The University of Minnesota

Renewable Biofuels and Fuel Flexibility:

Permitting Oat Hulls and other Biofuels as Part of the University of Minnesota Energy Efficiency and Fossil Fuel Use Reduction Program

January 26, 2004

Presented to:

The Minnesota Pollution Control Agency

As part of a permit amendment application to use oat hulls and other biofuels at the Southeast Steam Plant located in Minneapolis, MN.

Executive Summary

The University of Minnesota requests permission from the Minnesota Pollution Control Agency to use "biofuels" to produce steam at the Minneapolis campus. Biofuels are an exciting opportunity for the University to reduce our use of fossil fuels, lower greenhouse gas emissions and beneficially reuse an agricultural residue.

We seek approval at this time because we have found a local and reliable supply of biofuel – oat hulls generated by General Mills. Pilot tests were conducted earlier this year with Agency approval. Test results prove that oat hulls, when combined with coal, can be burned within existing permit limits and without affecting plant performance.

Using renewable biofuels such as wood, oat hulls and other non-fossil energy sources are just one small part of the Regents' broader commitment to energy efficiency and environmental responsibility. We actively manage energy consumption through a number of techniques and programs which have lead to lower energy use and less air pollution.

Energy Efficiency and Conservation

In the past 12 years, we have reduced campus steam consumption by nearly 23 percent despite an aggressive construction program that has increased total building space by nearly 18 percent. It is the result of a concerted effort to minimize energy losses at the steam plants and in each building. Conservation and efficiency improvements have eliminated the need to burn the equivalent of an additional 45,000 tons of coal per year.

Steam Plant Performance and Fuel Flexibility

The University undertook extensive steam plant renovations in the late 1990s. We installed new, energy-efficient boilers with state-of-the-art pollution controls. More than two-thirds of new installed capacity uses natural gas and fuel oil. The new capacity replaced a number of old coal-fired units at the Main plant in Minneapolis.

As a result of the renovation, we shifted from producing 90 percent of our steam from coal to a fuel-flexible program that relies on a minimum fuel mix of 70 percent natural gas and biofuels. Coal and fuel oil are now used for about 30 percent of all steam production and cogeneration.

We agreed to an annual voluntary limit on coal and fuel oil use as part of air quality permitting for the renovation. Our fuel-flexible design allowed us to accept the limit even though it is not required under state and federal rules.

Permitting expanded biofuels use at the Southeast plant will enhance our fuel flexibility while maintaining our ability to operate the renovated system as designed. And, as presented in this report, the University will continue to manage fossil fuel use and air pollution through a broad effort of pollution control, energy conservation and renewable fuels.

Our energy management programs go beyond state and federal requirements. Through diligence and creativity, we have

reduced our reliance on all fossil fuels while providing a safe and comfortable environment for all who use the University of Minnesota.

A Description of the University Energy System

The University of Minnesota manages 18 million square feet of building space in support of education and research conducted at the Twin Cities campus. Part of our responsibility is to provide heating, cooling and electricity to maintain the health, safety and comfort of the 60,000 students and staff we serve. Steam for heating, cooling and other processes is generated at two plants:

- The Southeast steam plant, located on the west side of the Minneapolis campus, and
- The St. Paul steam plant, located in the southeastern corner of the St. Paul campus.

The steam plants were renovated in the late-1990s to make the system more reliable, cost-effective and environmentally sound. The project was the result of nearly seven years of public review and analysis, beginning with an existing system review in 1989 and concluding with an intensive air quality permitting process in 1996.

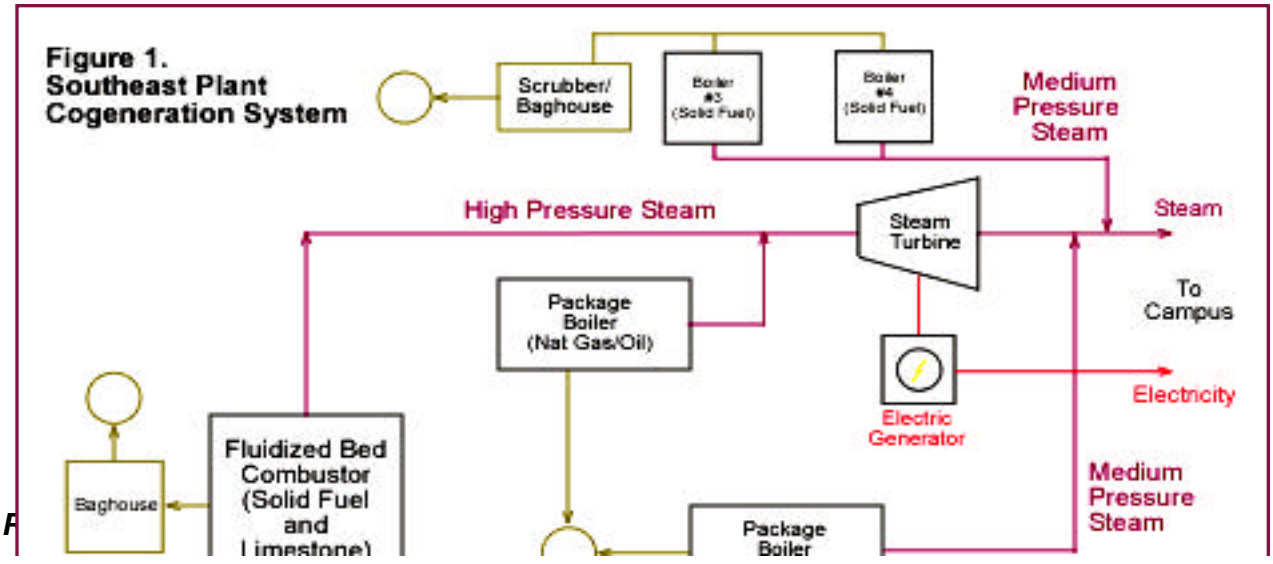
The renovation project's first stage was a four-year vendor selection process which culminated in April 1992, when Foster Wheeler was selected to rebuild and operate the plants. Fuel flexibility was a key element of the winning proposal.

