Community Assistantship Program

Communities and Local Energy: A Workbook--The Future is Now

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Prepared in partnership with
The Minnesota Project

Prepared by
Melissa Pawlisch
Graduate Student

University of Minnesota
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Center for Urban and Regional Affairs (CURA)
University of Minnesota
330 HHH Center
301--19th Avenue South
Minneapolis, Minnesota 55455

Phone: (612) 625-1551
Fax: (612) 626-0273
E-mail: cura@umn.edu
Web site: http://www.cura.umn.edu

COMMUNITIES AND LOCAL ENERGY: A WORKBOOK
THE FUTURE IS NOW

Developed for the Clean Energy Resource Teams

Written by:
Melissa Pawlisch
Carl Nelson
Lola Schoenrich

The Minnesota Project
September 2002

Funding provided by the Regional Sustainable Development Partners, Community Assistantship Program, The Energy Foundation, The Surdna Foundation, The W. Alton Jones Foundation, and The Unity Avenue Foundation.

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Regional Advisory Committee Members
Carl Michaud, Hennepin County - Metro Counties Energy Task Force
David Benson, South West Regional Development Commission
Greg Cuomo, West Central Research and Outreach Station
Janet Streff, Department of Commerce
Jon Hunter, Hennepin County - Metro Counties Energy Task Force
Linda Kingery, Regional Sustainable Development Partnerships – Northwest Region
Mike Reese, West Central Research and Outreach Station
Okey Ukaga, Regional Sustainable Development Partnerships – Northeast Region
Sharon Rezac-Anderson, Regional Sustainable Development Partnerships – Central Region
Sigurd Anderson, Experiment in Rural Cooperation (Regional Sustainable Development Partnerships – South East Region)
Dick Broeker – Experiment in Rural Cooperation
Mary Page – Statewide Coordinating Committee President, Regional Sustainable Development Partnerships
Dorothy Rosemeier – Regional Sustainable Development Partnerships -
Monica Siems – Former Statewide Coordinator, Regional Sustainable Development Partnerships
Cynthia Pansing – Statewide Coordinator, Regional Sustainable Development Partnerships

Technical Committee Members
Betsy Engleking, Great River Energy
Bob Cupit, Department of Commerce
Doug Tiffany, University of Minnesota Department of Applied Economics
Jim Boerboom, Minnesota Department of Agriculture
John Dunlop, American Wind Energy Association
Keith Butcher, Center for Energy and Environment
Matt Schuerger, Independent Consultant
Mike Taylor, Department of Commerce
J. Drake Hamilton, Minnesotans for an Energy Efficient Economy
Paul Burns, Minnesota Department of Agriculture
Paul Imbertson, University of Minnesota, Department of Engineering
Rory Artig, Department of Commerce

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PURPOSE OF THE WORKBOOK

This workbook was written for use by the Clean Energy Rebuild Teams and focuses upon opportunities for communities to become engaged in community energy planning, renewable energy, and distributed energy projects. It is our hope that this workbook will be useful to a broad range of communities and broad spectrum of audiences from local government officials, local utilities, businesses, farmers, community leaders, and individuals.

The focus of the workbook is to:

- Provide quick reference material that details potential energy alternatives and nuts-and-bolts of implementation
- Provide detailed case studies that illustrate how similar projects have previously been done in Minnesota
- Provide bibliographical references for further resources and lists of contacts

Additional copies of the workbook are available from ________________.

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CHAPTER 1: INTRODUCTION

SETTING THE STAGE

Over the past several years, regional organizations, states, counties and municipalities have begun to take a more active role in defining their energy future. Many factors have played a role in stimulating this renewed local interest, but whatever the impetus, the direction is clear. Communities are looking toward more locally controlled energy supplies and away from imported fuels and centralized power stations. Community energy is not a new phenomenon, and in fact, this trend represents both a renaissance back to early 20th century traditions and an advancement made possible by 21st century technologies.

Opportunities abound for Minnesota's rural communities to command a leadership role in the forthcoming technological revolution that focuses on local entities and renewable power resources rather than a centralized power station running on fossil and nuclear fuels. As the focus on renewable energy continues to grow, Minnesota is well aligned to play a leading role in setting the standard for future energy systems that can meet community energy needs while keeping dollars in the local community and achieving long-term environmental pay-offs. Just as Iceland now garners international attention for its revolutionary integration of domestic renewable fuel supplies with a vision for a hydrogen economy, Minnesota too can take a leadership role. By developing a plan that capitalizes on its indigenous resources, Minnesota can provide real economic benefits to communities all over the state while providing a cleaner a environment.

What WAS Community Energy?

Power generation across much of America was initially provided by small-scale onsite energy generation. Prior to 1900 nearly all power was generated from local sources. Farmers relied on windmills to pump their water. Mills depended upon local water supplies to power their operations. Onsite generators powered industries and theatres. However, as economies of scale made centralized power a cheaper and more efficient means of generation, the nation shifted toward purchasing power from these central suppliers and away from community energy. Between 1900 and 1930, the proportion of onsite electricity generation declined from 60% to 20% (Morris, 11).

What IS Community Energy?

Community energy today is based on local, onsite, distributed generation. Since the early 1900's, energy generation technology has changed considerably. Whereas throughout much of the 1900's centralized power stations were by far the most efficient and cost effective, today distributed generation is becoming increasingly efficient and cost effective. Today community energy can be fueled by a wide variety of renewable energy sources rather than depending upon fossil or nuclear fuels. This is an important distinction because it means community energy is actually a generation beyond the current system which depends largely on fossil fuels. Throughout this manual, distributed energy will be defined as energy which is both produced onsite and produced using indigenous, renewable, clean energy resources.

BOX: We will have a graphic of the State with its transmission lines (Grid view)
We will also have a few charts that show how much electricity we get from power big facilities and various fuel types. (Plant size = >50MW, 10-50MW, <10MW).

END BOX

How is the Electrical Energy System Structured Today?

Today our electrical energy system relies primarily on three components: generation, transmission and distribution. Most of the generation occurs at centralized power stations. In Minnesota, most of these centralized power stations rely on fuels like coal and nuclear to make electricity. These function by burning the fuel to heat water to create steam that turns a turbine and thus generates electricity. Once generated, high-voltage electricity is transported to local substations by a complex, and in places aging, electric grid, also known as the transmission system. At substations, transformers reduce the electric voltage for distribution to our homes and businesses completing the three-tiered chain.

BOX:

Why the Shift Back to Community, Distributed Energy?

There is no one answer to this question. The catalyst changes because individuals and communities will see community energy as a solution to many problems. The following presents a listing of many reasons behind the shift:

- Technology changes and improvements have made the shift possible
  - Improvements in fuel conversion efficiency
  - Manufactured technologies rather than custom design
  - Development of fuel cells and microturbines
  - Use of combined cycle steam technology to increase efficiency
  - Potential for energy storage mechanisms
- Need for improved energy reliability
  - Few businesses can withstand the costs of power outages
  - Many computerized industries now require cleaner power supplies (greater purity of the electron stream)
- Desire for greater energy autonomy/independence – Many communities with only one primary power line are vulnerable to power loss in cases of natural disasters or other incidents impacting the transmission system.
- Security concerns
  - Reliance upon foreign fuels makes the United States as a whole vulnerable to significant price spikes due to international conflicts and market fluctuations
  - Threats of terrorist attacks on central power stations have become a greater driving concern since September 11th for both nuclear power stations and fossil fuel power station
- Economic opportunities – Distributed energy generation fueled by indigenous resources stimulates economic development in rural communities.
- Environmental concerns – A shift to community energy should mean a shift toward clean, renewable energy supplies. This presents benefits for our air, our water, our soils, and our global climate.
- Health improvements – Paralleling environmental benefits, a transition toward cleaner fuels will allow us to breathe cleaner air and drink cleaner water reducing the negative health impacts associated with our current generation system.

END BOX

GETTING STARTED CRAFTING A COMMUNITY ENERGY SYSTEM

Start with Conservation/Energy Efficiency

The common misconception that conservation means sacrifice, that is, turning down the heat until you're cold and turning off all but one light, needs to be corrected. Sure, turning off the lights when you're not in the room, and keeping your thermostat set at 70 instead of 75 are good energy saving practices, but conservation and energy efficiency are more about using better technologies than they are about changing behaviors. In fact, in its *2001 Energy Planning Report*, the Minnesota Department of Commerce defines conservation as primarily physical improvements that result in less energy consumption and that can be relied on, once they are installed, to continue to use less energy into the future. Additionally, once installed, many energy efficiency measures are transparent to the user.

Conservation is the best place to start when trying to craft an energy future. Conservation is the cheapest and often the easiest way to modify our resource usage. While not directly influencing the fuel mix, conservation does reduce our overall energy consumption thereby minimizing the potential for shortages and reducing the negative impacts of fossil fuel or nuclear generation. Before looking to alternative solutions, individuals, community leaders, business leaders, and government must evaluate what steps should be taken to conserve our energy resources. Conservation includes technological changes such as using more energy efficient light bulbs and appliances, constructing buildings to take advantage of natural light and natural heating, installing better insulation, or even shifting some energy use toward non-peak load periods, all of which save money as well as energy.

For more information contact the Department of Commerce Energy Information Center. Energy Conservation Improvement Program page at: (651) 296-5175 or Toll-Free (800) 657-3710, through email at: energy.info@state.mn.us, or on the web at: http://www.commerce.state.mn.us/pages/Energy/MainInfoCenter.htm.

BOX: include a graphic with dollar bills and little heaters (with an X over the heaters?)

Saving on Heating Bills

What you can do:

- Get an energy audit; find out where you're losing heat
- Upgrade insulation and seal outdoor air infiltrations to keep heat from escaping
- Install new windows and doors that help insulate the home; replace any broken windows and doors; be sure that spaces around windows and doors are well sealed
- Switch to more efficient heating and air conditioning systems
- When building new, include energy efficient systems in your construction, and follow smart building practices (sustainable design) that take advantage of natural heating, cooling, and lighting benefits (United States Green Building Council http://www.usgbc.org/programs/leed.htm, www.usgbc.org)

END BOX

BOX: graphics here to include a picture of a compact fluorescent light bulb and the energy star logo

Conserving Electricity

What you can do:

- Change to compact fluorescent lightbulbs
- Shift to Energy Star appliances (http://www.commerce.state.mn.us/pages/Energy/EnergyStarMN.htm or http://www.energystar.gov/default.shtml)
- Upgrade to more efficient motors

END BOX

Then Move Toward Indigenous Resources and Community Energy Production

Even with significant conservation improvements however, there may still be an interest, and a need, for looking at new sources of energy for your community's needs. Renewable energy resources, especially local renewables, offer opportunities for communities to improve their generation methods to include healthier, more sustainable practices.

Ethanol epitomizes the way Minnesota's indigenous resources can be integrated into our energy resource mix. Ethanol allows us to use fewer fossil fuels while capitalizing on a locally supplied fuel resource that allows our cars to burn "cleaner". In addition, the Minnesota model stimulates the participation of small, farmer-based cooperatives so that the value-added component of the business stays in the local community rather than going to outside resources. At present, 10 of Minnesota's 14 ethanol plants are farmer owned.

These are two key components of the renewable energy shift needed in Minnesota. First, we need to identify opportunities to use our indigenous resources. By capitalizing on homegrown resources, we offer the potential for local economic development, for greater self-reliance and less reliance on foreign and volatile-priced fuels, and for cleaner energy resource options (as Minnesota's only indigenous energy resources are renewables). Second, we need to revolutionize the energy market and begin incorporating energy resources that make sense for our future. Resources that make sense will spawn greater energy independence and mitigate, rather than exacerbate, environmental impacts. Minnesotans must begin making choices today that look toward and redefine our energy future. This manual will present various energy technology options available and will discuss how communities have gone about shaping their energy future.

PURPOSE OF THE WORKBOOK

This workbook will provide users with quick reference material that will detail potential energy alternatives as well as the nuts-and-bolts for implementing such programs. As part of these descriptions, the workbook includes detailed case studies that describe how these projects have been implemented in the past and the level of success they have achieved. The workbook will provide a snap shot of the overall potential for each technology at this time, such as how many projects are out there, who supplies the equipment, and what the current cost per kilowatt hour is. Lastly, as a comprehensive resource, the workbook will provide a list of bibliographical references for those who wish to do more reading and research and a list of contacts for people looking for additional resources.

CHAPTER 2: CREATING A COMMUNITY ENERGY VISION

Communities need to be involved in creating a sustainable energy plan for their future. Integrating community efforts allows broader public participation and broader issue education. It allows communities to establish priorities that will guide their future energy acquisitions and to evaluate their local resources to determine how best to keep energy dollars in the local community. In fact, instituting a community planning process is the best way to protect the public interest and ensure that all community stakeholders, rather than a select few, are making their voices heard.

STAKEHOLDERS

Electricity is a unique commodity because we all use it. Electricity use encompasses a broad range of sectors, public and private, with numerous stakeholders each having their own perspective. Electricity is also unique because initiative to modify the electric system can start from anywhere, but usually needs to involve all the community's stakeholders. Key stakeholders include:

- Local Utilities – investor owned, cooperative, and municipal
- Local Government – state, county, city/township
- Local Business and Industry – commercial business and factories
- Farmers – owners of windy land and producers of bioenergy
- Local Residents – individuals interested in renewable energy and prices of electricity
- Public and Private Community Institutions – universities, colleges, experiment station, non-profits, prisons

Local Utilities

What can each of the stakeholders contribute to community energy planning? To start with, local utilities must be involved in any community energy system. Electricity is their commodity; almost all systems will need to plug into the utility system so they need to be involved early on in the process. Utilities can either make project happen, or stop them in their tracks. Utilities have several mechanisms by which they can support projects. They can own your communities distributed generation system, or lease your communities land to install a system, or even simply buy your community's green energy. They can provide favorable power purchase agreements that make the project economics viable. Utilities can also fund renewable energy research and demonstration projects as well as conservation projects. There are many options. In some instances utilities are actually mandated to fulfill these roles. So, while sensitive to energy pricing, many utilities may look favorable on potential projects that help them fulfill their requirements.

Local Government

Next, consider the role of local government. Local government officials are key leaders in any renewable energy project and there are a number of ways that local governments can promote the use of renewable energy technologies. They can use renewables to generate electricity for local government use. Some options include building renewable projects at schools and government buildings or implementing solar technologies at remote locations and in city parks. Local governments can also use cogeneration to generate electricity and capture the excess heat for use in government buildings or even in a broader district energy system. For communities with landfills, sewage treatment plants of feedlots, local governments can collect and burn methane to generate electricity.

Beyond developing their own resources, local governments can play a role by purchasing green electricity. Some options for purchasing include buying renewable energy for all consumers through community aggregation, forming a municipal power agency to procure green electricity, buying green power for government load, or even giving price preferences for renewable electricity. Lastly, local governments can use economic development tools to promote local renewable development, recognize and promote the use of renewables by others, and incorporate energy issues in local planning.

Local Business and Industry

Local business and industry play an important role in sustaining and growing local economies. They are also significant energy users. These businesses and industries are therefore important stakeholders to include in the community energy planning process. Businesses can take they lead in making efficiency upgrades and improvements. Business and industry can also partner with their local community to implement renewable energy projects that help solve a facility waste problem. This provides a mechanism to clean up communities and generate local energy while helping businesses take care of a problem and make a little money in the process. Another option is for a local industry to implement a cogeneration process that could either use the waste heat at the facility or partner with the local community and use the waste heat in a district energy system.

Farmers

Farmers can implement their own renewable energy projects, like installing wind turbines or anaerobic digesters, thereby reducing their grid-based energy consumption and their electricity costs. Farmers can also then sell their excess electricity back to the grid. New programs and incentives in the Farm Bill may allow farmers to make renewable energy projects a more viable option. In addition, farmers can lease their land to private developers or utilities that are willing to pay to install a system.

Local Residents

Local residents play an important role in ensuring that people in community are behind the larger community efforts. These residents can mobilize and organize community support to initiate community programs and to keep them growing. Local residents can also get involved by electing local officials that support renewable energy development and by supporting policies that encourage their development. Residents can also play a role in purchasing "green electricity" at increased prices, showing a commitment to this type of energy. Lastly, residents can take their own steps to implement energy efficiency improvement and organize their neighbors to do so as well.

Public and Private Community Institutions

Public and Private Community Institutions also contribute to community energy plan development, as they can serve as demonstration settings, and have the ability to invest public and private research dollars toward innovative research and projects. These larger organizations also have the ability to serve as a hands-on location to implement a pilot project that could spawn further developments down the road and as a place to bring community-wide efforts to fruition.

STEPS IN THE COMMUNITY ENERGY PLANNING PROCESS

The community energy planning process already has a foundation, both in Minnesota, across the country, and around the world. In Minnesota, numerous interested citizens have already taken leadership roles to promote conservation and efficiency improvements and local resource use to achieve a more sustainable energy future. Numerous conservation efforts and renewable energy projects have already been initiated across Minnesota and these examples can lend a wealth of real-life experience to other local communities interested in pursuing similar ideas. Additionally, numerous communities have already implemented community energy planning exercises and several publications are also available to guide this process. This is not to say that communities cannot build their own models or design their programs, but they needn't start over from scratch to create a methodology that works. Generally, steps in the community energy process will consist of the following:

1) Raise community awareness
2) Assemble community stakeholders
3) Assess and identify community issues and problems
4) Start with efficiency and conservation
5) Assess your renewable potential
6) Identify potential projects/owners/partners

Raise Community Awareness

Increasing energy awareness, which should include awareness of energy and consumption loads as well as energy alternatives, encourages people to incorporate cost-effective efficiency improvements into their everyday activities. It also helps community members develop a broader understanding of where our energy comes from and at what cost. This exposure can encourage a greater sense of ownership in our energy system and spawn a commitment toward energy sustainability, security, affordability, and environmental stewardship. Increased awareness also has the potential to expand the energy audience, tie people with various motives together, and bring others into the circle. By instilling a broader energy awareness, a more diverse set of stakeholders can be brought together to take part in the planning process.

Assemble Community Stakeholders

To some, energy concerns revolve around how to better produce energy while not impacting our environment, to others energy policy is a mechanism to encourage local economic development and bolster local communities strength. More diverse coalitions hold greater political and fiscal leverage in creating a system that works for their communal interests and in securing policies similar to their community-wide objectives. The more bridges that can be built, and more perspectives that can be brought together, the more likely communities are to achieve success.

The Regional Sustainable Development Partners is one organization that can help communities bring these various stakeholders together. The Rebuild Minnesota program, which will be discussed later in this chapter, also has the tools to help bring together various community stakeholders.

Assess and Identify Community Issues and Problems

Start with Efficiency Upgrades and Conservation Efforts

Before considering any alternative energy project, your community should first consider what steps to take in curbing energy use. For many of us, there are numerous things we can do around our homes, offices, and businesses that will trim our energy usage and trim our electricity and heating bills. State and local government efforts have made these changes increasingly accessible and have highlighted the ways in which government and utilities alike can partner with communities to encourage and perform these efficiency improvements.

Several programs in place in Minnesota deserve mention. The first is the Minnesota Department of Commerce’s Conservation and Improvement Program. This program was designed to reduce energy consumption. The original program began in 1984 and required that all investor owned gas and electric utilities spend 1.5% of their gross operating revenues on conservation efforts. As part of this requirement, these utilities were also required to submit conservation plans every two years that would outline where these conservation dollars would be spent. In 2000, the Minnesota Legislature updated the program to also include electric cooperatives and municipalities. Now all have to follow similar rules and put an equal portion of their revenues toward conservation efforts. The same legislation also added a provision that allowed up to 5% of the programs funds to be spent on renewable energy and distributed generation projects. Communities should contact their local utilities about these programs and find out how they can get involved.

The second program is Rebuild Minnesota, a part of the US Department of Energy’s Rebuild America Program that focuses on creating community partnerships between numerous stakeholders to conserve energy and improve energy efficiency while saving money. Rebuild Minnesota works with schools, municipalities and low-income family dwellings to uncover local solutions to meet local energy demand and build public and private partnerships among communities throughout the state. They provide assistance drawing community partnerships together and linking communities with the people and business that provide energy efficient products, services, information and strategies.

Other ideas regarding how to go about implementing efficiency and conservation measures are presented in Chapter 11.

Assessing Your Renewable Energy Potential

It is imperative that communities complete a comprehensive resource assessment prior to implementing a community energy program. A comprehensive resource assessment should consist of a community wide assessment that evaluates all of the potential resources available in your community or region. Renewable energy projects, especially at the community scale, can be quite expensive. It is important to understand what resources are available in your community and to avoid focusing too narrowly on one particular renewable energy technology. Beyond evaluating the energy resources, a comprehensive resource assessment must also evaluate these resources over a variety of different time horizons. The right renewable resource will be viable this year, next year, and 10 years down the road. In particular for biomass projects, an assessment must evaluate the cost, source, and availability of the fuel over a long time horizon. Communities need to be open to a variety of ideas, because it may turn out that the one technology you thought would work best actually won’t.

Identify Potential Projects/Owners/Partners

EXAMPLES THAT COMMUNITIES SHOULD CONSIDER

Phillips Community Energy Cooperative: Consumers Control of Energy Use

The goal of the Phillips Community Energy Cooperative is to create an urban energy cooperative that gives energy consumers greater control over their energy usage and to link conservation programs with under-served populations. Led by Michael Krause of the Green Institute, Peter McLaughlin, a Hennepin County Commissioner, and Lois Mack from the Department of Commerce, the project aims to provide a local model for communities interested in taking back control of their local energy use and energy costs. To achieve these aims, the Phillips Community Energy Cooperative will create a cooperative that delivers energy and conservation-related services at reduced costs that can be achieved by the larger membership base associated with a cooperative.

