Minnesota Agriculture Energy Efficiency and Renewable Energy Potential Study

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Prepared for:
Minnesota Farmers Union

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Executive Summary

1.1 BACKGROUND
In consultation with the Minnesota Farmers Union (MFU), GDS Associates, Inc. ("GDS") conducted this assessment of energy efficiency and renewable energy potential for agricultural producers in Minnesota.

The U.S. agricultural sector is moving into the fifth year of low commodity prices and this recession has put a significant strain on the agricultural sector. The good news is energy is one of the few areas where producers can control costs. This study looks at the impact energy efficiency and renewable energy can have on a farm and the potential benefits that energy efficiency and renewable energy installations may yield for producers in Minnesota.

While the agricultural sector may be small compared to industrial and commercial sectors in Minnesota, it is a large source of income for Minnesota. Agriculture accounts for almost one-third of Minnesota exports and is the second largest economic sector in the state, when including production and processing. As of 2017, about 51% of the land in Minnesota was agricultural in use and producing a wide variety of agricultural products.

Minnesota ranks first in the nation in green pea, oat, red kidney bean, sugar beet, sweet corn, and turkey production. Minnesota ranks second in the nation for hogs and spring wheat production, fifth in canola and vegetable production, seventh in potato production, and eighth in milk production. Farms have limited control over costs and what they get paid for their products and yet the agricultural industry exports over $7 billion annually, almost one-third of the state’s total merchandise exports. The value of Minnesota’s agricultural sector production was over $18 billion in 2017, yet the median gross farm income that year was only $28,551. In 2014, the best year on record for agriculture in the U.S., the typical farm only netted $10,000 that year.

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2 Minnesota Agricultural Profile 2017. [https://www.mda.state.mn.us/sites/default/files/inline-files/MN%20Ag%20Profile%202017.pdf](https://www.mda.state.mn.us/sites/default/files/inline-files/MN%20Ag%20Profile%202017.pdf)
4 Tom Vilsack, presentation during 2018 Sustainable Ag Summit
These are some staggering statistics, yet there are often not as many opportunities available to assist the agricultural sector in areas related to energy efficiency and renewable energy as other sectors, even though these present rare opportunities to control costs.

This study focuses on direct energy uses on farms (electric, liquid propane, and natural gas) and does not investigate indirect energy use (such as fertilizers and pesticides). It identifies the monetary, operational, and production benefits from energy efficiency improvements and renewable energy installations on Minnesota farms. In addition, it recognizes unmet needs and service gaps to support farmers in light of (1) Conservation Improvement Program exemption and shortage of human resource and technical capacity for many rural electric cooperatives and (2) demand charges, net metering, and other costs associated with renewable energy installations. The study pinpoints barriers producers face when trying to implement energy efficiency and renewable energy projects as well as potential opportunities to overcome these barriers.

For this study, GDS, the consulting firm retained to conduct this study, produced the following estimates of energy efficiency and renewable energy potential for Minnesota producers:

- **Monetary Benefits**
- **Operational Benefits**
- **Production Benefits**

The results provide information on energy efficiency and renewable energy opportunities available for producers to reduce production costs, optimize operations, position farms for expansion, and help them stay on their land and continue operations. The data used for this report was the best available at the time this analysis was developed.

### 1.2 RESULTS – ENERGY EFFICIENCY

While energy makes up only approximately 5% of all farm expenditures, energy is one of the only costs that a farm has some control over. The agricultural industry in Minnesota is using over 28.5 trillion Btu of energy annually, equaling almost $547 million annually. Of this, about 12.6 trillion Btu is from electric, liquid propane (LP), and natural gas. On farm direct energy use for electricity, LP, and natural gas costs Minnesota farmers about $261 million dollars each year. Given this, it is no wonder farms surveyed indicate significant interest in energy efficiency. Even in this challenging agricultural market, producers are moving forward with high efficiency equipment installations when possible. This study found that significant energy efficiency potential exists in the Minnesota agricultural sector, with estimates of up to 15% in energy savings possible for electric, natural gas, and LP. This equals potential savings of over 312 million Btu, or around $39 million, annually.
LED lighting showed the highest potential for energy savings, in the sampled reports. Additional high potential opportunities included variable frequency drives, automated controllers, high efficiency grain dryers, refrigeration heat recovery, and high efficiency space and water heating. The potential savings from the energy reports when broken down by fuel type, showed the majority of potential energy savings is from electric, followed by LP.

Energy efficiency may result in operational and production benefits, above energy savings. Operational benefits may include reduced labor for equipment repairs or equipment maintenance (for example self-tightening belts on new fans) and less time spent replacing burnt out lightbulbs. Other operational benefits may include higher employee job satisfaction and improved employee safety from new equipment, improved lighting, and improved heating/cooling equipment.

Production benefits can range from increased milk production to improved animal health and welfare to improved crop yields and more.

1.3 RESULTS – RENEWABLE ENERGY

Significant potential for renewable energy installations exists across rural Minnesota, in particular on farms and in agribusiness. Adding this renewable potential would have the double benefit of increasing the amount of energy produced from renewable sources and decreasing overall farm costs by “rolling back the meter” for farm-owned installations. Additionally, land leases for renewable systems can offer another revenue stream for farms. Agribusinesses often have available land mass and rural sites that are ideal for large-scale wind and solar installations. This has the ability to bring significant new and highly needed income to Minnesota farms. Further, land leases generally run for 20-35 years, locking in a significant new revenue stream and a new specialty crop, energy, for a farm. Both customer-owned generation and/or land leases for utility scale systems can help the farmer’s bottom line. In light of Minnesota’s significant renewable energy goal of achieving 25% renewable energy by 2025 statewide, Great River Energy’s (GRE) goal of 50% renewable energy by 2030, and Xcel Energy’s goal of 100% carbon free electricity by 2050, farms are well positioned to assist with renewable energy advances.
1.4 RECOMMENDATIONS

Barriers for producers when it comes to moving forward with energy efficiency improvements and implementation of renewable energy systems include:

- Poor agriculture economy
- Energy rate structures
- Lack of programs for un-regulated fuels
- High equipment and installation costs of some projects
- Inability to determine the most cost-effective projects
- Unaware of energy savings potential
- Not knowing what size/type of system to select
- Not knowing where to get financing
- Need assistance to access grant funding, utility funding and other cost share opportunities.

The greatest barrier is the current poor agriculture economy, which is a result of many factors and does not have simple solutions. However, opportunities for assisting producers with overcoming many of the other barriers to increasing energy efficiency and renewable energy installations, noted above, include:

- Improved dissemination of program information (state, utility, and federal)
- Improved partnerships between the private sector, public sector, utility companies, and producers to help increase energy efficiency and renewable energy opportunities
- Outreach to land lease companies, by agricultural associations or other groups, to increase opportunities for land leases of utility scale systems on marginal lands
- Improved Conservation Improvement Program (CIP) design, converting from utility-based programs to a state-based program or creation of a state based agricultural energy program
- Creation of LP (and other delivered fuels) energy efficiency programs and savings goals
Additional recommendations that would allow for improved estimates of energy use and renewable energy installations on farms in Minnesota include:

- Tracking of not only energy savings, but energy assessments/audits completed by utilities across all sectors
- Improved tracking of renewable energy installations and specifying type of site (residential, commercial, agricultural, industrial, community)
- State and utility energy efficiency potential studies that include the agricultural sector
- Completion of federal census reports more frequently

While the agricultural sector may be small compared to industrial and commercial sectors in Minnesota, it is a large source of income for Minnesota. To keep the farms in Minnesota, we must find ways to help farms overcome barriers and maximize the opportunities that they have to control farm costs and improve their bottom line. Without it, there will likely be more forced farm closures, less farms transitioning to future generations, and a loss of something that is, and has always been, a large and important part of Minnesota culture.

1.5 CONCLUSIONS

The agriculture sector is extremely important to Minnesota’s economy and decreasing costs where possible, such as energy costs, can help farms become more profitable. Working together we can help Minnesota farms maximize energy efficiency and improve their bottom line, ensuring farming continues to be a top economic sector in Minnesota for future generations. While there are barriers to producers in moving forward with energy efficiency improvements and renewable energy systems, there are numerous resources and opportunities available to help producers to overcome many of these barriers. Resources include federal, state, and utility programs offering energy audits, technical assistance, and financial assistance.

<table>
<thead>
<tr>
<th>Energy Audit Assistance</th>
<th>Technical Assistance</th>
<th>Financial Assistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>• NRCS-EQIP</td>
<td>• NRCS</td>
<td>• Utility</td>
</tr>
<tr>
<td>• Utility</td>
<td>• USDA</td>
<td>• CPACE</td>
</tr>
<tr>
<td>• GRE</td>
<td>• FSA</td>
<td>• NRCS-EQIP</td>
</tr>
<tr>
<td>• Dairyland Power</td>
<td>• CERTs</td>
<td>• USDA-REAP</td>
</tr>
<tr>
<td>• CenterPoint</td>
<td>• University Extension</td>
<td>MN Dept. of Ag.</td>
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<tr>
<td>• Great Plains</td>
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<td></td>
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<tr>
<td>• CERTs</td>
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The most effective way to overcome the barriers is through improved dissemination of information regarding the array of resources and assistance available to producers looking to improve the energy efficiency of their farm.
Study Methodology

The primary objectives of this study serve to identify the potential benefits to farms in Minnesota from energy efficiency improvements and renewable energy installations, as well as barriers to implementation of energy efficiency and renewable energy on farms. The study closely examines any unmet needs and/or service gaps to support farmers in becoming more energy efficient and/or moving forward with renewable energy projects.

In recent years, GDS has worked with many producers in Minnesota, as well as numerous producers in other states, to develop agricultural energy management plans. GDS compiled 85 of these completed Minnesota plans and examined the data to find where energy efficiency opportunities exist amongst various farms throughout the state as well as the estimated percent of energy savings that can be gained by a typical farm business in Minnesota.

This study synthesized data from completed farm energy audits and renewable energy installations, case studies, and Conservation Applied Research and Development (CARD) studies funded by the Minnesota Department of Commerce. Findings were reviewed to determine needs and/or opportunities for farms to reduce production costs, optimize operations, position for expansion, and assist producers to stay on their land and continue farming operations. The study evaluated the technical capacity in rural electric cooperatives, municipal utilities, and power associations to conduct energy audits and assessments for farms. The study analyzed and researched which energy efficiency measures and forms of renewable energy could most benefit farmers across Minnesota. Energy savings were compared to savings found in completed energy audits in other states including Colorado, Wisconsin, Iowa, and Michigan. GDS Staff conducted a phone survey of these Minnesota producers to learn whether any recommendations from the reports were implemented, to gauge further interest in energy matters, and learn if any producers had installed a renewable energy system.

A survey of existing energy efficiency programs at the federal, state, and utility levels was conducted to gauge impact, effectiveness, and reach. The study also looked at renewable energy financing programs and costs of and barriers to renewable energy across the state, including demand charges and net metering. Rural energy service programming from other states was reviewed to benchmark farm services available in Minnesota.

