V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Biotechnology, Biomaterials, and 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
112	Watershed Protection and Management	20%	0%	15%	0%
124	Urban Forestry	5%	0%	0%	0%
132	Weather and Climate	5%	0%	0%	0%
201	Plant Genome, Genetics, and Genetic Mechanisms	0%	0%	20%	50%
202	Plant Genetic Resources	2%	0%	10%	0%
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	10%	0%	5%	50%
206	Basic Plant Biology	5%	0%	5%	0%
402	Engineering Systems and Equipment	10%	0%	20%	0%
403	Waste Disposal, Recycling, and Reuse	11%	0%	0%	0%
511	New and Improved Non-Food Products and Processes	15%	0%	20%	0%
601	Economics of Agricultural Production and Farm Management	10%	0%	5%	0%
605	Natural Resource and Environmental Economics	7%	0%	0%	0%
	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	3.1	0.0	3.3	1.0
Actual Paid	3.2	0.0	8.3	1.0
Actual Volunteer	49.0	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**
133181	0	126226	93470
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
192558	0	146461	228891
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
369406	0	1597866	92108

V(D). Planned Program (Activity)

1. Brief description of the Activity

The Sustainable Energy program includes laboratory research, development of pilot scale projects in the field, educating clientele on the merits of particular energy practices and conversion technologies, and engaging the private sector to spur the commercialization and economic development of innovative and efficient energy systems. Specific examples of activity areas of this program are listed below:

* Develop biomass use for biofuels
* Designing optimum forestry and crops for bioenergy production.
* Produce value-added bio-based industrial products.
* Logistics/material handling
* Processing and management of end use waste products and byproducts
* Analysis of the global impacts of new generation biofuels
* Demonstration and commercialization of technologies that increase US energy independence
* Development of programs to train students and current county educators (in-service) to meet the new sustainable energy challenges.
* Energy conservation
* Alternative energy
* Understanding agricultural energy use and opportunities for conservation
* Smart and sustainable energy systems for communities
* Understanding the cost differences of energy usage
* Public outreach and engagement around energy public policy development
* Youth development programs to teach energy conservation, alternative energy sources, electricity and recycling.

- Clean energy project analysis via RETScreen

2. Brief description of the target audience

- Farmers
- Citizens
- Agency personnel
- Economic developers
- Regional planners

- Commercial Producers
- Land Owners
- 4-H Youth
- K-12 Youth
- State and Federal Agency Personnel
- Extension Educators
- Policy Makers
- Consumers
- Ag Related Businesses
- Energy Service Companies (ESCOs)

3. How was eXtension used?

Information is shared and supported by involvement in several COP's. For example, Home Energy, Wood Products, and Sustainable Ag Energy.

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1401	171	15	62

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

Patent Applications Submitted

Year: 2014

Actual: 1

Patents listed

Bio-nanoparticles as a novel nicotine vaccine

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	0	66	66

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of Sustainable Energy educational meetings, workshops, conferences, training sessions, demonstrations and field days

Year	Actual
2014	15

Output #2

Output Measure

- Number of Sustainable Energy fact sheets, publications, newsletters, and other print resources

Year	Actual
2014	89

Output #3

Output Measure

- Number of On-farm Demonstrations

Year	Actual
2014	6

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Increase farm profitability due to more energy efficient practices
2	Increase the number of individuals using energy more sustainably
3	Increase knowledge of sustainable energy conversion technologies
4	Vaccine developed against porcine reproductive and respiratory syndrome
5	research on energy signaling in plants has potential to increase plant biomass and lengevity
6	The Bioenergy Engineering Education Program (BEEP)
7	Research in arsenic transport in purslane may impact soil remediation

Outcome #1

1. Outcome Measures

Increase farm profitability due to more energy efficient practices

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Virginia farmers have tracked production expenses and realized the level of use and cost of fuel, oil, and electricity are continually increasing and are questioning how to design and implement efficient energy use plans. According to the 2012 National Agriculture Statistical Service (NASS) report, farm energy prices (including fuel, oil and electricity) increased approximately 19% from 2007 to 2011. It is estimated that across the 34 counties of Southside and Southwest Virginia, farmers spent more than $66 million in farm energy related expenses during 2011 (NASS, 2007 & 2012). Using the 2011 expense estimate, a 10% increase in on-farm energy efficiency (realized without compromising output), would result in an additional $6.6 million in income to farmers.

