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




2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
BIOENERGY TECHNOLOGIES OFFICE

Feedstock Supply & Logistics

March 4, 2019

Alison Goss Eng
Program Manager

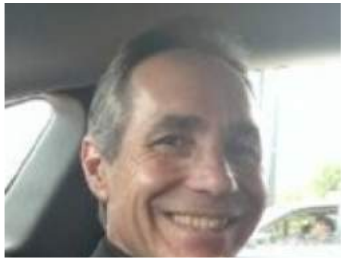
Program Overview

- The Team
- Goals & Approaches
- Challenges & Barriers
- R&D Strategy
- Budget
- Key Accomplishments
- 2017 Peer Review Response
- Future Directions
- Reviewers

The Team

Alison Goss Eng,
Program Manager

Mark Elless
Technology Manager



Art Wiselogel,
AST Project Monitor

Chenlin Li
M&O Contractor, INL

Luke Williams
M&O Contractor, INL

Andrew Kobusch,
AST Project Monitor

Owen Goldstrom, The
Building People

Shaina Aguilar, ORISE
Fellow

Bioenergy Technologies Office's Critical Program Areas

Production & Harvesting

Feedstock Supply
Develops technologies to cost-effectively transform renewable carbon sources into high-quality, sustainable, and energy-dense feedstocks.

Advanced Algal Systems
Focuses on improving the productivity of algal biomass and enhancing the efficiency of cultivation and harvesting.

Conversion & Refining

Conversion
Develops technologies to convert non-food feedstocks into biofuels, bioproducts, and biopower.

Conducts feedstock blend testing, separations, materials compatibility evaluations, and techno-economic analyses to focus research on highest impacts.

Distribution & End Use

Advanced Development and Optimization
Aims to reduce technology uncertainty in bioenergy by integrating individual technologies into a system/process and provides vital knowledge fed back to research programs.

Crosscutting

Sustainability and Strategic Analysis
Supports program decision-making and develops science-based strategies to understand and enhance the economic and environmental benefits of advanced bioenergy.

Feedstock Supply & Logistics (FSL)

Strategic Goal: *Develop science-based strategies and technologies to **cost-effectively** transform renewable carbon sources into **high-quality**, **sustainable**, and **energy-dense** feedstocks for biofuels, bioproducts, and biopower.*

Approaches:

- Defining requirements and specifications for high-quality, conversion-ready intermediates
- Developing fundamental understanding of the interactions between feedstock properties and conversion performance
- Identifying the key feedstock quality and performance factors affecting biorefineries
- Improving the efficiency of feedstock logistics operations

Cost-effective, high-quality, sustainable, and energy-dense feedstocks

FSL Major Goals FY 2019–FY 2030

By 2019, identify the key feedstock quality and operation factors to achieve a modeled operational reliability of 45% for advanced feedstock-conversion systems that can sustainably supply corn stover and pine residues at a modeled delivered feedstock cost of $86/dry ton.

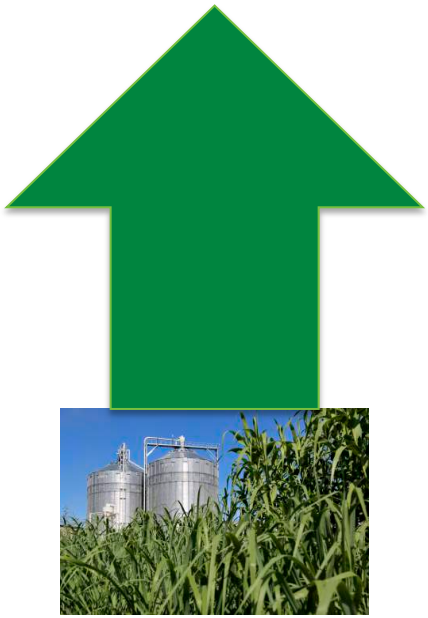
By 2020, identify key feedstock quality and operation factors to achieve a modeled operational reliability of 65% for advanced feedstock-conversion systems that can sustainably supply corn stover and pine residues at a modeled delivered feedstock cost of $86/dry ton.

By 2022, identify, characterize, and understand sources of variability in feedstock quality and energy content of renewable carbon feedstocks. Develop feedstock systems for these streams to deliver conversion-ready feedstock in support of the $86/dry ton goal.

By 2030, develop science-based strategies and technologies to cost-effectively transform renewable carbon sources into high-quality, sustainable, and energy-dense conversion-ready feedstocks at $71/dry ton.




Focus Areas



Improve the Quality and Quantity of Renewable Carbon Feedstocks

Reduce Cost of Renewable Carbon Feedstocks

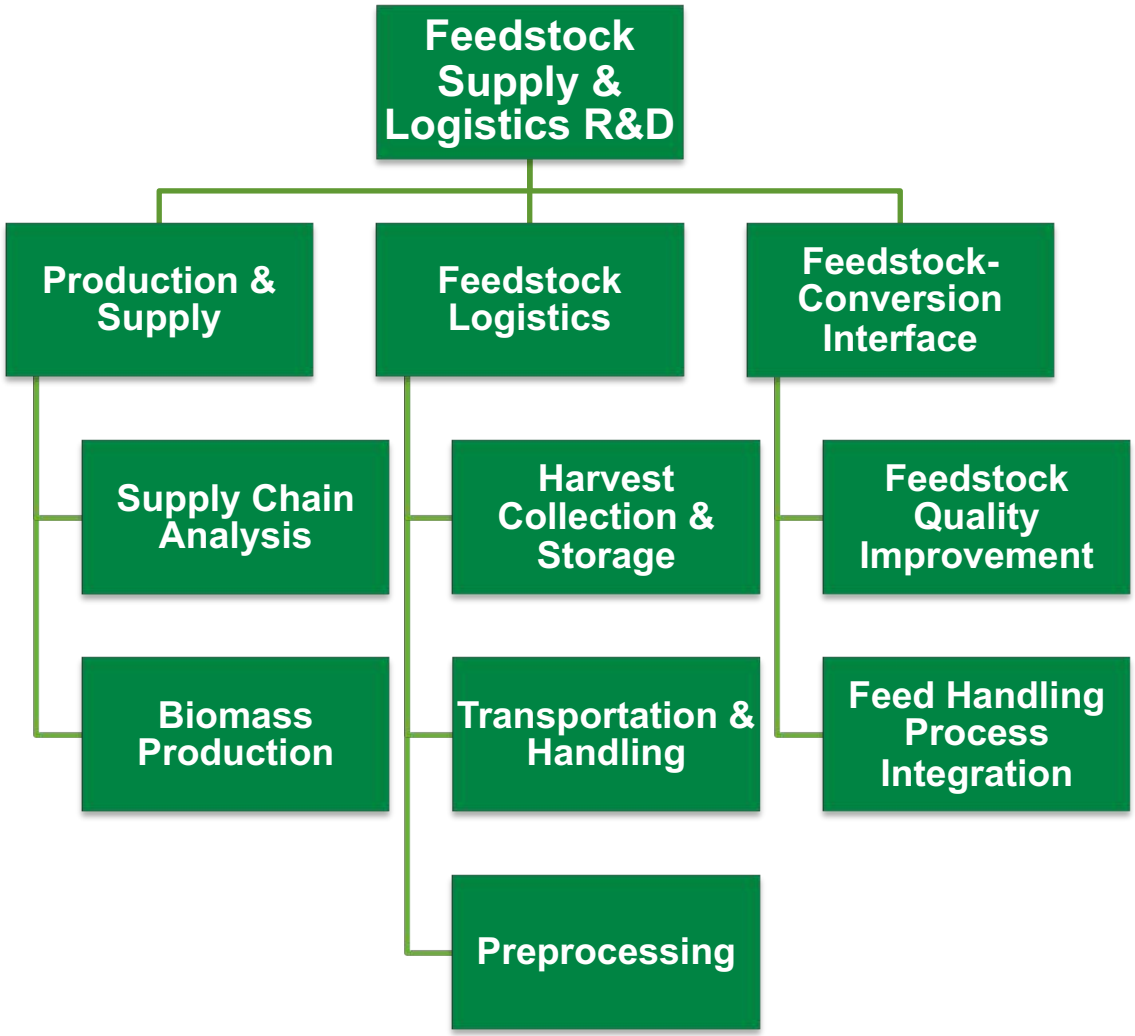
Strategies focus on improving the ***efficiency*** and ***reliability*** of harvesting/collection, storage, preprocessing, and transportation.

