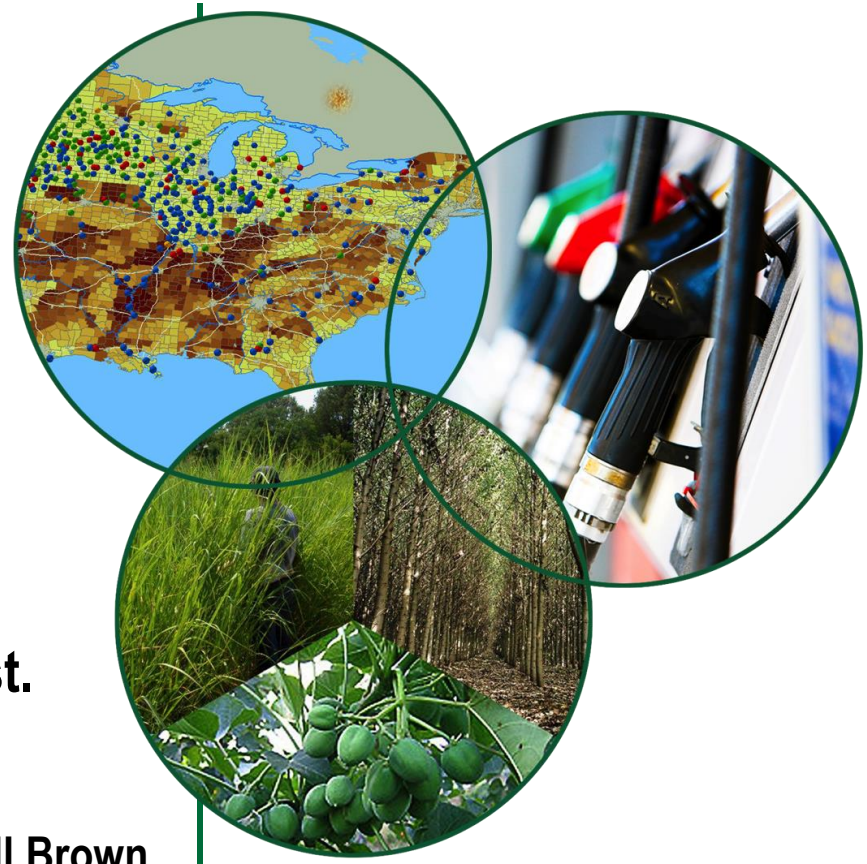
2013 DOE Bioenergy Technologies Office (BETO) Project Peer Review

Biofuels National Strategic Benefits Analysis



Date: May 21st 2013

Technology Area Review: Analysis & Sust.

Principal Investigator: Paul N. Leiby

Co-Investigators: Rocio Uria-Martinez and Maxwell Brown

Organization: Oak Ridge National Laboratory

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Biofuels National Strategic Benefit Analysis: Goals Statement

Advance DOE capability for strategic analysis and benefits assessment with modeling and analyses, to:

- "enable sustainable nationwide production of [commercially viable] advanced biofuels to … reduce U.S. dependence on oil … supporting the EISA goal(s)" (MYPP 2012:1)
- "understand and promote positive economic, social, environmental effects of biofuels" (MYPP Apr. 2012:2-99)

by:

- **Estimating comparative benefits of alternative configurations of the US biofuel system, including economic impacts, *resilience to shocks and energy security***
- **Assessing alternative policies to achieve EISA and drive the transition to commercially viable advanced biofuels**

Quad Chart Overview

Timeline

- Project start date: 12/15/2011
- Project end date: 9/30/2015
- Percent complete: 35%

Budget

- FY11 DOE funding: $0k
- FY12 DOE funding: $200k
- FY13 DOE funding: $300k
- Years funded: 1.5
- Avg. annual funding: $250k

Partners

- Ceres/Exelus
- Mansfield Oil
- ORNL GTAP, BILT and KDF teams
- Univ. of Maine

Barriers being addressed

- At-B. Limitations of **analytical tools** and capabilities **for system-level analysis** (for Strategic analysis of mkt barriers & benefits)
- At-A. Lack of Comparable, Transparent, and **Reproducible Analysis.**
- Ct-C. Inconsistent and **Unpredictable Policy Landscape** and Priorities

Project Management

- Monthly & Quarterly reports, program conf. calls.
- Assembla Project Management Workspace.
- SVN version control for source code.

Project Overview

- History:
  - Past transitional analysis work (e.g. TAFV, HyTrans, NAS models) viewed as insightful for other EERE alt fuel tech programs.
- Context:
  - Large changes in oil price, and feedstock prices; Deployment barriers; Boom/bust cycle in dry mill investment; Delayed biofuel.
- High level objectives of the project.
  - Evaluating biofuel policies/industry strategically, emphasis on national economic benefits & energy security (a central EISA goal)
  - Model/assess barriers and transitions
- Ask, for example:
  - How do we configure biofuels to promote resilience and security at acceptable cost?
  - How can barriers be passed?