Phillips Community Energy Cooperative will put into practice the idea that as people come together, they become more able to exert power on their local energy system. By setting realistic goals and providing a mechanism for community members to get involved, the project makes success attainable and enables future growth. Phillips Community Energy Cooperative also plans to research the feasibility of a renewable biomass combined heat and power facility that would provide district energy to Phillips neighborhood businesses and residences. This sort of visionary step would be a model for urban community redevelopment projects across the nation and would serve as an example to both urban and rural communities wanting to regain control of their energy future.

For more information contact; Phillips Community Energy Cooperative, Andrew Lambert, Green Institute, 612-278-7100, alambert@greeninstitute.org

International Council for Local Environmental Initiatives, Duluth: Local Climate Change Targets

The International Council for Local Environmental Initiatives is an international association of over 564 local governments working to combat global warming problems through local solutions. Its Cities for Climate Change Protection Campaign is an international effort to reduce greenhouse gas emissions and improve community livability by assisting local governments with energy management and conservation programs. Local government involvement is the primary focal point of the program, because local governments can directly control and influence many activities that produce greenhouse gas emissions via land use decisions, energy-efficiency building codes, and waste-reduction and recycling programs. Duluth, St. Paul, and Minneapolis are all members of Climate Change Protection Campaign and have begun reducing their greenhouse gas emissions by conserving energy and developing newer, cleaner systems for heating and electricity. By participating in this project, each of these Minnesota cities is hoping to take a leadership role in educating their citizenry and motivating their communities to take action. Minneapolis and St. Paul worked as founding members of Climate Change Protection Campaign in the early 1990's, but more recently, Duluth has begun efforts towards addressing greenhouse gas emissions.

In Fall 2001, Duluth achieved its first project milestone, which was to complete a greenhouse gas emissions inventory that would allow the City to evaluate the impact different energy-saving measures will have on reducing its emissions. With the inventory completed, the next steps in the Climate Change Protection Campaign process are to identify which energy-saving measures are already having a positive impact, to formally adopt a greenhouse gas reduction target, and to develop a Local Action Plan to guide proposed measures for emissions reductions.

To develop the Local Action Plan, the City of Duluth felt it was imperative to engage a broad range of community members. As such, it developed a community task force to serve as the foundation for the larger community and ensure strong communication and organization throughout plan development. Along with developing the long-term plan, the program has formed many partnerships and secured funding through a Rebuild MN program administered by the Department of commerce to install a 2.4 kW photovoltaic system on the Duluth Public Library. The system will be hooked to a monitor in the library that will show the clean energy being produced and serve as an energy resource center for the community.

During the planning process, the task force identified a number of focal points for kicking off the program, primarily focused on education and electricity conservation. A compact fluorescent light bulb campaign is being developed that will inform citizens and distribute these light bulbs through a combination of school presentations, community events, and the larger Minnesota Power sponsored Energy Star program. Duluth is also taking a bold step to include a Cities for Climate Protection chapter into its Comprehensive City Plan, making it the first city in the nation to incorporate climate change protection into its overall vision for community development – yet another way of shaping future energy options.

For more information contact; Carin Skoog, Duluth International Council for Local Environmental Initiatives, 218-723-3396, cskoog@ci.duluth.mn.us

Chisago County Case Study: A Community Energy Management Plan

In December 2000, Chisago County released its Chisago County Energy Management Plan. The plan was designed to set a vision for the community and guide its future energy decisions by outlining environmentally smart, sustainable, and economically defensible energy options. Developing the plan also allowed the public to become engaged in a broad planning process that laid the foundation for its comprehensive energy management strategy. To facilitate stakeholder communication in the process, the county board instituted a public participation process by appointing a citizen-based "Overlay and Essential Services" task force of 18 community members. The task force's mission was to review existing energy conditions, including local use patterns and local energy demand, and provide detailed recommendations for several sectors. Through this process they set guidelines for everything from siting and permitting of power lines and generation facilities, to criteria for scenic resource protection, to provisions for conservation and alternative energy.

Several Chisago County community members had already established a precedent for community involvement in energy concerns prior to developing the Chisago County Energy Management Plan. In 1996, a local citizens group, the Concerned River Valley Citizens, was formed to challenge Northern States Power, now Xcel Energy, regarding its proposed 230 kV, 348 mVa power line that would span the St. Croix River from Chisago County, Minnesota to Polk County, Wisconsin. NSP sought to construct this new line across the scenic St. Croix River to strengthen the grid interface between Minnesota and Wisconsin.

To the Concerned River Valley Citizens, the addition of a large power line across the St. Croix River was a violation of the principles behind the Wild and Scenic River Act of 1916 that aimed to protect the quality of the river and the land around it. So in an effort to combat the proposal, they learned all they could about the energy system, solidified expert witness support, and found funding for a battle with NSP. This was no small task and required that members of Concerned River Valley Citizens learn the ins and outs of the energy business from siting requirements and environmental requirements to technical and engineering expertise. They succeeded in blocking construction of the new line across the St. Croix but did not stop there.

Concerned River Valley Citizens realized the fight was not over. NSP would simply try to put a line somewhere else. They foresaw the need to develop a mechanism that would forever give them greater control over energy development in their county – they needed a countywide energy plan. The County Energy Management Plan project became a community-based effort to learn more about energy issues and shape a plan that would maintain a citizen-centered, locally controlled, sustainable energy future.

The Overlay and Essential Services task force served as the primary organizing and leadership group to lead community interactions. They worked with all members of the community including the general public and local elected officials and brought in assistance from the Department of Energy, engineers, and other communities already undertaking sustainable community work. This combination of people and broad community involvement helped ensure the success of the project and created a coalition the community could build upon in the future. It appears their timing was right. Xcel Energy filed a certificate of need with the Minnesota Public Utilities Commission in 2002 to install a different line across the St. Croix, now a lower voltage line with double the transmission capacity. The coalition built through the initial fight and through development of the energy plan, will now be mobilized again to combat another non-sustainable energy proposal.

For more information contact; Bill Neuman, Concerned River Valley Citizens, 651-257-6654, ayelink@earthlink.net

West Central Research and Outreach Center and Morris: A Real-life Demonstration Project

The West Central Research and Outreach Center (Research and Outreach Center) seeks to put the idea of community energy into practice in Morris, Minnesota. The Research and Outreach Center has crafted an idea to develop an integrated, community scale, research, demonstration and production Renewable Energy Center in close partnership with the University of Minnesota-Morris and other community and renewable energy collaborators. This would be a true community-wide effort involving many different components from installing renewable energy technologies, to researching technologies for conventional and cellulytic production of biofuels, to tying industry in with a community district heating system.

The local community is already interested in getting on board. The Renewable Energy Center plans to conduct research on biofuels and the installation of a series of wind towers. The University of Morris is now interested in becoming a “Green University” by using a biofuel or biomass generator to meet its energy needs. The local school district is proposing building a new elementary school that would incorporate a district heating system tied into the University. DENCO, a producer/farmer owned corn ethanol plant located in Morris, is also pursuing opportunities to join the mix. They are evaluating the feasibility of installing a thermal oxidizer to reduce the facility’s odors that would also produce a large amount of steam heat that could be sold for use in a district heating system. By selling some of the excess steam, they could recoup some of their oxidizer installation costs while contributing to a community-based renewable energy system.

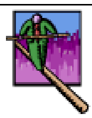
The Research and Outreach Center would serve as the catalyst and facilitator of community efforts to move in the direction of renewable energy systems, but the community itself would operate these systems. A true community program like this would be unique demonstration center that could give people around Minnesota and across the nation a working model of a truly integrated renewable energy program. To get the program moving the Research and Outreach Station hosted a Renewable Energy Workshop, attended by over 200 people from a variety of backgrounds, and also developed a twenty-six citizen Community Steering Committee. This steering committee will provide a citizens voice throughout project development and play a crucial role in ensuring public participation. While this case study presents a somewhat different model for community-wide planning, it demonstrates another option. Community energy planning can follow many models with different community members and organizations playing a leadership role and moving towns in the “right” direction.

For more information contact; Greg Cuomo, Morris and the West Central Research and Outreach Station, 320-589-1711

Community Discussions

Each and every one of the examples presents a mechanism used by a Minnesota community to take control of its energy system and plot a course to a better energy future. Each had different motivations and used different methodologies. To highlight the motivation behind, and attributes of, the various renewable energy options, a labeling system has been developed for use throughout this book. This system will pictorially emphasize why communities decided to implement a renewable energy project as well as the benefits provided by that particular renewable energy technology. Not all the technologies serve the same function and therefore, not all technologies are the right fit given varying community goals.

Symbols and Descriptors

	Environmentally friendly – appropriate for communities with environmental concerns including green house gas emissions
	Project that makes an excellent agricultural fit or works well on a rural landscape
	Assists communities with energy reliability concerns
	Provides opportunities to recycle waste materials and waste heat
	Yields economic opportunities for rural communities including job creation
	Affords greater energy independence, greater local control, and greater energy security
	Promotes learning about energy throughout community

HELPFUL RESOURCES FOR COMMUNITIES:

Green House Gas Inventory Report with recommendations for the development of Duluth's Local Action Plan, published October 2001, can be retrieved from http://www.ci.duluth.mn.us/city/information/ccp/GHGEmissions.pdf. This report outlines both the CCP milestone process and how to actually conduct the overall emission inventory.

Community Energy Workbook: A Guide to Building a Sustainable Economy developed by Alice Hubbard and Clay Fond of the Rocky Mountain Institute. Provides a systematic approach to involving communities in dictating their energy future.

Smart Communities Network: Creating Energy Smart Communities, a project of the U.S. Department of Energy: http://www.sustainable.doe.gov/municipal/intro.shtml - Provides resources and information that can help your community get started with energy planning and community-wide energy conservation. It focuses on the ability of conservation programs to help manage energy costs, reduce production of greenhouse gases, and involving the who community in energy management efforts.

Smart Communities Network: Creating Energy Smart Communities, a project of the U.S. Department of Energy: http://www.sustainable.doe.gov/municipal/sstoc.shtml - success stories for sustainable communities including for renewable energy and efficiency issues.

BC Energy Aware Committee: http://www.energyaware.bc.ca/welcome.htm - based in British Columbia, Canada, this site provides a forum to address community energy planning and the role of local governments in generating community energy planning. The website includes a "toolkit" which introduces the basic concepts and issues involved in generating a community energy plan, provides a number of community planning strategies based on community size, and offers case studies that portray pertinent information for a variety of stakeholders. The toolkit is geared toward local government officials but could be used by anyone interested in community energy planning.

Worthington Public Utilities Case Study:
* Symbols to be included: sun, dollar sign, hand holding city

Worthington Public Utilities received a grant from Windustry in September 2000 and assembled a task force of citizens to investigate the merit of wind power in Worthington. Investigation results were very positive, so Worthington Public Utilities joined with their power agency, Missouri River Energy Services, and Wisconsin Public Power Inc., another power agency, to install 4 new wind turbines, each with 900 kW of capacity. At present, Worthington Public Utilities' two partners each own two of the turbines, allowing them to qualify for the Renewable Energy Production Incentives as they fall under the 2 MW generation threshold. Energy generated by the wind turbines is fed into the power grid for the local community and the member cities of Missouri River Energy Services and Wisconsin Public Power, Inc. Worthington's electric customers can purchase this renewable energy in 100 kWh blocks for an extra $2.00/month (or 2 cents/kWh). This is essentially enough energy to power a refrigerator for a month.

So far, Worthington has found strong community support, strong government staff support, and broad community interest in the project. Worthington Public Utilities hopes to further encourage this interest by engaging the surrounding community through open houses that will not only educate citizens about how wind power works, but encourage them to stay interested in and involved with wind tower development. Worthington Public Utilities has already set aside land for two additional wind turbines and plans to install them within the next few years.

For more information contact; Don Habicht, Worthington Public Utilities, 507-372-8680, dhabicht@worthingtonpublicutilities.com

CHAPTER 3: WIND

Minnesota is known nationwide for its wind energy development. Most famous is the Buffalo Ridge in southwestern Minnesota that is characterized by excellent ("Class 4 and 5") wind conditions. There are, however, other regions of the state that also present potentially promising wind sites. As shown in Figure 1, (map of state wind class zones) many areas around the state are located in areas with Class 3 winds and better. So what do you really need to know? Read on.

Moorhead's *Capture the Wind* Success Story
***s**hould have a picture of the two wind turbines; symbols: sun, hand holding city, earth with graduation cap

Moorhead Public Service is now home to two 750-kW wind turbines, Zephyr and Freedom. Moorhead Public Service's *Capture the Wind* program has garnered national attention for its tremendous energy program innovation, its high levels of participation and its low premium rates. Moorhead customers pay an extra ½ penny/kWh for their electricity, which is made up of 1/3 wind and 2/3 hydro energy. By choosing to pay more, customers allowed Moorhead Public Service to build two wind turbines within city limits. In 2001 the *Capture the Wind* program received the American Public Power Associations Energy Innovator Award. It has been recognized by the National Renewable Energy Laboratory as having the highest customer participation rate in the nation with 7.4% of its customers participating in the green pricing program and for charging the second lowest premium rate for a customer driven wind energy program. Additionally, Senator Mark Dayton praised the program in February 2002 as a "stellar example of local initiative to reduce a city's dependence on fossil fuels for its electric power."

Capture the Wind was initiated in 1998 and began with numerous preparatory activities from establishing a monitoring site to measure and then analyze site wind speeds and directions to detailing wind turbine specifications to arranging financing. *Capture the Wind* allows utility customers to buy clean electricity generated by the wind turbines for a premium charge that amounts to approximately $5 per month for the average residential customer.

Moorhead Public Service's first turbine, Zephyr, began generating electricity in May 1999 and Freedom, the second turbine, came online in August 2001. Combined the two turbines generate 3,600,000 kWh of wind energy a year. As of June 2001, it was estimated that turbine use had prevented the release of 3,000 tons of greenhouse gases.

For more information contact; Chris Reed, Moorhead Public Utilities, 218-299-5199, creed@mpsutility.com

WIND BASICS (should have a picture here of a wind turbine)

Minnesota has thousands of megawatts of practical wind capacity potential. Specifically, Minnesota has the technical potential to generate over 387,000 MW of wind capacity, which is more than enough to fulfill our entire state's electric usage. Wind energy is the fastest growing electric generation technology in the world because the technology has developed to the point that it is cost-competitive with other technologies, the fuel is free, and environmental impacts are very low compared to other generating technologies (DOC, 55).

Turbines installed in Minnesota in 2001 were 1.5 MW each with an annual wind to electricity conversion efficiency of up to 40 percent. To put these in turbines in perspective, each of the three blades weighs in excess of 12 tons and rotates at only 20 revolution-per-minute (compared to 1,000 rpms for a small, home-sized wind turbine and 4,000 rpms for a typical car engine at cruising speed). The towers are in excess of 200 feet tall and can power over 650 average Minnesota homes each year.

In an effort to greater utilize this renewable potential the 2001 Minnesota legislature passed a law requiring all utilities to offer green electricity to their customers. Several utilities were already doing so, but it now allows all utility customers statewide to buy renewable electricity for a fraction of the cost of installing their own wind turbine. Most of the green electricity programs use 100% wind power that can be bought in 100 kWh increments for between 2-3 cents more per kWh.

Cut out (have a picture of blades and generator) – Wind turbines work by converting the kinetic energy in wind into mechanical power to run a generator than then produces electricity. Wind turns the blades, which spins a shaft connected to a generator that makes electricity. Major components of most wind turbines include the rotor, the nacelle, the tower, and foundation. The rotor is the spinning part of the turbine that turns the electric generator located within the nacelle. Most large turbines are roughly 200 feet tall so that the blades are positioned further off the ground, where the winds are typically stronger and are also less turbulent due to fewer obstacles. END BOX

Assessing Your Wind Potential

There are a few basic things to think about before ordering your wind turbine:

1. How strong are the winds in your area?

    - To begin, assess the general wind speed of your area by looking at a wind class map. Ideally you would be in an area characterized by Wind Class 4 or 5 winds (or better). If your site is characterized by Wind Class 2 winds or below, this is probably not a good option for your community.
    - The maps will not provide enough detail to get funding from a bank, but they should work for an initial assessment. The MN Department of Commerce also has wind speed and direction data from a wide network of data points that may provide more specific number ranges for your area.
2. Do trees or buildings surround you?
    - If obstacles such as trees and buildings surround your proposed site, wind may not be your best option, but there are other things to consider.
        - If the wind blows primarily from the north and you have buildings to the south, it's probably not such a problem.
        - If the wind blows from the north and you have forest to your north, then wind may not hold much electrical generating promise.
3. Is your site higher than it surroundings (for 1 to 2 miles) or are you located in a valley?
    - If you are located in a valley, it will probably be difficult for you to capture the amount of wind energy you will need to generate an adequate amount of energy.
    - If you are located on a prominent point or ridge, wind will probably be a much better option.
4. Will you be able to install a wind tower at a minimum of 500 feet from any road or structure? There is a required 500-foot setback distance.
5. Are tall towers allowed in your neighborhood or rural area?
6. Are you located near an airport? FAA regulations stipulate minimum distances from airport runways for structures of various heights that apply to wind towers, especially those over 200 feet tall.

Data to Gather from Nearby Wind Measurement Sites (from Harvest the Wind)

- Site elevation (higher is better)
- Monthly average wind speed (this will help determine the amount of wind power you are likely to generate)
- Wind Rose data (wind speed and direction frequency data, this will help evaluate your site and where best to put your turbine)
- Site exposure information
- Height above ground (again, higher is better, the height of the measuring station you can use the calculations above to determine how much additional power your will generate by raising the turbine)
- Data recovery (number of hours of valid data vs. total possible hours – ideally 90% of total)
- Data record (year and months with measurements)
- Site location with respect to your property (wind speeds generally increase to the north and west)

Cutout:
A new book, entitled "Farmers Guide to Farming Wind Energy as a Cash Crop" should be available by Fall 2002. This guide, written by Dan Juhl and Harvey Washerman, will be a

comprehensive guide for farmers interested in installing their own wind turbines and will include all of the necessary documents and pro-formas for installing a system. END CUTOUT

Do Your Own Measurements

The amount of energy in the wind is a function of wind speed. The energy in wind increases with the cube of wind speed. This means that if you double wind speed, the wind energy increases eight times. In addition, wind speed varies with height above the ground, and generally speaking as height increases so does wind speed. How the wind speed will vary with height depends about terrain, season, time of day, and other meteorological factors.

The cost of wind energy relates directly to the average wind speed at your site and the size of your wind farm. For example, the turbine in Moorhead produces just under 1.5 million kWh/yr with a 14 mph wind, while the same turbine in southwestern Minnesota produces 2.1 million kWh/yr with a 16 mph wind – more than 50% more. The wind speed makes a considerable difference. Construction of commercial scale wind energy plants currently costs about $800 to $1,000 per kilowatt of nameplate capacity. From a production standpoint, large-scale wind is now cost-competitive with conventional electric generation and costs are projected to decline further by 2006 (35-40%). Xcel Energy deployments have achieved levels of 3 to 4 cents/kWh.

There are economies of scale in wind development, and smaller wind projects are not quite as favorable at this point in time. There are, however, numerous programs that have been implemented to help improve these economics. Small-scale wind incentives for installations of 2 MW or less, and programs offering special financial assistance for these small-scale wind installations, are summarized on the tables provided in Appendix A. Some of the highlights include the federal Renewable Energy Production Incentive and the state Minnesota Renewable Energy Production Incentive along with both property and sales tax exemptions. Xcel has also set a standard small wind tariff at $0.033/kWh for any non-utility wind site (for any electricity sold back to Xcel throughout its service territory) and has established a standard contract and interconnection agreement for use with these non-utility wind sites.

In addition to the incentives for wind projects less than 2 MW in size, wind installations of 40 kW or less also qualify for net metering. Net metering allows these very small facilities to consume electricity from the grid when they are not producing power, and sell electricity back to the grid when they are producing power. This concept is discussed further in Chapter 11.

OTHER MINNESOTA EXAMPLES

Lac qui Parle Valley Case Study – Wind and Schools Combine

*****symbols: sun, dollar sign, earth with graduation cap

In 1997 Lac qui Parle Valley High School erected a 225 kW wind turbine. Minnesota Department of Public Services (now Department of Commerce) sponsored the turbine installation following a rigorous selection process in which Lac qui Parle Valley High School was selected as an optimal location based on wind velocity and consistency data as well as its rural location. The system was designed to start generating electricity when wind speeds hit 6 mph and produce at full capacity at 25 mph, and since installation, the turbine has generated an average of 36,000 kW per month, approximately 25-30% of the amount of electricity used by the school. This project has come to serve as a model for wind power generation at local schools.

