



U.S. Department of Energy
Energy Efficiency and Renewable Energy

DOE Hydrogen Program Systems Analysis

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Support decision-making by evaluating existing and emerging technologies, utilizing a fact-based analytical framework to guide the selection and evaluation of R&D projects and provide a sound basis for estimating the potential value of research and development efforts.

By 2007 Complete:

- Evaluation of transition scenarios consistent with developing infrastructure and hydrogen resources.

By 2008 Develop:

- A Macro-System Model of the transitional hydrogen fuel and vehicle infrastructure.

By 2010:

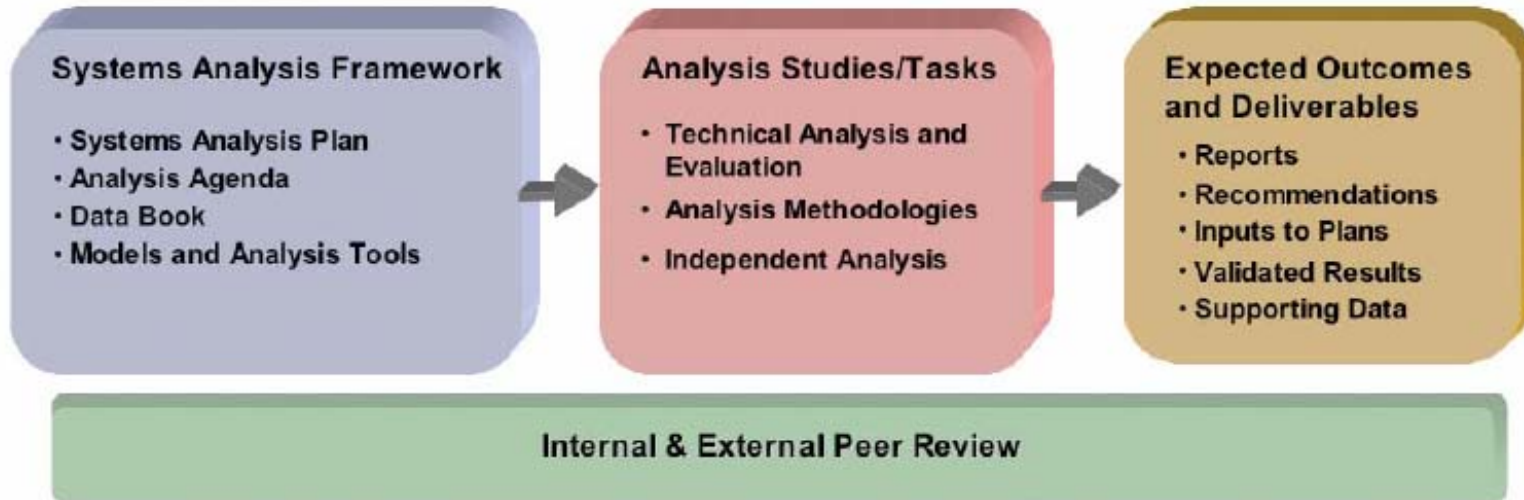
- Enhance the Macro-System Model to include the stationary electrical generation and infrastructure for a full hydrogen economy.

Continuously:

- Support the integration of the Hydrogen Program within a balanced, overall DOE national energy R&D effort.
- Provide and coordinate analysis of environmental and technoeconomic issues.
- Support a spectrum of analyses, including financial and environmental assessments.



Systems Analysis Approach



- Support Program decision-making processes and milestones.
- Ensure objective inputs.
- Provide direction, planning and resources/tools.
- Provide ongoing and planned studies and tasks.
- Provide independent analysis when required to validate decisions.
- Provide value-added products.
- Measure progress through a regular peer review process.
 - Respond to external review recommendations.