1 – Approach

1. Math-programming economic market model (BioTrans)

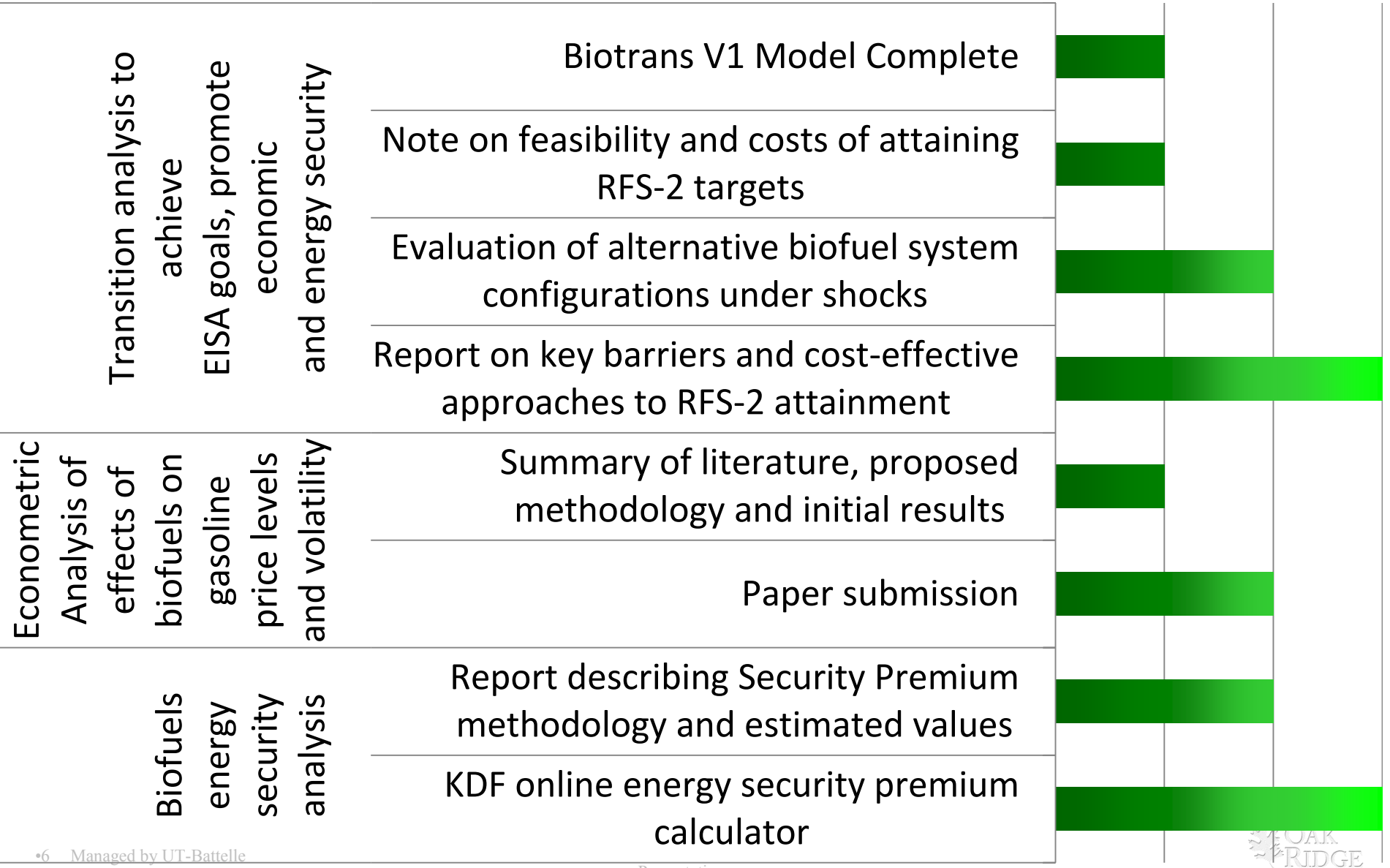
- depicts supply- demand landscape for biofuels, for market transition analysis
- *Classical* economic model imposes market discipline on outcomes
- *National, long-term* strategic focus (dynamic across 20 years)
- Representative portfolio of biofuel pathways compete (w/ each other & petroleum)
- Emphasis on role of *flexibility levers* throughout the system

2. Parallel econometric analyses

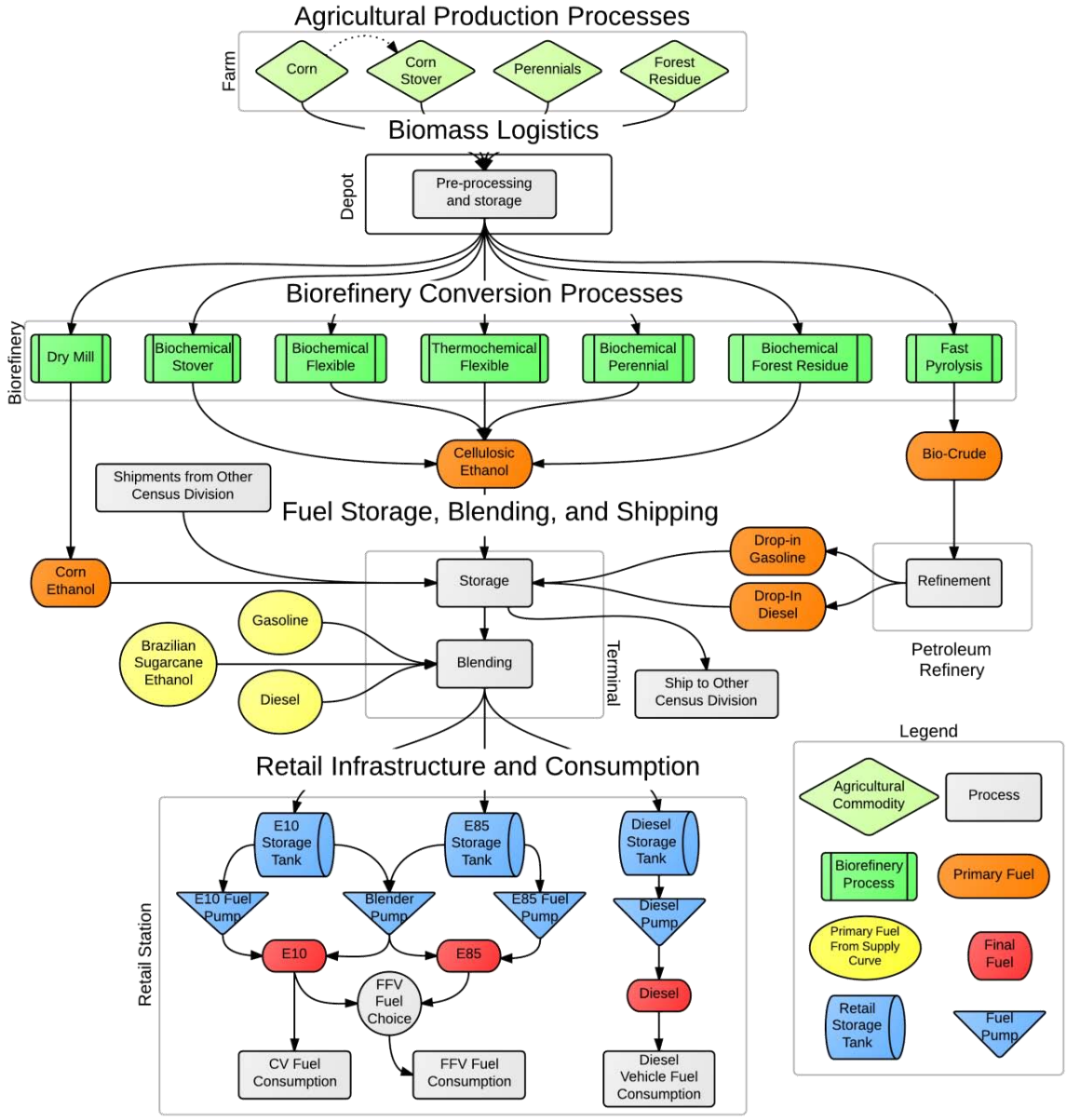
- of monthly ethanol and gasoline market data to flesh out the relationship between these two fuels and prices