GDS initiated the study by reviewing Minnesota’s electric and natural gas utilities as well as the liquid propane distributors. GDS also investigated the number and types of farms in Minnesota and historical energy use on farms in the U.S. and Minnesota, comparatively. GDS completed a thorough review of the historical and current energy efficiency and renewable energy programs offered to Minnesota farms including audits offered through milk cooperatives, farm associations, utility, state, and federal programs. The study then compared these programs to similar programs offered in neighboring states in order to benchmark program offerings in Minnesota. GDS reviewed energy efficiency and renewable energy case studies and Minnesota Department of Commerce – Conservation Development and Research (CARD) studies to find potential needs and/or opportunities for Minnesota to increase opportunities for farmers to improve energy use on their operations.
Introduction

This report highlights the importance of energy efficiency and renewable energy for Minnesota’s agricultural producers and assesses the potential for how much impact energy efficiency and renewable energy installations could have on farms in Minnesota. In addition, the report reviews programs available to producers that provide assistance for energy efficiency and renewable energy system installations. It also provides an overview of barriers that exist for producers interested in improved energy efficiency and/or the installation of renewable energy systems. Finally, this report will benchmark how the state of Minnesota compares to other states in program offerings and makes recommendations to remove barriers to increase energy efficiency and renewable energy installations in the agricultural sector. This section is an introduction into the current state of the agricultural sector.

The agriculture community has suffered several sector-specific and national recessions in the past ten years. The most recent recession is now going into its fifth year and, consequently, agricultural incomes are poor to nonexistent. While 2014 was the best year on record for the agriculture industry, a typical farm netted only $10,000 that year. Regardless of the product—milk, grain, meat, or produce—the costs of production outmatch sales, resulting in a cash-strapped industry statewide. By way of example, the typical full cost of production for 100 pounds of milk or hundredweight (cwt) in Minnesota in 2016, was just over $21/cwt, but dairy farmers were paid, on average, just over $18/cwt. The market in 2018 was similar, as seen in the graphic below, with average mailbox prices for milk in September 2018 coming in at only $16.25/cwt and only slightly higher in Minnesota at $17.32/cwt.

5 Tom Vilsack, presentation during 2018 Sustainable Ag Summit
6 Cwt definition: A hundredweight, a unit of measurement for weight used in certain commodities trading contracts. In North America, a hundredweight is equal to 100 pounds
The poor economy of the agricultural sector is one factor that has resulted in consolidation of farming operations. The data shows the total number of farms decreasing across the U.S. as many smaller farms have closed business and sold off livestock and land to larger operations. The number of farms in Minnesota has declined from 81,000 farms in 2009 to 73,200 (as of June 2018) and as of August 2018, the state of Minnesota now has less than 3,000 dairy operations. In addition, Minnesota lost just over 1,000 hog operations from 2007 to 2012 alone. According to Marin Bozic, Assistant Professor in the Department of Applied Economics at the University of Minnesota, in 2018, Minnesota dairies exited at a rate of 9.4%, a rate much higher than in the past. While some of these exits were the result of planned retirements, many were the result of the poor agriculture economy.

Figure 3-2 was presented during the 2019 Wisconsin Agriculture Outlook Forum. Note the elevated level of dairy exits during 2018 than in years past. The previous high level in 2014 was primarily the result of voluntary dairy exits as commodity and livestock prices were high and allowed producers to retire comfortably. The 2018 high level of exits was more the result of forced closures due to the poor economy.
Farms that are surviving are business savvy and many have diversified operations to achieve multiple revenue streams. Many farms feel that the current prices may become the new normal. Unless a farm can learn ways to work within the current pricing system, like cutting operations costs, or finding additional revenue streams for the operation, the farm long-term outlook is grim.

Some of the ways farms are finding to cut operating costs are to install energy efficient equipment and utilize various cost-share options available to help decrease out of pocket costs. Energy use makes up about 5% of all farm costs and is often a controllable cost for a farm, making energy efficiency one of the easiest ways for a farm to decrease operating costs.

This project reviewed energy management plans for over 80 farms in Minnesota. Over the past five years, on average, farm savings from the implementation of cost-effective energy efficiency improvements recommended in those reports, lead to average energy cost savings of 24%. These savings are consistent with savings averages from energy management plans in other states, where typical farm energy savings ranges from 5-30%. When savings from improved operational efficiency and increased production from upgraded heating, cooling or harvesting equipment are taken into account, even greater savings occur.

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Many farms have found that installation of renewable energy systems has helped to offset utility costs by “running the meter backwards” when they are producing electricity with solar photovoltaics (PV), wind turbines, or methane digesters. Farms are finding they can decrease purchases of liquid propane (LP) or natural gas with the use of solar thermal systems, ground source heat pumps, biomass systems, and methane digesters. Additionally, farms are finding opportunities to diversify income by leasing land to entities for wind turbine or other renewable energy installations. Land leases are generally set up for 20-35 years (the typical life of the equipment) and require no work on the part of the producer to maintain the equipment. Producers simply allow road access for system owners or operators to inspect and fix equipment as needed. A study by the Sarah Mills at University of Michigan found that farms with wind turbines installed on their land are more likely to feel that they can invest in the farm, investing about 2.5 times as much as a farm without a wind turbine, and the farms feel confident they will stay in production for future generations rather than go idle.\footnote{Farming the Wind: The Impact of Wind Energy on Farming. Sarah Mills, PhD. Center for Local, State, and Urban Policy, University of Michigan}
4. Background on Energy Use and Renewable Energy Installations on Minnesota Farms

Historical information from the agricultural sector in Minnesota that specifically looks at direct energy consumption and renewable energy installations on farms in Minnesota is outlined in this section of the report. Direct energy is energy that is used directly on farms, such as electricity, natural gas, diesel, gasoline and LP. The focus of the study is on direct energy use, specifically electricity, natural gas, and LP. The study does not investigate indirect energy use, such as fertilizers and pesticides and also does not investigate direct energy from diesel or gasoline. An overview of the number of farms and types of farms in Minnesota is provided in this report. It is necessary to understand how energy is consumed in the agricultural sector before an assessment of untapped energy efficiency savings potential as well as an assessment of the potential for renewable energy systems can be completed. This section provides detailed information on direct energy use in the agricultural sector.

4.1 MINNESOTA ELECTRIC AND GAS UTILITIES

In 2017, the state of Minnesota consumed a total of 1,806.9 trillion Btu of energy, ranking 18th in U.S. energy consumption. There are multiple utilities that provide electric and natural gas to Minnesota producers. Minnesota has a total of 176 electric utilities and 37 natural gas utilities. Estimates show over 170 LP suppliers throughout the state. Of the electric utilities, three are Investor Owned Utilities (IOU’s), 47 are cooperatively owned, and 126 are municipally owned. It should be noted that 19 municipal utilities offer both electric and natural gas service and one IOU offers both electric and natural gas service to their members. These combination utilities are counted individually in the electric and natural gas totals noted above.

Though IOU’s provide electricity to the majority of the state population, the cooperative electric associations cover most of the state’s geographic land mass and supply the majority of the state’s agricultural sector. More than 80% of the electricity used for farm operations in Minnesota is sold through rural electric cooperatives. Though natural gas lines are expanding, most of the agricultural sector relies on delivered fuels, primarily liquid propane (LP), in light of long distances from natural gas infrastructure and population centers. Approximately 10% of Minnesota residents are using LP as a heating source for their homes, which is about twice the national average. Unfortunately, LP usage data is difficult to obtain as LP is an unregulated fuel in Minnesota, unlike natural gas and electricity.

The state of Minnesota, like most states in the U.S., requires utilities to participate in promoting energy efficiency through the Conservation Improvement Program (CIP). In Minnesota, CIP is overseen by the Minnesota Department of Commerce, Division of Energy Resources. This program requires that 140 of the 213 electric and natural gas utilities participate in achieving 1.5% electric savings and 1% natural gas savings annually through CIP. Some utilities are exempt from participation due to their small size, though many of these utilities still offer some form of energy efficiency program to their members. For example,

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15 Attorney General Keith Ellison. [https://www.ag.state.mn.us/consumer/Publications/PropaneGas.asp](https://www.ag.state.mn.us/consumer/Publications/PropaneGas.asp)
some CIP exempt utilities are offering their members discounted LED light bulbs, discounted high efficiency water heaters, and appliance recycling programs, to name a few.

**FIGURE 4-1** shows the territory map for electric distribution utilities in Minnesota. Note that the size of utility service areas covered by cooperatives is much larger than those areas covered by IOUs’ or municipal utilities.

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**FIGURE 4-1. MINNESOTA ELECTRIC UTILITY SERVICE TERRITORIES**

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FIGURE 4-2 shows the territory map for natural gas distribution utilities in Minnesota. As the map depicts, natural gas service is primarily located in metro areas and does not extend into most of rural Minnesota.

4.1.1 Energy Rates on Farms in Minnesota

Electric rates in Minnesota vary across utilities and can be as low as $0.04/kWh and as high as $0.14/kWh. Rates also vary based on the farm’s rate class. Farms can fall under a number of rate classes including a residential rate, farm rate, commercial rate, or industrial rate and may or may not include demand charges. Demand is the amount of electricity drawn from and electric system at a given time, measured in kilowatts. A demand charge is a charge for electricity based on the maximum amount of a system’s electricity a customer uses\(^\text{17}\). Demand charges can be based on the highest 15-minute interval over a month or during a specified time of day, such as from 2 pm until 6 pm. Demand charges vary by utility and depend on the equipment running during the demand period.

On average, across the U.S., the cost of electricity for residential customers is $0.146/kWh, $0.113/kWh for commercial customers, and $0.083/kWh industrial customers\(^\text{18}\). In light of the wide range of electric utility rates across Minnesota, this report will estimate a $0.09/kWh rate for farms. This lower cost/kWh

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takes into account farm consolidation which largely results in a commercial or industrial rate. Further, demand charges will not be accounted for in energy savings as demand charges can vary across electric utilities anywhere from $4.00/kW to up to $30.00/kW. These charges are unique to each utility’s billing structure. Plus, it is impossible to estimate the combination of equipment running during the peak rate period, thus impossible to estimate overall demand savings per farm on average.

While natural gas use is less prevalent in the agricultural sector in Minnesota than in other states, there is some use on farms for space and water heating, as well as grain drying. The current price per therm of natural gas in Minnesota is $0.88/therm (residential), $0.60/therm (commercial), and $0.45/therm (industrial)\(^{19}\). Again, due to consolidation, the natural gas rate used for the remainder of this report for savings and cost estimates will be based on the $0.60/therm commercial rate for larger operations.

As previously discussed, LP is a non-regulated fuel. While an average cost per gallon is not listed, based on the current rate of LP from numerous suppliers in Minnesota (as of January 2019), the current average rate of $1.64/gallon will be used for estimated potential savings in the remainder of this report.