Key Challenges and Barriers

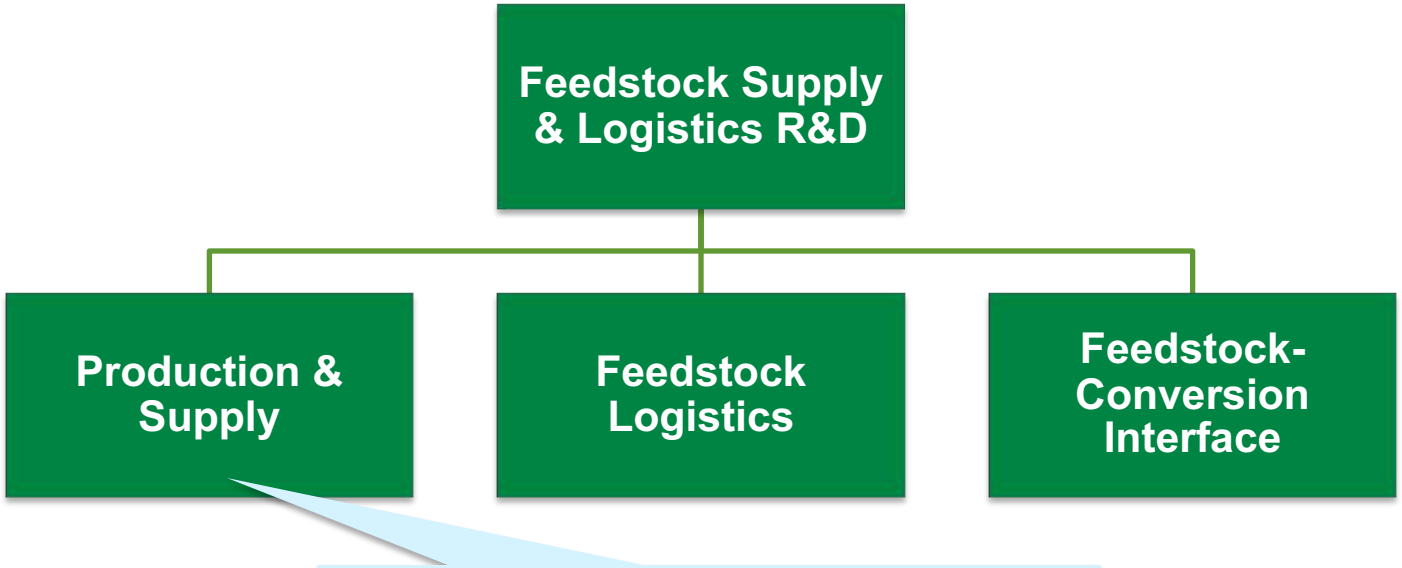
Overcoming challenges and barriers are crucial to reaching program goals.

- Feedstock Availability and Cost
- Production
- Feedstock Genetics and Variety Improvement
- Sustainable Harvesting
- Feedstock Quality
- Biomass Storage Systems
- Biomass Physical State Alteration
- Material Handling and Transportation
- Feedstock Supply System Integration & Infrastructure
- Operational Reliability

Current Work Breakdown Structure



R&D Strategy



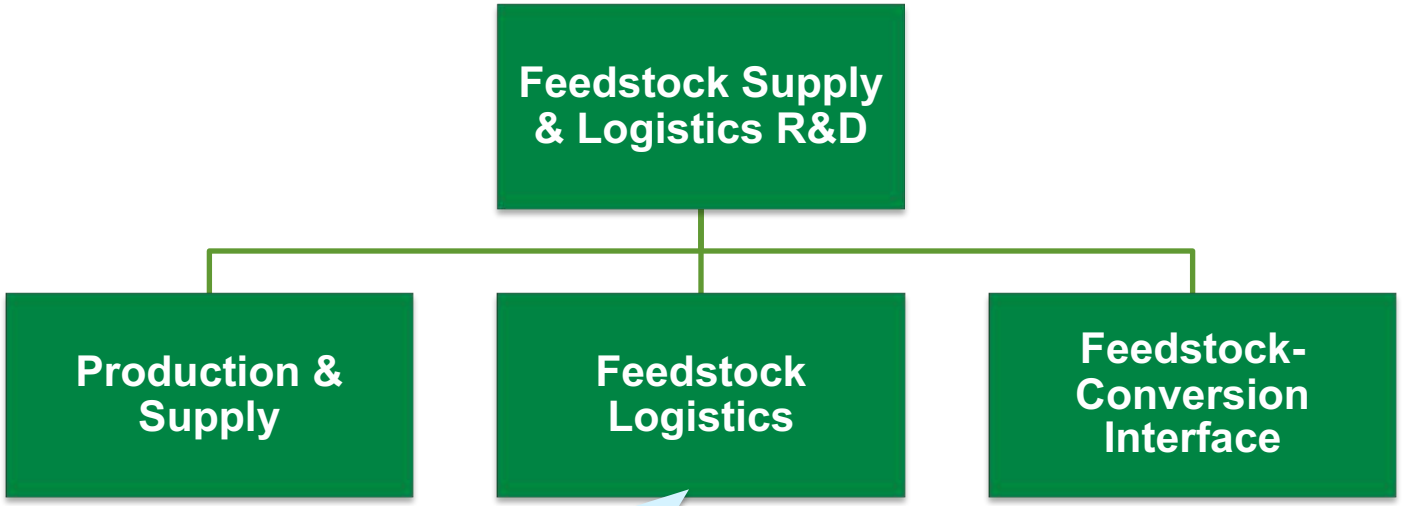
"Standing-in-the field" to Harvest

Focus:
- Yield mapping
- Supply Curves

OAK RIDGE National Laboratory

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

R&D Strategy



Harvest to Conversion

Focus:

- Harvest/Handling
- Collection
- Storage
- Transport
- Preprocessing

Idaho National Laboratory

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

R&D Strategy

Feedstock Supply & Logistics R&D

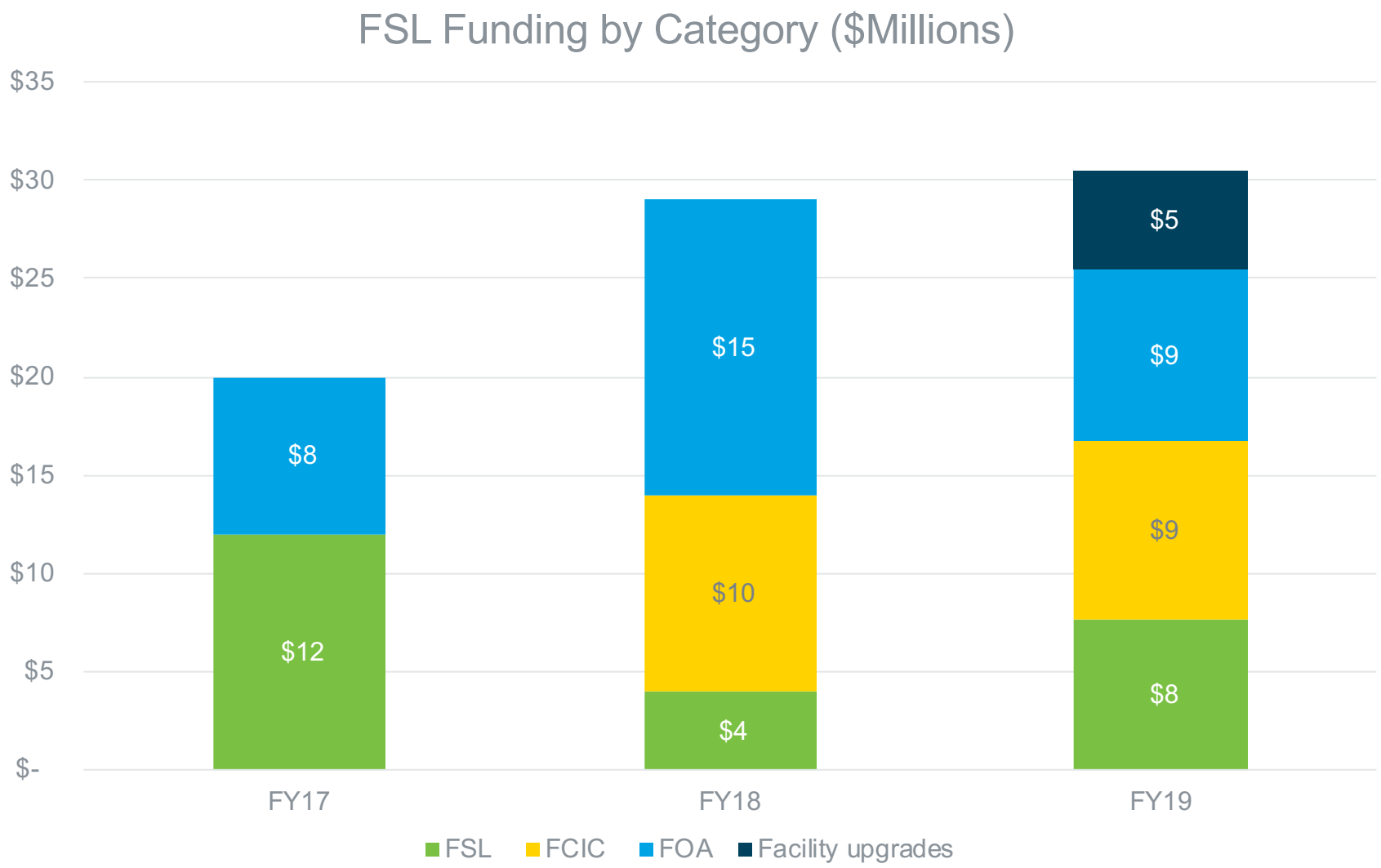
- **Production & Supply**
- **Feedstock Logistics**
- **Feedstock-Conversion Interface**

Feedstock Conversion Interface Consortium

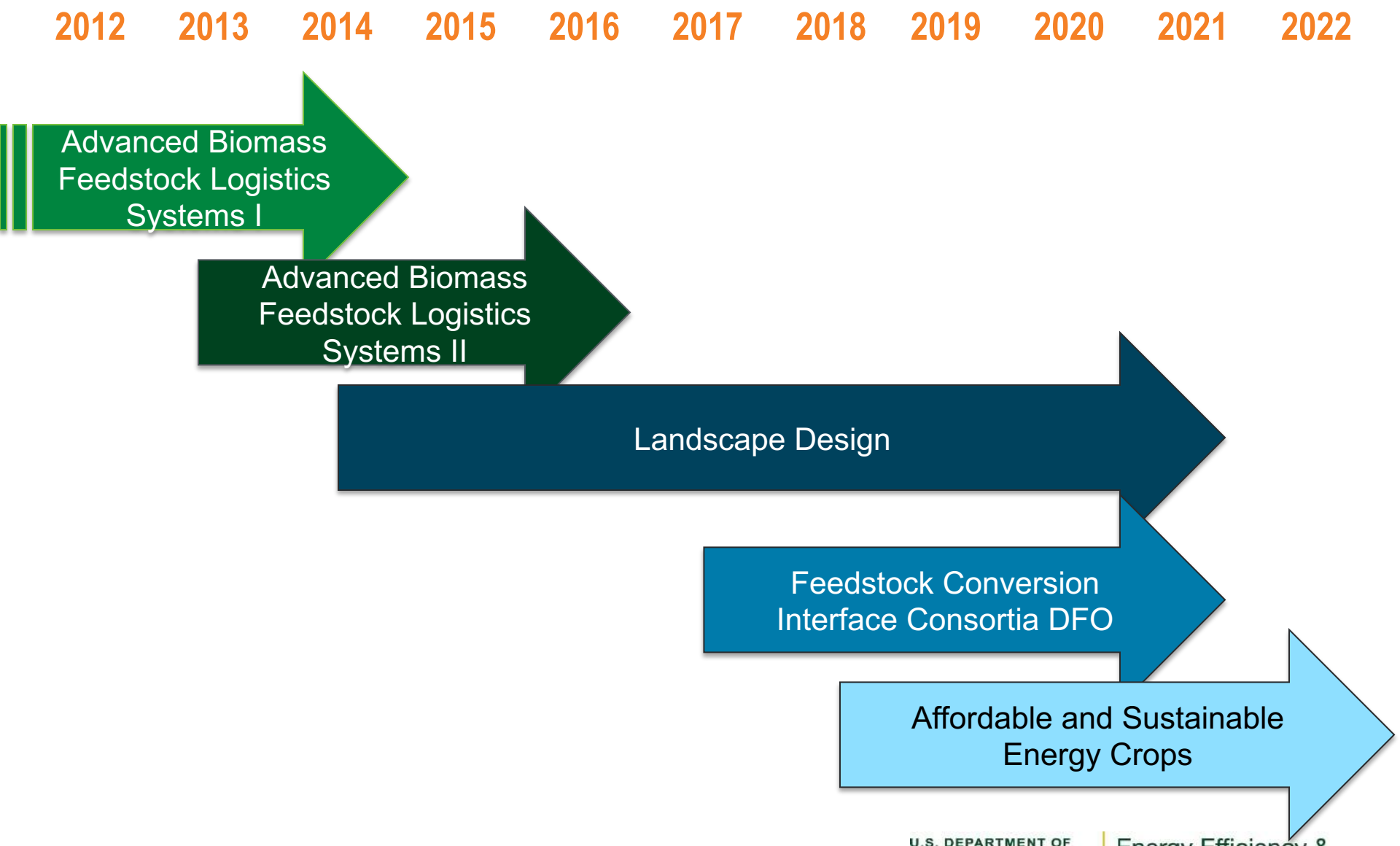
Focus:

- Improved feed handling in biorefinery
- Biomass characterization for quality
- Transforming biomass to conversion-ready feedstock

Funding History



R&D Strategy: Competitive & Lab Call Funding



Key Accomplishments

Regional Feedstock Partnership

Completed project and produced summary report. Resulted in 134 peer-reviewed papers, 4 book chapters, 26 conference proceeding articles, and 48 extension/outreach publications

Biomass Research & Development

Two BRDI awards ($3M) will develop diverse, cost-effective cellulosic biomass technologies for use in biofuels and biobased products

Co-chair of two BR&D Interagency Working Groups

Affordable and Sustainable Energy Crops (ASEC) FOA

Three projects awarded ($15M), using new varieties/cultivars of energy crops leading to increased availability, cost-effectiveness, and environmental sustainability of energy crop production systems

Landscape Design for Sustainable Bioenergy Systems FOA

One project awarded ($9M), establish multi-disciplinary landscape design process, improve sustainability metrics, and assess logistics systems to deliver feedstocks to conversion facilities for bioenergy

Feedstock Conversion Interface Consortia (FCIC)

Established consortia. Awarded seven DFO projects ($8M)

Feedstock Conversion Interface Consortium (FCIC)

Challenge: 7 out of 10 new pioneer biorefineries fail to achieve continuous profitable operations and only 3 out of 10 succeed.

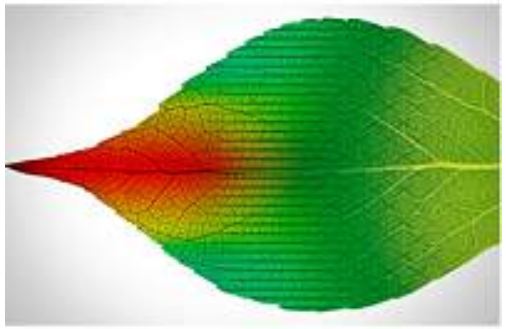
Vision: Quantify, understand, and manage variability in biomass from field through downstream conversion and to understand how biomass composition, structure, and behavior impacts system performance

- Provide First Principles based knowledge related to unit operations
- Provide transfer functions to bridge scales from bench to pioneer biorefinery
- Provide valuation of intermediate streams which can be commoditized

TOOLS FOR TECHNOLOGY DEVELOPERS AND BIOREFINERY DESIGNERS

Intra-agency Collaboration

- Engagement with Office of Science due to related R&D areas of interest Energy crops (BER), Sustainability (BER), Photosynthesis (BES)
  - BER Bioenergy Research Centers, particularly GLBRC (Great Lakes Bioenergy Research Center) with a thrust area in sustainability
- Engagement with ARPA-E through TERRA (Transportation Energy Resources from Renewable Agriculture) and ROOTS (Rhizosphere Observations Optimizing Terrestrial Sequestration)
  - Participate in review panels, connect through DOE Intra-agency quarterly meetings, also USDA REE engagement



SBIR

Shockwave

Technology

- Innovative corn fractionation system. Separates biofuel feedstocks into distinct fractions

Approach

- Produce cellulosic fibers for biofuel and bio-product markets and demonstrate quality of cellulosic fiber
- Improve operational performance to optimize production of cellulosic-rich fiber fractions
- Evaluate the conversion potential of cellulosic fibers to cellulosic sugars and biofuels