Foster Wheeler proposed a system that:

- Greatly increased natural gas / oil-fired steam capacity,
- Retained some coal-firing, but with state-of-the-art pollution controls,
- Included provisions for electricity to be cogenerated with steam, and
- Provided the capability to burn biofuels.

Foster Wheeler proposed to install a large gas/oil-fired boiler at St. Paul. More extensive reconstruction was to take place at the Southeast plant in Minneapolis. Two new gas/oil-fired

Figure 1.
Southeast Plant
Cogeneration System



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package boilers and a solid-fuel boiler were proposed to be installed. The solid-fuel boiler, called a circulating fluidized bed combustor (CFB), would be specially designed to burn a wide variety of solid fuels, including both coal and biofuels [see Figure 1].

The Southeast steam plant was also to be retrofitted to cogenerate electricity and steam (sometimes called "combined heat and power"). In the University's cogeneration system, steam is produced at a much higher pressure than is required for campus distribution. Before leaving the plant, the steam is expanded in a turbine, which is connected to an electric generator. The steam is then distributed to the campus at medium pressure.

Cogeneration is a highly efficient process. More fuel is converted to usable energy than separately generating steam at the University and electricity at remote power plants. We estimate that we reduce regional air pollution emissions by nearly 50 percent for each kilowatt of electricity we cogenerate.

While CHP and district energy systems can utilize renewable energy fuels, they often use fossil fuels. Due to the increased fuel efficiency, even use of standard fossil fuels can have environmental benefits."

From Designing a Clean Energy Future:
A Resource Manual

Because the renovation project substantially increased steam capacity at Southeast, the University would be able to retire a third steam plant from operation. The Main plant, also located on the Mississippi River, was designed to burn coal as its primary fuel. Main's boilers were old, had only limited pollution control equipment and were highly inefficient. As a result, air emissions were expected to drop, improving air quality in the surrounding community.

An air quality permit application for the proposed $100 million project was presented to the Minnesota Pollution Control Agency in early 1994. The application, containing thousands of pages of information, included emissions estimates, design criteria, and detailed computer modeling of air pollution impacts for both the old steam plants and the proposed project.

After a lengthy review, the Agency agreed that the Foster Wheeler project would meet all state and federal regulations, as well as improve air quality in the area. However, based on requests from the community, we agreed to conduct a voluntary environmental impact statement (EIS) under the direction of the Minnesota Environmental Quality Board.

Again, many months were spent reviewing the environmental impacts of the proposed project. The EIS was not limited to a review of air pollution impacts, but included a comparison of many hypothetical alternatives to the Foster Wheeler project. Water quality, land use compatibility, historical impacts (the Southeast plant is on the National Historic Register) and even potential project costs were assessed and subjected to public review and comment.

And again, when the EIS was completed, the project was found to be environmentally beneficial and allowed to proceed. On October 28, 1996, the Agency issued an air quality permit to the University.

Steam Plant Performance: Operating Efficiency and Fluctuating Demand

The renovation project selected by the University was subjected to substantial scrutiny. After seven years of public review, the University, the Environmental Quality Board and the Minnesota Pollution Control Agency agreed that the proposed project would improve air quality and would balance safety, economics and environmental goals. The renovated system has now operated for more than five years and has achieved lower emissions than considered during any part of the review process. We believe that biofuels are another small part of our continued progress towards total system optimization. Coal must continue to be an integral part of the system for the following reasons:

1) The fluidized bed combustor, along with one of the two new gas/oil-fired units, is part of the cogeneration system. Since these are the most efficient units at Southeast, it makes both economic and environmental sense to cogenerate when possible. (The third unit, a medium pressure natural-gas fired boiler, provides steam directly to campus when demand is below the cogeneration system's operating threshold.)

