U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

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

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Goal Statement

- The project goal is to develop a state-of-the-art biomass merchandizing and processing system to identify and reduce sources of variation along the supply chain of multiple, high-impact biomass sources, and to develop practices that **manage biomass variability** to deliver a consistent feedstock optimized for performance in specific technology platforms.

- The conceptual framework of the project recognizes that:
  - 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.

Quad Chart Overview

Timeline

- Start date – 8/1/2015
- End date – 7/31/2018

	Total Planned Funding (FY 15-Project End Date)
DOE Funded	$4,000,000
Project Cost Share	$2,626,750

Barriers

- FT-A Feedstock availability & cost
- FT-E Feedstock Quality & Monitoring
- FT-G Biomass Material Properties & Variability
- FT-I Biomass Material Handling & Transportation
- Tt-C Relationship between Feedstock Composition & Conversion Process

Partners

- University of Tennessee
- Auburn University
- Genera Energy, Inc.
- Herty Adv. Mat. Dev. Center
- Idaho National Laboratory
- North Carolina State University
- Oak Ridge National Laboratory
- PerkinElmer, Inc.

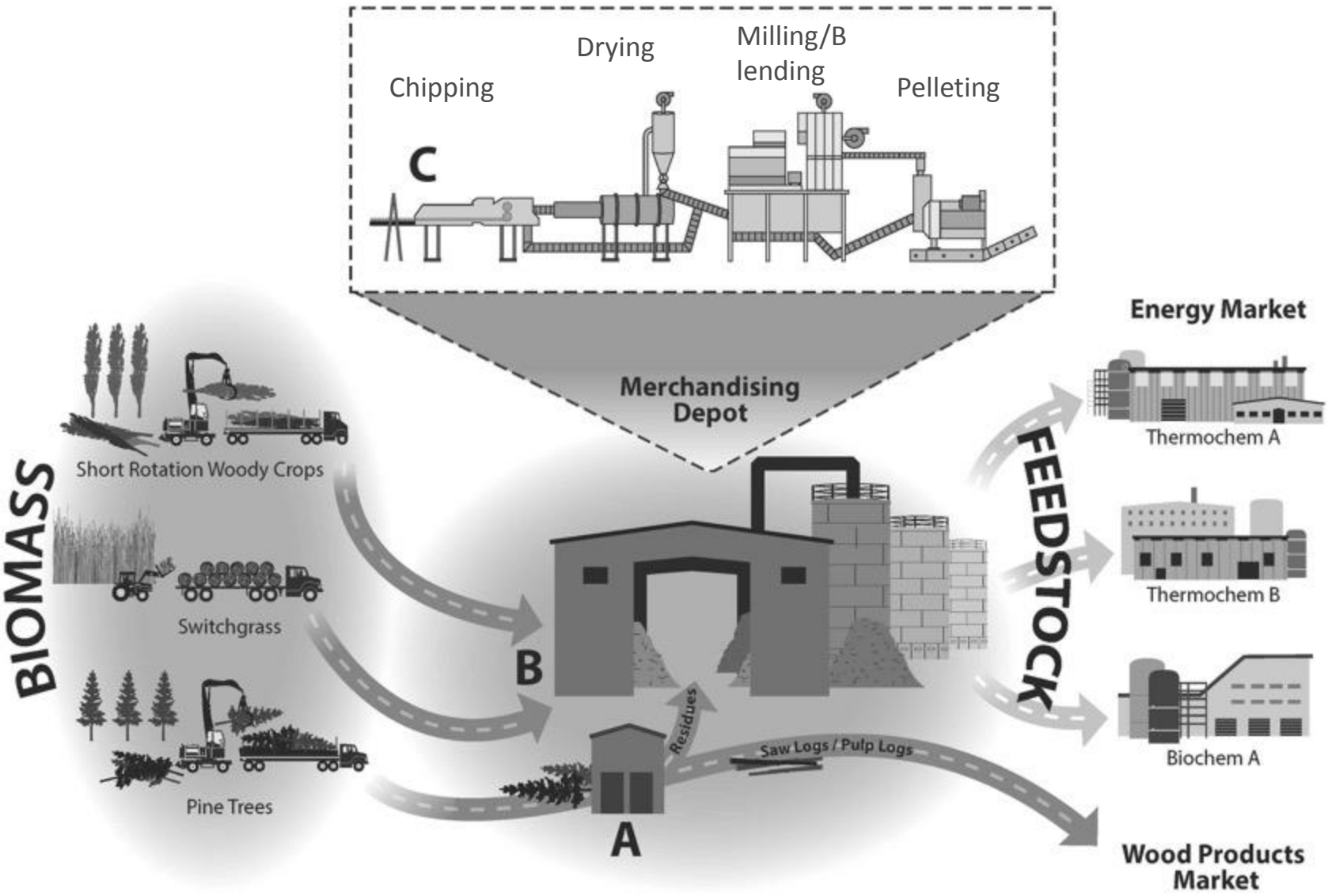
Building On Past Success

AU High Tonnage – Southern Pine

UT/GEI High Tonnage – Switchgrass

The "**Base Case**" for further work

Extended Merchandising

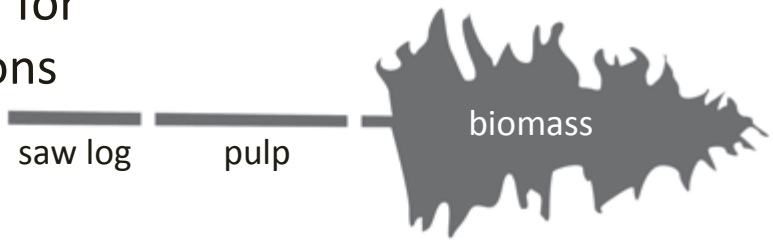


Project Objectives

- **Objective 1** – Demonstrate an integrated harvest, transport, and merchandizing system for maximizing value, quantity, and quality of biomass from southern pine forests.
- **Objective 2** – Introduce statistical process control methods that utilize biomass quality metrics obtained from novel, rugged spectroscopic sensor data to reduce feedstock cost, and improve quality.
- **Objective 3** – Explore the potential to formulate feedstock blends from diverse biomass inputs for improved processing performance at lower costs.
- **Objective 4** – 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.

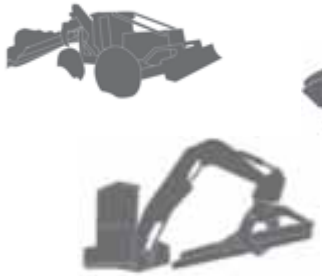
Extended Forest Products Merchandizing

Integrated Processing and Merchandizing System for thinning pine plantations



Full tree can be merchandized to provide optimal value/quality of saw log, pulp chips, and biomass quality by varying the bucking locations.

1st or 2nd forest thinning



Full tree transport

Integrated Processing and Merchandizing Operation (Depot)