What has been done
Understanding the urgency to address this need, VCE and its partners launched the 2010-2012 On-Farm Energy Efficiency Pilot project. Funded by a $248,842 grant from the Virginia Tobacco Commission, the program identified over $1 million in potential energy savings for 58 agricultural operations completing the energy audit process. These findings validated the assumption that farms were expending hard-earned dollars on inefficient equipment and that farm profitability would increase when areas of energy loss were identified and efficient technologies were installed.

In 2014, Virginia Cooperative Extension (VCE) secured a $373,000 grant from the Virginia Tobacco Commission to support farm energy efficiency in Southside and Southwest Virginia. Partnerships are in place with USDA Rural Development, Virginia Department of Mines, Minerals and Energy, Old Dominion Electric Cooperative, and other organizations to support this project.

Results

Fifty-three agricultural operations in Southside and Southwest Virginia have access/funding for energy audits and renewable feasibility studies, a cost-share program for retrofit and/or renewable systems, and over 13 educational programs on energy efficiency practices and technologies. Each operation received a $5,000 energy account. During 2014, 17 of the 51 operations have completed an energy audit, and 11 farms have used $47,500 in grant funding along with over $110,000 in individual funds to implement energy retrofits.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
601	Economics of Agricultural Production and Farm Management

Outcome #2

1. Outcome Measures

Increase the number of individuals using energy more sustainably

Not Reporting on this Outcome Measure

Outcome #3

1. Outcome Measures

Increase knowledge of sustainable energy conversion technologies

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The US Energy Information Administration published its forecast on woody biomass energy usage into 2015. This report estimates the use of biomass for energy purposes across the electric power, industrial, commercial and residential sectors. In nearly all sectors, the use of biomass for

energy purposes is anticipated to increase. New air quality regulations have been drafted that could affect the viability of certain types of combustion-based bioenergy projects (i.e., Boiler MACT, CISWI, NSPS). These regulations affect projects from residential units to centralized power plants. Bioenergy projects often face significant hurdles to their development and successful implementation. These hurdles can prevent good projects from happening as the developers lack the capital to invest in exploring the feasibility of a project let alone its development. This is too often the case with smaller projects which lack grant, corporate, or government support to assist in weathering the costs of project feasibility work, and many good fuel-switching opportunities go unexplored, and undeveloped. The collective effect leaves Virginia farmers and small businesses at a disadvantage to others that have successfully switched to less costly, and less volatile, renewable sources of energy. A common hurdle to project development is costly emission testing data, which has become more critical given the growing popularity of biomass utilization and the new air quality regulations.

What has been done
In collaboration with the Virginia Department of Environmental Quality, and the Virginia Department of Mines, Minerals and Energy, a pilot program was launched to assist Virginians interested in utilizing bioenergy with initial stack emission testing. This pilot program was designed for smaller projects that could not pay the initial cost of third party emission testing as a component to assessing the overall feasibility of the project.

Results
In 2014 this program focused primarily on support of the Chesapeake Bay Manure to Energy Initiative. Previous stack test data was used by technology providers to optimize their combustion practices and configure emission control technologies. Program efforts included preliminary stack data collection on a poultry-litter fired combustion unit at a demonstration farm in Port Republic, VA, a 500k BTU wood chip boiler, and a poultry-litter fired gasifier at North Carolina State University under consideration for an on-farm project on the Eastern Shore.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment

Outcome #4

1. Outcome Measures

Vaccine developed against porcine reproductive and respiratory syndrome

2. Associated Institution Types

- 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)
Porcine reproductive and respiratory syndrome (PRRS) is a highly transmissible disease characterized by reproductive disorders in sows, and respiratory distress and mortality in young pigs. In the US alone the economic losses caused by PRRS amount to more than 560 million US dollars every year. Vaccination is the most effective method of preventing infectious diseases. Currently, killed-virus and modified-live PRRSV vaccines are used clinically to control PRRS. However, both types of vaccines have inherent drawbacks. The unsatisfactory efficacy and safety of current PRRS vaccines drives the development of novel vaccines against PRRSV. Subunit vaccines, which eliminate the safety concern on virulent reversion of modified-live vaccines and allow the immune system to be focused on protective B cell or/and T cell epitopes in a particular viral protein, are the major focus.

