DOE Bioenergy Technologies Office (BETO) 2021 Project Peer Review

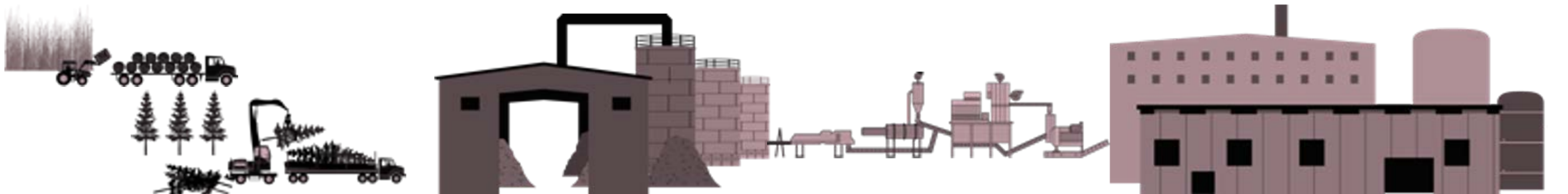
Next Generation Logistics Systems for Delivering Optimal Biomass Feedstocks to Biorefining Industries in the Southeastern US

March 9, 2021
Feedstock Technologies Program

Timothy Rials
The University of Tennessee Institute of Agriculture

Project Overview

- Continuing Project with DOE BETO regarding improved logistics (Logistics for Enhanced-Attribute Feedstock - LEAF)
  - Builds on advances in two previous High Tonnage projects (Pine at AU; Switchgrass at Genera)
- Current opportunities:
  - Advanced merchandizing systems to maximize quality and reduce cost from southern pine biomass residue found in approximately 40 million acres of traditionally managed pine plantations
  - A more extensive forest product mix will add value to woody biomass and reward landowners across the U.S.
  - Dependence on single sources of biomass significantly constrains the scale of conversion facilities.
  - Information is needed to effectively utilize the inherent variability of biomass characteristics to optimize process behavior.
- The project goal is to evaluate a state-of-the-art biomass merchandizing and processing system to identify sources of variation along the supply chain of multiple, high-impact biomass sources, and to develop practices to reduce biomass variability that lowers the cost of producing a hydrocarbon biofuel.



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  - Builds on advances in two previous High Tonnage projects (Pine at AU; Switchgrass at Genera)
- Current opportunities:
  - A … pine biomass r … ns
  - A … wners across t …
  - D … ion facilities.
  - I … stics to optimize p …

Relevance

This biomass blend concept will allow biorefineries to utilize a much larger proportion of the land within their procurement radius (e.g., pine and herbaceous crops in the southeast U.S.), thereby enabling larger scale, and more economically feasible facilities to be constructed and operated.

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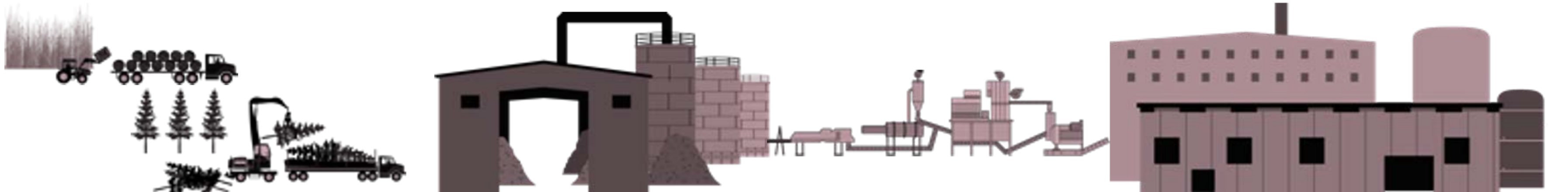


Management

TASK 1: Integrated Merchandising
Lead: Steve Taylor, AU

Tim McDonald and Tom Gallagher (AU)

TASK 2: Quality Monitoring
Lead: Niki Labbé, UT

Peter Muller (PE) Oladiran Fasina / Sushil Adhikari (AU), Tim Young (UT)

TASK 3: Formulated Feedstocks
Lead: Jaya Tumuluru, INL

Sam Jackson (GEI), Oladiran Fasina (AU), Steve Taylor (AU)

TASK 4: System Evaluation; Co-Lead: Steve Kelley, NCSU / Burt English, UT

Sunkyu Park (NCSU), Edward Yu (UT)

TASK 5: Project Management
Lead: Tim Rials

Genera Energy
IndusTREE
PPI
PerkinElmer For the Better
Perten Instruments a PerkinElmer company
John Deere

APPROACH

DIVERSE BIOMASS SOURCES

Pine Residue

Herbaceous

Woody Crops

TASK 1: INTEGRATED MERCHANDISING
Demonstrate an integrated harvest, transport, and merchandizing system for maximizing value, quantity, and quality of biomass from southern pine forests.

TASK 2: QUALITY MONITORING
Introduce statistical process control methods that utilize biomass quality metrics obtained from novel, rugged spectroscopic sensor data to reduce feedstock cost, and improve quality.

TASK 3: FORMULATED FEEDSTOCKS
Explore the potential to formulate feedstock blends from diverse biomass inputs for improved processing performance at lower costs.

TASK 4: SYSTEM EVALUATION
Quantify the spatially specific economic and life-cycle gains afforded by the new system incorporating advanced methods and instrumentation to improve feedstock quality and consistency relative to the current supply system.