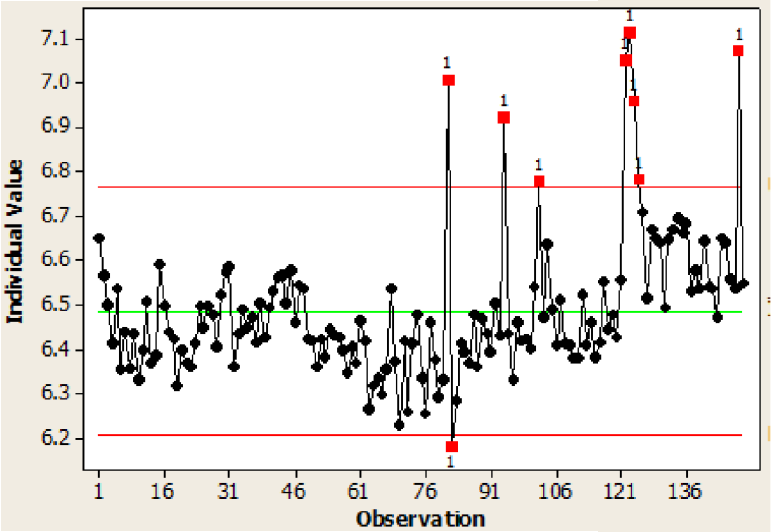
Biomass consumers

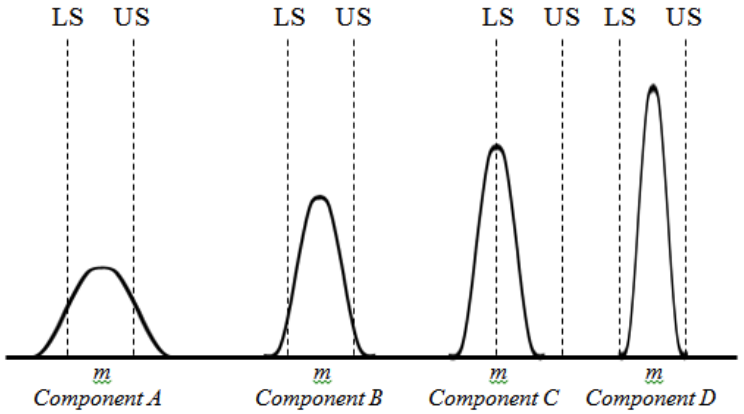
Sawmill

Pulp mill

Products optimized to meet market demands (cost and quality)
"Engineered Biomass" (Btu/lb, Ash, MC, P, K, etc.)
Saw logs
Pulp logs or clean chips