2) Since steam is provided primarily for heating and cooling, demand is relatively high in the summer and greatest in the winter. Steam demand frequently exceeds the total natural-gas fired capacity at the Southeast plant and other fuels are required.

3) Natural gas supplies are frequently curtailed to large users like the University when regional demand for heating residences and businesses is greatest. During these curtailment

COGENERATION IS STRONGLY SUPPORTED BY BOTH STATE AND FEDERAL OFFICIALS

The renovated Southeast steam plant has the ability to cogenerate both steam and electricity from two new boilers. One is fueled by coal and biofuels and the other uses either natural gas or fuel oil. Cogeneration is very efficient because less energy is wasted than from dedicated electricity production. State and federal officials have both endorsed cogeneration, even if only fossil fuels are used.

Louis Troche is team leader of the U.S. Environmental Protection Agency's Combined Heat and Power Partnership. He strongly supports the University's cogeneration system and the use of renewable fuels. Speaking on behalf of the University, Troche writes, "[The University's efforts to] cogenerate power while addressing concerns about heat-trapping [greenhouse] gases and criteria pollutants are commendable, and evaluating the possibility of burning biomass is a concrete example of their efforts in this area."

State leaders have also voiced their support for cogeneration, especially if renewable fuels are part of the system. In July 2003, the Minnesota Project, the Minnesota Department of Commerce, and the University of Minnesota's Regional Sustainable Development Partnerships released, "Designing a Clean Energy Future: A Resource Manual." Their support for using biomass as a fuel is clear: "When district energy systems include CHP [combined heat and power cogeneration], they can achieve the highest efficiencies. While CHP and district energy systems can utilize renewable energy fuels, they often use fossil fuels. Due to the increased fuel efficiency, even use of standard fossil fuels can have benefits."

periods, the University has two alternative fuel options: burn fuel oil in the natural gas-fired boilers, which increases emissions, or burn coal and biofuels in the fluidized bed combustor using cutting-edge pollution control with fewer emissions.

4) The University has successfully tested a blend of 35%oat hulls with low sulfur western coal using our existing material handling system. Utilizing the existing coal handling system allows the immediate use of oat hulls as a viable, environmentally friendly and economically advantageous fuel.

5) Our existing solid fuel system is not capable of feeding oat hulls alone into the boiler. Further investigation and testing is necessary to determine the viability of some other means of introducing the oat hulls as a solo fuel source.

For these reasons, coal-firing is an essential part of our energy system. Further restricting coal use beyond the voluntary 70/30 limit will; reduce energy efficiency at the Southeast plant; possibly compromise plant reliability and campus safety; and force the University to operate outside of basic plant design.

Steam Plant Performance: Drastically Lower Emissions

Air pollution from our steam plants has been reduced by more than half since 1996 (the year before the renovation was permitted). Our environmental performance has improved partly because of our reduced reliance on coal. But modern pollution controls and efficient combustion account for the greatest share of the

Natural Gas Supply is a Concern

Many experts are concerned about regional natural gas supplies through the next decade. This concern was expressed at a recent hearing on the effects of the "Metropolitan Emissions Reduction Project," a renovation project proposed by Xcel Energy that would convert uncontrolled coal-fired capacity at two Twin Cities power plants to natural gas. The project would increase statewide natural gas demand by 4 to 8 percent, adding stress to an already stretched system.

Andy Weissman, president of Energy Ventures Group, L.L.C., a national "boutique investment firm specializing in the energy industry," presented his concerns as part of his presentation to the Public Utilities Commission: "Supplies of natural gas available to U.S. market likely to fall massively short of projected U.S. needs every year between 2005 and end of the decade." He also called the pending natural gas supply crunch a "pending train wreck," brought about by production declines and a "Shift to natural gas as [a] near-exclusive fuel to meet incremental electricity needs of U.S. economy."

Maintaining limited fuel flexibility at the University of Minnesota reduces the financial and operating risks of increasing fuel-oil use. By retaining some coal-firing capability, we can operate with lower costs and with less air pollution. And the University still relies much more on natural gas for energy production than Minnesota utilities, which burn coal for 75 percent of their electricity production (see Figure 6 at the end of this document.)

reductions.

