Northeast Woody/Warm-Season Biomass Consortium

NEWBio

Quarterly Progress Report
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www.newbio.psu.edu
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Notice

This report was prepared by Penn State University and NEWBio research, extension and education partners from Cornell University, Delaware State University, Drexel University, Ohio State University, Rutgers University, SUNY College of Environmental Science and Forestry, University of Maine, University of Vermont, West Virginia University, USDA Eastern Regional Research Center, US DOE Idaho National Laboratory and US DOE Oak Ridge National Laboratory. This work was supported by Agriculture and Food Research Initiative Competitive Grant No. 2012-68005-19703 from the United States Department of Agriculture National Institute of Food and Agriculture ("USDA-NIFA").
PROJECT ADMINISTRATION

Project Organization and Governance
Project Director Tom Richard continues to lead the overall NEWBio effort, assisted by Associate Director Timothy Volk and Executive Committee members Larry Smart and Jingxin Wang. The committee is supported by Project Manager Barbara Kinne, who coordinates the day-to-day administrative operations.

- **Project Progress**
  Each thrust continues to show satisfactory progress in meeting task objectives and schedules. Visualizations to represent NEWBio progress toward its objectives and fulfillment of thrust tasks are undergoing revision and will be available next quarter.

- **Advisory Board**
  Advisory Board members are invited to attend monthly All Hands meetings and at least two are typically in attendance each month. Tom Causer, President and COO of Terra Green Energy LLC was the featured speaker for the January 29th All Hands. He discussed the economics of torrefaction production, and technologies. Terra Green was also the subject of one of NEWBio’s first case studies (below).

  The Extension thrust is engaging with our board members to develop case studies of their successful biomass businesses to provide to the general public practical, tangible solutions that work. Two case studies have been completed (see Appendix B):

  An Advisory Board teleconference will be held in May to share project accomplishments and NEWBio’s work plan for an anticipated fourth year of funding.

- **Communications and Collaboration**
  Monthly meetings remain the primary means of sharing results and updating project team members. The Executive Committee, Leadership Team, and thrust teams typically hold monthly teleconferences.

  NEWBio published three eNEWS issues this quarter, with feature stories on recent research publications, upcoming events, and funding announcements.
• **Annual Meeting**
  NEWBio’s 2015 Annual Meeting will take place on August 3-4-5 at West Virginia University in Morgantown. A preliminary agenda is under review by the Leadership Team, with invitations extended to our Board, sister CAPs, and other interested stakeholders. The theme this year is Commercialization and Industry Scale-Up.

• **Financial Matters**
  The Executive Committee and the Leadership Team reviewed budgets at the Y3 mid-year point. Expenditures are mostly on track, with excess funding in a few instances related to delayed or extended searches for specific personnel. This mid-year budget review assists in the submission of NEWBio’s Y4 funding reapplication.

  The Education Thrust requested permission to move approximately $7,000 in Graduate Online Distance Scholarship funds to the Secondary Educator Workshop task to support teacher stipends and travel to the Penn State and West Virginia workshops in July 2015. It is likely that these extra funds will ensure that both workshops completely filled.

• **Seed Grants**
  The mid-year budget review revealed unused matching funds that allowed four additional seed grant proposals submitted in December 2014 to receive all or partial funding in Y4 and Y5, and to fully fund an original awardee:

  o Social Availability of Marginal Lands (Human Systems Thrust), Theresa Selfa-SUNY ESF, Michael Jacobson-Penn State, Clare Hinrichs-Penn State, and Andrea Feldpausch-Parker-SUNY ESF, Investigators. Partially funded in original round of awards, now fully funded at $29,821.

  o Integrated Business Development Extension Model (Extension Thrust), Sarah Wurzbacher-Penn State, Daniel Ciolkosz-Penn State, Michael Jacobson-Penn State, Evelyn Thomchick-Penn State, Justin Heavey-SUNY ESF, and Shawn Grushecky-WVU, Investigators. Fully funded at $28,000.

  o Increasing the Impact of NEWBio/BBEP Teacher Workshops (Education Thrust), Matt Johnson-Penn State and Leah Bug-Penn State, Investigators. Fully funded at $18,323.

  o Development of Stochastic TEA Model for Short Rotation Woody Crop Production (Harvest, Preprocessing and Logistics Thrust), Tristan Brown-SUNY ESF, Jingxin Wang-WVU, and Timothy Volk-SUNY ESF, Investigators. Partially funded at $10,000.

  o Harvesting Switchgrass and Miscanthus for Biofuel Production on Surface Mines in West Virginia (Harvest, Preprocessing and Logistics Thrust), Jude Liu-Penn State and Jeff Skousen-WVU, Investigators. Partially funded at $6,155.
Proposals requesting USDA funding will receive USDA Program Manager review as part of NEWBio’s overall project reapplications for Y4 and Y5.

- **Data Management**
  The January 29, 2015 All Hands meeting devoted itself to a discussion on NEWBio data management procedures. The project team heard presentations from five data repositories and an update on NEWBio’s internal data file reorganization:
  - Aaron T. Myers, Oak Ridge National Laboratory
  - Victor Walker, Idaho National Laboratory
  - Peter Arbuckle, USDA National Agricultural Library (LCA Data Commons)
  - Cynthia Parr, USDA National Agricultural Library (Ag Data Commons)
  - Maurie Caitlin Kelly, Penn State Data Commons
  - Barbara B. Kinne, Penn State, NEWBio Shared Drive Data Management

  Post-meeting, Eric Fabio (PhD candidate at Cornell University and a member of the Feedstock Improvement Thrust) and Kay DiMarco (Richard ABE Laboratory Manager at Penn State and a Harvest, Preprocessing and Logistics Thrust team member) tested and provided critical feedback on NEWBio procedures. Additional updates are underway.

- **Plans for Next Quarter**
  - Hold an Advisory Board meeting via teleconference.
  - Submit NEWBio’s Y4 funding reapplication to grants.gov and the Y3 annual report to REEport.
  - Finalize Annual Meeting Agenda.
PUBLICATIONS AND PRODUCTS

Peer-Reviewed Journal Articles

Book/Book Chapter
None to report this quarter.

Conference Presentations


Smart, L.B. “Genomics assisted breeding of triploid hybrids of shrub willow for bioenergy”, Departmental seminar, Horticulture Section, School of Integrative Plant Science, Cornell University, March 16, 2015, Geneva, NY.

Other Publications/Presentations


Fact Sheets
None to report this quarter.
**Workshops, Field Days, Demonstrations, Symposia, Trainings**

Hoffman, L. Biomass and bioproducts of the future. March 6, 2015. Young women’s conference in Science, Technology, Engineering, and Technology, Princeton University,


**NEWBio Bioenergy Webinars**


EcoWillow 2.0 – Updated Economic Analysis of Shrub Willow Crops. Speaker: Justin Heavey, Senior Research Support Specialist, Forest & Natural Resources Management, SUNY ESF. February 10, 2015. Recording: https://www.youtube.com/watch?v=-u0QIYJFtXI.

Can cover crops play a role in shrub willow establishment for weed and nutrient management? Speaker: Eric F. Fabio, PhD Candidate, Cornell University. March 10, 2015. Recording: https://www.youtube.com/watch?v=-u0QIYJFtXI.

**Research Summaries, Case Studies, Videos**


**Proposals Submitted**

Antares Group Incorporated, T.L. Richard and A.R. Kemanian (Penn State Co-Investigators). Enabling sustainable landscape design for continual improvement of operating bioenergy supply systems. DOE Bioenergy Technologies Office submission. ($663,139 [Penn State request])


Olson, DiFazio, Evans, Keefover-Ring, Smart, Liu, Yin. “Dimensions US-China: Collaborative Research: Sex chromosomes and dioecy in plants as drivers of multi-level biodiversity”, National Science Foundation Dimension in Biodiversity Program, ($1.95 M).
Thrust 1: Human Systems in the Northeast Regional Bioeconomy

Human Systems focuses on understanding the values, legacies, and motivations that drive perceptions and decisions about land management and business development for biomass energy systems. The social science component at SUNY ESF collected and analyzed media content data over five years to understand community perceptions about the biomass industry in four regions near production sites in New York, with parallel media content analysis and preliminary interviews with switchgrass growers in Pennsylvania by Penn State. A database was completed with policies related to biomass in New York. IMPLAN analysis was initiated to evaluate economic impacts from biorefinery development in the region. The economic component has leveraged modeling work with the Cycles model and feedstock supply and price projections from Oak Ridge National Lab to evaluate potential production from marginal lands in the Northeast. Data compiled includes energy crop production budgets and soil, land cover, and weather data. The Cycles growth model is used to project energy crop yields, map biophysical marginal lands for BCAP areas, and is performing statistical analysis of POLYSYS outputs to examine drivers of land use change projections focusing on dedicated biomass feedstocks.

Task 1.1: Understanding social and economic constraints
Task 1.1.1: Economic availability

1. Planned Activities
   - Continue to revise landowner survey;
   - Pretest the landowner survey at NEWBio demonstration sites;
   - Assessing water quality externalities is ongoing.

2. Accomplishments
   - Wei Jiang, Penn State Doctoral Candidate, pretested the landowner survey in Crawford County, PA;
   - The Human Systems group refined landowner survey questions on using marginal lands to plant energy crops;
   - Implemented the online survey in Pennsylvania and Ohio.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   - Continue online data collection for survey;
Use online data for econometrics model testing and selection;
Continue economically marginal lands analysis.