Statistical Process Control

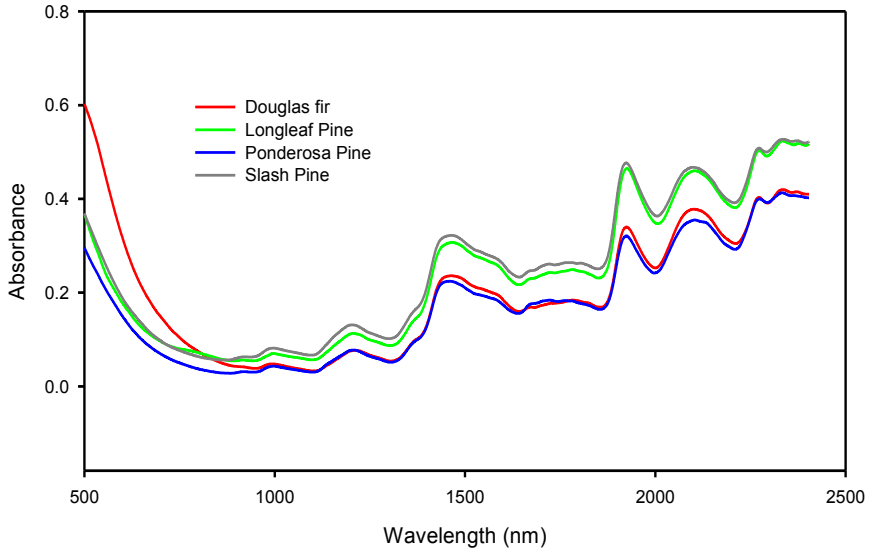


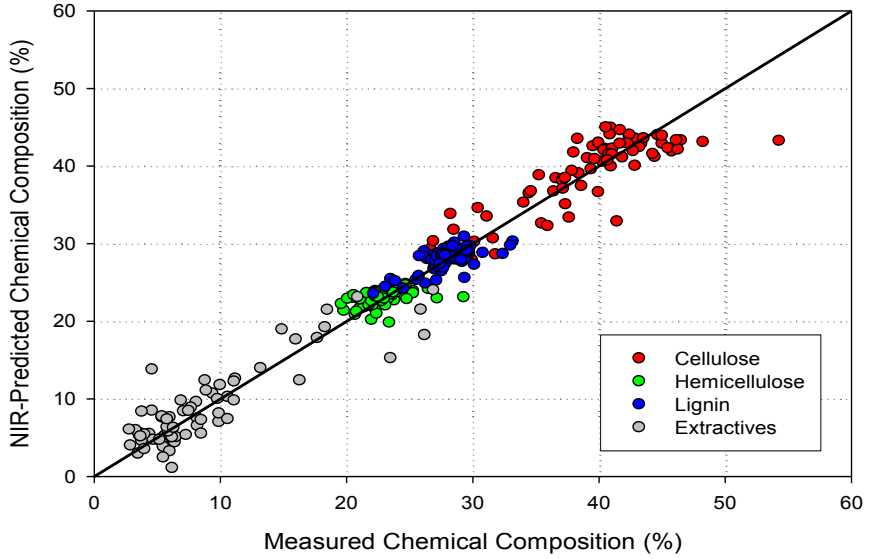


Cumulative variation from series logistics systems

- Quantifies 'natural variation' of system – initial framework for improvement
- Establishes a 'baseline of performance'
- Essential for determining capability of system
- Identify high variability components in the system
- Taguchi Loss Function applied to asses cost benefits arising from process refinements

Feedstock Quality Monitoring



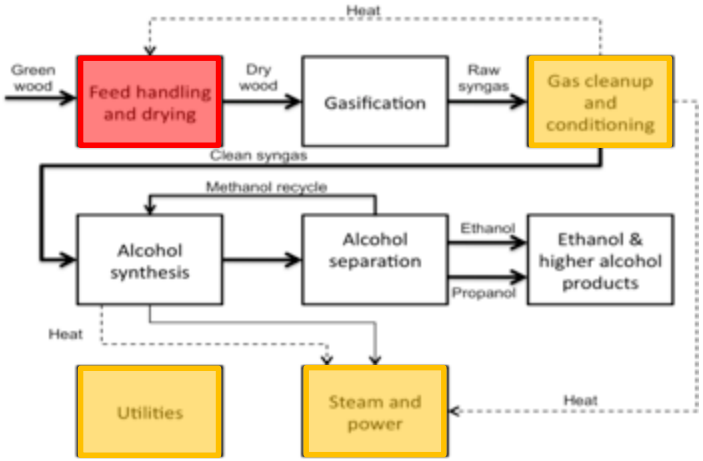


- Process monitoring relies on indirect metrics rather than the material being processed
- Harsh processing environment presents a challenge for spectroscopic sensors
- Industrial NIR will be built for on-line/at-line monitoring of key characteristics:
  - Ash content
  - Moisture content
  - Carbon content
- Information incorporated into SPC framework