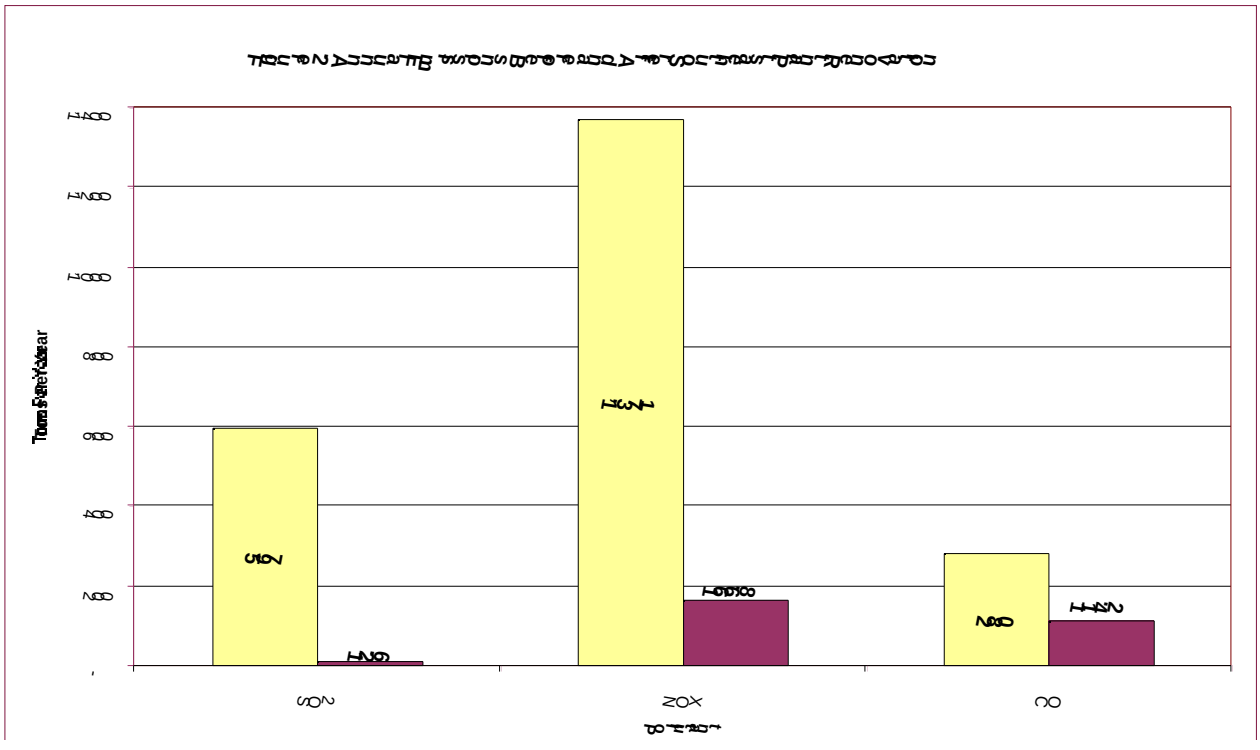
Before 1997, steam was produced by burning large quantities of coal in boilers that had only particulate emissions control. Except for two existing units at Southeast, sulfur dioxide emissions were totally uncontrolled. Nitrogen oxides and carbon monoxide emissions from all units were relatively high due to antiquated furnace design. Since the renovation all coal burned in Minneapolis is subjected to acid gas control and modern combustion techniques.

As a result of plant renovations, we have dramatically reduced emissions. For example, annual sulfur dioxide emissions have dropped from 597 tons in 1996 to 12.6 tons in 2001 (a 98 percent reduction), and nitrogen oxide emissions have been reduced by 88 percent [see Figure 2]. For these pollutants emissions have been reduced by more than we have reduced our reliance on coal (about a 65 percent reduction.)

The fluidized bed combustor is our primary coal-fired boiler. It was designed for fuel-flexibility and with state-of-the-art pollution control. Air is injected into the combustor through a windbox at the bottom of the unit and by tangential blowers surrounding the bed. The swirling, upward action of the air creates an air-bed into which coal, limestone and any biofuel is added. Air, fuel and limestone, are completely and uniformly mixed at low temperatures, reducing nitrogen oxides and carbon monoxide to very low levels. The limestone reacts with chlorine and sulfur contained in the fuel to form particulate sulfides and sulfates which are collected in a baghouse after leaving the unit.

The fluidized bed provides superior environmental performance. In fact, actual coal-fired emissions of nitrogen oxides and carbon monoxide are comparable to permitted emissions from the new gas/oil boilers. The greatest emissions of sulfur dioxide and other acid gases occur when the new package boilers operate on fuel oil [see Figure 3].