### 4.1.2 Types of Farms in Minnesota

As of 2017, about 51% of the land in Minnesota was agricultural use and producing a wide variety of agricultural products. Minnesota ranks first in the nation in green pea, oat, red kidney bean, sugar beet, sweet corn, and turkey production. Minnesota ranks second in the nation for hogs and spring wheat production, fifth in canola and vegetable production, seventh in potato production, and eighth in milk production\(^{20}\). Notably, poultry operations are the most energy intensive livestock operations, with about 6% of total farm expenditures going towards energy and 4% of total farm cash expenses going towards electricity\(^{21}\). This is significant given Minnesota is the largest turkey producer in the country. TABLE 4-1 shows selected 2017 rankings for Minnesota’s agriculture sector.

### TABLE 4-1. 2017 MINNESOTA AGRICULTURE RANKINGS (SELECTED)

<table>
<thead>
<tr>
<th>MN Rankings as of 2017</th>
<th>Total number of Farms</th>
<th>farms</th>
<th>73,200</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sugar Beets</td>
<td>tons</td>
<td>12,515</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Turkeys Raised</td>
<td>head</td>
<td>42,500</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>On Farm Grain Storage</td>
<td>million bushels</td>
<td>1,550</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Pork Exports</td>
<td>millions of $</td>
<td>717</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Grain Storage Capacity</td>
<td>million bushels</td>
<td>2,310</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Soybeans</td>
<td>bushels</td>
<td>380,230</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total Value, Principal Crops</td>
<td>millions of $</td>
<td>10,100</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Corn for Grain</td>
<td>bushels</td>
<td>1,480,220</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Vegetable Production</td>
<td>cwt</td>
<td>21,105</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Net Farm Income</td>
<td>millions of $</td>
<td>3,773</td>
<td>6</td>
</tr>
</tbody>
</table>

\(^{19}\) U.S. – EIA Minnesota state profile. [https://www.eia.gov/state/?sid=MN](https://www.eia.gov/state/?sid=MN)


Agriculture accounts for almost one-third of Minnesota exports, over $7 billion annually and is the second largest economic sector in the state, when including production and processing. Employment in agriculture and the food industry accounts for 15% of total jobs in the state. In rural Minnesota, agriculture accounts for over 20% of all jobs and in metro areas, agriculture employment accounts for 13% of all jobs. The employment impact of Minnesota’s agricultural production and processing supports over 365,000 jobs.22,23

### 4.2 AGRICULTURE SECTOR BASELINE ENERGY USE

In 2016 the agriculture sector consumed 1.872 trillion Btu of energy, accounting for about 1.9% of total U.S. primary energy consumption, with about 60% of this being consumed as direct energy on farms.24 When looking back from 2012 through 2016, the agricultural sector increased energy use by 10%, compared to a 6% growth in output. Of total direct energy use of farms, the majority of use can be attributed to diesel (44%), as this is used for powering field equipment as well as back-up generators and some pumps. The second largest fuel consumed is electricity (24%), followed by natural gas (13%), gasoline (11%), and LP (7%).25

### Minnesota’s Agriculture Industry

**Production + Processing = 2nd Largest Economic Sector**

- Supports over 365,000 jobs
- Over 20% of total jobs in rural areas
- 13% of total jobs in metro areas

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<table>
<thead>
<tr>
<th>Farm Expenditures</th>
<th>millions of $</th>
<th>17,205</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk Cow Inventory</td>
<td>head</td>
<td>455</td>
<td>6</td>
</tr>
<tr>
<td>Cheese Production</td>
<td>million pounds</td>
<td>713</td>
<td>6</td>
</tr>
<tr>
<td>Honey Bee Colonies</td>
<td>colonies</td>
<td>126</td>
<td>6</td>
</tr>
<tr>
<td>Milk Production</td>
<td>million pounds</td>
<td>9,864</td>
<td>8</td>
</tr>
<tr>
<td>Egg Production</td>
<td>million eggs</td>
<td>no data</td>
<td>11</td>
</tr>
</tbody>
</table>

22 Minnesota Agriculture, the Foundation of Minnesota Economy. [https://www.leg.state.mn.us/docs/2008/other/080928.pdf](https://www.leg.state.mn.us/docs/2008/other/080928.pdf)

23 Minnesota Agriculture Profile 2017. [file:///C:/Users/bethany.reinholtz/Documents/24610-001%20McKnight%20Foundation%20Ag%20Potential%20Study/MN%20State%20Ag%20Info/MN%20Ag%20Profile%202017.pdf](file:///C:/Users/bethany.reinholtz/Documents/24610-001%20McKnight%20Foundation%20Ag%20Potential%20Study/MN%20State%20Ag%20Info/MN%20Ag%20Profile%202017.pdf)


Energy PRODUCTION and CONSUMPTION in Agriculture

U.S. energy consumption in agriculture increased in 2016

Farms consume energy in many forms, mainly diesel, electricity, natural gas, gasoline, and liquefied petroleum gas (LPG). Diesel and, to a lesser extent, gasoline are used to power farm machinery. Electricity is used mainly for irrigation, cooling, and lighting. Natural gas and LP gas are used in heating and grain drying. Large amounts of natural gas are required in the manufacturing of fertilizer and pesticide, so these amounts are categorized as indirect energy consumption on farms.

In 2016, the agricultural sector consumed 1,872 TRILLION BTU of ENERGY accounting for about 1.9 percent of total U.S. primary energy consumption. About THREE-FIFTHS of this energy was consumed directly on-farm.

Fertilizer and pesticides made up about TWO-FIFTHS total energy consumed indirectly in agriculture in 2016.

Figure 4-3 shows consumption in both direct and indirect energy sources in the U.S. agricultural sector over the past 15 years. Note consumption of most sources has increased over the past few years.

FIGURE 4-3. ENERGY CONSUMPTION IN THE AGRICULTURE SECTOR BY TYPE OF ENERGY 2002-2016

Looking specifically at energy used in the agricultural sector in Minnesota, most electricity on farms is supplied through rural electric cooperatives. More than 80% of electricity on farms is from rural electric cooperatives, however, this only accounts for about 11% of total rural electric cooperative sales. Cooperatives in Minnesota supply over 14.7 billion kWh of electric to end-use customers annually, which is about 18% of the state’s total electricity sold and generated about $1.5 billion in revenue. A reasonable estimate of total electric sales for farms in Minnesota would be 2.02 billion kWh/year, or 6.9 trillion Btu annually. It is estimated that farms in Minnesota are using about 40.8 million gallons of LP annually and 20 million therms of natural gas annually. Total direct energy consumption on farms in Minnesota is at about 28.5 trillion Btu of energy, or 1.6% of total state energy consumption. Electricity, natural gas, and LP make up approximately 12.6 trillion Btu of energy on Minnesota farms, equaling approximately $261 million in annual farm expenses.

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28 Estimates assume 24% on farm energy from electric, 13% from LP, and 7% from natural gas.
In 2016, Minnesota energy use across sectors included 25.9% in the transportation sector, 20.5% in the residential sector, 19.3% in the commercial sector, and 34.3% in the industrial sector. Agricultural end use consumption is small in comparison to other end use sectors and is not broken out separately as it is combined with the residential, commercial, and industrial sectors. However, given the dire situation of the current agricultural economy, and that energy is one of very few controllable costs, this is a significant cost to producers each year. It is likely that the low total consumption by the agricultural sector is one of the reasons that the agricultural sector is not targeted in energy efficiency programs as much as other sectors.

Figure 4-4 shows percent energy consumption by sector. Note consumption in the agricultural sector is not accounted for separately, but included in residential, commercial, and industrial sector use.

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4.3 AGRICULTURE SECTOR BASELINE RENEWABLE ENERGY INSTALLATIONS

Unfortunately, the most recent data available regarding renewable energy installations for the agricultural sector is from 2009. An updated report has not been completed to date but will be available when the updated USDA 2017 farm census reports are released. Using best data available, as of 2009, a total of 8,569 farms in the U.S. reported having wind turbines, digesters, and/or solar panels installed on site, of which a total of 157 of these farms were in Minnesota. In 2004, a study was completed to examine the following:

- Amount of electricity generated by U.S. wind power and prospects for its growth
- The contribution of wind power to farmers’ income and rural communities
- The advantages and disadvantages for farmers of owning a wind power project versus leasing land for a project
- The USDA’s efforts to promote wind power in rural communities.

The study found that wind energy accounted only for about one tenth of 1% of total U.S. electric power generation capacity in 2003 and that in addition to environmental benefits, wind power had the potential to contribute significantly to America’s growing energy needs while providing economic benefits to farms and rural communities. The Department of Energy set a goal of producing 5% of the nation’s electricity from wind by 2020, estimating that this goal would provide $1.2 billion in new income for farmers and rural landowners. This goal was surpassed in 2017 when the DOE announced that wind energy contributed 6.3% of the nation’s electricity supply. In 14 states, it contributed 10% of total electricity generation, and more than 30% in four of those states. In total, U.S. wind turbines in distributed applications reached a cumulative installed capacity of 1,076 MW, which came from roughly 81,000 turbines connected to the electric grid. Thirty-five percent of distributed wind projects installed in 2017 were at homes and 25% were agricultural installations. As of 2009, a total of 1,420 farms in the U.S. reported having a wind turbine installed on their land, with 100 of these farms located in Minnesota.

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Solar photovoltaics (PV) has been developing on farms nationwide as farms offer a landscape with minimal shading for arrays, large buildings for roof mounting, and large expanses of land ideal for large systems. As of 2009, there were a total of 7,968 farms with installed PV and/or solar thermal systems. The Solar Energies Insight Association shows that solar PV accounts for 30% of all newly installed electric generation for 2018 in the U.S.\(^\text{32}\).

Minnesota generated 24.9% of its electricity from renewable energy sources in 2017 and is working towards a goal of 25% in renewable energy resources by 2025\(^\text{33}\). Additionally, Great River Energy (GRE) announced a goal of 50% renewable energy by 2030\(^\text{34}\), and in December 2018, Xcel Energy, one of the three IOU’s in Minnesota, rolled out a clean energy vision to deliver 100% carbon-free electricity to customers by 2050. As part of this vision, Xcel announced plans to reduce carbon emissions 80% by 2030, in the eight states it serves\(^\text{35}\). These goals provide an excellent opportunity to create new revenue streams for farm operations in Minnesota. Some notable changes in energy use in Minnesota from 2006 through 2016 include:

- Renewables tripled from 7% in 2006 to 22% 2016
- Coal decreased by about one-third from 62% in 2006 to 39% in 2016
- Wind increased more than fourfold, from 4% in 2006 to 18% in 2016\(^\text{36}\).