Forest Concepts

Technology

- Innovative rotary-shearing comminution system

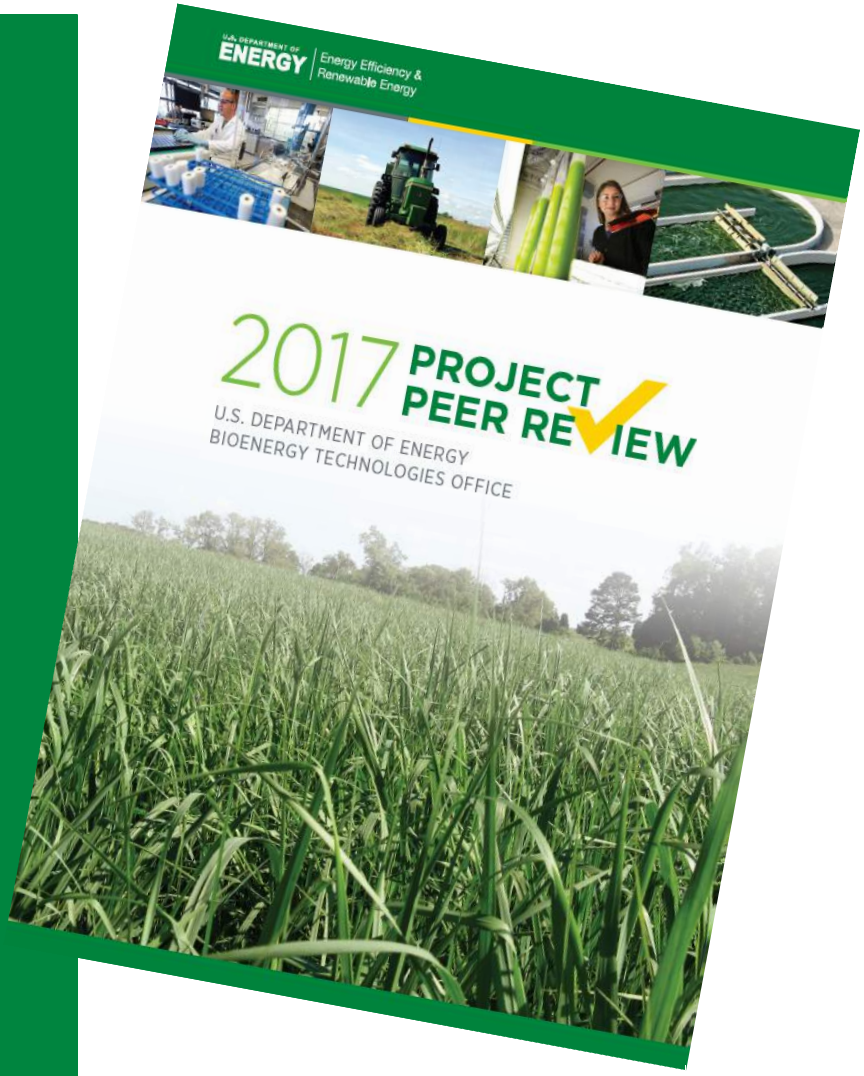
Approach

- This technology enables processing of high moisture and “wet bale” biomass to increase utilization of available biomass resources and reduce process wastes.
- Reduce the cost and improve the net energy balance of cellulosic biofuels and bioproducts

2017 FSL Peer Review

Key Recommendations:

- ✓ More effective collaboration with USDA,
- ✓ Increase emphasis on short to medium term feedstock and logistics issues, and
- ✓ Depot-level demonstration project

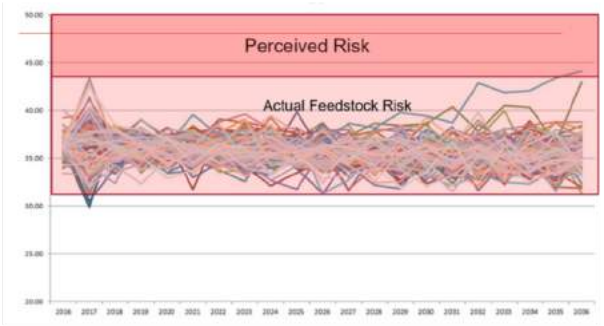


USDA Collaboration

- Three active Interagency working groups
- Goals for 2019 include:
  - Develop high-yielding regionally adaptive crops, and production and management strategies to enable large quantities of high-quality feedstock
  - Establish a fully developed biofuel and bioproducts production pipeline
  - Develop models and data of feedstock characteristics, equipment costs, crop investment, adoption risk, and policy to enable continuous improvement and adaptive management

Short- to Medium-term Feedstock and Logistics Issues

Densification	Storage	Supply Chain Risk
• Solve particle attrition and fines generation during grinding • Enable pelleting as a viable option for conversion-ready cellulosic feedstocks	• Reduce storage related quality variations in delivered biomass • Transform storage from a cost-center to a value-add operation	• Increased grower participation leads to reduced supply chain costs • Estimate risks and lower cost of capital of bioenergy projects



Future Directions: Carbon-Based Economy

The emerging bioeconomy utilizes diverse resources not traditionally FSL's focus such as solid waste and industrial gases. FSL is partnering with other parts of BETO to frame our work in a new way and apply existing capabilities to new challenges.

Introductions – FSL Peer Review Panel

- Mr. Brandon Emme, ICM, Inc.
- Mr. Glenn Farris, AGCO (*Lead Reviewer*)
- Dr. Ray Miller, Michigan State University
- Dr. Dana Mitchell, USDA Forest Service – Southern Research Station
- Ms. Lynn Wright, WrightLink Consulting (formerly ORNL, University of Tennessee)




Lynn Wright

THANK YOU, REVIEWERS!

Thank you!

Alison Goss Eng, PhD

Program Manager

Bioenergy Technologies Office

U.S. Department of Energy

Phone: (202) 586-9109

Email: Alison.GossEng@ee.doe.gov

www.linkedin.com/in/alisongosseng

www.twitter.com/AlisonGossEng

www.twitter.com/BioenergyKDF

www.bioenergykdf.net

Appendix

Introductions – FCIC Peer Review Panel

- Dr. Lorenz (Larry) Bauer, Consultant (*Lead Reviewer*)
- Mr. Brandon Emme, ICM, Inc.
- Mr. Glenn Farris, AGCO
- Dr. Benjamin Levie, Formerly Weyerhaeser
- Andrea Slayton, Slayton Technical Services