Steam Plant Performance: Greater Energy Efficiency Means Less Air Pollution



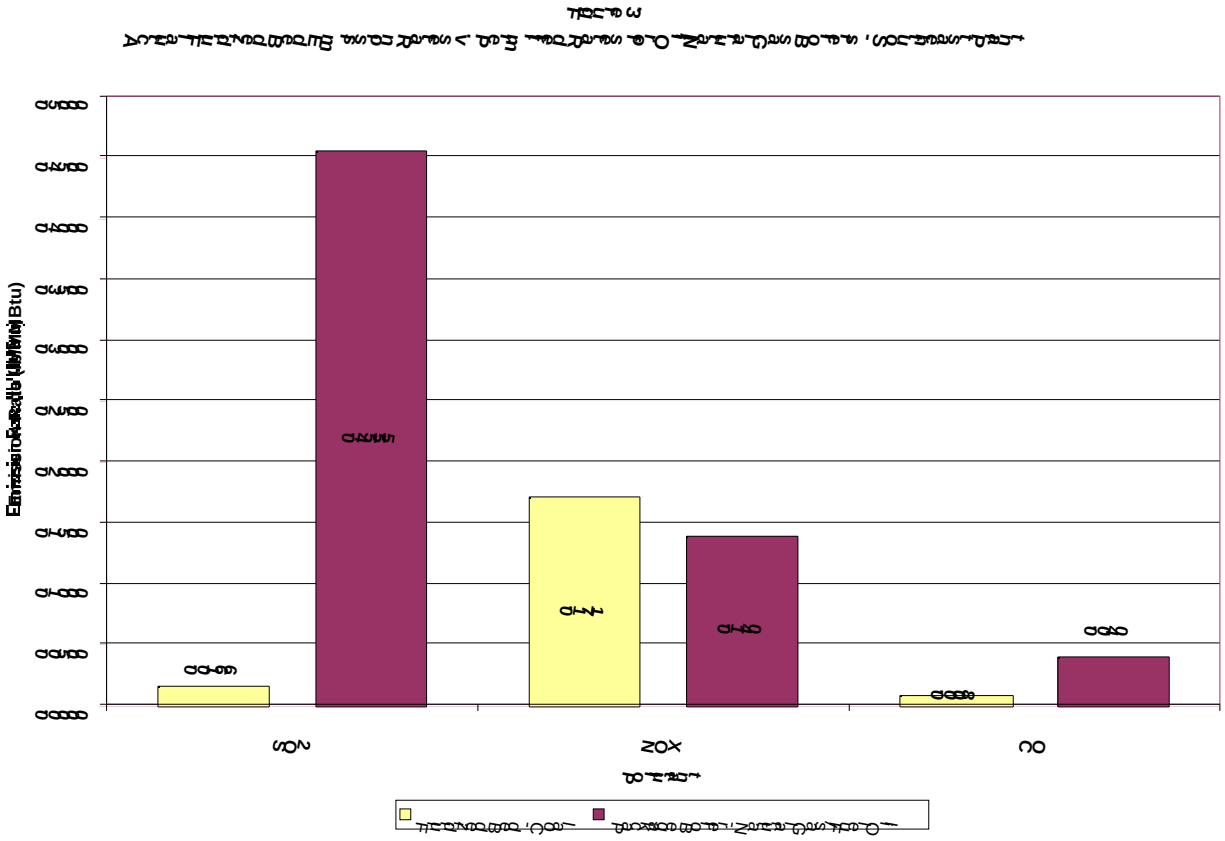
Emissions have been reduced in part because the new Southeast boilers are very efficient: they produce more steam from each gallon, cubic foot or ton of fuel than the old boilers they replaced. That's guaranteed. When the design, operation and maintenance agreements were negotiated with Foster Wheeler, the University included incentives (and penalties) for using energy wisely.

Specifically, Foster Wheeler shares the fuel savings when they produce a pound of steam for less than a contract guaranteed amount of fuel. In addition, they agree to charge for no more than 4,500 BTU of fuel for each kilowatt of electricity produced by the new units.