3. Steady attention to economic/energy security implications

2 – Progress: On Track towards FY13 Milestones Completion

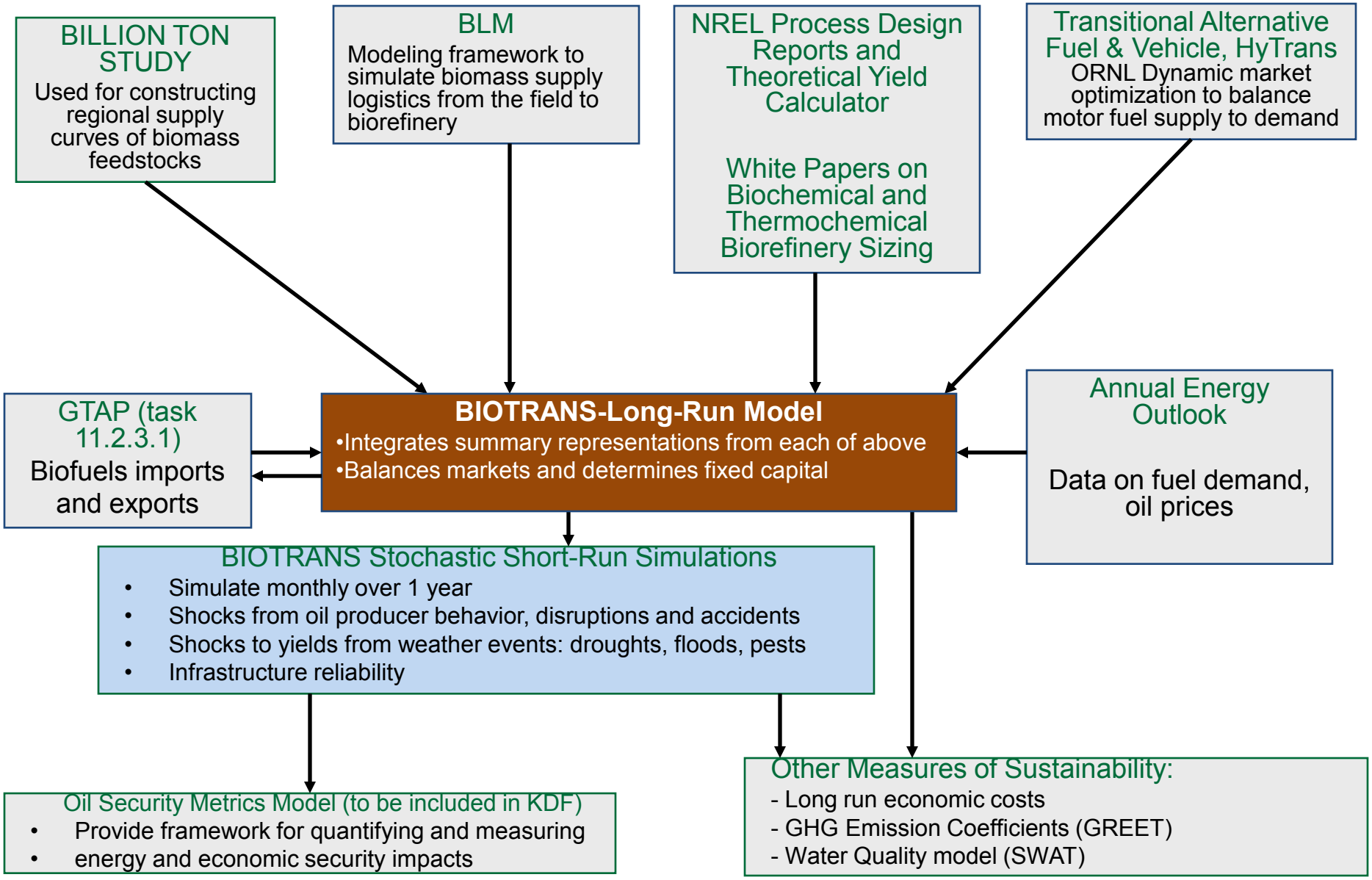


2 - Progress: Completed *BioTrans* Stage 1 Model Development



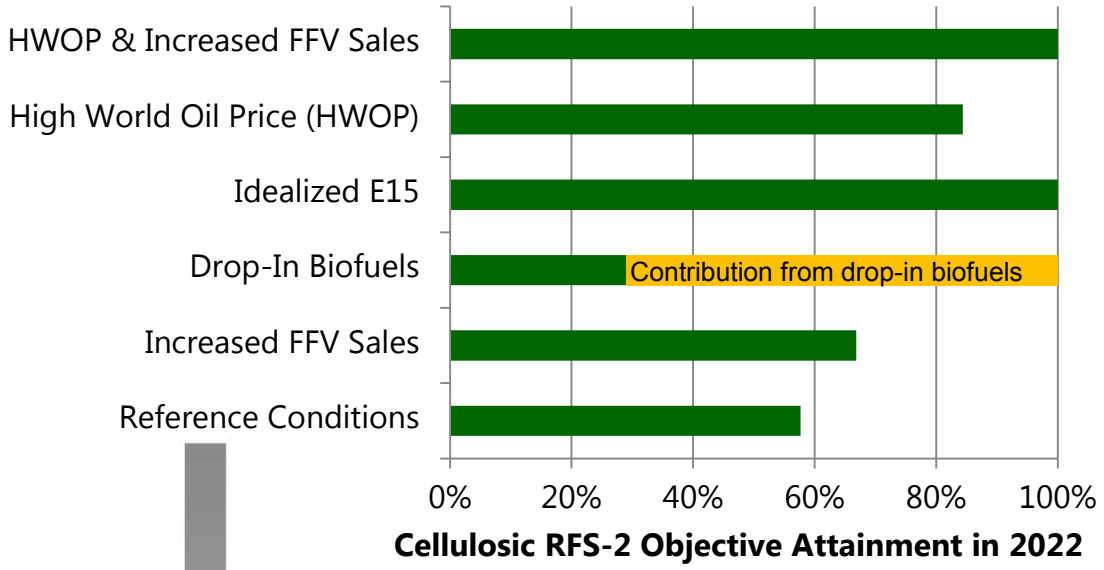
- National scope, 20+ years
- Regional disaggregation at census-division level
- Includes representative set of feedstocks and conversion processes, logistics, fuel retail, and fuel choice
- Focuses on the competition with gasoline and diesel in the light duty vehicle fuel market

BioTrans Builds on Existing Capabilities and Has Linkages to Multiple BETO Efforts



2 - Progress: Completed Note on Feasibility and Costs of Various Levels of RFS-2 Achievement*