Impact

Task 1 (All milestones met)

1. Determined biomass content for diverse tree characteristics.
2. Designed/built/tested trailer for whole-tree transport – achieved axle limits under DOT regulations.
3. Evaluated throughput of new processor (w/ John Deere; 2 campaigns).
4. Cost models completed and analysis used in system assessment.
5. **Merchandizing field trials showed that the approach encouraged production of saw logs rather than pulpwood – higher value product suite, greater biomass supply.**

Task 2 (All milestones met)

1. Assembled substantial library of biomass (pine residue, switchgrass, poplar) characterization data – ash, AAEM, carbon, HHV, etc.
2. Collected extensive library of NIR/FTIR spectroscopic data.
3. Created robust, predictive models for rapid analysis of biomass properties.
4. **Demonstrated the ability to assess chemistry of different biomass sources and pellet products.**

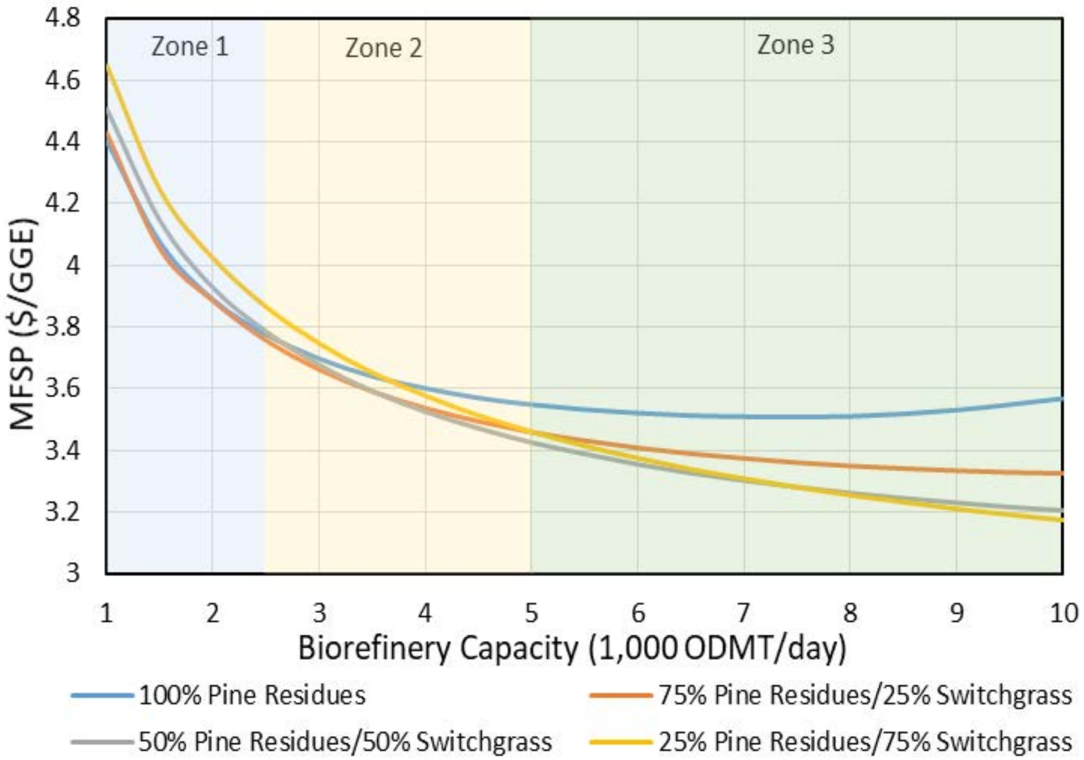
Task 3 (All milestones met)

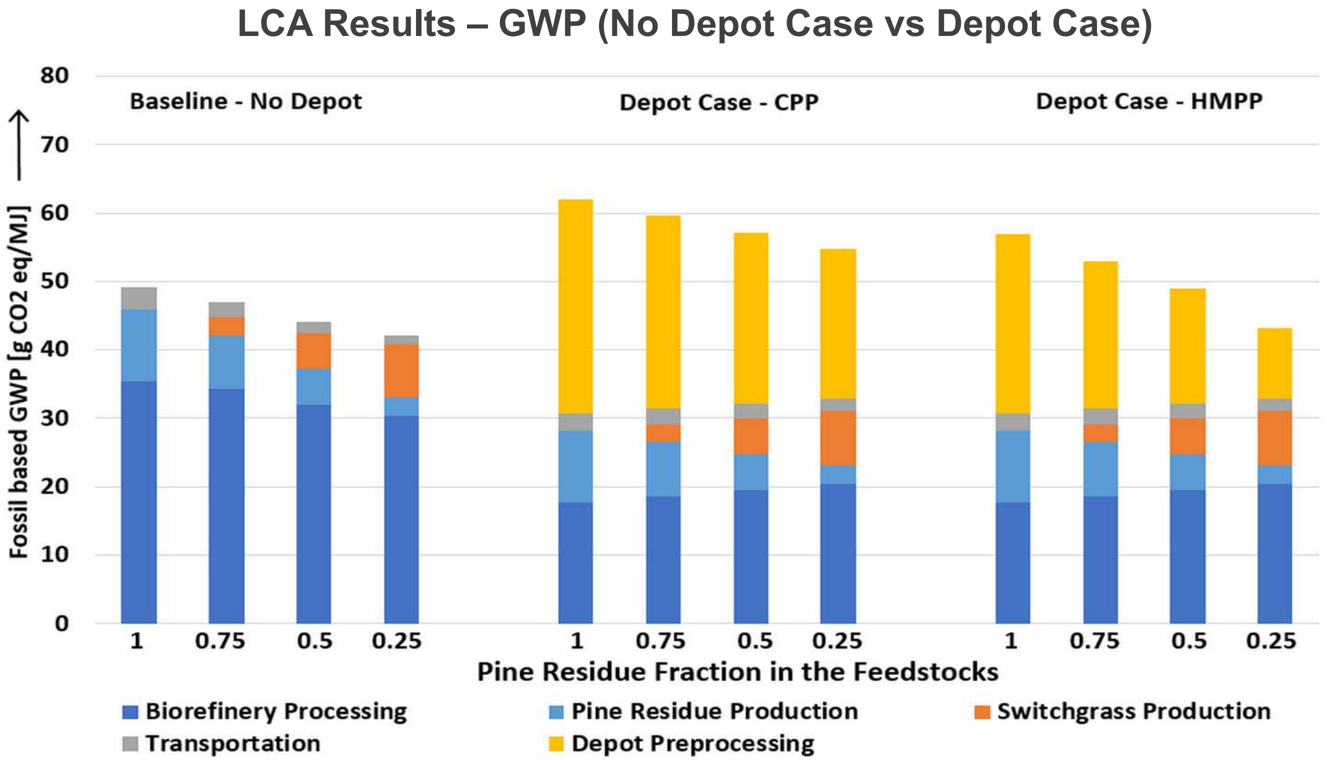
1. Successfully applied high-moisture pellet process to blends of different biomass.
2. Performance specifications were achieved for all formulations (SW/PR – 25 to 75%).
3. Energy consumption and pellet properties were enhanced at low to moderate switchgrass levels.
4. Bulk density was maximized at low SG additions due to particle structure.
5. **Extended pellet production & gasification campaign further validated pellet performance.**

