other sources commonly used for pellets, such as wood pallets and sawmill residues.

But the bark, branches, and needles in these pellets created “clinkers,” very hard lumps, in the Townsend system’s combustion chamber. Clinkers are made when partially combusted ash and minerals within the pellet fuel fuse together—and Townsend’s ash-removal mechanism wasn’t designed to handle them. During that first winter, the system had to shut down several times for repairs and modifications to the ash-removal mechanics.

“The school district burned through this first load of whole-tree pellets, then ordered a delivery of higher-grade pellets,” says a report by the Fuels For Schools Program. “While still producing ash and clinkers, the amounts generated by the higher-grade pellets are much more manageable.”

“The issues and setbacks in the beginning took time to work through,” but “my attitude through it all remained positive,” said District Maintenance Supervisor Jim Riddle, quoted in the Fuels For Schools report. “I can foresee this system will work well for us in the upcoming years as non-renewable energy costs continue to rise ... Now, when problems do arise they are fairly easy to troubleshoot and resolve.”

‘For Us, This Made Sense’

One reason Townsend went with a pellet system was that it’s compact, and space was at a premium: The system had to be placed beside the elementary-school playground. Also, compared to woodchips, pellet systems require fewer deliveries—and with this one’s location by the playground, that was also a factor.

“We receive approximately three deliveries per year,” Patrick says. “For us, this made sense. It’s a little more expensive for fuel,” compared to woodchips, “but it’s a lot less labor intensive” to operate.

Townsend’s Solagen biomass system is integrated directly with its fuel oil boilers, saving space and allowing for easy switchover when needed. To heat its elementary school during the 2008-09 heating season, Townsend burned 296 tons of pellets, delivered by Eureka Pellet Mills, at a total cost of \$38,604. The system also burned about 1,500 gallons of diesel fuel, using its backup oil burners for 25 heating days.

“On 10 of those days we used fuel oil because it was severely cold and the pellets would not keep up,” Patrick says. “Because the system was running continuously with no problems, we burned through a silo of pellets and ran out—our error—and had to wait for more pellets to be delivered.”

“Quite honestly, I look at our biomass system as an insurance policy,” he concludes. “If there was a world crisis revolving around oil, we would still be able to heat our schools, and we wouldn’t be held hostage.”



Opposite page: Entrance to the school complex in Townsend, Montana.

Above: Brian Patrick, superintendent of the Townsend school district and president of the School Administrators of Montana, stands next to the school’s pellet silo loader.

In Denmark, Two Schools Show How It's Done with Small Boilers

School Wood Pellet Heating System

Heating Capacity (output): 250 kW (850,000 Btu/hr)

Emissions Reduction and Combustion Control Equipment: O₂ sensor control

Year Installed: 2000

Thermal Output: Hot water

Two boarding schools in western Jutland are examples of the smaller end of the wide spectrum of biomass energy applications in Denmark, this smallest of Scandinavian countries.

“Biomass energy is a big industry in Denmark today, and the future holds even more promise,” says Svend Brandstrup Hanson, president of DANBIO, the Danish Bioenergy Association. “We have had great success in the use of all kinds of biomass in district energy at all scales, heating of individual buildings, biogas utilization, and more. In the future we will see a whole new industry in making liquid biofuels from farm and forest residues as well as from energy crops.”

The Verdersø Sports School and the Husby Boarding School, not far from each other, are each heated using locally produced biomass fuel, and both use boilers made by Twin Heat, a Jutland company. Verdersø School’s 250 thermal kW (850,000 Btu/hour) boiler, and Husby School’s 150 kW (500,000 Btu/hour) boiler both burn wood pellets that cost 1,200 Danish kroner (\$210 US per US ton), plus 25 percent in taxes.

While these biomass fuels are not cheap, they are much less expensive than oil, and both schools save money by using this local fuel. The two schools use boilers that are on the high end of the sizes made by Twin Heat, which also makes residential boilers.



“We are not a big company, and most of our sales are here in Denmark,” says Svend Eric Sund of Twin Heat. “We make small, high-performance boilers that burn wood pellets, woodchips, and grain. Our customers are about 60 percent farms, 30 percent houses, and 10 percent institutions. We have our boilers in about 20 schools.

“We fill a niche. Our customers want small solid-fuel boilers that operate reliably at very high efficiency with very clean emissions, and they are willing to pay for performance.”

Nearby the schools are two of Twin Heat’s residential customers, more examples of Denmark’s small-scale biomass boiler market.

At an old brick farmhouse with a thatch roof, in a farm building across the courtyard from the kitchen, a 12 kW (40,000 Btu/hour) Twin Heat boiler provides all the farm’s heat by burning rye and barley that the farm grows. In the next town, a house has a woodchip silo in the back yard, with an auger that automatically moves the chips inside to the boiler. The modest home uses about 18 tonnes (20 US tons) of local woodchips each year, at a cost of DKK 7,000 (\$1,300 US).

Modest Heating Bills, Tidy Heating Systems

The Verdersø Sports School caters to students who want to excel at competitive athletics. With 120 students of middle-school age, the school has a small, pleasant campus of comfortable, modern buildings and playing fields. Its pellet boiler plant—built in 2000 right in the middle of the school complex—occupies a trim, tidy building with a silo in back to store the pellets. The school uses 90-110 tonnes (100-120 US tons) of pellets per year, at a cost of DKK 200,000 (\$35,000 US). The boiler system cost the school only DKK 250,000 (\$45,000 US).

In Husby, the boarding school has just 70 students, and it needs only a little more than 90 tonnes (100 US tons) a year, at a cost of DKK 160,000 (less than \$30,000 US) to heat its cluster of school buildings. At this school, there is no outward sign that biomass fuel is being used since the pellets are stored in a basement bin of one of the school buildings next to the boiler room where the Twin Heat system is located.

The fuel delivery truck has a hose that connects to a port on the side of the building so pellets can be blown into the bin. A second port connects to a second hose that automatically sucks out the dust in the air from the delivery, storing it back in the truck, leaving the boiler room and bin area clean.

'Vibrant Markets' for Biomass Fuels

“Originally, wood pellets were made in Denmark from sawdust that came from the Danish furniture industry,” says Sund. “Now, there is more demand for all kinds of wood and we see pellets coming from other Baltic countries, too. In the future, who knows? They could come from anywhere that wood is grown.”

“Most of our farm customers burn fuel they grow themselves and residential customers burn fuels that come from very close to where they live. They use our boilers for heat—including space heat and barn heating—hot water, and drying grain.”

“Our biomass fuel industry in Denmark is mature,” says Hanson. “We have vibrant markets in straw, mill residues, forest wood-chips, grain, and plantation energy crops, with participation from large national companies and farm and forest co-ops as well as small entrepreneurs who serve local markets.”

On a tour of biomass sites in Denmark, Hanson pointed out a small wood-harvesting operation on private land.

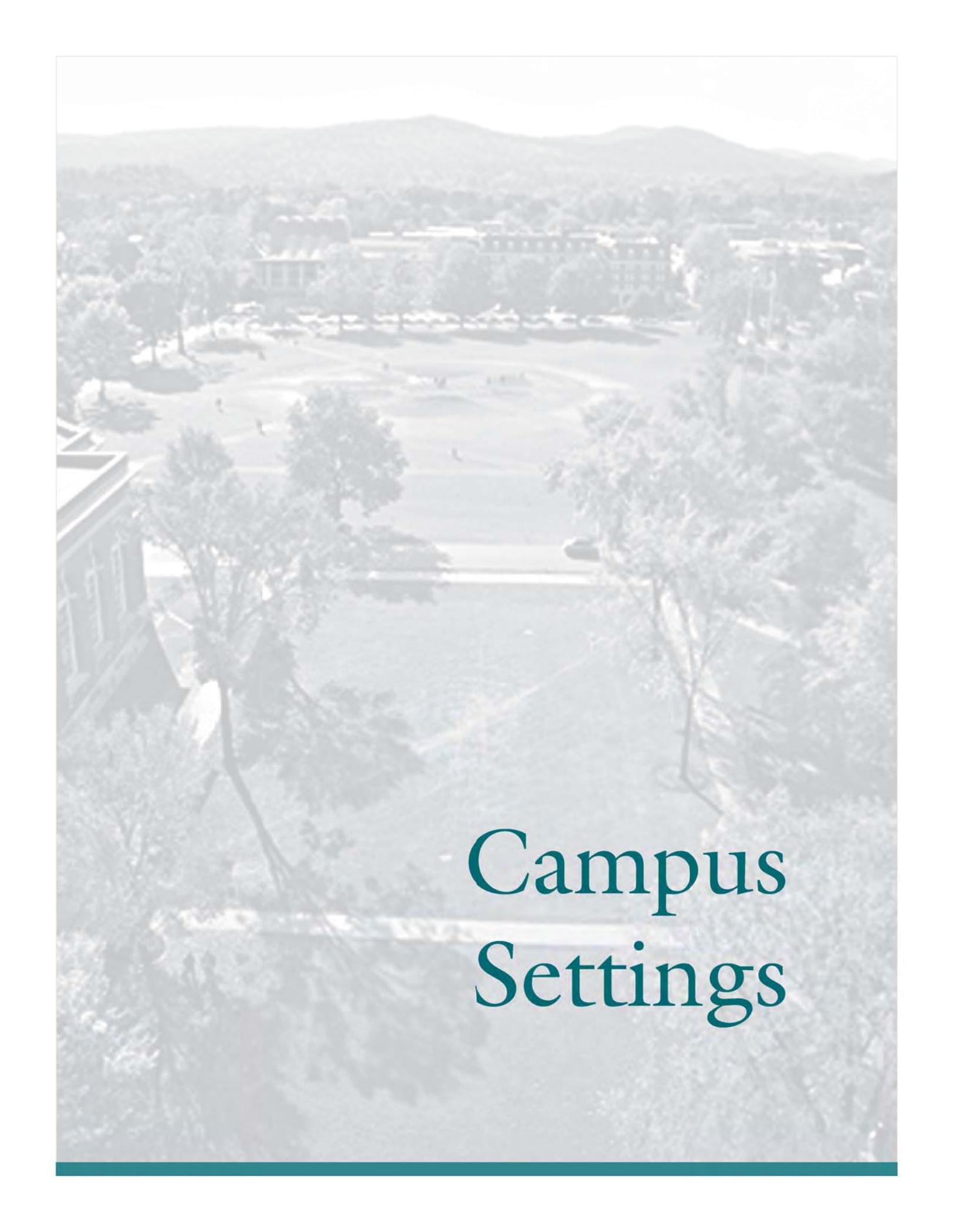
“This is a good example of what goes on at small scale all over Denmark,” he said. “This is a one-person business, where the owner invested DKK 1.4 million (\$250,000 US) in a modern tractor with a chipper and a wagon to deliver wood fuel to nearby customers. Here he is working on a Saturday morning, chipping small-diameter fallen trees, which he will deliver as fuel to a customer not far from here.”

“It is not a big operation—but it is a successful business, and he is making money.”



Opposite page: The campus of buildings at the Verdersø School and the Husby Boarding School.

Above: Twin Heat representative Svend Eric Sund shows off his company's pellet boiler at the Verdersø Sports School.



Campus Settings

Using Biomass for Energy in Campus Settings

For the colleges whose biomass systems are profiled in this section, environmental benefits are stacking up alongside cost savings.

For Middlebury College, a prestigious liberal-arts college in Vermont that has become a recognized leader in the fight against climate change, the impetus was a college-wide commitment to move toward carbon neutrality. A study group that included students, faculty, and staff found that three-quarters of Middlebury's carbon emissions were coming from fuel-oil combustion; using biomass for heating and cooling could displace half of that. The college's \$11 million biomass plant is expected to generate annual cost savings of almost \$2 million, while cutting greenhouse gas emissions by 40 percent (pp. 27-28).

For Chadron State College in Nebraska, the impetus was forest fires. The state's overgrown forests have become a serious fire hazard—and after an outbreak in 1989, Chadron became Nebraska's first college to convert to biomass (pp. 25-26).

Using waste wood from logging and thinning operations that reduce fire hazards, the campus has cut energy costs by half. After a recent rash of fires, the college is called a model by state officials who note that only 10 percent of Nebraska's waste wood is currently being used.

Economics were the bottom line for Mount Wachusett Community College in Massachusetts (pp. 29-30). The college was paying about \$400,000 annually for all-electric heat before shifting to biomass. From late 2002 to early 2008, the college saved about \$3.1 million in heating costs, while cutting greenhouse gas emissions by the equivalent of planting 3,539 acres of trees and taking 2,256 cars off the road.

The University of Idaho (pp. 31-32), is "proud of its environmental record," says the state's Fuels For Schools coordinator. The university uses its biomass boiler for nearly all its heating needs, saving about \$5 million per year on fuel.

Nebraska Biomass System Models a Use for Forest Thinnings that Cuts Fire Hazard

Campus Woodchip Heating System

Heating Capacity (output): 6 MW (20 MMBtu/hr)

Annual Woodchip Use: 9,000 tons

Emissions Reduction and Combustion Control Equipment: Cyclone, O₂ sensor control

Year Installed: 1991

Thermal Output: Steam

Forest fires are the urgent impetus for biomass energy in Nebraska.

Although the Great Plains state is only two percent forested, its woodlands—long allowed to grow over-dense, and thus fire-hazardous—erupted in the summer of 2006, in several complexes of blazes that altogether destroyed more than 68,000 acres.

“This was the first time in the state that we lost homes to forest fires,” notes Doak Nickerson of the Nebraska Forest Service. “It’s unprecedented, really, and it’s a reflection of fire hazard in the woods.

“Our forests are a product of years of little to no management. So you end up with a heavily stocked forestland, way more trees grown per acre than there should be,” he explains. “That becomes a big fire hazard.”

Concern over that danger and those losses—“catastrophic fires threaten our forests and rural communities,” declared State Forester and Forest Service Director Scott Josiah—has spurred a new interest in using wood from fire-reduction thinning, and from non-commercial timber, in biomass energy systems.

There is a model in place. The last year that saw a major forest-fire eruption in the state was 1989, when more than 20,000 acres were lost. That outbreak led to the 1991 construction of a woodchip heating plant at Chadron State College in northwest Nebraska.

Near the sites of the 1989 and 2006 fires, Chadron State has cut its overall energy costs by 50 percent as it burns more than 9,000 tons of wood each year to heat and air-condition its campus. The fuel supply comes from logging waste and forest thinning to reduce fire hazard. Producing 20 million Btu per hour, Chadron State’s large system heats and cools more than one million square feet of building space.



PHOTO COURTESY TOM COSTON

Both within and outside Nebraska, others are noticing. The wood burned at the state college “is one-half of one percent of the total wood grown in Nebraska each year,” said the 2007 annual report of the Nebraska Forest Service.

The potential benefits also go to the economy, the Forest Service notes.

“Years of steadily rising energy costs have negatively impacted Nebraska’s rural communities, some of which were already facing serious economic decline,” says Josiah. “Woody biomass utilization serves as a catalyst for rural economies.”

A Bet that Continues to Pay Off

“Twenty years ago, the administration of this college and the community leaders made a bold step forward,” Nickerson says of Chadron State.

“Back when natural gas was super-cheap, they went on a bet that fossil fuels would escalate over the next 20 years—and that turned out to be right. Now we continue to get visitors from other parts of the country, to take a look at how this college is saving tax dollars as well as doing a good deed for the forestland.”

“Some of that is the momentum that we have toward alternative fuel in the country,” notes Jane Darnell of the US Forest Service (USFS). But in Nebraska, she adds, the new interest is spurred largely by the “wake up call” that the 2006 forest fires sounded.

“That heightened the awareness and interest,” Darnell says.

“I think folks are saying, ‘Look what they’re doing at Chadron State.’ The forests are here, and they’re under-utilized.”

The state Forest Service has taken up the cause. “Woody Biomass Is Nebraska’s Untapped Resource,” trumpeted the headline of a Forest Service news release in early 2009.

Analysis funded by a USFS grant led the state service to conclude that “Nebraska has 1.3 million acres of timberland containing more than 41 million oven-dry tons of standing woody biomass,” according to the news release.

“Woody biomass is the low-hanging fruit for alternative energy applications,” Josiah said in the article, which noted that annual “net growth in Nebraska timberland produces nearly one million net tons of wood.

“Additionally, 270,000 tons of wood are generated each year from forest fuels treatment programs, range improvement activities, timber harvest operations, urban wood waste, and wood-processing operations.

“Currently, less than 10 percent of this waste wood is used.”

Up-Front Costs vs. Long-Term Payback

The Hurst biomass system at Chadron State cost about \$1 million when first installed, Nickerson says. “They just added on to the existing energy building that was there,” which had been housing natural gas-fired district energy boilers.

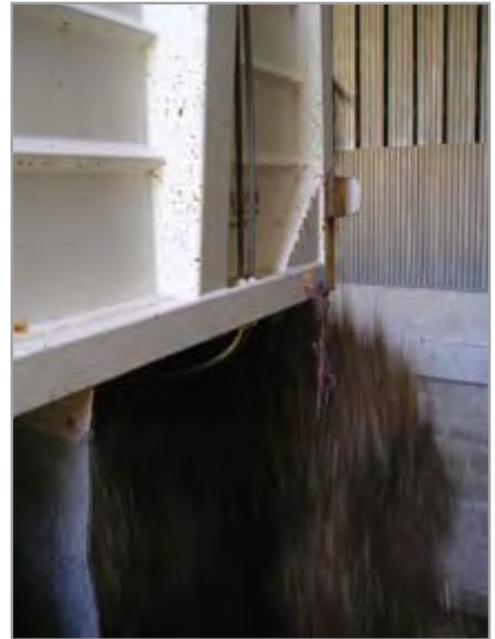
“Since then they’ve made about a \$1.3 million upgrade to the air-induction system, to make the two boilers more efficient,” Nickerson adds. “They’re getting more Btu out of the chips; it’s also really enhanced the air quality of their emissions.”

Chadron State also added an 800-ton air-conditioning chiller—using steam from the wood boiler—to cool some of the college’s buildings in summer, and thereby reduce electrical demand.

“The true success of this system was that the original engineering study said the savings in using woodchips, for the college, would create a payback of 10 years—and they actually paid the system off in six,” Nickerson says. “And that was before natural gas prices went where they are today.”

The up-front costs of wood energy plants can be higher than comparable fossil-fuel systems, he adds.

“Because of the up-front costs of capital investment, it’s a tough sell,” Nickerson notes. But “in those paybacks, wood continues to shine over fossil fuels.”



Opposite page: Chadron State College’s fuel supply comes from logging waste and forest thinning to reduce fire hazard.

Above: Chipped fuel is delivered to the fuel storage bin at the college’s woodchip heating plant.

College's Biomass Heating/Cooling Plant Aims to Cut Carbon and Costs—in Big Ways

Campus Woodchip District Energy System

Heating Capacity (output): 8.8 MW (30 MMBtu/hr)

Year Installed: 2008

Thermal Output: Steam

In 2004, when Middlebury College committed itself to cutting by eight percent its carbon emissions—a pledge it would later strengthen to full carbon neutrality by 2016—“among the different actions that were identified, biomass was clearly one that could make a big difference,” recalls Jack Byrne, sustainability coordinator at the renowned Vermont liberal arts college.

As the biggest of its emissions-reduction efforts, the college invested in a biomass-fueled, district heating and cooling system. After a feasibility study showed the idea to be practical, Middlebury broke ground in 2007 on an \$11 million biomass plant. Once online in late 2008, the new system is expected to be the primary heating and cooling source for the school's district energy system—and steam from it will also help fuel the college's cogeneration system, which meets about one-fifth of the campus's electricity needs.

When the college began looking at biomass in 2004, the price of No. 6 fuel oil—of which it was using about two million gallons per year—was \$.89 per gallon, notes Tom Corbin, director of business services. By summer 2008, it was more than \$3 per gallon. Middlebury expects the biomass facility to cut its fuel oil usage by half, replacing that million gallons of oil with 20,000–21,000 tons of chips per year. At fuel-oil price levels in summer 2008, that predicts an annual cost savings of about \$2 million. At the same time, the college has planted 10 acres of fast-growing willow shrubs on fallow farmland that it owns as a test project to determine if it can grow enough to meet up to half of its system's needs.

With or without the willow project, Middlebury also expects its biomass plant to:

- cut by almost 12,500 tons per year, or about 40 percent, the volume of greenhouse gases that it emits
- replace a distant fuel source with a local one, as the college requires that all of its biomass must come from fewer than 75 miles away



- generate 2–2.5 million kWh of electricity, with a renewable fuel
- benefit the economy of its home region, especially its forest-products industry—along with area farmers, if the willow project catches on
- serve as a learning and demonstration lab for biomass gasification technology in action

“Our hope is that the college's entry into biomass will greatly stimulate the growth of the local, sustainable woodchip market and bioenergy economy in Addison County and Vermont,” says Nan Jenks-Jay, Middlebury's dean of environmental affairs.

Added college President Ronald Liebowitz: “The biomass plant exemplifies the college's longstanding commitment to the environment—not only as an academic subject, but also as an integral part of the institution's operations.”

'Maximum Participation and Onboardness'

Middlebury students have played key roles in evolving the college's commitment to going carbon neutral. Formed in 2002, a Carbon Reduction Initiative Working Group included student, staff, faculty, and administration representatives—and students successfully urged the trustees to adopt its two successive carbon-reduction goals.

“Middlebury’s approach to reducing its carbon footprint was, and continues to be, maximum participation and ‘onboardness,’” write Jenks-Jay and Byrne in a chapter they co-authored for a recently published book, *The Green Planet: Meeting the Challenge of Environmental Sustainability* (APPA, 2008).

The carbon-reduction working group noted that three-quarters of the college’s emissions came from burning No. 6 fuel oil for heating and cooling—and a woodchip system could displace half of that. A study affirmed the potential for a biomass system that would use locally harvested fuel and could generate economic and learning benefits.

In 2004, trustees committed Middlebury to reducing greenhouse gas emissions eight percent below 1990 levels by 2012. In late 2006, trustees approved the biomass system plan—and in 2007, they voted that the college would go entirely carbon neutral by 2016. To meet that goal, the college is also moving on a brace of additional strategies, from mixing 20 percent vegetable oil into the fuel used in furnaces for 100 buildings not on the biomass district system to replacing college vehicles with hybrid cars and electric carts.

Test-Growing a Fuel Supply

“Really looking at the supply question, for us, was the critical piece,” said Byrne in summing up lessons learned in the process of moving to biomass district energy. Initially hoping to find a single, nearby supplier for all its woodchips, the college found that wasn’t possible and contracted instead with a New Hampshire wood-products broker. Middlebury has required that its chip supply be obtained from within 75 miles of the campus, and that a stockpile of it be stored no more than 25 miles away.

“That guarantees us a six-week supply,” said Byrne, who expects the biomass system to meet all of the college’s heating and cooling needs “for probably eight months of the year.”

“The other question it’s important to ask, that we asked for our willow project, is: Okay, right now there’s sufficient [fuel] capacity. But what happens five years from now, if many more people switch to wood as a fuel source, which is quite likely to happen?”

In hopes of ensuring its own, reliable, sustainably produced supply, the college looked into farming trees for fuel. It found that the State University of New York College of Environmental Science and Forestry (SUNY ESF) in Syracuse had been growing, testing, and studying willow crops for several decades.

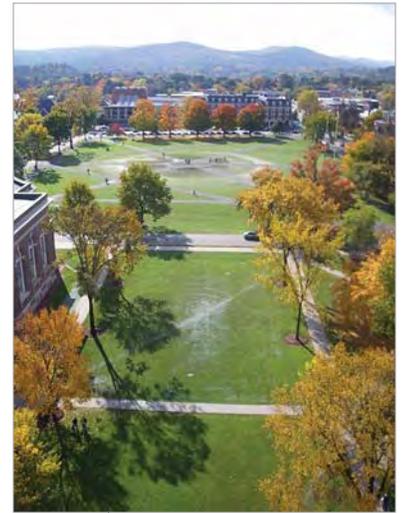
“They said, ‘You should do a test planting, and see how it goes,’” says Corbin, the college’s business services director. So the college planted about 10 acres in 2007. The willows—in this case, more fast-growing shrubs than trees—are first harvested after four years, then on a three-year rotation. The college hopes to harvest 25-30 tons per acre, the yield achieved by SUNY ESF. If it does, then planting and/or contract for the planting of 1,200 acres would meet half of the college’s biomass needs.

“That’s a lot of willows—and that’s a lot of work!” says Corbin. “The logistics are not going to be easy, but we look at it as investing in the willow crop.” Several people in the area have already inquired about raising willows, he said. The college has advised them to wait and see how the test plot fares.

“Ten years from now, I may look real smart,” Corbin quips. “Who knows? We’re going to have to try some of this stuff. We’ve got a lot of options.”

One key aim, he summed up, is to “control your supply of fuel—to know where it’s coming from, and how ‘green’ it is.

“On balance, our fuel source now is greener. That’s where we’re going.”



College Chip System Smoothly Generates Cost Savings

Campus Woodchip Heating System

Heating Capacity (output): 2.35 MW (8 MMBtu/hr)

Annual Wood Fuel Use: 1,200-1,400 tons

Emissions Reduction and Combustion Control Equipment: Baghouse

Year Installed: 2002

Thermal Output: Hot water

When Ed Terceiro, then executive vice president of Mount Wachusett Community College (MWCC) in Gardner, Massachusetts, approached the state Division of Capital Asset Management in the early 1990s for approval to heat the college campus with woodchips, he remembers that he met “with a bit of skepticism.”

“The concept of heating a facility this size with wood was rather unique,” Terceiro says. MWCC is a 450,000 square-foot building complex. Within the state oversight agency for capital construction projects, people envisioned college staff and students out back of campus with chainsaws, clearcutting to fuel the furnace.

But once Terceiro had laid out the numbers and the reasons why he had grown convinced that biomass heat made sense for his campus, the state agency became a key ally.

“After their initial skepticism, they were very supportive,” he recalls.

Back then MWCC had electric heat, and its heating-related utility bills were running about \$400,000 per year—double what similar-size campuses on oil heat were paying. With enrollments dwindling and costs rising, college leaders knew something had to be done.

When the college began researching its options for a new system, the assumption was that MWCC would go to oil or natural gas. But then the concept of woodchips was brought to the attention of Terceiro, a mechanical engineer by training.

“We did a lot of research,” he recalls—“and the more we got into this, the more it really started to look attractive.” MWCC is home to the Massachusetts Forest and Wood Products Institute; wood heat seemed a natural fit. Research suggested that it would have environmental as well as economic benefits. A feasibility study convinced college leaders to go ahead.



“We embarked on a mission to raise the funds,” Terceiro says. “We were thrown out of a lot of offices, believe me,” says the executive, who now serves as MWCC’s resident engineer and acting deputy commissioner for fiscal affairs at the Massachusetts Department of Higher Education.

The project’s total budget was \$4.3 million—higher than it might have been, because MWCC had neither a heating plant nor distribution piping for a hot water system. The whole infrastructure would have to be built new. Along with woodchip heat, MWCC also proposed a number of energy-saving measures, such as high-efficiency lighting and water-saving plumbing fixtures.

MWCC leveraged about \$1 million from the US Department of Energy, with key help from US Representative John Oliver (D-Ma.). It got \$750,000 from the Massachusetts Renewable Energy Trust, which administers a pool of money raised through a surcharge on electric bills that is used to assist renewable energy initiatives. Also, thanks to its energy-conservation measures, the college secured a number of rebates from its electric utility. Even with all that bundled together, MWCC still needed to leverage another \$1.8 million. To do that, MWCC signed a performance contract with an energy services company, NORESKO.

Adding up the Positive Impacts

The eight MMBtu/hour woodchip system was commissioned in late 2002—“and it didn’t cost the commonwealth a nickel,” Terceiro says. In its first year of operation, the system exceeded expectations for energy cost savings compared to fossil fuels.

It continues to prove its worth.

Between December 2002 and March 2008, “we’ve saved about \$3.1 million” by heating with woodchips instead of oil, Terceiro says. “Even more significant, from my point of view, we’ve saved about 30 million kWh of electricity and almost 15.5 million gallons of water.

“As a result of this one project, we’ve reduced our carbon dioxide emissions by almost 13,000 tons, nitrogen oxide by 21 tons, and sulfur dioxide by 55.5 tons. That would be the equivalent of planting 3,539 acres of trees—and of removing 2,256 cars from the road.”

From the start, Terceiro says the chip system “worked pretty much flawlessly from a mechanical and heat-generation point of view.” MWCC uses a sophisticated energy-management system that allows it to remotely regulate the heat, humidity, and carbon monoxide content in each classroom and other spaces. Thermostats in classrooms give professors six degrees of flexibility in resetting temperatures for individual comfort.

“This translates into a tremendous amount of efficiency,” Terceiro notes—“but it also translates into a tremendously more comfortable environment for our faculty and staff. Our issues in terms of complaints or people looking for assistance went down to just about nothing.”

“Where we did have problems, and it took us about a year to work them through, was with emissions control,” Terceiro says.

The college started with a core separator, then added a multi-cyclone for particulate matter removal. When it still couldn’t hit its targets for emissions control, it replaced the core separator with a more conventional baghouse. MWCC has learned to leave one of its six baghouse plenums off-line at all times, and the emissions system “has been running like a champ,” Terceiro says.

The college maintains an oil-fired backup boiler, which provides heat during the “shoulder” months of fall and spring. Once the wood system is fired up about November 1st, it meets 100 percent of MWCC’s heat and hot water needs through the winter.

Biomass fuel costs for 2008-09 ran to \$62,000 for 1,200 tons of woodchips, most bought at \$58 per ton, some purchased at \$50-\$53 (those lesser-quality chips didn’t work as well). The college also used about 6,000 gallons of fuel oil.

If the college had stayed with electric heat, Terceiro figures its annual costs for heat and air conditioning would now approach \$2 million.

“This whole process has taken on greater significance since 9/11—I think that’s obvious,” he concludes. Instead of sending 80 percent of its heating dollars “to a country that really doesn’t like us right now,” virtually all of MWCC’s energy spending stays in the local economy.

“I apologize if I sound a little bit passionate about this,” the college executive concludes. “I guess we have been.”



Opposite page: The campus of Mount Wachusett Community College.

Above: Woodchip delivery to the storage facility at the heating plant.

A Large Campus System Saves \$5 Million Annually on Fuel

Campus Woodchip Heating System

Heating Capacity (output): 18 MW (60 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, O₂ sensor control, moving grates, air pre-heater, economizer

Year Installed: 1986

Thermal Output: Steam

Since 1986, the University of Idaho has been heating its campus, and more recently also air-conditioning it, with woodchip biomass. “They say on the average that they save \$5 million a year over the cost of natural gas,” reports Mike Tennery, Idaho coordinator for the Fuels For Schools program.

In Moscow, on the border with Washington state, the university first looked into installing a biomass backup boiler for its campus heating system in 1978. Studies projected that a wood-fueled boiler would be cost effective, so the university had one installed to back up its natural gas-fired system.