What has been done
Virus-like particle (VLP) based vaccines are gaining increasing acceptance compared to subunit vaccines, as they present the antigens in more veritable conformation and are readily recognized by the immune system. We propose to use Hepatitis B core antigen as a carrier protein to display selected immunogenic epitopes from various viral proteins. E. coli was selected as the expression host due to its low cost of production and high level of protein expression. The protein was successfully expressed, and a process to purify the protein from the inclusion bodies was developed. The purified protein was test to block the infection of PRRSV of susceptible cells.

Results
In this study, hybrid HBcAg VLPs were generated by fusion of the conserved protective epitopes of PRRSV and expressed in E. coli. An optimized purification protocol was developed to obtain hybrid HBcAg VLP protein from the inclusion bodies. This hybrid HBcAg VLP protein self-assembled to 23 nm VLPs that were shown to block virus infection of susceptible cells when tested on MARC 145 cells. Together with the safety of non-infectious and non-replicable VLPs and the low cost of production through E. coli fermentation, this hybrid VLP could be a promising vaccine candidate for PRRS.

4. Associated Knowledge Areas

KA Code	Knowledge Area
206	Basic Plant Biology

Outcome #5

1. Outcome Measures

research on energy signaling in plants has potential to increase plant biomass and lengevity

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
During photosynthesis, plants use light energy to synthesize food for growth from carbon dioxide and water. As the key process in plant productivity, photosynthesis plays a vital role in every aspect of agricultural production. However, researchers and farmers do not fully understand how photosynthesis is affected by environmental, molecular, and genetic constraints. Alleviating some or all of these constraints could lead to substantial increases in plant productivity.

What has been done
To address these limitations a protein complex that contains a plant energy sensor has been identified and characterized. When this sensor is overexpressed, plants live longer and accumulate more biomass. We have examined regulation of this energy sensor and are investigating other novel proteins that are important for maintaining energy sensor levels, and hence, biomass and longevity in plants.

Results
One aspect of this work is to utilize these genes in cotton to regulate senescence and decrease use of chemicals used by farmers to regulate cotton senescence before harvest.

4. Associated Knowledge Areas

KA Code	Knowledge Area
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants

Outcome #6

1. Outcome Measures

The Bioenergy Engineering Education Program (BEEP)

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Whether due to worries of rising energy prices, climate change, or energy security issues, many citizens are concerned that our nation has become too dependent on foreign sources of petroleum and are troubled by the impacts that this dependence has created. The federal government signed into law the Renewable Fuels, Consumer Protection, and Energy Efficiency Act of 2007 which seeks greater energy independence and security and promote the production of renewable fuels. Additionally, the commonwealth announced in the 2010 Virginia Energy Plan a target of making Virginia the energy capital of the east coast by increasing in-state production of energy by 20 percent over the next 10 years. These policies are indicative of a broader interest to sustainably increase our energy independence while spurring economic growth. The 2007 Energy Act received considerable attention in June 2014 when gasoline was well over $3.27/gallon and livestock/poultry industries were challenged by high feed prices. Policy makers, farmers, and citizens of Virginia are facing new economic development opportunities and making difficult decisions related to bioenergy project and policy development. However, it is often difficult for the citizenry to fully understand the complex terminology, and energy conversion processes, related to bioenergy. As a result, decision making and opinion forming often occurs with incomplete, misunderstood, or inaccurate information.

What has been done
The primary goal of this extension program is to increase participant's knowledge and awareness of the basics of bioenergy. Specifically, the program seeks to inform participants on the many different forms of bioenergy, discuss the feedstocks typically used for the generation of bioenergy, and explain how the bioenergy conversion technologies actually work.