Renewable energy is strong in Minnesota. Minnesota ranked 5th in the U.S. in 2018 for PV installations and is one of the top two states with community solar installations for 2018\(^\text{37}\). The 2017 census survey has not been released yet. As a result, the total number of renewable energy installations on farms in Minnesota is estimated based on the 2009 USDA Census of Agriculture On-Farm Renewable Energy Production Survey. As of 2009, there were 100 farms in Minnesota with a total of 145 wind turbines, five farms with a total of six methane digesters, 73 farms with solar PV and/or solar thermal systems installed. Of these farms, 51 had solar PV systems and 34 had solar thermal systems, for a total of 157 farms with renewable energy systems installed. These systems saved, on average, $1,364 on utility bills per farm in 2009\(^\text{38}\).

From data collected by the Minnesota Utilities Commission, there were at least 20 additional PV installations on farms between 2010 and 2017. This number is likely much higher as many electric providers do not separate farms from residential and/or commercial facilities. It is likely that there are close to 230 PV systems installed on farms that are customer-owned and many more farms with larger solar arrays and wind turbines that are utility-owned on farm land that is leased by the utility or a third-party. However, given there are approximately 73,200 farms in Minnesota, there is likely a large opportunity for additional installations of renewable energy systems on farms. The Minnesota Department of Commerce currently tracks all renewable energy installations in the state. Improved

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\(^{34}\) Great River Energy sets 50% renewable energy goal for 2030. [https://greatriverenergy.com/great-river-energy-sets-50-renewable-energy-goal-for-2030/](https://greatriverenergy.com/great-river-energy-sets-50-renewable-energy-goal-for-2030/)

\(^{35}\) [https://www.xcelenergy.com/environment/carbon_reduction_plan](https://www.xcelenergy.com/environment/carbon_reduction_plan)

\(^{36}\) Minnesota State Profile and Energy Estimates. [https://www.eia.gov/state/?sid=MN](https://www.eia.gov/state/?sid=MN)


tracking by type of site (residential, agricultural, commercial, industrial, community) would assist in future studies.
Energy Efficiency Potential Estimates

Energy efficiency potential estimates for the agricultural sector in Minnesota are based on information derived from the following sources of information:

- Minnesota agriculture sector baseline energy use
- Completed agriculture energy audits
- CARD studies
- University studies on the energy savings associated with energy efficiency improvements

Cost savings are based on the previously noted $0.09/kWh, $0.60/therm, and $1.64/gallon LP. Barriers producers face when interested in implementing energy efficiency projects on the farm are also included.

5.1 ENERGY EFFICIENCY POTENTIAL

Minnesota has a long history with energy efficiency programs, starting in 1983. Recent estimates show statewide, the economic potential of energy efficiency could decrease forecasted electric and natural gas load by 33%, and CIP program potential could reduce electric load by 14%, and natural gas load by 11% by 2029. The current CIP requirements set a goal of 1.5% savings for electric utilities and 1% for natural gas utilities. Savings goals of 1.5% for electric utilities and 1% for natural gas utilities are achievable every year through 2029 and savings do not vary across IOU’s, cooperatives, or municipal utilities. In addition, that total statewide energy savings from the agricultural sector was found to be only about 1.6% of electric potential and less than 0.25% from natural gas potential. Given that, as noted previously, energy use by the agricultural sector in Minnesota is only about 1.6% of the state’s total use, it is not a surprise to see that the report shows that only a small percent of total CIP energy will come from the agricultural sector. The minimal savings from natural gas is also not a surprise, considering the majority of farms in Minnesota are using LP instead of natural gas for space and water heating needs. Considering the cumulative annual 2029 electric savings potential of 717 GWh and that 1.5% of total savings would be from the agricultural sector, it is a safe assumption the agricultural sector has the potential to achieve savings of 10.8 GWh by 2029 through electric energy efficiency through the CIP programs alone.

Prior to 2012, few programs offered energy management plans for farms. Statistics show through 2009 only 18 farms in Minnesota had an energy audit performed on their facilities. In 2012, in an effort to increase energy efficiency on farms, the NRCS started offering Agricultural Energy Management Plans (AgEMP), through their Environmental Quality Incentives Program (EQIP) to producers across the country. The program offers payments of up to 75% of the cost of an energy audit for all types of agricultural operations. In addition, milk cooperatives, Minnesota-based agriculture groups, and utilities have started to offer energy audit program opportunities to their members to help them understand where they are using energy and the best energy efficiency opportunities available to them. Total numbers of audits for all programs is not available as all programs are run independently without a central database to manage audit numbers.

GDS has completed numerous energy audits through these programs in Minnesota. This consolidated data was evaluated to determine where energy efficiency opportunities exist amongst farms throughout

References:

Minnesota and the estimated percent of energy savings that can be gained by a typical farm business in Minnesota. GDS compared savings to typical energy savings seen on the same types of farms in other states to determine if savings were consistent across states. GDS also researched energy efficiency and renewable energy case studies and Minnesota Department of Commerce – Conservation Development and Research (CARD) studies. All of this information was gathered to determine potential needs and/or opportunities in Minnesota to help farmers improve energy efficiency on their operations.

In reviewing 83 Minnesota farms that had energy audits completed from 2013-2018, overall energy savings averaged 24%, ranging from 1% up to 81%. Typical energy savings from audits completed in other states show a range of 5-30% savings is achievable, placing the Minnesota average in the typical range. Figure 5-1 shows the types of farms in the sample. The high number of dairy farms that received energy audits were due to specialty energy audit opportunities offered to dairy farms through Minnesota milk cooperatives.

**FIGURE 5-1. TOTAL ENERGY AUDITS BY TYPE**

Energy savings per type of operation varied, but overall averaged 130 MMBtu/year if all recommendations were implemented. It should also be noted that some farms consisted of more than one enterprise, such as a farm with irrigated row crops, grain drying, and beef cattle or a dairy with grain drying, or a hog farm with grain drying and beef cattle. Farm type in Figures 5-1 and 5-2 are based on the farm’s primary enterprise. Energy savings for the maple syrup operation is very low, in comparison to other farm types, due to the farm’s use of biomass as its primary energy source. Biomass savings is not looked at in this study due to the emphasis electricity, LP, and natural gas. Energy savings for the hog operations are relatively high as half of these energy audits consisted of mixed enterprises. Greenhouses growing year-round are high energy users due to the energy required to grow plants in Minnesota’s cold climate. Figure 5-2 shows average savings per type of operation.
Energy saving recommendations from energy audits fell into many areas. Specific energy efficiency equipment recommendations and the number of times a recommendation was included in an audit report can be found in Table 5-1 in Appendix A.

### 5.2 ENERGY EFFICIENCY SAVINGS ESTIMATES

The following sections present estimates for economic, production, and operational savings potential for Minnesota’s agricultural sector. The information compiled is based on energy savings opportunities from the 83 sampled energy audit reports, estimated market penetration of recommendations, energy savings seen in neighboring states, and potential for cost-share or incentives for the installation of energy efficiency equipment. In order to standardize energy savings from various energy sources, energy savings is represented in MMBtu (million Btu). Estimating 15% of energy consumption in the Minnesota agricultural sector can be saved by installing cost effective, energy efficient equipment, energy efficiency could decrease total energy use by the agricultural sector to about 312.3 million Btu annually. This equals approximately $39 million in annual farm energy costs.

#### 5.2.1 Summary of Findings

LED lighting showed the highest potential for energy savings in the sampled reports. Additional opportunities included variable frequency drives, automated controllers, high efficiency grain dryers, refrigeration heat recovery, and high efficiency space and water heating, to name a few. The estimated energy efficiency savings potential from each recommended measure, in the energy audit reports reviewed for this study, and can be found in Appendix A.
The potential savings from the energy reports can also be broken down by fuel type, as shown below in Figure 5-3. As can be seen, the majority of potential energy savings is from electric, followed by LP.

![Percent Savings By Energy Type](image)

Estimated energy savings of 15% took into account estimated market penetration of recommendations, such as LED lighting, VFD’s, high efficiency space and water heating, as well as the current agriculture economic situation. GDS Staff surveyed the farms to learn:

- Which, if any, energy efficiency measures have been implemented?
- Were the farms still in operation?
- Did they have interest in renewable energy?

Of the 45 farms that the team spoke with, four of the farms were no longer in operation or had significant operational changes. In addition, 28 of the farms had installed recommendations from the energy audit report and 10 farms were still planning on upgrading equipment but were waiting to find out about funding assistance (grants/rebates/incentives) before moving forward. Results from the survey show producers are interested in being energy efficient, but there are barriers to overcome in order to move forward with implementation.

5.2.2 Monetary Benefits

Estimating 15% of energy can be saved with installation of energy efficient equipment, total savings for the Minnesota agricultural sector could be as high as $39.1 million annually. Savings by fuel type can be seen in the table below.

<table>
<thead>
<tr>
<th>Fuel Type and Units</th>
<th>Baseline (fuel units)</th>
<th>15% Savings (fuel units)</th>
<th>Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity (kWh)</td>
<td>2,021,250,000</td>
<td>303,187,500</td>
<td>$27,286,875</td>
</tr>
<tr>
<td>LP (gallon)</td>
<td>40,826,305</td>
<td>6,123,945</td>
<td>$10,043,271</td>
</tr>
<tr>
<td>Natural Gas (therm)</td>
<td>20,114,806</td>
<td>3,017,221</td>
<td>$1,810,333</td>
</tr>
<tr>
<td>ALL FUELS TOTAL</td>
<td>NA</td>
<td>NA</td>
<td>$39,140,479</td>
</tr>
</tbody>
</table>
5.2.3 Operational Benefits

Energy efficiency may result in operational benefits, above energy savings. Operational benefits may include reduced labor for equipment repairs or equipment maintenance (for example self-tightening belts on new fans) and less time spent replacing burnt out lightbulbs. Other operational benefits may include higher employee job satisfaction and improved employee safety from new equipment, improved lighting, and improved heating/cooling equipment.

5.2.4 Production Benefits

Energy efficiency projects on a farm may lead to additional production benefits. Production benefits can range from increased milk production, improved animal health and welfare, improved crop yields, and more.

### Turkey Farm Production Benefits Example

Michigan State University (MSU) assisted a turkey farm in Ottawa County with the completion of an energy audit to find where the best opportunities were for energy savings. Once the audit was completed, it was found that substantial savings for the farm would come from replacing T-12 linear fluorescent lighting with LED lighting in the brooder house. The total project cost was $21,000 and the farm applied for and received a $4,900 rebate from their local electric utility, reducing the project cost to around $16,000. Since installing LED lighting, the farm has realized an annual savings in electricity and repair of $4,000 and $2,000 respectively. The return on investment for this project was calculated to be 2.67 years. Besides saving the farm money, changing the lights in the brooder house improved animal welfare, increased the weight of the turkeys leaving the brooder, lowered the brooder mortality rate and created safer working conditions for employees.