“As the new boiler was brought on line to produce high-pressure steam to heat 70 percent (three million square feet) of campus building space and provide hot water, it was found the biomass operation was very economical,” Tennery related in a 2006 report. “The biomass boiler became the lead boiler. It is run 95 percent of the time. Currently the university estimates heating costs, using the biomass-fueled boiler, are between one-quarter and one-third the costs of heating with natural gas.”

Two years after the biomass unit went online, “they ‘mothballed’ one of the [three] gas-fired boilers. That was 18 years ago, and it’s still mothballed,” said the ’06 report.

The system primarily burns cedar chips, mixed at about a two-to-one ratio with “slash” or scrapwood from logging, primarily white pine. With the slash fuel, “you have to really watch the quality,” says Tennery—“how much dirt there is in the fuel, whether you’ve got needles and if somebody has ground up a bunch of stumps, which have a lot of dirt and rocks.

“They bring in woodchips from a radius that varies, depending on the cost of diesel fuel.” Diesel powers both the trucks that haul the chips and many of the chippers that produce them. The lower diesel prices go, the farther the plant can go to source chips.



“The current radius that we’re using for practicality is between 50 and 60 miles,” Tennery says.

Maintenance needs at the college’s heating plant are regular but generally routine, said Dave Reber, an operating engineer at the plant. “About every six months we go inside the boiler to replace a lot of grates. Our augers wear out, so we replace them pretty frequently.”

“The boiler itself is fairly reliable—it’s just handling wood” that is the challenge, adds plant manager Michael Lyngholm. “There are jams. It doesn’t flow through the pipeline like natural gas would. But I guess it’s no worse than coal.”

Saving Over \$5,000 Per Day

One natural gas boiler remains as backup, but the university uses its biomass boiler close to 100 percent of the time.

“In 2003, the wood-fired boiler was shut down for a week to do routine cleaning and maintenance,” Tennery reported. “Up to shut-down, the university was burning \$1,700 per day in cedar chips. While the wood boiler was down, natural gas for the backup boiler cost \$7,000 per day.”

The biomass-powered Zurn plant produces steam heated to 150 psi; pressure-reducing valves cut that down to 60 psi for campus-wide distribution.

“The lower 60 psi pressure provides safety in the tunnel system that connects the steam plant to the buildings on campus,” said Tennery’s report. “The higher pressure at the boiler functions as a sort of heat storage to cover demand on campus; for example, the increased load generated by 4,000 dormitory residents all taking morning showers. A byproduct of central heating is snow-free campus sidewalks that lie above the steam tunnels.”

To add air conditioning to the system, the university installed eight water chillers during the 1990s. Five are powered by steam from wood, the others by electricity. “Summer steam loads are almost as high as winter heating loads,” said the ’06 report.

Fuel consumption runs up to about 70 daily tons in the winter and up to 100 tons per day in extreme cold weather. During the July 2004-June 2005 fiscal year, the university burned 23,000 dry tons of chips, or 1,660 truckloads. The system has used pellets and shredded paper, along with the cedar chips and logging slash. Moisture content works best at 30-40 percent, though the system has used fuel at up to 60 percent moisture. A small volume of wood ash, produced as waste from the boiler, is used as a soil acidity balancer on campus lawns.

“The steam plant is proud of its environmental record,” Fuels For Schools reported. “The plant passed emissions testing in 2005 with the stack emitting less than one half the allowable particulates. Stack gases are usually invisible.”

‘The System Works’

“This system was designed to experiment, originally, with different grades of wood fuel and different types of wood fuel,” Tennery adds. “Their air-quality permits require them to monitor their stack emissions very closely, which they do. They graph that, and they can adjust what’s going out of their stack by adjusting their burn rates.”

“About 90 percent of steam is condensed, collected, and returned to the plant for reheating, saving heat, water, and chemicals,” said the Fuels For Schools report.

In Idaho’s dry climate, the chip fuel is stored in the open, in a large off-campus stockpile that normally has several thousand tons of chips. A new covered storage shed has recently been built to protect some of the stockpiled fuel from precipitation. Maintenance workers haul the fuel into the boiler plant using a university truck. At both the storage yard and the boiler plant, a hydraulic “tipper” lift raises the closed end of the trailer almost 90 degrees, to empty the chips from the open rear end.

“Chips are then transported using an auger system adapted from grain-storage silo systems,” Fuels For Schools reported. “This system uses agricultural components which are readily available in the local area, making repair inexpensive and parts readily available.”

“The system works,” says Tennery. “They’re considering some changes to the system at the moment—but so far, none of them have been made.”



Opposite page: The University of Idaho’s central heating plant, whose woodchip system has been operating since 1986, sits in the middle of the Moscow campus.

Above: Truck dumper and fuel receiving station with fuel silo in the background.

College Draws Key Lessons Learned from Two Decades' Experience with Biomass Heat

Campus Woodchip Heating System

Heating Capacity (output): One 3.6 MW (12 MMBtu/hr) boiler

Emissions Reduction and Combustion Control Equipment: Cyclone

Year Installed: 1988

Thermal Output: Steam

In the late 1980s, a pioneering wood-fueled district energy system in Charlottetown, Prince Edward Island (PEI), caught the attention of the provincial government in nearby Nova Scotia. Interested in replicating what PEI had done, the province turned to a small, public college in Truro.

“The government was looking for a place to put in a facility and explore the concept,” recalls Phil Talbot, who was then, and still is, manager of the physical plant at Nova Scotia Agricultural College (NSAC). “We were burning two million liters (530,000 gallons) of oil a year, and we were sitting right in the middle of the province, surrounded by forest.

“When we first heard we were getting a biomass system, I took my chief engineer and a couple of operators that would run our system, jumped into the car, and went to PEI,” Talbot recalls. “I wanted them to interact with the operators that were running the system there.

“We learned a lot.”

NSAC’s woodchip-fueled campus central heating system was commissioned in 1988. Today, with more than two decades’ experience in running a biomass system, Talbot says one key lesson he’s learned goes way back to that first car trip.

“A wood energy plant is a lot of work, and one of the challenges you have is to bring your operators on board,” he declares. “There are plants that have failed, just because there was no buy-in” at that level.

From the earliest stages of installing its biomass system, the college involved its system operators. “It worked,” Talbot says of the system—“because they took a lot of pride in making it work.”



With a capacity of 12 MMBtu/hour, the college’s biomass plant, built by KMW Energy, provides heat and hot water to 65,000 square meters (701,000 square feet) of the campus. During the 2008-09 heating season, it used 5,850 tonnes (6,550 US tons) of wood fuel.

“We’ve gone as high as 8,820 tonnes,” Talbot says. “It depends on the weather. And if you have a breakdown for a few days, that’ll affect your total use. If we go down on a cold day and that wood burner has to go off, we can lose over a thousand dollars. The savings are pretty dramatic.”

The college maintains a backup system that uses No. 2 fuel oil. Last year, it burned 721,000 liters (190,000 gallons) of petroleum fuel.

“That was high,” Talbot says. “Last winter was a tough winter.”

Every month, his chief engineer produces a report that breaks down the system’s fuel use, and also indicates what the college would have spent if it were using only petroleum fuel.

“In 2007-08, when an average liter of oil was 81 cents, we saved \$623,000 CAD (\$654,000 US)—our biggest savings,” Talbot says.

Comparing chip and oil prices for each year of operation, since 1988 the woodchip system has saved the college a total of \$4,244,000 CAD (\$4,460,000 US).

‘Go in with Your Eyes Open’

Another lesson the college has learned, Talbot says, is that biomass fuel quality is key to system reliability.

“What’s your moisture content? What species of wood are you burning this week? How clean is it? Most of the problems that we have are in our fuel transfer system,” where augers deliver the chip fuel to the boiler. “When you’re trying to pass everything through an auger system, it has to be pretty decent.

“Moisture content is what we look for,” he adds. “If the moisture’s right, you can make it work.”

Forty-five percent water content is the ideal number. “We don’t accept anything under 30 percent or over 60. We don’t pay for it, and we have penalties when the moisture goes too high,” Talbot says. The college follows the manufacturer’s specifications in calling for chips no larger than five inches in any dimension, and for the percentage of sawdust it will accept.

“We experimented last year with ground wood, but didn’t get as much heat out of it,” Talbot recalls. With a consistency similar to mulch, ground wood “is more prone to jam in the augers and hoppers; it tends to freeze quicker in the bins,” compared to chips.

When chips failed to flow to the back of their fuel-storage bin, Talbot and his staff modified the bin, installing a traveling auger on a track that pulls the chips back to fill the whole bin.

“It was quite an expensive retrofit, but it works great,” he says.

The college also modified its system to allow for variable-intensity firings. The 1980s KMW technology is essentially a cone, made of cast-iron sections: chips are fed to the top of the cone, then tumble down to the fire ring, which is fed with air from below. Originally the system burned on full, heating water to produce steam, until steam pressure hit 110 pounds. The system would then shut off until pressure dropped to 90 pounds.

Having since installed variable-speed fans and fuel augers, “we can slow them down and speed them up in response to the demand of the system,” Talbot says.

With 20-plus years running a biomass system, Talbot and his staff have seen interest in what they’re doing wax and wane, generally alongside the price of oil.

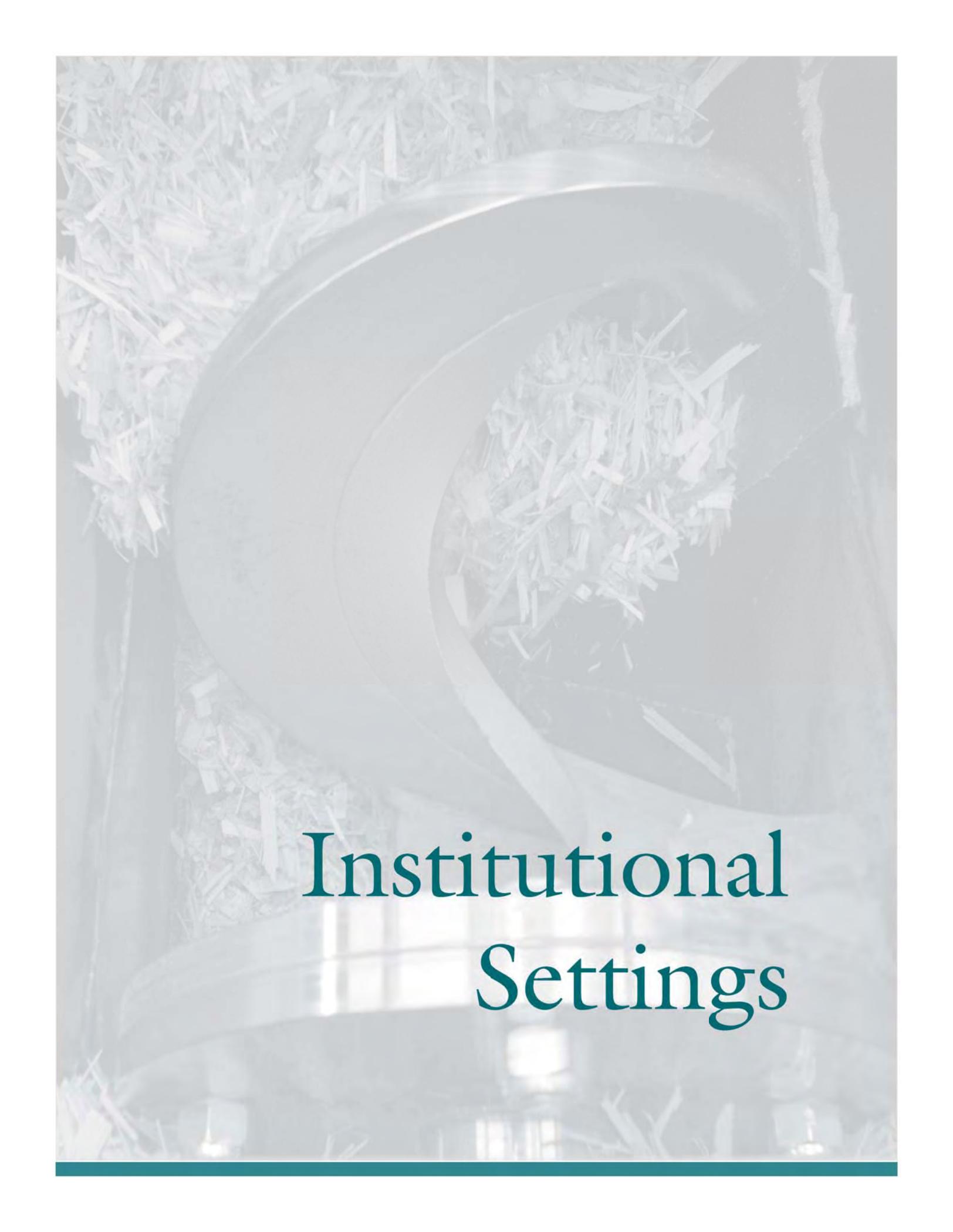
Ten years ago, when oil was relatively cheap, “people were shutting these systems down,” he notes. “It’s been quite a resurgence—but you need to go in with your eyes open.”

To those seeking his advice on adopting biomass technology, he says: “Do your homework. Know what you’re getting into going in, and make an intelligent, informed decision.”



Opposite page: Nova Scotia Agricultural College’s woodchip-fueled campus central heating system was commissioned in 1988.

Above: A traveling auger on a track was installed to ensure that chips flowed to the back of the fuel storage bin.

A photograph of a bird's nest filled with straw, with a bird's head visible in the foreground. The image is overlaid with a semi-transparent teal filter. The text "Institutional Settings" is centered in the lower half of the image.

Institutional Settings

Using Biomass for Energy in Institutional Settings

Institutions with 24-hour heating needs—like the rural hospitals, rehabilitation-center campus, and state correctional facility spotlighted in this section—are not always obvious settings for biomass heat. Often it takes a leader to see the possibilities.

In its rural, high-poverty region of eastern Oregon, Harney County District Hospital (pp. 37-38) faced financial pressures combined with an aged physical plant. When he proposed a new wood pellet system, CEO Jim Bishop got backing from his board, whose members were close to the region's fading timber industry. Today, the hospital's heat-pump system runs 24/7, clean and odor-free, and has generated enough cost savings to offset the hospital's payments on its MRI scanner.

Crotched Mountain Rehabilitation Center in New Hampshire (pp. 39-40) wanted both to build the optimum heating system and to support its heavily timbered area's economy. When heating oil prices were \$1.80 per gallon, Crotched Mountain President Donald Shumway set in motion the development of a custom-designed, computer-run woodchip plant.

Today, Crotched Mountain's fuel costs are stable, its fuel supplier is 10 miles away—and it won a 2009 "Lean and Green" award from Business New Hampshire Magazine, for showing leadership that was "both eco-friendly and business-savvy."

Some operators have learned hard lessons about making their biomass plant work. In South Dakota, a youth correctional center had its woodchip system installed by an out-of-state contractor, then had to improvise several mechanical fixes in the first winter (pp. 41-42). And in Prince Edward Island, a hospital that pioneered woodchip heat for its region shares its first lesson: make sure your fuel supplier consistently meets your specifications for chip size and moisture.

"We're still saving money, don't get me wrong!" says the hospital's chief engineer. And, he adds, after 27 years of round-the-clock operation, "the machine works great."

A Small Hospital, Wood Pellets, and Leadership

Wood Pellet Heating System

Heating Capacity (output): 149 kW (0.51 MMBtu/hr)

Annual Wood Pellet Use: 45 tons

Emissions Reduction and Combustion Control Equipment: Flue gas recirculation

Year Installed: 2007

Thermal Output: Hot water

This is a study of how one leader, equipped with good information and the determination to act on it, can shape a pioneering, practical energy choice for a vital institution in a struggling economy.

Jim Bishop, the self-effacing CEO of Harney County District Hospital in Burns, Oregon, doesn't tell the story of Harney's 2007 installation of a wood-pellet heating system quite that way. But others do.

"As a rural hospital, how do you put together the deals that will result in a new energy system that will save you money in the end?" asks Larry Swan, a US Forest Service (USFS) forest products utilization and marketing specialist based in Klamath Falls. "This whole thing worked for a small rural hospital in part because they had someone like Jim."

East of the Cascade Range in Oregon, Harney County covers more territory than the Commonwealth of Massachusetts, but has only 7,500 people. The high-desert landscape has vast patches of Ponderosa Pine, a declining wood-products industry, and 20 percent unemployment. The hospital in Burns—the county's largest employer—first hired Bishop, a former international wood-products consultant, to turn its finances around as chief financial officer.

When Bishop next became CEO, he faced the need to replace the hospital's 1949-vintage physical plant. He asked his friend Swan for advice about advanced-technology pellet heating. Swan passed along information about KÖB, an Austrian manufacturer that delivers its boiler systems preassembled in shipping containers.

"The architect was very skeptical about using wood for a hospital," Bishop recalls. But the CEO's calculations showed biomass to be a cheaper fuel source, long term, than oil or propane. (He figured on a 15-18-year payback, compared to oil prices. Steep increases in oil prices have since reduced the payback period to just three years.)



"His board was very open to considering it," adds Swan, "because they had a strong, historical tie to the wood products industry, which was rapidly dissipating. Jim understood how to work with the board on this."

"Finally," Bishop says, "the board and I just told [the architect], 'You know, we're really going to do this.' The architect then said, 'Okay.' They designed the pellet boiler into the system: It heats water, and the water goes to water-source heat pumps. The architect did a beautiful job of giving us a great system."

'Super-Quiet' and 'Trouble-Free'

Harney Hospital financed its \$269,000 system with a USDA loan, Medicare reimbursements, and local bank loans. It also sought and received an \$80,000 state tax waiver.

"The installation literally took two days. Everything came pre-assembled ... basically, we unloaded the container onto the slab," Bishop says. The new facility took up four spaces on the hospital parking lot.

The pellet system provides both heat and hot water. The hospital has been using propane to heat its air-intake system and its sidewalks in winter.

“We’re in a really cold climate—we use a lot of heat,” Bishop notes.

The pellet system runs seven days a week, all year round, providing hot water in the summer. Annual fuel costs: about \$9,000 for wood pellets, which meets 80-90 percent of the heating needs, plus \$30,000 for propane. The system is using about 45 tons of wood pellets per year, delivered at \$200 per ton from five hours away by Bear Mountain Forest Products, which runs two Oregon pellet plants.

The hospital is now shifting its air-intake and sidewalk-warming systems to pellet heat as well. “My guess is that a year from now, after we convert, we’ll be down to \$15,000 for propane and \$11,000 for pellets,” says Bishop. “Anything we can do to save money. We have to be sensitive to the fact that we’re a nonprofit hospital in a very poor county.”

So far, the cost savings from using pellet fuel have been enough to make the hospital’s payments on its MRI scanner, said Randy Brinkley, supervisor of facilities services.

The storage silo is just 12 feet in diameter by 15 feet high. The fuel-supply system is highly automated, and the combustion produces about 30 gallons of ash every couple of months, which the hospital donates to local gardeners.

As for the system’s operation, “It’s super-quiet,” Bishop says. “It’s so trouble-free that it’s good if somebody just glances at it.” Operators use the hospital’s computers to check in daily with the pellet system controls.

“There’s no odor at all,” says the CEO. “Because the boiler burns so intensely—it’s just really hot—and the pellets are compressed wood, it’s almost like burning coal. It’s very difficult to see anything at all when it’s running.

“Everybody seems to be worried that it’s going to break down. I think we’ve had two hours of unscheduled downtime in two years of operation.”

The Oregon Department of Environmental Quality reviewed the installation. “They concluded that they don’t have to regulate our installation because it meets all standards,” Bishop recounts.

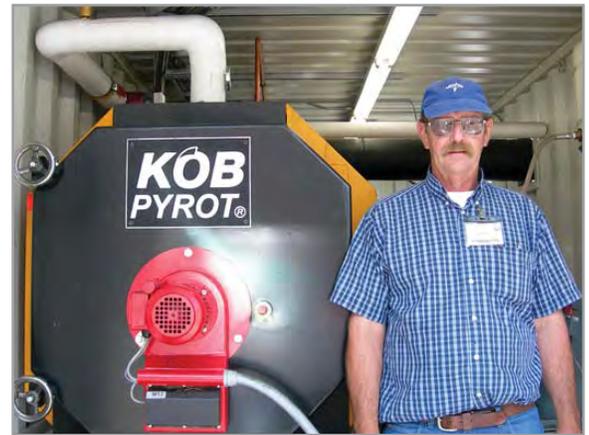
“As far as I know, we’re the first hospital in the United States that uses some kind of pellets,” he adds. Even so, Bishop hasn’t had many inquiries from other hospitals.

“I am talking to a lot of people from schools, school districts, colleges, universities. This makes infinite amounts of sense for anybody that’s burning heating oil, for any reason. The tradeoff is so clear.”

“I like it,” adds facilities supervisor Brinkley. “I’m an old woodsman, used to run big industrial wood boilers. This [system] is just a little guy, and he does real good.”

“The federal stimulus money has provided \$5 million to build a pellet manufacturing plant in our county or an adjacent county,” Bishop adds. “If this happens, we will be getting even cheaper pellets due to transportation savings.”

The projected pellet plant will use salvage wood from thinning operations in the national forests that both improve forest health and reduce fire danger.



Opposite page:
The entrance to the Harney County District Hospital.

Above: Randy Brinkley, supervisor of facilities services, stands next to the hospital’s Austrian-made pellet boiler, supplied by the British Columbia firm Fink Machine.

At Crotched Mountain, Woodchip System Generates Cost Savings and Fuel Security

Woodchip District Heating System

Heating Capacity (output): One 1.2 MW (4 MMBtu/hr) boiler and one 2.3 MW (8 MMBtu/hr) boiler

Emissions Reduction and Combustion Control Equipment: Baghouse, cyclone

Year Installed: 2007

Thermal Output: Hot water

In the forested hills of southern New Hampshire, the nonprofit organization Crotched Mountain Rehabilitation Center has worked since 1936 with disabled and brain-injured adults and children and their families, building hope and rebuilding lives. Several years ago, the sizable campus's aged, expensive, oil-fired heating system was close to the end of its life.

As Donald Shumway, Crotched Mountain's president, pondered what to do, he was driving to work each day past forests and lumber yards, then up the tree-lined mountain road.

"Our president is kind of a visionary guy—so he started thinking about wood," says Michael Redmond, Crotched Mountain's vice president for advancement and acting chief financial officer.

Could, Shumway wondered, a wood-fueled district system heat and cool 400,000 square feet of building area, including a central facility, a children's hospital, and a small school? Could woodchips be the optimum fuel choice? What assumptions could be made about price and supply? In how many years might fuel-cost savings from such a system repay its initial costs?

With funding support from several foundations, Crotched Mountain contracted with Biomass Energy Resource Center to produce a series of linked feasibility studies. In late 2005, the four completed reports assessed fuel supply, project economics, site planning, performance specifications, and implementation issues.

"The studies said 'Go, go, go,'" Redmond recalled. "That led us to the solution."

The winter of 2007-08 saw the first full-time use of that solution: a custom-designed woodchip plant where computer controls select and run parallel boilers—a four MMBtu/hour beside an eight MMBtu/hour unit—for maximum efficiency. Through the winter, the system met 100 percent of the campus's heating needs. Burning green hardwood chips at a price equivalent to \$.61 per gallon for fuel oil, it generated cost savings of about \$250,000.



Clean Emissions Don't Require State Testing

Crotched Mountain's twin chip boilers are fed by parallel conveyors that automatically unload two parallel storage bins, with a 150-ton combined capacity. At the base of each bin, an auger runs on a track to draw chips evenly from storage down onto the belts below. A truck bridge between the two storage bins allows trucks to back up and unload on both sides.

"We installed a very effective two-stage emissions-control system, consisting of a baghouse with a cyclone separator that reduces stack emissions to an extremely low level," says Ray Sebold, the project manager. The cyclone unit uses centrifugal force to pull out larger particulate matter, and the baghouse then separates fine particulates. As a result, what gets released into the air is mostly water vapor.

"With these emissions controls in place, the Department of Environmental Services does not require our plant to undergo monthly tests—which also saves on costs," Shumway says. Hot water from the system is now meeting virtually all the campus's heating and cooling needs.

"In time, as the technology develops, we might be able to use woodchips to generate electricity as well," adds Sebold.

With a present-day staff of about 700, Crotched Mountain envisions expanding its campus in the years ahead. The new system has the capacity to meet those needs, as does the two-mile buried piping loop that was installed along with it to connect most of the buildings to the wood boilers.

‘You Don’t Really Worry’

“We made our ‘go’ decision when oil was \$1.80 a gallon,” notes Redmond. “This winter, it was over \$3.” BERC originally estimated that fuel-cost savings would pay for the project within seven years; rising oil prices have since lowered that estimate to five years.

“The biomass wood resource from woodchips can be sustained indefinitely, it’s a healthier alternative fuel overall for people and the planet, and historically cost increases have been much more modest” than for fossil fuels, Shumway notes.

Crotched Mountain has contracted with a woodchip supplier 10 miles away and calls for chips that are matchbook sized or smaller, with consistent quality and moisture content.

The supply contract runs for five years, and has a two percent price escalator.

“So we know what our fuel costs are going to be for the next five years,” Redmond notes. “Nobody who’s using oil has any idea what their fuel costs are going to be.”

“We’re thrilled that we are purchasing our fuel supply from a local company,” says Shumway. “And we would much prefer to be supporting the New Hampshire forest economy, which remains very important to the state, than sending our money overseas.”

Alongside the two chip boilers, Crotched Mountain’s compact new central heating plant building has a smaller, oil-fired backup unit. During the 07-08 winter, that unit never had to be operated at all.

On a wall by the chip boilers, computer control boxes report on operations and will alert the staff if the system needs attention. Nearby is an ordinary-looking thermostat. It reports that water is leaving the furnace at 206°, and returning at 199°.

“That’s how efficient this system is,” Redmond observes.

Ash must be removed each day, and by the door stand several ash-filled galvanized-metal trash cans. Crotched Mountain operates a small dairy and egg farm, and the farmer in charge will pick up the cans, and mix the ash with organic fertilizer. Otherwise, Redmond says, the system operates its own controls so smoothly that it does not require a full-time, onsite supervisor.

“It’s kind of like the furnace in your basement,” he adds. “You don’t really worry about it.”



Opposite page: The woodchip plant at Crotched Mountain Rehabilitation Center.

Above: Michael Redmond, vice president for advancement and acting chief financial officer, stands alongside Crotched Mountain’s woodchip heating and fuel delivery system.

A Pioneering Chip System Plows through a 'Trial and Error' Year

Woodchip Heating System

Heating Capacity (output): 4 MW (13.4 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone

Year Installed: 2008

Thermal Output: Steam

In the Black Hills region of South Dakota, “logging leaves piles of slash”—the noncommercial parts of harvested trees—“that sawmills cannot use,” notes a recent presentation by a state correctional center that in 2008 became the state’s first public facility to fire up a biomass heating system.

“Using the assumption that 50 percent of the sawmill residues [are] available and 30 percent of the harvesting slash could be recovered and chipped,” the presentation continues, “the region would have 155,000 green tons of chips for use as fuel. Enough to heat 90 facilities identical to STAR Academy.”

STAR stands for State Treatment and Rehabilitation Academy. Near Custer, it’s the South Dakota correctional center for juvenile boys. The facility’s pioneering of biomass energy use in the state actually began with South Dakota’s governor.

Several years ago, Governor Mike Rounds attended a conference of the Western Governors Association that included discussions and information about using renewable energy, including biomass. Intrigued, he asked the South Dakota Division of Resource Conservation and Forestry to look into prospective uses in state operations. The division contacted the Biomass Energy Resource Center in Vermont, and offered to provide a feasibility study for any state facility that was interested in biomass heat.

One who responded was Robert Etkorn, physical plant manager at the STAR Academy. Etkorn was looking after a facility that dated to the early 1900s, and had previously been a tuberculosis treatment center and then a developmental center for the physically and mentally disabled. In 1995, the state turned the physical plant over to the Department of Corrections.



“Converting an old developmental center into a boys’ facility has certain challenges,” Bob Etkorn says. One was the STAR Academy’s two aged fossil-fuel boilers. One burned No. 2 fuel oil, the other fuel oil or propane. Both were more than a quarter-century old.

Etkorn filled out the paperwork to get a biomass feasibility study. “Everybody in Corrections pretty much looked at me like, ‘Whatever,’ until we got the feasibility study back and the numbers were quite good.”

The system’s projected costs, and the projected payback of those costs through fuel savings, looked encouraging. “So we sent the feasibility study up the line to the governor’s office,” Etkorn says. “The governor said, ‘How come we’re not doing this and saving money?’”

A followup study by Rapid City engineer John Hey projected somewhat higher costs—\$2.1 million—and a longer payback period, but the project went ahead. The state Energy Management Office provided a loan to cover the projected costs. When the project ran over budget, to \$2.6 million, the Department of Corrections covered the overrun.

“It was kind of a tough process,” Etzkorn says of the quest for funding. “But in the year that we’ve run it, we have made two loan payments—and we’ve more than made back those loan payments, plus a little extra,” in fuel cost savings generated by the biomass system.

Several Months of ‘Messing with It’

According to Etzkorn, the biomass system’s initial winter wasn’t easy. At all.

“When we first started the system, in February [2008], it was kind of a nightmare—very demanding and time-consuming,” Etzkorn says. The contractor that installed the system assigned an employee to provide training to the STAR staff—“but the gentleman who did that training was their computer guy,” Etzkorn says. “He didn’t know much about the actual operation of the system; he knew the computer [control] system, so he focused on that.”

Meanwhile, the system’s “operating parameters were really not set up correctly.” Finding the right settings, Etzkorn says, “was really a trial and error process.”

The fuel delivery system didn’t work well until the STAR staff improvised a fix. “It’s an auger system that just runs on the concrete floor of the chip bin,” Etzkorn explains. The augers “would go up against the fuel and they would get stuck—they wouldn’t pull any fuel out.” The staff solved that by welding teeth onto the auger. The contractor had to return to correct a related problem—an incline fuel-feed auger had been built on too steep an angle.

“There were a good three or four months when we were messing with it,” Etzkorn says. The contractor should have been onsite, making the adjustments; but it was based out of the area, and “that’s not realistic,” Etzkorn says. Etzkorn credits the project engineer, John Hey of Rapid City, for staying with the system and helping to make it work.

“He was excellent,” Etzkorn says.

‘The Potential Is There’

The STAR Academy’s woodchip system uses chips from logging, sawmill, and postmill operations, provided by a contractor that has “been very good to work with—they’ve helped us work out some issues,” Etzkorn says. “The postmill chips for a while were kind of dirty. The contractor has worked with his people, and they’ve cleaned that up quite a bit.”

The ash-removal system created problems, too. It’s a wet-ash, as opposed to a hot-ash, system, and its drag-chain system was often clogging. One of the ash augers has broken three times; after the third break, a local welder did a repair that has held up.

All this hassle—yet another struggle involved adjusting the system’s fans to optimize air flow for clean combustion—has taken its toll. In those first months, Etzkorn’s wife threatened to set up a cot for him at the heating plant. The manufacturer continues to work with him to iron out some problems that persist.