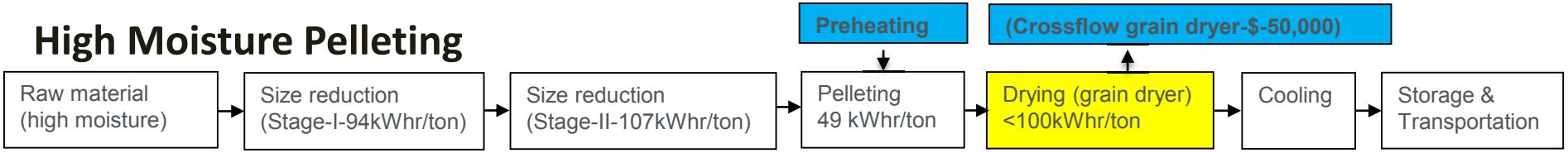
Feedstock Quality Improvement

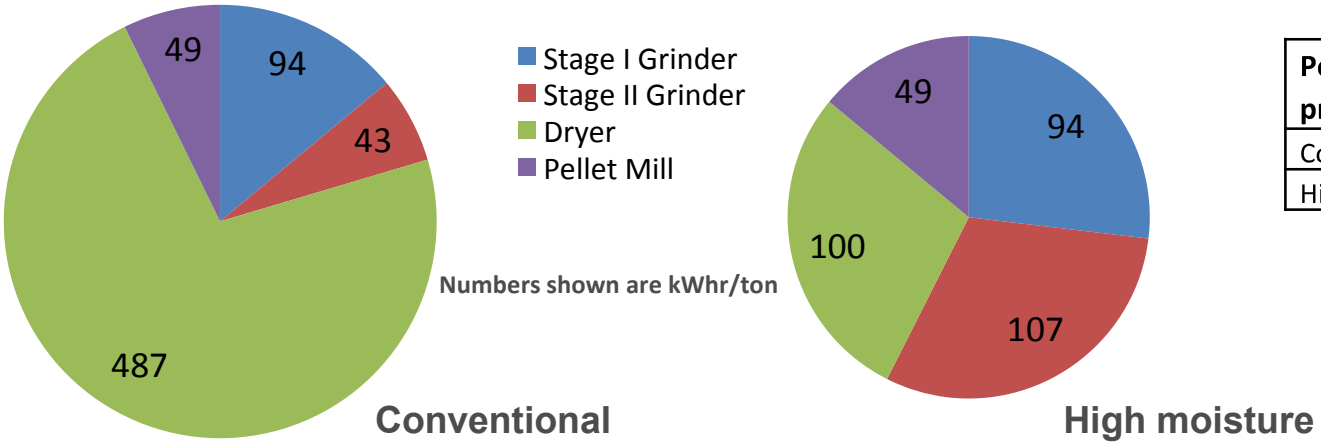
Inorganics Reduction

- Ash content and composition impacts process efficiency and cost, regardless of conversion platform
- Counter current washing or screw-presses will be evaluated