Lack of Prioritized List of Analyses Needs

- Current analysis activities not coordinated; on an adhoc basis
- Major demand for analysis work and projects will be forthcoming



Lack of Consistent Data, Assumptions and Guidelines

- Current data sources inconsistent
- Input assumptions vary for different tasks
- No guidelines for modeling and analysis



Lack of a Macro-System Model

- Current modeling architecture for overarching transitional and infrastructure analysis does not exist.
- Need to link wide range of models in order to analyze the hydrogen fuel infrastructure.

Lack of Understanding of the Transition of a Hydrocarbon-based Economy to a Hydrogen-based Economy

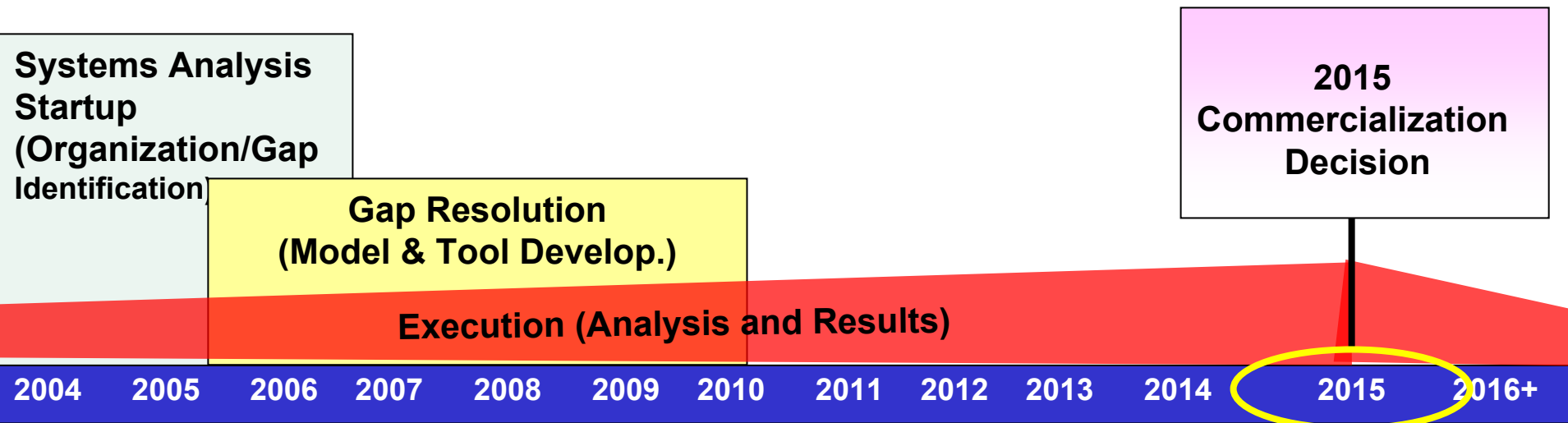
- Long-term hydrogen infrastructure and the evolution is not well understood.
- Numerous economic, social, political and technical influences involved in the transition.

Stove-Piped/Siloed Analytical Capabilities

- Each group and element perform separate analysis for similar subjects
- Systems analysis requires integration of analysis resources



Systems Analysis Planning



Planning Step Descriptions

Systems Analysis Startup

- Systems Analysis function established
- Systems Analysis incorporated into RD&D Plan
- Systems Analysis Plan
- Identify analytical gaps and “missing pieces”

Gap Resolution

- Data Book
- Analysis Repository
- Analysis Portfolio
- H2A Phase 2
- Macro-System Model
- Transition Models
- H2A Delivery Model
- HyTrans
- Incorporate H2A into PBA NEMS and Markal Models
- Macro-System Model with stationary electrical generation

Execution (Analysis and Results)