Of course, beyond the benefits of green power, the project also had to be financially viable. Installation of the turbine cost $248,907, and the school received funding via a $60,000 grant and a 10-year, $188,907, interest free loan from the Department of Commerce. Lac qui Parle Valley School expects to achieve a 10-year pay back based on electricity cost savings, sales of excess electricity, and government production payments. Since the turbine provides roughly one-third of the schools electricity needs, it has substantially reduced the annual electric bill (down from $80,000 to $60,000). In addition, electricity produced during non-peak school hours, such as nights and weekends, is sold to Ottertail Power Company at a rate of approximately 1.5 cents per kilowatt. This too has generated extra funds for the school. Lastly, the school receives payments from the state for each kilowatt sold (approximately 1.5 cents) and payment from the federal government for each kilowatt generated (approximately 1.5 cents).

Besides supplementing the school's energy needs, the wind turbine is also used as an education and research tool. Students at Lac qui Parle Valley High School have gathered information from the turbine for use in their economics, physics, and environmental class discussions.

For more information contact: Robert Munsterman, Superintendent of Schools, 320-752-4200, robertm@lqpv.com

Pipestone-Jasper School District Case Study – Another Example of the Wind Energy and Education Fit

*****symbols: sun, dollar sign, earth with graduation cap

In Fall 2001, the Pipestone-Jasper School District was awarded one of Xcel Energy's Renewable Development Fund grants to construct a wind turbine. Jack Keers, a Pipestone county commissioner, and Dan Juhl, a local wind developer, had urged the Pipestone-Jasper School District to apply for a grant to install a wind turbine at its new school to help supply part of its energy needs. The District was ideally positioned and seemed like the perfect fit for a school wind turbine project. It had secured funding to build a new school; its new school construction project was significantly under budget; it was situated in near the windy Buffalo Ridge region. As it turns out, applying for the grant was a great idea. With the Renewable Development Fund grant, the District must contribute $150,000 toward turbine construction and Xcel Energy contributes the remaining $850,000.

The new school property is a 55-acre piece of land located on the edge of town, and the wind turbine will be located on the northwest portion of the property to take advantage of the prevailing wind conditions. The school will install at 900 kW wind turbines that is expected to power all of the schools basic needs and then some. The District anticipates selling the excess energy back to Sioux Valley Southwestern Electric, which should allow them to achieve payback on their initial investment within 6 years and will also allow the school to raise a bit of money after the payback period.

In addition to the economic incentives, Jerry Horgen, Superintendent of Pipestone-Jasper School District, also see "great benefit in having the school set an example for the community by using renewable energy". As an educational institution, the District sees that it has a major role in educating the whole community and bringing the community together. The wind turbine project provides an ideal educational project for students of all ages, and will be incorporated into learning activities within the science department. Dr. Horgen stated that the wind turbines offer a great opportunity for "furthering environmental awareness in our kids." As of summer 2002, the project is moving along right on target. The new building is expected to open by January 2003 and wind tower construction is anticipated to begin during April 2003 and should be completed by July or August 2003.

For more information contact; Jerry Horgen, Superintendent of Schools, 507-825-5861 or Dan Juhl, DanMar and Associates, 507.562.1280

HELPFUL RESOURCES FOR COMMUNITIES:
Minnesota Wind Resource Analysis Program Report – February 2000 from Department of Commerce (DOC) presents data collected from 1995 through 1999. The Minnesota Wind Resource Assessment Program (MNWRAP) was sponsored by the Minnesota Department of Public Service (now the Department of Commerce) and electric utilities. In 1981, the Western Area Power Administration (WAPA) began providing wind data to DPS from western power areas, and in 1983, NSP began supplementing this data (UCS, Assessing Wind Resources, 6/5/02). In 1994 NSP turned all of it data over to DPS which them compiled a database of all available information and produced this summary report. This report is the 13th to be published, but the first to include data from the new and upgraded wind stations. The document can be found on the DOC website at: http://www.commerce.state.mn.us/pages/Energy/ModTech/pdfs/wrap_99.pdf.

Energy: Modern Technology – Wind, a Minnesota Department of Commerce website that includes several wind maps that highlight wind potential around the state. The maps are available at: http://www.commerce.state.mn.us/pages/Energy/ModTech/windmaps.htm.

Minnesota Wind Resources Analysis Program – October 1996 Report from DOC summarizes data compiled from Minnesota since 1981. Earlier edition of the report described above and more comprehensive.

Harvest the Wind by Lisa Daniels of the Sustainable Resources Center. Harvest the Wind presents a course guide to help individuals understand both the opportunities associated with wind and the potential barriers. It is a very comprehensive evaluation of topics from wind economics, to siting for your turbine, to turbine technology and case studies.
Windustry also has a spreadsheet for assessing costs, production, and incentive numbers. Spreadsheets can be retrieved from: Windustry http://www.windustry.org/calculator/default.htm.

Landownwer's Guide to Wind Energy: In the Upper Midwest by Nancy Lange and William Grant of the Isaac Walton League of America.

Assessing Wind Resources: a Guide for Landowners, Project Developers and Power Suppliers by Michael Tennis, Steven Clemmer, and Jonathan Howland of the Union of Concerned Scientists. This briefing paper is available at the Union of Concerned Scientists website (http://www.ucsusa.org/index.html). It provides any easy to understand and easy to use summary of how to assess the wind potential at your site.

Apples and Oranges, an article written by Mick Sagrillo and published in HomePower Magazine, provides detailed comparisons of various wind turbines. This article can be retrieved at: http://www.homepower.com/files/apples.pdf.

American Wind Energy Association article *10 Steps in Building a Wind Farm* can be retrieved at: http://www.awea.org/pubs/factsheets/10stwf_fs.PDF. This is a very useful document that outlines the items one should consider before moving forward with a wind project. This document also references other websites that list wind developers as well as wind consultants.

Also available on this site are a list of small turbine manufacturers that can be retrieved at: http://www.awea.org/faq/smsyslst.html and a summary of programs, incentives and resources available regarding small-wind project development in Minnesota available at: http://www.awea.org/smallwind/minnesota_sw.html.

ADDITIONAL REFERENCES:
Plugging Into Green Power
Lac qui Parle Valley newsletter, Jan-Feb 2002.

CONTACTS FOR ADDITIONAL ASSISTANCE:
Rory Artig
Minnesota Department of Commerce
Energy Division
Email: rory.artig@state.mn.us

John Dunlop
AWEA Great Plains office
Phone (612) 377-3270
Email: JRDunlop@igc.org

Byllesby Dam Case Study – Hydroelectric Power Revisited
*symbols: sun, recycling symbol, hand holding city

This case study is a great example of putting a decommissioned resource back to use. Construction of the Byllesby Dam was completed in 1911. It produced power for NSP until 1966. In 1968, NSP transferred ownership of the dam over to Goodhue and Dakota Counties. It remained decommissioned until the mid-1980's when the two counties jointly decided to put it back into operation. In 1987, North American Hydro began to refit the dam for hydro production. The Byllesby Dam now provides 2.6 MW of renewable energy via three generators and a 56-foot head.

Dakota County manages the dam, but the generation itself, along with the paperwork and operation and maintenance details, are contracted out to North American Hydro, a private firm. North American Hydro also provided the upfront capital to restart the project. The two counties and North American Hydro share the revenues from the electricity generation, which are generally put back toward dam maintenance charges. Although it does not generate a profit for the counties, it does help them cover their costs, while also putting local, renewable energy back into the grid.

For more information contact; Bruce Blair, Dakota County Park Service, 651-438-4960, bruce.blair@co.dakota.mn.us

CHAPTER 4: HYDROELECTRIC

Minnesota currently has about 32 hydroelectric generating stations that produce slightly less than 150 megawatts of capacity. Most of these projects are smaller than four megawatts of capacity, although there are a few projects with greater capacity. About 3% of Minnesota's energy consumption is currently derived by hydroelectric power, but Manitoba Hydro, a controversial hydro project in Canada, supplies the vast majority of this energy. Whereas most of Minnesota's hydroelectric stations function as run-of-river operations, the Manitoba hydro project, as well as many other hydroelectric stations in the Pacific Northwest, operate in peaking or storage mode. For further details on these operational styles, please see Hydropower Basics below.

Hydropower development typically requires that the supporting infrastructure (i.e., transmission lines, site access, dam development) is either present or readily available for development. Sites available in Minnesota have limited capacity and most of the significant hydroelectric resources of the state have already been captured. There is not, therefore, significant development potential for large hydropower projects, but a few small sites with the necessary infrastructure support do exist. These sites could present potential small-scale electricity generation opportunities for rural areas. Indeed, the Idaho National Engineering Laboratory prepared a U.S. Hydropower Resource Assessment for Minnesota in July 1996 that identified 40 sites with undeveloped hydropower potential. Most of these sites are classified as small (in the range of kW of capacity) hydropower sites, with 60% of the sites with capacities of 1 MW or less (Idaho National Engineering Laboratory http://hydropower.inel.gov/state/mn/mn.pdf).

In Minnesota, communities may find the opportunity to develop hydroelectric power at formerly decommissioned dams that, while storing water, are not taking advantage of their electric generation potential. These sites hold the most promise for future hydroelectric power development in Minnesota.

Crown Hydro Case Study – Renewable Energy for Metro Markets
*Symbols: sun, hand holding city

Crown Hydro received funding through Xcel Energy's Renewable Development Fund to renovate the former Crown Mill facility located on the east end of St. Anthony Falls. The project will consist of a reconstructed upper canal and intake tunnel, a powerhouse room containing two hydropower units with a total capacity of 3400 kW, an existing trailrace tunnel as well as a reconstructed trailrace tunnel, and an underground transmission line.

This project has yet to begin due to some remaining barriers. A few of these barriers include: a workable power purchase agreement with Xcel Energy (currently offering 3.2 cents per kWh), approval of Fish Restitution Plan by the Department of Natural Resources, approval from the State Historical Society, and a Leasing Agreement from Minneapolis Park Board to use their land. As numerous barriers remain before the project can break ground, it is unclear whether or not this project will more forward. However, it does provide an interesting example of how hydropower might work in Minnesota as well as the obstacles that must be overcome in securing such a project. Crown Hydro would take advantage of an existing untapped resource to provide additional capacity to the surrounding metro-area and provide clean, renewable energy to a highly populated, energy demanding community.

For more information contact; Tom Griffen, Crown Hydro, 612-825-1043, tgrifhydro1@usfamily.net

HYDROPOWER BASICS

Hydroelectric power plants convert the potential energy in water pooled at a higher elevation into electricity by passing the water through a turbine and discharging it at a lower elevation. The water moving downhill turns the turbine to generate electricity. The elevation difference between the upper and lower reservoirs is called the "head". Hydroelectric power facilities are typically categorized as either low head (under 60 feet) or high head. Most of the facilities in Minnesota are low head operations due to the relatively small elevation changes.

Operational Modes

Hydropower facilities operate via three primary operational modes. Many projects can function in more than one of these modes. As mentioned above, most of the projects in Minnesota function as run-of-river projects. The three types of hydropower operational modes include:

- Run-of-river mode uses the natural flow of the river by channeling a portion of the river to a canal to spin the turbine. This may or may not require the use of a dam, but technically required that the flow into the reservoir and out of the reservoir are equal.
- Peaking mode impounds and releases water when the energy is needed.
- Storage mode impounds and stores water during high-flow periods to augment the water available during low-flow periods, thus allowing flow releases in power production to be more constant. Pumped storage mode allows hydropower facilities to store power by pumping water from a lower reservoir to an upper reservoir during periods of low-energy demand. Then during periods of high-energy demand the water can be re-released to the lower reservoir to spin the turbines and create electricity.

BOX:

Limiting factors: Potential Environmental and Social Concerns

Large hydroelectric projects can have severe impacts on their surrounding communities and ecosystems. Some of the impacts can include complete dislocation of communities and flooding of surrounding villages or local extinctions and restriction of fish movement. Smaller scale projects, like those possible within Minnesota, tend to minimize these impacts. This is not to say that small hydro project will have no environmental or social impacts, but that they are often less severe. To better address the potential environmental and social concerns, it is imperative that project developers do an environmental analysis on their site that includes an analysis of the potential impact to flora and fauna. For projects of less than 5 MW, a formal environmental assessment is not required, but it would still behoove the developer to address these environmental issues to ensure community buy-in.

END BOX

Current Technology Status

Hydroelectric power generation is a well-developed technology and therefore is generally very reliable except during periods of sustained drought or in the presence of ice, both of which limit the availability of water to turn the turbines. Hydroelectric plants boast an overall efficiency of about 80 percent, significantly higher than that of either coal or natural gas. The capital costs for constructing a hydropower facility are estimated to be in the range of $1,700 to $2,300 per kilowatt (1996 dollars). Operating costs of hydroelectric plants are often low in comparison to those of fossil fuel plants because the flowing river water generally has no direct cost associated with its use.

A GOOD MINNESOTA CONCEPT

Park Rapids Case Study: An Opportunity to Retrofit a Former Structure (symbols: sun, recycling symbol, hand holding city)

Study on generating power at the Fish Hook River dam in Park Rapids began in 2000 as part of grant that funded research on alternative community energy generation possibilities. This study selected five study sites. One was the Fish Hook River dam. A hydropower facility was originally built at the dam in 1909 but was decommissioned in 1943, and has sat unused ever since.

Park Rapids saw a great opportunity at their underutilized dam. After all, they had both the dam and the plant already there. While the upfront capital costs would be high to obtain turbines, the project would put more renewable energy into the community and would reduce the amount of coal needed to generate Park Rapids electricity. Additionally, the current project could draw upon a 1982 feasibility study that had also evaluated the potential of reactivating the site but never came to fruition.

In nearly every sense, the project seemed well aligned. If successful, the project could serve as an example to other communities around the state with inactive power facilities at existing dams. Unfortunately, plans to reactivate the power facility on Fish Hook River were dropped in April 2002. Park Rapids City Council decided that the expected generation of only 100 kW/hour meant that the project was not economically feasible, and that at least 200 kW/hour would have been necessary for the project to move forward. In the end, it appears that delayed research findings may have stalled the project too long and swayed council members to pass up an opportunity without ever getting the full story. Project supporters are now looking at applying for an Xcel Energy Renewable Development Fund grant that could provide partial funding and help make the project a reality.

For more information contact; Paul Imbertson, 612-625-6529, imber003@umn.edu

HELPFUL RESOURCES FOR COMMUNITIES:

Office of Energy Efficiency and Renewable Energy: Hydropower Topics and *Hydropower Basics*: www.eren.doe.gov/RE/hydropower.html, and http://www.eren.doe.gov/RE/hydro_basics.html - sites include basic hydropower information and descriptions of types of turbines

U.S. Hydropower Resource Assessment for Minnesota developed by James E. Francfort of the Idaho National Engineering Laboratory for the US DOE and published in July 1996. This resource outlines sites available in Minnesota with undeveloped hydroelectric potential by dam status group and by river basin. The report can be retrieved at http://hydropower.inel.gov/state/mn/mn.pdf.

Minnesota Department of Commerce *2001 Energy Planning Report.* Includes basic information regarding hydropower projects in Minnesota and the potential associated environmental and social costs

St. Anthony Falls Laboratory: http://www1.umn.edu/safl/index.html. Provides information about research and publications available from this University of Minnesota research laboratory.

Minnesota Department of Natural Resources Hydropower: http://www.dnr.state.mn.us/waters/surfacewater_section/stream_hydro/hydropower.html - This website provide links to pertinent licensing organizations, information about potential environmental impacts, and listings of Minnesota's hydropower facilities.

Federal Energy Regulatory Commission: Hydropower: http://www.ferc.gov/hydro/docs/waterpwr.htm - Link to FERC site that outlines the preliminary and final permitting requirements as well as permit conditions reviewed (including environmental and safety issues) and parties that must be involved in any permitting process for a hydroelectric facility.

CONTACTS FOR ADDITIONAL ASSISTANCE:

John Thene
Associate Director, Contract Research and Engineering
St. Anthony Falls Laboratory
Phone: 612.627.4609
Email: thene@tc.umn.edu

John S. Gulliver
University of Minnesota, Department of Civil Engineering
Phone: 612.625.4080

Email: gulli003@tc.umn.edu

Minnesota Wood Energy Scale Up Project Case Study
*Symbols: sun, tractor, dollar sign
Begun in 1994, the Minnesota Wood Energy Scale Up Project, based in Alexandria, Minnesota, was the first biomass to electrical energy research project involving hybrid poplars. The project is a partnership between WesMin RC&D, the Oak Ridge National Laboratories Biofuels Feedstock Development Program, and local landowners. Currently, the project consists of 1,800 acres of privately owned cropland, all located within 50 miles of Alexandria. Landowners are supported in their efforts by cost share agreements for maintenance and pest control while the WesMin RC&D and Minnesota Department of Natural Resources work with landowners to plant and maintain the poplars as well as measure and collect tree growth data. The Biofuels Feedstock Development Program calculates the hybrid poplars annual yield. All of this data is then combined with economic data to assess on-going feasibility of hybrid poplar projects. The Minnesota Wood Energy Scale-Up Project represents a true community merger that has brought together numerous stakeholders all working to take charge of their energy future and economic development by capitalizing on a locally grown, perennial, renewable energy resource.

For more information contact; Dean Schmidt, 320-763-3191 x. 5, dean.Schmidt@mn.usda.gov

CHAPTER 5: BIOMASS

Minnesota currently has 123.6 MW of biomass electric generation capacity. The Union of Concerned Scientists estimates that with existing technology, biomass can produce 30 times as much energy as solar power and wind energy combined. But what exactly is biomass? Biomass is defined as any organic materials not derived from fossil fuels that can be converted to a fuel useful for generating electricity. Biomass can be waste products, as described in the Rahr Malting Case Study below, or can be dedicated crops, like those just described in the Minnesota Wood Energy Scale Up Project. Look at the "Sources of Biomass" section below for more details.

Rahr Malting Case Study – An Opportunity to Utilize Biomass' Potential
*should have a picture here to show facility; symbols: recycling symbol, dollar sign
Rahr Malting is a family-owned malting business located in Shakopee, Minnesota. As a malting facility, Rahr Malting must have a reliable energy supply to operate its plant and manage its ongoing biological processes. Indeed, its two biggest processing costs are electricity and natural gas. Rahr Malting produces 50,000 tons of biomass (low-value by-product) annually. It is also surrounded by numerous facilities (located within 50 miles) that could provide additional low-value biomass by-products and by farming land that could grow energy crops to supplement its biomass supply. Rahr Malting is considering building a 20 megawatt combined heat and power facility that at full capacity Rahr malting would be able to provide for all of its electrical needs, generate an additional 12 megawatts for the surrounding community, and supply a minimum 20-30% of its process heating needs.

However, as of summer 2002, the project is still on hold. As described in Rahr Malting's document *Rahr Malting 20 Megawatt Biomass to Energy Projec*, the size and scope of the construction project, the number and kinds of jobs created, the increased agricultural demand, and the energy generated will have extensive direct and indirect effects on the local economy. Rahr Malting is currently waiting to see if the final U.S. energy bill will contain incentives for biomass energy generation. Both the House and Senate bills have wording that would include such a subsidy, but the legislation is currently in conference committee and the final language has yet to be announced. In addition, Rahr continues to seek a partner to buy the 12 MW of excess energy that will be produced. This power purchase agreement is a crucial component to the project, and will be key to establishing the project's economic viability. The avoided energy costs and reduced operating costs for waste material transportation and disposal cannot ensure project viability. Hopefully, the pieces will come together to give Rahr Malting a needed financial boost to help push the project down the path to completion.

For more detailed information on the project, please see Rahr Malting's document *Rahr Malting 20 Megawatt Biomass to Energy Project* referenced in the links at the end of this section.

For more information contact; Paul Kramer, Vice President, Rahr Malting, 952-496-7002, pkramer@rahr.com

BIOMASS BASICS

Biomass generates electricity via combustion that releases the plants' stored solar energy. Biomass is therefore considered a renewable energy source because it can be either grown or created again. In addition to being renewable, another benefit of biomass is that it can be burned on demand, unlike wind or solar, which makes it a more reliable source of energy.

Sources of Biomass (feedstocks): (should have a map or something showing areas where these fuels might be located or where this is already being used or something like that)

- <u>Wood residues</u> – produced at lumber, pulp, veneer and other wood fiber mills; can also come from forest thinnings, urban tree trimmings, residual construction material, demolition material, wood pallets, and post-consumer waste; primarily used in direct combustion systems which is a mature technology; using these residues can help reduce the amount of material going to landfills (have picture of lumber yard or something where this could be implemented)
- <u>Agricultural residues</u> – include mill residues (left over after agricultural product is processed such as nut hulls and oat hulls) and field residues (left in field after harvest, like corn stover and wheat straw); this can impose environmental impacts on soil by removing materials that would have been used as a natural source of soil nutrients if they had been left in place – (should have picture of stover or nut hulls)
- <u>Energy crops</u> – include primarily willows, hybrid poplars, sweetgum, maple, and sycamore as woody crops and switch grass as the primary herbaceous crop; favorable alternative because crops can be grown in a more concentrated area (less dispersed geographically); an environmental benefit of energy crops is that they can be grown on degraded and abandoned land to reduce run-off and soil erosion; switch grass in particular can offer significant advantages in reduced fertilizer and pesticide use in comparison with conventionally grown crops and also benefits soil because it is a perennial crop (should have picture of various trees and switch grass)
- <u>Animal waste</u> – both wet (swine and dairy cow manure) and dry (poultry); can be converted to gas or burned directly for heat and power; see more in anaerobic digestion section
- <u>Sewage sludge</u> – comes from solids in wastewater collected from homes and businesses (biosolids); can also be converted to gas via anaerobic digestion; see more in anaerobic digestion section

- Biogas – methane derived anaerobic digestion and collected in landfill gas recovery systems; see more in anaerobic digestion section
- Biofuels – liquid fuels primarily used in transportation applications; includes biodiesel from soybeans and ethanol from corn; both of these crops are considered high environmental impact crops due to their heavy use of fertilizers and pesticides as well as the requirement for annual tillage; in the future other cellulosic materials may prove to be a more sustainable and yet viable biofuel source; see more in biodiesel and ethanol section

Environmental Considerations

There are several potential environmental concerns associated with using biomass feedstocks for energy. Many of these concerns relate to the necessity of incorporating sustainable agriculture practices into the growth of biomass energy crops. In some instances, using biomass for energy production rather than for use as a natural fertilizer or bio-product, means that the biomass is not being used in the most sustainable way. Additionally, the actual production of biomass energy crops should be done in a sustainable way that provides net environmental benefits to the ecosystem. Criteria that should be used to evaluate sustainable biomass energy production include:

- Impact on water quality – biomass crop growth should not cause pollution via sediments from erosion, pesticides, nutrients or waste products.
- Impact on soil quality – soil quality should not be degraded.
- Effect on wildlife – there should be no detrimental impact on local wildlife in comparison to alternative land uses.
- Effect on air quality – biomass energy production should improve air quality via net reductions in air pollutants.
- Net energy balance – more energy should be released through biomass than is consumed in producing it (including planting, cultivating, treatment, harvesting, and transportation).
- Diversity – biomass productions must avoid imposing a mono-culture; crop rotations must be incorporated.