### Dairy Farm Production Benefits Example

Improving barn lights and operating them according to a specific schedule can improve both the profitability and working conditions on dairy farms. This technique is known as Long Day Lighting. It has been well researched over the past 20 years and benefits include 1) increased milk production (5-16%), 2) improved heifer growth, and 3) more enjoyable and safer working conditions. The University of Wisconsin-Madison found that even after taking into account the increased cost of feed, as cows eat more with exposed to long-day lighting, and the cost to install and operate the lights, the increased milk yield pays for these costs in as little as one year. Additionally, MSU did a study in 2014 and found that by replacing metal halide lights in the dairy barn with LED lights, the owners realized a 50 percent reduction in lighting expenses. Based solely on increased milk production and with exceptional milk prices for 2014, a payback of just over one year was realized for the whole project. Anecdotally, the dairy farmer has noticed that cows in his milking herd have become more docile and less agitated.

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40 Energy efficiency benefits turkey production.

https://www.canr.msu.edu/news/agricultural_energy_conservation_tour_energy_efficiency_benefits_turkey_pro

41 Increase milk production and decrease energy consumption with long day lighting.

https://www.canr.msu.edu/news/increase_milk_production_and_reduce_energy_consumption_with_long_day_lighti
Production Benefits from Subsurface Drip Irrigation (SSDI) Example

Colorado State University (CSU)-Extension completed a study to investigate crop yields from implementation of SSDI for crop irrigation. The study found that *subsurface irrigation saves water and improves yields* by eliminating surface water evaporation and reducing the incidence of weeds and disease. Water is applied directly to the root zone of the crop and not to the soil surface where most weed seeds germinate after cultivation. As a result, *germination of annual weed seeds is greatly reduced* which lowers weed pressure on cash crops. In addition, some crops may benefit from the additional heat provided by dry surface conditions, producing more crop biomass, provided water is sufficient in the root zone. When managed properly with a fertilizer injector, water and fertilizer application efficiencies are enhanced, and labor needs are reduced. As an added benefit, field operations are also possible even when irrigation is applied\(^{42}\). University of California – Davis found similar results in studies of SSDI on irrigated alfalfa production systems.

Production Benefits from Energy Efficient Equipment on Poultry Barn Example

Anecdotal evidence from producers and equipment dealers shows some potential production benefits from the installation of energy efficient equipment on poultry farms. For example, waste heat recovery systems, in addition to saving energy, might also improve bird health. Ventilation waste heat recovery systems capture waste heat that is being expelled from the barn and pre-heat the incoming air to reduce heating needs in the barn. Using this system, poultry producers have noticed *birds have fewer respiratory problems* which are often caused by cold air. In addition, the *barns are less humid and drier barns help reduce foot problems* caused by wet barn floors. Finally, better air quality can help to *minimize the need for use of antibiotic medicine*. While a formal study hasn’t been completed yet, this anecdotal evidence looks promising for improved production benefits.

\(^{42}\) Fact sheet 4.716. [http://extension.colostate.edu/docs/pubs/crops/04716.pdf](http://extension.colostate.edu/docs/pubs/crops/04716.pdf)
5.2.5 Producer Case Study

Rice Lake Gardens in Duluth, Minnesota, is saving over 50% in greenhouse heating costs through their participation in the Natural Resources Conservation Service (NRCS) – Environmental Quality Incentives Program (EQIP). The greenhouse was started in 2012, has been expanding every year, and plans to continue expanding over the next couple of years. The greenhouse already had some energy efficiency equipment installed but Boyd was interested in further improving the energy efficiency of his greenhouse operation. He decided to have an Agricultural Energy Management Plan (AgEMP) completed. The energy audit report revealed Boyd could achieve over 50% in energy savings by installing a high efficiency boiler and a thermal curtain in the greenhouse with highest energy use.

Regarding energy efficiency, Boyd Maranell of Rice Lake Gardens notes, “We need to do everything possible to limit our use of our natural resources. Every little bit will help save our planet.”

Rice Lake Gardens is one of 88 producers that have been approved for funding through the EQIP program in Minnesota since 2012. A payment through EQIP covered approximately 75% of the cost of the energy audit. The greenhouse owner paid a minimal out of pocket cost to learn where energy opportunities were available and how much energy and money he could save. After the completion of the AgEMP, Rice Lake Gardens was able to apply for funding assistance for the installation of these energy efficiency improvements. Approximately 25% of the project costs for the new boiler and thermal curtain were covered by the EQIP program. Rice Lake Gardens was using wood as a heating fuel source for its greenhouse and has switched to liquid propane. EQIP is one of very few programs that provides cost share for fuels outside of natural gas and electricity.

The AgEMP program has been available in Minnesota since 2012 and all types of agricultural producers can apply to gain access to funding to assist with the cost for the energy audit. AgEMPs show a producer the big picture of energy use, identify the equipment using the largest amount of energy, and offer recommendations for energy savings. An AgEMP can help improve a producer’s bottom line, like in the case of Rice Lake Gardens, by helping the producer save energy and money. In addition, AgEMPs allow a producer to apply for EQIP payments to assist with implementation costs of equipment recommendations in the report. Cost share for implementation can be up to 75% of the project cost, which can be significant.

For other farms looking to save energy and money and improve the energy efficiency of their agribusiness it is recommended that they follow the same path as Rice Lake Gardens. Start by reaching out to your utility company, local Farm Service Agency, Minnesota Department of Agriculture, NRCS, USDA, and Extension offices. There are many programs available to assist producers to become more energy efficient. Many programs offer low and no cost technical expertise as well as grants, rebates, and incentives for installing new high efficiency equipment. Producers should take advantage of the programs and resources out there.
5.3 ENERGY EFFICIENCY BARRIERS

Undoubtedly, farms want to be more energy efficient and keep operating costs low. Nonetheless, lack of financial capacity due to low commodity prices is a primary barrier. Agriculture has experienced numerous recessions in the last 10 years, with the current recession dragging into its fifth year. With production costs higher than income, there is limited likelihood a farm will spend money on equipment that has not failed or in need of replacement. Follow up surveys completed by The Minnesota Project and GDS, noted that some of the suggested upgrades with longer paybacks (scroll-type refrigeration compressors, refrigeration heat recovery units, and ventilation) are usually done when a farm changed hands or when the equipment fails, and not merely at the suggestion of an energy audit. Additional barriers include fears about how new equipment might impact operations if the newer equipment had some unforeseen consequence, not necessarily energy related. The project team learned that some stakeholders including utility staff and farmers were not aware of different funding opportunities through the USDA, NRCS, utility companies, and the Minnesota Department of Agriculture. Additionally, participating farms showed hesitancy at filling out grant paperwork and had concerns about the complexity of the federal programs or what they perceive as, “the excess headache and paperwork,” that can come with participating in federal programs43.

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5.3.1 Producer Case Study

Felling Dairy LLC, in Sauk Centre, Minnesota, is interested in becoming as energy efficient as possible. To target the farm’s biggest opportunities for saving energy, Felling Dairy had an Agricultural Energy Management Plan (AgEMP) completed through NRCS-EQIP.

The AgEMP offers a step-by-step plan of the most cost-effective opportunities for saving energy and money. While the dairy had already invested in some energy efficiency measures, the AgEMP found additional savings for the farm of almost 23% in electric consumption and just under 10% in liquid propane (LP) consumption. This equals an estimated savings at almost $15,000 annually. The farm has not yet installed any of the recommendations in the report due to a poor agriculture economy and limited funds available. The farm cannot afford to upgrade to new equipment to replace equipment that is currently in working order.

“The energy audit was a very valuable use of our time. Our energy auditor’s knowledge and previous experience provided us with ideas we had never thought of previously. We were able to pinpoint energy savings which is very valuable to our operation.” – Jason and Marie Felling

The EQIP program covered approximately 75% of the cost of the energy audit. The dairy’s electric cooperative, Stearns Electric Cooperative, paid for the remaining 25% through a new agriculture energy management program. The dairy has applied to the NRCS-EQIP program for cost-share for cost-share funding to implement the priority energy efficiency improvements. The farm is waiting to find out if they are approved so that they can move forward with new lighting, commercial laundry, and high efficiency refrigeration equipment. The potential cost share of up to 75% through EQIP along with utility rebates will allow the farm to move forward with more than one energy efficiency project, even in the current ag market.

The NRCS AgEMP program is available for all types of agricultural producers to apply for funding to assist with the cost for the energy audit. In addition, many electric and natural gas utilities offer free energy audits or a cost share for an AgEMP. Dairy, hog, poultry, grain, irrigated crops, greenhouse, maple syrup, and other producer types can take advantage of these programs. Generally, an AgEMP is most beneficial for operations that are larger than hobby farms. For example, heated greenhouses in cold climates, producers that are concerned about high utility bills, and operations that have increased production over time, but facilities and equipment have not changed. AgEMPs can show a producer the big picture of energy use, identify the equipment using large amounts of energy, and offer recommendations for energy savings. An AgEMP can help improve a producer’s bottom line, by helping the producer save energy and money.
Minnesota has set significant renewable energy goals for the next 5-30 years, which may benefit farms financially. Renewable energy may also offer some unanticipated production benefits to farms. While renewable energy may offer many benefits to the agriculture community, there are barriers to installing these systems.

6.1 RENEWABLE ENERGY POTENTIAL

As noted previously, as of 2009, a total of 178 farms in Minnesota had a renewable energy system installed. During years 2009 – 2017, up to an additional 229 have installed solar PV systems. The state of Minnesota has a goal to reach 25% renewable energy by 2025, GRE announced a goal of 50% renewable electric by 2030\(^{44}\), and Xcel Energy’s stated goal is to reach 100% carbon free electricity by 2050. As of the end of 2017, Xcel Energy had reached 25% renewable energy generation in Minnesota with the next goal to reach 31.5% by 2020, with the primary renewable energy source being wind (30%) and an additional 1.5% from solar, with at least 10% of this from on-site solar under 20kW \(^{45}\). Given 80% of farms in Minnesota are receiving energy from rural cooperatives, the GRE goal may positively impact farms. Farms are uniquely positioned to help Minnesota reach its renewable energy goals. It is easy to see how an estimated 51% land, currently in agricultural use in Minnesota, and the 73,000 farms in Minnesota will play an important role in reaching these renewable energy goals.

6.1.1 Monetary Benefits

Interest in installing a renewable energy system varies with each operation. Some farms, such as organic growers, are interested based on their environmental interests. Others understand renewable energy may help them sell more product. Nonetheless, all farmers are interested in renewable energy because of its monetary benefits: Reducing energy business costs, selling a little energy back to the grid as an additional product, or leasing land to large-scale renewable developers. Specific monetary benefits include high dollar land lease payments per acre for solar or per megawatt for wind, net metering, power purchase agreements, decreased purchases of fossil fuels, and/or secondary revenue streams as a result of the renewable energy system. Farms benefit from privately-owned renewable energy systems by taking advantage of net metering to offset their own electric costs, or “rolling the meter backwards”, decreasing purchases of natural gas and LP by using renewable energy systems to offset space and water heating needs, and decreasing greenhouse gas emissions.