*Note: 2022 RFS2 cellulosic target is 16 billion gallons



Cellulosic RFS-2 Objective Attainment in 2022

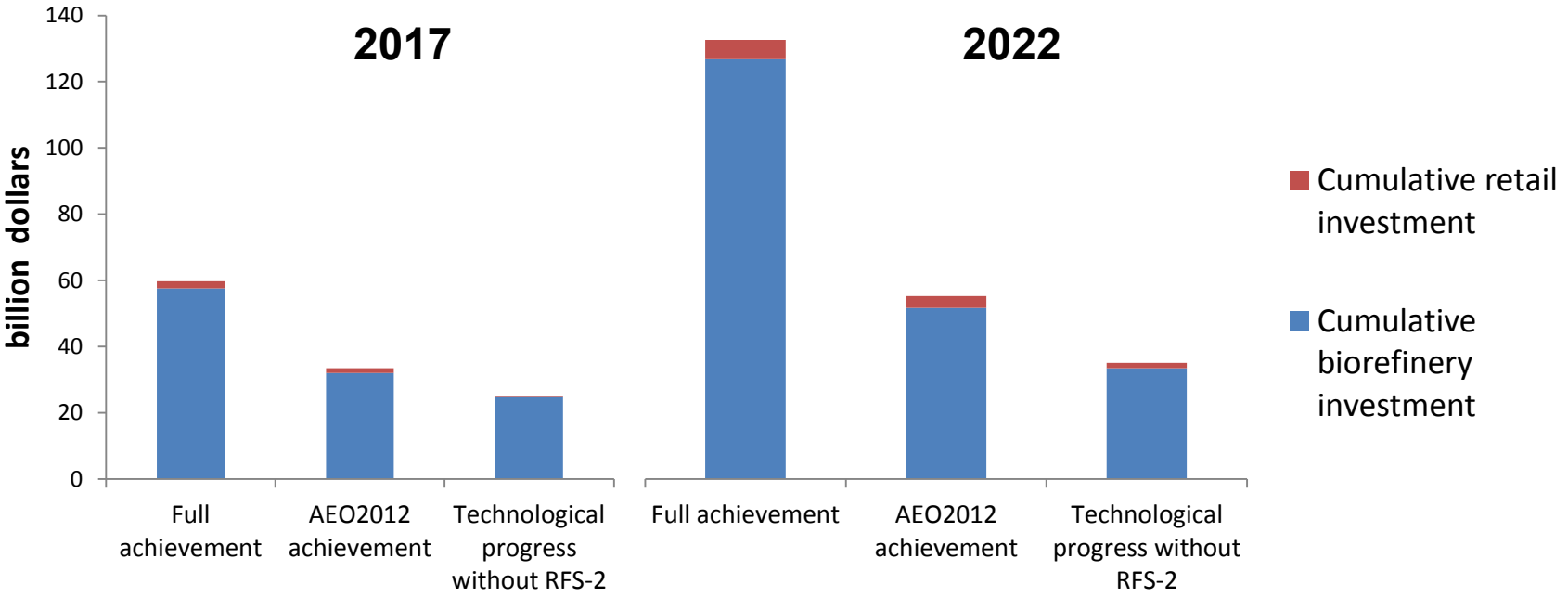
KEY BARRIERS:

- E10 "blend wall"
- FFV stock size
- Retail infrastructure introduction rate
- Inconvenience cost of E85 refueling
- Biorefinery investment rate limits

Reference Conditions:
-Grower payments $50/dry ton
-Biomass densification starting in 2017
-No drop-in biofuels
-Cellulosic ethanol n^{th} plant costs reached in 2017
-AEO2012 reference case oil prices
-Window for RIN banking and borrowing
-Current expiration dates for biofuel policy incentives

2 – Results: Retail Infrastructure Investment is Modest in Comparison to Biorefinery Investment, but risk may deter it.