Some of the above listed sources are more sustainable and environmentally friendly that others. More information on the environmental pros and cons can be found at Office of Energy Efficiency and Renewable Energy, http://www.eren.doe.gov/RE/bio_integrated.html. Generally the most positive environmental benefits of using biomass energy stem from the diversion of wastes that would have otherwise caused pollution (e.g., from methane, from water run-off) and from the displacement of fossil fuel energy use and therefore its associated environmental impacts.

BOX:

Facilities in Minnesota currently utilizing “bioenergy” fuel sources often use milling and logging residues. Some examples include:
Blandin Paper – Grand Rapids
Boise Cascade – International Falls
Champion Paper - Sartell
Potlatch Corporation – Cloquet and Bemidji
Minnesota Power – Duluth

New facilities in development to fulfill Xcel Energy 125 MW biomass mandate include:
St. Paul District Energy – utilizing urban wood waste
St. Peter CRP – utilizing whole tree technology
Fibrowatt – utilizing turkey litter
END BOX

Three Mechanisms to Convert Biomass to Fuel:

- Homogenization – most common homogenization includes sorting and size reduction (cutting, grinding, pulverizing); sorting helps eliminate contaminants and size reduction helps injection of material into combustor at a more constant rate and creates greater surface area to allow maximum burn efficiency; can also include dewatering
- Gasification – to convert solid biomass to gaseous fuels (synthesis gas or syngas); conversion by pyrolysis (heating of organic matter in absence of oxygen), partial oxidation, and steam reforming (inject biomass with hot steam to form syngas, usually in absence of oxygen)
- Anaerobic Digestion – of animal waste, or landfilled waste, or sewage sludge (all converted to methane); reduction of complex organic compounds by microbes in the absence of molecular oxygen, generates methane and carbon dioxide; this is discussed at length in the anaerobic digestion section.

Box:
Types of Generators that Produce Electricity from Biomass:

- Boiler-steam turbines – direct combustion of materials powers a boiler than drives a steam turbine; three types of boilers: stoker boilers (mechanical feed to introduce solid fuel), pulverized fuel boilers (solid reduced to a fine powder and then sprayed into combustion chamber), fluidized bed boilers (solid fuel introduced into a bed of preheated, non-combustible sand that is held in a fluidized state by air blowing upwards from underneath).
- Combustion turbines (gas turbines) – cheap and inefficient; rotating internal combustion engine; function by injecting liquid or gaseous fuel and combusting it with compressed air – the heat of combustion causes the gases to expand, these gases then rotate the turbine.
- Combined cycle turbines – cleanest and most efficient; combusts like a combustion turbine but the hot exhaust gases used to heat water in a heat recovery steam generator which then drives a steam turbine (as well as the original combustion turbine)
- Integrated gasification combined-cycle turbines (IGCC) – marries gasification with combined-cycle; while cooling of syngas from gasification is done with a heat recovery steam generator to get added electric generation by driving the steam turbine during cooling before combustion
- Reciprocating engines – internal combustion engine; most likely spark-ignition engines which inject fuel gas and air
- Co-firing – burning a certain amount of crop with coal in a boiler-steam turbine combuster – most likely way in which energy crops will become part of national power mix (can potentially be done at existing plants with little new capital investment)

END BOX

HELPFUL RESOURCES FOR COMMUNITIES:
Rahr Malting 20 Megawatts Biomass to Energy Project assembled by ME3 in October 2001 catalogues the story of the Rahr Malting biomass project from projected fuel costs to economic and environmental benefits. The document can be retrieved at: Rahr Malting http://www.me3.org/issues/biomass/rahrchpstudy.pdf.

From Plants to Power Plants: Cataloging the Environmental Impacts to Biopower, written by Nathanael Greene of the NRDC along with Roel Hammerschlag and John Martin. Currently in draft form, this publication is not yet available to the public, but when finished it will provide a wealth of information regarding the various biomass resources, their environmental impacts, and their use as an energy feedstock

Energy from Biomass, written by Loni Kemp of The Minnesota Project. This article details the three crops Minnesota farmers have the most experience with (corn, alfalfa, and hybrid poplar) that could be as biomass fuels and is available at the Minnesota Department of Agriculture website at: http://www.mda.state.mn.us/crp/biomass.htm.

Biomass for Electricity Generation, written by Zia Hag. This article details biomass feedstock supply curves – how much the various feedstocks cost, the likely supply quantity, and how much it would cost to transport them – also provides predictions regarding energy generation potential at various future time frames under several different scenarios (Kyoto controls, standard, 20% renewable energy standard). The article can be retrieved from the Energy Information Administrations website at: http://www.eia.doe.gov/oiaf/analysispaper/biomass/index.html -

Renewable Energy Policy Project website that covers a broad range of biomass information from feedstock descriptions to prices to associated environmental impacts. http://crest.org/articles/static/1/1004994679_6.html#biof

Primary biomass energy page at the Department of Energy http://www.eren.doe.gov/RE/bioenergy.html

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy contains detailed information regarding the various biomass resources http://www.eren.doe.gov/RE/bio_resources.html

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy discussion regarding the social, environmental and economic costs of producing/using biomass as an energy resource http://www.eren.doe.gov/RE/bio_integrated.html

Center for Rural Policy and Development at Minnesota State University, Mankato has a paper on producing short rotation woody crops; discusses economic and environmental benefits and barriers associated with growing woody crops on agricultural lands http://www.mankato.msus.edu/dept/ruralmn/woodycrops.pdf

CONTACTS FOR ADDITIONAL ASSISTANCE:

Doug Tiffany
College of Agricultural, Food, and Environmental Sciences
University of Minnesota
Phone: 612.625.6715
Email: dtiffany@dept.agecon.umn.edu

Dean Schmidt
WesMin Resource Conservation and Development Council
Phone: 320.763.3191, ext. 5
Email: dean.schmidt@mn.usda.gov

Perham Digester Pilot Program – An Example of a Digester Partnership
* Symbols: sun, tractor, recycling symbol, dollar sign

Perham Community Digester, located in Perham, Minnesota, will combine the waste streams of Little Pine Dairy, a 1400-cow dairy farm, with the waste streams of a food processing company. This project promises to be an excellent opportunity to test the possibility of combining multiple waste streams to create jobs at a central facility, increase the profitability and efficiency of both the dairy and food processing company, increase local energy self sufficiency, produce renewable energy, and provide multiple environmental benefits. This agriculture and industry partnership exemplifies the ways in which communities can come together to address their energy needs.

For more information contact; Ron Tobkin, Little Pine Dairy, rstobkin@eot.com

CHAPTER 6: ANAEROBIC DIGESTERS

In recent years there has been a resurgence of interest in anaerobic digesters for on farm use because of their ability to help control animal waste odor and other potential environmental problems (See Box 2 for more information). These environmental benefits combined with reduced electric bills has made anaerobic digesters another potential option for Minnesota's rural communities and farmers looking to take control of their energy usage and improve their environment at the same time. On farm uses are not, however, the only anaerobic digester options. Indeed, other industries have been reaping the benefits of anaerobic digestion for years, particularly for waste stream reduction. This chapter will discuss both on farm applications and non-farm applications to present the range of options for digester use.

Haubenschild Farms – Making Electricity on the Farm
*Symbols: tractor, recycling symbol

Haubenschild Dairy Farm, a 1000-acre, family owned and operated dairy farm located near Princeton, Minnesota, is a quintessential example of local energy production using indigenous resources and reusing waste products all-at-once. In 1998, as the owners planned to increase the scale of their operation, they considered installing an anaerobic manure digester. Haubenschild Farms received assistance from the Minnesota Department of Agriculture, Department of Commerce, and Office of Environmental Assistance, as well as the federal AgSTAR program. Construction of the digester began in the summer of 1999 and was completed in October 1999. Total cost of constructing the digester and generator system was roughly $355,000.

The Haubenschild Dairy Farm collects manure from its approximately 750 cows. The manure passes through a covered 350,000-gallon, in-ground concrete tank anaerobic digester. Suspended heating pipes heat the manure inside the digester and put bacteria to work breaking down the manure and creating methane. A 150-kilowatt engine-generator set is then fueled with the methane captured from the digester and used to generate electricity. The hot water used to heat the digester is recovered from the engine-generator's cooling jacket and reused to heat the barn floor space. The digested effluent is stored in a lined storage lagoon for later use on the fields for crop production.

The farm produces enough electricity to meet all on-farm electric needs plus enough excess electricity to power about 745 homes. The excess electricity is sold to East Central Energy, a local electric cooperative, which markets the "cow power" as green electricity to its

customers for a slight mark-up to cover its increased distribution expenses. Haubenschild Farms are expected to achieve payback on their initial investment in about 5 years.
(source: Final Report, Haubenschild Farms Anaerobic Digester, by Carl Nelson and John Lamb, December 2000, www.mnproject.org)

For more information contact; Henry Fischer, East Central Energy, 763-689-8055, henryf@ecemn.com

ANAEROBIC DIGESTER BASICS

Anaerobic digestion is a natural, biological process – similar to composting – that breaks down liquid manure, sewage, or industrial wastes, producing biogas in the process. Landfills also produce biogas that can be captured and burned. This biogas is about 55 – 70 percent methane, the primary component of natural gas, and therefore can make an excellent energy source. Anaerobic actually means "without oxygen," and the bacteria that produce the biogas generally thrive at two temperature "zones" from 95-105^{o} F, and from 125 to 135^{o} F. Although anaerobic digestion occurs at lower temperatures, it is not as efficient at producing biogas.

Good diagram on page 55 of From Plants to Power Plants of Carbon Cycle of Animal Manure – anaerobic Digestion Biopower; insert next to text.

Box 1: Three Primary Types of Digesters for On-Farm Use
While engineers have developed many digester designs for use in treating sewage and industrial waste streams – some of them quite complex – there are three basic designs in commercial use on farms.

- **Covered lagoon:** least expensive, large lagoon covered with impermeable cover, best for liquid manure; does not work well for energy production in Minnesota because it is not heated, but does help curb odors.
- **Complex Mix Digester:** works for manure with 3-10% solids (swine or dairy) that can be collected by a flush system; manure processed in heated tank (above or below ground) and solids kept in suspension by mixer; expensive to construct, and more expensive to operate/maintain than plug-flow.
- **Plug-Flow Digester:**(good figure on p.7 to add) works well for manure with solids concentration of 11-14 %, like cow manure; mixes manure then moves it through the digester in a "plug" (gummy clump of manure). Anaerobic digestion creates biogas that moves through digester; the digester is heated by suspended hot water pipes, and the gas is stored under an impermeable cover.

END BOX

Box 2: Environmental Benefits and Potential Concerns:
Environmental Benefits:
- Odor reduction
- Energy production – "green power" and distributed generation
- Pathogen reduction
- Possible weed seed reduction
- Greenhouse gas reduction

Potential Concerns:

- Nitrogen and ammonia emissions – Digesters break down organic nitrogen in the manure to an ammonia form. This can be both a benefit – it is more easily available as a nutrient to plants – and a potential concern, as ammonia nitrogen can be more easily lost to the air, where it is a pollutant. Nitrogen loss can be minimized by using proper management practices such as: injecting the digested manure into the soil instead of spreading it; maintaining a crust on the storage pond; and reducing the surface area of the storage pond.
- Water pollution from potential surface water run-off or groundwater contamination from liner leakage
- Air emissions from combusting biogas
- Safety concerns related to inhalation of biogas and biogas flammability.

END BOX

Will a Digester Work for My Farm?
AgSTAR Handbook includes 5 criteria for preliminary screening of potential anaerobic digester projects at dairy or swine feedlots. For complete information on conducting a pre-feasibility assessment, farmers should see the Ag STAR handbook.

1. Do you have a "large" confined livestock facility?
   Ag STAR defines large as at least 300 head of dairy cows/steers or 2000 swine, although digesters have been successful at smaller farms.
2. Can you ensure year-round, stable manure production and collection?
   A digester needs to be constantly and regularly "fed" manure to maintain methane-producing bacteria.
3. Do you have a manure management strategy that is compatible with digester technology?
   Digester technology requires the manure to be: managed as a liquid, slug or semi-solid; collected at one point; collected regularly; and free of large quantities of bedding and other materials (i.e., rocks, sand, straw).
4. Do you have a use for the energy recovered?
   Can a generator be installed to produce energy and will a local utility purchase it? Are your on-farm electricity costs high? Is there another use for the energy on-farm? If you answered yes to any or all of these questions, then anaerobic digestion may work for you.
5. Do you have someone to efficiently manage the system?
   Successful digester operation requires an interested operator who will pay attention to performing the daily routines of digester maintenance and possesses basic "screwdriver friendliness".

In addition to working for individual farmers, anaerobic digesters also present an opportunity for community cooperatives. This could be set up such that one company performs all of the maintenance and management of the anaerobic digestion systems at multiple farms. It could also be set up to gather the waste product produced at several smaller farms and process it at one centralized digester facility. This could make the project more economically viable for smaller farmers as their resources could be consolidated to meet the fuel input criteria.

OTHER TYPES OF ANAEROBIC DIGESTERS

AnAerobics and Seneca Foods Case Study – Anaerobic Digestion and Food Processing

*****Symbols: sun, recycling symbol, hand holding city

AnAerobics provides treatment services for organic waste streams using its patented and proprietary technologies. Seneca Foods is a corn and pea processing plant located in Montgomery, MN. The two came together when Seneca Foods realized it would need to expand its land application base in order to renew its wastewater discharge permit, and decided instead to contract with AnAerobics to treat its entire waste stream rather than continue land applying it. AnAerobics, although a wastewater treatment company, always recognizes the potential to generate energy from the tremendous volume of gas that is often produced at the treatment plant. So, while the primary goal of the project was to help Seneca Foods meet its waste stream requirements, AnAerobics realized that Seneca Foods was the perfect location for a complete treatment-to-energy system.

Using a proprietary technology that simultaneously treats both the solid and liquid waste, AnAerobics estimates that 85% of the solids treated will be converted to useable gas. This methane will then be used to generate 1.5 MW of energy capacity. This will allow Seneca Foods to utilize renewable energy all the while reducing its waste stream. The completed treatment-to-energy facility is expected to be fully operational in 2003.

For more information contact; Sarah Ploss, Seneca Foods and Anaerobics, 315-364-5062, sjp7@anaerobics.com

Landfill gas

Significant quantities of methane and other volatile organic compounds are emitted from municipal solid waste landfills. Biogas from landfills typically has a methane content of approximately 40-55%, with the remaining gas made up of primarily carbon dioxide (carbon dioxide), as well as some nitrogen (N_2) and hydrogen sulfide (H_2S) (Handbook of Biogas Utilization, 2-15). This gas can be used to generate electricity at the landfill site by collecting the gas and burning it to power a gas turbine and produce electricity. Most of the significant capacity landfill gas projects in Minnesota have already been constructed, but a study conducted in association with Lakefield Junction natural gas plant suggested that some landfill gas-based generation potential still exists in Minnesota. The study suggests that additional landfill gas projects could add roughly two additional megawatts a year in generating capacity. Existing municipalities and landfill facilities not yet incorporating such a process should explore the option to help lower their electric bills and to reduce the amount of methane they release.

Landfill gas systems convert energy at an efficiency rate of approximately 17 to 26%. Landfill gas systems are reliable and are expected to be available for combustion over 90 percent of the time. Capital costs for constructing a landfill gas facility is slightly under $1,000 per kilowatt. Annual operating costs are likely less than for a traditional fuel-fired power plant because the landfill gas is not typically purchased. At this point, few if any cost-effective sites remain in Minnesota (per MP-Allete investigation). Hence, the combustion of landfill gas serves more to improve the economics of solid waste management by producing onsite electricity, rather than to contribute significant capacity to the grid.

Some examples of existing landfill gas project in Minnesota include:
Browning Ferris Industries in Inver Grove Heights – Pine Bend Landfill
Neo Corp in Eden Prairie – Flying Cloud (Wood Lake Sanitary Services)
Neo Corp in Burnsville – Burnsville Sanitary Services
Power Recyclers Inc. in Anoka – Anoka Landfill

Wastewater Treatment

Much like Landfill gas, using methane generated from wastewater treatment can serve to improve the economics of wastewater treatment by producing onsite heat and electricity. Methane is generated as a byproduct of the anaerobic digestion process that is used to stabilize physical/chemical and biological sludges from treatment processes. These digesters produce biogas with methane contents ranging from 60-70% (Handbook of Biogas Utilization, 2-19). By retaining and using the gas, facilities have the potential to reduce their disposal costs, ensure power reliability, and improve their economic balance sheet.

Rochester Water Reclamation Plant Case Study – A Wastewater Treatment System in Action

*symbols: man on tight rope, recycling symbol, hand holding city

The Rochester Water Reclamation Plant has realized the value of making use of its existing resources. The Rochester Water Reclamation Plant generates methane gas as a major byproduct of its wastewater treatment process that includes anaerobic digesters to stabilize the biosolids. This methane has the potential to provide the plant with a renewable source of fuel that allows more efficient use of onsite resources, handles methane in a more environmentally friendly manner, and saves money on avoided energy costs. During the major plant expansion of 1980, two 400 kW generators were installed which used the methane gas to produce electricity. In 2000, with concerns popping up regarding "code red" energy crises, plant staff got the Rochester Water Reclamation Plant prepared. Partnering with the local Rochester Public Utility, and utilizing the technical knowledge of its staff, plant management decided to look for ways to use the facilities gas more efficiently.

In its current configuration, the Rochester Water Reclamation Plant produces enough methane to reduce its power purchasing needs by 25% during summer months, but it plans to increase this percentage with a number of upgrades. The two existing 400 kW generators are currently being upgraded to 1000 kW generators, both with turbocharged engines that will increase generator efficiency by 20%. The plan is to reroute the excess heat given off by the generators back to the anaerobic digesters. This added heat should increase methane gas available for use in the engine generators by another 25%. Overall, the upgrades should allow the facility to supply 100% of its short-term power needs, and supply 50% of its on-going energy needs – making a significant dent in its fossil fuel energy consumption and making significantly better use of its on-site resources.

For more information contact; Chet Welle, Rochester Water Reclamation Project, 507-281-6190 x. 3003, cwelle@ci.rochester.mn.us

Western Lake Superior Sanitary District Case Study – Wastewater Treatment and Energy

*symbols: man on tight rope, recycling symbol

http://www.wlssd.duluth.mn.us/PR72301.htm on 6/18/02 - taken from press release information.

Another facility that has put its wastewater byproducts to work is the Western Lake Superior Sanitary District wastewater treatment plant in Duluth. In 1999, the Western Lake Superior Sanitary District began a major renovation to install a $32.6 million biosolids anaerobic digestion project. In July 2001, it permanently shut down its incinerator and made the transition to its four, million-gallon capacity digesters. The new digesters use a high temperature-based process (120 to 140^{o} F) to reduce the organic portion of the wastewater to a biosolids product rich in organic matter and nutrients. This biosolids product is used in agricultural land applications. Equipment installed onsite allows the facility to utilize the gas byproduct as well. By the end of summer 2001, Western Lake Superior Sanitary District was using the waste-gas in a special waste-gas boiler to provide the majority of the Sanitary District's heating. Ultimately, in 2003 or sooner, the waste-gas may also power a combustion engine that will generate a portion of electricity used by the Sanitary District.

For more information contact; Kurt Soderberg, Executive Director, Western Lake Superior Sanitary District, 218-722-3336 x. 213

HELPFUL RESOURCES FOR COMMUNITIES:

Nelson, Carl and John Lamb. *Final Report, Updated: Haubenschild Farms Anaerobic Digester*. August, 2002. Can be retrieved from www.mnproject.org.

Ross, Charles C, Thomas Jefferson Drake, III, James L. Walsh. *Handbook of Biogas Utilization, 2nd Edition*. Published for US DOE, Southeastern Regional biomass Energy Program, Tennessee Valley Authority, Muscle Shoals, Alabama. Published July 1996.