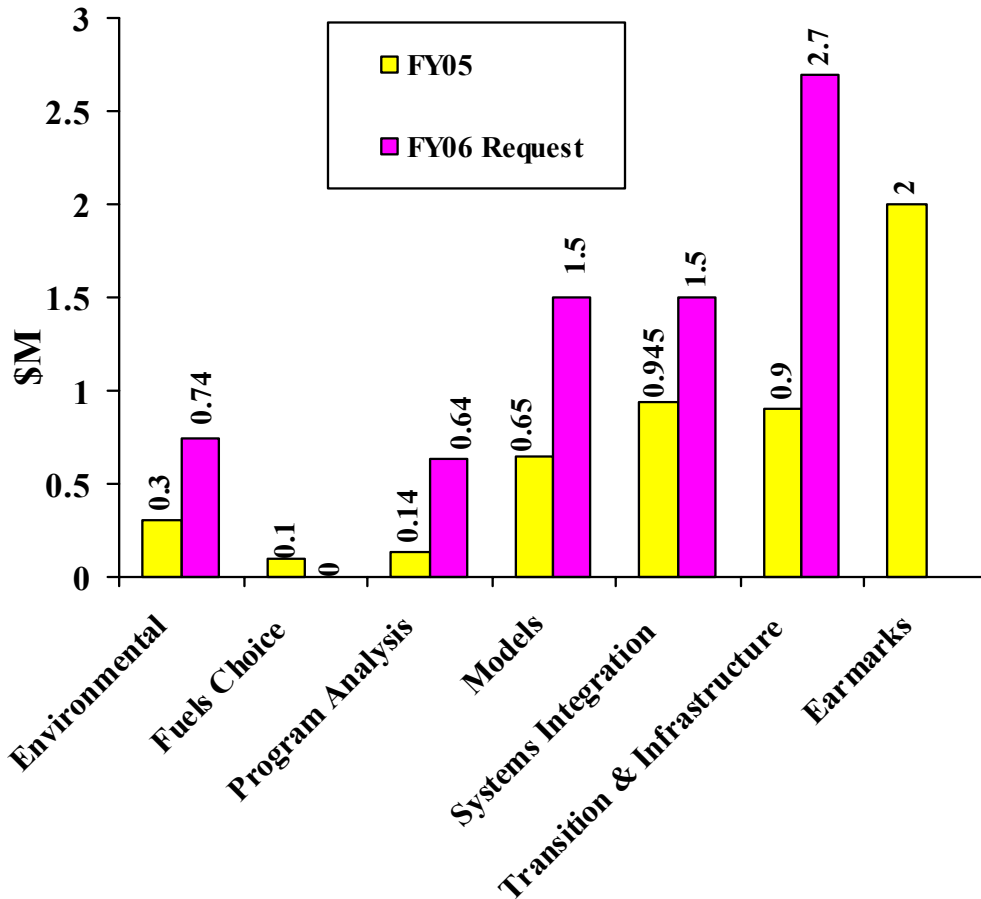
- Individual Technology analysis
- Hydrogen Economy Analysis
- Environmental analysis
- Well-to-Wheels analysis
- Policy analysis
- Transition and infrastructure analysis
- Energy efficiency analysis