Farms generally install a customer-owned renewable energy system to offset purchased energy. For solar thermal, biomass, or ground source heat pump systems, this usually means the farm can offset up to 100% of natural gas or LP purchased fuels used for space and water heating needs. Solar PV and wind can offset

\(^{44}\) Great River Energy sets 50% renewable energy goal for 2030. [https://greatriverenergy.com/great-river-energy-sets-50-renewable-energy-goal-for-2030/](https://greatriverenergy.com/great-river-energy-sets-50-renewable-energy-goal-for-2030/)

the purchase of electricity and a biogas system can offset for both electricity and gas needs. Monetary savings will be dependent on the size of the farm operation, farm energy needs, and renewable energy system size and production. Whether a farm can offset all of its electric needs with solar PV depends on the farm type.

Constructing and operating biogas systems can get extremely expensive, especially in today’s agricultural economy. While the cost of PV has decreased by 75-80% over the last 10 years and is currently approximately $2.00/watt installed, a biogas system can cost millions. It may be more beneficial for a farm to work with a utility or third-party contractor to lease a portion of their cropland for a set period of years for installation of a larger utility scale renewable system as an alternative, although this will typically only benefit farms close to electric transmission lines. U.S. wind farms are paying a total of $222 million dollars to property owners across the country, and this number is poised to grow exponentially over the coming years. According to Landmark Dividend, a ground lease acquisition company, a land lease for a utility scale wind turbine can pay up to $8,000/year and leases are typically set for up to 35 years. Land leases for solar systems are closer to $1,000/acre/year.

Renewable energy systems provide monetary benefits through secondary revenue streams for the farm. For example, anaerobic digester bio-solids may be sold to local gardeners or the grounds hosting a solar PV system can be turned into a pollinator habitat, thus allowing the farm to develop an apiary and sell honey and other products as new revenue streams. Secondary streams of revenue vary depending on the type of renewable system installed, the farm’s need for the by-products, and the farm’s ability to market and sell the bi-products.

Renewable Energy on Minnesota Dairy Farm Example

The University of Minnesota’s West Central Research and Outreach Center (WCROC) researched and tested whether dairy production could achieve a net zero energy status. To accomplish this goal, WCROC’s research faculty examined energy conservation, by means of installing more energy efficient technologies, as well as the installation of on-site renewable energy. The WCROC dairy installed 54 kilowatts of solar PV and 20 kilowatts of wind energy to power the dairy. Through these installations, the WCROC dairy has reduced energy consumption and operational costs. On-site energy coming from the solar PV and wind turbines has been able to successfully power the dairy operation to create a net zero energy dairy production facility. The WCROC learned the 50kW solar PV system provides a positive net present value (NPV) of $30,044 and the dairy is experiencing a net savings in energy costs and is making money from this system.

In contrast, the NPV for the wind turbines was calculated and found to be -$55,359. This negative NPV indicates that the WCROC dairy farm is not yet experiencing a net savings in energy costs from this system and is still paying back money for the initial cost of the system. In terms of internal rate of return (IRR) for the systems, the solar PV system IRR was found to be 8% (when including 30% federal tax credit and a 25% REAP grant), indicating that the value of the system is enough to support the cost of the system. However, the IRR for the wind turbines was found to be -3%, indicating that the value of the system is not enough to support the cost of the system. While the wind systems are not proving to be economically viable, the solar system is not only saving the WCROC dairy farm energy but is also creating a new revenue stream for the farm.

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47 https://www.landmarkdividend.com/wind-turbine-lease-rates/
48 https://craven.ces.ncsu.edu/considerations-for-transferring-agricultural-land-to-solar-panel-energy-production/
6.1.2 Production Benefits

In response to the population decline of pollinating insects, such as wild bees and monarch butterflies, the U.S. DOE - Argonne Environmental Service (EVS) researchers have examined the potential benefits of establishing pollinator habitats at utility scale solar energy (USSE) facilities to conserve pollinators and restore the ecosystem they support. Examining over 2,800 existing and planned USSE facilities in the contiguous U.S., researchers found over 3,500 square kilometers of agricultural land near existing and planned USSE facilities that could benefit from rehabilitation.

Establishing habitats could help reinstate the declining pollinator population. For example, crops like soybeans, almonds, cranberries, and most apple, pear, and plum trees all depend on insect pollinators for annual crop yields. If all existing and planned solar facilities near these crop types included pollinator habitats, with an increased yield by just 1%, crop values could rise $1.75 million, $4 million, and $233,000 for soybeans, almonds and cranberries, respectively. In addition, honey bee pollination alone adds more than $15 billion in value to agricultural crops each year in the U.S.50.

Figure 6-1 below, identifies 489 MW of utility scale solar developed or in development in Minnesota. Over 25,000 hectares of pollinator dependent agriculture is within 1.5 km of these facilities.

**FIGURE 6-1. UTILITY SCALE SOLAR NEAR AGRICULTURE LANDS IN MINNESOTA**

Biomass Energy System on Minnesota Broiler Farm Benefits Example

Viking Company, a broiler farm in Albany, Minnesota, installed a biomass heating system on one of their two broiler chicken barns in 2015 to test whether they could reduce thermal energy costs. The farm compared energy use of heating the barns and discovered not only energy cost savings of over $8,000 per year, but

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51 Map by Argonne National Laboratory
additional non-monetary benefits. The farm discovered the use of a biomass thermal heating system significantly reduced energy operating costs. Additionally, the farm experienced a dry, evenly heated barn and also saw reduced bird mortality and improved feed conversion. Using this system, the farm is removing combustion residues (nitrogen oxides (NOx), and carbon dioxide (CO2)) and is decreasing humidity levels in the barn. The farm also noted that with the biomass system, the barn is more comfortable to work in than the LP heated barn.
Producer Case Study

Viking Company is a family owned and operated poultry farm located in Albany, Minnesota. Bill Koenig has been raising broilers for over 36 years. When approached by a former colleague regarding installing a biomass system to heat his barns, he was immediately interested. Koenig discovered using biomass as a heating source could assist with regulating barn heating costs and save energy costs. It also utilizes a local, renewable energy source so it was a natural choice. The biomass system was designed and installed on only one of the barns, so energy costs could be compared to a second barn on the property, which was still using LP for heating. Over a two-year period, the findings were substantial. On average, the biomass system was saving the farm over $8,000/year in energy costs for barn heating which was the equivalent of paying between $0.53-0.85/gallon of LP.

“Biomass heating systems for poultry farms have amazing potential, just amazing. It is an opportunity to use a circular fuel from a local source and help to mitigate climate change and other potential issues.” – Bill Koenig

Viking Company first fired up the biomass system in August 2015 and is still using the system today. The farm is now looking to install a similar system on the second poultry barn. The farm plans to build on the many lessons it learned the first time around. They encountered some roadblocks along the way, such as a very limited pool of local equipment dealers. They also had to learn how to optimize the system for a poultry operation and how to work with their integrator to figure out a revenue return given the integrator paid for LP and now the farm would be paying for the heating fuel. The grant process was also very difficult for the farm.

Viking Company also found numerous benefits to the biomass system. In addition to energy cost savings, the farm also found improved air quality in the barn, more even heating in the barn, reduced humidity, reduced bird mortality, and overall enhanced conditions for the birds and farmer.

Viking Company did not complete this project alone. The project was a successful partnership between Viking Company, The Minnesota Project (now integrated CERTs), the Minnesota Department of Agriculture’s Agricultural Growth, Research, and Innovation Program (AGRI), and the Agricultural Utilization Research Institute (AURI).

Much can be learned from the Viking Company’s experience for other farms looking to save energy and money. Producers should take advantage of programs and resources like CERTs, Minnesota Department of Agriculture, and USDA-REAP. These programs are designed to make it easier for producers to save energy and money and have experts available to assist agricultural producers with getting renewable energy systems installed.
6.2 RENEWABLE ENERGY IMPLEMENTATION BARRIERS

Renewable energy systems have come down in cost significantly over the last ten years, especially PV systems. However, only about 1% of farms in Minnesota have installed a renewable energy system to date. Barriers include:

- Poor agricultural economy
- Lack of knowledge where to find assistance
- Electric rates and net metering
- Meter fees for an additional system meter and grid access fees
- Poor data on existing installations on farms

Surveys conducted by GDS with farmers reveal the top barrier is financial and directly related to the poor agricultural economy of the last five years. Farms have limited finances to put into low-cost energy efficiency improvements, let alone expensive renewable energy systems. Farms that are interested have a hard time finding financing due to the poor economy. Many farms are not aware of all the resources available to assist with implementation costs and some do not want to deal with federal programs that offer funding.

Changes in utility billing rate structures are also affecting some farms, such as rate structures moving from a simple energy charge to a demand rate structure. In a demand rate structure, the energy cost is typically low ($0.03-0.06/kWh), but an additional charge is added to the customer bill for demand. Electric demand is the maximum amount of electrical energy that is being consumed at a given time. Utility customers have a harder time understanding the charges associated the demand rate structure and the variability of the energy costs. Demand charges vary greatly across electric utility companies and can be anywhere from $4.00-28.00/kW.

Part of the economics that make a renewable energy system appealing is the ability to take advantage of net metering. This allows residential and commercial customers, who generate their own electricity (from solar, wind, or biogas systems) to feed electricity they do not use back onto the grid. Net metering is a billing mechanism that credits renewable energy system owners for the electricity they add to the grid. For example, if a customer has a PV system, it may generate more electricity than the building uses during daylight hours. If the building is net-metered, the electric meter will run backwards to provide a credit against what electricity is consumed at night or other periods where the building's electricity use exceeds the system's output. Customers are only billed for their "net" energy use. In general, only a portion of a renewable energy system's output goes into the grid. Exported electricity serves nearby customers’ loads. Renewable energy systems can offset the demand of a site, but it is unpredictable and cannot be relied on to offset demand. Thus, a low net metering rate can make the economics of a renewable energy system poor. In addition, historically low natural gas prices and the current low price of LP are a deterrent for producers looking to install renewable energy systems which would offset heating needs as this will increase the payback timeline and return on investment timing will be past what is acceptable by the farm.

In the past, renewable energy systems required a second meter to allow the utility company to track the amount of energy produced by the renewable energy system. This was in addition to the existing meter tracking farm energy use. The system owner was responsible for the monthly cost of having this meter on site, which can be as little as $10/month to as high as $90/month and varies across electric utilities. However, with new smart meters, this is generally no longer the case. However, a renewable energy owner is

52 Estimated based on utility reported distributed generation installations in Minnesota through 2018
responsible for a grid access fee, which is based on the size of the renewable energy system and applies for all systems over 3.5kW.

Maintenance costs are very low for most renewable energy systems. However, in the case of a methane digester the associated costs of maintenance of these systems can be very high as these systems are generally burning dirty gas, which is hard on system components. In this scenario, one option is to install additional equipment on the system to scrub the gas before combustion by the genset to create electricity. Adding this additional equipment is often cost prohibitive. These systems require specialized expertise to ensure they are running properly and to maximize performance, thus additional labor is generally needed to operate the system efficiently, further increasing costs for the farm owner/operator.

