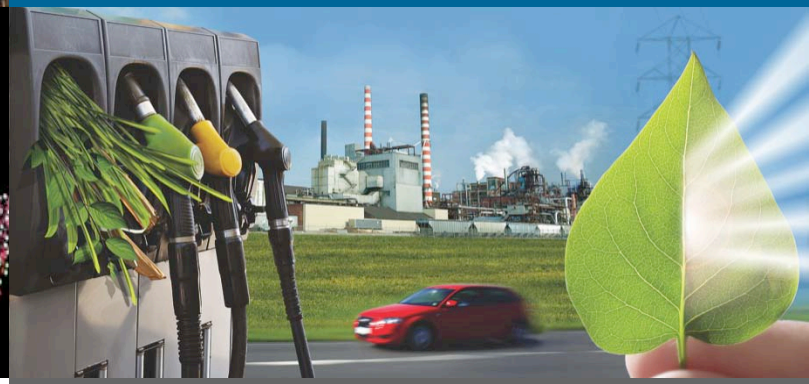
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



U.S. Department of Energy (DOE) Bioenergy Technologies Office (BETO)

2017 Project Peer Review Analysis & Sustainability

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Economic Analysis of Risk – WBS# 4.1.2.20

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Goal Statement

- Today a consistent method for **comparing and pricing risk** across project options **in the biomass supply chain** that supports biofuel production **does not exist**, **creating an investment barrier**.
- Guided by industry collaboration, **the goal of this project is to create a method** to systematically analyze, measure, and compare risks in a way that is consistent with best practices and sophisticated techniques used in the financial sector **so that investors can evaluate project risks** in the biomass supply chain.
- **This project builds a standards and certification framework** for the financial sector **to measure and compare risks** in the biomass supply chain; **analysts** in debt and equity finance, insurance, and government **can set risk premiums** comparable to alternative market opportunities, e.g. investments based on bond ratings.

Quad Chart Overview

Timeline

- Project start date 10/01/2016
- Project end date 09/30/2019
- Percent complete 35%

Barriers

- Ft-A (cost) Ft-I (scale up)
- At-A (transparent), At-C (data)
- Im-A (infrastructure), Im-B (capital risk), Im-C (standards)

Budget

	FY 16 Costs	Total Planned Funding (FY 17-Project End Date)
DOE Funded	$209.2K	$2.460M
A&S Funded	$209.2K	$627.6K
FSL Funded		$1.832M
Project Cost Share (Comp.)*		

**No cost-share partners on this project.*

Collaborators

- Ecostrat
- Stern Brothers

1 – Project Overview

- Established **standards and protocols**, and industry best-practices **are needed to evaluate biomass supply chain risks**. Investors and others do not have a consistent method for evaluating projects based on risks (e.g. project, market, technology).
- **Without** standardized **criteria**, financial sector assessments of risks in biomass investments are inconsistent, which **leads to unreliable estimates of project risks**.
- Unclear understanding of risk results in lower credit rating for feedstock supply projects: i.e. junk bond ratings. **This barrier places a financial drag on projects** that do get built, and prevents others from attracting investors **because of excessive financing cost and reduced competitiveness.**
- **This project solves the problem** with two parallel tasks,
  - Task A: Standards and Certification **Framework is** a high-level view (e.g. weather risk, market risk, sustainability risk, cost risk) of the feedstock supply chain, it categorizes relevant risks, then merges risks into **a structure to evaluate overall feedstock supply chain risk** by project investment.
  - Task B: Stochastic Techno Economic Modeling (**STEM**) **takes on** a component of feedstock supply chain risk. It develops a model to quantify **feedstock logistics cost risk using data** from design cases in INL State of Technology reports **for herbaceous and woody feedstocks**.