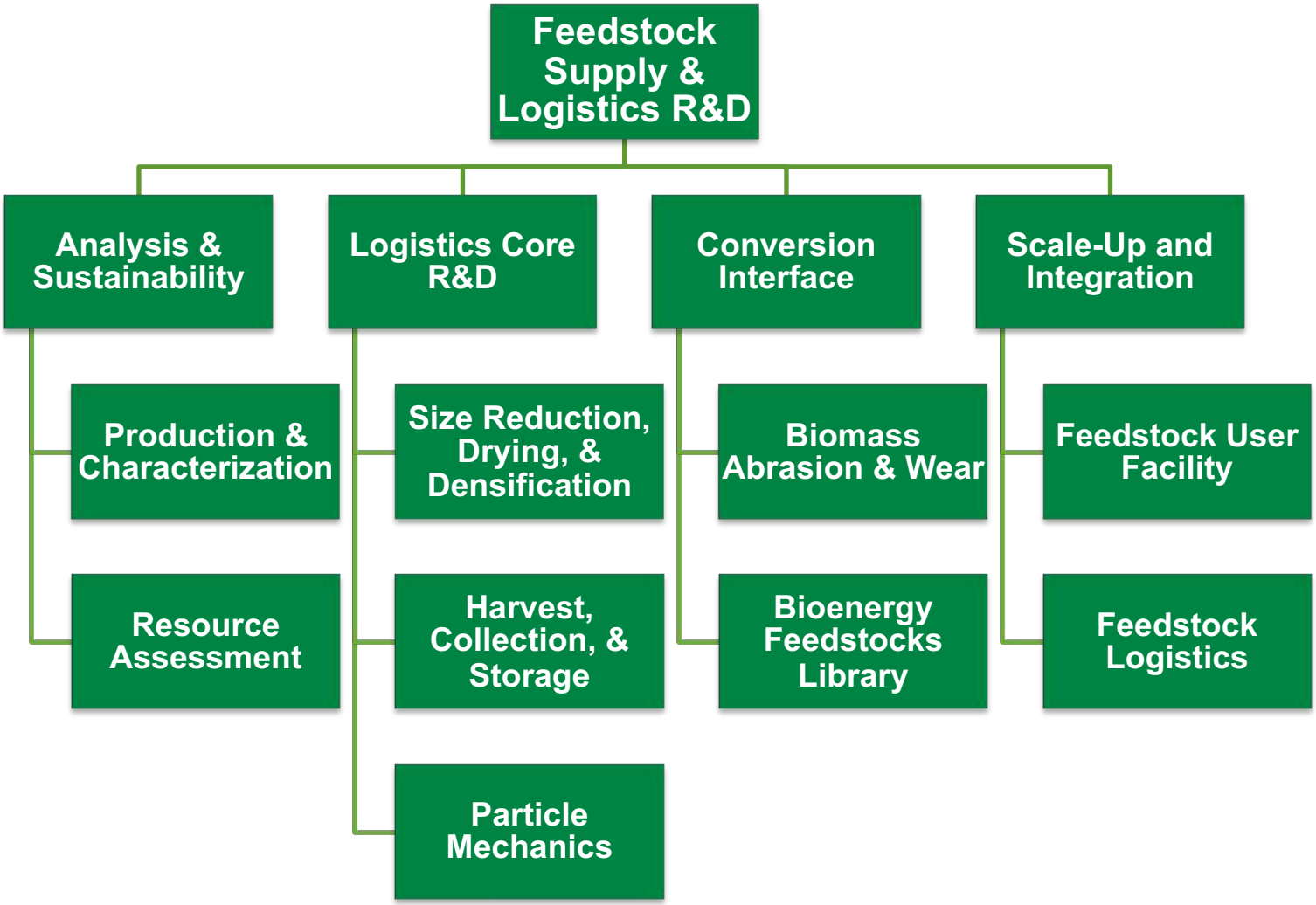


THANK YOU, REVIEWERS!

FSL Projects Overview

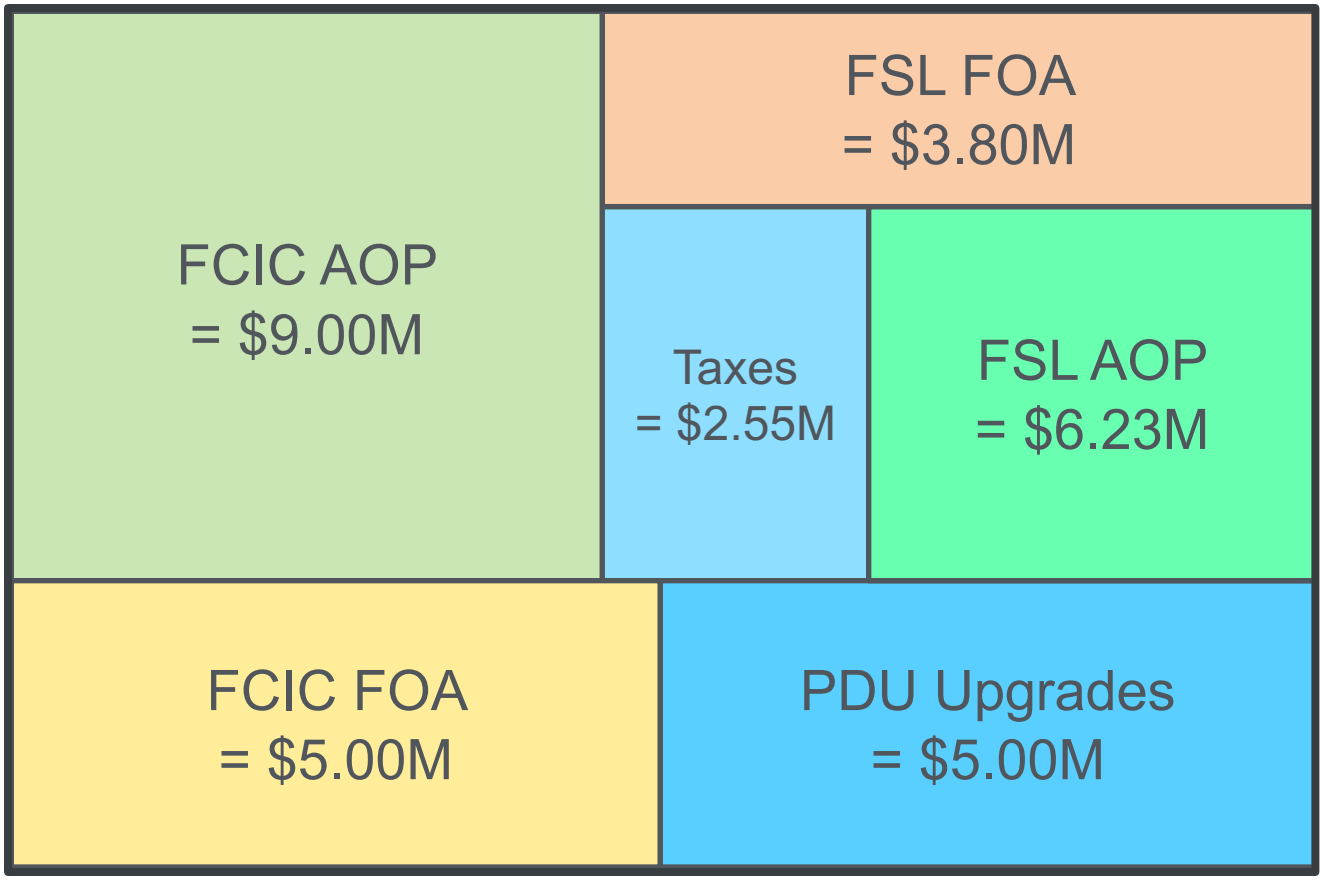
Project Name	ID#	Lead Org	Type of Org	Presenter	Award Type	Years	Funding
Feedstock Supply Chain Analysis	1.1.1.2	INL	Lab	David Thompson	AOP	2017-2020	$ 3,735,700
Supply Forecasts and Analysis	1.1.1.3	ORNL	Lab	Matthew Langholtz	AOP	2017-2020	$ 4,302,000
Resource Mobilization	1.2.1.5	INL	Lab	Damon Hartley	AOP	2017-2020	$ 1,020,000
Development of a wet logistics system for bulk corn stover	1.2.1.1000	INL	Lab	Lynn Wendt	AOP	2017-2020	$ 1,540,000
Size Reduction, Drying and Densification of High Moisture Biomass	1.2.1.2	INL	Lab	Jaya Tumuluru	AOP	2017-2020	$ 3,658,300
Biomass Supply Chain Risk Standards	1.2.2.2	INL	Lab	Rachel Emerson	AOP	2017-2021	$ 3,161,300
Sensors and Measurement in Harvest & Collection for Rapid Quality Control of Corn Stover	1.2.1.1	INL	Lab	Bill Smith	AOP	2016-2021	$ 6,400,000
Demonstration of an Advanced Supply Chain for Lower Cost, Higher Quality Biomass Feedstock Delivery	1.2.3.106	FDC Enterprises	Industry	Kevin Comer	Logistics II FOA	2013-2019	$ 6,282,282
Next Generation Logistics Systems for Delivering Optimal Biomass Feedstocks to Biorefining Industries in the Southeastern United States	1.2.3.107	University of Tennessee	University	Tim Rials	Logistics II FOA	2016-2020	$ 3,898,470
Improved Advanced Biomass Logistics Utilizing Woody and other Feedstocks in the Northeast and Pacific Northwest	1.2.3.108	The Research Foundation of SUNY/SUNY-ESF	University	Tim Volk	Logistics II FOA	2016-2019	$ 3,714,815
CEMAC: Evaluation of Agricultural Equipment Manufacturing for a Bio-based Economy	6.3.0.8/9/10	NREL	Lab	Chad Augustine	AOP	2016-2018	$ 400,000
Waste to Wisdom: Utilizing forest residues for the production of bioenergy and biobased products	3.4.1.4	Humboldt State University	University	Han-Sup Han	2012 BRDI FOA	2013-2017	$ 5,881,974