Yet even after all of that, he’s optimistic.

“We’re being very persistent, and the manufacturer usually comes around,” Etzkorn says. “They’re implementing things that we’ve discovered into their new systems. They’ve got a good product—they just need to make it better. The potential is there.”



Opposite page: STAR Academy’s three-bay chip storage facility.

Above: Auger and conveyor transporting chips from the storage bin (behind wall) to the combustion system.

After 27 Years, Pioneering System Is Still Heating a Small Hospital Campus

Woodchip Heating System

Heating Capacity (output): 110 kW (380,000 Btu/hr)

Annual Wood Fuel Amount: 1,600 tonnes (1,800 US tons)

Year Installed: 1982

Thermal Output: Hot water

In the world of community-scale biomass heat energy, the Canadian maritime province of Prince Edward Island has been a pioneer, with a woodchip-fueled district energy system heating much of downtown Charlottetown, the provincial capital, since the late 1980s. But that's not the oldest biomass system in the province: 44 kilometers (27 miles) east of Charlottetown, in the small town of Montague, the Kings County Memorial Hospital has been heating with woodchips since 1982.

What's more, the hospital's original biomass system is still in operation.

"We heat the hospital and the seniors' home next door," about 4,200 square meters (46,000 square feet) in all, says Leo Killorn, the hospital's chief engineer. "Our woodchip boiler is about 150 horsepower, and we have two oil backups, about 125 HP each."

Kings County Memorial serves a rural county of 20,000 people, with 2,000-population Montague its market center. The hospital's vintage Swede Stoker system can produce just under 110 kW (380,000 Btu/hour), and burns about 1,600 tonnes (1,800 US tons) of whole-tree chips each year, at a price of about \$49.50 CAD per tonne. The hospital uses about 45,000 liters (11,700 gallons) of No. 2 fuel oil annually in its backup boilers, which run mostly during the warmer seasons when wood heat is less efficient.

The chip boiler "heats both buildings, no problem—hot water as well," Killorn says. The boiler produces steam that is converted in a heat exchanger into hot water. The heat produced by the biomass system is also used to produce a separate supply of steam that the hospital puts through a heat exchanger to produce its own steam for sterilization, heat, and hot water.



For fuel, Kings County uses "mostly spruce and poplar, now," says Killorn. "We don't burn hardwood; that's better off going in the woodstoves." It uses a local contractor, and supply is not a problem.

"A lot of the sawmills closed up here, so there's a lot of woodsmen not doing so much," Killorn says. "If we put that contract in the paper, there'd be a lot of people wanting to do the business—because it's a living for somebody."

Challenges in Fuel Quality

The challenges for the hospital are not in obtaining woodchips—they're in the quality of the supply.

"If you have good, perfect chips, you wouldn't have a problem," Killorn says. "You've got to stay on top of your supplier all the time."

The issues that do come up are two-fold: moisture and chip size.

"We like them around 40 percent moisture content," Killorn explains. "We do a moisture content [test] every time we get a load of chips." The test consists of heaping a dinner plate with chips, weighing it, drying the plate-load for two minutes in a microwave oven, then weighing it again.

“They have the formula for figuring out moisture content,” Killorn says of his system operators.

“Forty-five percent is optimum. If the delivery fellow comes in over 45 percent, then he starts to get money taken off. It’s coming right out of the woods, so it’s impossible not to have moisture. Anywhere between 30 and 45 percent is great.” Based on a formula the hospital uses, Killorn’s staff figures out the average moisture content in each month’s supply, and subtracts from the payment for any percentage in excess of 45.

The other concern is with chip size. The hospital’s contract with its wood supplier says delivered chips must be able to pass through a 6-centimeter (2.5-inch) screen—“that means no sticks, right?” Killorn points out—and must be free of contaminants such as metal, glass, stones, and soil. Chips must also be free of excess snow, ice, and chunks of frozen fuel material.

The supply doesn’t always meet those standards. And when it doesn’t, trouble can show up in the fuel feed system. Four “drags,” like large bars, pull chips along the floor of the 230 cubic meter (8,000 cubic foot) storage bin, feeding them to the first of three successive feed augers. If a stick in the fuel feed gets lodged against one of the paddles on the first feed auger and stays there, that can cause the whole supply system to shut down.

“I try to be on top of this all the time,” Killorn says. “You could throw a couple of logs in a woodstove and walk away—but there’s a lot of moving parts in this thing.”

Because the fuel supplier works with various wooded properties that need to be cleared, the supply is not always consistent. “It’s always a struggle with your supplier, if you have a system like this,” Killorn notes.

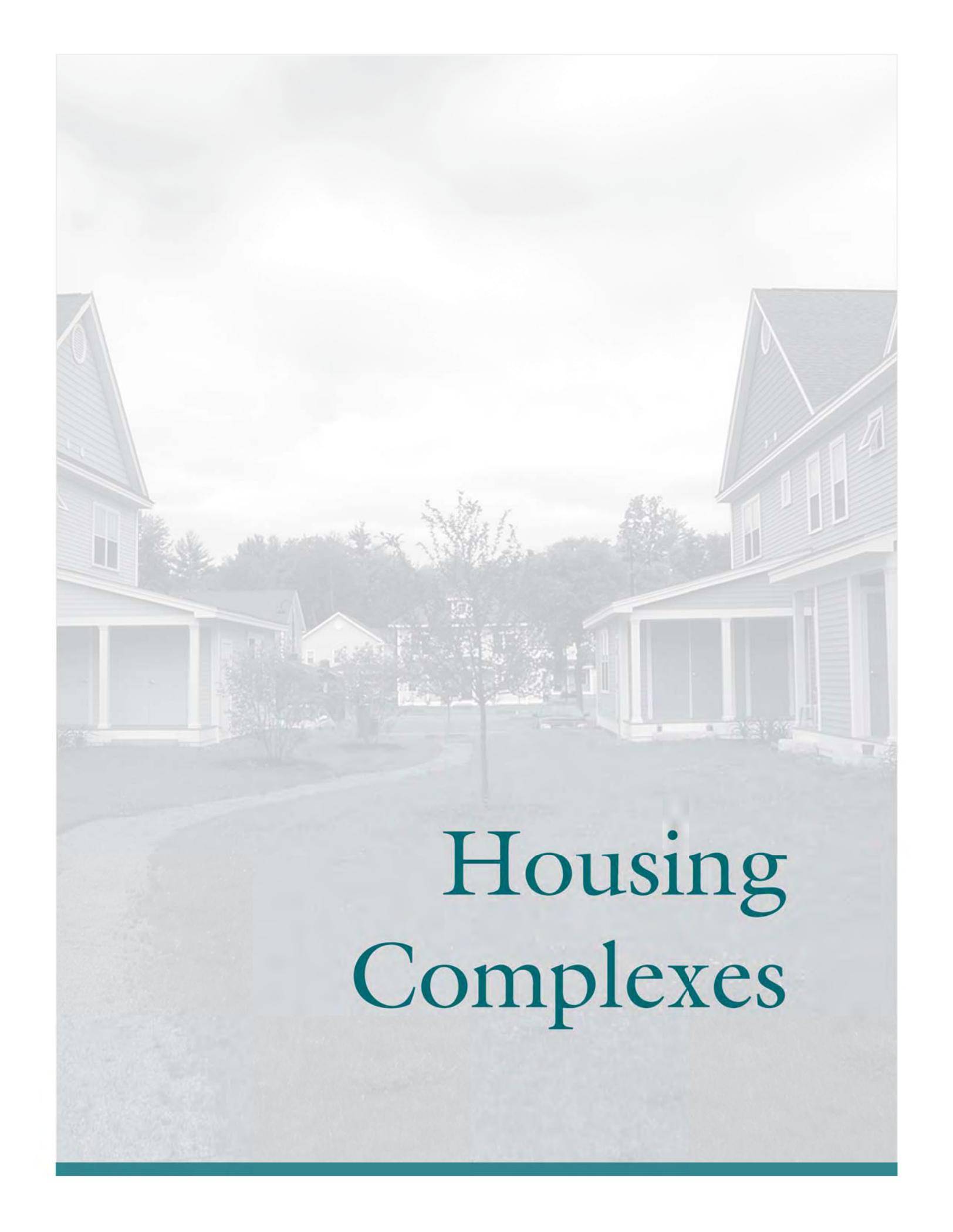
In future supply contracts, he’d like to have a provision that sets a penalty, to be taken out of payments to the supplier, when the chip system has to be shut down because of chip-quality problems and the oil backup is used.

“We’re still saving money, don’t get me wrong! And the machine works great,” Killorn concludes. “In 27 years, we’ve done the refractory over once, and we did the feed augers over once. This was the first wood boiler to go in on Prince Edward Island, and it’s still running.”



Opposite page: Kings County Memorial Hospital’s woodchip system provides heat and hot water to the hospital and the senior’s home next door.

Right: The hospital’s contract with its wood supplier says delivered chips must be able to pass through a 6-centimeter (2.5-inch) screen.

A photograph of a housing complex featuring several two-story houses with light-colored siding and dark roofs. The houses are arranged around a paved walkway that curves through a grassy area. There are trees and shrubs scattered throughout the scene. The sky is overcast with grey clouds. The overall image has a slightly faded, muted color palette.

Housing Complexes

Using Biomass for Energy in Housing Complexes

Using biomass heat in multi-unit housing facilities can benefit both residents and the institution that provides the housing. This can be especially attractive when tenants are low-income, elderly, or students.

When an affordable-housing complex in Barre, Vermont used electric heat, the very high monthly rates were causing tenants to move out, use dangerous space heaters, or keep their spaces so cold that mildew and condensation were a problem. Since the Green Acres complex switched to a woodchip system in 1992 (pp. 49-50), the costs of running the system have fallen by more than half—and the savings generated have been invested in tenant services, an energy fund, and a recent system upgrade.

Choosing a district system to heat a campus or complex of buildings offers the advantages of efficient fuel use and bulk fuel purchase. And when biomass fuel is already onsite or locally available, the benefits are even clearer.

Because Spring Valley Bruderhof, a cooperative community in Pennsylvania (pp. 51-52), is sited near forestlands and sustains itself by

building wood furniture, equipment, and toys, the community was well positioned to invest in a district heating system that it fuels with waste wood from its own operations, and with whole-tree chips sourced from the nearby woods.

When colleges invest in biomass, the fuel-cost savings also boost their bottom line. But the system may need to be selected and located carefully, to fit in smoothly with resident life.

When Dartmouth College in New Hampshire saw the chance to install biomass-fired district heat at a small graduate-student housing complex (pp. 47-48), its research led it to choose a wood pellet boiler. Compared to woodchips, a pellet system would require a lower capital investment, along with fewer fuel deliveries—an issue when the system had to “snuggle in” among housing units.

Reports Dartmouth official Tim McNamara: “This fairly large, complicated district heating system sits in a fairly dense neighborhood, with no complaints.”

Serving a Dense Residential Complex with a Pellet Boiler

**Residential District
Wood Pellet Heating
System**

**Heating Capacity
(output): 615 kW
(2.1 MMBtu/hr)**

**Annual Wood Pellet
Use: 250-300 tons**

**Emissions Reduction
and Combustion
Control Equipment:
Multi-cyclone**

**Year Installed:
2008**

**Thermal Output:
Hot water**

When Dartmouth College was mid-project with construction of 125 new housing units for graduate students, “we began to see a real big demand for these units, which are very popular with the students—so we saw the opportunity to do a second phase of the project,” recounts Tim McNamara, a college associate director for real estate.

McNamara is also a Dartmouth graduate who majored in Environmental Studies. He was interested in biomass, he says, “particularly here in New England, where it is such a huge renewable resource. So I posed the question whether, in this second phase, we should consider doing a district heating system fueled by biomass.”

The housing complex at issue was Sachem Village, a 50-year-old facility in West Lebanon, New Hampshire, a mile and a half from the Ivy League campus in Hanover. Both Hanover High School and the town’s Richmond Middle School have woodchip-fired heating systems.

“I talked to the operators and toured those two plants,” McNamara said. What he learned convinced him that for Sachem Village, the better choice was wood pellets. McNamara says he’d learned that the capital cost of a chip system “was probably twice that of a pellet system,” he says. Also, a chip system would require more frequent deliveries, not ideal for a new heating facility that “needed to be snuggled in among residential buildings.

“I was not thrilled with the idea of chip bins, of trucks making deliveries, and of the maintenance costs associated with the plant.”

So he set about looking for a pellet system at the two million Btu size that the project required. It wasn’t easy—most pellet boiler systems that he looked at were sized for smaller capacity—but he located a hybrid system, with “a conventional Burnham boiler sitting atop a Solagen stoker.



That’s pretty standard,” he says. “They hand-build the stoker, and you stick a conventional boiler on top of it.

“We decided to go through with it. We built 80 new units that we were going to hook to the district system,” plus 24 existing units that were being heated by a conventional, inefficient fuel oil boiler. Construction of the new district heating system began in the autumn of 2007. The pellet system was commissioned in the summer of 2008.

Fine Tuning the System

“We used 290 tons of pellets over the past year,” McNamara reported a year after the system came online. “We sized this system so that at full capacity, it’s supposed to provide 95 percent of our load.” The remaining five percent is supplied by a two million Btu per hour propane system that sits beside the pellet boiler, and can take over its full load if needed.

“In extreme cold, the propane [boiler] is always there to take over and shovel a little more heat into the system,” McNamara says. The whole system also has an emergency power generator “so if the power goes out, we’re able to keep the water in that underground loop hot all the time. We never let the loop go cold.”

After its first full year of operation, “I’d say the system has run very well,” McNamara assesses. Operators began with pellets that included three percent ash, but learned that one percent pellets gave much better performance. The higher ash content created some problems with “clinkers,” hard chunks formed when partially combusted ash and minerals in the pellets fuse together during combustion.

As for air quality, the system has a state air-emissions permit, and “we monitor the stack daily,” McNamara says. “We’re all very pleased; we have no visible emissions.” The heating system operates just 20 feet from its nearest neighbors, but it has been very quiet and has drawn no complaints about smoke, odor, or noise.

“Our challenges have been controls,” he says. “This is a highly automated system—and having that feedback to our main boiler plant on the campus was a bit of a challenge initially. But I think we’ve worked through that, and we’re now able to see what is going on with the boiler remotely, because it is largely an unmanned system.” Operators are also working out smooth coordination between the Schem Village system’s pellet and propane boilers.

“Ash removal continues to be a bit of a challenge,” McNamara adds. Because it was putting together a system that would not require daily in-person attention, Dartmouth chose automated ash removal—but then found that the system’s flexible auger tended to get bound up with clinkers. The auger has been replaced, and “we hope we’ve got it operating somewhat more reliably,” McNamara says.

Boiler Can Burn other Biofuels

“The transitions to solid fuel is always a challenge, when people are used to propane or oil, which don’t require as much hands-on effort,” McNamara observes. “It’s been challenging, but I know we’ll get there. I think in the long term this is going to prove to be a very positive step for us, both economically and in terms of the environment.”

Economically, the price of propane “right now is very competitive with pellets—but I don’t think that will continue in the long term,” McNamara says.

“We feel good that we’re using a New England renewable resource, and that we’re doing something to reduce our carbon footprint,” he sums up. “It feels good that we’re doing the environmentally responsible thing. The boiler also has flexibility, without modifications, to burn pea coal, switchgrass pellets, dried corn—so it’s a very flexible system in terms of solid fuels.

“This fairly large, complicated district heating system sits in a fairly dense neighborhood, with no complaints. It just wasn’t the right place for a chip boiler—and it’s great to have a fairly consistent, dried fuel. I think we made the right decision, in going with pellets.”



Opposite page: Schem Village provides graduate student housing for Dartmouth College. Eighty new and 24 existing units were connected to the pellet boiler system that went into operation in 2008.

Above: Tim McNamara, Dartmouth’s associate director for real estate, stands by the pellet boiler system in the student housing complex.

How a Chip System's Savings Made a Housing Complex Affordable Again

**Residential
District Woodchip
Heating System**

**Heating Capacity
(output): 600 kW
(2.2 MMBtu/hr)**

**Year Installed:
1992**

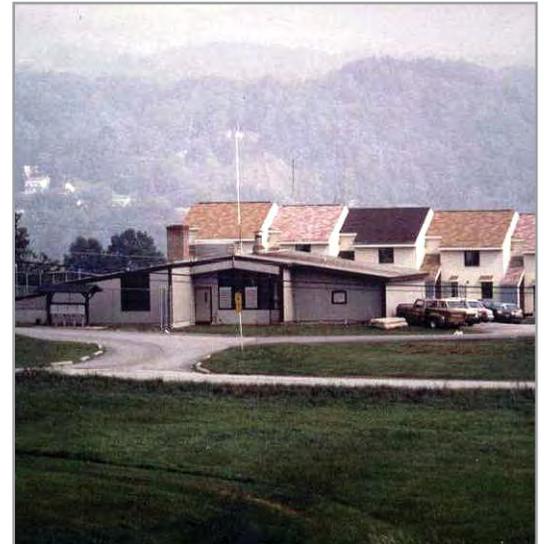
**Thermal Output:
Hot water**

In the late 1980s, low-income residents at Green Acres, a 50-unit affordable-housing complex in Barre, Vermont, were paying an average of \$250—often more than \$300—every winter month to heat their apartments. The complex had all-electric heat and hot water, and tenant after tenant was moving out of Green Acres after the bills had piled up too high. Others were using dangerous kerosene heaters, and nearly everyone was trying to get by in under-heated living spaces, leading to problems with mildew, icing, condensation, and “decreased tenant comfort and satisfaction,” noted a consultant’s 1988 report on the problem.

The electric heat that had looked like a good, cheap option when it was installed in 1970 was now threatening the future of the complex. After commissioning the consultant’s study, the Barre Housing Authority (BHA), which owns Green Acres, decided to install a new woodchip-fired heating and hot water system.

Installed in 1992 as part of a complex-modernizing project funded by the US Department of Housing and Urban Development (HUD), the chip system generated average, per-apartment fuel costs of \$24.49 per month during its first five years.

In its 10th year, the total costs of running the chip boiler and a backup oil unit, together with operation and maintenance costs for the whole system, were \$32,282—42,682 less than what it would have cost to run the old electric system at 2002 rates.



“I would recommend the woodchip system to almost anybody—but be careful with the installation,” says Don VanArsdale, maintenance director for the BHA. “Make sure the specifications are followed, especially the manufacturer’s specs.”

He says so because in recent years the BHA has had persistent trouble with corrosion in copper piping that was improperly installed back in 1992. The lesson learned, says Tim Maker, who served as a consultant to the Green Acres project, is that it’s vital to choose the right engineering firm to oversee the installation of a system like this.

“Hire an engineering company that has experience with European district heating pipe systems,” Maker advises. “These systems have a long, proven history of reliable operations, without failure—but if you hire a local engineering company to do this, to bury the pipe the way the system is designed, they may not do as good a job as a company that specializes in this type of work.”



There are only a handful of such engineering firms in the country, Maker adds. “But they are worth seeking out, and paying for.”

Green Acres’ experience is useful in other ways as well. To finance its system, BHA entered into a 10-year contract with the Vermont Energy Investment Corporation. Infrastructure for the new heating system was funded with \$540,000 of HUD money; installation of the chip boiler itself cost \$195,000 for a total of \$735,000 system cost.

Under the contract, the fuel-cost savings—compared with previous electric-system costs—were calculated at the end of each fiscal year. The system’s expenses were paid from the arrived-at savings; the remaining balance was put into three BHA funds.

Over the first five years, those funds grew from zero to \$140,310, entirely with savings generated by the chip system. The money was placed in a repair fund, an energy fund, and a tenant services fund. At the end of year nine, the repair fund had grown to \$27,917, and repairs had been so little-needed that the fund was used, in 2001, to pay for upgrading and modernizing the wood energy system.

In 1997, a five-year summary report on the performance of the Green Acres system by Maker’s Energy Efficiency Associates noted that “woodchip prices have increased less compared to the other energy sources. Over five years, woodchip prices paid by BHA have increased a total of four percent. Electric rates have increased 19.5 percent, oil by 17 percent, and general inflation has seen a 15 percent rise.”

In 2002, the 10-year summary report found that the complex’s monthly fuel cost to supply heat and hot water per apartment, averaged over the year, was \$30.83. “Under the previous electric heat system,” the report notes, “heat and hot water would have cost \$124 per apartment per month.” With the cost of heat and hot water removed from their electric bills, tenants saw those bills decrease, during heating season, from an average of \$250 per month to \$53 per month.

**Opposite page:
Green Acres Housing
Complex.**

Above: With the cost of heat and hot water removed from their electric bills, tenants saw those bills decrease, during heating season, from an average of \$250 per month to \$53 per month.

Heating with Biomass Creates a Circle of Use for Wood that Had Been Waste

**Residential
District Woodchip
Heating System**

**Heating Capacity
(output): 718 kW
(2.45 MMBtu/hr)**

**Year Installed:
2008**

**Thermal Output:
Hot water**

When a cooperative religious community in Farmington, Pennsylvania installed a wood-fired district heating system in 2008, the project turned a waste product into a useful fuel that benefits the whole community.

Spring Valley Bruderhof, which is home to as many as 400 adults and children in Farmington, sustains itself and engages many of its residents in a woodshop where the community manufactures wooden classroom furniture, equipment, and wheeled toys for schools under the brand name Community Playthings. (Spring Valley Bruderhof also produces a line of therapeutic equipment, such as chairs and standers, for people with disabilities.)

Bruderhof (in German, the word means brotherhood) is a Christian religious organization with communities in New York, Florida, Pennsylvania, the United Kingdom, Germany, and Australia. The organization recently changed its official name to Church Communities International.

One of the New York Bruderhof communities operates a US-built wood boiler. When Spring Valley became interested in using its wood waste in a similar heating system, members searched the Internet for more efficient woodchip boilers and found Fink Machine, Inc., a British Columbia vendor of the Austrian-built woodchip and pellet KÖB boilers.

“I took two of their guys to Austria, to see a district heating application,” says Burkhard Fink, owner of Fink Machine. “The KÖB boilers are very reliable, and that’s what the Bruderhof found out when talking to owners of such KÖB boilers. We installed the 2.45 MMBtu/hour boiler with the hydraulic push rod floor at Spring Valley in mid December 2008 and pushed the ‘start button’ on December 19, 2008. The boiler has been operating without interruption since then.”



Spring Valley’s KÖB boiler can produce up to 2.45 MMBtu/hour, running on a combination of dry wood waste from the woodworking shop, other waste wood from the community and its neighbors, and whole-tree chips sourced from nearby forestland.

“This is a farm country, with forest,” Fink says. “Spring Valley is using some of its own timber for chips, but most of the waste wood comes from its furniture plant and the surrounding area in the form of construction waste wood and tree trimmings.”

Regular Maintenance is Key

Austrian and other European biomass heating technology is often more advanced than that built in North America—and for good reason, says Fink: Europeans have had little choice but to innovate.

“The Europeans were forced into this because of the high population, their high energy costs, and their stringent air-quality standards,” he explained. “They had to come up with efficient equipment fast. In America, energy prices were down in the basement, and efficient equipment wasn’t required.”

Now that North American energy prices have risen, so has interest in the type of equipment that Fink Machine sells. Inquiries often center, Fink says, on how much work biomass boilers require, and how reliable they are likely to be.

“People always ask me, ‘How much time do I have to spend on it?’ That’s a very good question. My answer is ‘you get what you pay for.’” Fink says its needs should be minimal and predictable.

For a KÖB boiler, “half an hour a week should be plenty. With the automatic ash removal system and the automatic tube-cleaning system, the monthly maintenance is between 30 minutes and two hours at the most. Automatic ignition and a large thermal buffer tank also reduce monthly maintenance and increase the efficiency.

“If you use decent fuel, you have no problems. If you use poor fuel, with a lot of dirt, rocks, metal, and oversize pieces, you can have the best machine and it can give you a headache. Spring Valley has its own chipping station with a metal separator and therefore also has control over its chip supply.”

In Farmington since 1990, Spring Valley Bruderhof is, like other Bruderhof communities around the world, devoted to peace and collaborative work. It’s a sister community to New Meadow Run Bruderhof, also in Farmington.

The Bruderhof movement was founded after World War I in Germany, then was persecuted and driven out of the country after the Nazis took power in the 1930s. Members relocated to England, then again to Paraguay before the outbreak of World War II. Bruderhof first came to the US in 1954, starting Woodcrest Bruderhof near Rifton, New York. Its first Pennsylvania community was founded in 1957.

“The Bruderhof is a peace church whose members do not serve in the armed forces of any kind,” says a Wikipedia article on the movement. “The goal of the Bruderhof is to create a society where self-interest is yielded for the sake of the common good.”

At Spring Valley Bruderhof, one small result of this approach is that the community welcomes waste wood from the surrounding community. Rather than being dumped, scrap wood and trees that have been removed are put to use as fuel.

The community previously heated with oil, and its oil burner is still in service, for back up only.

“But obviously, the oil burner is off,” Fink says. “The biomass boiler handles 100 percent of the load.”



Opposite page:
The woodchip plant at Spring Valley Bruderhof, where most of its wood fuel supply comes out of its factory and the surrounding community.

Above: Spring Valley’s KÖB boiler can produce up to 2.45 MMBtu/hour.

A worker in a white hard hat and uniform is operating a large industrial machine in a government facility. The worker is leaning over a large, rectangular opening in a dark, metallic structure, possibly a furnace or a large container. The worker is holding a long, thin rod or tool that extends into the opening. The background shows a complex industrial environment with various pipes, cables, and structural elements. The overall scene is dimly lit, with a focus on the worker and the machine.

Government Facilities

Using Biomass for Energy in Government Facilities

Gordon Boyce, marketing and utilization forester for the commonwealth's Department of Conservation, says "We've got a project in Massachusetts called Lead by Example."

Leading by example is just what the two biomass heating projects profiled in this section—one in the Eastern United States, the other in the West—are doing.

In Belchertown, Massachusetts, the headquarters building for the state-managed Quabbin Reservoir in 2008 became the first state building not a school in Massachusetts to heat itself with biomass (pp.57-58). Each year, about 15,000 people are learning about the project at Quabbin's visitor center. At the same time, uncertainty about prices for petroleum fuels have generated high interest in biomass at Massachusetts schools and other public buildings.

The numbers are appealing. Quabbin's woodchip boiler was purchased and installed for \$480,000. It will burn about 350 tons of woodchips per year, displacing about 22,000 gallons of fuel oil, offsetting about 220 tons of fossil fuel-derived carbon dioxide, and saving more than \$75,000 per year

at current fuel oil prices.

Installing biomass facilities at appropriate locations, and managing them well, saves money, demonstrates the wise use of taxpayer dollars, and can demonstrate the use of clean, renewable energy that public agencies wish to promote. It also keeps fuel dollars in the local economy. In Boulder County, Colorado, a chip system that heats the headquarters of the county's Parks and Open Space Department uses wood entirely grown on land that the county owns and manages (pp. 55-56).

"This sets a good example within the state of using an often-wasted resource, forest byproducts, as a replacement for fossil fuels," says Therese Glowacki, resource manager for the Boulder department. And in a region plagued by forest-fire dangers, using wood from forest thinning operations—as the Boulder County system does—also reduces fire hazards while improving forest health.

"With the state of forests in Colorado, many other municipalities, school districts, and counties are also interested in using this technology," Glowacki reports.

Colorado System Models New Approach to Forest Health and Forest-Fire Prevention

Government Facility Woodchip System

Heating Capacity
(output): 970 kW
(3.3 MMBtu/hr)

Year Installed:
2006

The Boulder County, Colorado, Parks and Open Space Department manages about 30,000 acres of forestland, in which fire has been suppressed (the practice of not allowing natural fires to burn and remove debris from forest floors) for some 140 years. Across the American West, fire suppression has led to heightened fire danger by clogging the forest with burnable biomass.

To reduce this hazard and rebuild forest health, for about 35 years the Boulder department has been thinning its woods. But “once you thin a forest, what do you do with the biomass?”

That question was on the mind of Therese Glowacki, resource manager for the department, in 2001 when she traveled to a conference on potential uses for forest byproducts. She heard a presentation on using biomass for heat. At the time, Glowacki’s department was looking for a site for its new headquarters and shop campus.

“I said, ‘If we’re going to build a new building, why not heat it with chips from our forest?’ It just makes sense.”

Today, a 3.3 MMBtu/hour woodchip boiler supplies heat for the six buildings on the department’s new central office and shop campus. The chips come from the department’s own woods, where it thins 100-150 acres each year. This “vertical integration” of a biomass project, where the fuel is harvested on woodland owned and managed by the user of the heating plant, makes Boulder County a noteworthy model.

“For foresters or land managers who are already thinning a forest, the biomass energy system puts this wood to good use,” Glowacki says.

“This ... sets a good example within the state of using an often-wasted resource, forest byproducts, as a replacement for fossil fuels,” she adds in a summary posted online by the Governor’s Energy Office (www.colorado.gov/energy/renewables/biomass-projects-BoulderCounty.asp).



“With the state of forests in Colorado, many other municipalities, school districts, and counties are also interested in using this technology.”

For some of its harvesting, the county uses its own “roll-off” trailers, which can transport about 30 cubic yards of chips. These trailers can transport chips when they’re not in use for other purposes; they can also be used for temporary chip storage. For larger-scale harvesting, though, the county has found it’s more efficient to hire a transport company with 160-cubic-yard, live-floor vans.

“We can fill one of those in three hours, and usually get three trips a day out of it,” Glowacki said.

Planning a Sustainable System

Early in its planning process for the biomass system, Boulder County contacted the Biomass Energy Resource Center (BERC). Boulder staff members traveled to Vermont for a tour of chip-fired facilities before committing to their own project. BERC then served as wood-energy consultant for the plant’s construction.

“We worked closely with county staff and their professional team, the architect and engineer, on the details for how the chip system would be configured,” said Tim Maker then of BERC—“including onsite storage of wood-chip fuel and the use of the roll-off containers

to collect and store fuel prior to use. We also played a role in quantifying the size of the system based on the size of the buildings they planned to construct, at the outset and in the future.”

A feasibility study for Boulder County’s biomass system said all the needed fuel could come from the county’s own thinning operation, and that emissions from the biomass boiler would meet all state air-quality standards. The study found that a biomass system would cost about \$350,000 more than a natural-gas facility—but, it predicted, fuel-cost savings would repay that difference in 7-to-10 years. At the time, natural gas prices were just beginning to rise.

Along with reducing fire danger, using thinned forest biomass for fuel may also help with another big problem in Colorado’s woods: run-away infestation by mountain pine beetles. “It will get some of the biomass out,” Glowacki says. “And it will help with generation of new forest and reducing fire risk.”

Acting on Lessons Learned

Boulder County’s biomass system is not the first in its area. In the early part of this decade, the nearby town of Nederland installed a biomass heating and electrical cogeneration plant. That system was plagued with problems, and shut down after a couple of years.

Glowacki says her department learned several lessons from Nederland.

“The biggest thing is to get everybody on board—especially your facilities staff—so they know what it will take to get it running and keep it running.”

