

**V(A). Planned Program (Summary)**

**Program # 2**

**1. Name of the Planned Program**

Sustainable Energy

Reporting on this Program

**V(B). Program Knowledge Area(s)**

**1. Program Knowledge Areas and Percentage**

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
131	Alternative Uses of Land	0%		10%	
401	Structures, Facilities, and General Purpose Farm Supplies	5%		10%	
402	Engineering Systems and Equipment	5%		10%	
501	New and Improved Food Processing Technologies	5%		5%	
511	New and Improved Non-Food Products and Processes	5%		35%	
601	Economics of Agricultural Production and Farm Management	0%		10%	
605	Natural Resource and Environmental Economics	80%		10%	
610	Domestic Policy Analysis	0%		10%	
	<b>Total</b>	100%		100%	

**V(C). Planned Program (Inputs)**

**1. Actual amount of FTE/SYs expended this Program**

Year: 2014	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	7.5	0.0	38.5	0.0
<b>Actual Paid</b>	15.9	0.0	24.3	0.0
<b>Actual Volunteer</b>	0.8	0.0	0.0	0.0

**2. Actual dollars expended in this Program (includes Carryover Funds from previous years)**

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
289485	0	199045	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
2305320	0	798250	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
1050450	0	2518779	0

## V(D). Planned Program (Activity)

### 1. Brief description of the Activity

**MAES.** Research in this program is providing a better understanding of the trade-offs, and intersections of opportunities for sustainable energy with agricultural productivity, and environmental health. The promise of various crops for use as biofuel is being tempered by an understanding of the complexity of natural systems, and competition from other energy sources. Sustainable biofuel production, and the effects of its use on pollution and even human health, makes this an increasingly important issue for researchers to explore.

Research highlights for 2014 include:

- Field research continued in southern Minnesota to evaluate 26 clones of willow for establishment, and biomass production. Several poplar hybrids are also being tested in tight spacing arrangements to determine their suitability as a biomass source.
- Researchers are responding to concerns of the invasive qualities of switchgrass, which is being increasingly bred with improved agronomic traits to support bioindustrial feedstock requirements, by creating factorial experiments in a recently restored prairie. Preliminary data suggests significant differences between switchgrass cultivars, and remnant switchgrass establishment in the restored prairie.
- An in depth study began on identifying the optimal residual regulatory framework for railroads to provide transportation for rural goods.
- A new hybrid hot-melt adhesive was introduced with much of the 2-ethylhexyl acrylate removed and replaced with biomass macromonomers (MMs). Using MMs has shown little to no impact on strength, and film optical clarity. However, peel strength increased by 90 percent with the addition of MMs.
- Researchers discovered the laccase activation process (discovered and reported on in 2013), can be bypassed given the enzymatic saccharification process itself is an efficient step to activate wood biomass for crosslinking in wood bonding. Upon grinding the saccharified solid residue exhibits bond strength that is 250 percent stronger than wood biomass which has not gone through the saccharification process. Wood bond strength of saccharified residues is 70 percent of that for phenol formaldehyde resin (a commercial grade wood adhesive), but researchers believe with a proper bonding agent they can increase this to 80, or even 100 percent.
- A study on the compostability of saccharified wood found that paper sheets comprised of saccharified and non-saccharified woody biomass were almost completely composted after 90 days of incubation. But binderless films exhibited a mass loss of about 50 percent, indicating the "plastic like" nature of the product. Deductility improvement lowered this to 27 percent.
- Researchers examined the potential of using wheat straw as a source of high quality fiber to replace

recycled fiber. Two mechanical pumping processes were used to determine the response of straw fiber: (1) BIVIS screw extrusion process and (2) traditional Thermo mechanical pumping. While the BIVIS process produced material with high shive content and low strength, the refiner based mechanical pumping process resulted in fibers with properties meeting, or exceeding the requirements.

**Extension.** Sustainable Energy programming from U of M Extension is primarily carried out through the Clean Energy Resource Team project (CERTs). 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. CERTs activities in Extension are carried out with the following partners: University of Minnesota Regional Sustainable Development Partnerships, the Great Plains Institute, Southwest Regional Development Commission, the Minnesota Project, and the Minnesota Division of Energy Resources.