2 – Approach (Management)

- **Task A – Standards and Certification Framework**
  - INL, Ecostrat, Stern Brothers
    - » standards categories, risk factors and indicators
  - Advisory Board (industry, labs, universities)
    - » guide development of categories, factors, and indicators
    - » iterate with researchers
  - Started in FY17Q1, progress tracked with bi-monthly check-in calls with BETO staff, quarterly reports, annual milestones, and Go/No-Go decision point 30 March 2018
- **Task B – Stochastic Techno Economic Modeling (STEM)**
  - INL staff with expertise in uncertainty and risk, feedstock logistics
  - Student internships and university collaboration
  - Started in FY16Q1, progress tracked with monthly check-in calls with BETO staff, quarterly reports, annual milestones, and Go/No-Go decision point 30 March 2017

2 – Approach

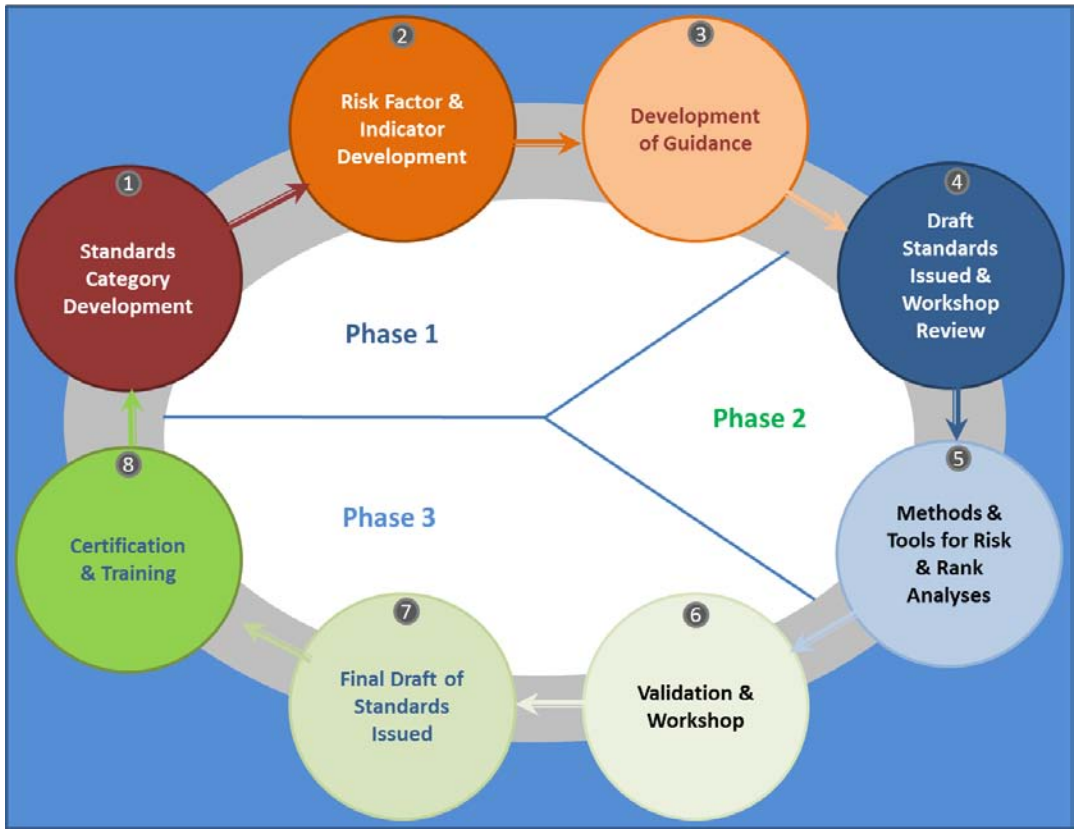
- **Success Factors**
  - Framework accepted by financial sector community
    - » At workshops participants' summarized responses indicate usefulness and acceptability
  - Method viewed as transparent, creating reproducible results
    - » Using same set of input data financial sector analysts (e.g. in lending, investing, and insurance) produce similar risk results
- **Key Challenges**
  - Management
    - Achieving financial sector 'buy-in'
  - Technical
    - Building set of perspectives to develop correct risk weighting factors
    - Developing model to merge quantitative and qualitative risk assessments

2 – Approach (Technical) Task A: Framework

Phase 1
Establishes set of risk categories risks (e.g. supply chain, feedstock quality)

Phase 2
Develops tools & methods to merge set of risks & evaluate management strategies