Parsons, Robert A. *On-Farm Biogas Production*. Published by Northeast Regional Agriculture Engineering Service. Ithaca, New York: 1984.

From Plants to Power Plants: Cataloging the Environmental Impacts to Biopower, written by Nathanael Greene of the NRDC along with Roel Hammerschlag and John Martin.

AgSTAR Handbook. This publication covers several chapters and appendices with pertinent information about how to go about designed and implementing an anaerobic digestion system The handbook can be retrieved at http://www.epa.gov/agstar/library/handbook.htm. This website provides links to each individual chapter, appendix, etc (all available as PDF documents). It also provides FarmWare 2.0 software. FarmWare will help you decide whether a methane recovery system can work on your farm. To learn how to use FarmWare, please follow the Tutorial Guide that is included with FarmWare Reference Manual (software is available for Windows 98 and 95).

Industry Directory for On-farm Biogas Recovery Systems. This publication can be retrieved from www.epa.gov/agstar/library/ind2.pdf.

Agriculture Utilization and Research Institute digester website: http://www.auri.org/research/digester/diglead.htm - Contains an analysis of the benefits of using an on-farm digester to treat manure as well as a checklist for farmers to use to decide if it is a viable option.

CONTACTS FOR ADDITIONAL ASSISTANCE:

David Schmidt
University of Minnesota
Phone: 612.625.4262
Email: schmi071@umn.edu

Phil Goodrich
University of Minnesota
Phone: 612.625.4215
Email: goodrich@tc.umn.edu

Carl Nelson
The Minnesota Project
Phone: 651.645.6159, ext. 21
Email: cnelson@mnproject.org

Voyageurs National Park Biodiesel Program
*Symbols: earth with graduation cap

Voyageurs National Park began its biodiesel program in September 2000 as part of a Department of Energy pilot program. Park maintenance officials were so pleased with how well the B20 worked in their 2 pickups that first winter, that they expanded their biodiesel program the following year to include all of their diesel equipment, including a barge. Initially park staff were concerned about using biodiesel in the barge since it sits unused from October to June, but they have had no trouble restarting it, and the biodiesel has significantly reduced its smoke output and diesel odors. In fact, Park Maintenance Supervisor Bill Carlson says they would use a higher biodiesel blend if it weren't so expensive to get it and transport it to the park. Voyageurs feels it is setting a good example for environmental stewardship, especially on water ways, by incorporating biodiesel into its fuel mix.

For more information contact; Bill Carlson, Rainy District Maintenance Supervision, 218-283-9821, William_K_Carlson@nps.gov

CHAPTER 7: BIODIESEL AND ETHANOL

(add a picture of a soybean or a soybean farm)

In Minnesota, the use of biodiesel is becoming more prevalent. In fact, Minnesota has been home to several demonstration projects that have put biodiesel to work in real applications. Some of these Minnesota examples include:

- Voyageurs National Park has operated all of it diesel equipped trucks on 20% biodiesel for two years as part of an experimental DOE program that was hoping to test the use of biodiesel in a "worst case" scenario for cold temperatures
- Brooklyn Park now operates its entire city fleet of diesel vehicles on 20% biodiesel
- Hennepin County operates 4 heavy-duty maintenance trucks on B20
- University of Minnesota operates two vehicles on biodiesel, one on B100 and the other B20
- Dakota Electric purchases 1000 gallons of biodiesel to blend in with its petrodiesel and has thereby qualified for 2 EPAct credits
- Department of Commerce received federal funding to perform a demonstration project using B20 in school buses for the winter driving season in 2001 and 2002
- The State Energy Office in the Department of Commerce funded a successful demonstration project using biodiesel in over 15 diesel generators during the Taste of Minnesota in St. Paul in 2000.

Incorporating biodiesel into our fuel mix would not only support the use of renewable energy resources and improve air quality, but it would also help provide additional income to farmers producing soybeans. To gain the biggest benefits from biodiesel, the focus should be toward using it as a transportation fuel, rather than as a substitute in diesel generators. Using biodiesel in generators simply serves as a patch to an existing electric generation problem, and does little to spawn innovative alternative generation solutions for the future. Currently over 27 Minnesota facilities, focused in this transportation sector, sell biodiesel as a 2% biodiesel, 98% petrodiesel blend (see table). Some of these facilities, located throughout Minnesota, will sell and deliver 100% biodiesel in bulk.

Brooklyn Park Case Study

*Symbols: hand holding city, earth with graduation cap

The City of Brooklyn Park was not willing to wait around for a biodiesel mandate. When members of the National Association of Fleet Administrators started talking about alternative fuels and alternative fuel vehicles, Steve Lawrence knew it was time to act. Jon Thiel, his director, agreed. They wanted to be proactive and felt that by acting now they could save a lot of money, and a lot of headaches, in the long run. So, in Fall 2001 the City of Brooklyn Park initiated their biodiesel program.

After one winter of operation with absolutely no complications, they have expanded their program and as of August 2002, now have 88 vehicle units running on B20 – one of the largest such projects currently underway in Minnesota.

City administrators thought that this effort would show the community that it was spending money wisely and planning ahead while making their operations more environmentally friendly. While the fuel is a bit more expensive than standard diesel right now (~ 4 cents higher), city staff feels it will reap the benefits of its forethought in the years to come. Brooklyn Park is now working with the U of M and Hennepin County to be "agents of change" in Minnesota and to further biodiesel development around the state. They have agreed to work with the University's Center for Diesel Research on testing fuel additives that should both reduce biodiesel emissions and enhance biodiesel's performance, making biodiesel an even better option in years to come.

For more information contact; Steven Lawrence, 763-493-8028, stevel@ci.brookly-park.mn.us

BIODIESEL BASICS

So what is biodiesel, you ask? Biodiesel is a fuel commonly made from a chemical reaction between soybean oil, methanol, and lye, although other non-petroleum oils and greases can be used. Biodiesel can be used in its pure form or can be blended to any percentage and is most often used in blends between 2 and 20 percent biodiesel with the remaining percentage filled with petroleum diesel. Biodiesel's use as a transportation fuel in diesel engines is becoming more wide spread, but it can also be readily used in standby, emergency and remote diesel electric generators. Using a biodiesel mixture rather than pure petroleum diesel to fuel emergency generators could help reduce many air emissions that result with use of diesel generators. However, as diesel generators are one of the most polluting sources of energy, biodiesel should not serve as a rationale to install this sort of generator, but rather as a means of improving the operation of, and pollution generated by, existing generators.

Biodiesel reduces concentrations of several air emissions (sulfur dioxide, carbon monoxide, volatile organic compounds, particulates) that result from diesel combustion in proportion to the amount of diesel fuel it replaces. Using only 2% biodiesel would help decrease diesel emissions, but diesel is still a very polluting fuel. Biodiesel slightly increases nitrogen oxide emissions in truck engines that speed up and slow down frequently. It is thought that diesel generators may be nitrogen oxides "neutral" due to their "steady-state" or constant-load generating output, but further research must occur before this can be answered definitively.

Since 2000, the cost of biodiesel has dropped significantly due to a federal program to encourage biodiesel production. In 1998 the US Department of Energy modified the Energy Policy Act (EPAct) to allow the use of B20 to help facilities meet their alternative fuel vehicle mandate. Unfortunately though, cost is still one of the primary barriers to widespread adoption of biodiesel. Currently most suppliers and providers charge an additional $0.01 per percentage point of added biodiesel per gallon, but this number varies. This cost increase can add up quickly for high biodiesel blends if you utilize a lot of fuel. The Cannon Valley Cooperative, located in Cannon Valley, Minnesota, is a rare example of a facility that actually offers solely biodiesel and does not charge any surcharge for its purchase. Other barriers include the lack of a developed distribution system and the lack of direct requirements or incentives to promote its use or to discourage the use of traditional petroleum diesel for utilities and consumers. (Add picture of Cannon Valley coop here).

Cut-out: 1998 EPAct allows regulated federal, state and utility fleets to receive credit for one required alternative-fuel light-duty vehicle for every 450-gallons of biodiesel (in any blend) used per year in a heavy-duty fleet vehicle. END CUTOUT

BOX:
Biodiesel Mandate – The Minnesota Biodiesel Mandate passed into law without the governor's signature on March 15, 2002. It stipulates that diesel fuel sold in the state after June 2005 for use in internal combustion engines must contain a certain minimum percentage of biodiesel fuel oil (2%) by volume. Exceptions to the mandate include railroad locomotives and off road taconite and copper mining equipment and machinery; a temporary exception was also included for motors at electric generating plants governed by the nuclear regulatory commission.
For more information see The Minnesota Session Laws webpage at:
http://www.revisor.leg.state.mn.us/slaws/2002/c244.html
END BOX

Box:
Energy Balance/Energy Life Cycle Inventory

Fuel	Energy Yield*	Net Energy (loss) or gain
Gasoline	0.74	(26 percent)
Diesel	0.83	(17 percent)
Ethanol	1.34	34 percent
Biodiesel	3.2	220 percent

* Yield in liquid fuel Btus per Btu of fossil fuel energy dedicated.
Retrieved from: http://www.mda.state.mn.us/ethanol/balance.html
END BOX

Environmental Benefits
As the percentage of biodiesel goes up, there are reductions in air emissions (including sulfur dioxide, carbon monoxide, volatile organic compounds and particulates). Especially when used with existing diesel generators (peaking or otherwise) located in dense population centers, biodiesel has the potential to greatly improve local air quality. The addition of biofuels to diesel and gasoline allows for more complete combustion, which therefore reduces the amount of carbon monoxide emissions and unburned hydrocarbon emission, causing an overall reduction in ground-level ozone causing pollutants. However, the addition of oxygenated fuels causes combustion temperatures to rise, which results in increased formation of nitrogen oxides.

Biodiesel blends of 100% or 20% also reduce visible smoke and odors. See table below for estimated amounts of air emission reduction.

Emission	B100	B20
Carbon Monoxide	-43.20%	-12.60%
Hydrocarbons	-56.30%	-11.00%
Particulates	-55.40%	-18.00%
Nitrogen oxides	5.80%	1.20%
Air Toxics	-1.5	-0.32
Mutagenicity	-1.7	-20%

Source: http://www.ott.doe.gov/biofuels/environment.html#table

Research on Future Applications

Minnesota is fortunate to have the Center for Diesel Research located right here at the University of Minnesota, Twin Cities. Kelly Strebig and his team at the Center for Diesel Research have been doing innovative research to test the potential for biodiesel in peaking and emergency generators. As part of this project they have initiated a pilot project to measure the air emissions resulting from various blends of biodiesel, from 10% to 100%, and with use in various engines. This research will contribute significant data that should help optimize future generator designs and fuel blends such that our diesel generators, if they absolutely must be put to work, will do so using at least partially renewable, cleaner burning fuels.

In another future thinking project, the Center for Diesel Research is involved in researching the use of raw soybean oil in gas turbines. This use would allow both reduced fuel processing and allow the use of biodiesel in larger power-production operations.

THE ETHANOL STORY

Minnesotans began using ethanol as a standard blend in their gasoline in 1996. At first it was just used during the winter and Minnesotans actually had to import their ethanol. Now, however, even with Minnesota auto fuel comprised of 10% ethanol year round, Minnesota is actually producing 40-50% more ethanol than it actually needs and exporting the rest. Ethanol has become a true success story in Minnesota, as it has produced another market for homegrown corn while also playing a major role in helping air quality and allowing Minnesota to shift away from MTBE. MTBE, a fuel additive that rose to the fore in 1990 as a fuel oxygenate, was found to pose a significant environmental threat to groundwater and surface water because it moved quickly when released, and was almost impossible to break down. Ethanol has become a popular replacement, and ethanol production has since grown from 0.2 billion gallons in 1980 to over 2.2 billion gallons in 2002.

Ethanol can be produced by either wet milling or dry milling corn, although Minnesota also uses whey to produce ethanol and other states have incorporated other feedstocks. Dry milling is the most common process used in Minnesota, and consists of grinding up the corn and adding water to make mash. The mash is then cooked to kill of the bacteria and the starches are exposed. Enzymes are added to covert the starch to sugar, which is then converted to ethanol by yeasts. The ethanol is then purified for use as a fuel.

Ten of Minnesota's 14 ethanol-processing facilities are actually owned by farmer cooperatives, which means that the farmer owners benefit from the economic value added, rather than losing it to a large company. This provides a mechanism to strengthen rather than depress Minnesota's rural communities. Minnesota's ethanol model could also be copied for other renewable energy resources.

The major hurdle restricting the more widespread growth of E85, an 85% blend of ethanol fuel with gasoline, is the state's poor ethanol infrastructure system and the inability to transport ethanol via a pipeline. However, as fuel prices rise and availability of oil declines there may be greater momentum to push for change.

Map of ethanol plants in MN: http://www.mda.state.mn.us/ethanol/images/ethanolplants.gif

HELPFUL RESOURCES FOR COMMUNITIES:

Clean Fuels: Developing Fuels to Benefit Minnesota's Environment and Economy. A brochure written by the Minnesota Department of Commerce includes descriptions of biodiesel as well as several other clean fuels, including ethanol and hydrogen. This brochure can be retrieved at: http://www.commerce.state.mn.us/pages/Energy/ModTech/pdfs/RENUFUEL.PDF.

Official website of the *National Biodiesel Board* that offers biodiesel basics, updates on current legislation and projects can be found at: www.biodiesel.org

The *National Corn Growers Association* has information on Ethanol and the Farm Bill at: http://www.ncga.com/

Carbohydrate Economy website is a veritable clearing house of resources on ethanol and other carbohydrate-based fuels accessible at: www.carbohydrateeconomy.org

CONTACTS FOR ADDITIONAL ASSISTANCE:

Kelly Strebig
Center for Diesel Research
University of Minnesota
Phone: 651.457.1404
Email: streb002@umn.edu

Doug Tiffany
College of Agricultural, Food, and Environmental Sciences
University of Minnesota
Phone: 612.625.6715
Email: dtiffany@dept.agecon.umn.edu

Ralph Groschen
Agriculture Marketing Specialist
Minnesota Department of Agriculture
Phone: 651.297.2223
Email: Ralph.Grolschen@state.mn.us

Ben Brown

Heartland Corn Producers
Phone: 507.647.5000

Minnesota Biodiesel Distributors

retrieved from http://www.biodiesel.org/default2.htm on 6/25/02

Company Location	Phone	Contact
Ascheman Oil, Danvers	320-567-2338	Ron Ascheman
Barnesville Farmers Oil, Barnesville	218-493-4606	Tammy Haden
Cannon Valley Coop, Northfield	507-645-9556	Andy Swanson
Chamberlain Oil Co., Inc.	800-922-8815 or 320-843-3434	John Chamberlain
Community Coop Oil, Essig	507-794-6655	Doug Lund
Consumers Coop, Clarkfield	320-669-4426	Jim Smally
Crystal Coop, Lake Crystal, Vernon Center & Nicollet	507-726-6459	Glen Thompson
CW Farmers Coop, Wolverton	218-995-2565	Roger Christiansen
Dooley Oil, Murdock	320-875-2641	Randy Dooley
Farmers Coop Oil, Echo	507-925-4114	David Forkrud
Glazier Plain Coop, Benson & Appleton	320-842-5311	Joel James
Harvestland Coop, Morgan	507-249-3196	Pat Macht
Hoffman Coop Oil, Hoffman	320-986- 2061	Ken Johnson
Hogan Oil, Dundee	800-620-6176	Gary Hogan
Hoyt Oil, Walnut Grove	507-859-2552	Dave Hoyt
LaSalle Farmers Elevator, LaSalle & Madelia	507-642-3276	John Hoeft
Meadowland Coop Wabasso Redwood Falls Lamberton & Revere Storden & Westbrook	 507-342-5163 507-637-2771 507-752-7352 507-274-5242	 Wade Mathiowetz Doug Bunting BJ Jenniges Terry Neperman
Milroy Farmers Elevator	507-336-2555	Dave Zick
Noble Co. Coop Oil	507-376-5121	Bernie Alberg
Prairie Lakes Coop– Cyrus, Starbuck & Glenwood	320-239-2226	Brad Mandersheid
Sanborn Farmers Elevator	507-648-3851	John Gode
Springfield Tire Center, Springfield	507-723-6283	
Tyler Oil Co., Tyler	507-247-3245	Ron Thooft
Weis Oil Co., Bird Island & Fairfax	320-365-4737	Jeff Weis

Hennepin County Solar Traffic Signal Case Study
*Symbol: sun, man on tight rope
One approach to utilizing solar energy is to mimic the project implemented by Hennepin County. In 1996 a solar powered all-way stop traffic signal was installed above a 4-way stop intersection in western Hennepin County. A federal grant program funded the project that consists of 4 LEDs and 2 solar panels, which are mounted atop 2 wooden poles to avoid shading and maximize the amount of sunlight captured. Each of the solar panels in 4 by 6 feet in size, and is equipped to charge a co-located battery pack with actually runs the signal flashers.

For more information contact; Jerry Smrcka, Solar Traffic Lights, 763-745-7740, or Larry Blackstad, Hennepin County, 612-348-5859

CHAPTER 8: SOLAR ENERGY

Solar energy presents many options for local renewable energy resource utilization from energy for electricity generation via photovoltaic systems to energy for heating purposes. While certainly regions of southwestern US possess a greater year-round solar resource, there are still plenty of opportunities here in Minnesota. In many instances, solar energy use in photovoltaic systems is most economical when a facility, home or instrument is unable to connect to the utility grid. A study completed by Minnesota Department of Public Service in 1992 for the Minnesota State Legislature identified several types of applications that would be most cost-effectives for PV systems. These included:

Government
- Lighting, for public lake access, trails, and rest rooms
- Communications, including telecommunication repeating stations and emergency call boxes
- Vehicle battery charging for snow removal equipment, earth moving equipment, and emergency vehicles
- Monitoring, including water level monitors, water quality monitors, and remote weather stations
- Warning signals, including weather warning sirens, traffic advance warning arrow boards, and navigational lights
- Off-grid facilities such as state park residences, remote equipment storage buildings, and fire towers

Travel and Tourism
- Residences, such as dispersed cabins and hunting facilities
- Battery chargers for recreational vehicles, trolling motors, and sailing vessels
- Lighting for boat launches/docks and-parking areas
- Water pumping for pond aeration and potable water

Agriculture
- Fence chargers
- Stock tank aerators
- Water pumps

Several case studies highlighted by the Center for Energy and Environment's *Renewable Energy Demonstration and Education in State Parks* project emphasize similar applications integrating both PV opportunities as well as passive and active solar thermal water heating systems. One of the most important issues the Center for Energy and Environment emphasized throughout the document was the need for proper planning of any renewable energy system. Improper planning often means that conceptually sound systems fail to fulfill expectations. As stated when renewable energy systems are designed with Minnesota's climate in mind they can operation as well as conventional systems and they are more cost effective." This sort of consideration is important as our solar resource varies both by season and by region. An initial analysis by the Department of Commerce indicates that there is a roughly 15% difference between the lowest and highest solar resources across the state of Minnesota. Regions of southwest Minnesota receive the most sunlight and northern Minnesota receives the least. The map shown here depicts the solar energy capabilities around the state. (Include a picture of MN solar energy map that depicts the solar energy capabilities around the state).

PHOTOVOLTAIC POWER BASICS

PV systems produce electric DC power from sunlight because of the photovoltaic effect (a semiconductive process that generates electricity without moving parts or emissions). Inverters can be added to get grid-compatible AC power. PV panels (a combination of many cells) produce the most electricity under periods of high solar insolation, which intuitively are during sunny summer days, when peak demand is highest due to increased air conditioning use. They are generally mounted on un-shaded south-facing exposures and have optimum energy production when the sun's rays are perpendicular to the panel. A panel that is set at the same orientation all year will receive the most number of hours of potential sunlight per day by orienting the panel due south (solar azimuth at 180) and per year by setting the tilt angle at the latitude of the site's location (increasing the angle of tilt will optimize winter production and vice versa). Tracking mechanisms are available that use a motor to automatically orientate the solar panels perpendicular to the sun as it travels across the sky.

The most common type of photovoltaic cell is constructed of semiconductor grade crystalline silicon wafers that have grid contact structures on the front and back to create an electric circuit. Photovoltaic cells can be linked together to form panels or arrays. Electricity is generated when light photons excite the bottom wafer to donate an electron to the upper wafer, resulting in the flow of electricity when attached to an electric circuit. These types of systems can provide enough electricity to either power an emergency phone box or a whole building depending on the size. PV systems do not create noise, air or water emissions, or have any moving parts and the panels themselves are designed to last for 20 years.

One of the key benefits of incorporating PV systems into our electricity generating system has to do with timing. The amount of energy that solar electric systems generate directly correlates with the sunlight intensity and length. This peak conditions occur most often during hot, sunny, summer days, when electricity demand is also at its peak. Thus, solar power offers an efficient and effective way to utilize intermittent renewable energy technologies when the power is most needed. The panels still produce electricity in the winter, but since the days are shorter, not as much.