In 2014, CERTs demonstrated the significance of its work over time by publishing 145 new stories to its Minnesota Energy Stories blog. These stories included case studies about CERTs seed grant projects, highlights of successful projects, interviews with business owners who made changes to energy consumption with CERTs intervention, and summaries of tours and events that focused on clean energy options. Continuing its work in public education, CERTs hosted 28 events to highlight energy-saving opportunities through workshops, tours, and forums. Additionally CERTs connected with Minnesotans directly through 108 other outreach activities, including convening meetings with community-based organizations and presenting and hosting at tables for other events. CERTs also launched two new campaigns to change practices across entire industries. "Light Up Your Station and Save" assisted Minnesota's convenience stores in using LED lighting retrofits in their canopies. "Gobble Up Savings" assisted turkey farmers in securing funding for LED lighting retrofits in their barns.

Overall, CERTs programming is saving or offsetting 10.9 billion BTUs annually. This is equivalent to heating 136 Minnesota homes for an entire winter.

## **2. Brief description of the target audience**

Extension programming through Clean Energy Resource Teams is delivered in seven regions spanning the entire state of Minnesota. Types of communities that CERTs works with include, but are not limited to, businesses, civic organizations, economic developers, faith groups, farmers, local governments, residents and neighborhoods, schools, and utilities.

Agriculture and natural resources industry representatives, biotechnology company representatives, policymakers, state and federal agency representatives, private citizens, and entrepreneurs.

**MAES** target audiences include all of the above, and also forest product industry, academic researchers including bio-engineering and forest researchers, and energy and land use economists. Also, agriculture and natural resources industry representatives, biotechnology company representatives, policymakers, state and federal agency representatives, private citizens, and new energy entrepreneurs.

## **3. How was eXtension used?**

eXtension was not used in this program

## **V(E). Planned Program (Outputs)**

### **1. Standard output measures**

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
<b>Actual</b>	61958	155465	825	21508

**2. Number of Patent Applications Submitted (Standard Research Output)**

**Patent Applications Submitted**

Year: 2014  
 Actual: 0

**Patents listed**

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

2014	Extension	Research	Total
<b>Actual</b>	0	20	20

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Seed grant dollars will provide opportunity and support for clean energy projects to occur in Minnesota communities.

Year	Actual
2014	7500

**Output #2**

**Output Measure**

- Workshops, tours and forums will provide unbiased information regarding energy efficiency and renewable energy to target audiences.

Year	Actual
2014	28

**Output #3**

**Output Measure**

- Subscribed members to the CERTs list serve will receive regular communication and education clean energy resources in Minnesota.

<b>Year</b>	<b>Actual</b>
2014	12005

**V(G). State Defined Outcomes**

**V. State Defined Outcomes Table of Content**

O. No.	OUTCOME NAME
1	Research will investigate and help develop novel sources of bioenergy.
2	Participants of workshops, tours and forums will report that they were able to make informed decisions about energy efficiency and renewable energy. (Target reported as percentage of those who took action.)
3	Activities will contribute to quantifiable annual energy savings, either through energy efficiency and conservation efforts or by offsetting current energy sources through the use of renewable energy. (Target expressed is the total number of million BTUs saved as a result of CERTs activities this year.)
4	Research will provide better understanding of the environmental trade-offs and human health impact of renewable energy sources.

## **Outcome #1**

### **1. Outcome Measures**

Research will investigate and help develop novel sources of bioenergy.

### **2. Associated Institution Types**

- 1862 Research

### **3a. Outcome Type:**

Change in Knowledge Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Actual</b>
2014	0

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

The desire for sustainable production of biofuels prompts the need to use non-food biomass feedstock, and green conversion technologies for biofuel production. A single acre of algae, because of its rapid growth rate, can produce over 5,000 gallons of biodiesel fuel per year--100 times as much as soybeans.

#### **What has been done**

University research related to algae as a biofuel source ranges from molecular genetics of algae species to growing and separating algae in wastewater to efficient methods of removing phosphorous from wastewater. First, researchers worked to identify high performance algae strains. Over 30 strains were screened with some growing well on wastewater. Second, novel cultivation processes and harvesting systems were developed and tested for efficient use of carbon and nutrient resources.