Task 1.1.2: Social Acceptability

1. Planned Activities
- Continue key informant interviews in New York, Pennsylvania, and Vermont;
- Begin landowner interviews in New York;
- Begin developing protocols for community focus groups in New York and Pennsylvania;
- Continue literature review;
- Analyze interview data;
- Work on paper and presentation for the April 2014 American Association of Geographers Annual Meeting.

2. Accomplishments
- Media analysis publication accepted by *Energies* journal.
- Completed 20 key informant interviews in New York, Pennsylvania, and Vermont
- Conducted focus group in BCAP Area 10;
- Scheduled five landowner interviews in New York; completed two landowner interviews in PA;
- Abstract accepted for the 2015 Rural Sociology Association Annual Meeting that was accepted (see highlight below).

3. Explanation of Variance
Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
- Continue key informant interviews in New York, Pennsylvania, and Vermont;
- Continue landowner interviews in New York;
- Analyze interview data;
- Finalize survey instrument to be implemented in New York;
- Advertise PSU rural sociology post-doc position;
- Continue to work on paper presented at AAG conference.

Task 1.2 Assess demonstration sites as they pursue scale-up of biomass crop production and supply chain infrastructure

1. Planned Activities
- Continue key informant interviews in demonstration sites;
- Continue planning and conducting focus groups in demonstration sites.
2. **Accomplishments**
   - Conducted focus group in BCAP Area 10;
   - Developed survey questions for landowner survey near demonstration sites.

3. **Explanation of Variance**
   Activities and accomplishments are on schedule. No variance to report.

4. **Plans for Next Quarter**
   - Finalize survey instrument to be implemented in New York;
   - Continue focus groups in demonstration sites, including Crawford County, PA.

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**Abstract Accepted for 2015 Rural Sociology Association Annual Meeting**

**Authors: Clare Hinrichs, Morey Burnham, Theresa Selfa, Andrea Feldspausch-Parker**

Public and private agendas in the U.S. continue to include the development of rural bioenergy. Yet the form and trajectory of that development have shifted in recent years amidst changes in the availability and acceptability of varied sources of both renewable and non-renewable energy, revised techno-scientific claims and commercial priorities about energy technologies, and evolving systems of environmental governance across multiple scales. Bioenergy proponents now claim that perennialized energy crop production on marginal lands (in contrast to grain based biofuel energy crops produced on cropland) offers a promising pathway for rural economic revitalization and increased energy security, while providing environmental services and supporting amenity interests in the landscape. In this paper, we examine shifting narrative constructions and emerging socio-environmental landscapes surrounding rural bioenergy systems centered on perennial crops in the U.S. Northeast. Integrating facets of the multi-level perspective on socio-technical transitions with a political ecology approach, we consider how varied spaces for bioenergy production in the Northeast have recently emerged, stalled, developed and/or disappeared. Using key informant interviews with landowners, policy makers, industry representatives, academics, and non-profit organizations, we compare the emergence and development of several broad types of bioenergy production systems in New York, Pennsylvania, and Vermont, including a shrub willow system used for power production and a perennial grass system used for home heating purposes. The paper describes and assesses 1) the assemblages of institutions, expertise, policies, landscapes and practices that shape the emergence and development of such “bioenergy niches”; and 2) the narratives and visions of sustainability that are enacted within and on behalf of these bioenergy niches and how such discourses shape niche formation and pathways. We find that the actors involved in each of the studied bioenergy niches imbue rural bioenergy production and development with their own meanings and goals, including mitigating property tax burdens, conserving open agricultural landscapes, and lowering home heating costs. The paper concludes by discussing the divergences and convergences between these Northeast rural bioenergy production systems, narratives, and goals, with a focus on how process oriented, fine-grained analysis of different bioenergy “niches” can expose both power and silence in regional bioenergy claims and goals. To understand the sociological significance of rural bioenergy projects—whether still imagined, now emerging, well established or abandoned—they must be situated within their community and regional socio-environmental contexts. Such contexts include complex interactions between landscape legacies, cultural values and attitudes of differentially empowered “stakeholders,” and competing forms of resource and energy extraction, rural and agricultural production and amenity-centered land uses. Our paper concludes by considering how a contextualized analysis of bioenergy narratives and socio-environmental landscapes can illuminate the role and significance of “bioenergy niches” and, further, how this approach can inform more locally appropriate, ethically sound and sustainability-oriented rural bioenergy development and policy.
Thrust 2: Feedstock Improvement for Perennial Energy Crops

Feedstock Improvement is identifying cultivars of switchgrass and shrub willow with improved performance and expanded range on marginal lands in the Northeast. Cornell has conducted 116 crosses, producing 45 families (39 of them new). Of the families produced, 25 have diploid progeny, 14 have triploid progeny, two have tetraploid progeny, and three have pentaploid progeny, all together representing 5,780 novel seedling individuals. Three crossing blocks have been established to generate half-sib families of tetraploid progeny for recurrent selection and novel triploid progeny. A total of 42 new accessions have been added to our breeding collection through acquisition from collaborators, nurseries, or arboreta. Association panels of *S. purpurea* have been established and evaluated on three contrasting sites, and these have all been genotyped for mapping studies. A QTL and selection trial has been established with over 270 new progeny. Yield trials to evaluate new willow cultivars have been established on eight sites across four states, including two on reclaimed mine land. A switchgrass trial including new lines from the Cornell and Rutgers breeding programs has been established on reclaimed mine land in PA. Field trials of switchgrass and willow have been surveyed for pest and disease incidence and new methods are being developed to characterize mechanisms of resistance.

Task 2.1: Breeding of non-invasive triploid hybrids of willow displaying hybrid vigor

1. Planned Activities
   - Prepare weigh wagon and equipment and begin harvesting the 2012 Association Trials, starting in Geneva. Collect stem segments just prior to harvesting at each trial.
   - Cut back first-year growth in the 2014 QTL Mapping and 2014 Crossing Block Trials
   - Collect shoots from nursery beds for cutting production.
   - Conduct controlled pollinations aimed at improved rust resistance and to generate new mapping populations.
   - Give a talk on heritability and trait mapping from 2012 Association Trial first-year data, and a talk on gene expression patterns among *Salix* parental species and *F*₁ hybrids at the Plant and Animal Genome XXIII Conference in San Diego, CA in early January, 2015.
   - Continue trait mapping work.
   - Analyze first year post-coppice growth data from the 2013 Family Selection Trial.

2. Accomplishments
   - Due to persistent snow cover across NY late into spring, the best option was to ship harvesting equipment to the WVU Agronomy Farm in order to harvest the 2012 Association Trial there, instead of starting in Geneva, NY. Cornell University’s Ny Vraa JF 192 harvester, JD 6170R tractor were commercially shipped the week of March 2, while the self-unloading weigh wagon was hauled with a Cornell trailer and heavy-duty truck the week of March 9.
Just prior to harvest stem segments were collected from four blocks for wood composition analysis.

Each of the 780 four plant plots was harvested with the JF 192 harvester and chips blown into the weigh wagon were measured to the nearest 0.5 lb. A subsample of chips from each plot of the first block was collected to estimate moisture content by genotype across the field.

Major support in field operations during harvest was provided by personnel from the DiFazio, Wang and Grushecky groups.

Harvesting equipment was then shipped to Portland, NY and harvesting of that Association Trial was conducted during the week of March 30. The same weighing and sampling procedures described above were employed. Harvesting equipment was then shipped back to Geneva, NY and harvesting of that trial will begin as soon as ground conditions allow.

Prior to harvesting the association trials first year growth of the 2014 QTL mapping trial was cutback using the JF 192 harvester with good results.

Talks on heritability and trait mapping from 2012 Association Trial first-year data, and on gene expression patterns among *Salix* parental species and F1 hybrids were given at the Plant and Animal Genome XXIII Conference in San Diego, CA in January.

First year growth of the 2014 Crossing Blocks was cutback using brush saws.

QTL mapping was initiated for traits that were measured in the 2014 QTL trial during the summer of 2014, including stem height and pest incidence.

First year stem height and stem diameters were collected and analyzed in the 2013 Family Selection Trial. Overall, ‘Fabius’ has shown to have the highest stem height and stem area overall over genotypes within this first year of growth. Figure 1 shows a summary of end of first season growth variables for each family.

Crosses were conducted to improve rust resistance by selecting individuals with the lowest incidence of rust evaluated in the Geneva *Salix purpurea* Association Trial. Crosses were also conducted using new genotypes of *Salix koriyanagi* imported from South Korea and new genotypes received from botanical gardens in the US. A self-pollination was conducted using a stable hermaphrodite of *Salix purpurea*, which will be useful in studying the mechanism of sex determination and in reducing the overall heterozygosity for genome sequencing.

Willow harvester and weigh wagon measuring plot weights in the *Salix purpurea* Association Trial in Morgantown, WV.
Figure 1. Box plot graph for plant height and stem variables by breeding family in the 2013 Geneva Family Selection Trial.
3. **Explanation of Variance**
   Most activities and accomplishments are on schedule. No variance to report.