Phase 3
Finalized categories and methods



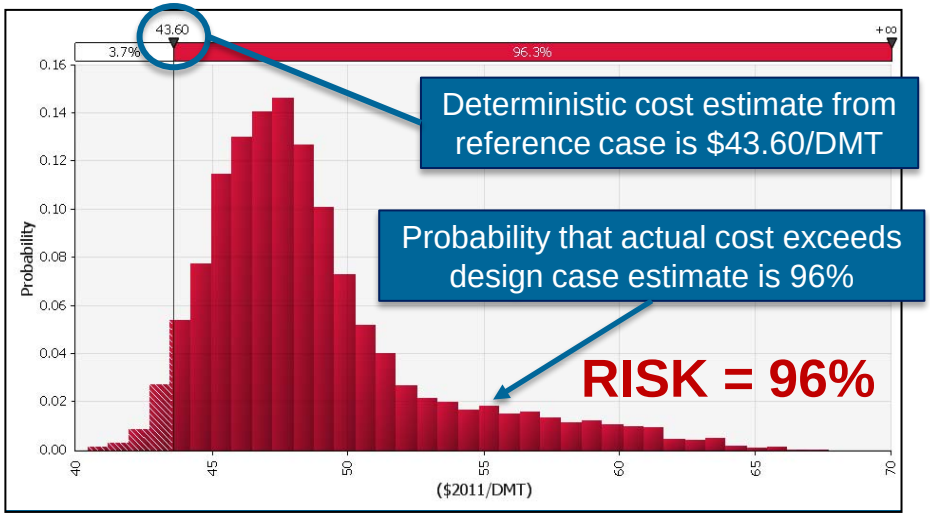
2 – Approach (Technical) Task B: STEM

- **Deconstruct biomass supply chain**, from the field to biorefinery throat, **into unit operations**.
  - harvest and collection, storage, transportation, preprocessing, handling and queuing
- By unit operation, **identify** uncertain economic, technological, and operational **variables** that **govern logistics cost**.
- By **random variable**, e.g. wages or hours operational, **fit** probability distributions (**pdfs**).
  - rely on observed data and expert opinion
  - generate minimum, maximum, most likely
  - apply statistics for pdf by equipment type
- **Link variables to** feedstock logistics **cost** model and **simulate** possible **outcomes** with Monte Carlo analysis.

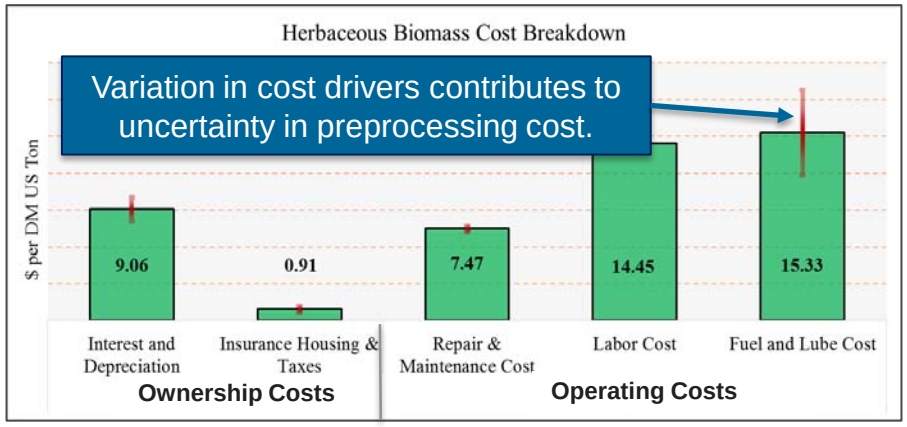
3 – Technical Results

- For reference cases, used STEM, **quantified uncertainty** in preprocessing cost
- **Identified** primary cost and **uncertainty drivers** in preprocessing **based on cost** categories

