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
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
## Progress: On Track towards FY13 Milestones Completion

### FY2013:

<table>
<thead>
<tr>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
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</table>

**Transition Analysis to Achieve EISA Goals, Promote Economic and Energy Security**

- **Biotrans V1 Model Complete**
- **Note on feasibility and costs of attaining RFS-2 targets**
- **Evaluation of alternative biofuel system configurations under shocks**
- **Report on key barriers and cost-effective approaches to RFS-2 attainment**

**Econometric Analysis of Effects of Biofuels on Gasoline Prices Levels and Volatility**

- **Summary of literature, proposed methodology and initial results**
- **Paper submission**

**Biofuels Energy Security Analysis**

- **Report describing Security Premium methodology and estimated values**
- **KDF online energy security premium calculator**
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

**BILLION TON STUDY**
Used for constructing regional supply curves of biomass feedstocks

**BLM**
Modeling framework to simulate biomass supply logistics from the field to biorefinery

**NREL Process Design Reports and Theoretical Yield Calculator**
White Papers on Biochemical and Thermochemical Biorefinery Sizing

**Transitional Alternative Fuel & Vehicle, HyTrans**
ORNL Dynamic market optimization to balance motor fuel supply to demand

**GTAP (task 11.2.3.1)**
Biofuels imports and exports

**BIOTRANS-Long-Run Model**
- Integrates summary representations from each of above
- Balances markets and determines fixed capital

**BIOTRANS Stochastic Short-Run Simulations**
- Simulate monthly over 1 year
- Shocks from oil producer behavior, disruptions and accidents
- Shocks to yields from weather events: droughts, floods, pests
- Infrastructure reliability

**Oil Security Metrics Model (to be included in KDF)**
- Provide framework for quantifying and measuring energy and economic security impacts

**Annual Energy Outlook**
Data on fuel demand, oil prices

**Other Measures of Sustainability:**
- Long run economic costs
- GHG Emission Coefficients (GREET)
- Water Quality model (SWAT)
2 - Progress: Completed Note on Feasibility and Costs of Various Levels of RFS-2 Achievement*

*Note: 2022 RFS2 cellulosic target is 16 billion gallons

**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

**Key Barriers:**
- E10 “blend wall”
- FFV stock size
- Retail infrastructure introduction rate
- Inconvenience cost of E85 refueling
- Biorefinery investment rate limits
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

- Full achievement
- AEO2012 achievement
- Technological progress without RFS-2

2017

2022

Cumulative retail investment
Cumulative biorefinery investment
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

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

E85 USE BY FFVs

Biofuel and Total Fuel Use

<table>
<thead>
<tr>
<th></th>
<th>Gasoline Sector</th>
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<th>Diesel Sector</th>
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<tbody>
<tr>
<td></td>
<td>Average biofuel</td>
<td>Total demand</td>
<td>Average biofuel</td>
<td>Total demand</td>
</tr>
<tr>
<td></td>
<td>content (%)</td>
<td>Billion gges</td>
<td>content (%)</td>
<td>Billion gges</td>
</tr>
<tr>
<td>Reference conditions</td>
<td>11.4%</td>
<td>127.7</td>
<td>2.8%</td>
<td>64.7</td>
</tr>
<tr>
<td>Drop-in biofuels</td>
<td>13.5%</td>
<td>126.9</td>
<td>4.9%</td>
<td>64.0</td>
</tr>
<tr>
<td>Increased FFV sales</td>
<td>12.2%</td>
<td>127.8</td>
<td>2.8%</td>
<td>64.7</td>
</tr>
<tr>
<td>Idealized E15</td>
<td>14.0%</td>
<td>128.2</td>
<td>2.8%</td>
<td>64.7</td>
</tr>
</tbody>
</table>
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
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)


- 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

<table>
<thead>
<tr>
<th>Task(s)</th>
<th>Milestone</th>
<th>Due date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.2.3.5.1.DL1</td>
<td>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.</td>
<td>3/30/2013</td>
<td>Complete</td>
</tr>
<tr>
<td>11.2.3.5.1.DL2</td>
<td>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.</td>
<td>6/30/2013</td>
<td>60% complete</td>
</tr>
<tr>
<td>11.2.3.5.1.DL3</td>
<td>Final report on key barriers and cost-effective approaches to achieve EISA goals nationally</td>
<td>9/30/2013</td>
<td>40% complete</td>
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<tr>
<td>11.2.3.5.2.DL1</td>
<td>Draft summary of literature, proposed methodology and initial empirical results</td>
<td>3/30/2013</td>
<td>90% complete</td>
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<tr>
<td>11.2.3.5.2.DL2</td>
<td>Paper on “Effect of Biofuels on Gasoline Price Levels and Volatility” submitted to peer-reviewed journal</td>
<td>6/30/2013</td>
<td>60% complete</td>
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<tr>
<td>11.2.3.5.3.DL1</td>
<td>Report describing the Biofuels Energy Security Premium and estimated values.</td>
<td>6/30/2013</td>
<td>30% complete</td>
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<tr>
<td>11.2.3.5.3.DL2</td>
<td>KDF on-line Calculator for Biofuels Energy Security Premium</td>
<td>9/30/2013</td>
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</table>
Publications, Presentations, and Commercialization

Reports


Conference Papers


Presentations


2 – Progress: On Track towards FY13 Milestones Completion

**Tasks**

- Transition analysis to achieve EISA goals, promote economic and energy security
- Econometric analysis of effects of biofuels on gasoline price levels and volatility
- Biofuels Energy Security Analysis

**Milestones**

- **BioTrans V1. model complete.**
  - FY13Q2
- **Note on feasibility and costs of attaining RFS-2 targets.**
  - FY13Q3
- **Evaluation of alternative biofuel system configurations under shocks.**
  - FY13Q4
- **Report on key barriers and cost-effective approaches to RFS-2 attainment.**
  - FY13Q4
- **Summary of literature, proposed methodology and initial results.**
  - FY13Q4
- **Paper submission.**
  - FY13Q4
- **Report describing Security Premium methodology and estimated values.**
  - FY13Q4
- **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