Task 4 (All milestones met)

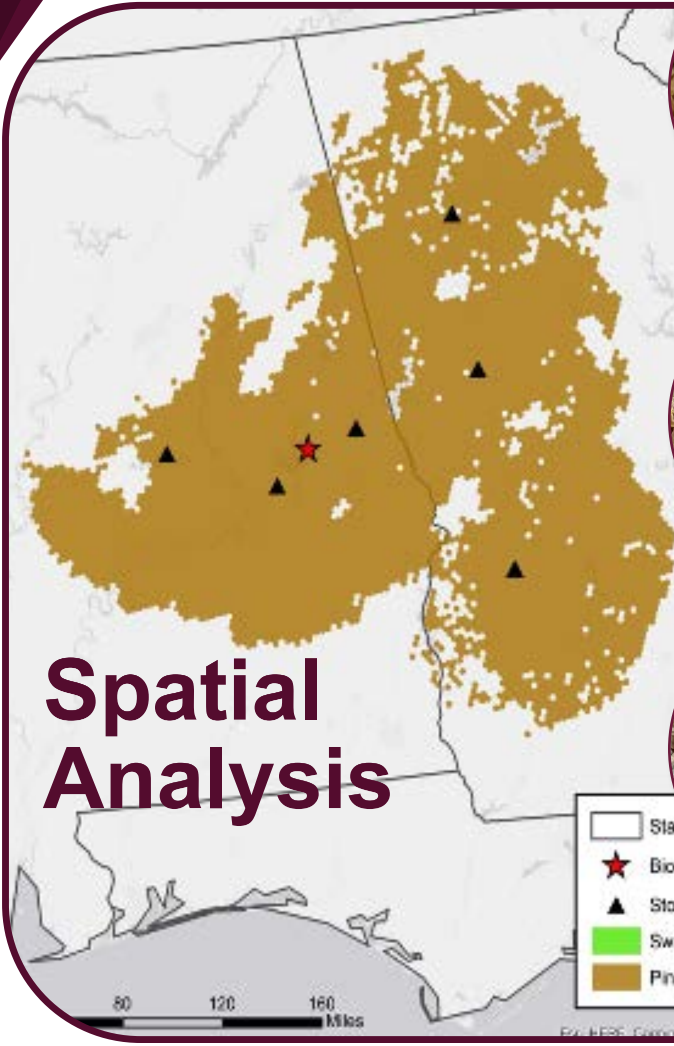
Examined both financial and life cycle issues for specific system attributes, including:

1. The effects of collection radius for differing biomass sources (e.g., tons/acre, and clean wood vs forest residues).
2. The effects of biomass MC and quality on product yield and quality.
3. The effects of variations in costs and GWP for different steps in the supply chain.
4. **Demonstrated the need to couple biorefinery size with biomass feedstock delivery for optimal economic and LCA impacts.**