Second, she said, “keep it simple.” Nederland attempted to produce both heat and power with its system; Boulder is providing only heat.

Third lesson: chip quality is crucial. As a municipal project, the Nederland plant took in chips as voluntary dropoffs from landowners who were thinning their woods.

This led to wide variations in chip quality, and to problems with contaminants like dirt and rocks.

“We have a tighter control on the quality of our chips,” Glowacki says.

The new campus is highly energy efficient—so fuel cost savings are running somewhat less than expected, Glowacki says. In its first winter, 2006-07, the system saved \$15,000 in fuel costs, compared to natural gas.

“From my perspective, it’s the right thing to do,” she concludes. “We’re putting our natural resources to work.”



Opposite page: The chip plant for the Boulder County Parks and Open Space Department.

Above: Chips to heat the six buildings come from the department’s own woods, where it thins 100-150 acres each year.

Woodchip System at Quabbin Ignites Interest in Massachusetts

**Government
Facility Woodchip
Heating System**

**Heating Capacity
(output): 587 kw
(2 MMBtu/hr)**

**Emissions Reduction
and Combustion
Control Equipment:
Multi-cyclone**

**Annual Woodchip
Use: 350 tons**

**Year Installed:
2008**

The first state-government building to be heated with biomass in Massachusetts, other than schools, showed itself off for the first time in late 2008. About 15,000 people each year walk into its visitor center. There's growing interest in bringing biomass systems into public facilities around the state, says the state forester involved with the new project.

"I will be talking this kind of system up throughout Massachusetts," adds Gordon Boyce, marketing and utilization forester for the Massachusetts Department of Conservation and Recreation (DCR). Soaring prices for petroleum fuels, he says, have "really got the phone ringing off the hook.

"There is tremendous interest ... We've got a lot of projects in the preliminary planning stage."

The state's first non-school investment in biomass heating is Quabbin Administration Building, in Belchertown, headquarters for management of the Quabbin Reservoir. A new, \$480,000 woodchip boiler began heating the facility in autumn 2008.

"The DCR and the state's Department of Energy Resources are very aggressively promoting the use of waste wood for heating schools and other public buildings in the Commonwealth. This is a good example for them," notes Kamalesh Doshi, program director for the nonprofit Biomass Energy Resource Center (BERC) in Vermont.

State government considered several of its buildings for biomass heating, through a 2005 feasibility study conducted by BERC. Quabbin was chosen to be the first project.



The new boiler will burn about 350 tons of woodchips per year, in place of about 22,000 gallons of No. 2 fuel oil.

"This will offset about 220 tons of fossil-derived carbon dioxide and save more than \$75,000 in its first year," says a state publication about the project.

Grant money paid for the new Quabbin system. Even without that funding, projected fuel-cost savings would repay the initial investment within six years.

One of the nation's largest man-made public water supplies, the Quabbin Reservoir was created in the 1930s, through the construction of two very large earthen dams. Along with the reservoir itself, the state manages 56,000 acres of state-owned forestland that surrounds it—and the long-term plan is to harvest woodchips from that land to fuel the heating system.

"Over time, they will be able to be completely self-sufficient for chips," says Boyce.

During the first year, the system will run on hardwood sawmill chips. Screened and consistent in moisture content, that fuel will help operators get the system running smoothly. In future years, the fuel will be bole and whole-tree chips sourced from reservoir lands.

“We designed the system so that it could handle that wide variety of chips,” says Boyce.

Air emissions are cleaned by a particulate multi-cyclone, along with advanced computer combustion controls.

“By using locally produced renewable wood fuel, the new biomass system at Quabbin will save millions of dollars, help to combat global climate change, contribute to national security and support the local economy,” says the state publication.

Because it previously heated with coal, the Quabbin facility had a below-ground coal storage bin—as do many other formerly coal-heated public buildings in Massachusetts. The coal bin at Quabbin was retrofitted to become the new chip-storage bin for Quabbin’s biomass system, saving costs by avoiding the need to build a new storage facility.

“That’s one important feature,” notes Doshi of BERC.

Here’s another feature:

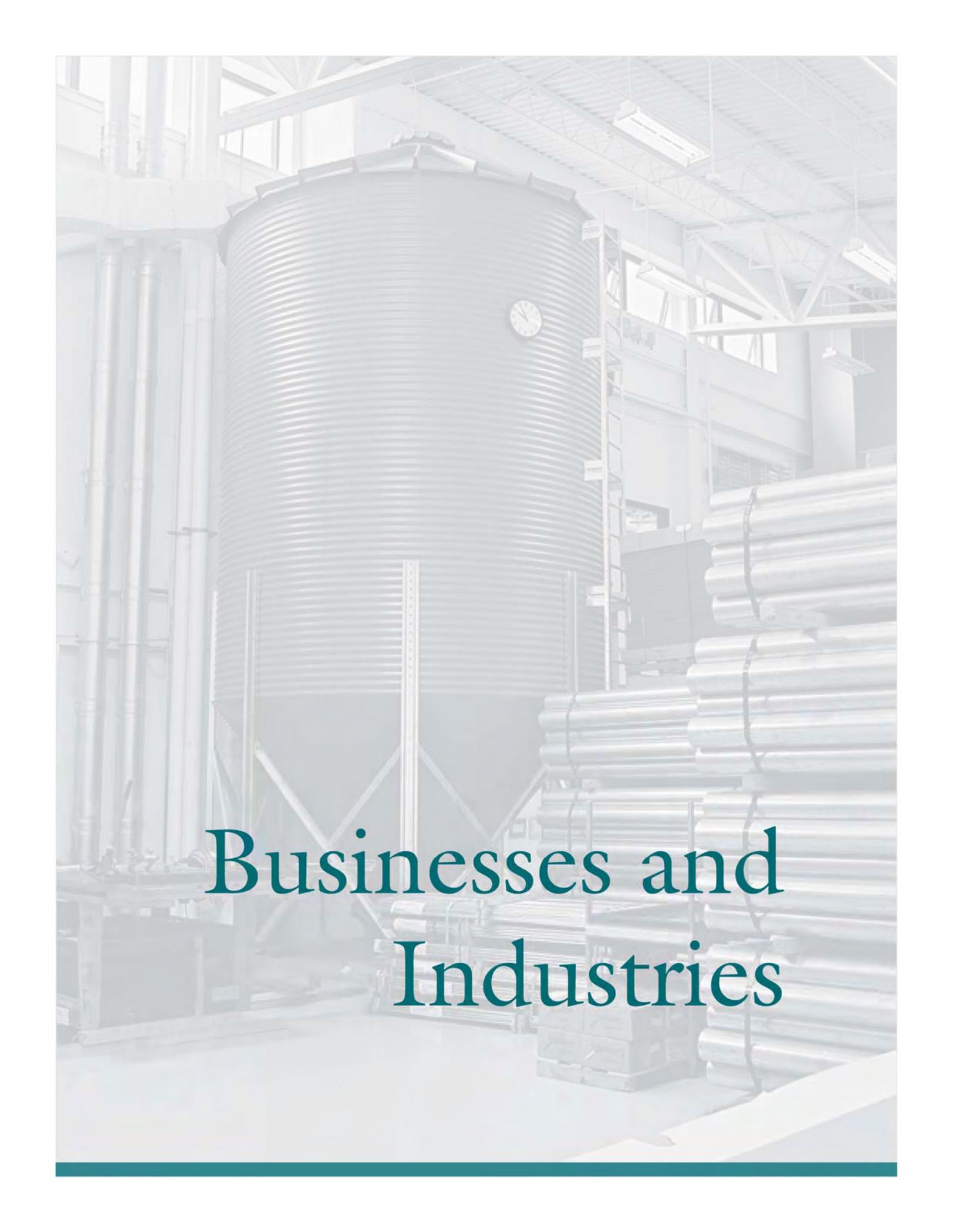
The building’s visitor center has a display panel on the new system, and a panel that will monitor the heat produced, the carbon offset, and the fossil fuels displaced.

“We’ve got a project in Massachusetts called Lead by Example,” adds Boyce. “It promotes green construction and renewable energy in state facilities. We’re hoping this Quabbin project is going to spur a lot of interest.”



Opposite page: The Quabbin Administrative Building.

Above: The Commonwealth of Massachusetts manages 56,000 acres of state-owned forestland that surrounds the Quabbin Reservoir—and the long-term plan is to harvest woodchips from that land to fuel the Administrative Building’s heating system.

A large, cylindrical, ribbed industrial water tank stands in a factory. The tank has a clock face on its side and is supported by a metal frame. To the right, there are several stacks of pipes or rods. The background shows the factory's interior with a high ceiling and structural beams.

Businesses and Industries

Using Biomass for Energy in Businesses and Industries

By seeing value in biomass, the private enterprises in this section have all found opportunity in changing times.

For some the challenge has been the struggling economy. With the sawmill industry in New England declining, one family-owned business has shifted entirely to supplying woodchips; its customers are a power plant, schools, and a college, all heating with woodchips and all within trucking distance.

“Biomass. I could see it blossoming,” says Vermont business owner Jim Lathrop (pp. 77-78).

In the United States and Europe, businesses whose assets include biomass—as woodlands, or as waste product from manufacturing—are harvesting this asset as heating fuel. In Ontario, a lumber firm that survives lean times through diversity is heating its dry kilns entirely with sawdust and shavings from its mills (pp. 73-74). A family business in Finland fuels its chip system with wood from its own land and recycled pallets (pp. 69-70). And an Alberta maker of custom cabinets that was paying high heating fuel bills is now getting all its heat from its own wastewood, and has a far cleaner, safer facility in the bargain.

“We suck up all the dust we can, so we can use it for heat,” explains owner Kent Madsen (pp. 75-76).

The cost savings from biomass can allow for reinvestment in the business; they can also point the way to new ventures. In a Finnish industrial park, four partners set up a woodchip system to heat their own businesses, and now sell heat to others (pp. 63-64). In Upper Austria, a fuel-transport firm now has two trucks delivering wood pellets (pp. 65-66). Super-efficient company headquarters in Austria and Vermont make biomass part of their innovative operations (pp. 71-72, 67-68). And, through an efficient underground woodchip storage system, an Austrian firm now supplies biomass heat to 10 industrial plants, (pp. 61-62).

“We can produce heat cheaper than our customers can themselves,” says the Austrian firm’s managing director.

Underground Woodchip Boilers Provide High-Efficiency Industrial Heat

Woodchip Heating System

Heating Capacity (output): One 1.2 MW (4.1 MMBtu/hr) boiler and one 320 kW (1.1 MMBtu/hr) boiler

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, electrostatic precipitator, moving grates, O₂ sensor control

Year Installed: 2006

Thermal Output: Hot water

The most unusual aspect of the woodchip system that heats the large Fronius International factory in Wels, Upper Austria, is this:

It's underground.

The heating plant is owned by Aigner Engineering, which supplies hot water under contract to Fronius, an international maker of welding machines, electronics, battery chargers, and solar-power equipment. At its Wels plant, Fronius uses the wood-heated water both for heating and industrial processes.

Aigner builds an efficient, optimally sized heating plant underground because, it calculates, that is the cheapest way to provide heat.

"We like building our plants underground," says Siegfried Aigner, managing director. "It really is the least-cost solution from the standpoint of operation and total cost."

Commissioned in 2006 next to the Fronius factory, the heating plant is entered by stairs leading down from ground level to a locked door. There are three stacks that extend 10-12 meters (30-40 feet) above ground and an above-ground crane for removing ash. Woodchip fuel is dumped into the underground storage bin by the delivery truck using two ground-level bulkhead doors.

The Fronius factory being heated has 38,000 square meters (410,000 square feet) of floor space. Its heat needs require a capacity of 3.2 thermal MW (11 MMBtu/hour). Of those, 250 thermal kW (850,000 Btu/hour) are used as industrial process heat.



Aigner's heating plant can produce a total of 2.8 MW (9.6 MMBtu/hour) of heat from three boilers: a 1.2 MW woodchip boiler, a 320 kW chip unit, and a natural gas boiler that can produce 1.3 MW. The two biomass boilers together produce 5.2 MMBtu/hour.

"When we build a plant, we optimize everything—we don't build anything oversized," Aigner explains. "Our wood boilers provide 98 percent of the total heat demand. Two percent come from the gas boiler, which is cheap in investment, but the costs for gas are about two times higher than for biomass. We would have to invest a lot extra to make one of our wood boilers bigger to cover that extra two percent heat demand."

The plant burns 7,800 cubic meters (2,700 US tons) of woodchips per year, stored in an underground fuel-storage bin that can hold 600 cubic meters (21,000 cubic feet) at a time. Two wood suppliers contract to deliver the fuel, which they procure from area farmers. One supplier delivers a fine-grade fuel, suitable for the smaller boiler. The second provides rougher-grade chips, which the larger boiler can burn.

"We have about one week of wood storage here," Aigner says. "Keeping the storage size low reduces our cost."

Incentive for Long-Term Relationship

“We own and operate 10 plants like this, all within a 200-kilometer (125 mile) radius,” Aigner explains. “We can produce heat cheaper than our customers can themselves, because we have shared staff and maintenance costs.”

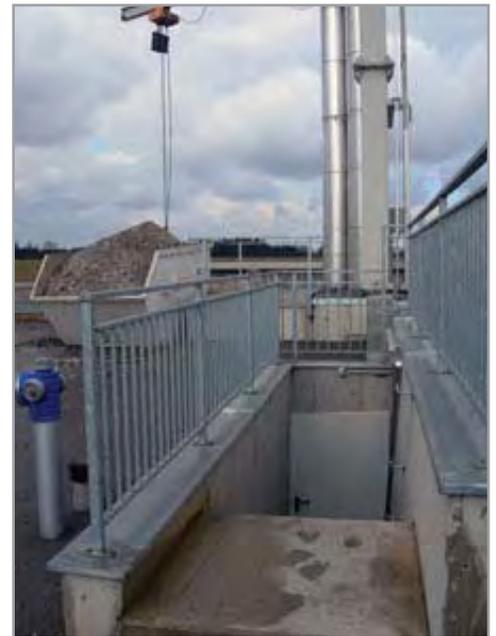
An operator visits the Fronius plant twice a week. Ash is removed automatically from the boilers, into a box down in the heating plant. The operator lifts the loaded ashbox with an electric winch to empty it into a dumpster that sits outside.

“Fronius put out a tender for bids to finance, build, own, and operate this plant,” says Aigner. “We got the contract. Part of the deal is that we rent the land from Fronius for 15 years. At the end of that time, we will renegotiate our contract. If that deal does not go through, or they award it to someone else, we can remove our boilers and walk away from the plant because it will be completely paid for at that point.”

Overall, the total system, including the underground building, cost Aigner Engineering €740,000 (\$960,000 US). The company has a 15-year financing contract on the project’s capital costs.

Aigner is a third-generation family business in Austria, which started as a plumbing and heating company, then spun off new firms that provide municipal waste-treatment plants and biomass contract heating. Both Aigner and Fronius have an incentive to maintain a long-term relationship—Fronius because it has a stable source of heat, Aigner because its costs for producing that heat will decline once it has finished paying off the plant’s capital costs.

“In our heat pricing agreements, we use a very transparent rate structure, including both fixed and variable costs,” Aigner says. “That keeps everyone happy.”



Opposite page: Aigner Engineering’s below-ground biomass plant on the premises of the Fronius manufacturing plant in Upper Austria.

Above: The entrance stairs to the below-ground boiler room, showing the ash dumpster and crane that hoists ash out of the boiler room.

Simple Business Has a Cost-Saving Product: Shared Heat

Woodchip District Heating System

Heating Capacity (output): 1 MW (3.4 MMBtu/hr)

Year Installed: 2005

Thermal Output: Hot water

District Heating Network Length: 450 m (0.3 mile)

District Heating Customers: 3

The Joutsan Ekowatti woodchip district-heat business is a shareholder venture that operates, mostly, without people.

It's centered in a simple blue metal building in an industrial park in Joutsa, central Finland. Inside is a one MW (3.4 MMBtu/hour) woodchip boiler that provides three businesses with heat via hot water distributed through an underground pipe network that covers just half of a kilometer (one-third of a mile).

All in all it's a neat little package and a working model for small-scale, commercial, biomass district energy.

"I started this system because I was worried about oil cost for my window-manufacturing business in this little industrial park," says business owner Tarmo Tamminen. "I wanted to burn woodchips because that is a very low-cost fuel and easily available, but my building was too small for a wood system. So I started a district heating system for the park.

"I chose my three partners, shareholders actually, to know things I didn't know," he continues. "We're all professionals. One is an accountant, one has a wood supply business, and the other has a property management business—he handles the 24-hour remote supervision of our plant."



The accountant does the system's administrative work. The wood supplier, a logging contractor with about 50 employees, supplies the fuel, working within a 20-30-kilometer (10-20 mile) radius to harvest whole trees, mostly hardwoods, that otherwise lack commercial value. Because dried chips are lighter than fresh chips and so cost less to transport, workers chip the trees and pile them up in the woods, covering them with a heavy-duty paper.

"A lot of wood fuel in Finland for small heating plants comes from small-diameter trees," notes Jyrki Raitila, research forester for biomass fuel production at the VTT Technical Research Centre of Finland. "Often it is stored to dry at the roadside before chipping and transport. There are contractors who cover wood piles with this special paper to protect it from weather while it dries for a year."

“We have an incentive to use a chipper instead of a grinder to produce our fuel, because you get less dust and better operation,” says Jouko Pirkkalainen, the partner who handles wood supply. “That’s easy for me, because I’m in the logging business and own the equipment. I have a vested interest in getting the best quality fuel because my partners and I are both the fuel suppliers and the plant operators.”

‘We Would Like to Own More’

To install their district system at the Joutsa industrial park, the Ekowatti partners put up a simple, slab-on-grade building and dug trenches to install the 450 meters (1,500 feet) of piping. They worked from specifications produced by an engineering company they had hired, one that specializes in small-scale energy systems. Their total investment in the district system: €500,000 (\$650,000 US), including €100,000 for the distribution network.

“Conventional banks like to give money to municipal district heating systems, but not so much to privately owned ones like ours,” Tamminen notes. “We financed through a government bank that loans money to environmental projects. Our system is only one MW thermal, so we don’t need an air permit or emissions testing.”

Each customer paid an initial connection fee, and each continues to pay a monthly bill that includes a fixed charge and a usage charge, the latter based on metered heat consumption. The rates are indexed to the prices of wood and oil.

The connection fees paid for the cost of the pipe network; the fixed charges on customer bills are paying off the building and its equipment. The shareholders will begin earning a profit as soon as their five-year loan for the plant is retired.

In creating their heating plant, the partners overbuilt capacity. Their boiler, building, and fuel-storage space are all larger than they need, so the system can expand, which its owners would like to do. The four have also built a second system, to supply other customers in another location.

“This was a simple project to do, and our second district heating project was so easy that we didn’t even hire a consulting engineer,” Tamminen says. “We got all the engineering we needed from the wood system vendor.”

Their second system, 10 kilometers (six miles) from the industrial park, serves a resort hotel and village, with cottages and an indoor swimming pool.

“We would like to own two more district heat systems,” Tamminen concludes.



Opposite page: The no-nonsense wood heating plant at the industrial park has both fuel storage and boilers in a single, simple building.

Above: Entrepreneur Tamro Tamminen and one of the other three owners of the biomass plant that serves three businesses in the Joutsa industrial park.

Going with the Future: A Transporting Company Shifts to Pellets

Wood Pellet Heating System

Heating Capacity (output): Two 49 kW (170,000 Btu/hr) boilers

Emissions Reduction and Combustion Control Equipment: O₂ sensor control

Year Installed: 2009

Thermal Output: Hot water

A few years ago, Mitter Transporte (a fuel transporting company) in the suburban town of Haid outside the central Austrian city of Linz felt strongly the currents of change—and its managers responded.

“It was clear that we had to incorporate wood supply into our business,” recalls Michael Nagl, the company’s fuel procurement manager. “The sooner the better!”

The pressures to move toward renewable fuels in Upper Austria, one of the country’s nine states, have converged from the state, national, and international levels. The European Union (EU) has adopted an initiative to increase to 20 percent by 2020 its share of all energy produced by renewable fuels (the current level is 8.5 percent), and to reduce carbon dioxide emissions by 20 percent in the same period—an initiative known as “20/20/20.”

EU member countries have until 2012 to develop action plans for achieving the 20/20/20 goals. The EU’s executive branch, the European Commission, has set legally binding individual renewable energy (RE) targets for each member country to meet, with stiff monetary “infringement” penalties if they don’t.

Austria has been among the most aggressive EU nations in developing RE uses—and Upper Austria has been a leader within the country, ahead of most of Europe, in implementing both efficiency and RE measures. Both the national and state governments are providing strong incentives to reduce fossil-fuel heating; Upper Austria has set a target of zero fossil fuels used for space heating by 2030.

While EU incentives are going to large research and development projects, and Austrian federal incentives are supporting large RE and biomass projects, Upper Austria has made a major commitment of funds for incentives to support residential, commercial, and district energy installations—efficiency, RE, biomass, and pellet installations.



The state’s Biomass Action Plan has set challenging goals for increasing biomass district energy use in towns and cities, and for speedily ramping up the use of pellet boilers in residences and businesses. The state’s “Heat with Pellets” educational campaign has placed billboards all over Upper Austria.

Renewing a Business with Tested Expertise

It was clear to Mitter’s managers that they could not viably stick with a business model based on transporting fuel oil. They responded, first, by searching out reliable sources of top-quality pellets (Austria has well-defined quality standards for different grades of pellets, based on ash content, type of wood used, moisture content, pellet size, and more).

Next, the company bought a pellet-delivery truck and trailer. Both the truck and trailer can hold 12 tonnes (13 US tons) of pellets, about enough to do six-to-eight home deliveries.

The demand for pellets was rising quickly and Mitter reacted by buying a second truck. It started delivering pellets from Vienna in the east all the way to Innsbruck in the west. Now, Mitter was running two trucks and transporting fuel from two different pellet manufacturers.

The business leaders didn't stop there.

“Our transport business has been successful over the years because we understand our customers and their needs,” Nagl says. “We saw that we had to better understand the heating needs of our customers, just as we are experts in oil delivery.”

So the company decided to install its own pellet boiler system, to heat three buildings with a total area of about 1,200 square meters (13,000 square feet)—its offices, its truck garage, and a maintenance shop.

Managers chose a Hargassner packaged boiler plant with two 49 kW pellet boilers (170,000 Btu/hour) capacity each. The system was delivered on a single truck, in two pieces that were essentially concrete boxes: the boiler room and the storage bin, the latter with a 22-tonne (25 US-ton) capacity.

The system manufacturer needed just two days to drop the boiler room and the storage-system boxes onto a concrete slab, bolt them down, put in the boilers, and connect the electrical and piping system, the latter to supply and return piping that Mitter had laid in from the three buildings to the slab.

In early 2009, one month after starting the project, Mitter was heating with pellets. The investment was €75,000-80,000 (\$95,000-\$105,000 US), partly defrayed by a government subsidy.

The new system displaces more than 15,000 liters (4,000 US gallons) of oil per year at a price of €1 per liter (\$5 US per gallon) for a total oil savings of €15,000. Now, Mitter burns pellets at €215 per tonne (\$200 US per US ton) and expects that the system will pay for itself within five years.

Each of the boilers automatically removes ash to a drawer, which is emptied periodically. Fuel is moved automatically from the storage bin to the adjoining boilers.

The heating system has been in operation only since the end of March 2009—too early to know the amount of pellets that will be used each year. Mitter Transporte is confident that the system will be a success.



Opposite page: Mitter's pre-fabricated pellet boiler plant, located behind the oil company offices. The boiler plant module was craned from the delivery truck to the concrete pad built by the owners.

Above: One of two pellet boilers in the plant, showing the ash drawer.

At a Super-Efficient Industrial Site, Pellet Boilers Are the Choice

Business Wood Pellet Heating System

Heating Capacity (output): Two 43 kW (150,000 Btu/hr) boilers

Annual Pellet Fuel Use: 25 tons

Year Installed: 2007

Thermal Output: Hot water

When David and Jan Blittersdorf, owners of NRG Wind Systems in Hinesburg, Vermont, were planning their business's new manufacturing and office facility—a building that would use one-fifth to one-third as much energy as typical facilities of comparable size—they pondered how best to heat it.

“Being in Vermont, and having grown up burning wood, I really liked the idea of pellets,” David Blittersdorf recalls. “Very clean-burning, dry, buy all your fuel at once.”

For their 46,000-square-foot facility, which opened in 2004 and manufactures wind testing equipment, NRG installed two Danish-made TARM boilers, each with 150,000 Btu capacity.

“The idea of the building is that it's not metered,” Blittersdorf says. “The emphasis is to be super-efficient, and then to do everything with renewables—with wind, solar, and pellets.”

NRG's total heating bill for the winter of 2007-08: \$5,905.

“Bulk pellets cost us about \$190 per ton last year, and we used 25 tons, or \$4,750,” Blittersdorf explains. The pellet fuel is made from various wood by-products of lumber milling and other wood processing. “This year we are paying about \$210/ton. Delivery from Jaffrey, New Hampshire is expensive. We need a local supplier!”

NRG uses a propane boiler for backup heat “that's just this little teeny thing next to the wood boilers,” Blittersdorf says. “We run it in the shoulder seasons, when we start heating, in October-November and in April.”



NRG also fuels its backup electric generator with propane, and spent \$1,155 for propane during the winter.

So Blittersdorf figures total heating fuel costs at \$4,750 plus \$1,555, or \$5,905.

“I'm a big proponent of multiple boilers instead of one huge one, because then you can stage things and work at maximum efficiency,” he says.

NRG Systems gets 53 percent of its electricity from solar photovoltaics and a wind generator, with 78.5 kW of solar voltaics on its roof, awnings, and a movable tracker. A 10 kW wind turbine is mounted on a 100-foot tower on a hill behind the building. Six solar hot-water collectors and a 240-gallon storage tank meet some of the company's hot water needs.

The architects who designed NRG's building won Vermont's top architectural award for the project, the 2004 Honor Award for Excellence from the Vermont Chapter of the American Institute of Architects.

“So few industrial buildings reach this level of sophistication,” said the award citation.

'It's Completely Controlled'

"The nice thing about the pellet system is, it's completely controlled," Blittersdorf says. "Very low maintenance, and very low amounts of ash. We burn 25 tons of fuel, but we only get a couple hundred pounds of ash. We clean the ash out a couple of times a week. We just use it on the garden—it's clean.

"I also like the super high efficiency. These boilers are 90 percent efficient, with very low pollution levels. And with the wood pellets, we're almost 100 percent renewable."

The heating system uses radiant floor technology, with almost 10 miles of radiant piping for both heating and cooling. A two-thirds-acre pond in front of NRG is used for cooling, heat pumping, storm water collection, and recreation.

Behind the headquarters building, NRG's 30-ton pellet silo is filled once a year, off season. "It's really nice to be able to buy your fuel in the summertime, and have your year's supply," Blittersdorf says. "I don't like deliveries in the winter."

Overall, the pellet system is working so well for NRG that it is installing two new pellet boilers in the 31,000-square-foot addition it is currently building.

"With the increase in our business," Blittersdorf says, "we've almost tripled our people since we opened three years ago."



Opposite page: NRG Wind Systems headquarters.

Above: Behind the headquarters building, NRG's 30-ton pellet silo is filled once a year, off season. "It's really nice to be able to buy your fuel in the summertime, and have your year's supply," (NRG owner) Blittersdorf says.

With a Mostly Home-Built System, a Family Business Trades Oil for Woodchips

Woodchip Heating System

Heating Capacity (output): 250 kW (850,000 Btu/hr)

Year Installed: 2007

Thermal Output: Hot water

Biomass-fueled district heating is a Finnish specialty: about half of the country's buildings, large and small, receive heat through a biomass district system.

"All municipalities and cities have district heating, using all kinds of biomass—woodchips, wood pellets, and peat," says Pekka-Juhani Kuitto, executive director of FIN-BIO, a nonprofit organization promoting bioenergy in Finland and beyond. "The big urban systems produce combined heat and power, but the smaller cities and towns have district heating only."

Then there are the very small systems, which are dotted all over Finland. Typical of those is the mini-district heating operation installed, run, and fueled with wood harvested by A. Reponen Oy, a family-owned company with 14 employees in the forested lakes district of central Finland.

"We didn't pay too much for this system," says Mr. Reponen, owner of the business. "We bought the wood boiler and built everything else ourselves—the building, the fuel handling equipment."

Reponen's woodchip boiler has a capacity of 250 thermal kW (850,000 Btu/hour). It heats a metal fabrication shop, where the family business makes components for backup electrical generators, along with Reponen's home 150 meters (500 feet) away and an equipment repair shop out back for the family's excavation and construction operations. The manufacturing shop is 2,000 square meters (21,000 square feet); the equipment shop is 150 square meters (1,600 square feet).



The Reponens produce their own chips using a mobile grinder that they own. The family has about 100 hectares (250 acres) of forestland from which it harvests about half the wood that it needs for heat. The rest it buys as recycled pallets, running all the wood for the district system through the family's grinder. The Reponens also own and use a harvester and a forwarder, a wagon used for transporting logs out of the woods.

When they built their district system in 2007, "We ran the pipe from the boiler house to the other buildings ourselves—not very expensive," Reponen says. "We moved an old oil boiler in for backup."

Pushing Oil Heat to the Margins

As a nation, Finland is working to remove petroleum fuel completely from its heating and power systems. "There is still oil used for heat in remote areas and for peaking power plants," says Kuitto. "We need to kick it out!"

“The European Union has given Finland a high target for renewable energy by 2020, since we are already ahead of other countries,” he adds. “We now get 28.5 percent of our energy from renewables, and by 2020 our target is 38 percent. There’s much to do.”

For the hard-working Reponen family, this is all about reducing the cost of heat. They invested €130,000 (\$165,000 US), in their district heating system, about €100,000 less than they might have paid an outside contractor for the project. At the time they installed their system, heating oil was about €0.80 per liter (\$4 US per gallon); it has since dropped to €0.60.

“Compared to other European countries, Finland has low oil prices,” notes Kuitto. “This has forced wood system manufacturers to innovate and compete against each other on price, to drive system costs down.”

Mr. Reponen reports few, if any, problems with the home-built system. A 15-minute daily check makes sure the heating plant is working smoothly. Once a week, another 15 minutes is spent cleaning out the ash.

“We basically leave the thing alone,” Reponen says. “It has an electronic call system, so if anything goes wrong with the boiler, we get a cell text message.”

Sensors in the boiler report operating data, such as the temperature of the heated water as it’s piped out of the plant. Two cameras in the boiler room also allow Reponen to look in from either his home or his office. The boiler has no emissions control devices, yet meets Finnish air-quality standards.

The system burns fuel of a wide range of quality, and up to 50 percent moisture content. The only trouble, Reponen says, comes if wood arrives too wet, frozen and mixed with snow.

Otherwise, the system runs fine. And that’s a good thing, because Reponen is a busy man. Asked if he is satisfied with his investment, he has an efficient answer.

He says, “Yes.”