Assessing Your Solar Potential: Photovoltaic System Basics You Should Know

- A typical solar installation in Minnesota would generate about 1,000 kWh/kW/yr; how much power do you need? How much power do you expect to generate? Solar generation will be greater in the summer than in the winter, but it is likely that your energy use will be too.
- Factors such as inverter and wiring efficiency, tilt angle of the panels, south-facing direction angle, and shading can increase or decrease this amount. If you are able to tilt your panels accordingly and orient them toward the south with any shading, you will achieve better results.
- Single-axis and dual-axis tracking capabilities (automatically following the sun across the sky during the day and season) increase the capacity of fixed technologies during general summer demand periods. Consider a system that allows tracking.
- Shading from tree branches, chimneys, other buildings, poles, and the like should be avoided. How is your property set up? Is this feasible for your site?
- Panels can be mounted on the roof, on the ground, or on poles. Does your property properly accommodate any of these methods or could it easily be modified to do so?
- Tilting the panels equal to the latitude of the location can optimize annual generation. You can optimize winter generation by increasing the angle above the latitude and vice-verse for the summer. A low tilt angle (more flat than vertical) for summer generation may be covered with snow for short periods during the winter.
- Optimize early morning generation by facing the panels more east of south and vice versa. Decide what time of day you want to maximize prior to installation.
- A utility might optimize the panels for summer, evening generation to coincide with their peak demand.
- A homeowner who is paid based on total generation, should generally optimize for total yearly generation (due south and latitude tilt).
- Installation costs will likely run between $7-9000/kW (DC panel rating).
- Off-grid applications can be cost-effective instead of building a new utility line as can small signs, outdoor lighting, cabins, etc. On-grid applications, even with subsidies, need a non-economic basis for continuing with the project for instance, education, environment, independence, technology interest, etc.

BOX:

Brightfields: Redeveloping Brownfields with Solar Energy

Brightfields is a concept developed by the Energy, Efficiency and Renewable Energy Network of the Department of Energy, that is defined as an abandoned or contaminated property (brownfield) that is redeveloped by incorporating solar energy. The idea is designed to address economic development, environmental cleanup, and ongoing air quality concerns by combining emission-free solar energy with high-tech solar manufacturing jobs at formerly abandoned sites. The Brightfields program supports a wide array of solar energy development alternatives from manufacturing facilities to solar farms (array installation).

Brightfields projects require buy-in from a variety of stakeholders and require community collaboration. Participants should include private businesses, utilities, community organizations, non-profits, and government agencies. More information about the program, how to get involved, how to evaluate your site potential, and how to get funding can be found at http://www.eren.doe.gov/brightfields/.

END BOX

SOLAR THERMAL ENERGY BASICS

Direct use of solar energy can also be employed in active and passive water heating systems. Tempering tanks are a low-tech passive solar system that can be used to heat water in Minnesota. Tempering tanks heat up water and save energy by reducing the amount of fuel needed to heat water in a water heater. Tempering tanks require less maintenance than active systems and are roughly 5 times less expensive.

Active solar thermal applications use collectors and mechanical pumps to supplement the sun's natural ability to heat water. Water is pumped into solar collectors stationed on south facing roofs, allowed to warm, and then stored in a pre-heat storage tank. This system requires a conventional water heater backup to ensure hot water on demand and during winter months. Active solar thermal applications work best on hot, sunny days. Active solar thermal heating water can save up to 50% of summer water heating needs, but a system serving a campground shower facility costs approximately $10,000.

Wild River State Park Active Solar Thermal Water Heater Case Study

*Symbols: sun, recycling symbol

Wild River State Park converted the fuel oil-fired water heater at one of its campground shower facilities to a liquid propane and solar thermal water pre-heating system in May 1998. Due to space constraints, it could only install an 82-gallon solar storage (pre-heat) tank, but that has proven to be enough to make a considerable impact on its water heating needs. The system works by pumping water from the well to the solar storage tank and from there cycling it through the solar collector system which is comprised of 4 flat plate solar collectors that then heat the water by capturing the solar radiation. Water is transferred through the solar collectors and back to the storage tank using a 10-watt 12-volt PV panel that powers a valve and circulating pump. Wild Rive State Park officials have found this system to be an excellent fit. It operates from April to October, and requires virtually no maintenance; it even drains itself in the winter. During the week, the solar heating system can heat the water to 190^{o} F, which eliminates the need to use the LP fuel. On the weekend, the system preheats the water to between 70^{o} F and 80^{o} F, minimizing the amount of additional heating required.

For more information contact; Shawn Donais, 651-583-2125, shawn.donais@dnr.state.mn.us

CUTOUT: Moose Lake State Park employs a tempering tank to assist with hot water in its shower system. The tempering system has saved about 15% of the liquid propane used at the shower facility. The system cost about $2000 installed, and saves approximately $30 per year in fuel costs.
END CUTOUT

BOX:

Solar Electric Rebate Program – Power from the Sun, Rebate from the State!

The State Energy Office is administering a Solar Electric Rebate Program for grid connected solar electric energy installations that will rebate between $2,000 and $8,000 per participant at a rate of $2,000 per kW (combined DC power rating of all solar panels in the system). Eligible participants for 2002 and 2003 include grid connected Xcel Energy customers. Eligibility requirements vary for 2002 and 2003, see: http://www.commerce.state.mn.us/pages/Energy/ModTech/pdfs/RebateInstructions.pdf. If

monies are still available in 2004, the program will be expanded to all of Minnesota. A short application form and site pictures must be approved before installation begins. For detailed program information, instruction, and an application, readers should view the above mentioned website, or call the Energy Information Center at 651-296-5175 or 1-800-657-3710.
END BOX

HELPFUL RESOURCES FOR COMMUNITIES:
A Consumer's Guide to Buying a Solar Electric System published by National Renewable Energy Laboratory in September 1999. This document covers pro's and con's of investing in a PV system, how to pick an installer, and how to fulfill permit requirements, how to get a net metering agreement, etc. Can be retrieved at: http://www.nrel.gov/ncpv/pdfs/26591.pdf.

What to Expect from your Renewable Energy Dealer by Richard Perez, an article from Home Power Magazine. This article provides information on solar power vendors and tips for working with renewable energy vendors. It can be retrieved from:
http://www.commerce.state.mn.us/pages/Energy/ModTech/pdfs/how2hire.pdf.

General solar information as well as links to rebates and incentives can be found at:
www.commerce.state.mn.us/pages/Energy/ModTech/solarmain.htm#Rebate.

Teaching tools for parties interested in either viewing primers or sharing information about solar power with others can be accessed at:
www.chicagosolarpartnership.com/teaching_tools/index.htm.

Using Renewable Energy In Minnesota Parks: A Guidebook for Park Managers, a guide for renewable energy projects, including solar projects that have been and could be implemented at Minnesota State Parks. The report can be retrieved from:
http://www.mncee.org/ceedocs/parkguide.pdf.

ADDITIONAL REFERENCES:
Center for Energy and Environment. *Renewable Energy Demonstration and Education in State Parks*.

CONTACTS FOR ADDITIONAL ASSISTANCE:
Mike Taylor
Energy Office
Department of Commerce
Phone:
Email: mike.taylor@state.mn.us

Top Deck Holstein Dairy Farm's Microturbine
*Symbols: Tractor, Recycling symbol, hand holding city
Top Deck Holstein Diary Farm, located in Westgate, Iowa, took a bold step in 2002 when it started using methane from its anaerobic digester to fuel a 30 kW microturbine and a 100 kW engine generator. The digester converts manure from 700 cows into methane that is then used to generate 130 kW of renewable energy demonstrating the fuel versatility of microturbines and their on-farm applicability. This energy will supply the farm's electric needs and put electricity back into the grid while reducing manure odor and converting the manure into other usable byproducts. Top Deck Holstein Dairy Farm's project is supported through a partnership between farm owner Roger Decker, Alliant Energy, the Iowa DNR, and Iowa State University Extension.

For more information contact; Bill Johnson, Alliant Energy, 608-742-0824, billjohnson@alliantenergy.com

CHAPTER 9: FUEL CELLS AND MICROTURBINES

FUEL CELLS: AN UP AND COMING ENERGY TECHNOLOGY

Fuel cells are on the cutting edge of future technologies and have the potential to reshape our energy future. The modern version of fuel cell technology was originally developed as part of the Apollo moon program. In fact, NASA has demonstrated the commercial viability of fuel cells by continuing to use them to power space flights. Fuel cells offer an opportunity for communities interested in pursuing demonstration projects as the technology is still under development and in need of practical trials.

A fuel cell is an electrochemical energy-conversion device that works as an energy storage device much like a battery. However, unlike batteries they do not run-down or require recharging; fuel cells will continue producing electricity as long as they are supplied with fuel. This is because fuel cells produce electricity via a chemical reaction between hydrogen and oxygen. So, as long as hydrogen and oxygen are flowing in, electricity flows out. Since fuel cells do not involve combustion, they generate significantly fewer air emissions. The only waste products generated by fuel cells are heat and water, although depending upon the fuel source some emissions may be generated in producing the hydrogen fuel. In addition, fuel cells can be sized from small kW scale applications to multi-MW scale installations because of their modular nature.

BOX.
A Technical Spin (will include diagram of a fuel cell, see picture at end)

Fuel cells work by harnessing the chemical attraction between oxygen, which is taken from the air, and hydrogen, which is stored in a tank, to produce electricity. A catalyst pries apart hydrogen atoms into a positive ion and electron. The positive ions pass through a membrane to bond with the oxygen; the electron travels around the membrane and through a circuit, generating electrical current. On the other side of the membrane, the oxygen, hydrogen ions and electrons recombine to form water. One of the primary concerns with using fuel cells is how the hydrogen will be derived. See more on hydrogen sources below.

The most likely future applications for fuel cells will be those that allow fuel cells to replace batteries. Current development focuses primarily on incorporating fuel cells into the transportation sector, but uses in the electricity sector are also under development. As foreshadowed in Iceland, it appears that initially fuel cells will be incorporated into public modes

of transportation, such as buses. Compact cars will likely come next, as the inefficiency of the internal combustion engine makes these gas-guzzlers an easy target. Applications in the electricity sector will likely follow closely behind. In addition to these broad sector applications, development is currently underway to create phones and other mobile electronics powered by fuel cells; work is even underway to design a fuel cell powered vacuum cleaner.
(excerpted from: http://www.technologyreview.com/articles/wo_leo020502.asp, retrieved 6/24/02)
END BOX

Today, one of the major obstacles in operating fuel cells is developing a sufficient source of hydrogen, and using the "right" renewable and local source of hydrogen. Hydrogen can currently be produced via two primary mechanisms:

1) **Electrolysis** generates hydrogen by splitting the water molecule into its two components, hydrogen and oxygen, by passing an electrical current through the water and then capturing the hydrogen. The question is how to generate the electricity to do it. One potential benefit of this method is that renewable energy resources, like wind and/or solar, could be used to generate the electricity to perform the electrolysis. This would be the most clean and environmentally friendly way of generating hydrogen and therefore, is preferable. Additionally, the benefit of combining these intermittent resources with fuel cells is that they allow intermittent energy to be used when available to produce hydrogen. The hydrogen can then be used to generate electricity when demand dictates, thus solving the dilemma of wind and solar resources and their intermittent nature.
2) **Reforming of fossil fuels** requires pre-treatment of the fuel, which could be crude oil, methanol, ethanol, natural gas, or even gasoline or diesel fuel, in a "fuel reformer" that extracts the hydrogen for use in a fuel cell. The draw back to this method is that it still requires the use of fossil fuels that are not local resources and still produces air emissions and greenhouse gases. On the other hand, reforming fossil fuels is a more efficient mechanism of using these fuels as it involves a chemical reaction rather than thermal production and results in more miles per gallon.

BOX:

Iceland: A Demonstration of the Coming Hydrogen Economy

Icelandic New Energy, Ltd. is a group made up of government, business, and academic institutions tasked with facilitating Iceland transition from a fossil fuel based economy to a hydrogen economy. Chemistry professor, Bragi Arnason, originally proposed the idea of transforming Iceland into the world's first hydrogen economy. His idea, with the backing of Vistorka, an Iceland consortium, and three multinationals, Shell Hydrogen, Daimler-Chrysler, and Norsk Hydro (all part of Icelandic New Energy, Ltd.) is now becoming a reality. Iceland will become the launching ground for testing hydrogen-powered vehicles and assembling a hydrogen refueling infrastructure. To top it off, all of the hydrogen will produced using electricity from renewable energy resources.

At present, the project is on track to open the world's first public access, hydrogen fuel station in April of 2003. Three hydrogen-fuel city buses, provided by Daimler-Chrysler, will be put into use in Summer 2003 and begin a two year pilot program. The fueling station will be the first of its kind to allow public access, and this demonstration is expected to yield critical information necessary toward establishing a hydrogen delivery infrastructure.

Box:
Fuel Cell Technologies
While most fuels cell technologies are still in their infancy, there are many types of fuel cell technology under development. Several of these technologies include:

- Phosphoric Acid (the first to be commercially developed)
- Proton Exchange Membrane (PEM – lightweight and attracting transportation market attention)
- Molten Carbonate
- Solid Oxide
- Alkaline
- Direct Methanol
- Regenerative

END BOX

The cost of fuel cells remains another barrier for widespread commercial use of fuel cells. Fuel cells are still quite expensive due to the issues of fuel supply, heat and water output integration and low manufacturing volumes. However, over time and with product evolution, costs are expected to become more competitive with other power generation technologies. Fuel cells can operate at conversion efficiencies of 47 - 65%, and have the added advantage of producing thermal hot water that can also be integrated into a combined heat and power system (see additional details in the Cogeneration Section). This makes them an efficient energy source that can evolve to serve multiple needs. As research continues, many companies are expected to enter the commercial marketplace over the next few years.

Fuel cells also provide the added benefit of providing a clean source of energy. Because the energy is generated by a chemical reaction, the electron stream generated from fuel cells is cleaner than that normally generated using conventional power plants. For many industries the quality of their power is not of extreme importance, but for some niche applications, such as computer chips, power quality is crucial.

As a key point of interest for Minnesotans, regenerative fuel cells have the potential to resolve the electricity storage issues by using a chemical electrolyte to convert electrical energy to chemical energy in a reversible process. This sort of technology would increase the flexibility and reliability of intermittent renewable resources such as solar and wind, as mentioned above.

MICROTURBINES: ON SITE GENERATION COMING TO THE FORE

Microturbines are small single-staged combustion turbines, usually powered by natural gas, that generate between 25 kW and 500 kW of power, although this size characterization varies. In addition to natural gas, micro turbines can also be powered by biogas, hydrogen, propane and diesel. Use of both biogas and hydrogen allows microturbines to capitalize on renewable energy resources. A joint USDA and US DOE demonstration project announced in July 2002 looks to capitalize on this renewable potential by generating biogas as a microturbine fuel via anaerobic digestion of cow manure. Additionally, as mentioned in the introduction to this chapter, a small dairy farm in Iowa, Top Deck Holstein Dairy Farm, started using a 30 kW microturbine fueled by biogas in May 2002.

Microturbine designs evolved from automotive and truck turbochargers, auxiliary power units for airplanes, and small jet airplanes. Microturbines are about the size of a small refrigerator, making them ideal applications for businesses with limited space. In addition to their small size, they also offer several other benefits including: low initial costs, low maintenance costs, ability to put several together to build a reliable and independent system, few moving parts, lightweight, low emissions, high efficiencies, and low electricity costs. Microturbines are composed of a compressor, combustor, turbine, alternator, recuperator, and generator but have only one moving part. The turbine, compressor, and generator are all located on a single shaft. Microturbines also have the mechanical benefit of using air bearings that do not require lubricating oil. Microturbines have a strong reputation of producing electricity efficiently while keeping emissions low. Like fuel cells, microturbines can also be paired with heat recovery systems to operate in cogeneration systems that can achieve efficiencies of up to 80%. Typically microturbines cost about $1000/kW (or range from $600 to $1200/kW).

Further research on microturbine technology is underway to develop new “flex-microturbines” that can produce more power generation using low-energy, low-pressure biogases including biomass or landfill gas. Those systems will need to incorporate catalytic combustors to use biogas and this technology shift will allow total elimination of nitrogen oxide emissions.

BOX:

Fuel Cell Vendors

Select vendors involved in development of fuel cells from the Midwest include: Technology Management, Inc. (TMI Systems), NexTech Materials, Ltd., McDermott Technology, Inc., Gas Technology Institute, Energy Conversion Devices, Inc., Argonne National Laboratory

For a full listing see: http://www.fuelcells.org/fcdevel.htm

Microturbine Vendors

Select vendors include: Ingersoll-Rand, Capstone, GE, Bowman Power, Turbec, DTE Energy, UTC

END BOX

HELPFUL RESOURCES FOR COMMUNITIES:

Fuel Cells 2000: the Online Fuel Cell Information Center Website: http://www.fuelcells.org/ - site is loaded with information about fuel cells from basic description of what fuel cells are to detailed descriptions of the various kinds of fuel cells. Also includes responses to frequently asked questions including how much fuel cells cost, where to get them, a list of reference and lots of links.

National Fuel Cell Research Center: http://www.nfcrc.uci.edu/ - site has a fuel cell information page that explains how fuel cells work, lists manufacturers and researches, and provides detailed information on research projects

For a list of all fuel cell publications from articles to books to videos and recordings visit the *Fuel Cell Library* at: http://www.fuelcells.org/biblio.htm

Distributed Energy Resources regarding the DOE microturbine program can be found at: http://www.eren.doe.gov/der/microturbines/microturbines.html

Technical descriptions about how fuel cells work is at: http://www.technologyreview.com/articles/wo_leo020502.asp

An explanation of how fuel cells work, their efficiency, and some less technical information is located at: http://www.howstuffworks.com/fuel-cell.htm

World Business Council for Sustainable Development: http://www.wbcsd.ch/casestud/iceland/ - article entitled "DaimlerChrysler, Shell, and Norsk Hydro: The Iceland Experiment" that details the case study of Iceland and the Hydrogen Economy

U.S. Department of Energy Hydrogen Information Network can be found at: http://www.eren.doe.gov/hydrogen/features.html

CONTACTS FOR ADDITIONAL ASSISTANCE:

Rolf Nordstrom
Critical Issues Research
Minnesota Planning
Phone: 651.297.5228
Email: rolf.nordstrom@state.mn.us

CHAPTER 10: COGENERATION AND DISTRICT ENERGY

Cogeneration, or Combined Heat and Power (CHP), is a range of technologies that simultaneously produce electricity and useful thermal or mechanical energy from a single energy source. The primary benefit of cogeneration is the increase in fuel efficiency that comes from using one source to generate multiple forms of energy.

Minnesota currently holds the technical potential to generate 1,600 to 2,100 MW through cogeneration at existing facilities (footnote: based on a survey completed by Minnesota Environmental Quality Board, a division of Minnesota Planning). Minnesota communities should explore opportunities to capitalize upon these potential resources because cogeneration provides more than simple efficiency benefits. Cogeneration allows Minnesota communities to reduce their air emissions from combustion since less fuel is burned when electricity and thermal energy are generated together. Cogeneration also reduces the discharge of hot waters from cooling towers into community lakes and rivers because the water is reused. Cogeneration adds smaller, local energy re-use resources to our communities and local businesses and provides a more local energy resource that limits the amount of fuel we use.

A variety of Minnesota fuels can be used for cogeneration; therefore, cogeneration presents numerous opportunities to utilize the local, renewable energy technologies already discussed throughout this manual, including biomass energy and anaerobic digestion systems.

District Energy – A Case Study for Biomass Fueled Cogeneration and District Energy
*Symbols: sun, recycling symbol, hand with city

District Energy St. Paul, Inc., is a private, non-profit, community-based corporation located in downtown St. Paul. District Energy owns the largest hot water district heating system in North America in addition to a rapidly expanding district cooling system.

Since 1999, Market Street Energy Company (a District Energy affiliate) and Trigen-Cinergy Solutions have been working to build a cogeneration system that will burn urban wood waste to produce electricity while simultaneously generating energy for St. Paul's district heating and cooling needs. The new cogeneration plant, which will be operational by winter 2002-2003, will be a 25 MW wood-waste fired facility that will supply over 75% of the thermal energy required by district heating and cooling customers in downtown St. Paul. The 25 MW of electricity will be supplied to the local grid under a 20-year contract with Xcel Energy.

A substantial portion of the wood waste used for cogeneration will come from downed trees, tree trimmings and branches from around the Twin Cities area. Using this material has several benefits. First, by turning regional wood waste into a useful product, the system will help keep energy dollars in the local economy, instead of importing fossil fuels. Second, using wood waste will help solve the ongoing environmental challenge of wood waste disposal, using approximately half of the 600,000 metric tons of wood waste generated in the metro area annually. Lastly, the project will significantly reduce air pollution by displacing 80% of the coal and oil District Energy currently burns every year, thereby reducing sulfur dioxide emissions by roughly 600 tons per year and reducing carbon dioxide emissions by roughly 280,000 tons per year. This efficient use of a renewable energy resource should serve as a model for communities looking to take similar steps.

For more information contact; Trudy Sherwood, trudy.Sherwood@districtenergy.com

COGENERATION AND DISTRICT ENERGY BASICS

As mentioned initially, cogeneration is a range of technologies that simultaneously produce electricity and useful thermal or mechanical energy from a single energy source. Typically a cogeneration system uses a process to produce steam that then generates both electricity (via a steam turbine) and thermal energy, but steam turbines, gas turbines, and reciprocating engine power technologies can all be adapted for cogeneration. By powering both electrical and heating (or cooling) requirements from a single fuel source, cogeneration greatly increases the overall efficiency of a fuel. Cogeneration is two to three times more efficient that separate generation of electricity and thermal energy because the heat that is normally wasted in conventional electricity generation is recovered and reused in another process. In fact, when the heat generated is fully utilized, cogeneration systems can achieve ~80% efficiency recovering the "waste heat" to provide heating and cooling.