Results

Work to help clientele better understand solar energy conversion technologies was begun, focusing on the educational trailer, and project development of four solar energy demonstrations: 1) 360W skid-mounted mobile solar water pumping unit for livestock stream exclusion programming in response to Chesapeake Bay TMDL/WIP II targets; 2) 1.08 kW utility-interactive net metered remote monitored, with local viewer, solar photovoltaic array to offset a small portion of the facility energy usage and use as an educational display among the 3,500 annual visitors at the Northern Virginia 4-H Educational Center; 3) system performance monitor for a 10-panel Inphase Energy micro-inverters installed at a tobacco curing farm in Chase City, VA used by Dr. David Reed, Southern Piedmont Agricultural Research and Extension Center for on-farm evaluations; 4) 96k BTU North Carolina manufactured SunQest Fresource SRCC-rated solar collectors, and two unrated Do-It-Yourself solar collectors manufactured by Sustainable Technology Institute in Richmond, VA installed at the Randolph Farm to use as working demonstrations for the 5,000 annual visitors and to offset a portion of the fossil-fuel based energy usage for the aquaponic facility.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
403	Waste Disposal, Recycling, and Reuse
605	Natural Resource and Environmental Economics

Outcome #7

1. Outcome Measures

Research in arsenic transport in purslane may impact soil remediation

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Arsenic is an extremely toxic metal that causes serious health problems to people worldwide. High levels of arsenic in soils can potentially lead to water and food contamination. Arsenic is carcinogenic, and exposure through drinking water, foods, or other sources can lead to various types of cancer, including cancer of the skin, lung, bladder and prostate. Although low concentrations of arsenic exist naturally in soil, its widespread uses as an herbicide, as an insecticide and in wood preservation have led to dangerous concentrations in many areas in the U.S. The Environmental Protection Agency reports that about 25% of wells in the U.S. contain amounts of arsenic that are higher than the levels allowed by that agency. Arsenic contamination is a local issue, too, occurring throughout Virginia, including in populated areas like Richmond. Removal of arsenic-contaminated soil from the environment will help clear the contaminant from our food supply, thus benefiting human health.

What has been done
Researchers at VSU have identified a novel gene responsible for arsenic transport in purslane.

Results
In previous work, they identified two purslane accessions with tolerance to arsenic and two accessions that show sensitivity to arsenic. Building on that, the VSU team has found that tolerant accessions have a significantly reduced ability to transport arsenic to their shoots. Using the genomic approach, scientists have identified a multidrug-resistant gene, ABCC2, the expression of which is highly inducible by arsenic in the roots of arsenic-sensitive purslane accessions, but not in the roots of arsenic-tolerant accessions, indicating that ABCC2 acts to control arsenic transport in plants. Understanding how arsenic is transported to shoots may lead to genetic engineering that will improve arsenic accumulation in purslane, and thus the plant?s potential for use in cleaning arsenic-contaminated soil. Cost-effective removal of arsenic from contaminated soil will benefit farmers and agriculture on local and international levels by making more clean and arable land available for agricultural production, especially in urban areas.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
206	Basic Plant Biology

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
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

The business income derived, acceptance of biotechnology, and energy usage could be affected by natural disasters, changes in the economy, government regulations and public policy changes. The availability of federal and state grants and initiatives can be affected by government priorities and changes in the economy. If greater emphasis is placed on energy conservation and alternative energy sources are implemented, these practices and alternatives will be encouraged. These factors may have immediate impact as they significantly influence items such as production economics, industry infrastructure, marketing systems, and consumer demand. Good economic conditions encourage use of alternative energy sources and viable biotechnologies. In Virginia, increasing petroleum values in traditional businesses and logistics are a significant challenge. The recent increase in bioenergy and biotechnology production and anticipated future growth of this alternative fuel sources will likely have major impacts. Scope of such impacts is unknown, but anticipated direction has influenced this planned program.

Changes in energy production capacity, energy costs, and federal resources (grants & contracts) could have unpredictable effects. The general economy, public policy and governmental regulations impact production and sales of bioenergy and acceptance of biotechnology. Appropriations and competing programmatic challenges affect the dedication of personnel and programs to the described programs. Population changes affect supply and demand for alternative energy products.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

None where developed

Key Items of Evaluation