Opposite page: Mr. Reponen, owner, outside the boiler plant that serves his family’s businesses.

Above: Buildings at A. Reponen Oy (equipment repair, metal fabrication shop, and home) are all on the mini-district heating system.

A Solar Firm's Super-Tight Building Aims to Become Heat-Energy Independent

Wood Pellet Heating System

Heating Capacity (output): Three 100 kW (340,000 Btu/hr) boilers

Emissions Reduction and Combustion Control Equipment: O₂ sensor control

Year Installed: 2008

Thermal Output: Hot water

One Austrian company's goal has been to build an industrial facility that will, in time, require virtually no external heating fuel or heat supply. Xolar Group, a fast-growing maker of solar hot water panels, is on a path to succeed. Biomass plays an important role, in the form of three relatively small wood pellet boilers tucked away in a basement of this large building.

Xolar Group's new headquarters and manufacturing center, completed in 2008 in Eberstanzell, Upper Austria, is a 21,900 square meter (235,000 square foot) building that is the largest passively heated and cooled structure in Europe. It uses a huge array of solar hot water panels on the roof to provide thermal energy for heating and cooling.

"Our manufacturing processes produce a lot of heat, so we have to do a lot of cooling," notes Andreas Ebner, Xolar Group's maintenance manager.

"This building has the highest level of air tightness of any industrial building ever built," he adds. "The heat requirement is almost zero. And we use natural passive cooling, in addition to the solar cooling."



It's below ground that Xolar Group's system really gets interesting. In its floor slab, the building has radiant heating—a grid of hot water piping. In most buildings, a radiant floor is used to heat the space above, but here it serves an additional function: The radiant floor also heats the soil below, to a depth of three meters (10 feet), all of it surrounded by insulating walls that hold in the heat.

Xolar Group has installed three modest-size wood pellet boilers, each with a capacity of 100 thermal kW (340,000 Btu/hour). The boilers provide supplemental heat that is gradually raising the temperature of the soil beneath the floor to 22 degrees centigrade (72° Fahrenheit), the temperature called for in the system design.

At that point—which Xolar Group estimates will take seven years to reach—the boilers, if all works according to plan, won't be needed any longer. The slab floor, kept always at comfort temperature, will serve to heat the space when heat is needed, and to cool the space when heat from the manufacturing process tends to make it too warm.

In essence, the pellet boilers are injecting biomass heat into the soil beneath the building like electricity charges a battery. Once the soil mass under the floor is up to temperature, the only heat input will be from the solar system.

At this point the pellet boilers will retire and the “heating system”—the ground and the floor slab, with daily solar input—will be self-contained and self-recharging.

Europe’s Largest ‘Passive’ Plant

“We are very proud of our new plant,” says Rainer Opletal, Xolar Group’s marketing director. “To achieve the European Union ‘passive building’ designation, the building must use less than 10 kWh of thermal energy per square meter each year for space heating.” That’s equal to using 0.03 gallons of heating oil per square foot.

Xolar Group’s heating and cooling system is computer controlled. At the heart of the system is a large, insulated “buffer tank” for storing hot water. The computer decides whether to dump heated water from the solar array or the pellet boilers into the buffer tank, or to circulate it directly to the radiant floor system that charges the soil. Heat stored in the buffer tank can also be directed, as hot water, either to the underground heat storage or to the air conditioning equipment that cools the office space.

Xolar Group is at the leading edge of renewable-energy use in Upper Austria, and the state is among the leaders in Europe.

Thirty-two percent of the total gross energy consumption in Upper Austria is provided by renewable energy sources, of which biomass constitutes 13 percent. The state aims to reach 100 percent of renewables (including biomass) by 2030.

As a renewable-energy business, Xolar Group is also growing fast.

“Our founder, Herbert Hümer, started Xolar Group in 2000,” Ebner says. “We sold 180,000 square meters (1.9 million square feet) of solar panels in 2008. Our goal is to sell one million square meters.”



Opposite page: The rooftop of Xolar Group’s state-of-the-art manufacturing plant showing the solar hot water panel array, the wood pellet boiler stack, and—on the vertical wall—photovoltaic siding.

Above: Xolar Group’s three pellet boilers, which are charging the ground beneath the building with even-temperated heat, will no longer be needed after seven years.

Lumber Firm's Waste Wood Now Heats Its Drying Kilns

Semi-Automated Woodchip Heating System

**Heating Capacity
(output): 350 kW
(1.2 MMBtu/hr)**

**Year Installed:
2004**

**Thermal Output:
Hot water**

In 2004, a fire consumed the two drying kilns operated by Chisholm Lumber in Tweed, Ontario. In this setback, the company saw an opportunity.

Already heating its two sawmills in nearby Roslyn with the big outdoor chunk-wood furnaces that are common in the region, “we decided we would like to put in a wood-fired boiler” at the Tweed site, “to provide heat and serve our dry kilns,” says company President Doug Chisholm.

“In the lumber business, you very rarely get a chance to build a greenfield operation,” he explains. “You’re always adding and expanding; you rarely get a chance to build from scratch.”

Taking this chance, Chisholm installed a dual heating system: a conventional oil-burning boiler alongside a modest-sized, 350 kW (1.2 MMBtu/hour) waste-wood boiler, to heat two dry kilns with a total capacity of 100,000 board feet. The wood boiler is a semi-automated system, meaning that wood fuel is moved by tractor from the storage pile into a hopper. The fuel is then automatically fed from the hopper into the boiler. This type of system requires more operator attention than a fully automated one, in which wood fuel is moved by augers from a large storage bin into the boiler without operator intervention.

Chisholm estimates that his operation uses the wood boiler, built by Grove Wood Heat located in Prince Edward Island, “about 95 percent of the time.

“We fire it with green sawdust from our sawmill, mixed with dry shavings from the planing mill,” he says. “We’re using about two to three tractor-trailer loads a month. We would sell that for about \$750-\$800 CAD (\$785-\$840 US) [per trailer load] on the open market.”



He figures the company factors in “about \$18,000 a year” as the value of the wood fuel it uses.

Sawdust and shavings can be sold to farms, for livestock bedding, and to the forest-products industry for fiberboard and similar composite products. Nevertheless, Chisholm notes, “nothing’s normal in the forest products industry these days—because a lot of the mills that would have taken these shavings in the past are closed down.”

Chisholm Lumber itself is running at only about 65-75 percent of its capacity. A diversified firm, it has been depending lately in large part on revenues from its retail yard and home-building operation. “Put it all in the air, and at the end of the day we’re surviving,” says Chisholm.

Fixing the Bugs, Mixing the Fuel

The company would be struggling even more if it had to heat its drying kilns with just the oil boiler. For three cold months at the start of 2005, Chisholm says, the oil system was up and running while the waste-wood system was still being installed—and the firm’s oil bill for those three months was \$42,000 CAD (\$44,100 US).

With the wood system on line, “we only use [the oil backup] when it’s very cold, or at peak periods when we need high temperatures for heat treating, something like that,” he explains. “It’s basically backup, but we do run them both to keep things going in the winter.”

The biomass boiler produces hot water, which is fed into a heat-exchange unit inside each drying kiln. The heat exchanger is, in essence, a large radiator; fans blow air over it and circulate the now-heated air through the kiln.

The waste-wood system has a small fuel-storage bin, about 2.5 meters by 3.7 meters by 2.5 meters (8 feet x 12 feet x 8 feet), and operators use a front-end loader to fill it most working days. Dried shavings are heaped on one side of the bin, green sawdust on the other. Operators learn how to blend these fuels for optimum combustion.

“There’s a fairly big learning curve to mixing the fuel,” Chisholm says. “It’s not very scientific—a bucket of this, a bucket of that. The operator gets a pretty good feel for what we need. If we could run it on 100 percent green sawdust, we probably would—but the shavings seem to give it some air inside the furnace, so it runs much better.”

The firing of the dual system is computer controlled, and favors the wood boiler until its capacity is exceeded. But operators still need to be on hand, Chisholm says.

“When the boys leave on Friday, there’s a roster of who’s going to look after the kilns on Saturday or Sunday, so we would have somebody there every day. We may not have to load [the wood boiler] every day, but someone’s there.”

“It’s been pretty reliable,” he says of the biomass system—“some mechanical bugs, but we’ve pretty much got it down. Those bugs are pretty much involved with the installation of any equipment. Once you learn how to run it, you’re fine.” The manufacturer was helpful in that process, he adds.

Asked what advice he’d give someone interested in installing a similar system, Chisholm says, “you need somebody who’s pretty hands-on. My cousin and business partner, Paul Chisholm, was instrumental in getting this thing operating—he can fix just about anything. You don’t just plug it in and hope it works. You have to have somebody who knows what they’re doing.”



Opposite page: After a fire in 2004 consumed the two drying kilns operated by Chisholm Lumber, the owner decided to install a wood-fired boiler.

Above: The automated removal of fuel from the hopper to the boiler, and the boiler’s combustion chamber.

For a Woodworking Business, Waste that Was a Headache Is Now Heating Fuel

Woodchip Heating System

Heating Capacity (output): One 540,000 kW (1.8 MMBtu/hr) boiler

Annual Wood Fuel Amount: 300 tonnes (330 US tons)

Emissions Reduction and Combustion Control Equipment: O₂ sensor control, moving grates

Year Installed: 2003

Thermal Output: Hot water

Asked how he got into heating his high-end woodworking business in Edmonton, Alberta with its own wastewood, Kent Madsen says: “To be perfectly honest, what motivated me to do this was, my partner drove me nuts.”

“This was Myron’s baby,” says Madsen, president of Madsen’s Custom Cabinets, of his now-retired partner, Myron Jonzon. “His daughter was in university, and she did a paper on waste heat—she’s an environmentalist—and she used our shop as a model. We were terrible: a poorly insulated building in northern Canada, our heat bills were crazy.

“She came up with a few ideas. Then we were doing an addition and expansion, and we said, ‘We’ve got to do something.’ They didn’t get a lot of buy-in from me at first. But when we got into it, I said, ‘This is pretty cool.’”

Madsen’s Cabinets produces custom cabinetry, doors, and architectural millwork: recent projects include the Alberta Art Gallery and the Air Canada lounge at Edmonton International Airport. In 2003, it installed the wastewood system, with a 540,000 kW (1.8 MMBtu/hour) capacity, that now heats its entire 2,790 square meter (30,000 square foot) facility. Virtually every ounce of wastewood the operation produces—scraps, shavings, and sawdust—goes into the 300 tonnes (330 US tons) of fuel that its heating plant burns each year.

“We’re burning particle board, we’re burning raw lumber—you name it,” Madsen says. “It all goes through our system. It burns very, very clean.



“I saw how this was working, and how the air quality in our plant was so much better,” Madsen says. “Our plant is spotlessly clean all the time. We suck up all the dust we can, so we can use it for heat.

“We built a much healthier environment for our employees, I’ll tell you. The other side of it is the amount of money we were spending on fuel—it’s not even an issue any more.”

When the company did its feasibility study for burning wood in 2002, it compared the costs of installing and running a biomass plant with the costs of keeping its then-active heating system, which burned natural gas.

“We all know what’s happened to natural gas prices since then,” Madsen says. “We still have the gas system in place. I think last year we turned it on for about two days.”

‘They Have Plenty of Fuel’

The heating plant at Madsen’s Custom Cabinets was built in Austria by KÖB, and was sold to Madsen’s Custom Cabinets by Fink Machine, Inc., of Enderby, British Columbia. Fink Machine owner Burkhard Fink worked with Myron Jonzon of Madsen’s Cabinets to design the right system for the facility.

Along with the wood boiler, the business needed to install two additional, key pieces of equipment. The first was a grinder, to reduce the size of larger wood waste. “They had a dust-collection system in place,” says Fink. “We improved and added onto that.”

The other new piece of equipment was a briquette press. That now squeezes sawdust and other fine wood waste into puck-shaped fuel, about five-by-five centimeters (two-by-two inches) in size.

In a boiler like this, to burn kiln-dried wood dust from a sanding machine “is not a good thing—it burns too hot, wants to explode,” Fink explains. “We avoided all that by installing the press.”

Before the briquette press was installed, Madsen’s silo for its collected airborne dust and particles wasn’t big enough to handle all the waste the business was producing. It had to be emptied around mid-summer; then, halfway through the winter, the business would be forced to buy woodchips for heating fuel.

“Once we put the press in, they didn’t have to dump anything in the summer,” Fink says. “And now they have plenty of fuel for the winter.”

The company now lists its fuel costs as zero. But, says Madsen, the real cost is “actually negative—because, you see, I used to pay people to haul that stuff away.

“A lot of people come into our plant and say, ‘Oh yeah, this is great!’ One of the reasons it’s great for us is, we have the fuel. We’re taking a product that was a headache, that we had to deal with by garbage trucks coming in every day, making a big mess, driving back and forth to the landfill—and now we’re using it as a fuel.

“I like the system now, but the accolades go to Myron and his daughter. I just wanted to go to work, flip the switch, turn the gas on, and forget about it. But now that we’ve got [the biomass system] in place, the benefits to the company far outweigh any of the work we have to do.”



Opposite page: In 2003, Madsen’s Custom Cabinets installed a wastewood system, with a 540,000 kW (1.8 MMBtu/hour) capacity, that now heats the entire 2,790 square meter (30,000 square foot) facility.

Above: Ash is automatically removed from the boiler and can be stored for disposal or other uses such as a fertilizer treatment.

Former Sawmill Business Now Grows with the Chip Market

Woodchip Supply Operation

From the yard of Lathrop Forest Products in Bristol, Vermont, Jim Lathrop can see a notch in the steeply forested wall of the Green Mountains. That's where his ancestor, Noah Lathrop, bought into a sawmill business in 1878.

Six generations later, just a few years ago, Jim was running one of the best-respected lumber-processing operations in Vermont. His focus was on high-quality sawlogs. Then in 2006 he auctioned off all his sawmill equipment, keeping only trucks, live-bottom trailers, and chipping equipment. He needed those for his new business, supplying woodchips—to a wood-fired power plant, a paper mill, and a growing number of Vermont schools and other institutions that are heating with wood biomass.

“Every business goes through a metamorphosis,” he said one recent afternoon, having just climbed out from welding a strut beneath one of his trailers. “I’m just rolling with the times.”

Just how dramatically Lathrop Forest Products has adapted is a story that could offer a national example for the struggling wood products industry. In Vermont, where the harvesting of sawlogs is as old a tradition as town meeting, Jim Lathrop can now tick off on his fingers the number of sawmills that have gone out of business in the last few years. The housing market and lumber prices have sagged, and top-quality hardwood is growing harder to find.

His business, in contrast, is growing.

“Biomass,” Jim said. “I could see it blossoming.”

Lathrop Products delivers about 50,000 tons of chips per year. Its primary customer is Burlington Electric, which runs the chip-fired McNeil Generating Station. The 50 megawatt plant primarily uses whole-tree chips that come from low-quality trees and from the tops and branches left after logging. But Lathrop also supplies half a dozen wood-heated public schools with a higher grade of biomass fuel—bole chips—which come mainly from the stems of fast-growing trees like poplar and pine.



That's the fast-growing niche business into which Jim is expanding.

“I’m working very hard to push the niche thing,” Jim said. Because bole chips are higher quality than whole-tree chips, they fetch a higher price.

Lathrop is the fuel supplier for nearby Middlebury College that has an \$11 million biomass heating and cooling plant as its primary heating system. Sheds on the Lathrop yard stockpile up to 1,500 tons of chips to assure the college of a steady supply. Jim's business is also now delivering chips to the main state office complex in Waterbury, Vermont, which has long heated with biomass and uses about 30 tons each day in winter.

“We're like a fuel supply dealer,” Jim said. “If you call up and want a load of chips, we'll deliver—even on short notice. Because we have it in inventory.”

In summer 2008, the per-ton price of bole chips was equivalent to heating oil at about \$1.60 per gallon. In 2007-08, one of Lathrop's customers, Bristol's Mount Abraham High School, saved \$75,434, compared to fuel oil costs, by heating with chip biomass.

“We went into chipping not knowing that oil was going up,” Jim said. “We just knew it was a good market. We walked into it at the right time.”

'I Call that Sustainable'

Just a few years ago, good-quality woodchips were available only as a byproduct of hardwood milling. That supply was limited, and the sawmills—including Lathrop's—viewed this piece of their business as an afterthought. Then in the early 1990s, a growing number of Vermont schools were investing in woodchip heat (45 public schools now have systems). State officials approached Lathrop about becoming a supplier.

Jim bought a used live-bottom trailer, for delivering chips to a couple of area schools. Three years later, he was supplying three times as many schools and had bought three new trailers.

He was still delivering his own mill chips. "It was a byproduct, and there was a market for it." He began getting more requests for chips than he could meet.

Then in 2002, he lost his primary mill to a fire. "The morning after, I had to lay off 40 men," he said. His wife and two sons were in the business with him.

"We had a think-tank session, after the fire," he said. "We came to the conclusion that the good-quality, mature sawlogs were not available for the number of mills. So we decided to go to the chipper."

The business bought a grapple skidder and a feller buncher, a mechanical tree harvester. Lathrop kept a smaller sawmill going until 2006, then got out of that business entirely.

To get chips, Jim now bids on logging contracts—anything upward in size from a two-acre project. Over the past quarter century, dozens of Vermont dairy farms have gone out of business—so onetime farmland has been growing up to brush and fast-growing trees. Lathrop has been clearing land for new farms, for pastures and orchards and vineyards, and for development.

The hardwood sawlogs that he harvests, Jim sells to sawmills. The remaining species, and the logging leftovers, he chips.

"I try to utilize everything—100 percent," he said. "Wood is growing 30 percent faster than it's being cut in this state. I call that sustainable."

When people and organizations interested in chip heating ask his advice, Jim said, he first assures them that the supply is there, if the system is designed to handle it.

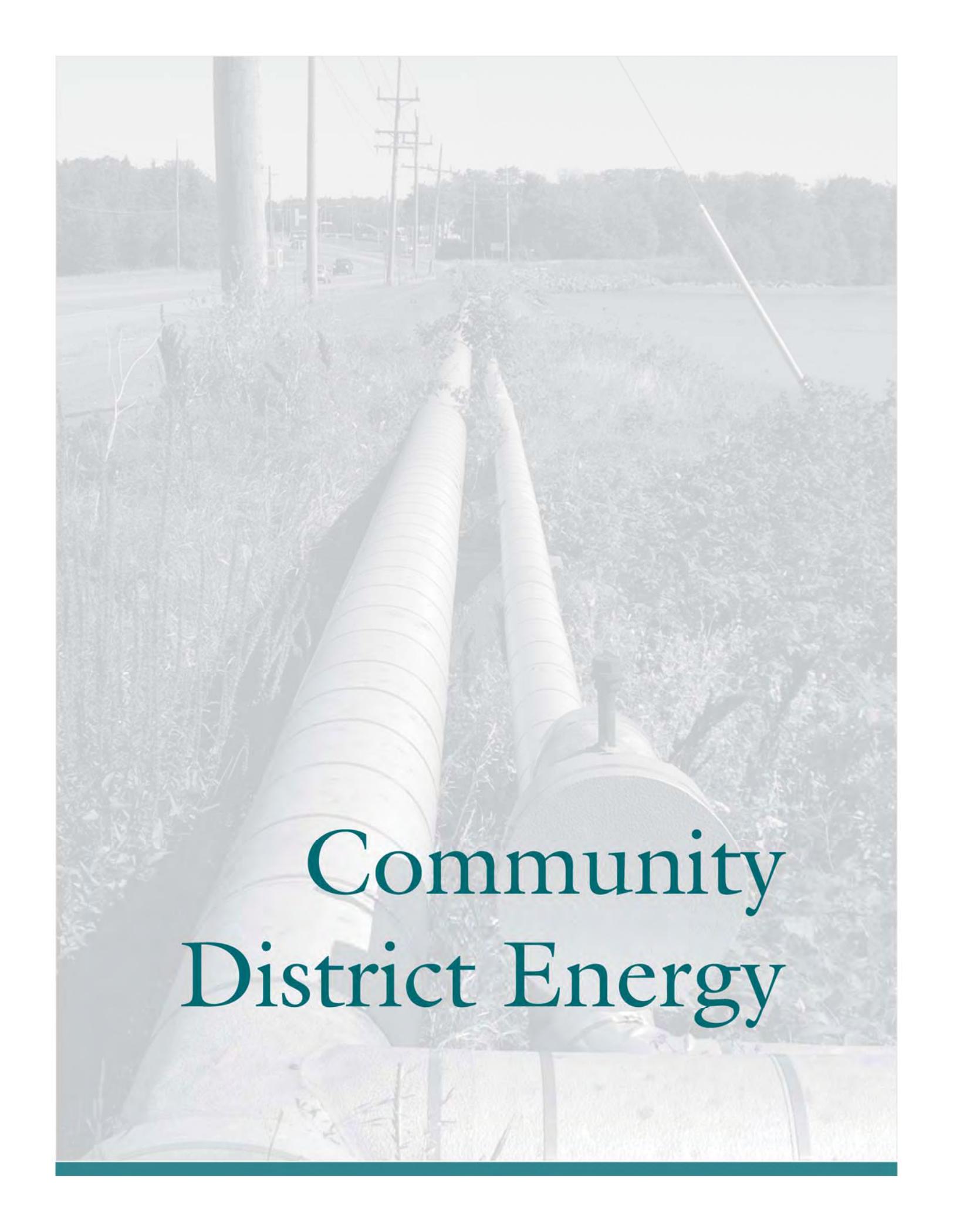
"I tell them to spec a boiler that'll handle bole chips—not just mill chips. Then you will have a chip supply. As you drive around the roads of Vermont today, you'll see all the old farms that are growing up to woods—poplar, pine, hardwood. A lot of that wood is going to be harvested. Why else am I six months or a year behind in my logging jobs?"

"I've always worked around the woods," he added. "I helped my grandfather log, I helped my father log. This was a natural progression as the sawmill business faded."



Opposite page: Jim Lathrop and his son, Justin, at Lathrop Forest Products.

Above: In 2006, Lathrop auctioned off all his sawmill equipment, keeping only trucks, live-bottom trailers, and chipping equipment.



Community District Energy

Using Biomass in Community District Energy Settings

Using a single biomass system to heat a number of buildings in a community has obvious advantages. The system buys fuel in bulk, and usually has just one heating plant to build, run, and maintain. Other benefits can become clear over the years that a community district system—such as those profiled here in Canada, Austria, Italy, Sweden, and Denmark—proves itself in operation.

In Europe, where fossil fuels are very costly and their long-term supply is uncertain, district systems have enabled hundreds of towns like Gleinstätten, Austria (pp. 85-88) to quit altogether using fossil fuels for heat. District systems strengthen the local market for biomass fuel, as has happened in the Alpine town of Toblach, Italy, where a growing district energy cooperative pays local farmers a premium price for woodchips (pp. 103-104).

Small-town systems often run as cooperatives, and often site their heating plants unobtrusively, as has Gjern Varmevaerk in Denmark (pp. 83-84). Operators learn to be vigilant about fuel quality, as in Charlottetown, Prince Edward Island, where a woodchip system has heated the provincial capital reliably for more than 20 years (pp. 105-106).

In Revelstoke, British Columbia, a community cooperative is in the black and looking to expand as it heats with an ample supply of wastewood from a local sawmill (pp. 101-102).

At first, townspeople may be concerned about smoke or odor—but because community systems are large enough to afford sophisticated emissions controls, those worries tend to evaporate. “Nobody has seen anything bad and there are no concerns any more,” says the system operator in Mullsjø, Sweden (pp. 97-98).

And because they provide a valuable service and economic benefits, biomass district systems can help communities develop in the way they want. In Oujé-Bougoumou, a native community in northern Quebec (pp. 99-100), biomass district energy has created jobs, kept money in the community, reduced heating costs, and helped fund new, energy-efficient homes.

For Four Farmers, Woodchip Boilers Drive an Expanding Business

Woodchip District Heating System

Heating Capacity (output): One 650 kW (2.2 MMBtu/hr) boiler and one 150 kW (500,000 Btu/hr) boiler

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, moving grates

Year Installed: 2006

Thermal Output: Hot water

District Heating Network Length: 1.8 km (1 mile)

Number of Customers: 25

In a way, says one of the four farmers who co-own a woodchip district heating system that serves a growing clientele in the rural Austrian town of Buchkirchen, the system owners are like doctors.

They take turns being on call.

“None of us spend much time at the plant—the system is fully automatic,” says farmer/owner Gerald Jungmair. “If anything goes wrong, the system calls us on our cell phones. We rotate being on call. Just like doctors!”

The new system, commissioned in 2007, was created by the farmers, and now provides hot water heat to 25 local customers—the town’s kindergarten and school, its municipal hall and other public buildings, an events hall, some multi-family housing, and several single-family homes. The heating plant’s two biomass boilers produce 650 thermal kW and 150 kW respectively, for a total of 2.2 MMBtu/hour and 500,000 Btu/year.

“This system took three-to-four years to put together,” Jungmair recalls. “The municipality was very interested, but it was really us four farmers who made it happen. We asked other farmers in town to join us, but in the end it was the four of us who formed the company and built the project. Now we operate it and sell heat.”



The engineer who the farmers hired to design the system called for an undersized woodchip boiler, with significantly less capacity than would be needed to meet peak demand, with an oil boiler to back it up. During the system’s first year of operation, the farmers felt they were burning more oil than they wanted or needed to—so they installed the second, smaller chip boiler and sidelined the oil unit. Today they burn no oil at all.

Their system uses 3,500-4,000 cubic meters (1,200-1,400 US tons) of woodchips per year. Its distribution network of pipes, buried in trenches in town, extends 1.8 kilometers (about one mile).

“We contract out when we need to extend our piping system,” Jungmair says. “We own everything right through the heat exchange station in each building on the system. Every heat exchange station has a sticker with the names and phone numbers of the four of us. We want them to call if there is a problem!”

Infrastructure Is in Place for Expansion

The farmers share their heating system's business functions. One manages wood supply procurement, a second processes invoices, a third takes care of bookkeeping, and the fourth handles sales to new customers. In their town of 4,000 people, they hope to add about five new customers each year. They already serve most of the larger local buildings, and have the distribution system installed to serve more.

Overall, the heating system cost €1 million (\$1.3 million US). The farmers secured incentive funding from the Austrian national government that contributed 30 percent of their budget. The farmers put up 15 percent of their own money

Fifteen-to-twenty percent of the project funding came from the connection fees that new customers paid. A government program subsidizes those connection fees.

The farmers borrowed the balance of the project cost as a bank loan. They anticipate about a 15-year payback on the overall system investment.

Another of the four owners says the plant has helped boost the farm economy in a way that benefits more than just their own cash flow.

“This is a farming region, not a forested area,” says co-owner Karl Kammerl. “Farmers own only small woodlots, maybe averaging five hectares (about 12 acres). My woodlot is a little bigger, a six-hectare lot plus some smaller patches of woods. The four of us who own the plant supply a lot of the wood, but we also buy from our neighbors. We always have enough wood!

“Our woods need thinning, but farmers have neglected this, until now. Now that we have a market for woodchips, more farmers are going back into their woods to do thinning and improve the quality of their forests.”



Opposite page: System co-owner Karl Kammerl showing the combustion chamber of the larger woodchip boiler.

Above: Buchkirchen's small farmer-owned district heating plant in rural Upper Austria.

A Town's Customer-Owned Pellet System Keeps Its Profile and Heating Costs Low

Wood Pellet District Heating System

Heating Capacity (output): 5 MW (17 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, baghouse

Year Installed: 1991 (new pellet boiler in 2006)

Thermal Output: Hot water

District Heating Customers: 490

The wood pellet district system that heats the small Danish town of Gjern Varmeværk is striking for several reasons. One is that it's just plain hard to spot.

The heating plant is fit so unintrusively into the midst of a residential neighborhood that a photographer, looking for a good view, found the plant to be almost hidden behind other buildings from almost every vantage point. Unless, of course, he looked up to notice the tall chimney, designed to keep any pollutants from affecting air quality in the village.

Another striking feature is that homes in Gjern must pay 26,000 Danish kroner (about \$4,700 US), just to connect to the district system. And pellets as a fuel are more expensive than woodchips. Even so, says plant manager Børje Laursen, "most all the houses in the village are on the district system.

"What is the price of oil here? Let me think. At people's houses they would probably be paying DKK 8-8.5 per liter (\$5.50-\$5.75 US per gallon) today," Laursen estimates. "We mostly stopped using oil in this town a long time ago."

Gjern has been heating with pellets for almost two decades. Local reasons for using this particular biomass fuel are that it can be burned in a very compact plant, and one that doesn't need a large chip-storage area, only a modest-sized silo.

"This is a small town—we only have 490 heat customers," Laursen says. "Our plant is right in the middle of the village, so it made sense to use wood pellets for fuel because the fuel storage and equipment don't take up much space."

The heating plant did originally use oil, which also can be burned in a compact facility. "Our plant is an old one, built in 1964," Laursen says. "Sometimes it feels as old as me!"



System Is Customer Owned

When Gjern went to pellets, it first used a converted boiler, a smaller unit.

"We started burning pellets here in 1991," the plant manager recalls. "For a while we tried using cheap industrial-grade pellets, but they gave us problems with clinkers. So now we buy only good-quality pellets. In 2006, we put in a new pellet boiler manufactured by Lin-Ka Energy, and most of our pipe was replaced about 10 years ago."

The price that Gjern pays for its pellet fuel is DKK 1,200 per tonne (about \$195 US per US ton).

"My house is 174 square meters (1,900 square feet), and heat from the system costs us DKK 1,500 (\$270 US) each month for 10 months, for all heat and hot water," Lauren reports.

Along with most local homes, the system serves a local school, some small industry, and an indoor swimming arena that uses about one-fifth of the heating capacity. It's common in European towns with district heating systems for the local pool to be the biggest customer, with local schools usually coming in second.

The heating plant is staffed by one person at a time, from 7:00 am to 4:00 pm, seven days a week, with on-call coverage at night. Two men trade staffing duties; the one who is on call during off hours can keep tabs on the system from his home computer. A retired local woman also works part-time for the system, spending two-to-three hours per business day doing billing and other administrative duties.

Gjern's is not a municipal system; its customers own it as a cooperative. Under Danish law, district heating systems that serve communities can't earn a profit, or develop a reserve fund. With typical homes here costing about DKK two million (\$360,000 US), the connection fees that homeowners pay to get on the district system can equal as much as eight percent of their home's purchase price.

"So you can get an idea," Lauren observes, "of how much people are willing to pay."

Heir to a Long Tradition

The first district heating plant in Denmark was built in 1903, and was fueled with a form of biomass: municipal solid waste. This system, in the City of Frederiksborg, evolved over the decades to become part of the Copenhagen district energy system, now one of the largest district heat networks in the world.

The nation has long been at the forefront of district energy. Since the energy crisis of 1973-74, national policy has moved the mix of fuels in Danish district energy away from fossil fuels toward a greater utilization of biomass, including straw, waste wood, and biogas.