Thermal energy from cogeneration can provide cooling and heating for individual facilities and commercial buildings or can be utilized more broadly in district energy systems at university campuses, hospital complexes and throughout whole communities. District energy systems can distribute steam, hot water, and even chilled water from a central plant to individual buildings via a network of pipes. Through this distribution system, district energy can provide space heating, air conditioning, domestic hot water, industrial process energy, and electricity. By integrating cogeneration systems with district energy, communities can achieve greater efficiency benefits and reduce their fuel use.

By utilizing hot water systems, instead of steam systems, cogeneration systems can achieve maximum efficiencies. This is because cogeneration systems will reach optimum efficiencies when used at lower recovery temperatures (and at steady loads) because more heat can be recovered. These sorts of systems can provide an important mechanism in community-wide efforts to create a more sustainable and unified, energy efficient system.

Primary Technologies for Integrating Cogeneration

Steam turbines, combustion turbines (simple cycle and combined cycle), reciprocating engines, and fuel cells are the primary technologies that can put cogeneration systems in motion. For more details on how they various generation technologies work, please see further details under "Generators: Types that Produce Electricity from Biomass" in the Biomass Section.

How should you evaluate your ability to incorporate cogeneration into your system?

The MN Planning Report lists several factors that are important in ensuring cogeneration will be cost effective. The report highlights the following factors as the most important things to consider when screening and prioritizing:

1) <u>Size of thermal and power loads</u>. The size of the load will dictate the type of technology that can be used. Remember, it is most cost effective to supply electric capacity at less than your peak demand so that your system is able to operate as much as possible at full capacity. Of course, if you are able to sell back to the grid at sufficient price, you can plan your capacity to exceed or meet your peak demand because the system will still be able to function at full capacity even if your facility does not need all of the electricity produced.
2) <u>Thermal and Electric load factors</u>. Equivalent Full Load Hours (EFLH) is the ratio of annual energy compared to the peak demand times 8760 (the number of hours in a year); high electric and thermal EFLH increases the feasibility of cogeneration.

3) Relatively high cost electric power resources. If other power resources (i.e., fossil fuels) are expensive, it will make alternative resources, including renewables, more cost competitive.

4) Cost-effective back up electric supply. Sometimes cogeneration may not meet all of your electric supply needs. It is important to have a cost-effective back up just in case.

5) Planned new construction or upgrades. It is best to plan cogeneration projects for new construction sites or sites in need of upgrades. These technologies are easier to incorporate with newer facilities that are likely to be more reliable and require less maintenance.

6) Relatively high-value market for excess power generation. If excess power can be sold at a sufficient price, it becomes more economical; Investment Tax Credit (ITC) provides a 10% ITC for qualifying facilities; Production Tax Credits (PTC) were also under consideration by congress – status?

7) Opportunity to re-dedicate cost of replacing existing thermal resources to the cost of a new cogeneration project. If the avoided costs for upgrades or replacements can be put back into the cogeneration project, the project becomes more cost effective.

8) Available and affordable fuel supply. If there is an opportunity to use lower-cost, easily accessible fuels with cogeneration as compared to current fuels used for thermal production, cogeneration presents an option to avoid higher costs.

IMPROVING COMMUNITY EFFICIENCY THROUGH COGENERATION AND DISTRICT ENERGY

There are several industrial facilities that have already incorporated cogeneration systems into their onsite operations. The paper industry in particular has significant experience operating cogeneration facilities and utilizing their biomass residuals (waste wood) to power their operations. Some of examples of companies that have integrated cogeneration into their operations include Blandin Paper (Grand Rapids), Boise Cascade (International Falls), Potlatch (Bemidji), and Champion International (Sartell). The paper industry is not alone in its smart business use of cogeneration; several other industries including mining and agri-processing industries also reuse their waste heat to achieve more efficient energy use. Use of cogeneration at these facilities should be commended, as these industries are helping reduce their overall energy usage and in some cases are also utilizing renewable resources.

Another step communities should consider is capturing the waste heat from local processing facilities and connecting it with community-wide heating and cooling systems. This would both promote private-public cooperation and decrease the energy usage of the entire community. In many instances, it would also allow communities to implement a renewable energy system that takes advantage of indigenous resources and reduces dependence upon fossil fuel energy. An example of this sort of project was the “West Central Research and Outreach Center and Morris: A Real-life Demonstration Project” case study mentioned in Chapter 2. The West Central Research and Outreach Station and the University of Minnesota-Morris are working with DENCO, a farmer-owned ethanol plant, to recoup the waste steam heat that DENCO would generate. The University of Minnesota-Morris would use this waste steam in a district energy system that would serve its needs and those of a new elementary school while allowing DENCO to recover some of its costs. The overall system would result in a greater community-wide energy partnership that would allow the community to capitalize on a local renewable energy resource and reduce its overall fuel usage.

Installing district energy systems is not without obstacles. These systems require significant capital investment to create the necessary infrastructure support. This means that whole communities need to be behind efforts to incorporate district energy, but district energy presents a real solution for improved energy efficiency and present a tangible way for communities to reduce their fuel consumption. District energy systems also allow companies who are willing to invest capital in more efficient equipment to partner with their surrounding communities and recoup some of their costs.

BOX 1:

Existing Cogeneration with District Heating in Minnesota

Public Utilities

Willmar – described in a Case Study below
Hibbing
Virginia – described in a Case Study below
New Ulm

Others

District Energy St. Paul Inc. (St. Paul) – described in introductory Case Study
University of Minnesota (Twin Cities)
Franklin Heating Station (Rochester)
Order of St. Benedict Inc. St. John's University (Collegeville)
END BOX

BOX 2:

Sites Identified by MN Planning Study with Cogeneration Potential

Good prospects, good data

- Rahr Malting Company (Shakopee), a case study describing this project is included in the Biomass Section
- Chippewa Valley Ethanol Company (Benson)
- St. Mary's Duluth Clinic (SMDC) Health Systems (Duluth)
- Duluth Steam Cooperative (Duluth)

Potential prospects, but data inadequate for assessment

- Seneca Foods Corp. (Rochester)
- Hormel Foods Corp. (Austin)
- St. Olaf College (Northfield)
- Crown Cork and Seal (Faribault)
- Froedtert Malt (Winona)
- Dairy Farmers of America (Zumbrota)
- Heartland Corn Products (Winthrop)
- US Steel – Minnesota Ore Operations (Mountain Iron)
- Potlatch Corporation (Brainerd), potential for additional capacity
- Boise Cascade (International Falls), potential for additional capacity

END BOX

Willmar Municipal Utilities, Cogeneration and District Energy Combined
*Symbols: recycling, hand with city

Willmar Municipal Utilities, established in 1891, currently provides district heating to 325 local customers. Its district heating system was built in 1913, and in 1982 the system was modernized to utilize hot water, rather than steam, to provide heating. Willmar's transition to hot water was based on Northern European technology and designed by engineers from Sweden. In making the upgrade to hot water, Willmar Municipal Utilities achieved higher efficiencies; CHP systems achieve optimum efficiencies at lower recovery temperatures and therefore favor the use of hot water rather than steam.

As part of the 1982 renovation, Willmar Municipal Utilities rebuilt the entire district heating distribution system. The district heating program started out serving only the commercial, institutional, and industrial buildings in the core business district, but began expanding in 1983 and continued expanding until 1990 to include its current customer base – 108 commercial, institutional and industrial facilities and 199 single family homes. When natural gas prices fell in the late 1980's, interest in district heating fell off, and there have been few expansions since.

Bart Murphy of Willmar Municipal Utilities stated that for Willmar, all the pieces just came together to make the expansion work. Although the upgrade was very capital intensive, they already had a heat source in-place, and local citizens already understood district energy. Existing customers liked the concept and understood it, so they didn't mind making a minor investment for the upgrades. In 1981, when they were planning to expand, the pricing was right for district heating because it would have cost significantly more to remove the whole system and connect every building to its own natural gas heating system.

Now, with natural gas prices lower than they were in the 1980's, the economics would be a little more difficult. Cities considering district heating might need to look toward bonding, low-interest loans, subsidies, tax credits, or some combination of each. The use of renewable fuels might help garner some of this funding. While Willmar still uses coal in its system, there are other systems experimenting with other fuel sources, including various biomass materials. Throughout the manual the focus has been on renewable fuels. Coal is obviously not a renewable fuel, and therefore other fuels are preferable, but if communities are using non-renewable fuels, district energy allows them to do so in the most efficient manner possible.

For more information contact; Bart Murphy, Willmar Public Utilities, 320-235-4422, bmurphy@wmuwillmar.mn.us

Virginia Department of Public Utilities, Cogeneration at a Local Utility
*Symbols: recycling symbol

Virginia Department of Public Utilities is located in Virginia, Minnesota along Minnesota's iron range. The utility was originally founded in 1892; the city of Virginia purchased the utility in 1912 and then began producing electricity and steam. The current power plant operates a 30-megawatt cogeneration power plant that consists of three boilers and four turbines and burns primarily western coal and natural gas, depending on the boiler. Electricity is produced by the power plant to fulfill the demands of the steam system. The steam district heating system supplies 2,500 customers including the downtown business area, city public buildings, and south side and north side commercial and residential areas while the electric system serves over 5,800 customers. Recent construction activities have forced the closing of steam lines to particular neighborhoods, reducing the number of homes served by steam heat.

Overall however, the cogeneration district heating system in Virginia has proven to be a long lasting, and energy efficient success.

HELPFUL RESOURCES FOR COMMUNITIES:

Opportunities to Expand Cogeneration in Minnesota written by Center for Energy and Environment and released in August 1996. Can be retrieved from: http://www.mncee.org/ceedocs/mmua_guide.pdf.

Inventory of Cogeneration Potential in Minnesota published by the Minnesota Environmental Quality Board and Minnesota Planning in August 2001. Can be retrieved from: http://www.mnplan.state.mn.us./eqb/pdf/2001/CogenInventory.pdf.

Deployment of Distributed Energy Resources: Sources of Financial Assistance and Information, published by the Federal Energy Management Program in January 2002. Can be retrieved from: http://www.eren.nrel.gov/femp/techassist/pdf/der_$available_1_24_02.pdf.

Consumer Energy Information: EREC Reference Briefs: Cogeneration or Combined Heat and Power posted by the Energy Efficiency and Renewable Energy Network of the U.S. Department of Energy. Can be retrieved from www.eren.nrel.gov/consumerinfo/refbriefs/ea6.html.

US Environmental Protection Agency / International District Energy Association, "District Energy Systems Integrated with Combined Heat and Power: Analysis of Environmental and Economic Benefits," 1999.

R. Neal Elliott and Mark Spurr, "Combined Heat and Power: Capturing Wasted Energy," 1999.

International Energy Agency/Resource Efficiency Inc, "Design Guide for Integrating District Cooling with Combined Heat and Power," 1995.

Minnesota Department of Energy, Planning and Development, "District Heating Planning in Minnesota: A community Guidebook," 1981.

Environmental Protection Agency: Combined Heat and Power: http://www.epa.gov/CHP/index.htm. Provides general technology information as well as success stories from around the country.

District Energy Library, operated by the University of Rochester: http://www.energy.rochester.edu/. This site provides a wide range of information on district energy and cogeneration including numerous links and publications.

Minnesotan's for an Energy-Efficient Economy: Cogeneration: http://www.me3.org/issues/cogen/ - website on cogeneration. Provides numerous links to pertinent information.

CHAPTER 11: PUTTING IT TOGETHER

START WITH CONSERVATION

Before considering any alternative energy project, first consider what steps you can take to cut back your energy use. As mentioned in the introduction, energy conservation has become much more a set of physical and technological efficiency improvements than it is a set of behavioral changes and these changes are often the easiest place to start changing your energy future.

As a first step, perform a benchmark evaluation on community buildings. Benchmarking is a free tool provided by the Energy Star program that can assess the relative performance of community buildings including office buildings, schools, hospitals, hotels and grocery stores (www.energystar.gov). Benchmarking rates buildings on a 100 point scale in comparison to similar structures. The average building score is around 50. If buildings have a score lower than 50, it might be worthwhile to invest in an energy audit. Energy audits are one of the best ways to determine whether or not there are easy, inexpensive cost saving measures you can implement to help increase your benchmark rating and improve your community's energy conservation. The Minnesota Department of Commerce's Energy Information Center lists numerous publications for residential, small business/commercial sites, and institutional and municipal buildings. Each section lists publications that will provide practical, easy-to-understand recommendations for energy saving strategies. The Energy Information Center also makes Energy Specialists available to customers that can assist with energy conservation questions (see contact information below).

Minnesota utilities also provide conservation tips and energy use/cost information about standard appliances. The CIP Program, as mentioned in Chapter 2, requires all MN Utilities, including investor owned, cooperative, and municipally owned utilities to all contribute 1.5% of their gross operating revenue to conservation/efficiency efforts (those designed primarily to reduce energy consumption). Most of these utilities list a variety of tips from how to minimize your lighting costs to what sort of insulation is available, all in a customer-friendly format. For residential customers, many of these utilities also offers Home Energy Audit services and rebates for purchasing energy-efficient appliances, including air conditioners, refrigerators, and water heaters. For small business, commercial, industrial, and government customers, utilities can partner with organization to not only evaluate energy usage, but also to help plan and implement efficiency upgrades. The references section of this chapter provides links to several utility's energy efficiency/conservation program websites.

Beyond the Department of Commerce and utilities, private organizations can also provide energy audit services to your home or business. The Center for Energy and Environment has been in involved in a wide variety of energy efficiency projects and has the technical staff and know-how to perform diagnostic tests, complete energy audits, and help with retrofits.

No matter how you get an energy audit or evaluation, be sure to first implement the cost-effective changes before reevaluating your true energy needs. As efficiency and conservation upgrades are typically the easiest and cheapest, it is important to take advantage of this low hanging fruit first. It is always best to reduce your energy usage rather than installing new generation. If after you have completed these modifications you are still in the market for new energy, consider one of the alternative energy resources outlined in this primer and take a step toward a community-based renewable energy future.

ASSESSING YOUR RENEWABLE ENERGY POTENTIAL

So you've finished your efficiency upgrades and conservation measures and now you've decided that renewable energy might be the final piece to solving your energy puzzle. How do you decide what renewable energy strategy is right for you? Well, it really depends on why you want to implement a renewable energy project. It is possible that you actually are not interested in it because of an inherent energy need, but rather as a mechanism to address some sort of existing pollution or waste problem. On the other hand, your community may be interested in integrating renewable energy in your community to aid in economic development, to help stimulate the rural economy, to provide financial benefits to farmers. Your community may simply want to use an energy resource that promotes a cleaner environment. As highlighted throughout the workbook, there are myriad reasons why people are becoming more interested in community energy, and it is important that your community assess what it wants to achieve by incorporating renewables into its energy mix.

If indeed you are interested because you have an energy shortage, would like to boost your energy self-reliance, or want to reduce your dependence on foreign oil, the first thing you need to do is assess what renewable resources are indigenous in your region. This sort of information is covered in each of the chapters, as are links to sites that can provide data for use in assessing your local load and resources. If however, your primary reason for seeking out a renewable energy alternative is to reduce your environmental emissions, from greenhouse gases to waste water issues, a different set of alternatives should be considered.

Again, these benefits are highlighted in each section with the case studies and associated symbols. There are numerous reasons that might push a community toward a more distributed, renewable energy generation system, but as a community it is important to develop an action plan and vision for the future. The second chapter should help provide ideas to assist your community in developing such a vision. Once your community has thoroughly evaluated its resources and primary concerns, it can move forward with an action plan that outlines what sort of project(s) should move forward and be better able to concentrate time and energy on those projects with the best local prospects.

OWNERSHIP

Ownership generally falls into two basic categories: public or private. As communities begin to select energy alternatives, they will also need to consider which ownership option will be most effective in accomplishing their goals. For some projects the choice is obvious, but for others, deciding who will own a project will be slightly more complex. For instance, when a particular entity within the community, either a private organization or a public institution, decides to move forward, they may automatically decide to own the project. Many of the school wind turbine projects are, for example, logically owned by the school district.

However, when a community sits down to establish a set of objectives for incorporating renewable energy into its energy future, its ownership options may be less clear. Communities must decide whether or not they want to own the generation, or partner with the local utility and share ownership, or simply buy renewable energy from the local utility. Appropriate mechanisms for local government were described in greater detail in Chapter 2, but recall that often local government's role will simply be to encourage and provide opportunities for renewable energy project development, and will not have to do with ownership at all.

When an individual farmer or an individual business is evaluating ownership possibilities, the issue can become even more complicated. Often, renewable energy operating equipment can have expensive upfront capital costs. This can make projects prohibitively expensive to do alone. Sometimes farmers will just lease their land to developers, rather than reaping the energy benefits for themselves. Cooperatives might in some cases present a collective option. This section will impart basic information about a few of these ownership options.

Public Ownership Mechanisms

School Districts benefit from some funding options not available to private sector entities. First, the school districts are eligible for grants and funding opportunities, and even bonding opportunities that it would not qualify for as a private entity. Second, with ownership by the district, district budgets are able to benefit from the reduced electricity costs, the electricity sold back to the utility, as well as the federal and state production incentives. These financial mechanisms are discussed further in the Financing section below. Beyond financing, schools also present a unique opportunity to educate the surrounding community with the installation of a renewable energy system. By attaching a system to the school, the school suddenly takes on a leadership role in educating the community not only about the science and operating mechanisms behind renewable energy, but also about the environmental and potential economic benefits associated with such a system. If schools can begin educating the younger generation of Minnesotans about renewable energy now, those children may become lifetime advocates of renewable energy in the future because they will have seen it work. The more people exposed to renewable energy options, the less foreign it seems, and the schools are an ideal and logical place to start this education project. On site energy facilities can also serve as important learning tools for science and economics classes and can serve as a hands-on resource to students and the surrounding community.

Counties and municipalities have the potential to draw on larger base of funding than individuals. They also have the benefit of being able to merge several smaller projects from many different buildings around their community into one larger project to secure a better overall bulk-quantity based price. An example of this is the metro counties energy-efficiency aggregation project. This project proposes to merge several energy-efficiency projects from several different locations into one larger bid package that would then have one contractor complete all the work. Counties and municipalities also have the benefit of having control over local land use and planning not specifically preempted by state or federal government. This allows these entities to exert some control over local energy planning matters and also engage the community around them in planning efforts. Aspects of this leadership role were emphasized in the Chisago County case study in Chapter 2.

Private Ownership Mechanisms

Individuals, farmers and businesses have the benefit of choosing their own motivation for the project and determining which conditions are most important to measuring the projects success. If the goal of the project is to be more environmentally conscience, then the metrics will be different than if the goal is to increase farming profits. Economically speaking, one of the benefits of private ownership is the eligibility for production tax credits. These credits can make or break the financial feasibility of project and are therefore an important element to consider. Of course, the economic drawback of private ownership is that you and your business alone incurs all of the upfront costs, but again, it depends upon your personal motivation. In some scenarios, it may be possible to actually partner with a larger firm or simply contract out one's land. In any case, it will be important that individuals pursuing renewable energy project seek the advice of experts, like project developers, engineers, and attorneys, to ensure that the process goes smoothly and that all necessary requirements are met.

Cooperatives present opportunities for some renewable energy resources, but not for all. Two examples from Minnesota where cooperatives have definitely worked include the Minnesota Agro-Forestry Cooperative, assembled with help from WesMin RC&D, that has linked landowners from around the state to help them facilitate collective purchase agreements for farmers in similar areas and Minnesota's farmer-owned ethanol cooperatives that have played an integral role in ensuring that farmers received the value-added benefits of ethanol processing. On the other hand, some renewables just do not fit as well in the cooperative model. Wind cooperatives, for example, have limited economic viability because they are not eligible for the 1.5 cent/kW federal production tax credit. The USDA provides information about how agricultural cooperatives work and how to form your own. For more information see their online documents: http://www.rurdev.usda.gov/rbs/pub/cir55/c55text.pdf and http://www.rurdev.usda.gov/rbs/pub/cir7/cir7.pdf.

Businesses, farmers and individuals also have the ability to work more as a loosely knit agreement between like-minded parties rather than as a formal business entity. A group of farmers in Wisconsin has recently discussed jointly hiring an engineer to develop plans for an anaerobic digester. In this scenario, they will each install their own digester, but they will have shared the cost of developing an engineering design. This sort of approach has great potential to help individuals cut costs by sharing the financial burden.

FEASIBILITY STUDY

No matter what ownership option makes the most sense, it will be necessary to complete a feasibility study for the project to get bank funding. These studies are used to determine the feasibility of the proposed project at the proposed site. These studies examine both the technical feasibility and the financial feasibility of the project and help to outline potential obstacles before a project gets started. Overall, the report should make a recommendation about whether or not the project should move forward, as well as the data that led to that conclusion. Most of these studies include the following primary sections, although reports can vary as to their order and contents:

- **Introduction:** this section will introduce the report, indicate its purpose, and provide an overview of the report contents.
- **Background:** this section will outline the motivation for conducting the project (the problem), the potential impacts/benefits of implementing the project, and a description of the facility, its components, and a site map; this section should also foreshadow how the option will be evaluated.
- **Technology choice:** this section will outline the proposed system, how it would fit in with the existing facility, what gains the system would provide, and how these would be used; it would also outline other options that could be used instead.
- **Financial analysis:** this analysis will evaluate how much the system would cost and how the owner would pay for it. Different entities, like state government and industry, may have different approaches and include different components when completing a financial analysis and therefore financial analyses must be tailored to the specific project. For

instance, this section could also include a cost-effectiveness evaluation that would detail social, environmental, and avoided cost benefits in addition to the simple payback period.