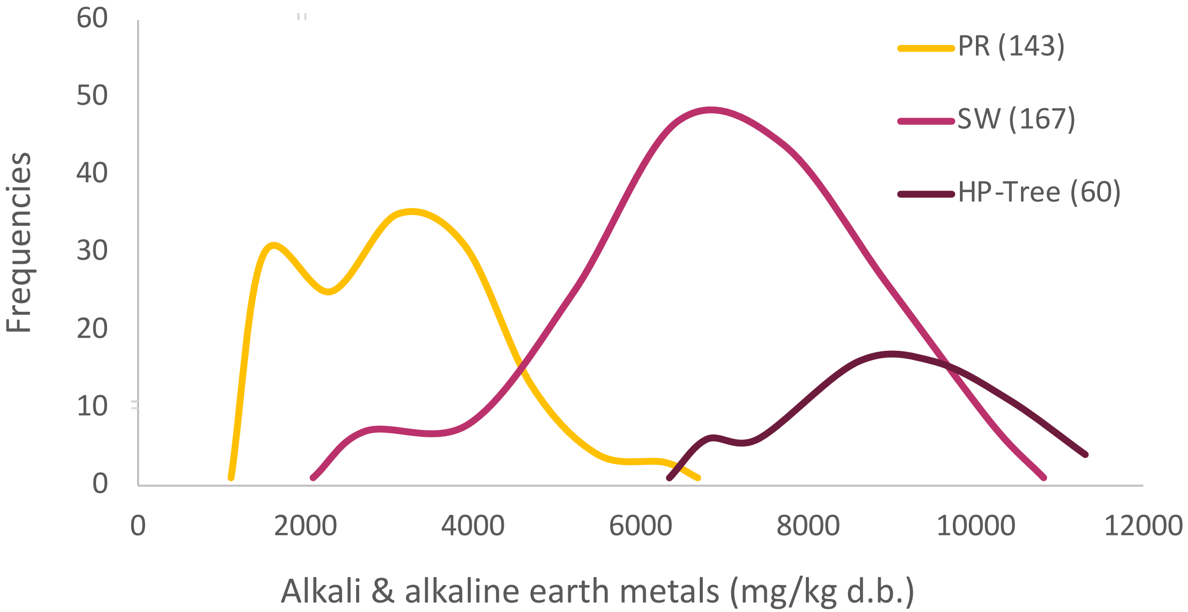
Progress and Outcomes

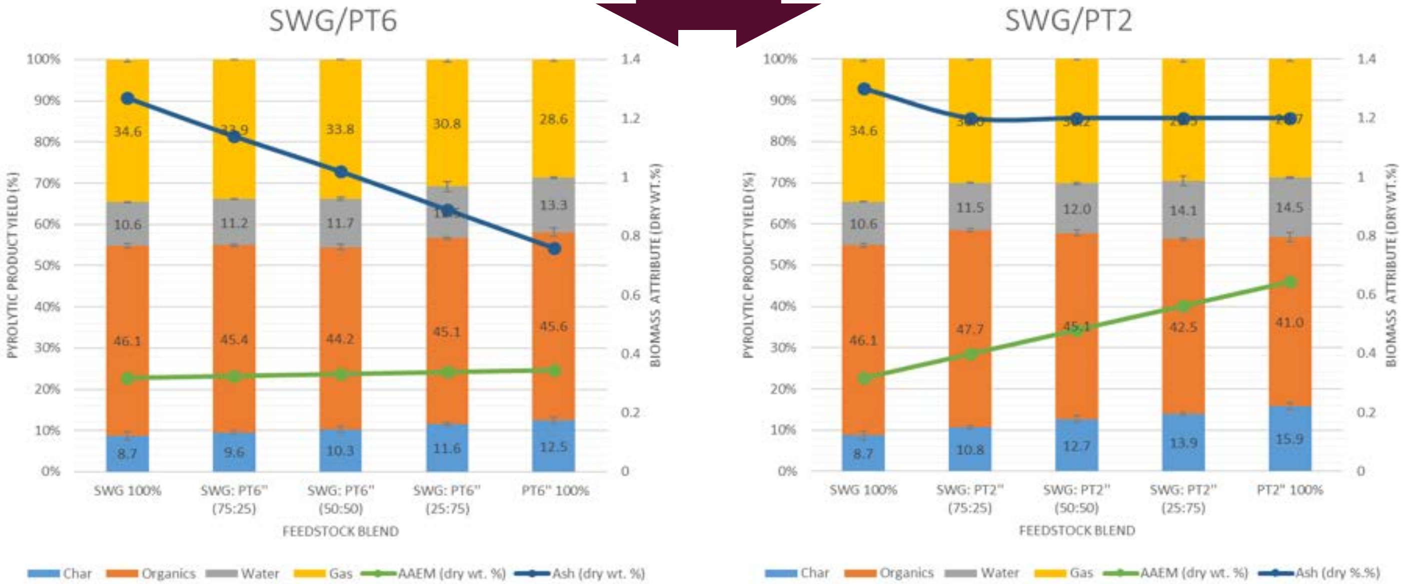


Pine Residue

Switchgrass

Hybrid Poplar





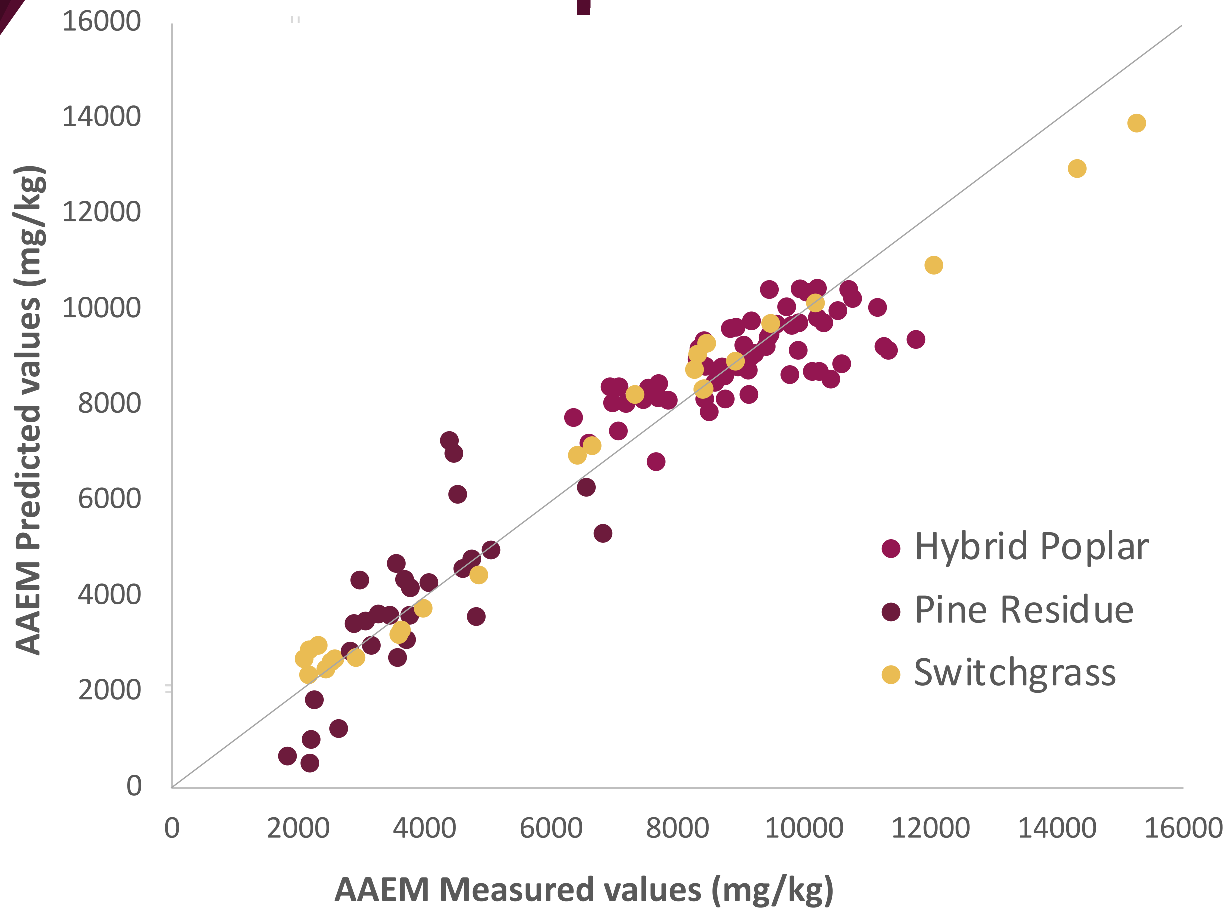
Progress and Outcomes Cont'd.