The effectiveness of a coherent national energy policy is evident in Denmark's success in moving toward a post-oil future. According to the Danish Board of District Heating, one of those successes has involved making buildings nationwide more efficient. Over the last 30 years, these efficiency measures have reduced the per-capita heat requirement of Danish buildings by more than 50 percent.

At the same time that efficiency has reduced the need for heat, the technology to provide that heat has become increasingly sophisticated. Danish systems have benefited from the development of state-of-the-art pre-insulated district heat piping, hot water pumping systems, biomass boilers, heat meters, and heat exchangers.

Gjern Varmeværk is one of hundreds of small town biomass district heating systems that have benefited from this small country's national network of long-term support for efficiency and renewable energy.



Opposite page: The Gjern pellet heating plant is situated in the middle of the village, surrounded by houses and shops.

Above: District Heating Manager Børje Laursen in his workshop at the central heating plant in Gjern.

Town's Dual-Fuel District System Gives It Secure Heat, Renewably Fueled

Woodchip District Heating System

Heating Capacity (output): 2.5 MW (8.5 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, condensation plant, moving grates

Year Installed: 2006

Thermal Output: Hot water

District Heating Network Length: 5.7 km (3.5 miles)

Number of Customers: 75

Many Austrians feel a double impetus to move toward renewable energy systems. Along with weaning their country and communities from imported oil, they tend to see the supply of natural gas, imported mainly from Russia, as uncertain—especially after Russia cut off supplies during a quarrel with Ukraine in the winter of 2008.

This small country's response has been striking. More than 300 biomass district energy systems are now operating within the south-central state of Styria alone. These range from tiny systems that serve a few buildings to one that heats Graz, the state's capital city. Many district systems have been developed by local entrepreneurs who partnered with an energy company—as happened in Gleinstätten, a small market town of about 1,500 people.

"We always partner with local people for establishing district heating systems," says Evelyn Schweinzger, marketing director for Nahwärme, the company that worked with local resident Wolfgang Walzl to develop Gleinstätten's wood-and-solar district system. Nahwärme, a developer of community district-energy systems, is a spinoff and partner of S.O.L.I.D., a larger firm that designs and installs central solar energy systems.

Gleinstätten's district heating system uses both biomass and solar technologies to produce hot water. The water is distributed through 5.7 kilometers (3.5 miles) of in-ground piping to heat the town's municipal buildings, schools, a number of commercial buildings, some houses within the compact village, and Gleinstätten's historic, Renaissance-era castle and church.

"We often integrate solar into our biomass heating projects—we look for the right mix for each project," says Schweinzger. "We do small community projects, so we do not do any electricity production."



The Gleinstätten wood boiler provides 2.5 MW of thermal energy (8.5 MMBtu/hour), along with heat generated by 1,315 square meters (14,000 square feet) of solar hot water panels on the plant's roof. Additionally, up to 300 kW (one MMBtu/hour) of heat can be provided by the condensation plant, which recovers heat from the flue gases. The system required a total investment of €3.2 million (\$4 million US). It sells heat to its customers for 6.5-8 Euro cents per kWh (\$24-\$30 US per MMBtu).

A Flexible System, Simple to Maintain

Wolfgang Walzl had grown tired of commuting about 35 kilometers (20 miles) to his job in Graz, and wanted to start a local business in his hometown. He started the project, and Nahwärme—which now has 29 similar projects, all over Austria—came in as his partner. The other partners in the Gleinstätten company are three townspeople and the local farmers' wood supply co-op.

"Here in Gleinstätten, the first idea was to get the town off Mideastern oil—but people in Austria also want to get free of Russian natural gas," says Schweinzger of Nahwärme. "We've seen our gas supply cut off in midwinter when there were pipeline disputes between Russia and Ukraine."

“Last winter, Russia turned off gas supplies to Ukraine in a dispute over prices, which left large parts of Eastern Europe without supplies during a bitterly cold spell,” explained a July 2009 article in the Wall Street Journal. “Europe gets a quarter of its gas supplied from Russia, mostly via pipelines through Ukraine. Several southeastern European countries almost totally depend on that gas.”

The Gleinstätten district system has been working very well.

“Hot water district heating is very flexible,” says Harald Blazek, project manager for S.O.L.I.D. “You can use both biomass and solar hot water to provide the thermal input, and you can use it for both heating and cooling. The equipment for turning hot water into cool water has almost no moving parts, and is very easy for maintenance.”

Gleinstätten’s system is small, but has a very effective emissions control mechanism—a typical multi-cyclone particulate removal device, together with a condensation system to increase efficiency and add a much higher level of emissions reduction.

The plant can burn high-moisture green wood, and generally uses fuel that is a mix of ground-up wood and bark. The woodchips are fed into a rotating sorter drum, whose various-sized holes allow the chips to sort out into bins for rough, fine, and finer grades. As a secondary revenue source for the district heating business, some of the finer chips are sold on the residential fuel market—Austria has a robust market for various grades of chips. The plant itself uses about 10,000 cubic meters (3,500 US tons) of chips per year.

The system produces two waste products: solids, such as wet ash from the boiler, are taken to a local landfill, while liquid wastes from the condensation system go into the municipal sewage treatment system. In summer, the plant continues to produce heat, some of which it uses to dry its chips for winter use and for sale. A nearby window manufacturer also buys hot water in summer to heat its drying kilns.

Staffing the district system requires two hours of one person’s time each day in winter, one hour in summer.

Summing up his project, Watzl speaks of both tradition and innovation.

“This area has a strong solar tradition—a lot of solar collectors were installed in the state of Styria starting years ago,” he says. “The idea of integrating solar hot water into our wood-heating plant was quite natural.”



PHOTO COURTESY S.O.L.I.D.

Opposite page: The Gleinstätten district plant gets heat from two renewable sources: biomass and solar (the latter shown by the solar panels covering the roof of the fuel storage shed and boiler plant).

Above: A tractor moves fuel from the storage shed to the wood boiler’s day bin.

With Wood Waste, a Sawmill Heats Its Town

Woodchip District Heating System

Heating Capacity (output): 5 MW (17 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone

Year Installed: 2005

Thermal Output: Hot water

District Heating Network Length: 7 km (4.5 miles)

District Heating Customers: 150

In the very small village of Dalstorp in the Swedish municipality of Tranemo kommun, the Hållanders Sawmill is a big employer. Since 2006, it has also been the town's primary heat supplier.

The mill built a biomass heating plant on its property, about 1.5 kilometers (one mile) outside of Dalstorp, and created a spinoff business that uses its own mill residues to generate heat in a five thermal MW woodchip boiler. About 60 percent of that heat goes into the mill's lumber-drying kiln, adding value to its product; the rest travels on seven kilometers (4.5 miles) of piping to provide district heating to the town.

The sawmill's only heating customer is the town. The mill sends out one bill to its customer each month.

"The kommun of Tranemo spent SEK 15 million (\$1.8 million US) to build the pipe network, which they own," says Lars-Ola Segerqvist, a Hållanders employee and operator of the district heating plant.

"Our company built and owns the plant here at the sawmill, which makes hot water for district heating and for our dry kilns. It cost us SEK 20 million (\$2.5 million US) to build the plant. The kommun is responsible for the network, billing for their customers, and all customer service. We just make the heat."

"The kommun has connected 150 customers to the district heating network, about 70 percent of the building heat load in the village."



Dalstorp's total population is about 1,500. Among those served by the biomass system are a furniture maker and a manufacturer of auto parts, along with some smaller industry, a school, elder housing, a small grocery store, and a number of residences. In all, about 70 percent of local buildings are connected to the district heating system.

"There is one neighborhood where all the houses have electric heat," Segerqvist notes. "It would cost each house about SEK 75,000 [\$9,000 US] to convert from electric heat to hot water, not counting the additional district heat hookup charge of SEK 22,000 [\$2,700 US]. Those houses have not connected to the system. At least, not yet."

The sawmill-owned heating plant has a heat meter onsite, which measures the temperature of the heated water leaving the plant and the lower temperature of the water that returns. Billing to the kommun is based on the difference between those two temperatures.

Innovation in a Thriving Marketplace

The system enables Hållanders Sawmill to generate revenue from what was once a waste product—but no longer is. Today, wood waste in Sweden is a valuable product, in a thriving marketplace.

“If we hadn’t built this plant, we would have sold the bark and sawdust as fuel to other district heating systems in the area,” Segerqvist says. At the office his boss, one of the mill owners, just smiled when asked if this is a good business venture for the sawmill. His facility’s look of obvious success was answer enough.

The success of biomass heating in Sweden has fueled competition and innovation among the various plant equipment manufacturers. The Järnforsen woodchip boiler system in Dalstorp is a good example.

“To get the very best, cleanest combustion of wood fuel, there must be a very long flame path before the hot gases reach the heat exchanger, so that the gases are kept hot and all the carbon in the wood will be converted to energy,” explains Järnforsen Vice President Silve Piejko. “We supply combustion air in just the right places and increase turbulence in the firebox, all to promote complete combustion and clean emissions. We use an oxygen sensor at the exit from the boiler to tell the computer exactly how much air to supply to the fire.

“When we do all these things, and do them right, we do not have to work so hard to clean up the emissions. Just a multi-cyclone is all we need for a plant like the one in Dalstorp.”

Still, when required, it is possible to go to the next level. Järnforsen hopes to install condensing systems downstream of the multi-cyclones on a number of their systems. These devices improve system efficiency—by recapturing energy used to drive off moisture in green wood—and cut particulate emissions by as much as an additional 90 percent.

If this happens at the Hållanders plant, it will give the owners one more thing to smile about.



Opposite page: The plant that provides heat to the town network and the sawmill’s dry kilns.

Above: One of the Hållanders’ mill workers talking to the wood boiler supplier outside the fuel loading area.

Quietly High-Performing Woodchip Gasifier Is Producing District Heat and Power

Woodchip CHP and District Heating System

Heating Capacity (output): 4 MW (14 MMBtu/hr)

Electrical Capacity: 1.6 MW

Emissions Reduction and Combustion Control Equipment: Electrostatic precipitator

Year Installed: 2000

Thermal Output: Hot water

District Heating Network Length: 10 km (6 miles)

District Heating Customers: 900

A key goal, and an elusive one, in the worldwide quest to develop an efficient, reliable, clean gasifier to convert wood into electricity using an engine instead of a steam boiler, has been to build one that runs a dependable 4,000 hours per year.

In Jutland on the western coast of Denmark, a 1.6 MW (electric) gasifier system owned and operated by a subsidiary of the US firm Babcock & Wilcox has been running, very quietly, without promotion or much attention, more than 8,000 hours for each of the past several years.

Testifying to its quiet operation, there are usually no cars parked out front of the plant—just an operator’s bicycle, leaning against a wall.

“Most gasifiers are in the development stage,” notes Kim Jensen, assistant manager at Babcock & Wilcox’s Vølund plant in Harboøre, and one of two men who run the plant. “Ours has run more than 95 percent of the time, 8,300 hours per year.

“Is this plant very hard to take care of? Well, let’s just say we’ve gotten really good at golf.”

The plant converts woodchips into a gas that burns clean enough to fuel an internal combustion engine. Two engines in the plant burn that gas, producing rotary motion that drives a power generator.



The gasifier produces electricity, but Babcock & Wilcox treats the power as its second energy product. It gets heat, the primary product, from three sources: the heat that comes from the engines’ coolant, the heat that is pulled from the engine exhaust, and the heat produced by the cooling process that cleans the gas from the gasifier.

The product of all this heat capture is hot water for a district heating system that warms buildings in the town of Harboøre a kilometer away. The total length of the Harboøre district heat network of buried piping is 10 kilometers (six miles).

Although most gasifier projects focus more on power production, the Harboøre plant works with the actual proportions of power and heat that it produces: more than twice as much heat as electricity. The system’s thermal output capacity is four MW, or 13.5 MMBtu/hour. Its electrical output is 1.6 MW, sold to the power grid. In the summer, when there is little demand for heat, little electricity is produced.

The system uses wood harvested from forests within a 20-30-kilometer (10-20-mile) radius of the plant. Using wood for energy is nothing out of the ordinary in a country so committed to renewable energy that windmills are a common sight on the western coast where the Vølund plant stands.

'It Works Perfectly'

"Woodchips are delivered into this bin, which holds enough fuel for four days," explains Plant Manager Jørn Snejbjerg. "The electric eye of the overhead crane system continually locates the highest part of the chip pile and sends the crane there. It scoops up about a cubic meter of woodchips, travels to the back of the bin, and then drops the fuel into the receiving hopper. It's all automatic and it works perfectly."

"There aren't many commercially operating wood gasifiers in the world running internal combustion engines for making electricity," adds Assistant Manager Jensen. "This one is unusual because it can use green woodchips with no need for fuel drying, and the chips don't have to be very uniform."

The gasifier is a vertical cylinder that produces, along with the combustible gas, a thick, heavy tar.

"The tar from the gasifier is separated out by the gas coolers," Jensen says. "We store it and then we burn it in the winter in an oil boiler, to get more heat output for the system. We have a treatment system for the water from the gas coolers. When we're done it's almost clean enough to drink."

The plant has two backup boilers, one that can burn fuel oil as well as the waste tar, another that runs on natural gas.

The Harboøre plant was commissioned in 2000, and Vølund spent the first five years fine-tuning it for optimal performance. It has been since 2006, Snejbjerg and Jensen say, that the plant has been running more than 8,000 hours per year—so smoothly that the operators have spare time to improve their golf game.



Opposite page: The Vølund gasifier plant that provides district heating to the town of Harboøre.

Right: Overlooking the coastal town of Harboøre, showing two different kinds of state-of-the-art renewable energy options: wind and biomass gasification.

In a Village Center, a Woodchip Plant Simply Works

Woodchip District Heating System

Heating Capacity (output): 325 kW (1.1 MMBtu/hr)

Emissions Reduction and Combustion

Control Equipment: Multi-cyclone, O₂ sensor control, moving grates

Year Installed: 2006

Thermal Output: Hot water

District Heating Customers: 5

When the residents of the village center in Koivulahti, a town in western Finland, learned that a small biomass district heating plant was being built in the midst of their village, they were worried. And they said so.

“There were some in Koivulahti who said it would smell and it would create smoke and be a nuisance in town,” says Mikael Mehlin, one of two local farmers who contract with the owners to operate the heating plant.

“They were so concerned that they came to me and asked when it would start up,” Mehlin goes on. “My answer was: ‘It’s been operating all the time for the last two months.’ They never noticed.

“After that, no one was worried.”

The plant is owned by Koivulahti Värmaservice, a shareholder company that includes the owners of the five village buildings that the district system heats—a health clinic, three apartment buildings, and a mini-mall, along with the bank that financed most of the project’s capital costs. The building owners formed Värmaservice to install and own the heating system, which arrived on trucks as two modular units. Made by Megakone, the plant has a heating capacity of 325 thermal kW (1.1 MMBtu/hour).



“We weren’t the only ones that bid on the contract to operate this little plant—there were four others,” Mehlin says. “We were the low bidder. I would say it worked out well for us. Our only real investment was to buy a chipper and a trailer for delivering fuel.”

The operators also provide the fuel, paying €9 per cubic meter (\$35 US per US ton) for woodchips. The modular unit’s storage bin has an angled roof that opens up, and the delivery truck backs up a gently sloped concrete ramp to dump the chips. A rotating flail in the base of the storage bin turns to move the fuel with sweeping arms. As the arms push the chips over an open slot, the fuel drops through that slot to the bottom of the bin, where an auger moves it into the firebox for combustion as needed.

“This little plant has an oil burner and an oil tank,” Mehlin notes. “We filled up the tank, but we plan never to use the oil.”

‘This Is Pretty Easy for Us’

Near the city of Vasa, Koivulahti is largely a bedroom community in an affluent region of Finland that is populated largely by Swedes. A federal government incentive program covered 20 percent of Koivulahti Värmaservice’s budget for buying and installing the heating plant, and for installing underground pipes to distribute the heated water it produces. The company borrowed the rest from the bank that maintains an ownership share in the firm.

“We can usually help our clients get financing. We have a good relationship with one finance company,” says Jari Luoma, owner of Megakone. “Generally, they like to see 30 percent down and financing over five-to-seven years. In Finland, the lenders know district heating and they are comfortable with it.”

Mehlin and his partner bill Värmaservice €32 per MW hour (\$12.50 US per MMBtu) for the heat the five building owners use—covering fuel and labor, but excluding the financing costs for the system capital, which Värmaservice pays directly to its lender.

As a modular system, Koivulahti’s has limited capacity for expansion, which suits the system owners, who basically wanted to provide heat to their buildings. The system is working well, with few if any headaches for those involved.

“We’re farmers,” says Mikael Mehlin. “My partner raises pigs. I grow grain and produce eggs. Operating a district heating plant is a good match for us. We sell woodchips from our own woodlands, buy chips from others, and get paid to run the plant.

“This is pretty easy for us, for me and my partner,” he adds. “We just keep the bin full of chips and send our customers, the Värmaservice building owners, one bill every month. Then they pay us. It’s a simple business. We would like to do a few more just like this.”



Opposite page: The small Koivulahti pre-fabricated Megakone central heating plant, the roof of which opens up to accept wood fuel deliveries.

Above: Mikael Mehlin, the contractor who buys the fuel, operates Koivulahti’s small district heating plant and sells heat to five buildings.

Town's Public District Heating System Runs Clean on Woodchips—and Earns a Profit

Woodchip District Heating System

Heating Capacity (output): 5 MW (17 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone

Year Installed: 2008

Thermal Output: Hot water

District Heating Network Length: 20 km (12 miles)

Says Silve Piejko, vice president of Järnforsen Energi System, a Swedish wood boiler system manufacturer, “Sweden decided to get off fossil fuels a long time ago. Now we have wood-fired district heating everywhere.”

But, he added, “in Sweden we don’t have any government incentives for biomass energy for schools, municipal buildings, or district energy systems. Incentives aren’t needed. District heating pays off the initial investment in about 15 years.”

The system that serves the village of Hovmantorp lies within the kommun or municipality of Lessebo in central Sweden, and is one example of the publicly owned district woodchip systems that operate all over this country. Hovmantorp’s modest system is unassuming, very clean, high-tech, and low-maintenance. It just works—and it makes a profit, which Swedish law allows municipally owned energy systems to do. The profit comes back to the kommun, to use in any part of municipal operations.

Inside a plain red box of a building, the district heating plant produces up to five MW of thermal energy (17 MMBtu/hour). The plant, commissioned in October 2008 as the heart of Lessebo’s newest municipal heating system, cost 30 million Swedish kronor, (\$3.6 million US), a typical cost for a five MW plant.

The plant’s fuel costs are 0.23 SEK per kWh (\$8 US per MMBtu). Its heat is sold to local customers at triple that cost: 0.7 SEK per kWh (\$25 US per MMBtu). The typical residential customer also pays 49,000 SEK (\$6,000 US) to connect to the system.

“I should have bought into a few district energy systems 10 or 15 years ago!” laughs Piejko. “Then I would have had a comfortable retirement.”



A Sophisticated, Full-Cycle System

Lessebo decided in recent years that all municipally owned property should be served by a renewable energy system. “Our municipality has four village centers, and all will be on wood-fired district energy,” says Per-Johan Johansson, operator of the Hovmantorp system. “Three of them have district heating systems now, and another one will start up soon.”

The Hovmantorp district system, including 20 kilometers (12 miles) of heat distribution piping, serves about 200 houses in the village, along with municipal offices, a school, senior housing, a sports/gymnasium center, and several small businesses and light-industrial facilities. The heating plant and distribution network both have capacity for growth, and the municipality has plans to expand its service over time. The distribution pipes run beneath rights of way at the edges of local roads, not under sidewalks, making them relatively easy to install and service.

Swedish law has strict requirements for public district heating systems. Someone must check the plant once each day, and active alarm functions must be in place. If something goes wrong, someone must respond within half an hour.

The aim is to guarantee an absolutely reliable system. For the same reason, all public district systems must have a backup oil or gas boiler, with full operating capacity. Hovmantorp has an oil boiler.

Yet this municipality has no full-time employees assigned to any of its district heating plants. Four staff members are responsible for overseeing the systems; each has other responsibilities to the kommun.

“I probably spend one-to-two hours a day here at the plant,” says Joahansson, operator of the Hovmantorp plant. “If my cell phone gets an automated alarm message saying there is something wrong with the boiler or the pumps or something, I have to be here in less than 30 minutes.

“We tell the fuel supplier what quality of fuel we require,” he adds. “We have specifications that say the maximum amount of sawdust, the maximum chip size, moisture content range, things like that.” All chips for the Hovmantorp plant are sourced from a sawmill 15 kilometers (10 miles) away, on a 12-month fuel-supply contract. Fuel deliveries are made by double tractor trailers that tilt sideways as their sidewalls open.

“The European Union sets standards for wood boiler safety,” says Piejko—“but each country sets its own standards for efficiency and emissions. Sweden has some of the strongest emissions regulations in Europe. The combustion equipment (at Hovmantorp) is designed so well that we have no trouble meeting the standards.”

Hovmantorp’s plant meets those standards with only a multi-cyclone particulate-removal system, which is considered a fairly basic form of emissions control. The plant has space reserved for a condensing system that would clean its emissions even further.

Sweden’s wood-heating industry has advanced to the point where even ash disposal is handled in technically sophisticated, well-informed ways. There is a widespread network of businesses that collect waste ash from wood energy facilities like those in Lessebo—and a second network of businesses redistribute the ash into Sweden’s forestland, so the nutrients that come out with the harvested trees find their way back into the forest ecosystem.

Overall, the impacts of Sweden’s widespread investment in biomass energy may best be expressed in an anecdote. Karin Haara, executive director of SVEBIO, a Swedish biomass district energy trade organization, recently hosted a trade mission from China, visiting Sweden to see biomass energy at work. The delegation visited dozens of systems around the country.

“At the end,” Haara relates, “they said, ‘This is very impressive—but you’re a wealthy country, and we are poor. We can’t afford this.’

“I said, ‘We’re a wealthy country because we did this, 20 years ago.’”



Opposite page: Lessebo’s compact, sophisticated district heating plant sits on a small site just outside of town.

Above: Clean wood fuel—a mixture of sawdust, shavings, and chips—from a local sawmill are delivered by tandem tractor trailers that tilt sideways as their sidewalls open.

Company Supplies District Heat, Providing Income for Five Farmer/Shareholders

Woodchip District Heating System

Heating Capacity (output): 250 kW (850,000 Btu/hr)

Year Installed: 1995

Thermal Output: Hot water

District Heating Customers: 5

Across Scandinavia, and in Austria as well, many small, wood-fired district energy systems that were developed by farmers are serving communities. Some of these systems run as cooperatives. One of those is in the small town of Lundsbrunns, in central Sweden near Jönköping, where several farmers own, manage, and supply wood for a woodchip-fired system that sells heat to a single customer: the local municipality.

“There are five of us farmers who own this company. Each owns shares, and each of us has a role in running it,” explains co-owner Tomas Anderson. A grain farmer, Anderson is the co-op’s chief financial officer. He also stops by the heating plant, twice a day, to check on it—once after bringing his child to school in the morning, then in the afternoon after picking his child up.

“One partner manages the wood supply,” he adds. “One does the books and billing, one does repairs on equipment, and one is business manager.”

Farmer-owned energy co-ops are common in Sweden. “Back in the early 1990s, there was a problem with agricultural overproduction, and farm land was taken out of use,” says consulting forester Björn Vikinge. “Farmer energy co-ops were created to make up for lost farm income.” Although the Lundsbrunns system is a shareholder corporation, Vikinge says its creation in 1995 was part of that general movement.



‘This Is a Good Business’

The Lundsbrunns heating plant was built earlier, by a local farmers’ association in 1982, with three electricity-powered boilers. When the five farmers created their corporation in 1995, they bought the plant and invested 1.1 million Swedish kronor (\$130,000 US) to install a woodchip boiler with 250 thermal kW capacity (850,000 Btu/hour). With the distribution piping already in place, the farmers took on a 15-year contract to supply heat and hot water to five buildings owned by the municipality.

“We have just one customer,” Anderson affirms. “We send out one bill every month. This is a good business.” The buildings that they heat include the kindergarten, a school, the municipally owned senior housing, and a nursing home.

In all, the company sells 1,000 MW hours (3,400 MMBtu) of heat each year—an annual sales volume of 650,000 SEK (\$80,000 US). Its sale price for the district heat is 0.65 SEK per kWh (\$23 US per MMBtu). The single meter that measures their system’s billable output is right inside the heating plant.

For fuel, the farmers buy wood from themselves. Their company pays each one according to how much they supply. If the farmers can’t harvest enough wood from their own lands, they can easily locate other area suppliers.

“We know everybody in town,” Anderson says, who also runs an excavator business. “Getting more wood takes just a few phone calls.”

From the company, each farmer also draws a salary, along with a share of the profits. Administration of the plant requires, Anderson estimates, a total of five hours per month.

The heating plant has a backup oil boiler. “Even though the oil boiler supplies only seven-to-eight percent of our heat output, oil is almost our biggest operating expense,” Anderson says. “We’re thinking about putting in a wood pellet boiler, so that we could use 100 percent biomass.”

While this is a good business for Anderson’s company, he says that to be a really good business it would have to sell about twice as much heat as the farmers are selling now. But it hasn’t been easy to get other potential customers interested in the concept of a farmer-run woodchip heating system.

The farmers tried to develop a small woodchip plant for a spa with an indoor swimming pool that needed a lot of heat, but the business decided to put in its own pellet boiler. Lundsbrunns kommun went out to bid to build a biomass plant for district heating in another area of the municipality, but chose wood pellets over a woodchip system.



Opposite page: This small wood-fired district heating plant heats just 75,000 square feet of clustered municipal buildings in Lundsbrunns.

Above: Farmer and Lundsbrunns Bioenergi CEO Tomas Anderson stops by to check on the plant on his way to town each day.

Modular Units Make for a Low-Cost, Profitable System

Wood Pellet District Heating System

Heating Capacity (output): Three 3 MW boilers totaling 9 MW (31 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, baghouse

Year Installed: 2006

Thermal Output: Hot water

District Heating Customers: 160

When the Swedish town of Mullsjø went from oil to wood pellets to fuel its district heating system in 2006, it brought in three modular units manufactured by the Danish company Lin-Ka Energy, each pre-assembled with a complete boiler house and pellet silo. The cost, for buildings, boilers, and pellet storage, was 18 million Swedish kroner (\$2.2 million US), for a system that serves 95 percent of the 5,000-resident town.

The modular units now stand and operate side by side, providing district heat to 160 local customers, including 130 single-family homes. Adding in the cost of distribution piping, the town's complete investment in its district system was SEK 35 million (\$4.2 million US).

"The district heating company is making a profit every year," says Hans Gille, the operating engineer. "After we have completed five years, we will start to pay some of the profit back to the municipality. They can use the money for anything they want: schools, roads, nursing home, whatever."

The three-unit plant's capacity is nine thermal MW (31 MMBtu/hour). The district system charges residential customers a hookup fee of SEK 46,000 (\$5,500 US), including taxes, which is well under the actual connection cost of SEK 60,000-100,000 (\$7,000-\$12,000 US), depending on the distance from the pipe main to the home.

"The district energy company is completely owned by the municipality of Mullsjø, but we are separate from the municipality,"



Gille explains. "The district energy company borrowed all the money to build the system from a local bank, and the municipality provided the security for the loan."

Residential customers pay SEK 0.85 per thermal kWh (\$30 per MMBtu); commercial and industrial users pay SEK 0.60-65 (\$23-\$25 US). Rates comprise two components—the cost of energy, which is variable, and the system's capital cost, which is fixed. The district energy company pays SEK 1,400 per tonne (\$154 US per US ton) for its pellet fuel.

'No Concerns Any More'

A town of 5,000, Mullsjø originally hired Gille to study the potential for converting its oil-fired heating system to biomass.

"After we submitted our report they decided to make the investment and offered me the job of designing it, overseeing the construction, and running the system," he says.

The municipality is currently looking to expand its system to serve another 40 customers. “When we do an expansion,” says Gille, “we do not need to hire a consulting engineer. Even though I am an electrical engineer, I am able to do the design myself.

“Before we built the system here there was a huge debate in town,” Gille recalls. “Some people thought there would be noise, smell, smoke. It really surprised me. But after it was built, nobody has seen anything bad and there are no concerns any more.”

The kommun has kept its old oil boilers as backup, but rarely has to use them.

“We have strict regulation of ‘dust’ emissions (particulate matter) in Sweden, based on national standards,” Gille says. “The kommun can impose stricter standards if local conditions require it. Our pellet boilers have to emit fewer than 100 mg/m³ of dust and tested at 92-97 mg. The kommun tells us how often we have to test.

“The hot water district energy pipe we use in Europe is all based on strict standards developed in Europe in the late 1970s. The standards are high and have needed very few modifications in the last 30 years,” Gille concludes. “It’s a commodity and all the pipe is the same, whether it’s manufactured in Sweden, Denmark, Austria, or Finland. We just buy from whoever is cheapest at the time we bid it.”

Among the buildings served by the district system are a number that are owned by the kommun—not just the town hall but also, as is common in Sweden, the local school, swimming pool, elderly housing, and nursing home. When it decided in 2005 to move to biomass district heat, the kommun set itself the goal of reducing by 50 percent the total oil consumed through municipal operations.

A year later, with the quickly installed modular heating plant up and running, the kommun found it had already reduced its total oil use by 75 percent.



Opposite page: Mullsjø's modular pellet-fired district heating plant.

Above: The small town of Mullsjø, located in central Sweden.

Waste Wood Helps Fuel a Native Community's Development

Woodchip District Heating System

Heating Capacity (output): One 1 MW (3.4 MMBtu/hr) boiler and one 1.7 MW (5.8 MMBtu/hr) boiler

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, moving grates

Year Installed: 1991

Thermal Output: Hot water

District Heating Network Length: 2.9 km (1.8 miles)

District Heating Customers: 160

In the mid 1980s, people in the tiny Cree Nation community of Oujé-Bougoumou, in the James Bay region of Quebec, were reminded every time they drove their region's major highway of the stark contrast between their own values about resource use and the practices of the world around them.

On that highway stands a large sawmill that produces lumber for sale in the United States. As has long been common in Canada, the mill was then incinerating all of its wood waste in a large "beehive" burner that smoked away 24 hours a day, with giant mounds of sawdust piled outside waiting to be burned up.

For the Crees, "this meant taking only what is wanted for commercial reasons ... such a stark contrast to the traditional aboriginal approach of harvesting only what is required for use and finding a use for all parts of any items harvested from the environment," according to the Oujé-Bougoumou community's website.

The beehive burner was a painful reminder of how natural resources were being used as local Cree communities struggled for survival, "isolated and marginalized from the economic and political life of the region."

In 1986, as the James Bay Cree began an assertive push for government help to improve their economy and living conditions, the Oujé-Bougoumou community started to discuss the idea of generating its own heat through a district system fueled through biomass fuel—such as sawmill waste. A number of Scandinavian communities were already doing this, local leaders had learned. But when an engineering firm the community had worked with was asked to do a pre-feasibility study, it said such a system would be far too expensive. The Cree were not convinced.