While this report provides estimates of the number of renewable energy systems installed on farms in Minnesota, data is limited. The Minnesota Department of Commerce requires that all renewable energy systems be documented with the department, to track systems installations and system sizes. However, tracking of specific site type is only done as residential, commercial, industrial, or community. The lack of tracking for agricultural specific installations makes it challenging to know exactly how many systems have been installed in the agricultural community and the typical sizing of these systems.
6.2.1 Producer Case Study

Groetsch Dairy in Albany, Minnesota, milks approximately 250 cows using robotic milking units in a freestall barn. This third-generation dairy is owned and operated by Steve and Lisa Groetsch. While the dairy is interested in installing a solar PV system, it has not moved forward with the project because of the out-of-pocket cost for a solar array. The cost is especially important to the Groetsch family given the current agriculture economy. In addition, being an agricultural operation, they may not be eligible to take advantage of the federal tax credits and the accelerated depreciation of the system. These factors make the payback of a system less desirable.

“Energy efficiency, such as LED lighting is easy, it just makes sense. However, with solar PV, the biggest hold back is the cost of the system. We were told that without federal tax credits, the system would not have a reasonable payback. We are also unsure of what the right system size is for our farm. In the end, we need more information on the economics of these systems before we can move forward.” – Lisa Groetsch

Groetsch Dairy has already maximized energy efficiency on the farm. The next appropriate step is to evaluate whether a renewable energy system is a viable option to offset their energy use. Uncertainty of what size system would be best for the farm and the unknown economics of a system are holding them back from moving forward.

The good news is Groetsch Dairy does not have to evaluate the merits of a renewable energy system alone. There are public resources available to help them including the Clean Energy Resource Teams (CERTs) of the University of Minnesota’s Regional Sustainable Development Partnerships. CERTs assists farms, small businesses and other entities with feasibility studies. These studies help these entities make informed decisions about whether energy efficiency or renewable energy systems will make sense for their operations before committing to purchasing one. These studies will outline system sizing, the economics of a system, and the estimated system payback. They also identify how tax credits, depreciation and different rate structures influence project economics, as well as estimated project costs from equipment dealers and installers. Once the farm decides to move forward with the system, the farm could apply for a USDA – REAP grant to cover up to 25% of the cost of the project. In addition, CERTs Staff can help the farm with finding financing through programs such as Property Assessed Clean Energy (PACE) loans, the MN Livestock Investment Grant program, and, in some instances, utility rebates for renewable energy.

For other farms looking to save energy and money it is recommended that they follow the same path as Groetsch Dairy. Start with energy efficiency upgrades and then look at renewable energy options. Producers should take advantage of the programs and resources out there like CERTs, EQIP, and REAP. They are designed to make it easier for producers save energy and money and have the expertise on staff to assist agricultural producers.
Energy Efficiency and Renewable Energy Programs

Producers in Minnesota have the opportunity to participate in numerous energy efficiency and renewable energy programs. An overview and discussion on the various programs offered to Minnesota producers to assist with the costs to implement energy efficient improvements and renewable energy systems follows. In addition, a review of program offerings in other states was completed to assist with recommendations to improve existing offerings in Minnesota.

7.1 ENERGY EFFICIENCY AND RENEWABLE ENERGY PROGRAM REVIEW - MINNESOTA

Producers have the opportunity to participate in and take advantage of various energy efficiency programs through utility, state, and federal programs. Through 2009, only 18 farms had an energy audit of their facilities performed54. Since 2009, new programs have emerged and there have been numerous energy audits completed for farms in Minnesota. Audits have been funded through the NRCS – EQIP Program, the Minnesota Project, and utility programs. According to the NRCS in Minnesota, a total of 88 energy audits have been approved for funding through EQIP since October 2012. The Minnesota Project assisted with the completion of 46 additional energy audits for farms in Minnesota, via funding through various CARD grants, eight have been completed through GRE’s new Agricultural Energy Management Program, and an unknown number have been completed through Dairyland Power, CenterPoint, and Great Plains Natural Gas Company’s energy audit programs. EQIP offers payments of up to 75% cost share for implementing the energy efficiency recommendations included in the audit report, however, EQIP payments are part of an annual to bi-annual competitive process and thus not all projects are approved for funding. Additionally, there is a waiting period from the time the application is submitted and when the funding is awarded, which can be a challenge for producers looking to move forward quickly. Farmers can’t wait that long if they have equipment that is already failing. EQIP only offers funding for energy efficiency projects and currently does not fund renewable energy projects.

USDA-Rural Energy for America Program (REAP) is another federal program available to producers for implementation of both energy efficiency and renewable energy projects. This is a competitive grant, loan, and grant/loan combination program that can fund up to 25% of the project cost as a grant for installation of energy efficient equipment and renewable energy systems. This program can also finance up to 75% of a project as a low interest loan or loan/grant combination. This program cannot be combined with the EQIP program and has funding rounds in April and October, annually.

The federal government offers tax credits to farms and businesses that choose to install a renewable energy system. Tax credits vary in amount based on the type of renewable energy system, however, solar and wind (100 kW or less) currently receive a 30% income tax credit through the end of 2019. There is also a modified accelerated cost-recovery system (MACRS) or accelerated depreciation applicable to renewable energy systems as “energy property” which many businesses utilize to make it more cost-effective to install renewable energy systems. Energy property under MACRS has a five-years property schedule with 50% bonus depreciation available for the year the system is placed in service. Unfortunately, many agricultural producers cannot use these tax advantages because they have not been profitable and have little or no tax liability.

As noted previously, 140 of the 213 electric and natural gas utilities in Minnesota are required to participate in CIP. Many other exempt utilities still opt to offer some energy efficiency opportunities to their customers and there are only 10 utilities in Minnesota that do not have any farm customers. Program offerings vary by

utility but generally include rebates for LED lighting, high efficiency motors, and variable frequency drives. There are many utilities that also offer custom rebates for installation of energy efficient equipment, which allows for innovative farm projects to receive rebates. Some utilities also offer energy audits that are either free or require a small cost share. This includes 33 electric cooperatives and one municipal electric utility as well as two natural gas utilities. After a thorough investigation of exempt utilities, and findings confirmed in the Minnesota Energy Efficiency Potential Study: 2020-2029 55, it was found that although some utilities can file for exemption, many utilities participate in energy efficiency programs regardless of exemption status. CIP exemption does not determine if a producer moved forward with implementation but may determine how soon the recommendation would be implemented as a farm may wait until another funding source was available to assist with project costs.

Many utilities in Minnesota offer programs to assist with the installation of renewable energy systems including solar PV, wind, solar thermal, biomass, anaerobic digestion, geothermal, hydroelectric, and combined heat and power. Rebates vary based on the utility providing energy to the site. Producers should check with their utility company prior to making any decisions on installing a renewable energy system to ensure the renewable energy system they are installing meets the requirements to be eligible for the utility rebate. In addition, the Minnesota Public Utilities Commission allows for system installations up to 1 MW. A system owner can generate in excess of their usage; however, net metering is only applicable for systems under 40 kW. These smaller systems are reconciled monthly and customers may opt to receive a payment or a credit on the next bill at the retail utility energy rate. For producers installing systems larger than 40 kW, and not over 1 MW, the next excess generation will be credited at the avoided cost rate, which is less than the retail cost rate, or producers may elect to be compensated in the form a kWh credit. Excess credit will be reimbursed at the end of the calendar year at the avoided cost rate. This is typical in many states and encourages renewable energy installations that are sized to meet the facility’s needs and not overproduce energy.

The Minnesota Department of Agriculture has a variety of funding opportunities for producers to take advantage of for improving energy efficiency and installing renewable energy systems. These are in the form of both grants and loans and include livestock investment grants, sustainable agriculture demonstration grants, value-added grants, the beginner farmer loan program, and the agricultural improvement loan program. Additional information on all of the available programs can be found on the Minnesota Department of Agriculture’s website, https://www.mda.state.mn.us/funding?field_category_target_id=All.

The Clean Energy Resource Teams (CERTs) is a statewide partnership with a shared mission to connect individuals and their communities to the resources they need to identify and implement community-based clean energy projects. One of the programs offered through CERTs is Renewable Energy for Greater Minnesota. This program works with farms and rural businesses to help figure out the best opportunities for energy efficiency and renewable energy for the operation. CERTs can help a farm identify potential funding sources and financing options such as Property-Assessed Clean Energy (PACE) financing. PACE can finance both energy efficiency and renewable energy projects and is repaid as a separate item on a business’s property tax assessment. About 70% of the state’s population has access to PACE. Counties offering PACE can be seen in Figure 7-1 below. The yellow dots represent locations where PACE financing has been utilized.


7.2 ENERGY EFFICIENCY AND RENEWABLE ENERGY PROGRAM REVIEW – OTHER STATES

Wisconsin, Iowa, and Colorado also offer energy efficiency and renewable energy programs to farmers. Wisconsin’s Focus on Energy program is a statewide program covering approximately 95% of the state’s electric and natural gas utilities. In contrast to Minnesota’s CIP program, where program offerings vary across utilities and are not consistent across the state, the Focus on Energy statewide program makes it easy for residents and business owners to know what opportunities are available as they are consistent across utilities. Focus on Energy has a program with a team specifically dedicated to agricultural facilities. In the past, Focus on Energy offered an Agribusiness program which provided free energy assessments to farms to help producers find opportunities for energy savings. This Focus on Energy program completed over 3,000 assessments between 2001-2012. While the program has changed and no longer offers energy assessments, it does offer a broad suite of prescriptive incentives for the installation of energy efficient equipment, as well as custom incentives, which allow producers to install innovative energy efficiency equipment not listed on the standard prescriptive application.
In terms of renewable energy incentives, the Focus on Energy program offers three primary opportunities for funding assistance. The first is a competitive grant program, RECIP, which is opened three times per year through a request for proposals. This competitive grant program is available to non-residential customers and can fund up to 50% of project cost for PV, solar thermal, biogas, biomass, geothermal, and wind systems. The second program is a prescriptive renewable energy incentive for installation of solar PV or geothermal systems. The program is available to both residential and business customers and cannot be combined with the RECIP program. The program offers a rebate of up to 12% of the project cost for a solar PV system and a flat incentive of $650 for a geothermal system. The final Focus on Energy program offering is feasibility study grants for facilities looking at new or upgrades to existing anaerobic pre-treatment and anaerobic digester projects. The pre-treatment study grant is eligible for 75% reimbursement of cost, up to a maximum grant of $15,000, while the feasibility study grant for anaerobic digesters is eligible for 50% reimbursement of cost, up to a maximum grant of $15,000.

Iowa has set up their energy efficiency programs more similarly to Minnesota, with each utility providing the program best matched to their energy efficiency goals. The IOU’s are required to offer energy efficiency programs while cooperative and municipal utilities are exempt and can opt to offer energy efficiency programs. As in Minnesota, many of the exempt utilities do offer some of energy efficiency program to their members. Many utilities offer rebate programs for farms and one IOU offers free farm energy assessments to their members.