Previous Work Breakdown Structure

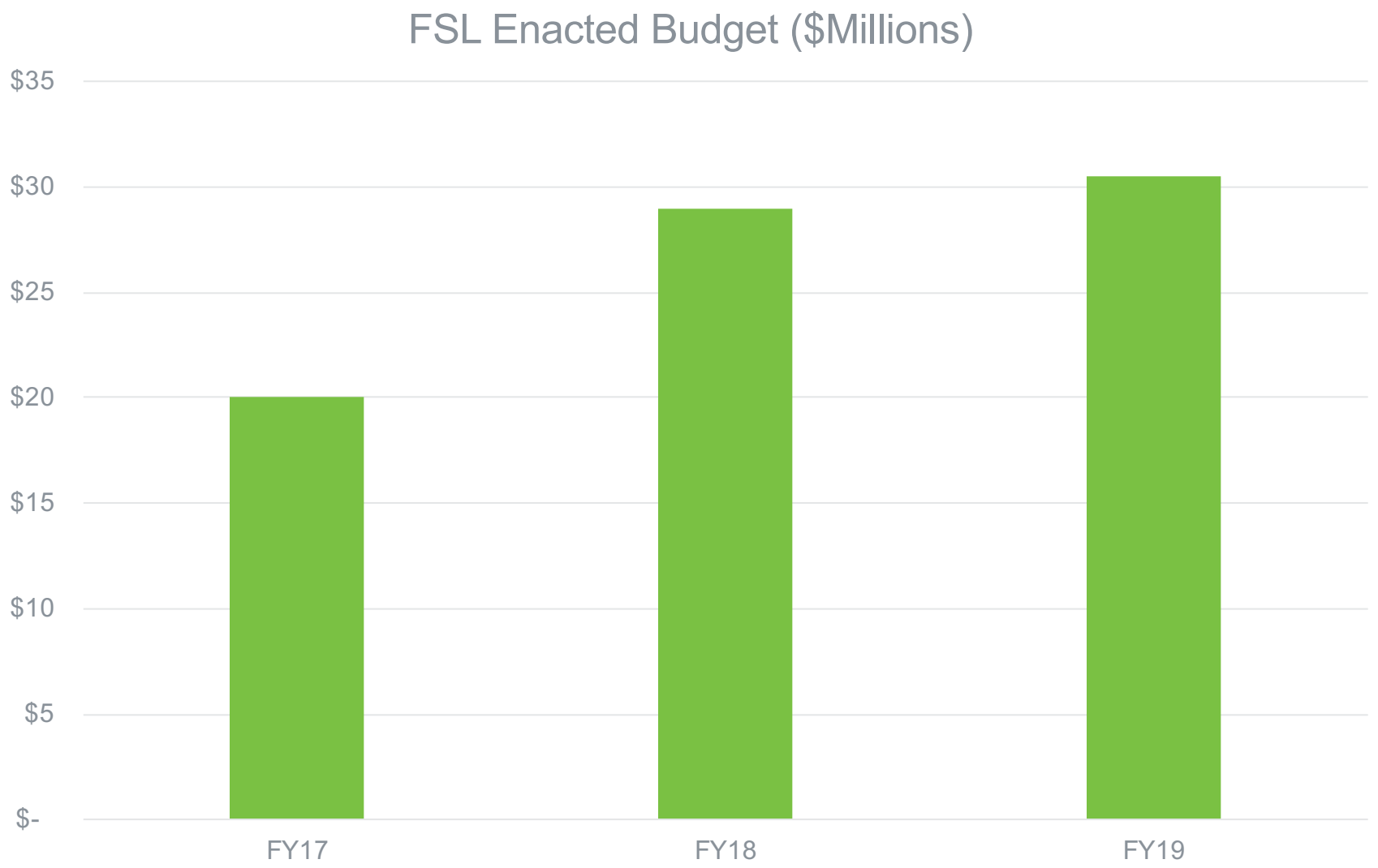


FY19 FSL R&D Funding

FY19 + Forward Funding FSL = $31.58M



FSL Funding History (cont.)



ASEC FOA Highlights

Areas of Focus:

- New varieties/cultivars of energy crops relative to predecessor varieties
- Regional adaptation
- Cost to produce
- Sustainability

Projects:

- Three projects selected; total federal share of $14.63M
- Next-Generation Feedstocks for the Emerging Bioeconomy (University of Illinois at Urbana-Champaign)
- Sustainable Herbaceous Energy Crop Production in the Southeast United States (Texas A&M AgriLife Research)
- Next Generation Miscanthus (North Carolina State Univ.)

Affordable and Sustainable Energy Crops (ASEC) FOA

On May 5th the U.S. Department of Energy (DOE) announced a FOA to support R&D related to the production of affordable and sustainable non-food dedicated energy crops that can be used as feedstocks for the production of biofuels and bioproducts.

Projects selected under this FOA will seek to:

- Conduct small-scale field testing of new varieties of energy crops
- Measure crop performance and environmental effects relative to traditional cropping and pasture systems
- Define cost-effective methods for planting, harvesting, collecting, and storing biomass

FOA Application Details:

- Funding Amount: Up to $15,000,000
  Funding Number: DE-FOA-0001917
- Letters of intent are due by May 30, 2018
- Full applications are due by June 27, 2018

FY18 FOA - Affordable and Sustainable Energy Crops (ASEC)

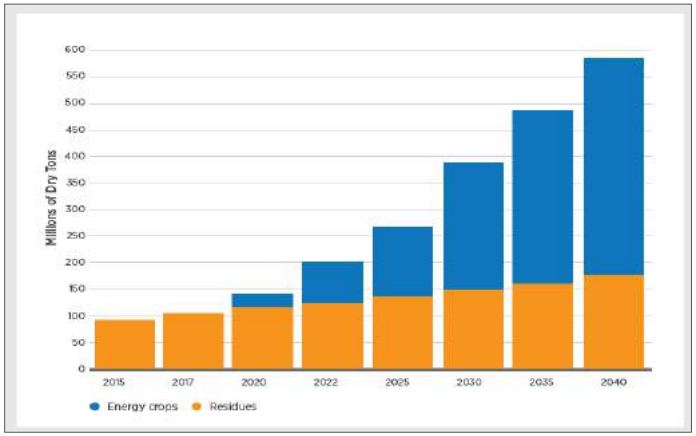
- Goal: Provide the scientific foundation and real-world data that enables industry to increase the availability, cost-effectiveness, and environmental sustainability of energy crop production.