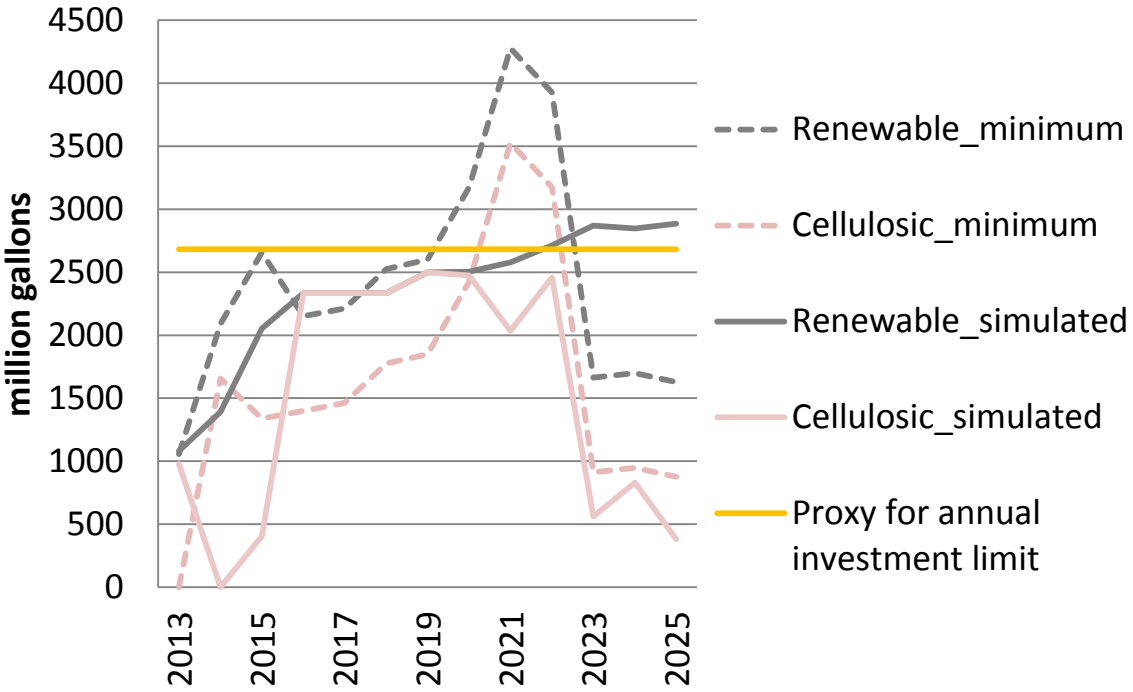
Simulated cumulative investment expenditure for various levels of RFS-2 attainment



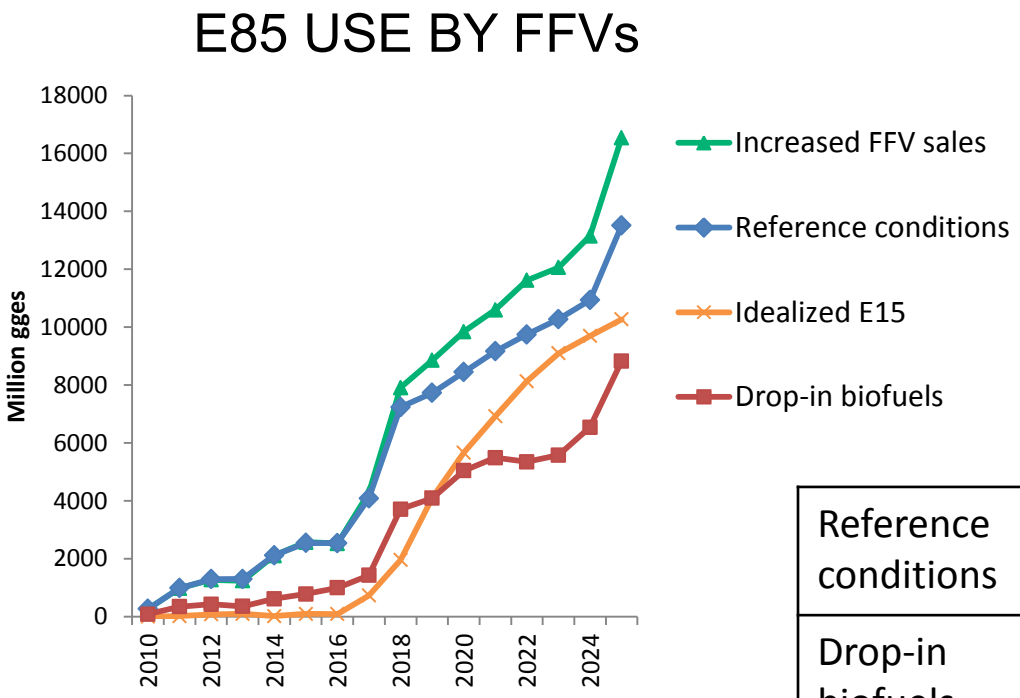
2 – Results: Even in Absence of Risk, Biorefinery Investment Levels Required for RFS-2 Compliance with ethanol are Difficult to Attain

Simulated biorefinery investment timing (solid lines) compared to:

- timing implied by RFS-2 annual mandate increments (dashed lines)
- peak historical annual dry mill capacity addition



2 – Results: An idealized transition to E15 aides in addressing the "blend wall" but has two side effects: reduction in E85 usage and increase in total fuel consumption