4. **Plans for Next Quarter**
   - Complete the harvest of the final 2012 Association Trial in Geneva, NY
   - Continue trait mapping work, including yield and biomass composition data
   - Continue seed extraction and sowing from crosses made in early 2015
   - Prepare new nursery beds and begin planting out progeny from 2015 breeding work
   - Score each genotype in the 2013 Family Selection Trial and in other families in nursery beds for gender
   - Fertilize three of six reps at each Association trial site with 19-19-19 at 200 lbs N per acre in order to assess response to fertilizer

**Task 2.2: Genetic basis for pest and disease resistance in willow and perennial grasses**

1. **Planned Activities**
   - Complete any unfinished analysis of 2014 pest and disease incidence.
   - Collect cuttings for 2015 controlled feeding assays.

2. **Accomplishments**
   ✓ Cuttings were collected from the parents and 20 progeny in a *Salix purpurea* x *S. viminalis* hybrid family that is segregating for susceptibility to potato leafhopper. The progeny were selected to capture a range of field damage ratings from the 2014 season. These cuttings will be used in the summer for controlled feeding assays to better assess susceptibility and eventually map loci for resistance.

3. **Explanation of Variance**
   Most activities and accomplishments are on schedule.

4. **Plans for Next Quarter**
   - Conduct controlled feeding assays with potato leafhopper on segregating hybrid willow progeny to assess genetic mechanisms of resistance;
   - Survey willow yield trials for pest and disease incidence and damage;
   - Collect samples from susceptible and resistance willow genotypes for RNA-Seq analysis of plant response to pest feeding;
   - Survey willow QTL mapping populations for pest and disease incidence to map loci controlling resistance;
• Scout for disease and pest incidence in switchgrass breeding trials in NJ, NY and PA. Collect data if evident.
• Scout for disease incidence in switchgrass mapping population in NJ. Collect data if evident.
• Scout for disease incidence in switchgrass fungicide trial in NJ. Collect data if evident.
• Conduct controlled feeding assays with potato leafhopper on segregating hybrid willow progeny to assess genetic mechanisms of resistance.
• Survey willow yield trials for pest and disease incidence and damage.
• Collect samples from susceptible and resistance willow genotypes for RNA-Seq analysis of plant response to pest feeding.
• Survey willow QTL mapping populations for pest and disease incidence to map loci controlling resistance.
• Fungicide applications will begin this week on the cultivar/anthracnose trial in NJ. Subsequent applications will be made over the next few months.

Task 2.3: Breeding and selection of willow and switchgrass cultivars adapted for Northeast conditions

1. Planned Activities
   • Complete end of season diameter measurements in the 2013 Fredonia Amendment Trial.
   • Measure plant height and stem form, and stem diameters in the 2012 Rock Springs Yield Trial. Collect stem segments from each plot for density and composition measurements.
   • Analyze height, stem diameter and plant form data collected in the 2012 and 2013 trials.
   • Remainder of Cornell switchgrass samples will be ground and then analyzed using NIRS. Selected samples will be sent to Dairy One for wet chemistry.
   • Remainder of Rutgers switchgrass samples will be ground and analyzed using NIRS.

2. Accomplishments
   ✔ Diameter data collection was completed in early January in the 2013 Fredonia, NY Willow Amendment Trial. Figure 2 shows a selection of elite cultivars exhibiting a wide range in response of plot stem area to soil amendments applied in June, 2014. Since stem area in the unamended control plots is similar among these cultivars this may suggest differences in nutrient uptake and or nutrient use efficiency.
   ✔ Stem diameter, plant height, crown form and stem segments for biomass composition were all collected in mid-January in the 2012 Rock Springs, PA Yield Trial with much assistance from the Kemanian group at Penn State.
   ✔ Figure 3 shows comparison of second year heights between the 2012 Geneva, NY & Rock Springs, PA Yield Trials. Overall mean height was greatest at Geneva as in the first year of growth. The cultivars ranking in the top six are mostly the same at each site.
Figure 4 shows a comparison of crown form between these two sites, with the cultivars ranked the same as in the height figure. The differences are less clear between the two sites.

- Stem segments have been measured for density, milled and analyzed for biomass composition using HR-TGA. Other stem samples have been received from willow yield trials outside of the NEWBio trial network and will be measured in the same fashion, and the data will be added to the G x E yield and composition database.

- Cornell switchgrass samples were ground, analyzed using NIRS, and selected samples were sent to Dairy One for wet chemistry analysis. A new calibration equation was developed and applied to all samples. Cellulose content in Ithaca ranged from 34.45 to 38.11 percent. Ash content ranged from 3.54 to 5.88 percent.

- Rutgers switchgrass samples were ground, and will be analyzed with NIRS in the next couple of weeks. Samples will be shipped to cross thrust groups this week for analysis.

- Seedlings of 40 top performing lines in NJ and Phillipsburg were germinated in the greenhouse in preparation for a nursery planting next quarter.

Figure 2. Mean plot stem area for a selection of cultivars in the 2013 Fredonia, NY Willow Amendment Trial.
Figure 3. Mean plot height across 28 cultivars in two of the 2012 willow yield trials.

Figure 4. Mean plot crown form across 28 cultivars in two of the 2012 willow yield trials.
3. **Explanation of Variance**  
   Most activities and accomplishments are on schedule.

4. **Plans for Next Quarter**  
   - Continue processing stem samples for density and biomass composition  
   - Analyzed growth and composition data  
   - Assess switchgrass winter survival in nurseries at Cornell and Rutgers. Nurseries will be evaluated for numerous traits including: plant survival, green-up, vigor and other bioenergy traits.

**Task 2.4: Breeding and selection of willow and switchgrass yields on reclaimed mine land**

1. **Planned Activities**  
   - Assess survival and develop a list of replant cuttings for the 2014 Mylan Park Yield Trial.  
   - Collect replant cuttings for the 2014 Mylan Park trial from Geneva nursery beds. Prepare from nursery beds or order cuttings from Double A Willow for the 2015 Philipsburg trial.  
   - Cornell switchgrass samples will be analyzed using NIRS. Selected samples will be sent to Dairy One for wet chemistry.

2. **Accomplishments**  
   - First year growth of the 2014 Mylan Park trial was cutback. This was done during the trip to harvest the 2012 Association Trial at the Agronomy Farm and there was not enough time to assess the need for replants. A visit will be scheduled soon after budbreak to count survival.  
   - A planting design was created for the 2015 Philipsburg reclaimed mine willow trial. Spent mushroom compost was spread over a 150 ft x 100 ft area. An adjacent area upslope of equal size will serve as the unamended control. A "multivator" was purchased that will till soil in each row where willows will be planted in spring. This should allow better willow rooting/establishment.  
   - Cuttings for the Philipsburg trial were ordered from Double A Willow. Two cultivars are not yet available for purchase through Double A Willow, so they were harvested from nursery beds in Geneva and stored in the freezer.  
   - Cornell switchgrass samples analyzed using NIRS and selected samples were sent to Dairy One for wet chemistry analysis. A new calibration equation was developed and applied to all samples. Cellulose content in Philipsburg ranged from 32.47 to 38.54 percent. Ash content ranged from 2.65 to 5.20 percent.
3. **Explanation of Variance**
   Time did not allow a winter survival assessment in the 2014 Mylan Park trial. This will be done after budbreak and a decision will be made as to whether or not there is a need to plant replacement cuttings. Survival of this trial prior to winter was greater than 96%.

4. **Plans for Next Quarter**
   - Continue site preparations at the Philipsburg site, make cuttings for two cultivars not purchased from Double A Willow and plant the trial in mid-May
   - Conduct any necessary weed control in the 2014 Mylan Park trial and assess the need for replanting cuttings
   - Assess switchgrass winter survival in nurseries at Philipsburg. Nurseries will be evaluated for numerous traits including: plant survival, green-up, vigor and other bioenergy traits.
Thrust 3: Harvest, Preprocessing, and Logistics of Integrated Biomass Supply Chains

For perennial crop systems like willow, miscanthus and switchgrass, harvesting and transportation can account for 40 to 60 percent of the delivered cost of biomass. Woody biomass logistics modeling has been accomplished to estimate the delivered cost of biomass feedstocks and optimize the locations of facilities. Logistic variables considered in the model include feedstock availability in terms of time (seasonality), the siting, extent, and productivity of the SRWC plantations, geographical distribution of wood and agricultural residues, collection, transportation, and storage. Biomass storage studies for willow, switchgrass and miscanthus have documented compositional changes and dry matter loss, and these results are being integrated into the INL Biomass Logistics Model. Harvesting of willow biomass crops using a NH FR9000 series forage harvester and a recently designed FB130 woody crop headers on almost 55 ha in upstate NY demonstrates promising results. A key lesson learned during the project is that ground speed alone is not a good indicator of system improvement because harvester throughput is related to the combined effects of ground conditions and standing biomass at the site.

Task 3.1: Significantly reduce the harvesting cost per ton of biomass feedstocks from willow and perennial grasses
Task 3.1.1: Optimize the operation of the forage harvester

1. Planned Activities
   - Process time-motion data from large-scale harvests for use in price uncertainty analysis of willow biomass crops using the EcoWillow model.

2. Accomplishments
   - Preparation of peer-reviewed paper underway.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   - Continue to collect time-motion data from large-scale willow harvests.
Task 3.1.2: Detailed time and motion data collection and fuel use analysis

1. Planned Activities
   - Continue to process time-motion data from large-scale harvests;
   - Continue to collect time-motion data of miscanthus harvesting.

2. Accomplishments
   - Analyzed harvesting data from winter 2014;
   - Harvested 50 acres of miscanthus and collected time-motion, fuel use, and other logistics modeling data.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   - Continue to determine time-motion data collection procedures and experimental design.

