Impact of Hydrogen Production on U.S. Energy Markets

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This presentation does not contain any proprietary or confidential information
Overview

Timeline
• Project to start May 2005
• Project end date is September 2008

Budget
• Total project funding is $1.3 million
• Funding for FY05 TBD

Partners
• EEA Inc.
• Brookhaven National Lab
• Power & Energy Analytic Resources

Barriers
• Lack of Consistent Data, Assumptions, and Guidelines
• Lack of Macro-Systems Model
• Lack of Understanding of Transition of a Hydrocarbon-Based Economy to a Hydrogen-Based Economy
Objectives

• Develop a consistent, integrated framework for evaluation of impacts of hydrogen production within U.S. energy markets.

• Evaluate costs and timeliness of various scenarios of a developing hydrogen supply infrastructure.

• Evaluate impacts on U.S. energy markets including price and consumption changes for coal, natural gas, renewables and electricity.

• Identify most economic routes and financial risks of hydrogen production.
Approach

• Primary modeling framework will be the MARKAL model.

• MARKAL will be modified to incorporate latest and most consistent cost and performance data for alternative hydrogen production technologies.

• Additional analyses on natural gas markets will be performed using models from EEA. Key relationships will be incorporated/calibrated into MARKAL
Approach (cont.)

- Additional analyses on coal and electricity markets will be performed using models from PEAR. Key relationships will be incorporated/calibrated into MARKAL.
- Scenario analyses and sensitivity analyses to be performed with MARKAL.
- Results to be presented in series of briefings and reports.
## Milestones

<table>
<thead>
<tr>
<th>Milestone #</th>
<th>Task #</th>
<th>Date Completed</th>
<th>Description of Completed Analysis</th>
<th>Deliverable Milestone</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Nov-05</td>
<td>Development of consistent set of technical and economic assumptions to be used in the analysis</td>
<td>Appendix for Final Report</td>
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<td>Apr-06</td>
<td>Hydrogen Market Assessment</td>
<td>Briefing</td>
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<td>3</td>
<td>3</td>
<td>Apr-06</td>
<td>Completion of Scenario Development</td>
<td>Briefing</td>
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<td>4</td>
<td>4</td>
<td>Sep-06</td>
<td>Completion of Initial Feedstock Market Impact Analysis</td>
<td>Draft Report on each feedstock</td>
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<td>5</td>
<td>Feb-07</td>
<td>Completion of Power Generation and Other Market Analysis</td>
<td>Draft Report</td>
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<td>6</td>
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<td>Feb-07</td>
<td>Completion of Draft Integrated Analysis</td>
<td>Briefing</td>
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<td>Jul-07</td>
<td>Completion of Final Integrated Analysis</td>
<td>Briefing</td>
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<td>7</td>
<td>Dec-07</td>
<td>Complete Draft of Final Report</td>
<td>Draft Report and Briefing</td>
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<td>May-08</td>
<td>Complete Optional Analysis</td>
<td>Report and Briefing</td>
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<td>11</td>
<td>7</td>
<td>Sep-08</td>
<td>Final Report available for publication</td>
<td>Final Report</td>
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Milestones
MARKAL for Integrated Market Analysis

Resource Extraction → Refining & Conversion → Transport → Generation → Transmission & Distribution → Utilization Devices → End-use

Other Sources → Refined Products
Crude Oil → Refined Products
Renewables
Coal
Natural Gas
Nuclear
*Electrolysis → Hydrogen

* Hydrogen → Fuel-Cell Vehicles

* Electricity → Air-conditioning
Space Heating
Water Heating
Office Equipments
Misc. Electric Building
Misc. Electric Industrial
Process Heat
Petro/Biochemicals
Other Transportation
Passenger Travel
MARKAL for Integrated Market Analysis

• Generates least-cost energy path based on life-cycle costs of technologies
• Utilizes a bottom-up approach to identify an optimal technology/resource mix to meet demands in a balanced energy market
• Consists of a dynamic integrated framework to assess market competition, technology diffusion and emission accounting
• Produces outputs that facilitate the analysis of economic tradeoffs among alternative energy infrastructure systems
Model Interactions in Hydrogen Market Analysis

GMDFS: Gas Market Data and Forecasting System
HSM: Hydrocarbon Supply Model
PEAR Models: PEAR Competitive Generation Cost Model & PEAR Compliance Options Model
TAFVM: Transitional Alternative Fuel Vehicle Model
HFCM: Highway Fuel Consumption Model
Model Interactions in Hydrogen Market Analysis

- **TAFVM & HFCM** generates demands (e.g. fuel cell vehicles) used in **MARKAL**
- **HSM & GMDFS** provide natural gas supply and power demand used in **MARKAL**
- **PEAR Models** determine coal production and use
- **MARKAL** incorporates disparate elements from individual models to perform integrated analysis
Unique Features of Project

• Integrates supply/demand and various fuel markets
• Inter-temporal approach that looks at technology evolution and stranded investments
• Evaluates energy markets over the long-term (2005 - 2050)
• Examines alternative scenarios and sensitivities
• Focuses of on the competition among production technologies
• Considers hydrogen demand levels, technology costs, regional cost variations, and feedstock prices
• Estimates impact of hydrogen production on hydrogen feedstock prices and consumption changes in other energy markets
EEA Gas Market Model

- EEA’s model is a general equilibrium representation of gas markets throughout North America.
- The model simulates North American gas markets on a monthly basis, solving for gas demand, production, storage activity and prices within many regions and nodes.
- Creates a monthly balance of gas supply and demand at over 120 market locations integrated by an extensive pipeline network.
  - Balance includes pipeline flows and storage injections and withdrawals at each location.
Monthly Gas Quantity And Price Equilibrium

Production And Storage Gas Price

Deliverability

Production

Pipeline Value

100%

Pipeline Load Factor

Gas Transmission

Gas Price

Inelastic Demand

Distillate Switching

Residual Oil Switching

Quantity Consumed

Gas Demand

Includes Storage During The Injection Season

Production And Storage

Only Includes Storage During The Withdrawal Season
Uses of the EEA Gas Model

• Facility investment decisions
  – Own investment
  – Competitor’s investment
• Gas supply planning
• Gas and oil resource economics
• Evaluate weather risk
• Gas infrastructure requirements
• Due diligence for M&A activity
• Certification and rate case proceedings
• Policy studies
Scenarios and Sensitivities with EEA Gas Model

• Most forecasts have been created for planning purposes for the next 5 or more years.
  – Scenarios can be run through 2035.

• Many levers for scenario analysis. The most commonly changed variables include:
  – Gas supply drivers
  – Power plant additions and availability
  – Pipeline/storage expansions
  – Economic growth
  – Weather
  – Oil and coal prices