The community approached the federal Energy Research Laboratory, then part of the Department of Energy, Mines and Resources (now the CANMET Energy Technology Centre, within



Natural Resources Canada), which had helped Charlottetown in Prince Edward Island develop its downtown biomass district heating system. The lab staff did a new study that urged the community to move forward, and its department shared with Oujé-Bougoumou the costs of a full feasibility study.

The study projected that, if Oujé-Bougoumou installed a biomass district heating system, it could create new jobs, keep more money in the community, gain more control over its energy costs, and reduce those costs over the long term.

In 1991 the community began to build a district heating system, fueled by wastewood in a one thermal MW (3.4 MMBtu/hour) biomass boiler and a one MW backup oil boiler.

"The district heating system was created at the same time that the Oujé-Bougoumou Cree Nation built a new permanent village from the ground up," says Heating Communities with Renewable Fuels, a 1999 "Municipal Guide to Biomass District Energy" co-published by CANMET and Vermont's Community Renewable Energy (CORE) program.

"By the 1980s, community members had been scattered throughout their traditional territory after being displaced during 50 years of exploration and development by the mining industry," the guide says.

“Agreements with the Province of Quebec in 1989 and the Federal Government in 1992 resulted in a financial settlement that made possible the construction of the new village.”

As the community and its heating needs grew, Oujé-Bougoumou added a second biomass boiler in 1998, with 1.7 MW (5.8 MMBtu/hour) capacity. Total cost of the project was \$46 million CAD (\$42.5 million US). The biomass boilers burn sawdust and other wood waste from the nearby mill, with the backup oil boiler supplementing the biomass system during peak hours.

Energy Savings Help to Build Houses

“Oujé-Bougoumou residents pay a fixed percentage of their income into a fund to cover the construction, operations, maintenance, and heating of their homes,” the community says. Oujé-Bougoumou has used money that it has saved through the use of biomass fuel, combined with energy-efficient building design, to build additional houses. “Dollars which otherwise would leave the community to utility companies or to fuel suppliers are now captured locally and provide the capacity to finance future projects.”

The district system serves 140 homes and 20 public buildings, using a distribution system with 2,300 meters (1.4 miles) of polyethylene piping and 600 meters (0.4 miles) of steel pipes. The community reported a 200-tonne reduction in its carbon dioxide emissions the first year, and continues to cut its production of nitrogen oxides by about 35 percent, or 160 kilograms (350 pounds), each year.

In 1993, Community District Heating Coordinator Duncan Varey estimated that Oujé-Bougoumou’s cost of producing one thermal MW of heat from its biomass plant was just 7.96 percent of what it would cost to produce the same MW from oil, and 3.4 percent of what it would cost to produce that MW from electricity sold to it by HydroQuebec.

The community estimated then that its system had cut individual home-heating bills by \$150 CAD per year.

The biomass system is completely automatic, from fuel feed to ash removal. A built-in telecommunications system allows for remote supervision and troubleshooting. The twin boilers can burn a range of waste wood, from bark to sawdust, from green to kiln-dried.

Today, “We the Oujé-Bougoumou Eenou (Cree for person) have a challenge to develop ways of using the forest resources which are in harmony with the environment and which will sustain our local economy indefinitely,” the community’s website says. “In the same way we are showing the world with our district heating system that it is possible to generate energy in such a way as to be in harmony with the environment, and with a view to contributing to the growth and development of our community, we now need to demonstrate that it is possible to do the same thing in the area of forestry.”

Oujé-Bougoumou has won national and international recognition for its work on sustainability. Awards have included:

- a 1995 Best Practices for Human Settlements designation by the Together Foundation and the UN Centre for Human Settlements
- A 1995 “Global Citizen” award from the United Nations Association, honoring Oujé-Bougoumou for developing a community that is both environmentally and people-friendly
- An invitation to exhibit at the 2000 World’s Fair Expo2000 in Hannover, Germany, for exemplifying “the balancing of mankind, nature, and technology”



Opposite page: The district system provides heat for the residents of the Cree Indian village of Oujé-Bougoumou, 550 kilometers (340 miles) northwest of Quebec City.

Above: Entrance sign to the village.

Mountain City Creates a New Fuel: Its Own Forests

Woodchip District Heating System

Heating Capacity (output): 1.5 MW (5.1 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, electrostatic precipitator, moving grates

Year Installed: 2005

Thermal Output: Thermal oil, hot water, steam

District Heating Network Length: 2 km (1.2 miles)

District Heating Customers: 5

Revelstoke is a scenic and compact mountain city with a fast-growing ski area and a large cedar sawmill in the forested Columbia River Valley of British Columbia. When volunteers here decided to create a biomass district heating system, to be fueled with ample wood waste from the sawmill, they had a working model to follow—their own.

In the early 1990s, nearly all of its region's timber products were being shipped away for processing. So residents created a community forest company that runs a city-owned tree farm and harvests 100,000 cubic meters of wood per year. Today, virtually all of the region's timber is processed in Revelstoke.

Following that model, in 2001 local volunteers began working on a biomass energy project. Again they created a wholly owned subsidiary of the city, the Revelstoke Community Energy Corporation (RCEC), to be managed by a volunteer board on which city staff and council members form the majority.

At the time, the sawdust and other wood waste created by the Downie cedar mill was going up in smoke, in an antiquated “beehive burner” whose air emissions required that it be retired under provincial edict.

“People in Revelstoke always had an interest in seeing that energy put to good use,” recalls Geoff Battersby, a retired physician and former local mayor who served as the energy project coordinator and lead champion.

Organizers initially proposed a combined heat and power (CHP) dual project: a biomass energy plant would supply heat to the city and the sawmill, and would also generate power. But rates for buying power at the time were so low that planners developed just the district heating system: a 1.5 thermal MW (5.1 MMBtu/hour) biomass boiler with two kilometers of piping to major buildings in the city core.



Total investment was \$6.6 million CAD (\$6 million US). That included \$3 million for the central plant and equipment, \$2 million for design, engineering, and other early phases, \$1.1 million for energy transfer stations, and the rest for financing and other costs.

The Downie mill donated an acre of land for the heating plant, and continues to supply sawmill and other wood waste without charge on a 20-year contract. The mill buys about half of the heat produced by the plant for use in its drying kiln, and it provides staffing for the heating plant.

“Our mill cuts only cedar—that’s where all the green fuel for the district heating plant comes from,” says Aubrey Salon, the Downie employee who runs the plant, spending about half of his time there. “I like the cedar sawdust a lot as fuel, but the hog fuel is too irregular and gives me lots of problems.”

The plant’s struggles with mixed-quality fuel are not the only learning experience—local folks sometimes use stronger terms—that Revelstoke has had. Although project leaders today say they would “absolutely” do the project again, and are working on expanding it, they have had their share of bugs to work out.

Challenging Oil-Water Heat Exchange

Much of the trouble developed because of a provincial staffing requirement that Revelstoke calls antiquated, and is lobbying to change. British Columbia mandates that boilers above a certain size be manned 24/7. Had it built a 1.5 MW (5.1 MMBtu/hour) hot water boiler, Revelstoke would have fallen under that edict. (Local advocates note that in Scandinavia, biomass systems up to 20 MW (68 MMBtu/hour) in size are routinely remote-operated.)

So Revelstoke installed a boiler that heats “thermal oil,” which can carry much more heat than water. The hot oil is sent through heat-exchanging steam generators, to produce hot water for the district heating system and steam for the mill’s drying kilns.

“The initial problem we had was that we were getting water contamination into the oil,” Dr. Battersby says. That water would expand as it heated and cause oil to blow out through an expansion tank. Once that problem was fixed, there was another—tubes in a steam generator were failing because of corrosion due to oxygen in the water.

Frustrating?

“I’ll say,” Dr. Battersby agrees. “And not only did it set us back in getting more customers online to meet our projections, but it cost us a lot of money to repair all these things. However, we’re still afloat, still showing black ink.”

Meeting Goals, Planning Expansion

Revelstoke did this project to improve its air quality, reduce greenhouse gases, displace the need for trucked-in propane (the 8,000-population community’s nearest neighbors are 100 and 150 kilometers, or 60 and 90 miles, away), create alternate sources of energy and city revenue, and add value to a resource that could be processed locally. Those goals are being met—and customers are happy.

“The system has served our B&B, Minto Manor, very well and reliably,” says David Johnson, who is the volunteer RCEC president.

“Based on that kind of positive experience of customers, we want to expand to serve more buildings in Revelstoke.”

The system currently serves the city aquatic center and winter sports arena, high school, and a local hotel along with Minto Manor. RCEC is working to add 10 more—the municipal and federal buildings, Catholic church, and others.

“Our rate structure is based on a capacity charge and an energy charge,” Johnson says. The capacity charge reflects the cost of connecting a customer, plus financing. The energy charge is set linked to the competitive costs of energy.

“Overall, we aim to be about five percent below Terasen Gas,” Johnson says. “The costs are indexed to the Energy Consumer Price Index in British Columbia each year.”

Dr. Battersby says the RCEC’s biggest long-term concern “is that the mill might go down, for whatever reason. It’s a risk.” But Downie is highly competitive in the North American cedar market—and the demand for its wood waste has developed strongly.

“Within six months of our signing the contract, their waste stuff came to have a value,” Dr. Battersby says. “They can sell the rest as far off as Florida.”

And Revelstoke still owns its community forest. So its fuel resource remain its own.



Opposite page: David Johnson, president of Revelstoke Community Energy Corporation, inspecting the heat meter at Minto Manor, one of the system’s five customers.

Above: Revelstoke sits on the banks of the Columbia River in the middle of British Columbia’s Rocky Mountains.

How Three Alpine Resort Towns Became District Heat Champions

Toblach/Innichen Woodchip District Heating & CHP System

**Heating Capacity
(output): One 10
MW (34 MMBtu/hr)
boiler and two 4
MW (14 MMBtu/hr)
boilers**

**Electrical Capacity:
1.5 MW**

**Emissions Reduction
and Combustion
Control Equipment:
Multi-cyclone,
electrostatic
precipitator,
condensation plant,
moving grates, O₂
sensor control**

**Year Installed:
1995**

**Thermal Output:
Hot water**

**District Heating
Network Length:
44 km (27 miles)**

**District Heating
Customers: 900**

In 1994, the mayor of Toblach, an affluent resort town in Italy’s region of the Alps near the Austrian border, asked a young municipal employee named Stefan Clara if he could take charge of creating a new, woodchip district heating system to serve the town of 3,300. Clara said yes. Then he hurried back to his office to find out what “district heating” was.

He knows now.

Today, Toblach’s woodchip district heating system serves more than 900 buildings in two towns. It’s owned and run through an innovative co-op membership, and it has expanded to produce electricity, and to heat more than 90 percent of the buildings in Toblach and the neighboring community of Innichen, four kilometers (2.5 miles) away. Customers are reportedly very happy with the district system, whose initial development in the mid-1990s paralleled that of a similar system in the neighboring town of Olang. Today there are 60 wood-fired district heating systems in Italy’s South Tyrol region, whose total population of 550,000 is smaller than Vermont’s.

As part of a feasibility study for the Toblach system, Stefan Clara went door to door, talking with the owners of the town’s larger buildings, including the 60 local resort hotels. The feasibility study had set a target of 70 percent customer commitment as a threshold for building the biomass plant and pipeline.

After three months, the mayor asked Clara if he had reached that goal. Again, Clara said yes—but, in fact, he hadn’t quite made it.

“I was so scared,” he recalls—“but as soon as the decision to build was made, I quickly got the remaining commitments.”

In 1995, the Toblach system went online with two, four MW thermal (14 MMBtu/hour) Kohlbach woodchip boilers, and with 120 buildings connected. Membership has since grown to more than 500 members in Toblach and 400 in Innichen. Clara, who guided the



PHOTO COURTESY LEO HALL

system for its first 10 years, led the development of the co-op membership arrangement, in which each customer/owner has one vote and can join in decision-making. The most important member is the municipality itself, which owns the local schools, a number of city buildings, and a large office complex.

Building owners provided 20 percent of the system capital, with one-fifth of their portion coming from the municipality. Grants from the provincial government of South Tyrol met between 30 and 40 percent of the initial capital cost for the system, with low-interest loans providing the rest. To help out, local banks deferred principal payments in the system’s early years.

Expanding and Repaying Debt without Raising Rates

Along with its cooperative membership, the Toblach system has taken a forward-looking approach to building its fuel supply. To strengthen the link between energy use and local, family-owned forests, the system pays local farmers 75 percent more than the market price for woodchips, which today is €30-40 per tonne (\$35-\$45 US per US ton), close to US prices. Northern Italian heating oil prices were €0.70 per liter (\$3.50 US per US gallon) when the Toblach system was built. They are now about €1 per liter.

The system innovated again when it expanded in 2003 to serve Innichen, population 3,100, with its large hospital, nursing home, swimming-pool complex, and bigger hotels than Toblach's. Along with laying pipe to the town, the plant added combined heat and power (CHP) capability, using a new system called "organic Rankine cycle," or ORC, built by the Italian firm Turboden.

Unlike the steam boiler technology that is conventional for CHP, ORC does not develop high pressures, is much safer, and requires very little operator attention. To power the ORC system and serve the Innichen heat network, the plant added a third woodchip boiler, with 10 MW (34 MMBtu/hour) capacity. It cost €8 million to expand the central plant in Toblach and add the new wood boiler and ORC equipment there, not including the pipe cost to connect the two towns and provide heat to buildings in Innichen.

Adding the ORC sharply increased revenue to the system, because Italy at the time was paying green-power producers to supply electricity to the grid under a generous "feed-in" tariff. Although the feed-in rate has fallen since then, it is still high and provides valuable revenue that has allowed the co-op to prosper.

These revenues supplement those from the system's co-op members. The price members pay for their heat—about €80 per MW hour (\$30 US per MMBtu)—has not changed since 1995.

Since it was commissioned, the Toblach system has been earning money and building reserves. When the system has repaid its construction debt, the co-op's board will decide whether to reduce rates or pay dividends to members.

The Toblach system has been regarded as a European leader in district energy because it has innovated consistently, it pioneered the user/co-op ownership model, it installed the biggest ORC system available at the time, it uses emissions-control equipment that achieves

the best-available results, and it works with co-op members to help them reduce their use of heat energy. Also, the system supports local forest owners, and it has made its central energy plant a center for educating children, the public, and ecotourists—all while keeping rates flat for 15 years.

In Olang, Performance Converted Skeptics

A few miles west along the Upper Valley of the Rienz River, the resort town of Olang commissioned its district heating woodchip system just before Toblach's. Olang has 3,000 residents and nearly 3,000 hotel beds. After a nearby fiberboard plant closed, area loggers, mills, farmers, and forest landowners wanted a new market for woodchips.

Even so, "there were skeptics," recalls former mayor Alfred Jud. "They thought the system wouldn't run in the summer, and they would have to keep their boilers and water heaters. But that wasn't the case."

Rising oil prices in the mid-1990s stimulated signups to Olang's system, which now serves 90 percent of the buildings in town. Olang's plant has two, four MW (13.5 MMBtu/hour) Mawera chip boilers, and a 680 kW ORC for power production. It is owned by its original 160 local investors/customers, while its total number of customers has grown to 300.

Jud stresses the importance of maximizing the efficiency of buildings connected to the district system, through insulation, new windows, overall tightening-up, and better thermostatic controls. This, he notes, makes the whole district heating system more efficient.



PHOTO COURTESY LEO HALL

Opposite page: The Toblach district energy plant in the Dolomites of northeastern Italy.

Above: Thermal oil heater of the ORC CHP plant, similar to the one in Toblach.

In Prince Edward Island's Capital City, a Biomass Pioneer Just Keeps on Working

Waste Wood and Woodchip District CHP System

Heating Capacity (output): 35 MW (120 MMBtu/hr) boiler

Electrical Capacity: 1,200 kW

Annual Wood Fuel Amount: 62,000 tonnes (67,200 tons)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, O₂ sensor control

Year Installed: 1986

DH Customers: 125

Thermal Output: Hot water Steam (1 customer)

One of North America's biomass energy innovators has been the district energy system in Charlottetown, the capital of Prince Edward Island, which uses woodchips and municipal solid waste plus some fuel oil to heat the city's commercial center and large buildings. Initially developed in 1986 to serve the city's complex of provincial office buildings, the Charlottetown system was Canada's first biomass district heating initiative—and more than two decades later, the expanded facility continues to operate virtually trouble-free.

"In terms of the operation, it's actually pretty smooth," says Dave Godkin, general manager of the Charlottetown District Energy System, which provides hot water for heat to about 125 downtown buildings, and generates 1,200 kW of electricity, most of which is used internally with the balance sold to the power grid.

"The municipal solid waste provides the base load for the entire system," Godkin explains. "Wood is next; then, once the wood is fully loaded, we go to No. 4 oil. For backup and ultimate peaking, we use No. 2 oil. This is really nothing new for district heating systems, to use multiple fuels."

What is most notable about the Charlottetown system may be its very absence of drama. Through a major system consolidation and expansion in the mid-1990s, a series of ownership changes, and the recent decline of the region's forest-products industry, the plant has simply, quietly continued to do its job.



The present-day system evolved out of three earlier projects. A local waste-to-energy plant was built in 1983 to turn municipal solid waste into electricity and steam heat. In 1986, the original woodchip district heating plant was separately constructed to serve the provincial office buildings, using public funds and operated by the public PEI Energy Corporation. Over the next decade, the PEI energy system expanded to serve a number of the downtown commercial buildings as well. In the same time period, the University of Prince Edward Island, also in Charlottetown, built its own wood-fired district heating plant to serve its campus.

In 1995, the privately owned firm Trigen Energy Canada, Inc., bought all three plants, then consolidated the boilers into one facility at the site of the waste-to-energy plant. In 1997, Trigen installed a new, high-efficiency wood boiler (manufactured by KMW Energy), cogeneration equipment, and state-of-the-art emissions controls on the waste-to-energy plant. The original city woodchip plants were shut down.

Trigen was then bought by a US firm, US Energy Systems, and several years later PEI Energy was spun off and acquired by a Canadian income trust called Countryside. It was subsequently bought by PEI Energy's current owner, Fort Chicago Energy Partners of Calgary.

Fuel Supply Appears Secure

Under Fort Chicago's ownership, the system continues to provide heat via hot water to most of downtown Charlottetown: the provincial government offices, the University of Prince Edward Island, the Atlantic Veterinary College, the Queen Elizabeth Hospital, two shopping malls, and a number of other commercial and apartment buildings.

No new expansions are in the works, says Godkin. "We've got most of the larger buildings connected—and the smaller the buildings get, the less economical they are to try and connect, because of the costs of installing piping, heat exchangers, and other equipment."

Each year, on average, the district system uses 36,000 tonnes (40,000 US tons) of wood and about 26,000 tonnes of solid waste, providing 85 percent of the plant's fuel supply with those materials, the rest with oil. For years, the entire wood supply was sawmill waste from a large local mill owned by JD Irving Ltd.—but that mill "shut down here a couple of years ago," Godkin says.

"We had to switch to chips from whatever land clearing and forest clearing we have here," he explains. "We've got two contractors. They do some forestry work, some land clearing work, and we rely on them to source out the material."

The province is not heavily forested, but Godkin isn't worried about wood fuel supply.

"PEI has a relatively small forest industry, and the amount of material we take is really a drop in the bucket," he says. "Whole-tree chips certainly may be an option or a possibility in our future; it depends on what happens with the forestry industry. I'm confident that the wood is there."

The Charlottetown boilers produce high-pressure steam that is converted to high-temperature hot water for the district heating system, and is also provided as steam to the hospital. The system's demand is approximately 40 thermal MW (140 MMBtu/hour).

Asked if there are any major operational issues, Godkin says, not really.

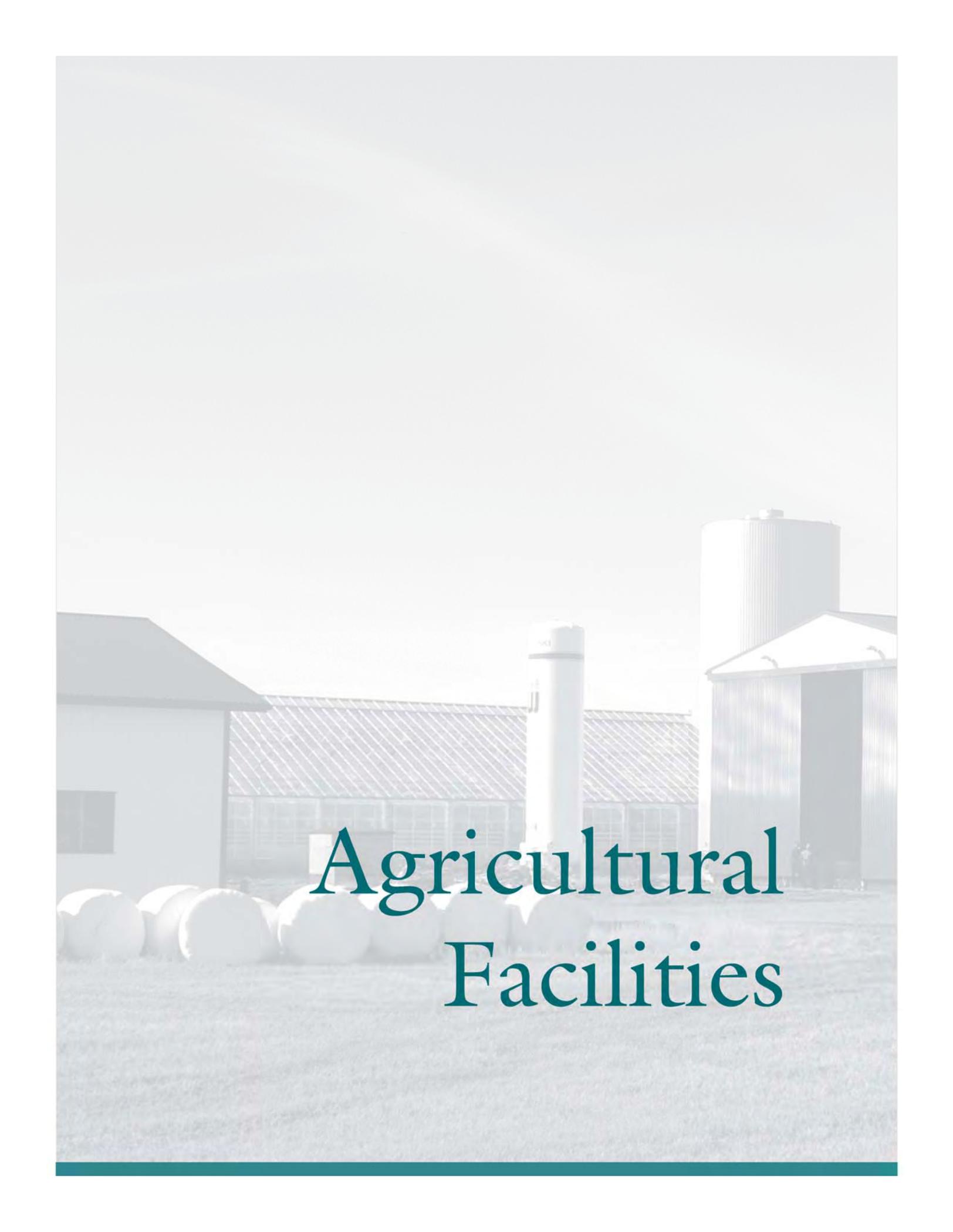
"We do have from time to time some issues on fuel quality, but certainly we're not nearly as susceptible to fuel-quality issues as some of the smaller systems are. Things actually work fairly well, other than the kind of normal maintenance that systems like this requires."

Not too long ago, PEI Energy estimated how much oil it would be using, if it had to heat its customers entirely with fuel oil. The estimate, for petroleum oil avoided each year: 16,000,000 liters (4,160,000 gallons).



Opposite page: The Charlottetown system was Canada's first biomass district heating initiative.

Above: The system, now owned by Fort Chicago Energy Partners of Calgary, provides hot water for heat to about 125 downtown buildings, and generates 1,200 kW of electricity that is sold to the power grid.

A photograph of an agricultural facility, including a large barn with a corrugated metal roof, two tall cylindrical silos, and several large round hay bales in the foreground. The scene is set in a grassy field under a clear sky. The image is overlaid with a semi-transparent teal filter.

Agricultural Facilities

Using Biomass for Energy in Agricultural Facilities

Farmers are often in a position to use their own or their neighbors' biomass fuels in heating operations, as do the Austrian farmers whose profitable, growing biomass district-energy business is profiled on pp. 81-82. This section spotlights two Scandinavian operations, both of which use biomass systems to meet all or most of their heating needs.

Different regions produce different biomass fuels—and in Närpiö, Finland, a farmer who grows tomatoes hydroponically in a greenhouse can choose between wood pellets, peat, or woodchips to run his two compact biomass boilers. Although he'd rather burn wood, which burns cleaner in his system, peat is more abundant and therefore cheaper to buy, says farmer Mats Nordstrom (pp. 109-110).

Also in Närpiö, a family tomato and cucumber farm that uses biomass in a modular boiler can burn either woodchips or peat (pp. 111-112). Either way, the operation has been able to turn off its oil heat completely since installing the biomass system.

“Our greenhouses are big and take a lot of heat,” says farmer Stefan Nordmyr. “This year we burned biomass only—no oil.” As oil prices rise, he expects the financial benefit of biomass to grow with them.

Compared to fossil fuels, woody biomass prices tend to remain relatively stable. On a Btu basis, the cost of biomass fuel is generally less than half the cost of fuel oil—and over the past 20 years the real price of wood energy has actually declined. These relative costs of heating fuel are especially important for greenhouse operations like these, because their structures require a great deal of heat.

“This year, when the oil price is down, I'll burn some oil,” says Nordstrom. “But when the price goes up again, I won't.”

Farm Cuts Fuel Costs with a Flex-Fuel Biomass System

Woodchip and Peat Pellet Heating System

Heating Capacity (output): Two 400 kW boilers totaling 800 kW (2.7 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Cyclone, O₂ sensor control, moving grates

Year Installed: 2007

Thermal Output: Hot water

Mats Nordstrom's farm in Närpiö, Finland raises hydroponic tomatoes in a 7,500 square-meter (80,000 square-foot) greenhouse, a relatively small facility in this agricultural area where many farms raise crops in large greenhouse facilities. Nordstrom's plants grow in vertically supported vines, all the way to the top of this indoor space—and the cost of keeping these tomatoes warm is a major part of his farm's operating budget.

Nordstrom used to depend entirely on oil to deliver this heat. But in the 2008-09 season, he drew on an oil burner for only 20 percent of the heat his greenhouse needed.

"This year, when the oil price is down, I'll burn some oil," he says. "But when the price goes up again, I won't."

Nordstrom now has that choice because he recently installed two small, modular biomass boilers that sit side by side next to his greenhouse.

Produced by Megakone, a Finnish company that specializes in small-size, modular boilers that are quickly installed and reliable to operate, the heating plant at Nordstrom's farm can burn either wood pellets, peat, or woodchips. Nordstrom uses peat pellets and woodchips; he says peat is generally cheaper, but it creates more problems in combustion than woodchips.



"The two Megakone heating plants together require about two hours per week of labor," the farmer explains. "If we burn peat, there is slagging on the grates and it takes more of our time. That's why we would prefer to burn wood. Unfortunately, we do not have a good supply of small woodchips in this area and we are forced to burn peat."

"A heating station fully completed at the factory is more economical than a new heating station built at site," says Megakone's website. "The building of a heating station could not be any easier—site building has been minimized! Before you know it, the station is heating the production premises. The silo can easily be filled with a front loader and frequent filling is no longer necessary."

Megakone has sold more than 500 of its modular units, and many other farmers in Nordstrom's area also heat their greenhouses with biomass. Nordstrom's boilers each produce 400 thermal kW, or a total of 800 kW (2.7 MMBtu/hour).

Improving System Efficiency

Nordstrom's farm is about 50 kilometers (30 miles) from Vasa, a Finnish industrial city. Like many communities of northern New England, his local economy has suffered from the loss of a local paper mill. About half the jobs in Närpiö were lost when the mill closed, the farmer says.

Nordstrom buys his tomatoes in the flower stage, and raises them to full maturity in eight weeks. In his greenhouse, hot-water heating pipes run alongside the vines as horizontal pipes and vertical flex tubes.

Biomass fuel in the area is sold on the basis of its energy content rather than its volume or weight. For his woodchips, Nordstrom pays €33 per MW hour (\$13 US per MMBtu).

"Our smallest, residential-size systems are 30 kW (100,000 Btu/hour) in capacity," says Jari Luoma, CEO of Megakone. "Mostly they are used to burn pellets. But some are owned by small hobby forestland owners who chip their own fuel."

In actual practice, about three-quarters of the heat that Nordstrom's greenhouse requires comes from its electric lighting. About 600 kW of heating capacity are delivered by the lights.

"Greenhouses require a lot of heat," Nordstrom says, "and our lights—needed for enhanced growing conditions—provide a tremendous amount of heat. This is a big operating cost for us."

He adds, "I'm thinking about putting in a big accumulator, or buffer tank"—an insulated tank that can store the hot water produced by the heating plant, then distribute it as needed. "The heat load of a greenhouse is very spikey, so a buffer would even that out and make the biomass system run more efficiently."



Opposite page: The two Megakone modular boiler plants (red, at center) heat 7,500 square meters (80,000 square feet) of greenhouse. The gray shed stores fuel. Many greenhouse operations in this agricultural area of Finland use woodchips or some form of peat for fuel.

Above: Owner Mats Nordstrom in his biomass-heated tomato greenhouse. When off the farm, Nordstrom can check the status of the greenhouses using his cell phone.

Dual-Fuel Biomass System Heats a Farm's Large Greenhouses

Woodchip and Short Peat Heating System

Heating Capacity (output): 3 MW (10 MMBtu/hr)

Emissions Reduction and Combustion Control Equipment: Multi-cyclone, flue gas recirculation, O₂ sensor control, moving grates

Year Installed: 2008

Thermal Output: Hot water

A family farm in Närpiö, Finland that raises tomatoes and cucumbers in two large, long greenhouses heats them entirely with biomass, burning woodchips and peat in a modular boiler system that can produce three thermal MW (10 MMBtu/hour).

“Our greenhouses are big and take a lot of heat,” says Stefan Nordmyr, the farm owner. “This year we burned biomass only—no oil. Last year oil prices were down, and we didn’t save much by using biomass.” As oil prices rise, the family expects to accumulate more significant savings.

The farm’s boiler plant is built by Nakkila, and arrived in two pieces—a top and a bottom half of the heating plant, including the building that houses the boiler. The farmers only had to lay down a concrete slab, and put up a simple fuel storage building.

“The fuel storage building is six meters by 20 meters (20 feet x 65 feet),” Nordmyr says. “The fuel delivery truck can drive right in over the hydraulic scrapers, dump his load, and leave in just a short time.” The trucks have room inside to raise their loadbeds and pull forward as the fuel tumbles out.



“Because the Nakkila boiler plant comes as a modular system, on just two trucks, it goes up very fast,” Nordmyr adds. “It took us only six months to build this entire system.”