Task 3.1.3: Cost effective technologies for harvesting perennial grasses

1. Planned Activities
   - No work planned.

2. Accomplishments
   None to report for this quarter.

3. Explanation of Variance
   No variance to report.

4. Plans for Next Quarter
   - Continue data analysis.

Task 3.1.4: Optimize the operation of the perennial grass harvester

1. Planned Activities
   - Miscanthus field harvesting planned using round baling harvesting equipment in West Virginia;
   - Analysis of field harvesting data;
   - Miscanthus conditioning and compression indoor studies planned.
2. Accomplishments

✓ Harvested 50 acres of miscanthus in Easton, Illinois which produced 600 large square bales.

✓ A self-propelled windrower was used in Easton field harvesting and two different conditioning methods; flail and steel crimp rolls were tested to compare bale density, fuel use, and other logistics data.
3. **Explanation of Variance**
   - In general, all harvesting was delayed due to the weather.
   - Due to weather and other restrictions, it was very difficult to find and harvest a miscanthus field in the Northeast U.S. To ensure the coverage for our tasks and outcomes, we conducted miscanthus field harvesting in Easton, Illinois (not part of the original research plan).
   - The original field harvesting budget for Y3 was insufficient. Supplemental resources were provided via Penn State matching funds.

4. **Plans for Next Quarter**
   - We plan to harvest two miscanthus trials in West Virginia.

**Task 3.1.5: Feedstock Logistics, supply chain and modeling optimization**

1. **Planned Activities**
   - Revise models based on new research and new data sets.

2. **Accomplishments**
   - Added more scenarios and analyses to the model;
   - Revising an article’s manuscript based on additional information.

3. **Explanation of Variance**
   Activities and accomplishments are on schedule. No variance to report.

4. **Plans for Next Quarter**
   - Plans call to complete model development and optimization.

**Task 3.2: Quantify the role of preprocessing for densification and storage on transportation efficacy and downstream fuel conversion**

**Task 3.2.1: Quantitative metrics of preprocessing parameters of biomass densification**

1. **Planned Activities**
   - Analyze torrefaction results and expand cross-lab analysis of feedstock.

2. **Accomplishments**
   - Tested and compared samples of non-modified feedstock.

3. **Explanation of Variance**
   Activities and accomplishments are on schedule. No variance to report.
4. Plans for Next Quarter
   • Expand cross-lab analysis of modified feedstock (hot water extracted and torrefied).

Task 3.2.2: Effects of preprocessing transportation and downstream fuel conversion

1. Planned Activities
   • Analyze measurements of energy and fuel yield from torrefied biomass;
   • Investigate acidogenic digestion of switchgrass and winter rye.

2. Accomplishments
   ✔ Finalized data analysis and submitted a paper on pyrolysis of switchgrass;
   ✔ Made good progress on acidogenic digestion; submitted concept papers to DOE’s ARPA-E and USDA-DOE’s Biomass Research and Development Initiative, journal article revised and resubmitted to Membrane Technology.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Continue to analyze measurements of energy and fuel yield from torrefied biomass;
   • Continue to investigate acidogenic digestion of switchgrass, willow and winter rye;
   • Continue the analysis of biomass via py-GCMS, and pilot-scale pyrolysis of willow, switchgrass and miscanthus.

Task 3.2.3 Biomass densification

1. Planned Activities
   • Expand densification studies;
   • Measure the energy consumption of miscanthus conditioning.

2. Accomplishments
   ✔ Revised reports for the torrefaction and preprocessing work;
   ✔ Miscanthus samples were collected from WV field and conditioned using an indoor conditioning device;
   ✔ Conditioned miscanthus was baled using a small square baler. Then, bale compression was tested to acquire energy consumption vs. bale density data.
3. Explanation of Variance
Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
- Continue to expand densification studies.

Task 3.3: Assess the storage requirements and effects of long term storage on the quality of willow and perennial grasses
Task 3.3.1: Storage system development and assessments for perennial grasses

1. Planned Activities
- Long-term storage studies for switchgrass and miscanthus, analyze storage impacts.

2. Accomplishments
✓ Continued to monitor ongoing studies on grass storage and to examine additional opportunities to expand research;
✓ Submitted a paper on willow storage;
✓ Published a paper with a conversion stakeholder (Mascoma’s IP team at Dartmouth) that included characterization and storage data for immature rye biomass.

3. Explanation of Variance
Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
- Continue long-term storage studies for switchgrass and miscanthus harvest, analyze storage impacts.

Task 3.3.2: Storage system development and assessments for willow

1. Planned Activities
- Complete and submit paper on long-term storage studies for willow.

2. Accomplishments
✓ Submitted paper undergoing second revision.

3. Explanation of Variance
Activities and accomplishments are on schedule. No variance to report.
4. Plans for Next Quarter
   - Continue long-term storage studies for willow and analyze storage impacts

Task 3.4: Techno-economic analysis, cost engineering, and life cycle analysis of densification, storage preprocessing and biorefinery integration

Task 3.4.1: Develop an integrated supply chain model

1. Planned Activities
   - Test and revised algorithms for alternative supply chain scenarios.

2. Accomplishments
   ✓ Mapped NEWBio test sites including crop types.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   - Continue to test and revised algorithms for alternative supply chain scenarios.

Task 3.4.2: Cost engineering models for satellite preprocessing and storage

1. Planned Activities
   - Refine cost estimates.

2. Accomplishments
   ✓ Examined near-term market for willow;
   ✓ Collected willow data;
   ✓ Continued work on LCA.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   - Continue to refine cost estimates.
Task 3.4.3: Life Cycle analysis, techno-economic analysis, and model integration

1. Planned Activities
   - Refine spatial-statistical LCA study for feedstock collection, transportation and collect data.

2. Accomplishments
   ✓ Completed LCA model and prepared the first draft of an LCA paper;
   ✓ Started TEA process.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   - Continue TEA work.
Thrust 4: System Performance and Sustainability Metrics

Simulations of biomass potential and water use for both warm season grasses and willow were obtained for 30 years at three locations representative of the geographic range of the project with a site in Illinois included for comparison purposes. Within the NEWBio region, northern locations seem suitable for willow while southern locations are suitable for both grasses and willow. A concentrated effort simulating growth in both so-called marginal soils and agricultural soils is underway for the BCAP area in NW PA and eastern Ohio, with an alfalfa-corn rotation as a comparison crop. Simulations of annual systems that can incorporate winter rye to the biomass sources in the NE are also underway. At the field level, monitoring is occurring consistently to assess nitrous oxide emissions, N recycling in perennial crops, and carbon and water fluxes. A white paper addressing the risks associated with biogenic volatile organic carbon emissions and ozone formation from willow has been prepared, and will be used to support a sustainability assessment that includes some indications of air quality risks or benefits. Following the matrix of indicators for bioenergy systems prepared by ORNL, we are designing our own matrix that maps the activities of NEWBio thrusts and will allow consistent reporting for each demonstration site. The life cycle assessment and techno-economic analysis aspects of sustainability concentrated on collaboration with the HPL thrust; activities focused on defining biomass-biofuel pathways and collection of cost data. Life cycle costs for wood pelleting systems were developed through collaboration with industry in New York State. The Sustainability thrust had been leading the development of NEWBio’s data management plan (DMP), and handed that over to the Administrative thrust for Barbara Kinne for implementation starting in January 2015.

Task 4.1: Site- and crop-specific knowledge gaps
Task 4.1.1: Biomass production

1. Planned Activities
   - Replace eddy towers.
   - Finish soil cluster in BCAP area.
   - Finish winter biomass sampling of willow at Rockview, Rock Springs and Geneva.
   - Finish first estimation of the comparative net primary productivity (C balance) of willow and corn at Rockview.

2. Accomplishments
   - Tower replacement under way, not completed yet.
   - Soil clustering for Ohio/PA BCAP area under way.
   - Winter sampling of willow is still ongoing.
Eddy towers in corn plots were removed and reinstalled after harvest.
Net primary productivity and evapotranspiration of willow and corn at Rockview completed.

3. Explanation of Variance
Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
- Place and lift new tower in willow field at Rockview.
- Finish soil clustering and simulations in BCAP area.
- Start preparing a manuscript based on Cangiano’s master thesis.
- Complete data storage of 2014 eddy covariance data.

Task 4.1.2: Nitrogen demand and alternative supply

1. Planned Activities
- Continue monitoring experiments (routine)
- Finish winter rye and stover manuscript.
- (other activities not planned but executed are added)

2. Accomplishments
- Sampling continuous. We are monitoring light interception in 15N experiment at Rock Springs twice a week.
- 15N boxes have been removed from the ground.
- Samples are being ground and prepared for isotope analysis.
- A.M. Ramcharan is completing simulations to prepare a draft manuscript dealing with winter rye/corn stover removal in the NE and the Chesapeake Bay area.
- Completed simulations of switchgrass response to nitrogen in Lebanon Co, PA.
- Brian Richards et al. at Cornell, working on a sister AFRI project, reported the response of switchgrass to N rates; results are remarkably similar to the simulated response rate.

3. Explanation of Variance
Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
- Continue routine monitoring experiments;
- Finish rye and stover manuscript.
Task 4.1.3: Nitrous oxide emissions

1. Planned Activities
   • Advance simulation of N$_2$O.

2. Accomplishments
   ✓ Draft manuscript on methodology for sampling N$_2$O emissions is under review.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Advance simulation of N$_2$O emissions;
   • Work with Richards to simulate the N$_2$O emissions measured at the Ithaca site (nine days of measurements across multiple treatments).