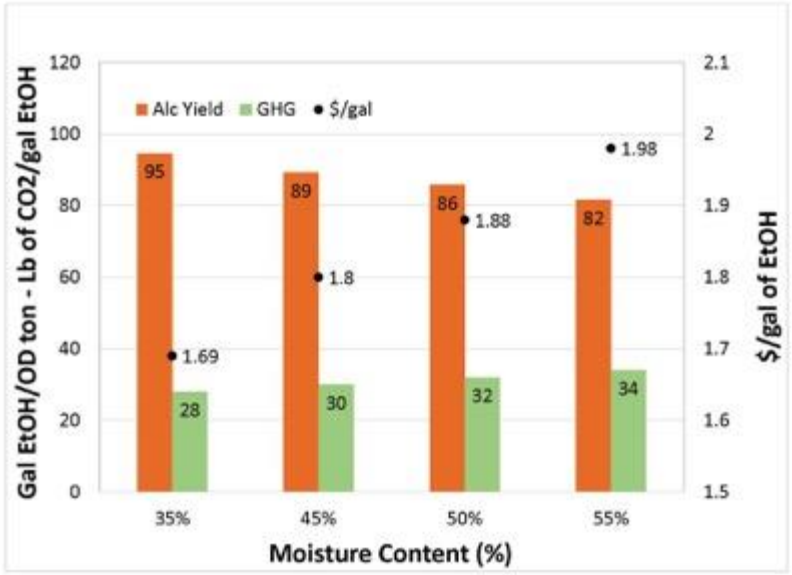
High Moisture Pelleting

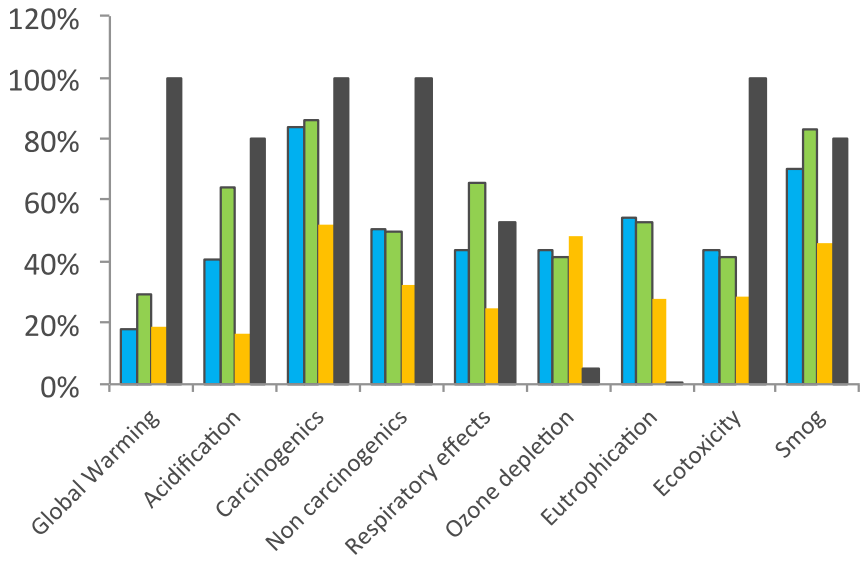




Pelletization process	Total energy (kWhr/ton)