Biofuel and Total Fuel Use

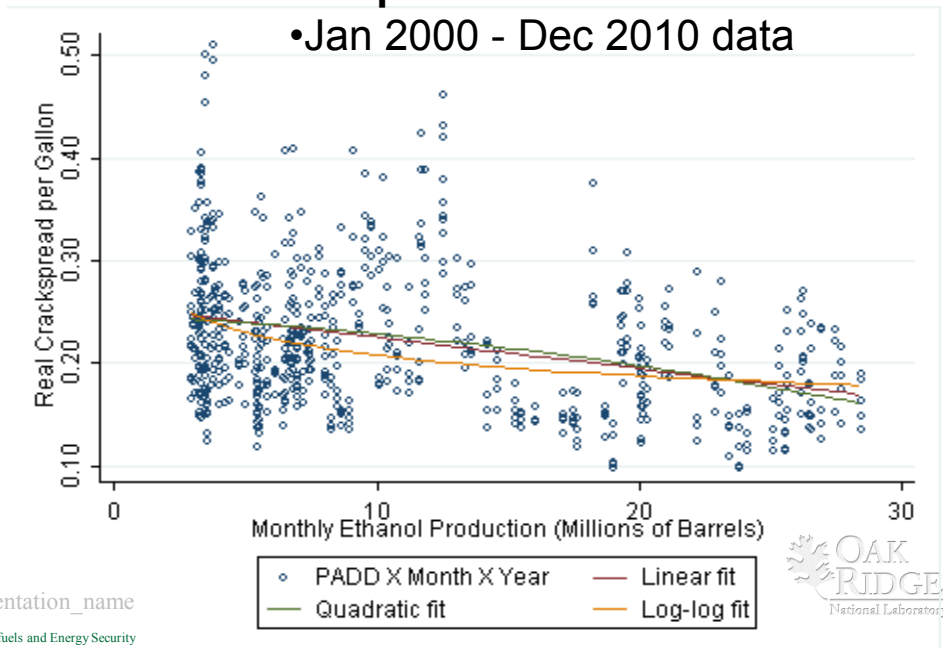
	Gasoline Sector		Diesel Sector	
	Average biofuel content	**Total demand**	**Average biofuel content**	**Total demand**
	(% of gges)	Billion gges	(% of gges)	Billion gges
Reference conditions	11.4%	127.7	2.8%	64.7
Drop-in biofuels	13.5%	126.9	4.9%	64.0
Increased FFV sales	12.2%	127.8	2.8%	64.7
Idealized E15	14.0%	128.2	2.8%	64.7

Idealized Assumptions:
- No changes required in retail infrastructure
- Decision between consumption of E10 and E15 is based exclusively on relative prices

Task 2: Analysis of the Effect of Biofuels on Gasoline Price Levels and Volatility

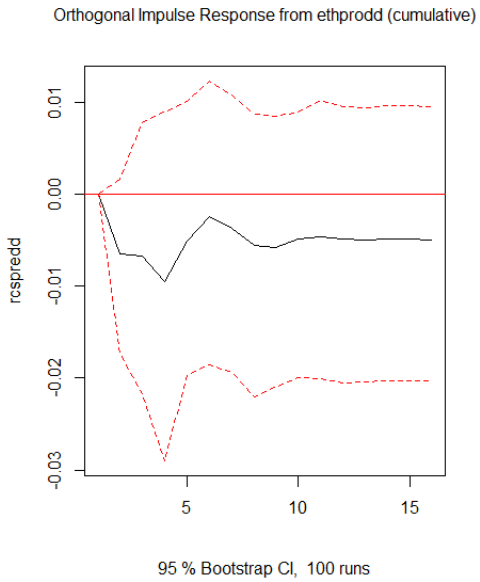
- Relevance: Biofuels *economic* benefits depend on their fuel market impacts (products and crude):
  - fuel price levels (costs/benefits)
  - price stability (energy security – another topic)
- Context: controversial papers suggested ethanol production had very large gasoline price reduction effect
  - Need for careful reconsideration, to support DOE analysis
- Approach:
  - Empirical - statistical analysis of multiple monthly time series
  - Conceptual - identify possible channels for ethanol production to affect gasoline price

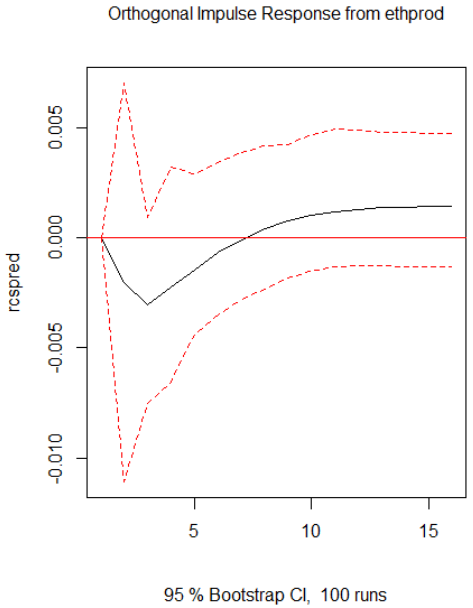
Real Crack Spread vs. Ethanol Production



Task 2: Analysis of the Effect of Biofuels on Gasoline Price – Results

- Replicated Du and Hayes (2012)
  - Extended time range, tested alternative specifications, identified issues
- Applied two improved time series methods
  - VAR and VECM with corrections for nonstationarity
  - These methods provide much more modest, but more defensible, estimates of ethanol price impact.
  - Effects vary by region and time, indistinguishable from zero in many, but support modest (~10c/gal) in some regions
- Paper in draft to be revised and submitted for publication in Q3