Systems Analysis Budget

FY 2006 Budget Request = \$7.08M

FY 2005 Appropriation = \$3.40M

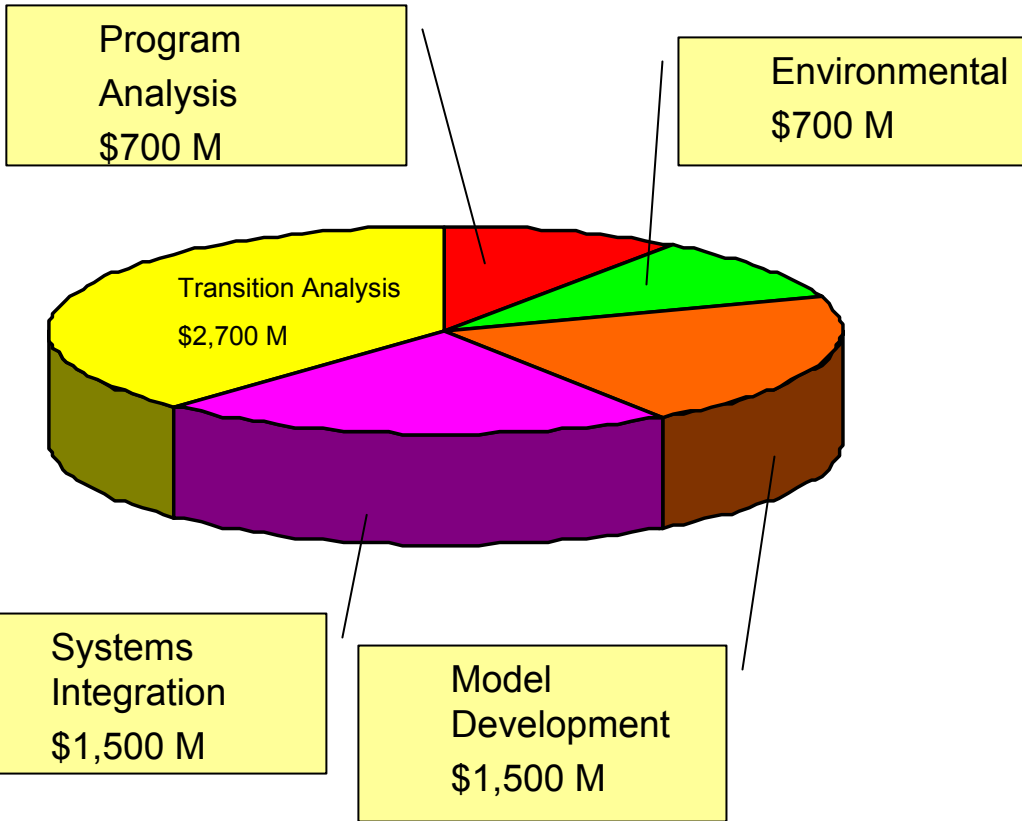


- **Emphasis:**
Conduct cross-cutting life cycle analysis, emissions, environmental and systems integration analysis to identify the impacts of various technology pathways, assess associated cost elements and drivers, and identify key cost and technological gaps.



Systems Analysis Budget Details

Hydrogen Program Systems Analysis FY06 Budget



FY06 : Focus on Transition and Macro-System model development and analysis.

- **Transition Analysis**
 - Direct Tech. Inc.
 - Infrastructure evolution and development
 - Energy & Environ. Anal Inc
 - Resources eval.
 - RCF, Inc
 - Transition optimization
 - NREL
 - Geographic delivery eval.
- **Systems Integration**
 - Risk Management
 - Integrated Baseline
- **Model Development**
 - Macro-System Model
 - Linking model for H2 economy assessment
 - Other models (H2A, HyDS)
- **Environmental**
 - WTW for pathways with PSAT
 - Environmental analysis for projects (NEPA)
- **Program Analysis**
 - Infrastructure develop support
 - H2A analysis Support
 - Energy resource evaluation



2005 and 2006 DOE Systems Analysis Projects

Program Analysis

NREL
Oak Ridge Nat. Lab.

Models

NREL
Oak Ridge Nat. Lab.

Transition and Infrastructure

Direct Technologies, Inc (DTI)
Energy and Environmental
Analysis, Inc (EEA)
NREL
Oak Ridge Nat. Lab.
Brookhaven Nat. Lab.