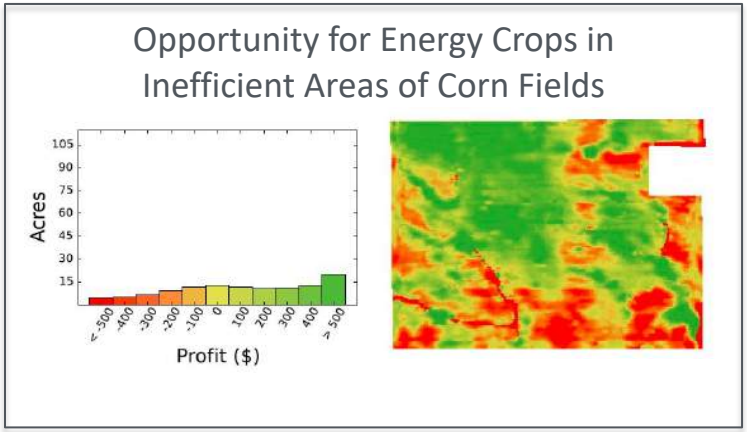
- Impact: Increased sustainable supply of affordable, reliable, and resilient biomass feedstocks for conversion systems that produce advanced biofuels and performance-advantaged coproducts at less than $3/gge.

TRL (start to end of projects)	# of Awards	Federal $$ Per Award	Total Federal Funding	Award Duration	Cost Share (%)
4 to 5	3-6	$2.5-$5M	$15M	5 years	20%

R&D Challenges Addressed by ASEC FOA

- The United States has the technical potential to produce 240-380 million tons of energy crops annually by 2030, depending on yield-growth assumptions (DOE *BT16 Report*).
- Current cellulosic material is limited to agricultural and forestry residues.
- To achieve high volumes, energy crop production must be dependable, high-yielding, cost-effective, and environmentally sustainable.
  - To reduce biofuels to <$3/gge need to reduce delivered feedstock cost to < $84/ton. Research is needed to drive down production costs while increasing volumes of energy crops.
  - Empirical data are needed on the yields and environmental effects of newer varieties of energy crops associated with different geographic locations, soil types, and management practices (e.g., nutrient inputs) to drive sustainable productivity of affordable volumes of energy crops.





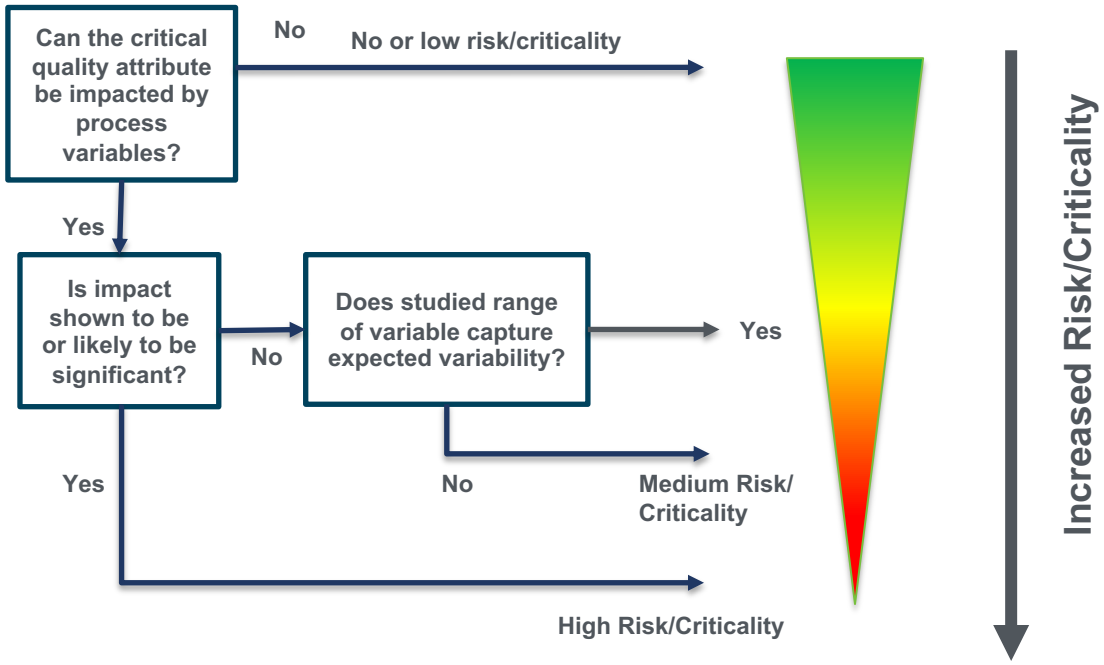
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

FCIC: New Goals and Structure

New Goals and Structure (2019 onwards):

- Shift in approach from “quality by testing” to “quality by design”
  - Disciplined methodology employed by the pharma industry to manage variability in processes

- 5 “processing” tasks: (feedstock variability, materials handling, preprocessing, low-temp conversion, high-temp conversion)
- 3 Enabling tasks: (materials of construction, crosscutting analysis, data integration)



Tasks Aligned With Operational Problem Areas

Feedstock → Preprocessing → Conversion → Characterization → Post processing → Products

Feedstock Variability:
Develop tools that quantify & understand sources of biomass feedstock variability with the objective of reducing sources of variability.

Preprocessing:
Develop tools to enable technologies that provide well defined, homogeneous, quality controlled feedstock.

Conversion (HT and LT):
Develop tools to enable technologies that produce homogeneous, quality controlled intermediates that can be converted into market ready products.

Enabling Tasks

Crosscutting Analyses TEA/LCA & Merit function Development:
Develops tools that enable valuation and intermediate streams and quantify impact of variability. Merit function develops tools that optimize on selected target globally.

Materials Handling:
Develop tools that enable continuous, steady, trouble free feed into reactors

Materials of Construction:
Develop tools that specify materials that do not corrode, wear, or break at unacceptable rates.

Data Integration/Data Management & Validation:
Develop tools that can facilitate the transfer of data and information both internally and externally. Verify and vet tools developed in the other tasks via reliability models, iCorps, industrial engagement.