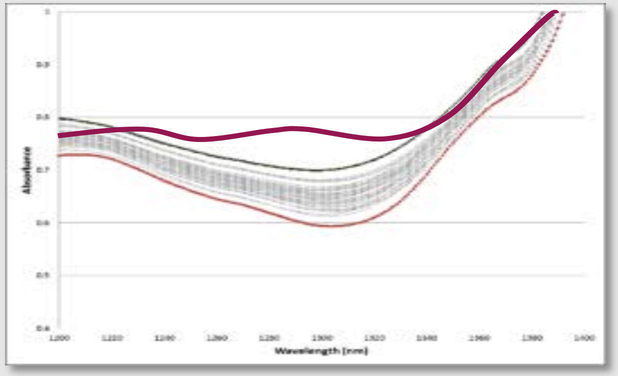
- Harvested ca. 2 tons of pine residue (2"- and 6" tops).
- Immediately transported to Idaho National Lab to prevent mold.
- Conditioned for storage until processed.
- Switchgrass processed & shipped earlier by Genera.

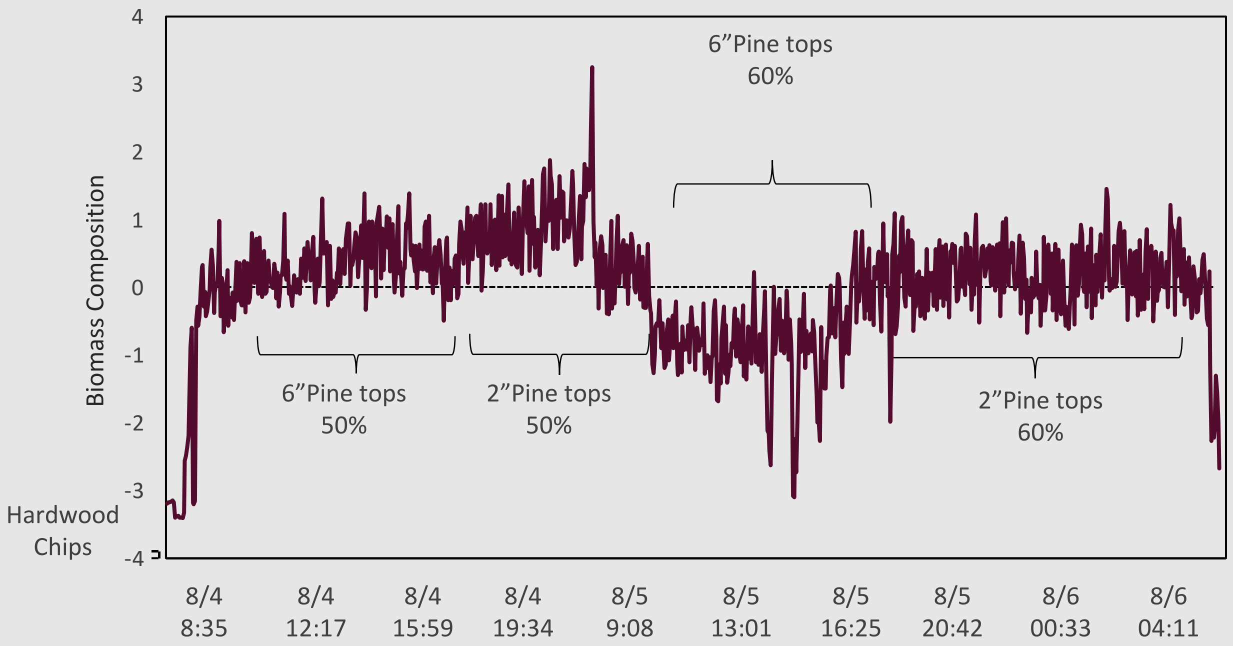
- Blends formulated with 2" and 6" tops at 40% and 60% weight composition pine/switchgrass.
- High-moisture process handled all sample conditions.
- Pellets shipped to AU for gasification (samples to UT for analysis).

- Extended gasification campaign conducted at AU.
- Spectra collected on-line with at-line sampling.
- Process sensors & syngas composition monitored.
- Data analysis is nearly complete…results are encouraging.

PROGRESS AND OUTCOMES CONT'D.







Summary

1. Merchandizing field trials showed that the approach encouraged production of saw logs rather than pulpwood, resulting in a higher value product suite, and greater biomass residue supply.
2. The blending depot (pine residue/switchgrass) allows for 8 additional biorefineries (2,000 MT/Day; 90% operating efficiency), increasing annual regional fuel production by 400B gallons; however, feedstock cost increases by $6/ton (not including pelleting).
3. The demonstrated on-line monitoring of biomass properties with NIR sensors introduces the ability to deliver consistent feedstock quality, and the added benefit of gaining unique insight to conversion efficiency.
4. The added cost of feedstock consistency afforded by depot blending is anticipated to be offset by downstream process efficiencies, including reduced downtime and handling challenges.
5. Given the complex nature of biomass feedstock (e.g., ash, carbon, moisture, density, etc.), and the complex systems in a TC biorefinery (e.g., capital costs, scale, heat integration and materials handling), optimizing either system alone will likely result in a suboptimal outcome.

Quad Chart Overview

Timeline
- Project Start Date: 2/1/2016
- Project End Date: 1/31/2021

	FY20 Costed	Total Award
DOE Funding	$573,294.14	$4,000,000
Project Cost Share	$490,893.65	$2,626,750

Project Partners
University of Tennessee, Auburn University, Genera Energy, Inc., Idaho National Laboratory, John Deere, North Carolina State University, Oak Ridge National Laboratory, PerkinElmer, Inc., Proton Power, Inc.

Project Goal
Deliver high-quality feedstock blended from different biomass sources in the Southeast.

End of Project Milestone
Refine the depot system that receives both woody biomass and switchgrass through separate supply lines, then processes these biomass sources, and, where appropriate, produces blends of feedstocks engineered to meet specifications for specific biorefineries.