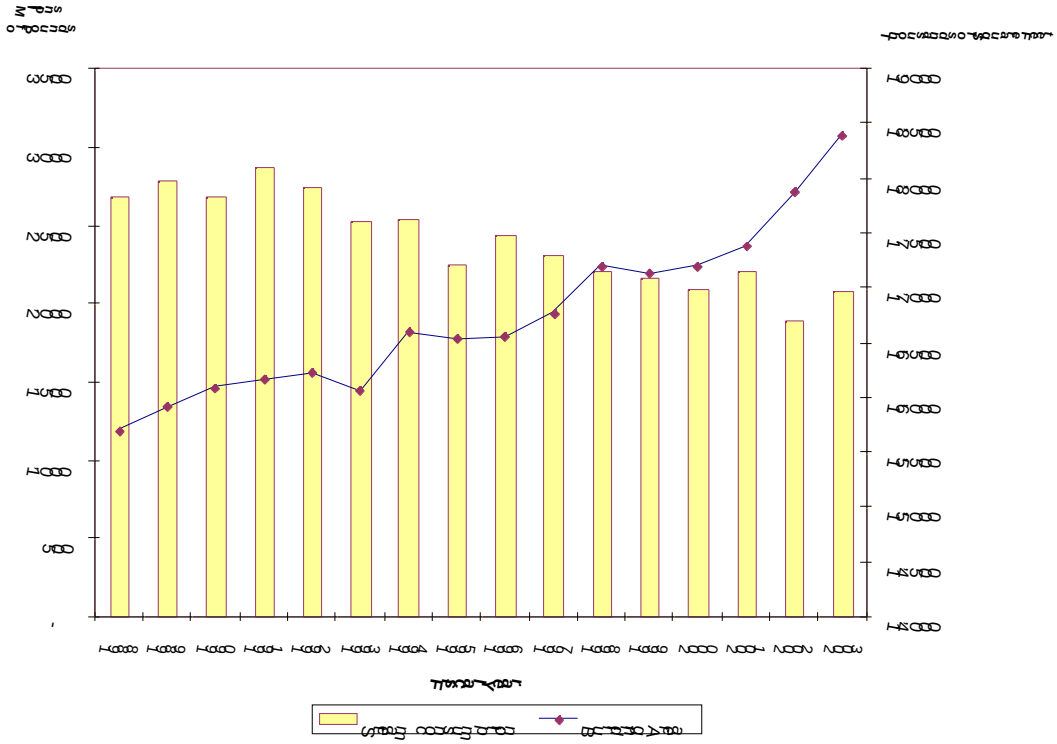
The University also agreed to efficiency guarantees: we are required to return at least 90 percent of the steam generated by Foster Wheeler as condensate water at 160° F, so cold make-up water doesn't have to be added to the system.

Our fuel-to-steam conversion efficiency has increased by approximately 10 percent with the new plant design. In addition, electricity produced from our cogeneration system reduces the fuel used by area electric utilities by the equivalent 7,700 tons of coal per year.

Greater system efficiencies mean less fossil fuel burned, less money spent and less air pollution.



Conservation and Energy Efficiency: Eliminating Demand for Fossil Fuels



We are committed to energy conservation in each and every building at the University of Minnesota. Our program is permanent, fully funded and highly successful.

Our Facilities Management Energy Efficiency Group was founded in 1994, on the heels of U-BEEP, the original University of Minnesota Building Energy Efficiency Program. The Facilities Management group is made up of eight staff members who are responsible for the proper design, operation and maintenance of our energy systems.

The efficiency program has been highly successful; reducing campus steam requirements by nearly 23 percent while total building space has increased by 18 percent [see Figure 4].

Technology, education and staff diligence have all played a part in the program's success. Nearly every building is monitored by a centralized data management system. Program staff can quickly respond to changes in building operation. Staff can also compare buildings that are used for similar activities to determine if building upgrades will improve energy performance.

Once upgrades are identified, improvement costs and benefits are calculated. If the improvements can be repaid through energy savings within six years, they are implemented. The University maintains a $6 million revolving fund to upgrade building systems, so capital requests do not have to go through traditional funding obstacles.

New buildings must meet the latest energy code, but the University takes the process a step further. Nearly every new building design is subjected to the "Xcel Energy Assets" program, where energy conservation improvements beyond what is required by code are considered.

Finally, we maintain, schedule and operate our building systems to minimize energy consumption. Staff members are

trained to identify and fix chronic problems, and all personnel are encouraged to shut things off when they're not being used. It's not exactly rocket science, but it is highly effective.

Based on the energy performance of our steam plants and buildings, we estimate that improvements made in the last decade save the equivalent of 45,000 tons of coal from being burned each year.

The University saves the equivalent of 45,000 tons of coal per year from our energy conservation programs and through efficient steam plant design and operation. Regional utilities avoid using another 7,700 tons of coal per year due to cogeneration at our renovated Southeast steam plant.

Fuel Flexibility: Replacing Fossil Fuels with Biofuels at the Southeast Steam Plant

Using biofuels at Southeast is not a new idea because they have always been part of the plant design. The original air emission permit for the renovation included the ability to burn wood, which was the only biofuel available to the University at the time the permit was granted. Other biofuels were not included at that time because very little emissions data is available for other biofuels. We were not comfortable accepting permit limits for future fuels without a chance to confirm their operational and environmental feasibility.

The University has burned limited but increased amounts of wood in each of the past two years. In fiscal year 2003, 32,000 MMBtu of wood were burned, or about nearly double the 17,000 MMBtu burned the year before. For FY 2003, wood made up 1.5 percent of all fuels used in Minneapolis.

Our ability to use wood has been limited by a lack of available supply at the specifications required by the University and Foster Wheeler. For this reason, the University has been seeking other renewable biofuels to supplement our flexible-fuel mix.

Fuel Flexibility: Oat Hulls as a Biofuel

We have now identified oat hulls as another viable biofuel. Oat hulls are a byproduct that is produced by General Mills at two plants in the metropolitan area. We believe that up to 60,000 tons could be available to the University each year.

General Mills is seeking a customer who can beneficially use oat hulls throughout the year. Based on successful pilot tests this summer, we believe we can use oat hulls to the benefit of the University, General Mills and the environment.