Task 4.1.3: Carbon storage

1. Planned Activities
   • Maintain eddy system.
   • Continue soil sampling and storage.
   • Finish root sampling.

2. Accomplishments
   ✓ See 4.1.1 for EC advances.
   ✓ Root sampling completed for Fish Creek and SX61 at Tully, NY and Belleville, NY.
     Both trials were planted in the spring of 2005 and are now at the end of their third rotation (three-year-old shoots on a 10-year-old root system). Preparing report for review.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Maintain eddy system.
   • Continue soil sampling and storage.
Task 4.2: Benchmark scenarios

1. Planned Activities (broad plans)
   - Continue simulations for both annual and perennial crops.
   - Finish soil clustering to advance simulations of BCAP area.
   - Added activity: create a standard yield by location database to be used in point and aggregated analysis.

2. Accomplishments
   ✓ Soil clustering methods are continuous. We are trying to reproduce the approach followed by Sanabria and Goss for the Conservation Effects Assessment Project. Wei Jiang has prepared an algorithm in R to reproduce the technique described by those two investigators. This work has not been completed and is still ongoing.
   ✓ Data from the PRISM-EC or energy crop regressions has been downloaded at the county level. This database is being analyzed with the goal of establishing clear benchmarks. Advantages: simulations for the three perennial energy crops use a similar methodology. Disadvantages: potential mismatch between predicted and observed data, lack of detail to segregate energy crops in cropland vs marginal land, lack of response to management.
   ✓ Woodbury, Langholtz, Richard, Jacobson and Kemanian (and students!) are completing comparative enterprise budgets for energy crops and grain crops in the Chesapeake Bay area, with a focus on switchgrass and corn.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   - Continue simulations for both annual and perennial crops.
   - Finish soil clustering to advance simulations of BCAP area.
   - Complete preparation of local and regional yield database.

Task 4.3: Regional feedstock supply and environmental assessment

1. Planned Activities
   - Define physical sites for extension and education demonstrations.
   - Define virtual sites for education and regional simulation demonstrations.
   - Establish water quality impacts and air quality impacts for industrial activity and emergent pollutants.
   - Begin to evaluate land use change impact on biodiversity and landscape.
Define harmonized database for LCA and non-market impacts
Define data management for thrust and overall project.
  o Integrate, conceptually, biomass production modeling with landscape characterization.
  o Continue planning the coupling of biomass and water quality models (air quality is under way).
Continue promoting data model development for each NEWBio thrust (a statement preserved from previous quarter).
Complete an initial internal draft review of the extent to which bioenergy feedstock production may increase emission of biogenic volatile organic carbon compounds, and how these compounds may reduce air quality.

2. Accomplishments
  ✔ Baxter and Kirby (PSU) are filtering historic land use data to establish the specific fields that can be considered available for energy crops.
  ✔ Kammerer, Mortensen and Kemanian are developing a comparative analysis of the land use and other attributes for the miscanthus BCAP area, the willow BCAP area in NY, and Lancaster County in southeastern PA in relation to the Chesapeake Bay.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Continue with plans from previous quarter, with the formal addition of Kirby and Baxter to the team.

Task 4.4: Biomass to biofuel life cycle analysis and multi-criteria sustainability

1. Planned Activities
   • As in previous quarter, continue data collection to compile techno-economic analysis (TEA) models.
   • Continue work on sustainability matrix towards a specific example, possibly the BCAP area in Ohio / PA.
   • The LCA/TEA group has focused on working with the HPL group to plan a logistics and pre-processing life cycle inventory.

2. Accomplishments
   ✔ Reported under Thrust 3 – Harvest, Pre-processing and Logistics.
3. **Explanation of Variance**  
Activities and accomplishments are on schedule. No variance to report.

4. **Plans for Next Quarter**  
- As in previous quarters, continue data collection to compile techo-economic analysis (TEA) models  
- Continue work on sustainability matrix towards an specific example, possibly the BCAP area in Ohio / PA  
- The LCA/TEA group has focused on working with the HPL group to plan a logistics and pre-processing life cycle inventory (and some reporting occurs within that thrust).  
- Prepare winter-rye /corn stover sustainability assessment manuscript.
Thrust 5: Safety and Health in Biomass Feedstock Production and Processing Operations

Safety and health aspects of the biomass product supply chain will be addressed from a holistic, systems perspective. The Safety team participates in biomass production activities with NEWBio partners, including the harvesting and storage of biomass crops. This provides insight into hazards present in biomass production not found in traditional agricultural crops, and how safety committees within organizations function. Fire and respiratory hazards are being investigated as areas of particular concern to biomass producers. Development of a “Safety and Health Management Training Manual for the Biomass Production Industry” is underway in Year 3.

Task 5.1: Biomass safety program development

1. Planned Activities
   • Hold additional meetings with extension multimedia professionals to determine the method of information dissemination;
   • Have initial information available in determined format.

2. Accomplishments
   ✓ Learned new software necessary for compiling short media videos from pictures and other media sources;
   ✓ Initial “Learn Now” short video is complete and was sent to outside vendor for closed-captioning. Will be completed by mid-April. This short video focuses on the hazards of winter harvest that may be unique to biomass growers.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Gather materials and images needed for the next two “LearnNow” videos. Themes of these will be fire and respiratory hazards as related to on-farm biomass production.
   • Complete one of these additional short videos.

Task 5.2: Safety and health hazard inventory

1. Planned Activities
   • With the Extension thrust, complete the initial information provided to NEWBio equipment users. This will include safety information with reference to the complete equipment manual.
2. **Accomplishments**
   - Obtained funding through NEWBio seed grant program to further investigate fire hazards, rural fire department needs, and other topics unique to the fire hazards related to large-scale promotion and growth of biomass crops in rural areas. This will occur in Year 4 of the NEWBio project.
   - Visited willow harvesting in Pennsylvania. Example of fire issues related to willow harvest were evident.
   - Obtained all equipment manuals for the NEWBio equipment program.

3. **Explanation of Variance**
   Activities and accomplishments are on schedule. No variance to report.

4. **Plans for Next Quarter**
   - As possible, continue to visit sites that are harvesting biomass. Switchgrass and miscanthus are all scheduled to be harvested within Pennsylvania. Collect images and machine information that differentiates biomass crop harvest from traditional crop harvest.
   - In cooperation with the Extension thrust, complete the material available to NEWBio equipment program users.

**Task 5.3: Develop, conduct and evaluate a comprehensive safety and health management program**

1. **Planned Activities**
   - Continue adaptation of “Safety and Health Management Planning for Beginning Farmers and Ranchers” to the biomass industry.
   - Collect photographs as needed to use in this publication.

   Direction of Task 5.3 is changing to focus on development of materials for a comprehensive safety and health management program and making the materials available to biomass educators and producers. With the lower-than-expected adoption of on-farm biomass production, there has been no indication that an audience of sufficient size is available to present this program in-person to producers.

2. **Accomplishments**
   - Photographs were collected as visits to additional biomass production sites happened.
   - Sections have been revised to reflect the differences between traditional crops and biomass crops.
   - Tables and charts have been changed to reflect the on-farm production of biomass crops.
3. **Explanation of Variance**
   Activities and accomplishments are on schedule. No variance to report.

4. **Plans for Next Quarter**
   - Continue adaptation of “Safety and Health Management Planning for Beginning Farmers and Ranchers” to the biomass industry. All changes needed should be completed by the end of the third quarter.
   - Continue to collect images as needed to use in this publication.
Thrust 6  Extension

Working with NEWBio advisory board members, industry partners, and other organizations, Extension identified field demonstration sites in Pennsylvania, New York and West Virginia that serve as bases of operation for NEWBio outreach work and research. In participation with the Crawford County (PA) Commissioners, Extension has organized a field-scale perennial grass planting at a public farm. In New York, over 830 acres of new willow biomass crops were established in the spring of 2013, and previously established acres were harvested; almost 2,500 tons of biomass from these fields have been delivered to a ReEnergy biopower facility in Lyonsdale, NY. In West Virginia, a MeadWestvaco 30-year-old reclaimed surface mine site was planted with willow, switchgrass, and Miscanthus. The equipment access program, which makes specialized energy crop farming equipment available to farmers, has assisted in the purchase of two willow harvesters and a willow planter in cooperation with advisory board member and corporate partners Double A Willow and Celtic Farm Energy. Our bioenergy workshops and webinars utilize industry and NEWBio team members as presenters; participants are drawn from industry, academia, and the public. The Extension and Education Teams also developed fact sheets, display materials, and other printed and online media to assist in communicating NEWBio content. Working with eXtension.org, NEWBio has a landing page to index all NEWBio publications and outreach resources. Priority topics are identified along with contributors for these publications.

