V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Sustainable Energy including Biotechnology

☑ 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
202	Plant Genetic Resources	15%	0%	15%	20%
205	Plant Management Systems	15%	0%	20%	20%
401	Structures, Facilities, and General Purpose Farm Supplies	5%	0%	5%	0%
402	Engineering Systems and Equipment	20%	0%	20%	20%
403	Waste Disposal, Recycling, and Reuse	20%	0%	15%	20%
404	Instrumentation and Control Systems	10%	0%	10%	0%
511	New and Improved Non-Food Products and Processes	15%	0%	15%	20%
	Total	100%	0%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	7.0	0.0	10.0	5.0
Actual Paid	8.0	0.0	10.0	6.8
Actual Volunteer	0.0	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**
156929	0	159319	507562
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
156929	0	159319	308574
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
572000	0	1141400	1205622

V(D). Planned Program (Activity)

1. Brief description of the Activity

• Developing productive efficient systems to profitably produce a variety of crop and forestry based substrates for biofuels production
• Developing engineering solutions and systems to efficiently convert raw materials into useable fuels
• Exploit bioprocessing systems to produce a variety of compounds thatmight have utility in processing and manufacturing processes
• Advance or knowledge of energy use and conservation in human, agricultural, animal and processing environments
• Communicate solutions and systems to users through extension education and demonstration activities
• Further study of cattails as a feedstock for biofuels

2. Brief description of the target audience

Scientists, commercial and limited resource farmers, regulatory entities, homeowners, general public, agribusinesses

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
Actual	1560	4562	0	0

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
Actual	10	47	57

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Studies on producing agricultural and forestry substrates for biofuel production

Year	Actual
2014	10

Output #2

Output Measure

- Studies on engineering conversion processes for biofuels and other components

Year	Actual
2014	20

Output #3

Output Measure

- Educating homeowners, growers and processors through workshops and other group educational approaches on sustainable energy topics

Year	Actual
2014	1842

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	New crops or other biofuels substrates identified
2	New bioprocessing technologies developed
3	New bioproducts identified
4	Number of households improving energy conservation measures
5	Installation of energy saving strategies on animal and crop production facilities

Outcome #1

1. Outcome Measures

New crops or other biofuels substrates identified

2. Associated Institution Types

- 1862 Extension
- 1862 Research
- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Farmers in North Carolina are in need of a promising biofuel feedstock crop that can produce biomass using swine waste.

What has been done
Growth and yield of the Giant Miscanthus (GM) grown with the application of swine waste was studied over a period of two years by NCA&T scientists. Observations were recorded on biomass yield from plots applied with fertilizers and swine waste.

Results
Swine waste applied at a uniform rate produced GM yields with good utilization of nitrogen and quality biomass. Timing of harvesting appears to be important. Early harvest (H1) produced significantly higher yield than later harvest (H2). This could be due to the fact that GM transports and stores much of its nitrogen in the rhizome during winter months for utilizing in the spring months. The moisture content of biomass harvested later in H2 is lower than H1 biomass and therefore easier to handle in terms of transporting and processing to bioenergy and biofuel processing plants. Overall, the results show that GM is a promising biofuel feedstock crop for NC farmers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
202	Plant Genetic Resources

205	Plant Management Systems
511	New and Improved Non-Food Products and Processes

Outcome #2

1. Outcome Measures

New bioprocessing technologies developed

2. Associated Institution Types

- 1862 Extension
- 1862 Research
- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Various conversion technologies have been used to produce biofuels from perennial grass. Despite advances in technology, the ability to produce biofuel as a single source of revenue remains infeasible; alternative applications are necessary. The application of an integrated green biorefinery has the potential of processing green grass into multiple product streams such as biofuels, proteins and valuable bioproducts.

What has been done
In NCA&T labs, freshly harvested Giant Miscanthus culm was reduced in size by a chipper/shredder and then pressed and separated into green juice and solid cake, using a Carver laboratory press. The solid cakes were then pretreated with hot water. The resulting hot water pretreated GM cake was used for the production of bioethanol through a simultaneous saccharification and fermentation process and the nutrient rich juice was used for microalgae cultivation.