#### **Results**

Life cycle assessments are being used to show how the environmental performance of wastewater-based algae biofuels is generally better than freshwater-based algae biofuels. But, results show only algae biofuels produced from wastewater with a high nutrient loads can have lower environmental impacts than petroleum gasoline. Digestion wastewater has high levels of COD, N and P that make it ideal for this system. This research has resulted in the identification of promising new algae stains, and improved growth conditions for mass cultivation of algae, which resulted in efficient use and management of organics and nutrients in waste streams. Results have been shared with the academic community, and at on-site demonstrations with government officials and the public.

#### 4. Associated Knowledge Areas

KA Code	Knowledge Area
131	Alternative Uses of Land
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes
605	Natural Resource and Environmental Economics

#### Outcome #2

##### 1. Outcome Measures

Participants of workshops, tours and forums will report that they were able to make informed decisions about energy efficiency and renewable energy. (Target reported as percentage of those who took action.)

##### 2. Associated Institution Types

- 1862 Extension

##### 3a. Outcome Type:

Change in Action Outcome Measure

##### 3b. Quantitative Outcome

Year	Actual
2014	50

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

Specific target audiences have different means available for saving energy and using clean energy resources. Introducing new technology and its viability for everyday use can help people adopt new clean energy technology. Adoption will result from opportunities for business owners and citizens to share stories and take a look at options, and network with others who have made changes.

###### **What has been done**

CERTs hosted 28 events in 2014, reaching audiences such as farmers, small business managers, residents, local units of government and utilities. Each educational event includes content on specific topics such as efficient lighting, biomass energy, major mechanical upgrades, solar energy, and suggested actions Minnesotans can take to advance clean energy.

###### **Results**

CERTs carefully considers the likelihood of attendees to take action as a result of events. In 2014, intended adoption varied according to the event. For example, 45 percent of attendees at

the Solar Powering conference were likely to start a solar project; 63 percent of turkey barn owners were likely to use LED lighting; 53 percent of those examining solar options were likely to adopt, etc. Past evaluations indicate, though, that only 30 percent of positive responders follow through on a hopeful project. Considering this, approximately 1 billion BTUs of energy savings or offset is likely to result from attendees taking action after CERTs events.

#### 4. Associated Knowledge Areas

KA Code	Knowledge Area
401	Structures, Facilities, and General Purpose Farm Supplies
402	Engineering Systems and Equipment
501	New and Improved Food Processing Technologies
511	New and Improved Non-Food Products and Processes
605	Natural Resource and Environmental Economics

#### Outcome #3

##### 1. Outcome Measures

Activities will contribute to quantifiable annual energy savings, either through energy efficiency and conservation efforts or by offsetting current energy sources through the use of renewable energy. (Target expressed is the total number of million BTUs saved as a result of CERTs activities this year.)

##### 2. Associated Institution Types

- 1862 Extension

##### 3a. Outcome Type:

Change in Condition Outcome Measure

##### 3b. Quantitative Outcome

Year	Actual
2014	10860

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

Minnesota's energy supply is not as clean, efficient, reliable, and affordable as it could be. Minnesotans spent \$16 billion and consumed a total of 1,852.2 trillion BTUs of energy (electricity, natural gas, petroleum products, coal and biomass) in 2010 to supply energy needs. Energy use spreads across four main sectors: Transportation (26 percent total use for buses, automobiles), residential (23 percent total use), commercial (19 percent total use) and industrial (32 percent total use).

### **What has been done**

CERTs works with Minnesota communities to connect them to resources, research-based information, and networks that advance clean energy projects. The goal is to help Minnesota meet energy efficiency and renewable energy goals, many of which were signed into law in 2007 as Minnesota's NEXT Generation Energy Act. The law requires Minnesota utilities to produce 25 percent of energy using renewable resources by 2025 and established a statewide energy conservation goal of 1.5 percent of annual retail electric and gas sales each year.