Task 6.1:  Integrated demonstration sites

1. Planned Activities
   - Represent NEWBio/regional bioenergy activities at PA Farm Show
   - Conduct Farm Energy IQ Program in State College, PA
   - Make linkages between NEWBio bioenergy interests and private forest management issues at PA Private Forest Landowners’ Conference
   - Complete necessary planting, replanting, maintenance, and harvesting activities at demonstration fields as seasonally appropriate (few activities planned for quarter 1)
   - Continue developing outreach opportunities via field days, tours, and demonstrations
   - Continue monitoring new BCAP funding opportunities for additional willow acreage
   - Provide technical assistance and training opportunities for EcoWillow 2.0

2. Accomplishments
   - NY Demonstration site:
     - Communicated with NY willow growers by phone and email on topics of equipment management, potential funding opportunities, upcoming growing season and data collection needs.
o Updates continue to suite of willow, BCAP outreach materials
o EcoWillow 2.0 publicized through blog post (see deliverables section)
o Local presentations, publications, field events on NEWBio work relevant to demonstration site completed (see deliverables section)
  ▪ 3 Tully willow site tours for SUNY Cortland ecology students
o Continued assistance and coordination by extension staff to facilitate research in this demonstration region
  ▪ March: Presentation on willow for focus group—Watertown, NY (cooperation with human systems research)

✓ NW PA/NE OH Demonstration site:
o NEWBio was represented at a local Farm Bureau community meeting hosted by Ernst Conservation Seeds with an agenda centering on future energy issues for farmers in the region, including bioenergy (March 13).
o Local presentations, publications, field events on NEWBio work relevant to demonstration site completed (see deliverables section)
  ▪ PA Farm Show—Harrisburg, PA
  ▪ Conservation District Program—Meadville, PA
  ▪ Farm Energy IQ Program—State College, PA (same program also held in Fairlee, VT, but outside of demo site region.)
  ▪ PA Private Forest Landowner’s Conference—Altoona, PA
o Continued assistance and coordination by extension staff to facilitate research in this demonstration region
  ▪ December (previously unreported): Tour for NEWBio safety and health team at Aloterra’s farm headquarters and processing facility to inform biomass processing safety guide content
  ▪ February: Landowner survey pre-test with local landowner focus group—Meadville, PA (cooperation with human systems research)
  ▪ March: Participation in Forest Futuring research exercise at Allegheny National Forest research lab, to address consequences of current forest management patterns, loss of forest resilience, issues associated with potential increase in low-use wood, etc.

✓ WV Demonstration site:
o Necessary maintenance/management applied to planted demonstration areas
  ▪ Coppiced last year’s willow plantings.
  ▪ Ordered new willow varieties to replant replicated sites from the first year after losing many to weeds and equipment.
Continued assistance and coordination by extension staff to facilitate research in this demonstration region
  - 2 papers submitted based on research in demo site region.

3. Explanation of Variance
Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
- Complete necessary planting, replanting, maintenance, and harvesting activities at demonstration fields as seasonally appropriate;
- Continue developing outreach opportunities via field days, tours, and demonstrations:
  - Syracuse, NY Symposium on Energy;
  - Ashtabula, OH Bioenergy Workshop;
  - Rock Springs, PA Timber 2015 Forest Products Equipment and Technology Expo;
- Continued assistance and coordination by extension staff to facilitate research in this demonstration region:
  - Develop materials for online graduate courses in bioenergy for Higher Education Challenge Grant efforts (cooperation with education team) and introduce focus group to regional bioenergy examples in demo region.

Task 6.2: Biomass equipment access program

1. Planned Activities
- Complete equipment access fact sheet including relevant safety information;
- Continue managing scheduling and distribution of equipment;
- Continue investigating safety procedures, updating knowledge on this subject;
- Work with Celtic Energy to amend the user agreement to better address potential damage that may occur to the header.

2. Accomplishments
- Continued monitoring use of machine reservation schedule;
- Coordinated with equipment users to understand limitations on availability, new maintenance issues that have risen in priority (potential for damage to rented equipment may need to be better incorporated into rental agreements);
- Assisted in coordinating harvester use at East Lycoming School;
- Safety procedures regarding machinery, logistics continue to be monitored based on existing systems (field visits to current biomass operations);
✓ Fact sheet detailing equipment access program is in progress, including safety
information pertaining to available equipment.

3. Explanation of Variance
Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
• Continue managing scheduling and distribution of equipment;
• Continue investigating safety procedures, updating knowledge on this subject.

Task 6.3: Small business and economic development

1. Planned Activities
• Continue work on biomass business models;
  o Analysis of paper and paperboard industry;
  o Biomass transportation models;
• Continue working on media analysis and publication.

2. Accomplishments
• Transportation analysis white paper is complete and is in the editing phase.
• Marketing analysis of paper and paperboard industry is complete and in review.

3. Explanation of Variance
Responsibility for media analysis was transferred out of our thrust and has therefore been
removed from our report. Otherwise, activities and accomplishments are on schedule. No
variance to report.

4. Plans for Next Quarter
• Continue work on biomass business models;
  o Analysis of paper and paperboard industry;
  o Biomass transportation models.

Task 6.4: Expand eXtension.org for willow and warm-season grasses

1. Planned Activities
• Maintain and update NEWBio index of resources on eXtension website;
• Manage NEWBio Ask an Expert section on the eXtension site;
• Publish one expert bio for NEWBio extension collaborators on eXtension;
• Publish one research summary;
• Publish information sheet providing overview of NEWBio commercial collaborators;
• Publish two case studies of successful biomass businesses;
• Continue posting NEWBio webinars to eXtension Learn;
• Utilize eXtension Farm Energy and NEWBio Facebook and Twitter accounts to broadcast NEWBio events and resources;
• Coordinate web conference with other CAPs-Extension – use network to improve outreach efforts.

2. Accomplishments
✓ NEWBio index of resources updated and maintained on eXtension website;
✓ More prominently displayed “Ask an Expert” link on NEWBio website homepage;
✓ One Ask an Expert inquiry fielded;
✓ Published one research summary (see publication section);
✓ Published two case studies (Ernst Conservation Seeds and Terra Green Energy LLC);
✓ NEWBio webinars continue to be posted to eXtension Learn;
✓ Facebook and Twitter used to broadcast NEWBio events and resources;
✓ Joined Cross-CAP calls to discuss outreach techniques within other bioenergy CAPs, marketing strategies/industry interactions (2):
  ✓ January 2015 meeting focused on policy engagement;
  ✓ March 2015 meeting focused on social media.

3. Explanation of Variance
Delayed publications will be added to plans for the next quarter.

4. Plans for Next Quarter
• Maintain and update NEWBio index of resources on eXtension website;
• Manage NEWBio Ask an Expert section on the eXtension site;
• Publish two expert bios for NEWBio extension collaborators on eXtension;
• Publish one research summary;
• Publish information sheet providing overview of NEWBio commercial collaborators;
• Publish two case studies of successful biomass businesses;
• Continue posting NEWBio webinars to eXtension Learn;
• Utilize eXtension Farm Energy and NEWBio Facebook and Twitter accounts to broadcast NEWBio events and resources;
• Coordinate web conference with other CAPs-Extension – use network to improve outreach efforts.
Task 6.5: Interactive and innovative learning-lessons tools

1. Planned Activities
   - Target outreach opportunities at PA Farm Show, Farm Energy IQ program, PA Private Forest Landowners’ Conference, etc.;
   - Develop “successful biomass industry” profile series for publication;
   - Continue delivery of bioenergy webinars;
   - Continue to prepare fact sheets;
   - Continue to hold workshops, field days;
   - Continue to populate website, NEWBio blog;
   - Continue to complete educational presentations;
   - Send out monthly e-newsletter;
   - Utilize NEWBio social media presence (Facebook, Twitter) to broadcast NEWBio events.

2. Accomplishments
   ✓ Two profiles completed for “successful biomass industry” profile series;
   ✓ Bioenergy webinars delivered monthly;
   ✓ No fact sheets completed this quarter, but strong outreach presence with other methods.
   ✓ Multiple field days and tours completed at demo sites;
   ✓ Updates completed to NEWBio website, including more prominent featuring of Ask and Expert and social media links;

Google Analytics for www.newbio.psu.edu, Jan-Mar 2015
✓ One blog entry completed;
✓ Multiple relevant presentations completed;
✓ E-newsletters with NEWBio news and events sent out monthly;
✓ Maintained active social media presence via Facebook, Twitter;
✓ Regular maintenance and updates of ESF Willow website (www.esf.edu). Heavy traffic to the site continues with 2,887 page views this quarter including 364 downloads of the new willow brochure published last quarter, making 700 downloads in last two quarters.

3. **Explanation of Variance**

Almost all activities and accomplishments are on schedule with little variance to report.

4. **Plans for Next Quarter**

- Continue developing “successful biomass industry” profile series for publication;
- Continue NEWBio outreach at field days, presentations, events;
- Continue delivery of bioenergy webinars;
- Continue to prepare fact sheets;
- Continue to populate website, NEWBio blog;
- Continue to complete educational presentations;
- Send out monthly e-newsletter;
- Utilize NEWBio social media presence (Facebook, Twitter) to broadcast NEWBio events;
- Continue working with Moon library staff to create willow digital commons page on ESF institutional repository to contain theses, technical reports and other often requested materials not available on the willow website.
Thrust 7  Education

The NEWBio education thrust has effectively strengthened the education pipeline to support the biomass industry in the region in the following ways: by training undergraduate students in bioenergy from multiple institutions (eight students trained in Summer 2013; seven trained in Summer 2014), and providing graduate bioenergy education to working professionals (21 scholarships awarded thus far). Furthermore, the long-term education pipeline was enhanced through the training of K-12 educators who are in turn teaching bioenergy concepts to their students.

Task 7.1:  Secondary educator training

1. Planned Activities
   • Continue recruitment;
   • Collect applications/assist applicants by phone;
   • Purchase workshop supplies.

2. Accomplishments
   ✓ The registration website was activated, and information on the workshop has been sent to contact groups throughout PA and WV.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Recruitment continued;
   • Finalize preparations for workshops (Week of June 29 in PA, Week of July 13 in WV);
   • Purchase workshop supplies.