Conventional	672
High moisture	350

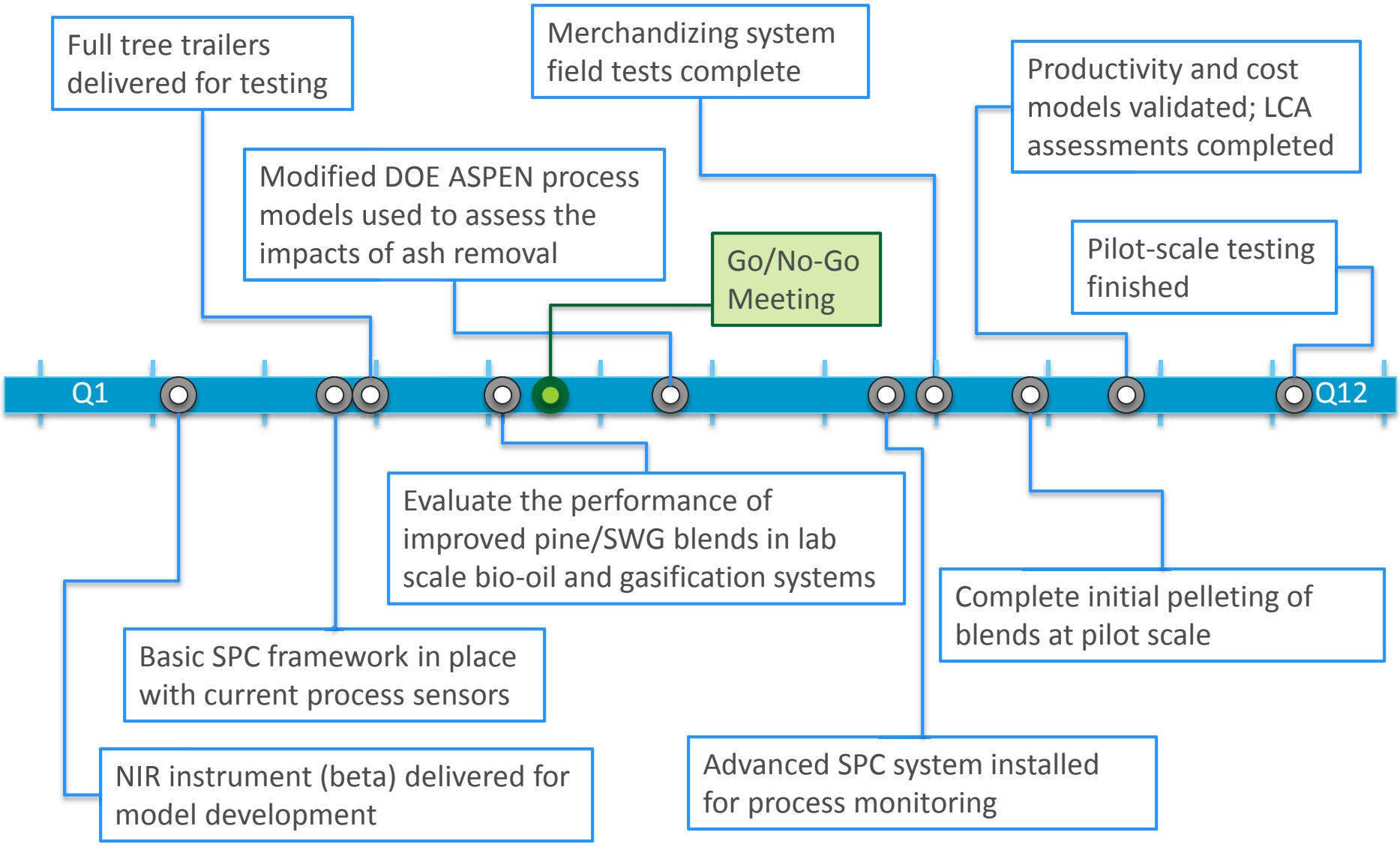
Compositionally-Sensitive Process Models