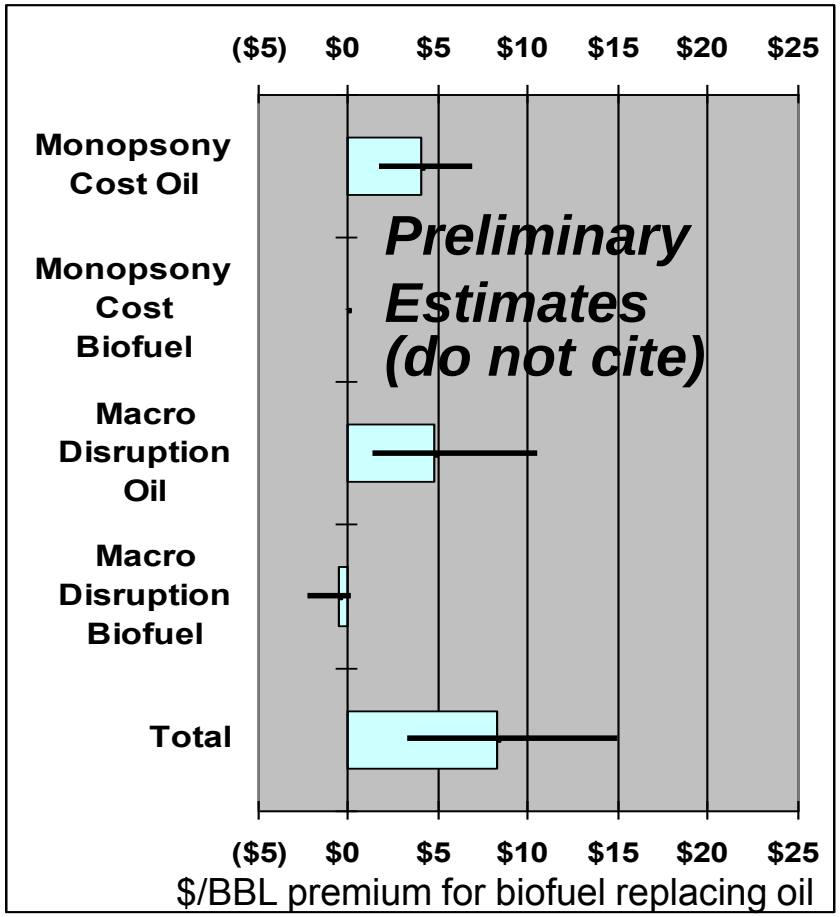




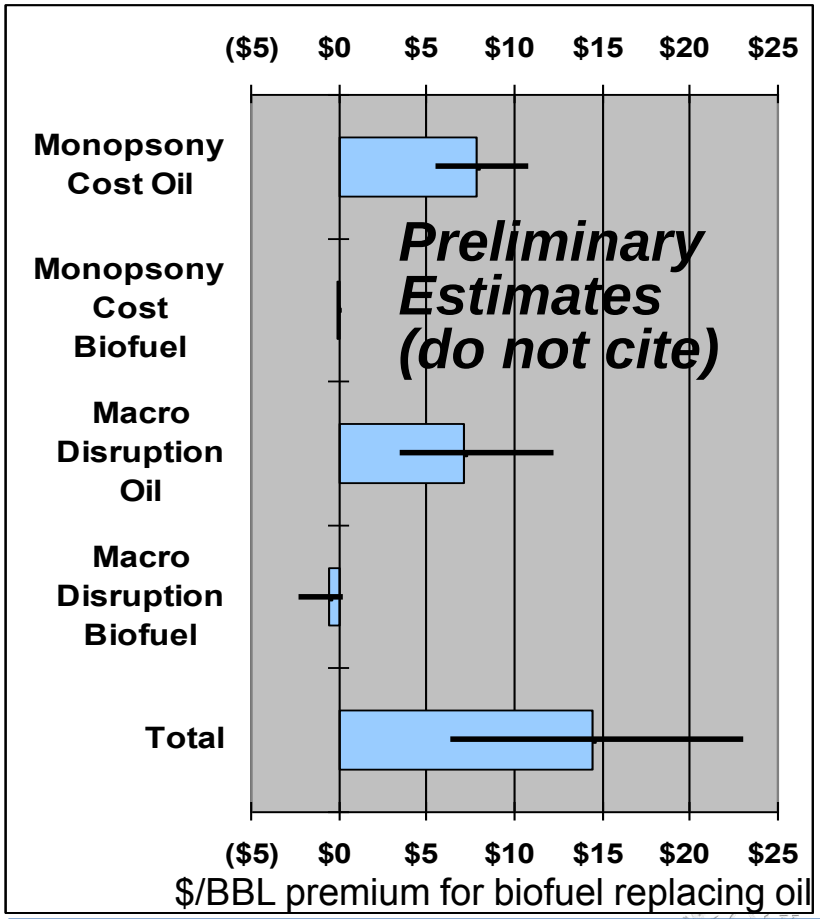
Task 3: Developing Biofuels Energy Security Premium Calculator for KDF (Initiated, Qtr 3-4 activity)

Estimated Security Benefits of biofuels decomposed into demand market power component and disruption component.

Estimates from security market model and disruption simulations.



•Case if No Elasticity Gains



•Case with Demand Elasticity Gains

Task 3: Developing Biofuels Energy Security Premium Calculator for KDF

- **Motivation:**
  - To refine and publicize (through KDF) simple summary measure ($/gallon) of biofuels security benefits
- **Approach:**
  - Developing and implementing a U.S. Energy Security Premium calculation specific to biofuels
    - Oil premium method developed, peer-reviewed by panel commissioned by EPA
  - Adding a new feature to KDF by posting the Biofuels Security Premium estimation
    - Some capability for user interaction, revising certain market conditions/assumptions
- **Progress:**

  Methodology revision outlined, implementation path devised.

3 – Relevance

- **Identifying barriers to market deployment of biofuel pathways is a key for the success of BETO's Biomass Program**
  - **Explore strategies to address barriers to BETO-sponsored technologies near commercial viability**
- **Private companies involved in biofuels R&D (e.g. Ceres, Exelus) are interested in insights from our transitional model approach.**
- **Our modeling approach can be used to validate the economic viability of biofuel production pathways against other biofuels**
- **Energy Security is a central goal for biofuels**
  - **but biofuels systems configurations differ, and should be carefully assessed and designed to assure they enhance security**

4 - Critical Success Factors

- **Establish effective model scale and scope**
  - Configure BioTrans to be well-suited for exploring costs and benefits of national bioenergy policies (both in the long-run and during shorter-run shocks)
- **In transitional analysis, capture the crucial dimensions of infrastructure compatibility, capital constraints, and market choice**
- **BioTrans modeling approach complements and builds on others**
  - Economic theory provides a framework for consistent behavior by firms and consumers, and assessing potential market outcomes
  - Incorporates latest information on technical status, barriers, and markets
- **Testing, benchmarking and parameter validation**
  - Our empirical analysis of observed behavior and market outcomes supports parameter validation (e.g., for price transmission from ethanol to gasoline)
- **Provide value by consistent focus on understanding the market effects and energy security value of biofuels, at national level**