Systems Integration NREL

Environmental Analysis

Argonne
NREL

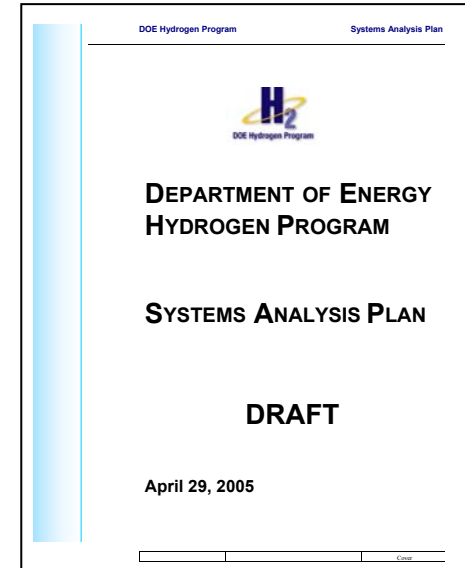
Fuels Analysis

TIAX



Systems Analysis

- **Program Analysis**
 - Completed a thorough review of the Hydrogen Program hydrogen cost target of \$1.50/gge.
 - Revised the hydrogen cost goal to a range of \$2.00 to \$3.00/gge.
 - Peer reviewed the cost target
 - Established a “process” for determining the hydrogen cost goal
- **Planning/Organization**
 - The 1st Systems Analysis Section completed for the RD&D Plan to establish the organization of the Systems Analysis function.
- **Systems Analysis Plan**
 - Review draft of the Systems Analysis Plan completed (4/2005).
 - Internal review followed by Peer Review.
- **Analysis Portfolio**
 - Working with Systems Integrator to develop the Analysis Portfolio.





Technical Accomplishments/ Progress

- **Data Book**
 - Outline for data, assumptions and guidelines prepared.
 - Completed search of other elements' data book versions
- **Modeling and Model Development**
 - H2A
 - A “Beta” test was performed with the modeling community to insure consistency and accuracy with outside modeling community.
 - Beginning 2nd phase of the model for scaling, GreenHouseGas (GHG) emissions calculations and links to the GREET model.
 - Macro-System Model
 - Systems Integration preparing the model definition.
 - Model search is being performed to capture required model attributes.
- **Repository of Analysis, Study and Data**
 - Systems Integrator is working to develop an automated database of all analysis, studies, models and data.
 - Contractor is performing a search of all information related to hydrogen to be incorporated into the database.



Application of Systems Analysis in the Hydrogen Program

Analysis of Current Hydrogen Cost Target

- The current hydrogen cost target of \$1.50 / gge (untaxed, 2001\$) for 2010 was developed in 2002.
- Represented a snapshot in time based on distributed natural gas reforming
- Timeframe is not consistent with the 2015 industry commercialization decision



Application of Systems Analysis in the Hydrogen Program

General Principles for Development of Cost Goal

- Provide a "yardstick" for assessing technology performance
- Use as a gauge and guide for R&D
- Develop cost goal through a well defined, transparent process
- Goal reassessment will be based on major changes in technology or external drivers

Application of Principles for the Cost Goal Development

- Cost Goal is pathway independent and defined as a range.
- Consumer fueling costs are equivalent or less on a cents per mile basis.
- Evolved gasoline ICE and gasoline-electric hybrids are benchmarks.
- R&D guidance provided in two forms
 - Evolved gasoline ICE defines the upper bound to be used to gauge pathways and projects
 - Gasoline-electric hybrid defines a lower bound to be used to guide projects for resource allocation



Application of Systems Analysis in the Hydrogen Program

Mechanics

$$\text{H2 Cost (\$/gge)} \leq (\text{EIA Gasoline Price in 2015}) \left[\frac{\text{Fuel Economy H2FCV}}{\text{Fuel Economy Competitive Vehicle}} \right]^1$$

Input	Value	Source
Gasoline price projection for 2015	\$1.26 / gal (untaxed, 2005\$)	EIA Annual Energy Outlook, 2005
Ratio of FCV fuel economy to evolved gasoline ICE	2.40	NRC H2 Economy Report
Ratio of FCV fuel economy to gasoline hybrid	1.66	NRC H2 Economy Report

Results

- Hydrogen Goal Upper Bound = \$3.00 / gge
- Hydrogen Goal Lower Bound = \$2.00 / gge