Task 7.2:  Regional Bioenergy Scholars

1. Planned Activities
   • Complete recruitment for 2015;
   • Select bioenergy scholars for 2015.

2. Accomplishments
   ✓ Applications were collected and reviewed;
   ✓ Scholars were selected for 2015 at the six host sites.
3. **Explanation of Variance**
   Activities and accomplishments are on schedule. No variance to report.

4. **Plans for Next Quarter**
   - Complete plans for 2015 scholar training and placement
   - Conduct training of scholars and deliver them to their host mentor sites

**Task 7.3: Graduate distance education in bioenergy**

1. **Planned Activities**
   - Market Program.
   - Delivery of one course: FOR 880 - Bioenergy Feedstocks.
   - Award scholarships for Summer Semester 2015.

2. **Accomplishments**
   - FOR 880 is underway
   - One scholarship was awarded for Spring Semester 2015
     - Danilo Quadros
   - Five scholarships were awarded for Summer Semester 2015
     - Sirajus Salehin
     - Joseph Volcko (a former Bioenergy Scholar)
     - Kittikun Songsomboon
     - Danilo Quadros
     - Yang Qiu
   - Two former scholarship recipients (Edward Johnstonbaugh, Sarah Wurzbacher) completed the Graduate Certificate in Bioenergy from Penn State.

3. **Explanation of Variance**
   Activities and accomplishments are on schedule. No variance to report.

4. **Plans for Next Quarter**
   - Marketing of program.
   - Delivery of two courses (ABE 884 – Bioenergy Systems and ABE 885 – Bioenergy Harvest and Logistics).
   - Award of scholarships for Fall Semester 2015.
Thrust 8   Leadership, Stakeholder Involvement, Knowledge-to-Action (K2A) and Program Evaluation

NEWBio’s external evaluation first and second year reports focused on project infrastructure, communication and collaboration. The reports provided recommendations to maintain the project’s high level of momentum and team member enthusiasm, and to further engage with our external stakeholders and advisory board. Team meetings continue to play an important role in the collaborative process. We use our monthly e-newsletter (25-30 % open rate, over 500 active contacts) to relate research updates and other articles and news related to biomass and bioenergy to the project team, our advisory board, industry and agency partners, and the general public. Critical leadership discussions are ongoing with existing and potential conversion partners who are investigating potential biorefinery sites and are evaluating needs related to biomass pricing and quantities. Of particular note is a new collaborative relationship with Delta Airlines, which has purchased a petroleum refinery outside Philadelphia and is working with NEWBio to explore opportunities to insert biomass feedstocks and intermediates into that refinery process train.

Task 8.1: Executive and thrust conference calls

1. Planned Activities
   - Continue monthly teleconferences for Executive Committee and Leadership teams.

2. Accomplishments
   ✓ Held Executive Committee teleconferences on January 15, February 13, and March 17.
   ✓ Held Leadership teleconferences on January 22, February 19 and March 19.
   ✓ Held a total of 14 thrust and working group teleconferences to address such subjects as the data management, switchgrass harvesting, feedstock budgets, ecosystem services, and techno-economic analysis efforts.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   - Continue monthly scheduling for Executive Committee and Leadership team meetings.
   - Continue participation in thrust team meetings.
Task 8.2: All Hands teleseminars and meetings

1. Planned Activities
   - Continue monthly teleseminar schedule to deliver project updates and share thrust progress toward goals and objectives.
   - Engage thrusts, especially graduate students and corporate stakeholders, in the planning and organization of our monthly teleseminars and the August annual meeting.

2. Accomplishments
   ✓ Held three All Hands teleseminars:
     ○ January 29 featured presentations by five research libraries identified as potential repositories for data generated by NEWBio:
       (1) Aaron T. Myers, Oak Ridge National Laboratory
       (2) Victor Walker, Idaho National Laboratory
       (3) Peter Arbuckle, USDA National Agricultural Library (LCA Data Commons)
       (4) Cynthia Parr, USDA National Agricultural Library (Ag Data Commons)
       (5) Maurie Caitlin Kelly, Penn State Data Commons
     ○ February 26 featured two presentations that were very well-received by the project team. Both talks were subsequently scheduled for a wider audience through the NEWBio webinar platform:
       (1) Timothy Kelsey, Professor of Agricultural Economics at Penn State and Emily O’Coonahern, Undergraduate in At Econ at Penn State, *New Bioenergy Economic Analysis for the Northeast*, the results of work completed through NEWBio Y2 Seed Grant funding.
       (2) Lara Fowler, Adjunct Professor of Law and PSIEE Research Fellow at Penn State, *A Quick Overview of U.S. Law and Policy Affecting Second Generation Biofuels*.
     ○ March 26 was a project-wide discussion of thrust activities to date, with a focus on communication, coordination, and consistency of information flows and data assumptions. The session was titled “Cross-Thrust Information Flow and Integration” and featured each thrust leader presenting a high-level summary of team activities, data outputs generated, and data gaps/needs from other thrusts. The session also included an update on the reorganization of NEWBio’s internal drive.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Complete scheduling for Spring 2015 All Hands teleseminar topics/speakers.
Task 8.3: External Advisory Board meetings and strategic planning

1. Planned Activities
   • Invite Advisory Board members to participate in NEWBio All Hands teleseminars.

2. Accomplishments
   None to report this quarter.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Board members will be kept informed of NEWBio meetings and field activities.
   • A mid-year Advisory Board teleconference will be scheduled and held.

Task 8.4: Task and project evaluation

1. Planned Activities
   • Participate in leadership and team teleconferences.
   • Observe team interactions.

2. Accomplishments
   None to report this quarter.

3. Explanation of Variance
   Activities and accomplishments are on schedule. No variance to report.

4. Plans for Next Quarter
   • Participate in leadership and team teleconferences.
   • Observe team interactions.
   • Plan survey and interview participants for Y3 evaluation.
Appendix A

NEWBio Task List and Timelines

a. Task List with Milestone and Deliverables Timeline

b. Task List with Progress Timeline
<table>
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#### Key Deliverables
- **Project Milestones**: O
- **Fact Sheets, Reports, Articles, Videos**: X

#### Activity Level
- Low Activity
- High Activity
### Thrust 1: Human Systems in the Northeast Regional Bioeconomy

#### Task 1.1
- Understanding social and economic constraints

  - Task 1.1.1 Economic availability
  - Task 1.1.2 Social Acceptability

#### Task 1.2
- Assess demonstration sites as they pursue scale-up of biomass production and supply chain infrastructure

### Thrust 2: Feedstock Improvement for Perennial Energy Crops

#### Task 2.1
- Breeding of non-invasive triploid hybrids of willow displaying hybrid vigor

#### Task 2.2
- Genetic basis for pest and disease resistance in willow and perennial grasses

#### Task 2.3
- Breeding and selection of willow and switchgrass cultivars adapted for Northeast conditions

#### Task 2.4
- Breeding and selection of willow and switchgrass yields on reclaimed mine land
### Thrust 3: Harvest, Preprocessing and Logistics of Integrated Biomass Supply Chains

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## Thrust 4: System Performance and Sustainability Metrics

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## Thrust 5: Safety and Health in Biomass Feedstock Production and Processing Operations

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Appendix B

NEWBio Business of Biomass Case Studies:

Ernst Conservation Seeds Transforms Leftover Biomass into Energy Product

Terra Green Energy: Pioneers in Torrefaction for Commercial Co-Combustion
Ernst Conservation Seeds Transforms Leftover Biomass into Energy Product

Farm Energy April 14, 2015

Switchgrass biomass left over after seed harvest had little value for Ernst Conservation Seeds until the company began using it to manufacture pellets.

Switchgrass pellets. Photo credit: Calvin Ernst.

Table of Contents

Introduction

Ernst Conservation Seeds in Meadville, Pennsylvania has been growing and marketing grass seed for more than fifty years. The company has always been dedicated to conservation plantings using native species, and recently cultivated a market for the biomass that remains in the field after seed harvest.

When seeds are harvested, the stripped switchgrass remains in the field. Until about a decade ago, this leftover warm-season grass was simply burned off or sold for animal bedding. Then the company built a mill for manufacturing densified pellets from it. These are now being sold to the oil and gas industry for use as an industrial absorbent, and have the potential to reach other markets as well.

Bales at field edge. Photo credit: Calvin Ernst.

Besides making useable products, the mill could be a model for others considering getting into biomass production and is an important part of a developing infrastructure in the renewable energy supply chain. "We wanted to prove the concept that native grasses could become an economical source of energy or fiber," said Calvin Ernst, president.

From Crown Vetch to Conservation and More

Calvin Ernst founded the company in 1984 to grow and sell crown vetch (a low-growing vine) for erosion control. In the 1980s, he began transitioning from grains and
non-native forage seed to native grasses, mainly for conservation uses.

Today, the company produces switchgrass, big bluestem, indiangrass, little bluestem, Virginia wildrye, and cordgrass, all of which can be pelletized for fuel or absorbents. It also grows seed from nearly 400 other species of native and naturalized grasses for a wide range of uses and markets. It’s a decidedly family business, with Ernst’s wife, Marcia, playing a crucial role from the beginning. Today, their three children are also involved.

Besides pellets, Ernst has other interests in renewable energy, including selling some switchgrass seed for cellulosic ethanol research and production. “I think native grass bioenergy and forages hold a lot of potential, particularly when you look at the value of other ecological services that they provide such as wildlife habitat, nutrient uptake, water purification, and carbon sequestration,” Calvin Ernst said.