Funding Mechanism
FOA Number: DE-FOA-0000836

Advanced Biomass Feedstock Logistics Systems II

Issue Date: January 25, 2013

THANK YOU

UT AgRESEARCH
INSTITUTE OF AGRICULTURE
THE UNIVERSITY OF TENNESSEE

HERTY
Advanced Materials Development Center
GEORGIA SOUTHERN UNIVERSITY

OAK RIDGE
National Laboratory

AUBURN
UNIVERSITY

GENERA ENERGY®

Perten
INSTRUMENTS
a PerkinElmer company

INL
Idaho National Laboratory

PerkinElmer®
For the Better

PPI

IndusTREE

NC STATE UNIVERSITY

JOHN DEERE

ADDITIONAL SLIDES

Responses to 2019 Reviewers Comments

Criterion 1: Approach (25%)

Comment: A major barrier mentioned was on of feedstock availability and cost but didn't' see where this was addressed in the work. I did not see where the cost of the raw biomass was accounted for in the presentation or it was at all.
Response: We have built a simulation model of a logging `system' at scale to evaluate costs of the consolidation depot concept. The system was composed of 9 individual logging operations hauling to 12 consumption points. Each operation was assumed to consist of felling, skidding, loading, and hauling operations, plus any modifications to implement the type of residue collection done. The systems modeled were of three types:

- A `base' system in which no residues were collected. Tree-length products only were hauled to destinations.
- The base system plus residue collection. Limbs and tops were chipped, and a fixed number of additional trucks were assigned to an operation for hauling residues to a single consumption point.
- The logging operations collected and loaded whole trees that were hauled to a single collection center where processing into log and pulpwood products, plus residue chips, occurred.

The base system was modeled as a calibration step. For each logging operation, a simulated stand model was generated, and its parameters varied until output from the crew matched, on average, haul data provided by a partner. Once calibrated, the two residue-producing models were evaluated using the same stand conditions. In the case of in-woods chipping operations, products were hauled to the same locations as the base model. Results showed simulated costs for residues using in-woods chipping averaged $23.75 at the delivery point. For the depot model, the cost was $19.60 to the same location. We have not completed the analysis of impacts on other wood costs due to the extra handling required at the depot. Further work is also being done to ensure consistency in simulation model structure to achieve greater confidence in comparisons between the systems.

Criterion 2: Accomplishments / Progress (25%)

Comment: The cost reductions of high moisture pelleting are clear, but the qualitative downside of these pellets is not mentioned in relation of the thermochemical green diesel process associated with this project.
Response: In our techno-economic model, we assume no change in the physical properties of feedstocks during pelletization, except moisture content and size. This assumption is supported by the experimental results performed at INL (not presented at the Review due to the time limit). It is noted that the quality of the feedstocks (i.e., carbon content, ash content, and moisture content) can be enhanced with the blending of feedstocks, which also improves the logistic stability. Hence, no disadvantage in feedstock quality is observed by employing pelletization.

For the second question, our process model fully considers the feedstock properties (i.e., carbon content, ash content, and moisture content) and different variable combinations lead to different yields of the final hydrocarbons. Hence, changing the blend ratios does alter the feedstock quality, then change the hydrocarbon yields, and finally vary the selling price, which has been considered in the simulation model. Changing the preprocessing pathways and biorefinery size do not change the feedstock quality.

RESPONSES TO 2019 REVIEWERS COMMENTS

Criterion 3: Relevance (25%)

<u>Comment</u>: It appears that a full operating depot, with a full compliment of moving equipment interactions to model, was not tested. However, the pieces of the project address many of the needs of a fully operating depot.
<u>Response</u>: The project budget was reduced significantly from the original request, eliminating complete depot testing. We are confident that independent assessments of unit operations will provide the necessary data for evaluation of the project's impact.

Criterion 4: Future Work (25%)

<u>Comment</u>: There is no detail around these final phases of the project as well as no timeline of any potential issues identified.
<u>Response</u>: Primarily a reflection of time limitations, the timeline for the remaining work is in place and on track. The biggest issue is simply potential delays in paperwork associated with the budget adjustment.

Go/No-Go Review Highlight (Sept. 2016)

Comment: The reviewers offered thoughtful and constructive comments for for each of the Go/No-go decision criteria. Reviewers were unanimous in their opinion regarding the "Go" decision for criteria #1 through #7 (i.e., Tasks 1 and 2):

1. Completed design for prototype log trailer for transporting full trees
2. Completed economic analyses to document costs associated with re-purposing & multiple handling of wood residues for other markets
3. Appropriate detection technology platform to provide high quality, accurate characterization of biomass feedstocks selected (the quality of the NIR sensor models (R2> 0.65))
4. Retrieved and integrated biorefinery existing data (air velocity, pressure, etc.) into statistical process control system
5. Completed initial process analysis, defining major sources of variation
6. Robust NIR models to predict biomass quality metrics from laboratory studies made available for process studies
7. Spectral sensor installed in merchandizing depot to monitor biomass

Their opinions were split between "Go" and "Not sure" from criteria 8 and 9. Below are the criteria that the reviewers regarded as the weakest segments of the review:

8. Switchgrass/pine blends prepared and characterized to meet target specifications, and to establish protocols to reduce variability.
9. Please comment on plans, as presented, for LCA. *[This is not a Go/No-go decision criterion.]*

For criterion 8 (Task 3), the main criticism was that reviewers were not able to understand what constitutes "success" for this criterion. Additionally, the goal was not very clearly defined. Nor was it clear how many blends would be explored during this work, or why. What are the desired target specifications for these blends? The strategy for creating blends that reduce variation in the physical and chemical characteristics of the feedstock entering a biorefinery was not convincingly presented. When adding the need for a dynamic capability for producing such blends in a biorefinery environment, this goal becomes even more unclear (though outside the scope of this project).

Criterion 9 (Task 4) was not used as a Go/No-go criterion, but some useful comments were provided by the reviewers: The project team appears very strong, the work is clearly important, and the preliminary work presented seems very encouraging. However, there were signs of inadequate communication and cooperation among all the partners, and the importance of this should be re-emphasized to the project leader in writing, even though it was communicated to him in the closing discussion. Another issue that was raised in the final discussion was a lack of distinction between what had been done in previous grant projects and what was being done in this new project. However, on additional review this is not as serious an issue as originally thought.

Comment: The comments regarding criterion 10 (*overall impressions of progress toward overall project goals and objectives, as you understand them*) were also not used for the Go/No-go decision. However, there were issues around communication among the project participants. It seemed clear that at least some of the project participants were not very well connected to the rest of the project activities, even within the same task. In response, we've been working to improve this issue by 1) Introducing an additional monthly web discussion, 2) Additional "specific issue" teleconferences, and 3) Face to face conversations were scheduled to more tightly integrate the team.