- **Shortcomings:** this section should address the significant issues and potential pitfalls associated with the project and feasibility study analysis and propose solutions and recommendations to address these issues.
- **Conclusion:** final opinion regarding whether or not the project should move forward (should not be overly positive if the data does not support it)

Ideally, the lending organization will be able to read through the feasibility study, clearly follow the points and arguments, and arrive at the same final conclusion.

ENVIRONMENTAL ASSESSMENT

Before proceeding with any project, it would be prudent to evaluate the potential environmental impact a project may have on local site conditions. For some projects this may not present a huge obstacle. After all, few wind projects or solar installations will have significant detrimental environmental impacts on their surroundings as long as they are site appropriately. However, the addition of an anaerobic digester may have environmentally damaging side effects, as could reintegration of a hydroelectric generation facility on a historic dam. By evaluating the potential environmental concerns in advance, communities and property owners can avoid unexpected mishaps in the future.

For most small generation projects, a formal environmental assessment or environmental impact statement is not required. In fact, the Minnesota Planning document *Guide to Minnesota Environmental Review Rules* includes an exemption category for construction of an electric generation plant with a capacity of less than five megawatts. This document also outlines the difference between an Environmental Assessment Worksheet and an Environmental Impact Statement and when the two are required. Anyone considering a new project should review this document (http://www.mnplan.state.mn.us/pdf/rulguid3.pdf) and talk with a representative of the Environmental Quality Board of Minnesota Planning (the organization which oversees the environmental review process) to clarify what permitting and environmental review documentation is required.

PERMITTING

In Minnesota, there are several governmental authorities that may require you to submit a permit. Permitting may be at the local, state, or federal level; be sure to check with all. One of the first permits that should be considered is the environmental rule outlined above. In addition, for wind turbines over 5,000 kW (or 5 MW), the Environmental Quality Board has specific requirements for obtaining a wind-siting permit, under 5000 kW it's a local issue. These regulations can be found at http://www.mnplan.state.mn.us/eqb/wind/index.html. The Federal Aviation Administration (FAA) also requires that wind projects complete a permitting process. For anaerobic digesters, operators will also need to contact the Minnesota Pollution Control Agency to complete their environmental review.

Other agencies that all renewable energy projects may need to involve include the Department of Natural Resource, the Midwest branch of the US Fish and Wildlife Service, and the State Historic Preservation. All projects will probably need to obtain building and electrical permits from either the city or county building department. In many cases the contractor installing the equipment can take care of these permits, but this should be negotiated in advance. Power developers will also need to address any necessary Federal Energy and Regulatory

Commission (FERC) permits. Often it will be easiest to seek assistance from an experienced developer to help maneuver through the complicated array of permits, but it will always be prudent for any project to involve these agencies, or any other potential permitting agencies, prior to starting a project to ensure that it will not be halted somewhere further down the road.

CONNECTING TO THE GRID

It is very important to involve the local utility from the very beginning of any project that will tie into the electric grid. Each utility has requirements for interconnection in order to protect the safety of their line workers and maintain the integrity of the power system. These requirements may vary with the size and type of generator. The utility may require the customer to pay for special engineering studies to determine the impact of adding additional generation to the grid, which can be expensive. Usually extensive studies are unnecessary for small projects. The utility may also charge fees for services necessary for the generator to operate, such as upgrades to utility lines.

Many utility-required standards and studies are appropriate for larger generators, but may be unnecessary and burdensome for smaller generators. As well, requirements may vary considerably from utility to utility. Because of this, in 2001 the Minnesota legislature required regulatory officials to develop generic interconnection standards and rates that will "promote the use of distributed resources…. [and] provide for the low-cost, safe, and standardized interconnection of facilities" (MN Statues, 216B.1611). This process is expected to be concluded in 2003.

In other states that have adopted standardized interconnection agreements, including Texas and California, the standards have been successful in encouraging distributed generation. California, for example, has a "pre-certification" process for manufacturers of distributed generating equipment. Once a system is pre-certified, the utility cannot require an individual customer to pay for additional studies that have already been covered in the pre-certification process.

NET METERING

Net metering allows qualifying facilities (or independent power producers) to consume electricity from the grid when they are not producing power, and sell electricity back to the grid when they are. This flow can typically be measured using your standard utility meter that spins forward when the utility is supplying energy and spins backward when the utility is taking energy. Net metering agreements are often considered a strong benefit for qualifying producers who then receive 2 to 3 times the wholesale price for their electricity.

Minnesota's statute-based net metering laws were established in 1983 and apply to all of the state's investor-owned utilities, municipalities and rural cooperatives. Qualifying facilities of 40 kW or less are eligible for the program, and there is no limit to total statewide capacity allowed. Utilities are required to purchase net excess generation at the average retail rate.

The purchase of net excess generation at retail rates distinguishes Minnesota's net metering legislation from programs in most other states. Only Wisconsin also provides for the purchase of net excess generation at retail rates. It is also worth noting that Minnesota, Maryland, Nevada, New York, and California are the only states where net metering is mandated in statute by the state legislature. As of 2000, the Minnesota Department of Commerce reported that there were 110 facilities with net billing arrangements. Of these facilities, 23 were photovoltaic and 87 were wind facilities.

Source:
http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=MN01R&state=MN&CurrentPageID=1

FINANCING

Financing covers a broad range of items from production incentives to low-interest loans to economic development resources. The following gives a brief overview of the types of funding available.

State and Federal Production Payment

For starters, anyone interested in pursuing a renewable energy project should review the list of renewable energy production incentives available to Minnesotans. A comprehensive list of incentives for Wind, Hydropower, Biomass, Solar, and Ethanol can be found at www.commerce.state.mn.us/pages/Energy/ModTech/proincentives.htm. Copies of this table are found as an attachment to this chapter. Highlights of these incentives include federal and Minnesota state production incentives for wind, biomass and solar. All non-taxable entities receive a federal incentive of 1.5 cents/kWh for wind, biomass and solar. Both wind and biomass receive an equal state incentive payment. Solar systems installed in Xcel Energy's electrical territory are eligible for a solar rebate of $2000/kW for up to 4 kW of nameplate capacity. To view even more detailed information both www.dsireusa.org, a database that summarizes all state and federal incentives for renewable energy, and www.eren.doe.gov/power/repi.html, the Department of Energy webpage that outlines the federal renewable energy production incentives, provide helpful information.

State and Federal Loans and Grants

Beyond production incentives, there are also numerous loan programs available to help finance renewable energy projects. The Minnesota Department of Agriculture has summarized both the federal and state financing programs. Copies of these summaries are provided as an attachment to this chapter. At the federal level, the Farm Service Agency, the Small Business Administration, and the US Department of Agriculture all offer some sort of financial assistance, either in the form of loans or grants. In fact, the US Department of Agriculture offers several different funding options from Rural Economic Development Loans and Grants that support electric utilities to Rural Business Enterprise Grants and Opportunity grants that can assist with community planning efforts. It also offers funding via a Biobased Products and Bioenergy Program, ideal for farmers interested in biomass production. At the state level, several low-interest loan programs exist including the Wind Energy Pilot Loan Program, the Value Added Stock Loan, the Agricultural Improvement Participation Loan, the Manure Digester Loan Program, and the Sustainable Agriculture Loan Program. Each of these provides loans at or below 6%.

Schools, municipalities, counties and other government units are eligible for State Loan Money through the Department of Commerce. These loans present borrowers with lower interest rates because the state has enough buying power to garner lower borrowing rates. Schools are also eligible for "lease-purchase agreements", which are favorable interest rate loans available to schools because they are non-taxable, or can issue capital notes, which are like bonds but do not require election approval. Of course, schools can also open a renewable energy project to a general bonding referendum, which could then either be voted up or down by the community. Grants are also likely available to schools through the US Department of Education, US Department of Energy, and through environmental education entities.

Farmers may also be able to receive funding via the new Clean Energy Title in the Farm Bill that is scheduled to provide over $100 million in annual funding for clean renewable energy development projects (wind, solar, biomass, geothermal, and hydrogen), energy efficiency programs, and carbon sequestration programs to reduce greenhouse gases. One part of the Clean Energy Title establishes a loan, loan guarantee, and grant program to assist farmers in purchasing renewable energy systems and making efficiency improvements. Other programs will direct additional funding toward biomass research, development and education. Final rules and appropriations will likely be completed by the end of calendar year 2002. See The Minnesota Project website for further information (www.mnproject.org).

Private Lending

Of course, any entity can also seek financing via a private sector bank. Before heading to the bank, project developers will need to have their project proposal materials, feasibility study, and site data ready. In instances where part of the project objective includes selling power to the local utility, it will be important to have a power purchase agreement from the local utility. The purchase agreement will help the bank gauge the financial viability of the project and evaluate the potential payback period. Local banks around Minnesota are becoming increasingly amenable to funding renewable energy projects, but they must feel comfortable with the forecasted revenue stream, and a utility agreement will play a big role in solidifying that assurance.

Renewable Development Fund

Xcel Energy created the Renewable Development Fund in May 1999 as a response to the 1994 Minnesota legislation regarding spent fuel storage at the Prarie Island Nuclear Plant. The Fund is designed to provide funding for renewable energy projects. Xcel Energy completed its first round of funding under this program in 2001, and will begin the second funding cycle in late 2002 or early 2003. At that point Request for Proposals will be issued for wind, biomass, solar and hydro projects. Funding will be split between new development projects that result in the production of renewable energy, and research and development project that would lead these technologies toward full commercialization.

MAKE IT HAPPEN

The first and most important step in making your community energy project happen, is choosing something realistic for your community. Sure there are a number of other steps that must be completed, but that’s really the crucial choice. If you live in a valley or basin, don’t pick wind. If you live in an area completely shrouded in shade, don’t pick solar. If you don’t have a good, local source of biomass, don’t plan your community around it. Be sure to pick something that fits well with your community goals and vision. Be sure to pick something that you and/or your community can get behind and that fits your motivation for doing a project. The attached checklist will give you a list of other things to consider as you move along in the process, but it may be more important to talk with other people who have already done projects like the one you’re proposing, or even to talk with a professional project developer. Making the right choices up front, doing the pre-panning research, contacting the right people, engaging your community and completing the necessary planning will be time consuming and at times difficult, but to do the project right, will all be important and will pay-off in the end.

HELPFUL RESOURCES FOR COMMUNITIES:
Energy Star, a program of the US Environmental Protection Agency and US Department of Energy: www.energystar.gov. To use the free benchmarking tool, simply click on the button that reads "Benchmark your building's energy performance".

Database of State Incentives for Renewable Energy: www.dsireusa.org. This website includes lots of information including actual incentives, summary of provisions, contact information, etc.

Office of Power Technologies: Clean Power for the 21st Century Website: http://www.eren.doe.gov/power/repi.html. This site details the Renewable Energy Production Incentive (REPI).

Minnesota Department of Commerce's *Energy: Modern Technology – Solar*: http://www.commerce.state.mn.us/pages/Energy/ModTech/solarmain.htm#Rebate. This links brings you directly to information regarding the Department of Commerce's solar rebate program. It also has links about how to pick a supplier, links to other resources, and a map of solar energy potential around the state.

For more information about any utility conservation programs, visit your utilities website. Some examples include: Xcel Energy at: http://www.xcelenergy.com/CCD/, Ottertail Power Company at: http://www.otpco.com/asp/energywizard.asp, Great River Energy at: http://www.greatriverenergy.com/HTML/environment/env_dsm.html.

Xcel Energy: Interconnection Guidelines For Parallel Operation of Distribution Connected Customer-Owned Generation: http://www.xcelenergy.com/EnergyMarkets/CustInterconnectGuide/TOC.asp. This document applies to Xcel Energy territories in Michigan, Minnesota, North Dakota, South Dakota and Wisconsin (Effective date: January 2001).

Headwaters Regional Development Commission: Economic Development: http://www.hrdc.org/document/econdev.html. This site provides great information for economic development and financing in the Headwaters Region (Bemidji); also provides numerous links to other organization that could provide funding.

Northwest Minnesota Foundation: Grants: http://www.nwmf.org/html/programs.htm. A source of funding information from Northwest Minnesota Foundation that offers both grants and loans to programs utilizing new technologies.

USDA Rural Business-Cooperative Service Program: http://www.rurdev.usda.gov/rbs/. This site provides numerous links into a number of different funding opportunities including the programs mentioned in the text under "Financing" (http://www.rurdev.usda.gov/rbs/busp/bprogs.htm and http://www.rurdev.usda.gov/rbs/biomass/biomass.htm) and also provides a link to the Value Added Development Grants Program.

Minnesota Rural Development site, available at: http://www.rurdev.usda.gov/mn/rural_business.htm, provides information regarding various loan, lending, grant programs for rural businesses in Minnesota.

Minnesota Department of Commerce's *Energy: Information Center*: http://www.commerce.state.mn.us/pages/Energy/MainInfoCenter.htm - Commerce's Energy Information Center web page that lists publications for residential, small business/commercial, and institutional and municipal buildings.

Minnesota Planning: Environmental Review: http://www.mnplan.state.mn.us/eqb/review.html#How%20it%20works - information about environmental review process, documents, and how the Environmental Quality Board works for development and approval of new projects

Minnesota Planning: Wind Turbine Siting: http://www.mnplan.state.mn.us/eqb/wind/index.html - particular information regarding wind project permitting and siting for wind projects over 5 MW

Online Technical Writing: Recommendation and Feasibility Reports: http://www.io.com/~hcexres/tcm1603/acchtml/feas.html - online technical writing manual for feasibility studies

Minnesota Department of Agriculture: Financial Assistance: http://www.mda.state.mn.us/feedlots/manuredirectory5.htm - for information on financial assistance resources for farmers

ADDITIONAL REFERENCES:

Minnesota Planning. *Guide to Minnesota Environmental Review Rules*.

CONTACTS FOR ADDITIONAL ASSISTANCE:

Energy Specialists, and Commerce's Energy Information Center
Phone: 651-296-5175 or 1-800-657-3710 (toll-free)
Email: energy.info@state.mn.us

Environmental Quality Board
Environmental Review Division
Phone: 651-296-8253

Victoria Rico
Rebuild Minnesota
Phone: 651.296.2429
Email: rebuild.Minnesota@state.mn.us

Chris Gilchrist
Conservation Improvement Program (CIP)
Phone: 651.297.4634
Email: Chris.Gilchrist@state.mn.us

CHAPTER 12: TOWNS OF TOMORROW – CREATING A VISION FOR THE FUTURE

Minnesota is rich in renewable energy resources that will allow us to achieve a sustainable energy future with energy resources that can ensure economic development, environmental improvements, and revitalization of our rural and urban communities. This workbook has explored many of the energy technologies available to communities interested in diversifying their energy supply to include this indigenous, renewable energy. It has shown that there are many reasons communities have chosen, are choosing, and will continue to chose renewable energy technologies. As highlighted by the symbols throughout the manual, some communities are motivated by the environmentally friendly nature of the these technologies, some see opportunities for economic development and job creation, some want greater energy independence, and some want to clean up an existing waste problem. All of the communities described in the case studies have become more livable and more sustainable.

With wind, biomass, solar energy, and increased efficiency through conservation and cogeneration, the community energy system of tomorrow could be very different from the one we have today. But could it really? After all, each community is part of a larger system. Our electric system is owned by multi-state investor-owned utilities and large cooperatives. It is shaped and regulated by state policy. Our state system is interconnected with the regional electricity system and that with the national system. National policy and regulation affect what happens in each city here. The way that we produce and use energy in the United States affects people and the environment on the other side of the globe.

Sure, good ideas implemented on a local level make one community a better place to live and work. But what difference does it make in the bigger picture? In fact, creative vision for real change usually comes from people at the local level. Think about the change in national understanding of smoking, of campaigns against drunk driving, of recycling. Recycling programs started with a few scout troops collecting aluminum cans and newspapers. Today, everyone has a recycling bin out back. Successful vision and change at the local level drives state policy changes and success at the state level drives national policy.

Vision from community energy projects is already impacting thinking within Minnesota state government. Because of a citizen-driven initiative, Lake City is looking at the feasibility of adding wind energy to the local municipal electric system. One of the citizen leaders was interested in the possibilities for partnering wind and fuel cells. Cruising the web, one day, he came across information about a hydrogen fuel cell initiative in Iceland, and began a correspondence with officials there. Through this relationship, an Icelandic delegation visited Minnesota in the spring of 2002 to talk about their hydrogen initiative. People in state government got interested, and now state officials are beginning to examine the potential role of hydrogen in Minnesota's future.

Minnesota is well positioned to lead the nation in supplying our industries, farms, homes and government with renewable energy that not only creates economic opportunities but also removes constraints current energy practices impose on future generations. To ensure progress, Minnesotans need to balance a broader vision of how our energy resources should be managed, with a practical assessment of what we can achieve. Minnesota has the resources to take the next bold step. It is simply a matter of creating a vision, for our state and our communities.

Consider the following examples:

EFFICIENCY OF THE FUTURE

Imagine a state where the local government, local businesses, and local people all agree that creating energy efficiency in all sectors, from residential, to commercial, to industrial, would be their primary energy focus. Efficiency would be the guiding principle behind their future energy planning. This state, not unlike Minnesota today, had a growing population and was faced with projected energy short-falls within the decade. To make matters worse, it was almost completely dependent upon imported fossil fuels.

With government taking the lead, and partnering with local utilities and businesses, policies were enacted that transformed their engineering and manufacturing practices to build more efficient new homes and buildings and to produce goods more efficiently. Citizens of the state supported these efforts by buying more efficient homes and autos, and by electing government officials and supporting legislation that worked to encourage continued efficiency improvements.

If fact, a real example of such a place can be seen in Sweden, where energy efficiency has become the norm. Swedes, from government officials, to manufacturing leaders, to the average citizen, decided that they would have the most efficient housing in the world. They have made energy efficiency a priority. In roughly twenty years, they have been able to make housing manufacturing one of their most innovative and modern industries, and have become a model for the rest of the world.

Minnesota too could make huge strides just by implementing greater efficiency improvements. If all state, county and municipal run buildings were renovated with strict requirements for energy conservation, Minnesota could take huge strides in reducing its energy demand. If every person in the state were to switch to Energy Star appliances, the state could make huge strides in reducing its energy consumption. If communities all around the state partnered with their local utility to improve the efficiency of their homes and businesses, the state could make huge strides in reducing the amount of coal it burned. There are so many options. Minnesota just needs to lay out the vision.

WINDS OF TOMORROW

Imagine yet another state that saw the future of its economy in wind power. It had a strong wind resource with economic and physical potential for significant wind development, like Minnesota. It also had a strong manufacturing sector that was home to industry pioneers, similar to Minnesota's own. Leaders of this state, including local government officials, business leaders, and community organizers, foresaw the need for renewable energy and decided to invest the state's resources into wind turbine technology. The people of this state had a vision and positioned themselves to meet an inevitable future demand. Not only would they be well aligned to benefit from future economic development, but they would also gain much needed hands on experience implementing wind programs.

Such a "state" already exists. Denmark decided in the late eighties to power the country with wind energy. Danish industries have since become the dominant manufacturers of wind turbines. In fact, most of the wind turbines now erected in Minnesota were manufactured in Denmark. Minnesota has the potential to mimic the efforts put forth by the Danes. Minnesota has a greater wind resource, a strong manufacturing base, and the technological know-how to become world leaders in wind manufacturing. Wind is the world's fastest growing energy source. Minnesota must take advantage of its position and capitalize on this burgeoning market.

We could decide today that 20% of our energy supply will to come from renewable energy resources by 2020. We could partner with other Midwest state to lay the groundwork for this system so that by the end of the decade, there would be thousands, say 6,500 megawatts of new wind energy in the region.

HYDROGEN: THE COMING REVOLUTION

While the hydrogen economy is still an idea gathering momentum, what if a state decided today to begin a transition in that direction? Imagine how well positioned that state would be in twenty years and the economic advantage it would have. It could begin its quest by investing research dollars into using renewable resources to split water into hydrogen and oxygen and into developing fuel cells that could be used in automobiles and in homes. Perhaps it would start by implementing a pilot program that ran city buses on hydrogen fuel cells.

This concept is actually not far fetched. In 2001, Icelanders proclaimed to the world their intent to become the world's first hydrogen economy – completely free of fossil fuels. Iceland plans to derive all its hydrogen via electrolysis powered by renewably generated electricity. Rather than waiting for someone else to take the first step, Iceland stepped into the forefront, and became the world's leader in creating a vision for a fossil fuel-free energy future. It in fact, plans to begin this transition by using fuel cells on city buses and expanding it from there. The first public hydrogen fueling station will open in Iceland in April of 2003. By taking such a step, Icelandic developers will be able to begin building a nation-wide hydrogen infrastructure system – positioning themselves well ahead of the rest of the world and primed to market their knowledge as everyone else plays catch-up.

Minnesota, too, could create such a vision. We could, as a state, as communities, as leaders, set a goal and then plot a course, enact policies, and create incentives to achieve it. Community level initiatives could drive that vision. What are we waiting for?