- Project targeting thermochem-ical platform (pyrolysis and gasification)
- DOE model updated to include compositional effects
- Process modeling to address:
  - Impact of feedstock and process on financials
  - Impact of feedstock and process on lifecycle burden
- Experimental validation will emphasize pyrolysis oil specs established by DOE

Key Project Milestones



Project Relevance

The strategic goal of Feedstock Supply and Logistics (FSL) is to develop technologies to provide a sustainable, secure, reliable, and affordable biomass feedstock supply for the U.S. bioenergy industry.

- The team will demonstrate a large-scale, integrated system for recovering an underutilized resource from harvest of mature pine stands and developing switchgrass production areas in the Southeastern U.S.
- This proposed feedstock system has the potential, through blending of biomass sources to produce engineered bioenergy feedstocks, to:
  1. Reduce the overall cost of the feedstock by removing inefficiencies in the biomass distribution system (≤ $80/dry ton);
  2. Improve the quality of the biomass feedstocks by sensing and SPC techniques during processing to reduce the variability in physical and chemical properties; and
  3. Improving the profitability of the biorefineries by demonstrating the utility of blending various biomass sources to produce a least-cost biomass feedstock blend.
- This least-cost biomass blend concept can allow biorefineries to procure larger volumes of biomass, thereby allowing larger scale, and more economically feasible biorefineries to be constructed and operated.

Potential Challenges

- Achieving full payloads when transporting full trees to processing facilities
- Meeting expected cost reductions in centralized processing and merchandizing system without constructing full-scale facilities
- Achieving the target spectral quality (Signal/Noise ratio > 100,000:1) for diverse biomass samples in the process environment
- Meeting NIR model quality (R^2> 0.65) for online deployment:
- Obtaining sufficiently wide range of biomass characteristics for robust model development

Summary

- **Cost:** The envisioned harvest, transport and centralized biomass merchandizing and processing system should be capable of delivering biomass at, or below, cost targets achieved in the previous High Tonnage projects. Those total system costs were found to be about $64 per green ton of biomass.
- **Quality:** We intend to meet processor specifications through formulated blends enabled by online sensing equipment and statistical process control techniques. We also intend to decrease culls of deliveries to roundwood mills by over 50%.
- **Quantity:** The primary factor relating merchandizing system performance with its ability to deliver commercially viable quantities of low-cost, high-quality biomass feedstocks will be the utilization of relatively expensive equipment working at the depot.

Questions