Cost Risk in Herbaceous Preprocessing



Identifying Uncertainty Drivers

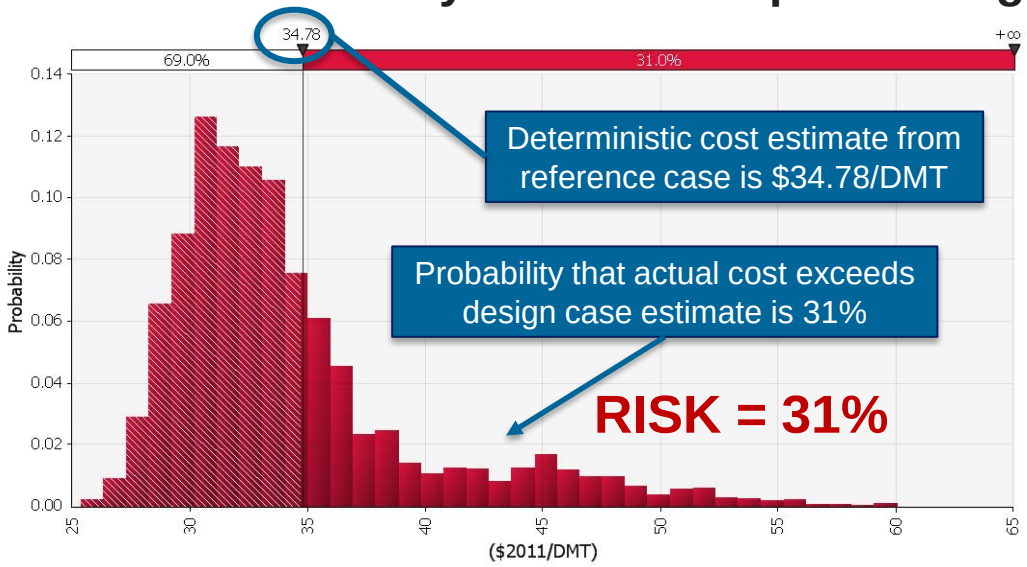


- **Translated uncertainty** in preprocessing **to feedstock logistics cost** (but more unit operations to quantify)

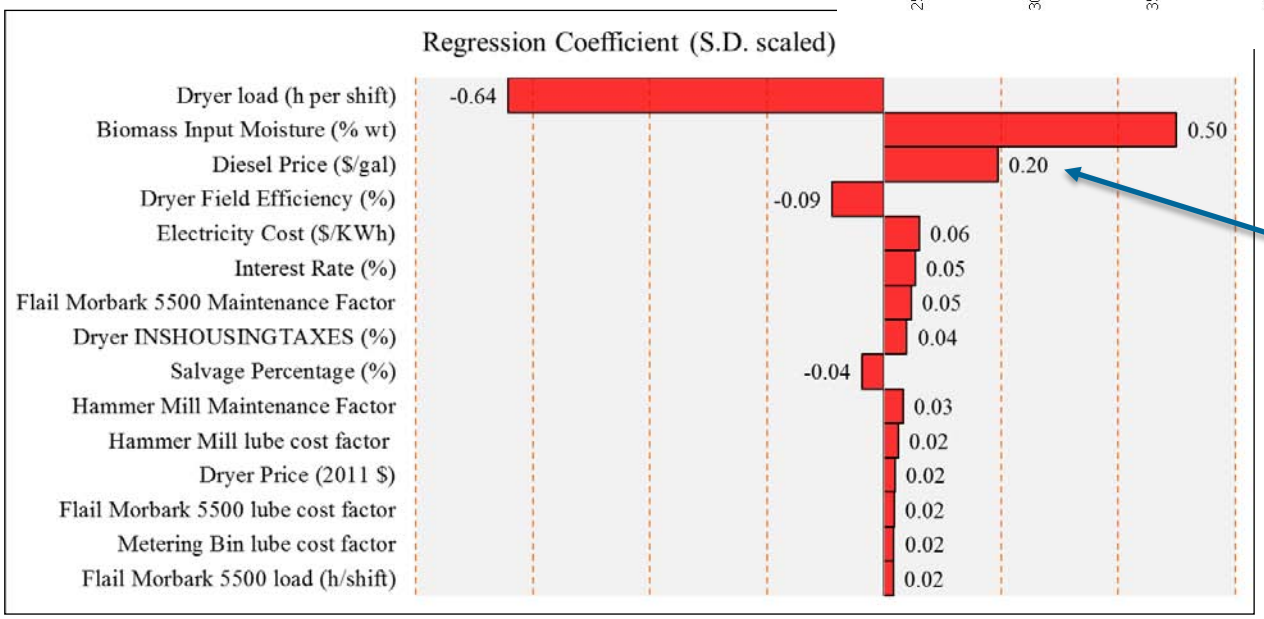
3 – Technical Results (cont'd)