Fuel Flexibility: Successful Pilot Tests and Environmental Performance of Oat Hulls

We requested permission from the Minnesota Pollution Control Agency to test a combination of oat hulls and coal earlier

this year. Up to 4,000 tons of material would be needed to “shake down” operations and to test emissions. Approval was given by the Agency on February 18, 2003, noting that the characteristics of oat hulls and coal are similar. Emission testing was undertaken to evaluate emissions associated with this fuel source

We began pilot operations using a blend of 9 percent oat hulls and 91 percent coal. Emission testing was performed on March 28 after we had become comfortable with the biofuel blend. A similar process was used for a 35 percent blend later in the summer. Each test was successful: the plant operated as required and emissions were well below permitted levels for coal combustion in the fluidized bed [see Figure 5]. Comparable emissions resulted from each test.

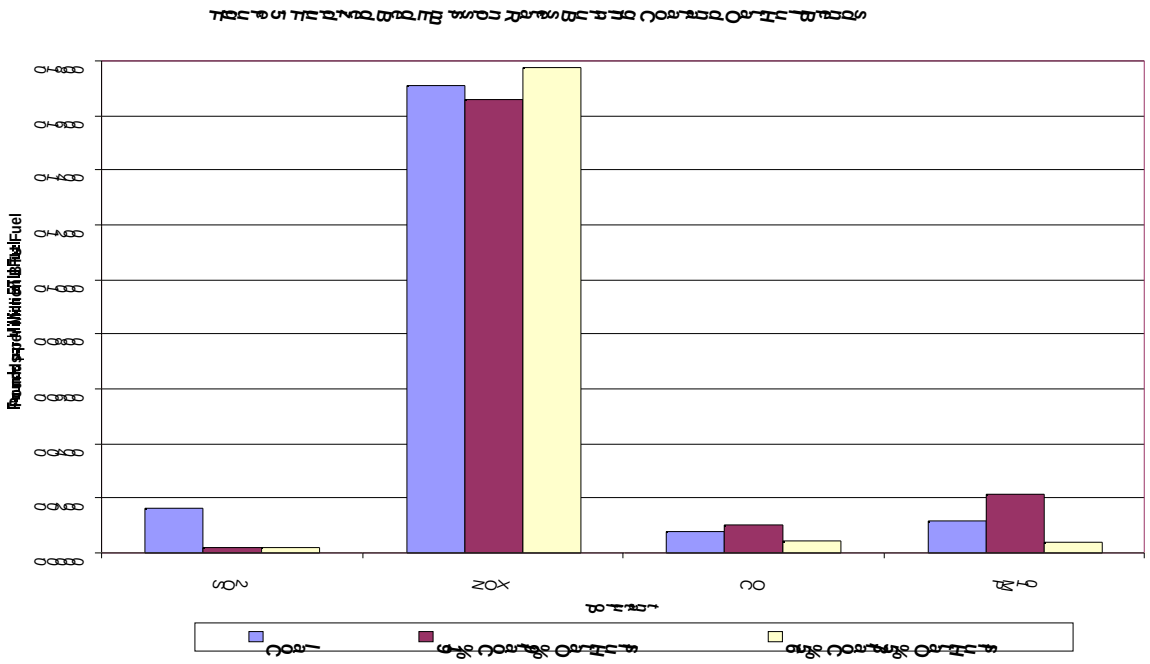
Based on results of tests conducted this year, we believe we can burn oat hulls at up to 50 / 50 blend with coal with a new equipment installation. The University is also interested in blending oat hulls with natural gas in the fluidized bed combustor, but we know of no other facility that uses this combination. Substantial testing with new equipment is required to determine if we can burn oat hulls and gas together. A preliminary estimate of approximately $2,000,000 is required for this equipment.

Unfortunately, testing is not possible before making necessary capital expenditures to modify the plant. Even with modifications, we are not sure that the system will be reliable (an important consideration on a University campus).

Since we have a proven ability to burn the oat hulls with coal, and coal is an integral part of our existing system, we plan to mix oat hulls with coal at this time.

The University could burn up to 15,000 tons of oat hulls per year by blending oat hulls with coal. With new material handling and burner equipment, it is expected that we could burn more than 30,000 tons per year, replacing a similar quantity of greenhouse-gas producing fossil fuels.

Fuel Flexibility: Proposed Permit



Conditions for Biofuels

We are excited about the test results. We are able to blend renewable biofuels in combination with coal at the Southeast plant, reducing daily coal inputs while complying with permit conditions and closing the carbon cycle on a portion of our energy needs.

To successfully consummate an agreement with General Mills, the University has to be able to accept oat hulls throughout the year. This presents some difficulty for the University, as the fluidized bed combustor is not operated during extended periods in May and October, the periods of lowest steam demand. These periods are best used for routine maintenance of the unit. Otherwise, the fluidized bed is operated without electricity production, and the elevated steam pressure produced by the bed must be reduced without energy recovery.