Results
The results showed that liquid hot water pretreatment and the subsequent simultaneous saccharification and fermentation processing of Miscanthus could be an effective way to produce bioethanol. The results also showed that the green juice could be a highly nutritious source for microalgal culture. NCSU scientists also are investigating lignocellulosic feedstocks like

miscanthus and switchgrass to understand how treatment of the biomass with alkaline chemicals changes the chemistry of lignin. They also are researching how interaction of biocatalysts (enzymes) crucial for converting carbohydrates (cellulose and hemicellulose) to sugars with lignin limits their catalytic function. Understanding the fundaments of the lignocellulosic conversion process and the mechanism by which enzymes help to produce sugars can allow researchers to develop processes that are more economically and functionally feasible. Knowledge of the inhibition effect of lignin on enzymes can be the basis for developing enzymes that are more robust.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes

Outcome #3

1. Outcome Measures

New bioproducts identified

2. Associated Institution Types

- 1862 Extension
- 1862 Research
- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Algal biomass consists of three major components of carbohydrates, proteins and lipids. The mass fractions of these three constituent components in algae (and their potential commercial importance) depend on the algal species and cultivation conditions.

What has been done
A simultaneous saccharification and fermentation process was developed by NCA&T researchers to produce ethanol from the algal carbohydrates. The ethanol under a supercritical condition was

used for the simultaneous extraction and transesterification of the algal lipid into biodiesel. Meanwhile, a thermochemical process was used to produce organic fertilizer from the solid microalgae residue in which the N and P have been enriched after the removal of carbohydrates and lipids.

Results
A biorefinery was developed to produce three bioproducts of ethanol, biodiesel and organic fertilizer from wet algae.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
403	Waste Disposal, Recycling, and Reuse
511	New and Improved Non-Food Products and Processes

Outcome #4

1. Outcome Measures

Number of households improving energy conservation measures

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	1506

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Because of soaring home energy costs from the past several years, homeowners are looking for ways to reduce their energy usage and cost while seeking ways to help our environment.

What has been done
Energy conservation workshops were held at four Durham County branch libraries. Conscientious homeowners seeking to gain knowledge about the energy inefficiency and waste particular to their individual homes participated in one of the energy educational workshops and subsequently

followed through with home energy assessments and correctional energy retrofits offered through Extension's E-Conservation program.

Results
Results from the combined E-Conservation workshops and the home energy assessments followed up with individual home retrofits averaged each homeowner a savings totaling $27.50/ month on energy costs, averaging a cumulative reduction of $11,550, along with an annual collective reduction of 41 metric tons of carbon emissions. Statewide, nearly 500 participants of Extension programs reported that they engaged in best management practices related to energy conservation, resulting in $49,000 in energy cost savings.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment

Outcome #5

1. Outcome Measures

Installation of energy saving strategies on animal and crop production facilities

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Energy costs for electricity and curing fuel for tobacco represent one of the highest expenses for tobacco growers, second only to labor expense.

What has been done
Cooperative Extension has educated growers on methods to reduce curing costs and to increase fuel efficiency at meetings, in newsletters, and one-on-one visits. In 2014, an on-farm testing was conducted in Johnston County on seven new curing barns, one existing older barn, and four barns with heat recovery and recycling systems. A field day was conducted at this site in the fall,

and many growers are using the data that was generated to make new barn purchase decisions.

Results

Grower surveys show that 1,350 curing barns now use automatic ventilation controllers in Johnston County. These controllers reduce fuel consumption by an average of 40 gallons of propane per cure. It is estimated that each of these barns cycled at least 8 times during 2014 representing a potential fuel savings of 432,000 gallons of fuel valued at over $583,200. Additionally, research data is encouraging farmers to update barns to newer, more efficient models with 115 new barns purchased in Johnston County over the past two years. These new barns reduce fuel consumption by approximately 15% when compared to the barns replaced.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges

Brief Explanation

Economic and environmental considerations related to energy use, sources and conservation continue to present challenges to both producers and users of energy. North Carolina's bioenergy research efforts have focused on developing biomass sources and processes suitable for capturing biofuels from those materials. That has been a slow process, even though plant breeders and agronomists continue to work toward prolific and productive plants to produce biomass. Energy conservation in homes and business continues to get some emphasis, especially as it relates to solar energy. And some of our research and engineering efforts have targeted energy use in both cooling and heating livestock and poultry buildings, with some success with solar approaches for heat and geothermal processes for cooling. Considerable opportunities may exist for continued impact in these areas.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Our research support base is modest, but nevertheless, our scientists and extension workers in this area have demonstrated the capacity to acquire external grants, publish their work in peer reviewed journals, and generate new processes and products. Plant

breeders and agronomists have been successful in developing new cultivars of biomass producing grasses for potential biofuels production. Process engineers have made progress in solving some of the challenges to producing cellulosic ethanol, though commercial applications are not in operation in the state. One recent challenge was defunding by the state of the North Carolina Biofuels Center, which provided significant funding for biofuels research, although a portion of the funding was restored through another agency. Continued opportunities may exist for exploiting this area, particularly in research of producing biomass and discovering processes to make production of cellulosic ethanol efficient.

Key Items of Evaluation

Tools to fully capture accomplishments in this field of science to be revised as we have indicated in other program areas.