V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Sustainable Energy

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	30%		30%	
601	Economics of Agricultural Production and Farm Management	30%		30%	
605	Natural Resource and Environmental Economics	30%		30%	
610	Domestic Policy Analysis	10%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

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

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	22.0	0.0
Actual	0.0	0.0	46.2	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
0	0	188446	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2429503	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	3506593	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MAES research on sustainable energy issues is providing a foundation for agricultural and natural resource stakeholders and policy makers to support sustainable energy development on a variety of fronts. In 2010:

- In the first study of its kind, researchers compared water use in corn-ethanol production on a state-by-state basis. They found that ethanol production in Minnesota and Iowa uses far less water overall than similar processes in states where water is less plentiful Water usage could be an important factor in policy decisions about where ethanol plants are built. The study concluded that both energy security and water security are important, and that improvement in one area should not be made at the expense of the other.
- A plan to create the world's only wind-to-hydrogen-to-ammonia system has made progress at the West Central Research and Outreach Center in Morris, Minnesota. A companion facility to a wind turbine already in place has been designed. It will convert wind into hydrogen that can be used to create storable electricity. The hydrogen also will be combined with nitrogen separated from air to produce nitrogen fertilizer.
- Modification of wood pulp mills into integrated forest biorefineries presents an good opprotunity to produce, in addtion to cellulose fiber, co-products including fuel grade ethanol and additional energy. To gauge that potential, a process model has been developed. It was used to compare three integrated biorefinery scenarios. Results showed the economic feasibility of integrated forest biorefineries.
- Researchers have developed a consortium of about 70 scientists and 50 collaborating organizations and firms to develop regional bioenergy systems for production of advanced liquid biofuels, based on a network of four "landlabs" to be established across the upper Midwest.
- Researchers have devised a way to incorporate high amounts of biomass in acrylic pressure-sensitive adhesive, reducing the amount of plastic.
- Researchers have developed the technology for mass cultivation of microalgae on wastewater for biofuel production.
- An analysis of the logistics system requirements for the widespread collection of different types of cellulosic biomass has changed the focus on the need to find local or nearby uses of biomass crops.
- Projected enterprise budgets for energy crops including switchgrass and corn stover, were published.
- An analysis of "green" swine barn technologies showed that some combinations may be profitable such as under-slat manure scrapers and geothermal air cooling.

Alternative and sustainable energy sources are critically needed for the United States. In Minnesota, the boon and bust of the corn-based ethanol industry has affected rural economies as, unfortunately, the extensive use of corn as a feedstock creates a myriad of economic, social and environmental issues that challenge sustainability.

Alternative sources of feedstock for energy production, such as cellulosic biomass, are being proposed to meet demands while addressing environmental and social issues. Success will depend on the development of efficient conversion technologies, a robust supply of feedstock in known quantity and quality and equitable financial incentives for farmers.

The overall goals at the University of Minnesota are to: 1) conduct fundamental research on plants and microbes to develop genomics-based solutions for renewable energy sources and 2) develop economically feasible and ecologically sustainable solutions for producing biofuels from cellulosic biomass and other sources, especially as it pertains to developing new feedstock genotypes.

. Extension's interdisciplinary team is serving on state, regional and local committees and forums with public and private entities that are developing effective markets and technologies. In 2010, Extension developed grant proposals in partnership with contiguous states to better develop regional initiatives related to sustainable energy.

2. Brief description of the target audience

Primary audiences for outreach and education are producers of biomass feed stocks, as well as processors of biomass fuels and bio-products. Secondary audiences are policy makers at the local and state level, as well as users who influence public policy and demand for bio-fuel products.

V(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	0	0	0	0
Actual	1100	7000	0	0

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

Patent Applications Submitted

Year: 2010
Plan: 0
Actual: 4

Patents listed

20100028 Hydrothermal Carbonizaion of Distiller's Dry Grain

20100040 Transforming Corn from a Commodity Crop to a Higher-energy, Multipurpose biofuel Crop

20100056 Algae Oil Extraction Process

20100213 Bio-renewable Plasticizers for PVC and Other Plastic Materials

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Plan	0	15	
Actual	2	36	38

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Graduate student research assistants

Year	Target	Actual
2010	10	14

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Research will provide information on new uses for ethanol byproducts.
2	Research will provide information on technologies for use of on-farm energy sources.
3	Research will provide better understanding of the economic impact and environmental trade-offs of renewable energy sources.
4	Plant genetic research will provide information to create new alternative fuels

Outcome #1

1. Outcome Measures

Research will provide information on new uses for ethanol byproducts.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	0	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
As the price of corn continues to remain volatile at best, livestock producers are continually looking for more cost effective animal feeding strategies. Dried distiller's grains with soluble (DDGS) are a common byproduct of ethanol production from corn, and have been used in the formulation of cattle and swine diets.