How the Ernst Biomass Operation Works

Designed and overseen by Calvin Ernst’s son, Michael, the 10,000-square-foot mill began production in 2012. Three years after opening, the $6 million mill pelletizes and processes over 10,000 tons of grass and hay per year, with the capacity to pelletize as much as 30,000 tons. The native grass seed production is within a 20-mile radius of the pelletizer, which is operated under the name Ernst Biomass.

To secure biomass for the plant, Ernst mows and windrows the straw after harvesting seed from its 5,000 acres of native grasses. In the spring, the straw is baled in round bales that are stored at the edges of the fields until they are transported to the processing plant. The material must be dry for baling, but the mill also has the capacity to dry the biomass after it is delivered to the plant. Ernst also purchases hay from local growers to increase the plant’s utilization.

Early Hurdles
Ernst experimented with several products before settling on pellets. It researched mixing paper and cardboard waste with warm-season grass. It also produced switchgrass briquettes for a Pennsylvania school district for two years and made several truckloads of briquettes for co-firing with coal. “Our experiences proved that we could not make a consistent product without a switchgrass straw dryer. By drying the straw for our pelletizer, we now produce a premium dry product with good quality control,” Calvin Ernst said. The dryer came only after a fourteen-month wait for a state DEP permit.

Briquettes worked successfully for co-firing but had limited use in the industrial absorbent market, where the pelletized product shines. Fortunately, Pennsylvania’s recently reinvigorated oil and gas industry increased demand for industrial absorbents just as Ernst’s pellet production came on line. Now most of Ernst’s switchgrass pellets are used by that industry to stabilize liquid waste in oil cuttings, making disposal easier.

Ernst also sells some ground switchgrass and large, soft pellets for animal bedding. It’s constantly improving the plant’s efficiency by increasing the capacity of conveyors and grinders while seeking new markets—which might include energy production.

Pallet mill. Photo credit: Calvin Ernst.

A Local Asset

Between them, Ernst Conservation Seeds and Ernst Biomass employ 75 full-time workers, 15 of them in pellet production. The mill also benefits the local economy by offering some income to landowners within 20 miles of the plant who lease their farmland to Ernst.

Though few local growers have yet been willing to invest in planting and establishing their own switchgrass stands, Ernst expects interest to pick up now that there are better-established markets. The expiration of contracts in the Conservation Reserve Program, a U.S. Farm Service Agency program that pays landowners for conservation practices, should also make more acreage available for native grass production.

Goals for the Future

Ernst continues to think big. “Our goal is to plant an additional 1,000 acres of native grasses this year to produce seed and better utilize our biomass plant,” Calvin Ernst said.

Meanwhile Ernst Biomass serves as a working model for practical production of biomass products for use in many industries, including renewable energy. “We welcome interested producers to study our operation and learn from our experiences,” Ernst said. “I think anyone who has patience and persistence, with an end goal in mind, can convert biomass into useful products.”
“We feel that we have only scratched the surface of biomass uses.”

For More Information

- Ernst Conservation Seeds
- “50 Years and Still Growing,” Business Magazine, August 2014, Manufacturer and Business Association

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Terra Green Energy: Pioneers in Torrefaction for Commercial Co-Combustion

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A torrefaction demonstration facility employs a patented process to convert biomass into a renewable, energy-dense carbon carrier that functions much like coal, and which can be burned in existing coal-fired power plants.

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Torrefaction reactor. Photo credit: Terra Green.

An Innovator in Commercial Torrefaction

Terra Green Energy LLC, a renewable fuels technology development company in McKean County, PA, has developed a unique torrefaction facility for commercial production. Torrefaction, a “mild pyrolysis” process, transforms biomass into a form that is compatible with existing coal technology and requires less expensive storage options.

Terra Green finished building its Commercial Torrefaction Demonstration Facility in November 2014. The plant serves as a model to show potential customers how a full-size commercial plant could work, and by spring of 2015, Terra Green plans to be working with a power plant that will test their product on a large scale.

Terra Green has patented a torrefaction process which is a thermochemical pretreatment that can be used on almost any type of biomass, including wood from coppiced plantations or natural forests. Grass material can also be torrefied, but Terra Green focuses on wood feedstocks. Wood is chipped, and then heated at temperatures between 250° to 300° C (392° to 572° F) in the absence of oxygen. This removes the moisture content and some volatile organic compounds, and converts the biomass into a solid product that can be used directly or formed into a pellet, briquette, or other densified product. The torrefied biomass is more brittle and easier to grind than raw biomass, a significant benefit to operators of pulverized-coal boilers.
The Advantages of Torrefied Biomass

As a fuel, torrefied biomass is a relatively consistent and uniform product that has some advantages over wood pellets and chips. Pelletized torrefied wood has a higher bulk density and energy content than regular pellets, so more of the product (by weight) can fit into the same space for more efficient transport. Torrefied biomass is also hydrophobic; this ability to repel water may allow it to be stored outdoors without much preparation or worry.

Torrefied biomass can retain 90 percent of the energy value of the original biomass, providing 9,000–10,000 BTU per pound, or 21–23.2 MJ/kg. It has about twice the caloric value of green wood chips and up to 1.5 times the caloric value of wood pellets. Its moisture content is low, about 1 percent.

A torrefied woody biomass product stores, travels, and functions much like coal. It can be burned in existing power plants, helping to lower their overall greenhouse gas emissions and improve air quality. Therefore, it has significant market potential as a renewable fuel that can be co-fired along with coal in conventional electricity generation plants, according to Tom Causer, president and chief operating officer of Terra Green. Augmenting coal with torrefied biomass reduces fossil fuel use and helps coal-based power plants comply with renewable energy-use standards.

Generating electricity isn’t the only use for torrefaction. The product shows promise in heating markets as a replacement for white wood pellets. Torrefied pellets have a much higher heat content, so fuel storage hoppers need to be refilled less frequently. In addition, the hydrophobic (water-repellant) nature of the torrefied pellets eliminates moisture problems that plague white wood pellet storage. Even though this intriguing market potential exists, Terra Green is so far keeping its focus on larger, commercial co-firing applications.

Terra Green’s Demonstration Facility

Combustion unit. Photo credit: Terra Green.

Terra Green’s demonstration facility has the capacity to produce about 1,000 pounds of torrefied wood an hour, or 12 tons a day. It uses virtually no fossil fuels in the process, with the exception of some electricity for fans and other ancillary equipment. This is because, during torrefaction, the hemicellulose component of the woody biomass is volatilized, producing combustible gases that produce the thermal energy required for both pre-drying and torrefaction when burned.

The company aims to fill a niche for small-scale biomass processing plants that could easily fit into rural communities and produce between 65,000 and 100,000 tons of torrefied biomass annually. Like the demonstration plant, such facilities would include a torrefaction reactor and a combustion unit to burn gases from the process to heat the reactor. Building a commercial facility would cost approximately 255 times the plant’s annual capacity in tons, according to Causer, citing “Black Pellets – A Financial Analysis of Costs and Benefits,” a 2014 report by Dr. William Strauss of FutureMetric. Therefore, a commercial plant with 55,000 tons of annual capacity would cost roughly $16 million, and would process about 165,000 tons of raw, green biomass (at 40-percent moisture) a year.

Torrefaction’s Role in Existing Power Production Facilities

Co-firing with torrefied biomass offers the important advantages of using existing coal-fired power facilities, reducing the need for
new capital investment, and mitigating greenhouse gas emissions. Burning torrefied biomass would help coal-fired power plants meet future carbon emission-reduction goals set by the U.S. Environmental Protection Agency while still employing their valuable capital assets. It would use waste wood, forestry residues, and purpose-grown wood energy crops (such as hybrid willow) as feedstocks.

Co-firing with torrefied biomass could have positive social and economic implications for local economies as well. “The synergies of co-firing have great value,” Causer said. If torrefied biofuel replaces a portion of coal in power plants, EPA regulations are more likely to be met, which means plants have a better chance of continuing to operate. And though somewhat reduced, coal is still used, so coal industry employees and the communities that host electrical generation facilities maintain their tax base and jobs.

Sizing operation. Photo credit: Terra Green.

Causer reports seeing significant progress in co-firing biomass in coal plants over the last few years. One plant in Ontario, Canada, is converting to biocoal pellets, which are much like torrefied wood. Another coal-fired plant, Gulf Power’s Herbert Schelz Generating Plant in Florida, co-fired up to 100-percent torrefied wood pellets in 2014. In these tests, they found that adding torrefied wood reduced nitric oxide (NOx), SOx, mercury, unburned carbon losses, and carbon dioxide emissions compared with emissions streams from coal-alone systems.

**The Future of Torrefaction**

The coal-fired electrical generation industry is changing, Causer predicts that coal will continue to be burned for the foreseeable future—but it will be supplemented with biomass such as torrefied grass or wood that can be fed directly into the power plant alongside the coal. Not far in the future, he anticipates that forest biomass and purpose-grown energy crops—hybrid willow in particular for the Northeast—will supply the large amounts of biomass that commercial torrefaction plants would require in order to supply a steady source of renewable fuel to power facilities.

**For More Information**

- Terra Green Energy LLC, Shenport, PA 814-569-2350.

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NEWBio’s vision is to build robust, scalable and sustainable value chains for biomass energy in the Northeast United States.