5. Future Work

- **(A) Extensions/Application of BioTrans**
  - Improved representation of extended blends use and drop-in fuel introduction
  - Including risk and limited foresight for investors (Interactions with shocks)
  - Enhanced fuel/vehicle choice characterization
- **(B) Advanced benefits analysis**
  - Short/long run disruption simulation capability for biomass and oil supply/demand shocks
  - Environmental and security benefits quantification
- **(C) Combined empirical analysis of oil and biofuel markets**
  - Estimation of price impact of U.S. biofuel, gasoline, crude oil. RINs, E85, mid-blends.
  - Estimate biofuel impacts on price stability/volatility, demand.
- **(D) Collaborations with other BETO teams (BSM; BLM; ORNL's Resource Analysis; Global Modeling and Land Use; KDF team) and universities**
  - On sharing data/methods
  - On biofuel strategic and transition analysis

Summary

- **Approach**

  - **Combining optimization and econometric analysis** tools to examine scenarios about the future and analyzing observed market outcomes

- **Technical accomplishments**

  - **Completed BioTrans V1 model development** and preliminary results on RFS-2 attainment
  - **Initial estimates of effect of ethanol on gasoline price** levels

- **Relevance**

  - **Identifies market barriers** to advanced biofuel deployment and **explores strategies** for addressing them and **establishing benefits**

- **Critical Success Factors**

  - **Capturing central issues for market effects and transition** to alternative fuels: infrastructure compatibility, capital constraints and fuel/vehicle choice

- **Future Work**

  - **Refining model specification, applying**, for informative accounting of costs and benefits

- **Technology Transfer/Outreach**

  - **KDF public deployment** of Security Premium Calculator with user-interactive features

Additional Slides

Project Milestones and Deliverables

Task(s)	Milestone	Due date	Status
11.2.3.5.1.DL1	Short initial note reporting comparison of costs and feasibility of attaining 2017 EISA/RFS2 goals (and 2022 goal) under alternative system configurations. Seek to identify barriers.	3/30/2013	Complete
11.2.3.5.1.DL2	Evaluation of performance of alternative biofuel system configurations under shocks to feedstock supply or to the price of outputs (biofuel or co-products) and competing petroleum-based fuels.	6/30/2013	60% complete
11.2.3.5.1.DL3	Final report on key barriers and cost-effective approaches to achieve EISA goals nationally	9/30/2013	40% complete
11.2.3.5.2.DL1	Draft summary of literature, proposed methodology and initial empirical results	3/30/2013	90% complete
11.2.3.5.2.DL2	Paper on “Effect of Biofuels on Gasoline Price Levels and Volatility” submitted to peer-reviewed journal	6/30/2013	60% complete
11.2.3.5.3.DL1	Report describing the Biofuels Energy Security Premium and estimated values.	6/30/2013	30% complete
11.2.3.5.3.DL2	KDF on-line Calculator for Biofuels Energy Security Premium	9/30/2013	10% complete

Publications, Presentations, and Commercialization

Reports

Uria-Martinez, R. P. Leiby and M. Brown (2013). "Feasibility and Costs of Attaining 2017 and 2022 RFS-2 Goals under Alternative System Configurations," Discussion Draft, March 30, 2013.

Conference Papers

"Advanced Biofuels System Configuration in the U.S.: Cost and Performance Tradeoffs", Rocio Uria-Martinez and Paul Leiby, ORNL. Selected Paper prepared for the 2012 AAEA Annual Meeting, Seattle, Washington, June 2012.

"Over the Blend Wall: E85 Retailing Costs and Constraints", Rocio Uria-Martinez and Paul Leiby, ORNL. Conference paper submitted for the Transportation Research Board Annual Conference. Jan 24, 2012.

Presentations

"Advanced Biofuels System Configuration in the U.S.: Cost and Performance Tradeoffs", Rocio Uria-Martinez and Paul Leiby, ORNL. Presentation in AAEA Annual Meeting, Seattle, Washington, August 14, 2012

"Bioenergy Security" Paul N. Leiby and Rocio Uria-Martinez. Presentation to the DARPA Young Faculty Awards Group at Oak Ridge TN, December 13, 2011.

"Modeling Energy Security and Economic Sustainability Issues in the U.S. Biofuel Industry". October, 2011. Presentation at the 30th USAEE/IAEE North American Conference. Washington, DC.

2 – Progress: On Track towards FY13 Milestones Completion

TASKS	MILESTONES	DUE DATES
Transition analysis to achieve EISA goals, promote economic and energy security	• BioTrans V1. model complete.	FY13Q2
	• Note on feasibility and costs of attaining RFS-2 targets	
	• Evaluation of alternative biofuel system configurations under shocks	FY13Q3
	• Report on key barriers and cost-effective approaches to RFS-2 attainment	FY13Q4
Econometric analysis of effects of biofuels on gasoline price levels and volatility	• Summary of literature, proposed methodology and initial results	FY13Q2
	• Paper submission	FY13Q3
Biofuels Energy Security Analysis	• Report describing Security Premium methodology and estimated values	FY13Q3
	• KDF on-line ES Premium calculator	FY13Q4

Acronyms

- BILT Model: Biomass Infrastructure and Logistics Transport model
- BLM Model: Biomass Logistics Model
- EISA: Energy Independence and Security Act
- GTAP Model: Global Trade Analysis Project
- GREET: Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
- HyTrans Model: Hydrogen Transition Model
- KDF: Knowledge Discovery Framework
- ORNL: Oak Ridge National Laboratory
- SVN: SubVersion code version control system
- SWAT: Soil and Water Assessment Tool
- TAFV Model: Transitional Alternative Fuels and Vehicles Model
- VECM: Vector Error Correction Model
- VAR: Vector Auto Regression