### **Results**

CERTs quantifies total BTUs of energy saved annually through its campaigns, technical assistance, utility support and seed grants. The 2014 total is 10.9 billion BTUs in annual energy savings or energy offset by renewable energy. Among these efforts, CERTs' assistance to utility conservation programming resulted in 5.5 billion BTUs of energy savings. The "Recycle Your Holidays" lights recycling campaign resulted in 3 billion BTUs saved, and the 2014 Seed Grant Program saved 783 million BTUs by funding local energy efficiency and renewable energy projects. A program offering individualized technical assistance to rural small businesses and farmers resulted in the implementation of 14 solar projects generating 220 million BTUs.

## **4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
401	Structures, Facilities, and General Purpose Farm Supplies
402	Engineering Systems and Equipment
501	New and Improved Food Processing Technologies
511	New and Improved Non-Food Products and Processes
605	Natural Resource and Environmental Economics

## **Outcome #4**

### **1. Outcome Measures**

Research will provide better understanding of the environmental trade-offs and human health impact of renewable energy sources.

### **2. Associated Institution Types**

- 1862 Research

### **3a. Outcome Type:**

Change in Knowledge Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Actual</b>
2014	0

### 3c. Qualitative Outcome or Impact Statement

#### Issue (Who cares and Why)

Recent concerns about the U.S.'s dependence on foreign oil, and the environmental impacts of fossil fuels have led to increased interest in finding domestic sources of energy. Corn-based ethanol, as an alternative to gasoline, has particular implications for the upper Midwest as this area supplies the U.S. with the majority of the corn grain used for ethanol, and is largely thought to be a major contributor to future biomass production.

#### What has been done

Researchers wanted to understand more about the life cycle air quality impacts of ten alternatives to gasoline as they relate to human health--rather than climate change. To accomplish this they looked at all the stages of production, and use of a fuel, and determined how much people would be exposed to pollutants, calculated damage to health, and the economic costs associated with this damage. They then modeled the effects of replacing 10 percent of U.S. vehicles that currently run on gasoline by 2020.

#### Results

Results showed the potential for both positive and negative effects on human health based on the energy used. Corn ethanol combined with internal combustion engines and electric vehicles powered by electricity from coal had health effects that were 80 percent worse compared to gasoline vehicles. But electric vehicles powered by electricity from natural gas, wind, water, or solar energy were shown to reduce health impacts by at least 50 percent compared to gasoline vehicles. The most important implication of this research is that electric vehicles can cause large public health improvements, but only when they are paired with clean electricity. Research results have been shared with policy makers and regulators, as well as, those that work in the agriculture and energy sectors.

### 4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
605	Natural Resource and Environmental Economics
610	Domestic Policy Analysis

### V(H). Planned Program (External Factors)

#### External factors which affected outcomes

- Appropriations changes
- Competing Public priorities
- Other (no factors)

#### Brief Explanation

The goal to accumulate additional BTU savings in Minnesota yearly is being achieved.

**MAES.** Researchers reported decreasing interest from stakeholders and a reduction in

available funding for projects related to sustainable energy. Several noted they focused on project goals related to climate change rather than sustainable energy in 2014 for this reason. Lower costs of fossil fuels are believed to be a primary reason for this shift.

#### **V(I). Planned Program (Evaluation Studies)**

##### **Evaluation Results**

The CERTs evaluation plan tracks the intentions and follow through of those who are educated or receive seed grants for projects. With careful examination of reported intentions to use solar technology or LED lighting, for example, followed by examination, CERTs has learned they have created, to date, 10.9 billion BTUs in annual energy savings or energy offset by renewable energy. Ongoing evaluation has demonstrated that about 30 percent of those intending to make a change actually make the change.

##### **Key Items of Evaluation**

Ongoing evaluation has demonstrated that about 30 percent of those intending to make a change after a CERTs educational event actually make the change. Still, examination of reported intentions to use solar technology or LED lighting, for example, followed by examination, shows that CERTs has created, to date, 10.9 billion BTUs in annual energy savings or energy offset by renewable energy. This number has and will continue to climb each year. Last year, BTU savings was the equivalent of heating 130 Minnesota homes for an entire winter. This years' savings increased that to 136 Minnesota homes.