Title: The Nexus: Heating Greenhouses with Bioenergy from Waste Streams

Project/Research: Project

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Description:

Introduction

Appalachian farmers struggle to maintain profitability with limited acreage (USDA, 2014) and short growing seasons. In order to extend the growing season, many farmers in the region dedicate a portion of their limited acreage to greenhouse production. However, the cost of heating those greenhouses with fossil fuels can comprise 40% of total production costs (Pena, 2005), ultimately excluding many producers from being able to justify greenhouse production. The Nexus Project at Appalachian State University (ASU) is an effort to develop technologies that allow greenhouses to be heated economically with renewable bio-energy—on-farm waste streams like manures, vegetative and woody wastes—and to share these technologies with resource-limited farmers.

Approach

The research project has a number of moving parts that include inductive and deductive research designs. The designs and construction of three biological waste heating systems—biovolitaization kiln, compost pile, and anaerobic digester—were based on a combination of proven designs and theoretical principles. The social and educational components, as well, are not to be lost in the research process. The objective of the Nexus

is to engage both university students and the greater community in educational opportunities that will ultimately promote greater environmental awareness and economic self-sufficiency throughout the region.

Preliminary Results

We successfully constructed and monitored three biomass heating systems—a biovolaitization kiln, a compost heating system, and an anaerobic digester—and also researched, constructed, tested and monitored heat storage and delivery systems. We positively tested the heating and heat transfer apparatus, and the heat storage tank, in a trial that delivered 88,200 BTUs in five hours. Heat transfer computer models predict that 26,000 BTUs per hour will be necessary to maintain a 60 ^{o}F temperature in our greenhouse in Boone through winter. Results from our tests indicate a capability of producing 16,899 $\pm$ 6,337 BTUs per hour from the BV and solar thermal systems alone. With the addition of compost heating and biogas digester energy (i.e., 35,000 BTUs per hour estimated from the computer model), results indicate a strong potential for complete greenhouse heating using biomass energy available to any farm.

Conclusions/Future Work

The Nexus Project has proven the feasibility of collecting heat for greenhouses from biological farm wastes. The project has attracted students, faculty, farmers, and community groups to engage in the conversation we have started about long-term community sustainability. Further study is needed to develop useful ways to deliver the heat collected to greenhouse plants in a way that is efficient, convenient, and cost effective. This is to include (1) outreach to farmers through interviews, site visits, and Cooperative Extension events to assess specific needs and capacities for technology transfer, (2) integration of system components through Arduino-controlled heat delivery systems for greenhouse plants and fish, and (3) compressed storage of BV and AD farm gasses for on-demand heat delivery and improved viability for technology adoption.

References

Pena, J. (2005). Greenhouse vegetable production economic considerations, marketing, and financing. Retrieved from Aggie Horticulture: http://aggie-horticulture.tamu.edu/greenhouse/hydroponics/economics.html

United State Department of Agriculture (USDA). (2014). 2012 Census of Agriculture: North Carolina State and County Data. Retrieved from http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/North_Carolina/ncv1.pdf