V(A). Planned Program (Summary)

Program # 7

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
133	Pollution Prevention and Mitigation			10%	
403	Waste Disposal, Recycling, and Reuse			20%	
511	New and Improved Non-Food Products and Processes			40%	
605	Natural Resource and Environmental Economics			15%	
610	Domestic Policy Analysis			15%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	2.5	0.0
Actual Paid Professional	0.0	0.0	1.3	0.0
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**
0	0	28724	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	157746	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	101088	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

This program focuses on biofuel and bioenergy production. We have increased activity and funding of this area as indicated in the Plan of Work. The program so far is focused on examining different biomass feedstocks for the production of biofuels (ethanol, biodiesel, syngas) and biomaterials, nondestructive methods for characterizing the physical and chemical properties of lingo-cellulosic biomass, and syngas production from co-firing coal and biomass. The feedstocks examined so far include algae, switchgrass and mixed grasses, and residual woody biomass from forestry operations.

A continuing project focuses on production of biofuels and bioproducts from biomass. Biomass gasification technology has been proven at small-scale. The biomass gasification process requires large amounts of feedstock supply, is an expensive process and has some operational problems. The main problems are: tar formation and subsequent clogging of pipe lines due to tar accumulation and low melting point of ash present in woody biomass leading to agglomeration which cause de-fluidization of fluidized bed gasifiers. Hence, economics and operational problems limit biomass gasification technology at commercial scale. While biomass gasification technology matures, coal-biomass gasification with some modifications in coal fed gasifiers seems promising as an option for commercial scale syngas production. Co-gasification of biomass and coal produces a synergistic effect to gain environmental and technical advantages over biomass or coal gasification alone. In 2013 use of coal-hardwood pellet mixtures was evaluated to produce syngas using an air as well as air-mist mixture as gasifying agents in a downdraft gasifer. Results showed that coal agglomeration adversely affected the gasification process when mixtures with 80% or more coal were fed. Use of 20% of coal and 80% biomass in a down-draft gasfier helps to increase carbon conversion efficiency without any significant decrease in the hydrogen concentration of the syngas.

As prices of oil continue to remain high and predicted known oil reserves remain finite, the need to find alternate sources of energy and chemicals has become more urgent than ever. Lignocellulosic biomass, a renewable non-edible resource represents such an "alternate source." As non-renewable energy sources such as whale oil and petroleum oil were the primary energy sources for the 19th and 20th centuries respectively, lignocellulosic biomass, may be the energy and biochemical source for the 21st century. Tremendous amounts of wood residues are generated by various forest products operations in West Virginia. This presents a potential opportunity for economic development for the state. One of the goals of this project is to develop new methods of extracting lipids from Camelina sativa and producing biodiesel, a goal that was attained in 2013.

2. Brief description of the target audience

The target audience for this program area includes the bio-fuels and materials industries, the electricity generating industry, researchers, regulators, policy makers, and foresters.

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	0	0	0	0

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

Patent Applications Submitted

Year: 2013

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	16	16

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Presentations on research at professional meetings

Year	Actual
2013	30

Output #2

Output Measure

- Energy policy papers

Year	Actual
2013	3

Output #3

Output Measure

- Completed graduate degree programs

Year	Actual
2013	3

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Work with the electrical generation industry to increase the percentage of renewable sources of biomass co-fired with coal (% increase per year)
2	Develop new processes for converting lignocellulose to usable sources of energy (number of new processes).
3	Percentage of participants in workshops held in the State on sustainable energy production and use who gain an understanding of the issue (% who report gains in knowledge).

Outcome #1

1. Outcome Measures

Work with the electrical generation industry to increase the percentage of renewable sources of biomass co-fired with coal (% increase per year)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The economy of WV is heavily dependent on the coal and natural gas industries, both exhaustible fossil fuels. There is a need to diversify both the State economy and our portfolio of energy sources. Increasing the amount of renewable energy production will help diversify the State economy, reduce our dependence as a country on imports of fossil fuels, and lead to a more sustainable energy supply. One way to do this is combining coal with renewable sources of biomass to produce energy products.

What has been done
A continuing integrated project focuses on production of biofuels and bioproducts from biomass. Biomass gasification technology has been proven at small-scale. The biomass gasification process requires large amounts of feedstock supply, is an expensive process and has some operational problems. The main problems are: tar formation and subsequent clogging of pipe lines due to tar accumulation and low melting point of ash present in woody biomass leading to agglomeration which cause de-fluidization of fluidized bed gasifiers. Hence, economics and operational problems limit biomass gasification technology at commercial scale.

Results
While biomass gasification technology matures, coal-biomass gasification with some modifications in coal fed gasifiers seems promising as an option for commercial scale syngas production. Co-gasification of biomass and coal produces a synergistic effect to gain environmental and technical advantages over biomass or coal gasification alone. In 2013 use of coal-hardwood pellet mixtures was evaluated to produce syngas using an air as well as air-mist mixture as gasifying agents in a downdraft gasifer.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
403	Waste Disposal, Recycling, and Reuse
511	New and Improved Non-Food Products and Processes

Outcome #2

1. Outcome Measures

Develop new processes for converting lignocellulose to usable sources of energy (number of new processes).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
As prices of oil continue to remain high and predicted known oil reserves remain finite, the need to find alternate sources of energy and chemicals has become more urgent than ever. Lignocellulosic biomass, a renewable non-edible resource represents such an "alternate source."

What has been done
One of the goals of a Davis College project is to develop new methods of extracting lipids from Camelina sativa and producing biodiesel.

Results
Biodiesel was produced from Camelina in 2013.

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes

Outcome #3

1. **Outcome Measures**

Percentage of participants in workshops held in the State on sustainable energy production and use who gain an understanding of the issue (% who report gains in knowledge).

Not Reporting on this Outcome Measure

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes

Brief Explanation

The sequestration in 2013 limited the funding we were able to use to conduct our research program in this area.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Experiment Station research program evaluation will take place at two levels and on two different time cycles. All programs will using these general criteria plus additional criteria tailored to each program as detailed in the Plan of Work under Outputs and State Defined Outputs and Outcomes.

Annual evaluation will continue as before, looking at productivity in terms of immediate impact:

- Referee journal articles and books
- Professional presentations
- General audience papers and news reports
- M.S. and PhD graduates
- Trends in terms of competitive funding

And in terms of longer-term impact:

- Citations in scientific journals
- Patents
- Successful technology transfer or start-ups based on research programs
- Awards based on continuing impact and research excellence

In addition, every five years we will have a full portfolio review of our research programs in terms of:

- Long term productivity

- Relevance to our constituent groups and the State and Region
- The allocation of research inputs among the programs
- Consideration of eliminating some research programs that are not productive or have diminished relevance given NIFA and State priorities
- Consideration of adding additional program areas given NIFA and State priorities

As discussed last year this program is still relatively new. It is progressing well and has attracted high quality competitive funding from AFRI and DOE as well as increasing its visibility in the region (as measured by competitively funded AFRI research projects with Penn State, Rutgers and Cornell).

Key Items of Evaluation

One area we did evaluate this year was our commitment to bioenergy research given the rapidly changing energy markets due to the increasing production from unconventional oil and gas extraction. We decided to keep our focus on bioenergy because of its future potential, the availability of biomass in this region for conversion, and the expected pressures from global climate change on fossil fuel use in the near future. We also decided to strengthen our faculty resources in the water area and to work jointly with the College of Engineering to help investigate the environmental impacts of shale gas extraction.