To resolve the requirement to accept oat hulls throughout the year, we propose to burn the oat hulls in Southeast Units 3 and 4 when the fluidized bed is off-line. These boilers have extremely efficient limestone spray dryers and baghouses that scrub acid gases and collect particulates.

The pilot testing process used for oat hulls was a successful technique for determining operating and environmental performance. Consequently, we request that the process used for oat hulls be formalized as a standard criteria for adding other biofuels in the future. Formalizing the process within our permit will maintain the University's operating flexibility and avoid unnecessary effort by the MPCA if other biofuels are found to be acceptable in the future.

Fuel Flexibility: Biofuels and Coal

We at the University believe it is important to minimize the combustion of all fossil fuels. Biofuels such as wood and oat hulls are one of a number of actions the University has taken to limit our use of fossil fuels.

The University is not asking for any change to our voluntary limit of using at least 70 percent natural gas and biofuels. We will continue to operate under the voluntary permit limit even though we are allowed to burn more coal under federal and state rules.

Additional restrictions would benefit neither the University or energy conservation in general. With further restrictions we would:

- Cogenerate less electricity;
- Needlessly waste steam pressure;
- Place greater pressure on an already stretched regional natural gas system;
- Be forced to burn larger quantities of distillate fuel oil than would otherwise be required during periods of natural gas curtailment; and
- Operate with greater risk to system reliability and student comfort and safety.

As presented in the previous sections, we stand behind the success of our energy efficiency and conservation programs:

- Our new boilers are highly efficient;
- We cogenerate electricity, which is encouraged by all levels of government;
- We maintain a trained staff and state-of-the art controls to minimize energy consumption at campus facilities;

- We already use nearly three times less coal in our fuel mix than state utilities [see Figure 6]; and
- We are working to replace a portion of our fossil fuel consumption with renewable biofuels.

Renewable biofuels are encouraged by federal and state governments through legislative requirements, loans and subsidies. Our commitment to biofuels is a response to government's call.

We believe that conservation and renewable fuels benefit both the University and the community-at-large. We will continue to seek ways to reduce energy consumption through current and new campus-wide initiatives. We ask that additional biofuels use be permitted at our Southeast steam plant as part of our overall program.

Iowa University recently received approval from the U.S. Environmental Protection Agency to burn oat hulls. According to Iowa Governor Tom Vilsack, "The project is a great example of how cost effective it can be to use an environmentally-friendly fuel source."

From: Iowa Department of Natural Resources

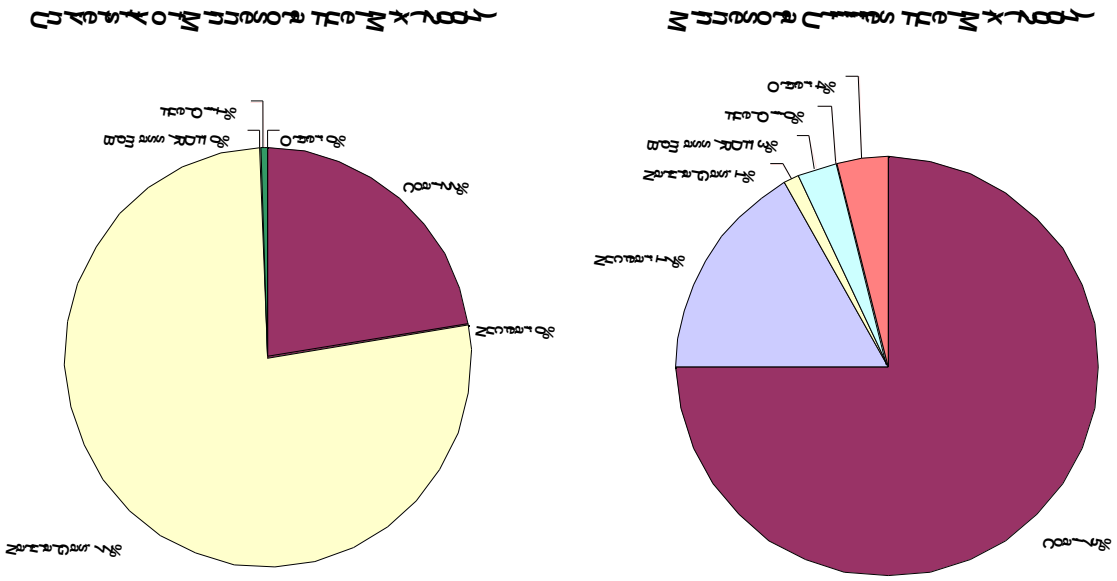


Figure 6. The University of Minnesota relies more on natural gas than state utilities.