- **Identified** cost and **uncertainty drivers** in preprocessing **based on equipment** type

Cost Risk in Woody Biomass Preprocessing



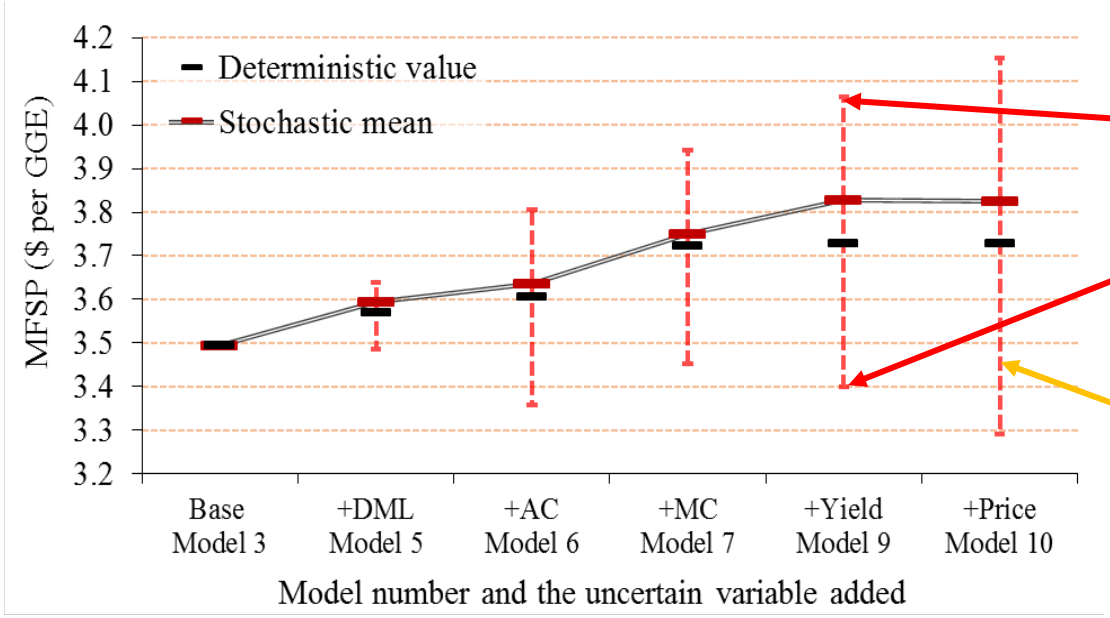
Identifying Uncertainty Drivers



Coefficients show how variation in preprocessing cost changes given a change in variation in equipment type or parameters in cost calculation.

3 – Technical Results (cont'd)

- Developed a model to quantify **impact of uncertainty in biomass supply chain on minimum fuel selling price** in the conventional supply system (Zhao et al., *in preparation*)
- Impact **based on** uncertainty in biomass **quality and quantity**



Whisker plots show how uncertainty in underlying parameters translate to uncertainty in MFSP. Uncertainty in quality variables drive uncertainty in MFSP. Uncertainty in dry matter loss, ash content, and moisture content (Model 7) lead to a wide range of MFSP possibilities.

With all uncertain parameters reflected (Model 10) MFSP ranges from $3.30/GGE to almost $4.20/GGE.

4 – Relevance

Overcoming Financing Barriers with a Framework to Standardize and Quantify Risks

- Supports BETO's strategic goal to develop **commercially viable** bioenergy and bioproducts,
- Supports BETO's crosscutting goals to establish a basis for **quantitative metrics** for planning and management, and to develop **analytical methods** to advance **understanding of risks** in bioenergy,
- Leverages financial sector experts to develop a consistent, verifiable **method** and **data analysis** needed for analysts in the feedstock supply industry and in the financial sector **to evaluate risks** in supply chains,
- Transparent method of risk analysis, consistent with finance sector best practices **reduces high cost of financing** because with better, standardized information investors can price investments based on calculated risks,
- **Standardized approach** to risk in biomass supply **enables risk mitigation**, **risk reduction** improves access to capital for biomass projects, and **better access to capital** improves projects' competiveness.