Large farm greenhouses like this one have uneven heat needs, less during the day and much more on cold nights. For this reason, the Nordmyr farm’s heating plant also has an accumulator tank, which stands outdoors next to the storage building.

The insulated tank looks like a small silo. It receives heated water from the boiler, and sends it to the greenhouses in flows regulated to meet the fluctuating demand.

The biomass system heats a total area of 15,000 square meters (160,000 square feet). The system’s total cost, including the foundation work and fuel storage building, was €1.4 million, or \$1.8 million US.

Peat Competes with Wood as Fuel

Both peat and woodchips are commonly available in Finland as a fuel source, and they compete for market share. Three forms of peat are available: peat pellets, which look like wood pellets but are a darker brown; peat briquettes, bigger, less dense, and less homogenous than pellets; and “short peat,” which comes in little, roughly cylindrical logs about 12.7 centimeters long and 5-6 centimeters in diameter (5 inches long and 2-2.5 inches in diameter). Short peat is often used in mid-sized heating plants, as it has more energy per weight or volume than woodchips. At large district energy and power plants, wood and peat fuel are often mixed together.

Ground-up stumps are often produced through land-clearing for peat production in Finland. Trees growing on peat land, generally small diameter, are logged off, then the stumps are pulled and ground up for fuel. Peat is then mined in shallow excavations across the expanse of cleared land. After, the land is replanted with trees. If weather permits, peat is air-dried to reduce its moisture content; it comes from the ground very wet.

“We consider peat to be ‘slowly renewable’ because it regenerates over a few hundred years,” says Pekka-Juhani Kuitto, executive director of FINBIO, a nonprofit organization that promotes bio-energy through information and lobbying. “Here in Finland, we harvest peat at a rate slower than it regenerates. We are having a difference of opinion with the EU about whether or not peat is a renewable fuel.”

Nakkila boilers like the Nordmyrs’ are designed to run best on rough fuels, like logging-residue wood, short peat, and ground-up stumps. They use a “wet ash” removal system, which brings ash out in a clumpy slurry and is much quieter and less dusty than automatic dry ash systems.

“Our market is mostly in Finland and Sweden,” says Mika Rantanen, sales representative for Nakkila Boilers. “We are just starting to sell into Norway. They have been slow to adopt biomass because they have their own oil from the North Sea. Denmark is tough because they only want to use Danish equipment.”

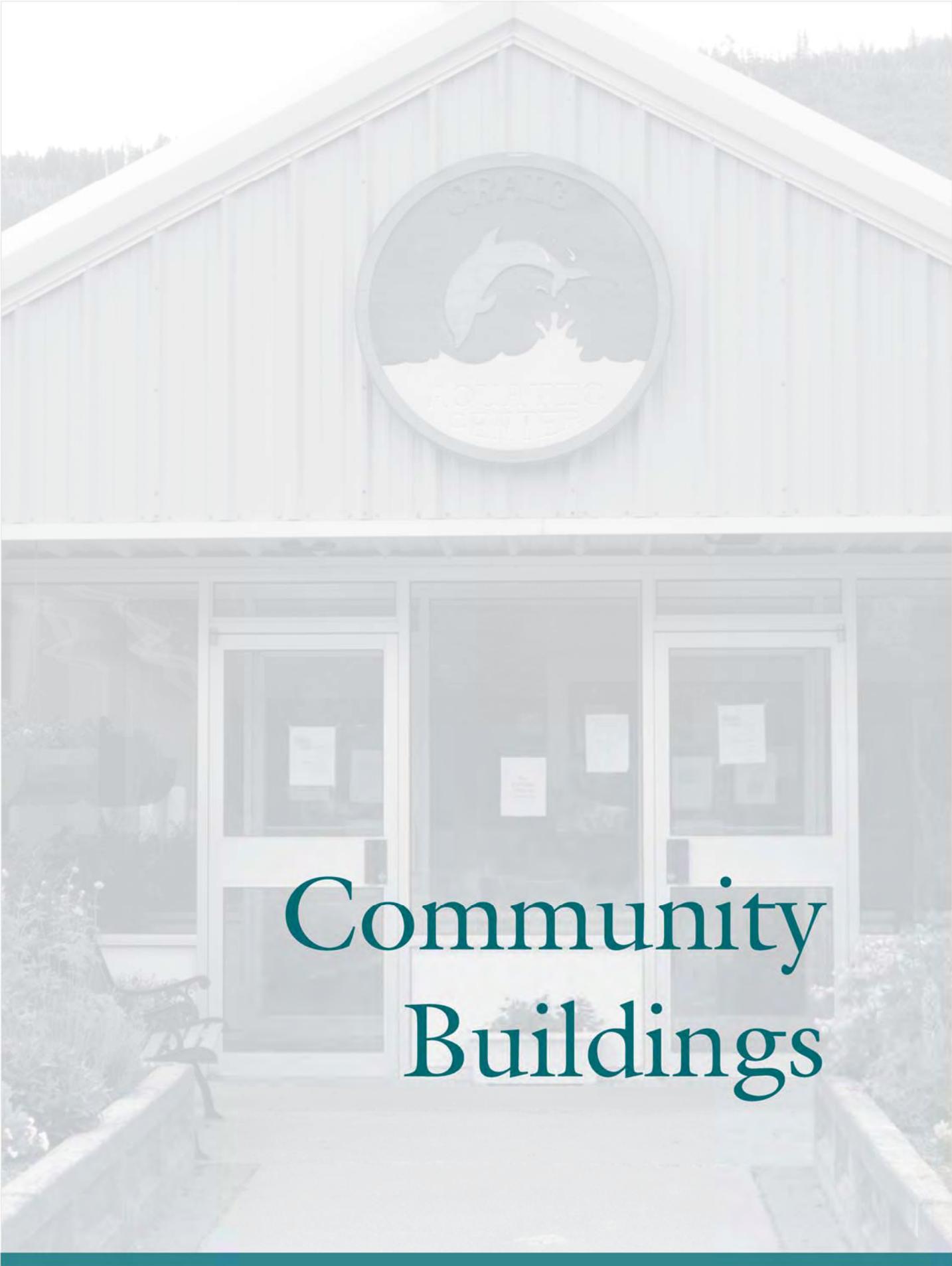
In practice, the Nordmyr family has found peat, though a cheaper fuel, to be harder on its system than chips.

“When there is a wet summer, they have trouble harvesting peat and the price goes up—then we burn woodchips,” Nordmyr says. “Every year it seems like the peat comes from farther away.”



Opposite page: Nakkila Boilers manufactures its plants in two pre-fab sections delivered on flatbed trucks and connected onsite.

Above: Fuel stored in the shed (at center) is conveyed automatically to the boiler plant on the right. The large hot water storage (buffer) tank sits to the left of the shed. The buffer tank is used to even out the greenhouse’s temperature swings from day to night.



Community Buildings

Using Biomass for Energy in Community Buildings

Using biomass heat in community buildings, especially those that serve a social or educational purpose, can do more than just save on fuel costs. It can also create opportunities to innovate and educate.

The projects described in this section each provide an example. In the Champlain Valley of Vermont, a pellet boiler is heating an interfaith sanctuary and meditation center with wood pellets (pp. 115-116), while the property surrounding it is growing various types of fuel grasses, in an experiment aimed at discovering how well grass pellets will work in boilers like this one. If this project can expand the options for locally sourced biomass fuel, its impacts could spread far and wide.

In Craig, Alaska, biomass wasn't even considered as an option for heating the city's aquatic center—until fuel oil rose from \$1.46 per gallon to more than \$3 in a year. When a visit to a Montana town whose schools heat with biomass showed that these systems can burn clean, Craig took the plunge. The city is now saving about 70 percent on fuel costs for its biomass plant, which is able to heat two local schools along with the pool building (pp. 117-118).

A 900-year-long tradition of heating with wood at Lambach Abbey in Austria (pp. 119-120) was revived in recent years, when the abbey abandoned fossil fuels and installed a twin-boiler woodchip plant. Like other systems profiled here, the abbey sources all its wood fuel locally, from its own or neighboring farmers' lands.

And in Minnesota, two environmental education centers have heated their campuses with simple, robust cordwood systems for more than 20 years. Both use their heating plants to show thousands of visitors the living link between energy and the environment, and to bring the idea of a sustainable energy system to life (pp. 121-124).

“And you're looking at a pretty good return on your dollar,” adds Todd Rogenkamp, director of the Long Lake Conservation Center.

A Sanctuary's Modest Pellet Boiler Will Help Test Local Field Grasses

Wood Pellet Heating System

Heating Capacity (output): 145 kW (0.5 MMBtu/hr)

Annual Wood Pellet Use: 30-40 tons

Year Installed: 2007

Thermal Output: Hot water

The handsome sanctuary of the All Souls Interfaith Gathering, an ecumenical worship and meditation center in Shelburne, Vermont, is surrounded by gently rolling fields and woods that slope to the shore of nearby Lake Champlain. If a current experiment goes well, those fields may soon supply fuel for the biomass hot water boiler that heats the sanctuary—and that could help to open up new vistas for locally produced biomass fuel.

All Souls installed a 145 kW thermal (500,000 Btu/hour) pellet boiler, produced by Solagen of Oregon, in 2007. The simple, high-temperature system has been burning 34-40 tons of wood pellets each Vermont heating season to heat the 14,000 square-foot sanctuary.

"It burns very cleanly," says project supervisor Christopher Davis of the pellet boiler. "The idea here was for something that was efficient and that could use renewable fuel—preferably something we could grow locally, like right on the site."

Davis managed the project that rebuilt and expanded a former residence into the All Souls Sanctuary (www.allsoulsinterfaith.org), remaking its one-time garage into a heating plant downstairs and a program space above. Davis also manages the Meach Cove Trust, which runs a scenic former 19th-century estate, a 1,000-acre property, that surrounds All Souls.

In the summer of 2009, Meach Cove's fields hosted the experiment that grew various grasses to test their potential as alternative sources of pellet fuel.



"Can we grow it here?" Davis asks of grass fuel for biomass boilers.

To answer that question, All Souls is collaborating with several other Vermont groups: the University of Vermont Extension Service, the Vermont Sustainable Jobs Fund, nearby Shelburne Farms, and the Biomass Energy Resource Center (BERC).

In June, Meach Cove planted a multi-variety crop of potential fuel grasses. After the harvest, Davis says, "We'll work with these other groups to figure out, 'Can we pelletize it?' This boiler will be one of the test sites."

Meach Cove Trust will work with BERC and the Sustainable Jobs Fund to find a processor to press the grass into pellets, test the system, and monitor results.

"We have a boiler here that's working really well, and will be part of this testing," Davis says. "We'll be able to adjust it to burn whatever we need."

'It's Just a Concrete Cave'

As he speaks, Davis pulls several plastic jars off of shelves in the small boiler room that houses the pellet boiler. One jar holds pellets compressed of blended sawdust and hay. Another has inch-thick rounds made of chopped, compressed hay.

All Souls researched pellet burners and settled on the Solagen unit, which is designed to burn fuel at very high temperatures and “allows us to burn any type of combustible fuel that fits into its four-inch opening,” Davis says.

The pellet boiler has two adjoining chambers. First is a stoker, with air holes through which fans force air while an auger pushes in fuel pellets. Ignition in the stoker creates a very hot fire that is blown into the second chamber, the firebox. In high-fire mode, the boiler runs at 900-1,200 degrees Fahrenheit, with a surrounding water jacket regulating the temperature.

“There are no moving parts in there,” Davis says, shining a light into the burn chamber, now cooled down for the summer. “It’s just a concrete cave, with a smooth bottom.”

As new fuel moves into the stoker, it pushes ash to the base of the firebox, where another auger draws it out. An induced draft fan pulls the heated air up and into the triple-pass boiler, or heat exchanger, where it heats water to 170-180 degrees.

“What we have learned is that the boiler knows two things,” Davis says. “It maintains a temperature to supply hot water to the building: It gets called to produce more hot water, and it does that very efficiently. When that is satisfied, it goes from high-fire mode into standby mode.”

The system runs at high-fire just about 25 percent of the time, burning about 58 pounds of pellets per hour and filling a 30-gallon ash barrel about every five days.

“We haven’t burned [alternative fuels] in large quantities yet,” Davis concludes. “This is our second season. What we know is that we’ve worked out the operating issues, and made the adjustments for air and fuel-feed rates. Now we have a clean-burning system that is saving us, [compared to] \$2.50 per-gallon No. 2 fuel oil, about 20 percent.

“Last year, when oil went to \$4, that would have paid for this boiler in less than two seasons.”

Will this little boiler be part of opening up new fields of fuel cost savings for the future? The answer to that question will start to become clearer after this year’s grass harvest is all in.



Opposite page: The pellet boiler plant and storage bin at All Souls Interfaith Gathering in Shelburne, Vermont. The sanctuary it heats can be seen in the left background.

Above: The pellet boiler's burn chamber, showing the auger that draws out ash to the base of the firebox.

Heating with Woodchips in a Wet Climate

**School and
Municipal Woodchip
Heating System**

**Heating Capacity
(output): 1.2 MW
(4 MMBtu/hr)**

**Annual Woodchip
Use: 800 tons**

**Emissions Reduction
and Combustion
Control Equipment:
Multi-cyclone,
O₂ sensor control**

**Year Installed:
2008**

**Thermal Output:
Hot water**

What became Alaska's first fully automated, woodchip-fired district heating system began as a sort of afterthought.

When Craig City Manager Jon Bolling commissioned a 2003 analysis on the prospects for converting the municipal aquatic center's heating system from costly propane to diesel fuel, the analysis also mentioned another alternative: wood.

"I was not particularly interested," Bolling recalls. But the Alaska Energy Authority, a state agency, offered to commission a report on the wood-heat idea from Tom Miles, a wood-energy consultant in Portland, Oregon.

Miles found that a wood-fired system could not only heat the aquatic center—which provides a pool, spa, and workout facilities for the tiny city, population 1,300—it could also provide heat for the nearby Craig elementary and middle schools.

Still, diesel oil looked like the lower-cost option. Miles estimated it, looking ahead, at \$1.46 per gallon.

"A year later, we were paying \$3-\$5 per gallon," Bolling says. Wood was looking more and more attractive.

So the city manager joined Karen Petersen, Cooperative Extension Service agent for Prince of Wales Island—the landmass in southeasternmost Alaska that includes Craig—and five others on a trip to see a woodchip-fired system in Darby, Montana.

Bolling still had concerns.

"I didn't want there to be a potential blue haze of smoke over our town, and I didn't want people complaining and coughing because of effluent in the air," he says. "Of course, we discovered when we got [to Darby] that their system burned very clean. You couldn't even see effluent coming out of the stack."



Walking around Darby, Bolling asked locals how they felt about the system. "Nobody said it made them cough or made their kids sick," he said. "People were generally supportive."

"We left Darby convinced that we could apply the technology we saw there in southeastern Alaska."

'A Bit of Selling, But Not a Lot'

The Craig City Council was interested enough to join the US Forest Service (USFS) and the Alaska Energy Authority in each providing \$30,000 for a design and engineering study. The study projected at \$1.5 million the cost of a chip system to serve the aquatic center and both schools. The city assembled about \$1 million in grant funding from the federal Natural Resources Conservation Service (NRCS), the USFS, the state Energy Authority, and the Denali Commission. Craig borrowed the remaining needed funds at 4.8 percent through a low-interest loan program for renewable energy projects.

In town, “there were people who had the same concerns I did—so I gave a few presentations,” Bolling says. “There was a bit of selling to be done, but not a lot.”

When bids came in higher than expected, project planners downsized the building that would house the system, and broke ground in August 2006.

“We were fortunate to have some good skilled labor in town—people who were willing to work as temporary city employees for the duration of the project,” says Bolling. “Still, it was an expensive building.”

The Craig Wood Energy Project—including the wood system supplied by Chiptec, a Vermont-based manufacturer—was commissioned in April 2008.

A Unique Feature: Chip-Drying with Heated Air

Craig has an abundance of chips, with an active sawmill nearby; but Prince of Wales Island is a rainy region, so the fuel, mostly western hemlock, often came in wet. During the system’s first year of operation, moisture content of the chips varied from 40-70 percent. So, the Craig system includes a forced-air chip-drying system—a feature that is unique, as far as its operators know.

Some of the system-generated heat is vented into the chip bin through perforated hot-air ducts under its floor. The ducts push the warm air through the chips, drying them in the process. An evacuation fan moves the now-humid air outdoors.

“We can manually adjust the drying system to increase the temperature of the warm air that’s being forced through the chips, and increase the volume of the air that’s going through the chips,” explains Paul Coffey, who lives in Craig, works for NRCS, and has been closely involved with the system.

“A little bit of moisture is good,” he adds. “It acts as a lubricant to move the chips through the augers.” But if the chips are too dry they tend to get pulverized by the augers, create dust, and the fuel burns too hot and fast. So, as different chip loads come in with varying moisture contents, adjusting the system for optimum efficiency is an ongoing challenge. Still, air quality has not been an issue.

“We’ve had people ask why we’re not operating our wood boiler,” the city manager says. “Sometimes when it’s running, you can’t see steam coming out of the stack.”

Through its first heating season, the Craig system burned about 800 tons of woodchips, at about \$20 per ton, for a fuel cost of roughly \$16,000, plus about \$20,000 for backup propane. Compared with what the costs would have been to heat entirely with propane, the city saved about 70 percent on its heating bill.

Both the aquatic center and the schools used their backup diesel system more than they wanted to, because the chip-system operators were learning how to optimize chip moisture and run at full efficiency. But looking ahead, says Cooperative Extension agent Petersen, “the desire is that this chip plant will replace 100 percent of the propane and diesel systems in the months when the schools are open.”

“There’s no reason this facility couldn’t be replicated all over Alaska—at least where there is a wood supply,” Bolling concludes. “Wood is carbon neutral, and the supply is controlled locally. As the years progress, there’s no reason these plants can’t be built as combined heat and power (CHP) plants, and thereby remove the need for non-renewable petroleum products.”



Opposite page:
The Municipal Aquatic Center in Craig, Alaska.

Above: Fuel bin floor showing air grates from the chip-drying system.

A Wood-Heating Tradition of 900 Years Is Modernized at an Austrian Monastery

Woodchip Heating System

Heating Capacity (output): One 1.1 MW (3.8 MMBtu/hr) boiler and one 550 kW (1.9 MMBtu/hr) boiler

Emissions Reduction and Combustion Control Equipment: Multi-cyclone

Year Installed: 1997

Thermal Output: Hot water

When natural gas service reached the market town of Lambach in Upper Austria in 1996, local homeowners stopped burning wood. That meant they also stopped buying their firewood from historic Lambach Abbey, a monastery that had been harvesting wood from its own forests for more than 900 years.

Abbot Gotthard Schafelner decided he needed to find a new market for the low-grade wood from the forestry operation. So he put in a woodchip boiler to heat Lambach Abbey, along with its 700-student school. The monastery had been burning fossil fuels since 1920, when it installed a central heating plant, fueled at first with coal and then later with oil.

“When we first went back to wood from oil, we used a hand-fired solid-wood boiler,” says monastery forester Josef Wampl. “That was too much work. The abbot really wanted to get off fossil fuels so he decided to install these woodchip boilers. This is much better!”



It was in 2007, after 10 years with the solid-wood system, that the abbey invested in its new, fully automated, twin-boiler system. Each year the heating plant burns about 8,000 cubic meters (2,800 US tons) of woodchips, green or dry, plus sawdust, shavings, and bark.

“This has made it possible to get all the heat for our buildings from our own forestland and from nearby farmers,” Wampl reports.

The boilers have individual heating capacities of 550 thermal kW (1.9 MMBtu/hour) and 1.1 million kilowatts (3.75 MMBtu/hour), for a total capacity of 1.65 MW thermal (5.6 MMBtu). The monastery sources wood from a radius of 15 kilometers, buying any wood that does not come from its own forests at €55 per tonne (\$40 US per US ton) to heat a complex with 17 monks, 20 employees, and the 700 students.

‘No Problem’ Meeting Emissions Test

“This is not a forested area of Austria; here it is mostly farms,” Wampl says. “But the monastery has 470 hectares (about 1,100 acres) in small parcels all around the area. That supplies most of our wood, but we also buy some from local farmers who cut on their forest plots.”

The fuel supply is 80 percent fir, 20 percent hardwood. The monastery dries its greenest chips with a system that blows warm air up through its storage pile; some chips are air-dried simply by the time they spend in storage piles; and some are burned green.

“The state—Upper Austria—put in 30 percent of the cost of the system,” the monastery forester says. “To actually get the final check, we had to test the emissions to show they met the air standards. If they didn’t, we would have had to fix the system so it would pass. But we had no problem meeting the emissions test. All of the manufacturers of wood boilers in Austria can meet the national and state standards—otherwise they couldn’t stay in business.”

The Lambach abbot’s decision to go with wood heat was not exactly revolutionary. After all, the abbey heated with wood, also harvested from its own forests, for all but 60 of its first 960 years. The historic Benedictine monastery was founded in about

1040. Its monks were forced out during World War II by the Nazis, whose leader, Adolph Hitler, had lived in Lambach as a boy and attended a local school that employed Benedictine monks as teachers. The monastic community returned to the abbey after the war’s end.

Today, many Austrians are eager to get their heating needs met with a fuel other than natural gas, which is supplied by nearby Russia and was briefly cut off during a dispute between Russia and Ukraine in the winter of 2008. One Lambach family whose home is now heated with woodchips is forester Wampl’s.

His son is not that happy about it.

“At home we have a small woodchip heating system,” notes Stefan Wampl. “Frankly, it is a lot of work and kind of a pain, but my father gets free woodchips as part of his pay from the monastery. Woodchip systems are really good for big places, but not so good for a house.”



Opposite page: The Lambach Abbey, one of the oldest in Europe, has heated with wood for almost all of its 960-year history.

Above: The processing of wood fuel from monastery forestland is carried out at the central heating plant.

A Simple System with a Quarter-Century Service Record

Cordwood Heating System

Heating Capacity (output): 500 kW (1.8 MMBtu/hr)

Annual Cordwood Use: 120 cords

Year Installed: 1984

Thermal Output: Hot water

The five GARN cordwood burners that power the campus heating system at Long Lake Conservation Center are robust exemplars of a key transition in the story of biomass energy. Three of the units have been working for a quarter century—and they embody the shift from old-fashioned woodstoves to far more powerful, clean-emission central units.

In its east-central Minnesota town of Palisade, Long Lake has been providing environmental education and outdoor learning experiences to its region's young people and adults since 1963. A public entity owned and operated by Aitkin County, Long Lake heated its campus with individual building woodstoves until 1984, when it installed three GARN boilers. The system was developed and installed by the St. Anthony, Minnesota firm Dectra Corporation, which has been providing GARN wood heating systems for 30 years.

"Long Lake at that time looked at this as an opportunity to provide a commercial application of wood energy, and an opportunity to bring all our heating together under one roof," says Todd Rogenkamp, the center's current executive director. During a major expansion in 1998-99, the center installed two more GARN units, along with two large additional buildings.

The system heats seven buildings: a dining room, administration center, learning center, cross country ski hut, laboratory, lecture hall, and two dorms. Maintenance staff members stoke each boiler every three hours during peak heating season.



"Typically I fill all five boilers in about 15 minutes," says maintenance coordinator Dave Conway. "The last time we stoke is 10 pm when the our night guy takes off. There's enough water to stay hot until I come in the next morning."

"We burn about 100 cords in a winter, to heat 48,000 square feet," says Rogenkamp. "It's a very efficient way to heat. We've saved hundreds of thousands of dollars over the years by heating with wood."

The center pays \$107 per cord for its fuel, split and delivered. Aitkin County's land department oversees and manages the center's 760 acres of county-owned woodland. "All our wood comes off Aitkin County lands—our own or other lands," Rogenkamp says.

"All the county woodlands are Forest Stewardship Council certified," he adds. "So not only are we burning wood that's a sustainable product, we're also burning wood that comes off appropriately and meticulously managed woodland."

“We contract with someone to come cut wood for us at our center. It provides employment to the local economy, a lot of which is forest-product driven, here in east central Minnesota.”

‘A Proof of the Pudding’

Long Lake’s wood system continues to meet all of its heating needs—and those can be extreme needs. “We have long stretches of days where we don’t get temperatures above zero,” Rogenkamp says. “Our lows get down to 30 or 35 below.”

Housed in a single-building Energy Center, the Long Lake system heats a total of 12,500 gallons of water that are piped underground throughout the campus.

Within the buildings around the campus, “our heat is supplied by a variety of different methods,” Rogenkamp says. “That’s one of the unique things about the GARNs: they’re very adaptable to different heating uses. If you have radiant baseboard heating, the GARNs work with that. You can match them up with forced-air and with in-floor heating. We have all three: one building with forced air, two buildings with in-floor, and the rest with radiant baseboard.

“We use our wood system as part of our education here. Whether we’re talking with students or adults, we show them how they can be sustainable, how they can live a sustainable life by using a renewable energy resource.

“Part of Long Lake’s mission is to promote the wise use of natural resources—so having the GARN system here is a proof of the pudding, so to speak. These units show that we’re taking advantage of a renewable resource, we’re using it wisely, we’re using a system that is efficient. And the GARN units meet US Environmental Protection Agency standards for particulates, etc., with regard to heating with wood.

“As far as lifespan, these units have been outstanding,” Rogenkamp concludes. “People are asking, ‘How am I going to get the best bang for my buck?’ With these units, you’re not talking about a huge cost to get started. And you’re looking at a pretty good return on your dollar.”



Opposite page: Maintenance Coordinator Dave Conway typically fills five boilers (with cordwood) in about 15 minutes.

Above: Four of the five GARN cordwood boilers in Long Lake’s wood heating plant.

A Place Where Wood Heat Is a Lesson in Itself

Cordwood Heating System

Heating Capacity (output): 900 kW (3 MMBtu/hr)

Annual Cordwood Use: 175-200 cords

Year Installed: 1988

Thermal Output: Hot water

To a great many of the 17,000 people who visit the Wolf Ridge Environmental Learning Center in upper Minnesota each year, a biomass-fired campus heating system is part of the learning process.

Since 1988, Wolf Ridge has used four GARN cordwood boilers to generate heat and hot water for its campus in Finland, northeastern Minnesota, about six miles from Lake Superior's north shore. The system heats five buildings, in three loops, totaling 81,000 square feet—and although the big wood “stoves” (they are actually boilers) are low-tech and more than 30 years old, learning how well they work is still an education for many visitors.

“We probably get more enthused attitudes from the adults who come here for coursework than the kids,” says Peter Smerud, executive director at Wolf Ridge. “The kids think it’s cool. But the adults are really interested.”

About 70 miles northeast of Duluth, Wolf Ridge operates year-round with a staff of 60 and 380 beds for overnight programs. Elementary, middle, and sometimes high schoolers are the primary audience for its hikes, canoe and kayak trips, wilderness adventures, and onsite programs in environmental science and sustainability. The center also runs teacher workshops, family programs, and a grandparent-grandchild residency that it created within Elderhostel.

“You could say the education at Wolf Ridge is taking place on two levels,” explains Smerud. “One is the fourth-through-eighth graders who come here, but then we’re also teaching the teachers.

“When we were building a new facility in the mid-80s, we said, ‘What kind of technology should we be looking at?’ We’re in a forested environment, and it made sense to heat with wood,” Smerud says. The system, he adds, “helps bring jobs to an area that could use it.”



‘That Birch Came off Our Property’

Each boiler heats 3,200 gallons of water, which circulates around the campus in a closed-loop system. The simple system is robust: It has kept Wolf Ridge warm through winter nights that have reached 58° Fahrenheit below zero.

“It’s cost effective, but you’ve got to rely on people. We need to fill those stoves every three to four hours, because there’s a lot of buildings to heat.”

In the heating season, Wolf Ridge’s maintenance supervisor Gary Olson oversees the stoking of the system on each of its day, evening, and night shifts. At each stoking, wood is loaded from a pile just outside the building into a wheel barrel and moved over to the boilers to be unloaded. It takes 15-20 minutes for one person to stoke all four.

On average over the past decade, Wolf Ridge has burned 175-200 cords of wood per year, almost all paper birch. “We own 2,000 acres; last year and this, all of that birch came off our property,” Smerud says. “We’re trying to make commitments of certain parts of our property to look at sustainable fuel sources.

“The cost to run our system for a year, including all the wood, labor, maintenance, electricity for pumping water, etc., equals \$47,000 in a very cold climate. We’re still throwing wood through most days in May!”

‘They’ll End with, ‘Thank You’

When they bring students and others to see the Energy Center that houses the biomass system, Wolf Ridge educators show how the system works. The fire in the stoves is burning very hot, above 1,600 degrees; a fire this hot creates a very clean burn.

The educators take students to the wood pile, and add logs to the fire. Then, to bring the fuel-side into focus, they talk about trees.

“We say it takes about four-to-five trees per cord,” Smerud said. For a year’s fuel supply, “we’re talking at least 800 trees. We can go right outside the building, outside our energy center. We can look at the woods and say, ‘Those trees right there.’”

“Our goal is really to connect kids and adults to an energy need and to the resource. For most of us, there’s very little connection: When I get cold, I turn up the thermostat and it gets warmer. Here, it’s pretty easy to make the connection.

“We can also connect this to choices. I can choose to insulate more; I can choose how to design my house. What are actions we can take, besides just turning up or down my thermostat?

“We’ll get emails from parents periodically, saying ‘My kid came home as the new conservation police of the house! I can’t leave a light on; the thermostat is turned down when we leave for the day,’” Smerud says. “They’ll end with, ‘Thank you. My child is driving change within the household, because of the motivation they got at Wolf Ridge.’”

These days, Wolf Ridge is improving its system’s efficiency and considering new biomass options. In the summer of 2009, the center is replacing its aged, fiberglass heat distribution pipes. Unable to bury its pipeline very deep—because bedrock lies quite close to the ground surface—Wolf Ridge has been losing about 47 percent of its heat to the ground. Newer, insulated polyethylene piping added with a new building in 1996 loses only about 12 percent, according to Smerud.

The fuel and labor savings that will result from replacing the older piping “could be really exciting for us,” Smerud says.

“Now we’re looking at replacing those GARN stoves. We’re committed to wood, and to staying with the centralized plant; but now we can look at going to woodchips, to automated systems where we don’t have to have someone there on Christmas night.

“But even in this heavily forested area of the state, there isn’t really the chip supply yet,” Smerud concludes. “There certainly is the potential for it—so we’re looking at that. It certainly seems logical that this is a great resource that will be there.”



Opposite page: Gary Olson is Wolf Ridge’s maintenance supervisor. Since 1988, the campus has used four cordwood boilers to generate heat and hot water.

Above: On average over the past decade, Wolf Ridge has burned 175-200 cords of wood per year, almost all paper birch harvested from its 2,000 acres.





Renewable • Reliable • Resourceful
Biomass Energy Resource Center

PO Box 1611, Montpelier, VT 05601-1611
ph 802-223-7770 x121 • fax 802-223-7772
info@biomasscenter.org • www.biomasscenter.org