What has been done
Before this research, producers did not know the affects of the use of DDGS on animal growth and health. Studies incorporating DDGS in cattle and swine diets have been conducted to. Based on those results, studies of the use of DDGS in poultry diets have begun.

Results
Research has determined that additions of commercial additives to corn-soybean meal-30 percent DDGS diets have minimal effects on nutrient digestibility in nursery and finishing pigs, and do not improve growth performance. Also periodical inclusion and removal of 40 percent DDGS from diets did not adversely affect growth or carcass traits. A feeding trial of commercial toms fed diets with DDGS of varying fat and oil content showed that descreasing the fat content of the distiller's grains tended to decrease the metabolizable energy content. All these studies are providing animal producers with needed information to determine their animal feeding strategies, and providing a use for an ethanol by-product.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

Outcome #2

1. Outcome Measures

Research will provide information on technologies for use of on-farm energy sources.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	0	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Strategies for development of small scale on-farm energy sources are appealing because they would increase the economic stability of the farm, and increase local energy options.

What has been done
Research is being conducted in several areas. One study assessed the cost competitiveness of small-scale, on-farm production of canola and soybean based biodiesel and straight vegetable oil biofuels. Another research project is evaluating anaerobic digestors on dairy farms to determine their performance at different milk levels.

Results
Valuing feedstock at market price, canola biofuels were more cost competitive than soybean-based biofuels. Straight vegetable oil biofuels were less costly than biodiesel due to reduced input costs. However, unless the proice of petroleum diesel increases substantially, the economics of small-scale on-farm canola and soybean biofuels production is not cost competitive. The dairy farm digestor study is providing practical information to help clear the way for wide adoption of anaerobic digesters on dairy farms.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

Outcome #3

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	0	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Much needs to be understood about how public policy can realize the potential of producing energy from forest biomass.

What has been done
Following a nationwide analysis of state policies aimed at increasing energy production from forest biomass, a study on the physical, economic and social availability of woody biomass in Minnesota was completed. Focus groups and surveys were adminstered to private landowners to assess their willingness to participate in a bioeconomy.

Results
State biomass policies are increasingly seen as key to advancing renewable energy goals. The contribution of private forestlands to biomass supply was previously unknown in the region and this research showed economic potential in various contexts. As a result of this research, states are beginning to model their biomass policies along the production supply chain to identify policy gaps for biomass use. Local communities and municipalities are now more confident in their assessment and adoption of biomass conversion.

4. Associated Knowledge Areas

KA Code	Knowledge Area
131	Alternative Uses of Land
605	Natural Resource and Environmental Economics
610	Domestic Policy Analysis

Outcome #4

1. Outcome Measures

Plant genetic research will provide information to create new alternative fuels

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	{No Data Entered}	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Alternative fuels from corn aren't new, but what if one kernel of corn could be used to create both ethanol and biodiesel?

What has been done
Plant genetic researchers received a sample of corn from breeders in North Korea that had much higher oil content than U.S. varieties. But because North Korea is a closed state it was impossible for the researchers to get enough of the corn to study. So they used genetic mapping to create hybrids for further study.

Results
The high oil corn lives up to its name. Tests have shown its oil content at 20 percent. The typical U.S. crop has about 3.5 percent oil, and current high-oil hybrids are only around 7 percent.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Competing Public priorities
- Competing Programmatic Challenges

Brief Explanation

The importance of developing sustainable energy options became increasingly critical as Minnesota faced natural disasters such as flooding which threatened agricultural producers and communities, and as the costs of traditional energy sources increased. At the same time there was increasing interest in options in biofuels besides corn ethanol, due to international food security and hunger concerns. All of this created an impetus for research on alternative energy sources, conservation, and public policy issues related to sustainable energy.

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

Evaluation Results

Key Items of Evaluation