5 – Future Work

Task A – The Framework

- Develop the method to integrate diverse set of risks (e.g. market risk is not directly comparable with sustainability risk) such that unified measure of risk established – FY18
- Integrating will require application of state of the art methods from risk analysis in economics, operations research and decision science
- Work with financial industry stakeholders to track that framework development is consistent with other risk assessment tools used in industry today – FY19
- Test framework with stakeholder workshops, based on feedback adjust as needed

Task B – STEM

- Complete cost risk modeling for remaining unit operations (harvest and collection, handling and queuing) – FY17
- Support ongoing BETO cost studies with risk analysis, include risk assessment on future State of Technology Reports – FY18

Summary

- **Overview**: Consistent risk analysis in biomass supply chain is missing. Without a standardized approach, high financing costs result.
- **Approach**: A two-pronged solution: 1) Developed Framework to assess and integrate diverse risks (e.g. quantity and quality), 2) Developed STEM to quantify the cost risk and feed data into the Framework.
- **Accomplishments**: Using STEM, researchers **quantified uncertainty** in a unit operation, used Monte Carlo Analysis to **translate** the impact **to logistics cost,** and for a supply chain design **quantified** the **impact** of biomass supply uncertainty **on biofuel prices**.
- **Relevance**: Supports commercial viability, quantitative metrics and analytical methods to understand risks. Leverages industry engagement to guide evaluation method for consistency with finance industry best practices for risk assessment. **Standardized assessment reduces high-cost financing.**
- **Future Work**: Develop categories of risks and standards, create integrated assessment framework and engage with industry stakeholders to guide development. Extend cost-risk analysis to all unit operations and support BETO-INL cost studies with risk assessments on state of technology.

Thank You

Questions

Response to Previous Reviewers' Comments

- **A theme from reviewer comments at the previous Peer Review was that the project was somewhat unfocused and insufficiently funded to analyze policy effects on biofuels.**

  ➔Researchers focused on project risks in the feedstock supply chain for the specific purpose of addressing the financing and investment barrier to industry expansion. Researchers changed the project name to reflect this re-direction and focused effort.

- **Another theme from the previous Review was that identifying strategies and means by which to reduce risk in the cellulosic biofuels industry is key to industry success.**

  ➔ Project now directly addresses this: the standards and certification framework supports reducing high financing costs. The project is now working to fill the gap of standardized risk assessment, which supports improving access to capital for new projects. The framework enables risk mitigation and strategies to reduce risk.

Presentations and Publications

- Hansen, J. & Nair, S. (2016). The economic analysis of risk. *Presentation to* BETO A&S Special Topics Presentation, webinar originating at Idaho National Laboratory, November 7.
- Hansen, J. (2016). Risk analysis in the bioenergy feedstock supply chain. *Presented to* the Economics Club at Idaho State University, Pocatello, ID, October 12.
- Hansen, J.K., & Nair, S.K. (2016). Brief Overview of Feedstock Supply Chain Risk Assessment and Integrated Landscape Management. *Presented at* Bioenergy Supply-Chain Modeling Workshop, National Renewable Energy Laboratory, Golden, CO, June 29 – 30.
- Zhao, X., Hansen, J.K., Tyner, W. & Nair, S. (2017). Quantifying supply risk at the cellulosic biorefinery: A stochastic techno-economic analysis. Unpublished manuscript.
- Hansen, J.K., Searcy, E.M., Jacobson, J. (2017). Managing risk at the cellulosic biorefinery. Unpublished manuscript.
- Hansen, J., Jacobson, J., Roni, M. (2015). Quantifying Supply Risk at a Cellulosic Biorefinery. In K. Chichakly, & K. Saeed (Eds.), *Proceedings from the 33rd International Conference of the System Dynamics Society*. Albany, New York: System Dynamics Society.