Colorado also has energy efficiency programs set up similarly to Minnesota, with each utility providing programs best matched to their end use members and efficiency goals. However, in 2015, the Colorado Energy Office (CEO) created an Agricultural Energy Efficiency program to assist producers in improving energy efficiency and moving forward with renewable energy projects. The program was created in response to findings in the Colorado Agricultural Energy Market Research Report. The report found that Colorado farmers spend more than $400 million annually on energy, equaling 7% of the industry’s total expenses. The program offers no cost energy audits and preliminary renewable energy feasibility studies for Colorado producers. Additional technical support is provided to farmers to help them understand recommendations in the energy audit report and feasibility study and assist them in applying for funding and incentives.

Overall, producers in Minnesota have a variety of federal, state, and utility programs for farmers to utilize to become more energy efficient and to make their investment in a renewable energy system more cost-effective. However, it is a challenge to find all the programs given the utility-based program arrangement in the state and it may be a challenge for producers to find someone with farm energy expertise to assist them with making informed decisions. A state-based program allowing for consistency and ease of access to information, may make it easier for producers to learn about the opportunities available. While state-based energy programs are not common, only found in seven states (Alaska, Maine, New Hampshire, New York, Oregon, Vermont, and Wisconsin), these programs make it easy for farmers to implement energy efficiency measures and provide go-to sector-based energy advisors and dedicated resources to assist agricultural customers. Given the challenge of a state-wide program, the state could consider a program more similar to Colorado’s agriculture energy efficiency program, that would be a non-utility, state-based program for the agricultural sector. A statewide program would allow for an improved understanding of energy use across the Minnesota agricultural sector and where the largest opportunities for improvement can be found.

While state-based energy programs are not as common, these programs make it easy for farmers to implement energy efficiency measures.

Conclusions

With support from the Minnesota Farmers Union, GDS conducted this assessment of energy efficiency and renewable energy potential for agricultural producers in Minnesota. The focus was on direct energy (electric, natural gas, and liquid propane) and benefits to farms from energy efficiency improvements and renewable energy installations. GDS identified barriers producers face when implementing energy efficiency and renewable energy projects and offers some options and opportunities that may assist in overcoming some of these barriers.

Primary findings:

- Poor agriculture economy is the primary barrier to energy efficiency and renewable energy on farms
- Producers in Minnesota are interested in maximizing energy efficiency
- Producers are interested in renewable energy systems, but total number of installations is unknown due to current tracking system
- Numerous state, utility, and federal programs offer technical assistance to farms
- Numerous state, utility, and federal programs offer financial assistance to farms
- Not enough of dissemination of information about opportunities available to assist farms

There are no simple solutions to overcoming some of the barriers found during this study, but there are opportunities to overcoming others. Barriers without a simple solution include the current poor agriculture economy, energy rate structures that include low energy costs and high demand costs, lack of energy efficiency programs by un-regulated delivered fuels, and high maintenance costs of larger and more complicated projects, such as anaerobic digesters.

Many barriers can be overcome with the existing technical expertise and funding and financing options available to Minnesota producers. The most effective way to overcome the barriers is through improved dissemination of information regarding the array of assistance available to producers looking to improve the energy efficiency of their farm. With the numerous resources available to assist producers, the following barriers to implementation can be overcome fairly easily:

- Inability to determine the most cost-effective projects
- Unaware of energy savings potential
- Not knowing what size/type of system to select
- Not knowing where to get financing
- Need assistance to access grant funding, utility funding and other cost share opportunities.

An overview of some opportunities to overcome these barriers include:

- Improved dissemination of program information (state, utility, and federal)
- Improved partnerships between the private sector, public sector, utility companies, and producers to help increase energy efficiency and renewable energy opportunities
- Outreach by agricultural associations or other groups to land lease companies to increase opportunities for land leases of utility scale systems on marginal lands
- Improved Conservation Improvement Program (CIP) design, converting from utility-based programs to a state-based program
- Creation of LP (and other delivered fuels) energy efficiency programs and savings goals
- Creation of a state based agricultural energy efficiency and renewable energy program

Additional recommendations that would allow for improved estimates of energy use and renewable energy installations on farms in Minnesota include:

- Tracking of not only energy savings, but energy assessments/audits completed by utilities across all sectors
- Improved tracking of renewable energy installations, specifying type of site (residential, commercial, agricultural, industrial, community)
- State and utility energy efficiency potential studies that include the agricultural sector
- Completion of federal census reports more frequently

Outreach to improve dissemination of information should take place at many levels including at the state, federal, and local level and should be happening through the Department of Agriculture, CERTs, producer associations, extension offices, equipment dealers, and utilities. Outreach could take place via in-person presentations by experts in the field, extension agents, agency and utility representatives as well as via webinar for those unable to make it to the in-person presentations. Additional outreach should occur through mailers, informational pieces in publications, social media, etc.

There are numerous programs that offer no cost or low-cost energy audits to farms, including Great River Energy, Dairyland Power, CenterPoint Energy, and Great Plains Natural Gas Company as well as NRCS-EQIP. Energy audits can lead to access to implementation cost-share and provide a baseline for farms to have a starting point for determining their potential renewable energy system needs. The CERTs program offers assistance with feasibility studies for renewable energy systems as well as assistance with finding financing for renewable energy systems, such as PACE. In addition, the University of Minnesota – Extension agents, USDA representatives, NRCS representatives, and Farm Service Agency (FSA) can be of assistance in directing producers to potential cost share and financing opportunities.

The creation of a state-based program that would provide dedicated experts to assist farm customers with their energy use questions, energy savings calculations, and recommendations of the best energy efficiency technologies to select for their operations. While this could reduce producers’ confusion over programming availability as the program would be the same statewide, it would require significant changes to the CIP programming and is likely not a short-term opportunity. Another option would be to create a new program specifically targeted to the agricultural sector, similar to what Colorado has done.

A lack of programs and cost share assistance in regard to delivered fuels, such as LP, is significant in much of the Midwest, including Minnesota. Minnesota could consider implementing energy efficiency programs and savings goals on delivered fuels rather than just on electric and natural gas. Again, this is challenging, but it has been done in a few states including Iowa, Vermont, Maine, and Massachusetts. Another option is for farms to work with federal energy efficiency programs that provide funding on energy efficient equipment regardless of fuel type.

Farms could support renewable energy projects by leasing land to large scale projects, which would lead to income for the farm, without the upfront purchase costs and the ongoing maintenance costs. Many companies work to lock-in land leases for these types of projects and farmers can take advantage of these programs without having to shoulder the added burden of ownership and maintenance of a renewable energy
system. Outreach to land lease companies across the agricultural sector may assist with increasing the number of farms with renewable systems on their land.

There are resources available that list all the programs available to producers for both energy efficiency and renewable energy projects. The dsireusa.org website maintains updated program lists for all states nationwide. Awareness of this resource could assist producers in locating energy efficiency and renewable energy funding sources.

In conclusion, Minnesota has robust options available to improve energy efficiency and install renewable energy systems on farms. Producers in Minnesota are very interested in becoming as energy efficient as possible and being excellent stewards of the land, but they need to have information available to know where to turn with questions, opportunities, and project feasibility to move forward in the current agriculture market. Working together, across all sectors of agriculture, from universities and state departments, to federal agencies and utilities, across the private and public sector, we can support farms and assist with improving energy efficiency and increasing renewable energy systems installed on our farms. Agriculture generates significant income for the state and employees hundreds of thousands of residents and has been a part of the culture of Minnesota for centuries. Finding ways to assist Minnesota’s agricultural community will not only help the farmers but will ensure continued employment for many Minnesotans for future generations.
### TABLE 5-1. ENERGY EFFICIENCY MEASURES RECOMMENDED IN SAMPLED ENERGY AUDITS

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<tr>
<th>Equipment or End Use</th>
<th>Number of Farms</th>
<th>Measures Include*</th>
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<td>Engine Block Heater</td>
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<td>- Engine Block Heater Timer</td>
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<td>Envelope</td>
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<td>- Building Envelope Improvements</td>
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<td>- Insulation</td>
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<td>- Tunnel Doors</td>
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<td>- Efficient Greenhouse Glazing</td>
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<td>Grain Dryer</td>
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<td>- High Efficiency Grain Dryer</td>
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<td></td>
<td>- Automated Controls</td>
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<td>- Irrigation Water Management</td>
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<td>- Premium Efficiency Motor</td>
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<td>- Pump Re-bowl</td>
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<td>- Variable Frequency Drive</td>
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<td>- High Efficiency Pumping Plant</td>
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<td>- Low Energy/No Energy Livestock Waterer</td>
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<td>- Efficient Heating Equipment</td>
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<td>- Thermal curtains (greenhouse)</td>
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<td>- VFD Milk Receiver Jar Pump</td>
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<td>- High Efficiency Fans</td>
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<td>Water Heating</td>
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<td>- High Efficiency Water Heaters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Refrigeration Heat Recovery Systems</td>
</tr>
</tbody>
</table>

*Not all measures recommended on all farms
FIGURE 0-1. SUMMARY OF ENERGY EFFICIENCY SAVINGS BY MEASURE FROM SAMPLED REPORTS IN MMBTU

<table>
<thead>
<tr>
<th>Measure</th>
<th>MMBtu Savings</th>
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<tbody>
<tr>
<td>Lighting</td>
<td>6806</td>
</tr>
<tr>
<td>Grain Dryer</td>
<td>1492</td>
</tr>
<tr>
<td>Variable Speed Vacuum Pump</td>
<td>1332</td>
</tr>
<tr>
<td>Automatic Controller</td>
<td>1197</td>
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<td>Space Heating</td>
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</tr>
<tr>
<td>Livestock Waterers</td>
<td>830</td>
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<tr>
<td>Refrigeration Heat Recovery</td>
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</tr>
<tr>
<td>Water Heater</td>
<td>620</td>
</tr>
<tr>
<td>Insulation</td>
<td>611</td>
</tr>
<tr>
<td>Irrigation Pumping Plant Improvements</td>
<td>568</td>
</tr>
<tr>
<td>Fans</td>
<td>552</td>
</tr>
<tr>
<td>Greenhouse Measures</td>
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<tr>
<td>Refrigeration Compressor</td>
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<tr>
<td>Variable Speed Milk Pump</td>
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<tr>
<td>Laundry</td>
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</tr>
<tr>
<td>Plate Cooler, well water</td>
<td>149</td>
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<tr>
<td>Irrigation Water Management</td>
<td>112</td>
</tr>
<tr>
<td>Freezer Door Curtain</td>
<td>107</td>
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<tr>
<td>Tunnel Doors</td>
<td>103</td>
</tr>
<tr>
<td>Engine Block Heater</td>
<td>83</td>
</tr>
<tr>
<td>Pasteurizer</td>
<td>54</td>
</tr>
<tr>
<td>Irrigation VFD</td>
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</table>

Irrigation Water Management

<table>
<thead>
<tr>
<th>Measure</th>
<th>MMBtu Savings</th>
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<tbody>
<tr>
<td>Irrigation Water Management</td>
<td>112</td>
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<tr>
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