Publications, Presentations, Awards

Refereed Proceedings and Papers:

- Pan, P; McDonald, T; Fulton, J; Via, B; Hung, J. 2017. Simultaneous moisture content and mass flow measurements in wood chip flows using coupled dielectric and impact sensors. *Sensors*. doi:10.3390/s17010020.
- Daniel, M.J., T. Gallagher, T. McDonald, D. Mitchell, and B. Via. 2018. Differences in Total Stem Value when Merchandizing with a Tracked Processor Versus a Knuckle-boom Loader in Loblolly Pine. *Forest Res Eng Int J. 2(4):184-187. DOI:10.15406/freij.2018.02.00045.*
- Hess, J.R., A. Ray and T. Rials (Eds.). 2018. Advancements in Biomass Feedstock Preprocessing: Conversion Ready Feedstocks. Frontiers In Energy, Special Topic. (The special topic in this open-source journal compiles 23 original research articles.)
- Ou, L., H. Kim, S. Kelley, S. Park. 2018. Impacts of feedstock properties on the process economics of fast pyrolysis biorefineries. *Biofuels, Bioproducts and Biorefining.* 12(3): 442-452. https://doi.org/10.1002/bbb.1860.
- Young, T.M., O. Khaliukova, N. André, A. Petutschnigg, T.G. Rials, C.-H. Chen. 2019. Detecting special-cause variation 'events' from process data signatures using control bands. Journal of Applied Statistics. 46(16):3032-3043. https://doi.org/10.1080/02664763.2019.1622658.
- Edmunds C. W., E. A. Reyes Molina, N. André, C. Hamilton, S. Park, O. Fasina, S. Adhikari, S. S. Kelley, J. S. Tumuluru, T. G. Rials, N. Labbé. Blended feedstocks for thermochemical conversion: biomass characterization and bio-oil production from switchgrass-pine residue blends. Frontiers in Energy Research, Bioenergy and Biofuels. 2018, 6, 79, DOI: 10.3389/fenrg.2018.00079.
- Pengmin Pan, Timothy McDonald. 2019. Tree size estimation from a feller-buncher's cutting sound. Computers and Electronics in Agriculture. 159:50-58. DOI: 10.1016/j.compag.2019.02.021.
- Daniel, M.J., T. Gallagher, T. McDonald, D. Mitchell, and B. Via. 2019. Productivity and cost estimates for incorporating tracked processors into conventional loblolly pine harvesting regimes in the Southeastern United States, International Journal of Forest Engineering, DOI: 10.1080/14942119.2019.1611131.
- Metzner C., M. Platzer, T.M. Young, B. Bichescu, M.C. Barbu, and T.G. Rials. 2019. Accurately estimating and improving costs for the cellulosic biomass supply chain with Statistical Process Control and the Taguchi Loss Function. BioResources. 14(2): 2961-2976. doi:10.15376/biores.14.2.2961-2976.
- Edmunds C., C. Mukarakate, M. Xu, Y. Regmi, C. Hamilton, J. Schaidle, N. Labbé, S. Chmely. 2019. Vapor-phase stabilization of biomass pyrolysis vapors using mixed-metal oxide catalysts. doi.org/10.26434/chemrxiv.7447877.v2.
- Tumuluru, J.S. 2019. Pelleting of Pine and Switchgrass Blends: Effect of Process Variables and Blend Ratio on the Pellet Quality and Energy Consumption. *Energies. 12(7)*: 1198. https://doi.org/10.3390/en12071198.
- Daniel, M., T. Gallagher, D. Mitchell, T. McDonald, B. Via. 2019. Productivity and cost estimates for incorporating tracked processors into conventional loblolly pine harvesting regimes in the Southeastern United States. INTERNATIONAL JOURNAL OF FOREST ENGINEERING 30(2):155-162. DOI: 10.1080/14942119.2019.1611131.
- Young, T.M., O. Khaliukova, N. André, A. Petutschnigg, T.G. Rials, and C.-H. Chen. 2019. Detecting special-cause variation 'events' from process data signatures using control bands. Journal of Applied Statistics. Published online: 11 Jun 2019. https://doi.org/10.1080/02664763.2019.1622658.
- Young, T.M., P.K. Lebow, S. Lebow, and A, Taylor. 2020. Statistical process control as a method for improvement for the treated wood industries. Forest Products Journal. 70(2):165-177.
- Young, T.M., R.A. Breyer, T. Liles, A. Petutschnigg. 2020. Improving innovation from science using kernel tree methods as a precursor to designed experimentation. Applied Sciences. 10(10):3387. https://doi.org/10.3390/app10103387.

Publications, Presentations, Awards

Refereed Proceedings and Papers:

- Schraml R., K. Entacher, A. Petutschnigg, T. Young, A. Uhl. 2020. Matching score models for hyperspectral range analysis to improve wood log traceability by fingerprint methods. Mathematics. 8(7):1071 https://doi.org/10.3390/math8071071.
- Lan, K., Ou, L., Park, S., Kelley, S.S. and Yao, Y., 2019. Life Cycle Analysis of Decentralized Preprocessing Systems for Fast Pyrolysis Biorefineries with Blended Feedstocks in the Southeastern United States. *Energy Technology*. https://doi.org/10.1002/ente.201900850.
- Lan, K.; Ou, L.; Park, S.; Kelley, S. S.; English, B. C.; Yu, T. E.; Larson, J.; Yao, Y. Techno-Economic Analysis of Decentralized Preprocessing Systems for Fast Pyrolysis Biorefineries with Blended Feedstocks in the Southeastern United States. *Renewable and Sustainable Energy Reviews* 2020. Under review.
- Lan, K., Park, S., Kelley, S. S., English, B. C., Yu, T. E., Larson, J., & Yao, Y. 2020. Impacts of uncertain feedstock quality on the economic feasibility of fast pyrolysis biorefineries with blended feedstocks and decentralized preprocessing sites in the Southeastern United States. GCB Bioenergy. https://doi.org/10.1111/gcbb.12752.
- Sharma, B. P., Yu, E. T., English, B. C., Boyer, C. N., Larson, J. A. 2020. Impact of Government Subsidies on a Cellulosic Biofuel Sector with Diverse Risk Preferences toward Feedstock Uncertainty. Energy Policy. 146:111737. DOI: 10.1016/j.enpol.2020.111737.
- Hyungseok Nam, Shuang Wang, Sanjeev KC, Myung Won Seo, Sushil Adhikari, Rajdeep Shakya, Doyeon Lee, Saravanan R Shanmugam. 2020. Enriched hydrogen production over air and air-steam fluidized bed gasification in a bubbling fluidized bed reactor with CaO: Effects of biomass and bed material catalyst. *Energy Conversion and Management*. Vol. 225. pg. 113408.
- Young, T.M., R.A. Breyer, T. Liles, A. Petutschnigg. 2020. Improving innovation from science using kernel tree methods as a precursor to designed experimentation. Applied Sciences. 10(10):3387. https://doi.org/10.3390/app10103387.
- Schraml R., K. Entacher, A. Petutschnigg, T. Young, A. Uhl. 2020. Matching score models for hyperspectral range analysis to improve wood log traceability by fingerprint methods. Mathematics. 8(7):1071 https://doi.org/10.3390/math8071071.

Non-refereed Proceedings and Papers:

- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2016. Whole tree transportation system for timber processing depots. In Proceedings of Council on Forest Engineering annual meeting. Council on Forest Engineering. Morgantown, WV.
- T. McDonald, M. Smidt, J. Fulton. 2017. Big data in forestry. Presented at the 40th International Council on Forest Engineering meeting, 31 July - 2 August, 2017, Bangor, Maine. 5 pp. http://cofe.org/index.php/meetings/proceedings/153-2017-conference-proceedings
- Daniel, M.J., T. Gallagher, T. McDonald, D. Mitchell, and B. Via. (2018). Changing Times: How Technique & Technology Advancements Could Promote Woody Biomass Harvesting in the United States. In proceedings of Council of Forest Engineering (COFE) annual meeting.

Publications, Presentations, Awards

Presentations at Professional Meetings:

- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2016. Whole tree transportation system for timber processing depots. Council on Forest Engineering Annual Meeting, Vancouver, British Columbia, Quebec, Canada. September 19-22, 2016.
- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2016. Whole tree transportation system for timber processing depots. Short rotation woody crop conference. Ft. Pierce, FL, October 11-13.
- André, N., W. Edmunds, S. Jackson, N. Labbé, T. Young, and T. Rials. 2016. *Reducing the Cost of Consistent, High-Quality Feedstock from Biomass*. American Institute of Chemical Engineers Annual Meeting, San Francisco, CA; November 14-17.
- Ann K.; Ou, L.; Park, S.; Kelley, S. S.; English, B. C.; Yu, T. E.; Larson, J.; Yao, Y. Techno-Economic Analysis and Life Cycle Assessment of Decentralized Preprocessing System for Fast Pyrolysis Biorefineries with Blended Feedstocks in the Southeastern USA. AICHE meeting, Section 637d, Nov. 14, 2019.
- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2017. Whole tree transportation system for timber processing depots. Southeastern Society of American Foresters. Miramar Beach, FL, January 29-31.
- Rials, T.G. 2017. *Next Generation Logistics Systems for Delivering Optimal Biomass Feedstocks to Biorefining Industries in the Southeastern United States*. DOE-BETO Project Peer Review, March 6-9, Denver, CO.
- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2017. Whole tree transportation system for timber processing depots. Southern Region Council on Forest Engineering Meeting. Mobile, AL, March 7-9.
- Edmunds, C.W., N. André, T. Rials, N. Labbé. 2017. *Biomass formulation to control feedstock properties for thermochemical conversion*. Symposium on Biotechnology for Fuels and Chemicals. San Francisco, CA, May 1-4.
- Rials, T., N. Labbé, N. André, C. W. Edmunds. 2017. *Producing consistent, high-quality feedstock from mixed biomass sources*. Symposium on Biotechnology for Fuels and Chemicals. San Francisco, CA, May 1-4.
- Edmunds, C.W., C. Hamilton, T. Rials, N. Labbé. 2017. Thermochemical conversion of blended herbaceous and woody biomass feedstocks. American Institute of Chemical Engineers (AIChE) Annual Meeting. Minneapolis, MN, Oct. 29 – Nov. 3.
- Edmunds, C.W., C. Hamilton, T. Rials, N. Labbé. 2017. Investigating the impact of blended feedstocks on vapor-phase pyrolysis products and pyrolytic bio-oil properties. Materials Research Society (MRS) Meeting. Boston, MA, Nov. 26 – Dec. 1.
- Marissa "Jo" Daniel, Tom Gallagher, Timothy McDonald, Dana Mitchell, and Brian Via. 2018. *Tracked Processors & Centralized Logging Depots: The Potential Future for South-eastern Logging*. Council of Forest Engineering Conference Presentation, Williamsburg, VA, July 15-18.
- Marissa "Jo" Daniel, Tom Gallagher, Timothy McDonald, Dana Mitchell, and Brian Via. 2018. *Changing Times: Technique & Technology Advancements to Promote Woody Biomass Harvesting in the USA*. Council of Forest Engineering Conference Presentation, Williamsburg, VA, July 15-18.
- Sharma, B., T.E. Yu, B.C. English, C.N. Boyer, and J.A. Larson. 2018. *Stochastic Optimization of Cellulosic Biofuel Supply Chain under Feedstock Yield Uncertainty*. 10th International Conference on Applied Energy, Hong Kong, August 22-25.
- Tom Gallagher. 2018. *Hot Loading Versus Set-Out Trucking*. Southeastern Forest Engineering Conference Presentation, Auburn, AL, September 5.
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- Presented high moisture pelleting of pine and switchgrass blends in pilot-scale pellet mill in the American Society of Agricultural and Biological Engineers 2019 Annual International Meeting, July 07, 2019 - Wednesday, July 10, 2019, Boston Marriott Copley Place, 110 Huntington Ave, Boston, Massachusetts 02116.
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Website:

- https://arec.tennessee.edu/research/beag/leaf-project/southeast-analysis/