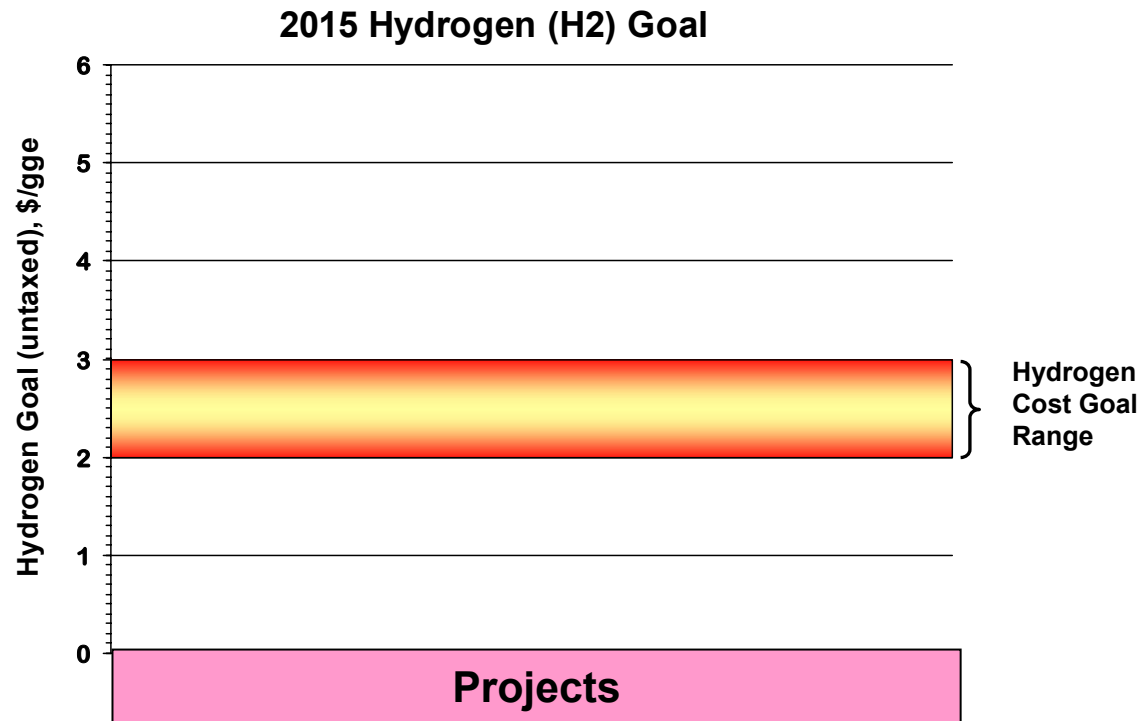
¹ Ratio of FCV fuel economy to competitive vehicle



Application of Systems Analysis in the Hydrogen Program

Program Hydrogen Cost Goal Revision:

- The Hydrogen Cost Goal should be revised expressed as a range (untaxed in 2005\$/gge) for 2015.
 - The upper bound of the Hydrogen Cost Goal will be \$3.00 and used as a gauge for R&D projects.
 - The lower bound of the Hydrogen Cost Goal will be \$2.00 and used to guide the R&D projects (highest resource allocation).
 - The Hydrogen Cost Goal should be reevaluated in the event there is a major change in technology, markets, and/or other external drivers.



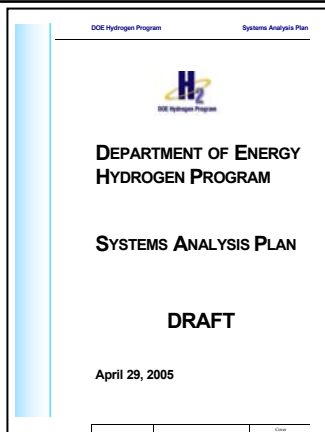
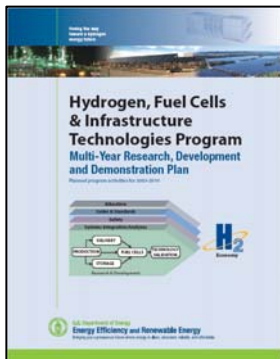
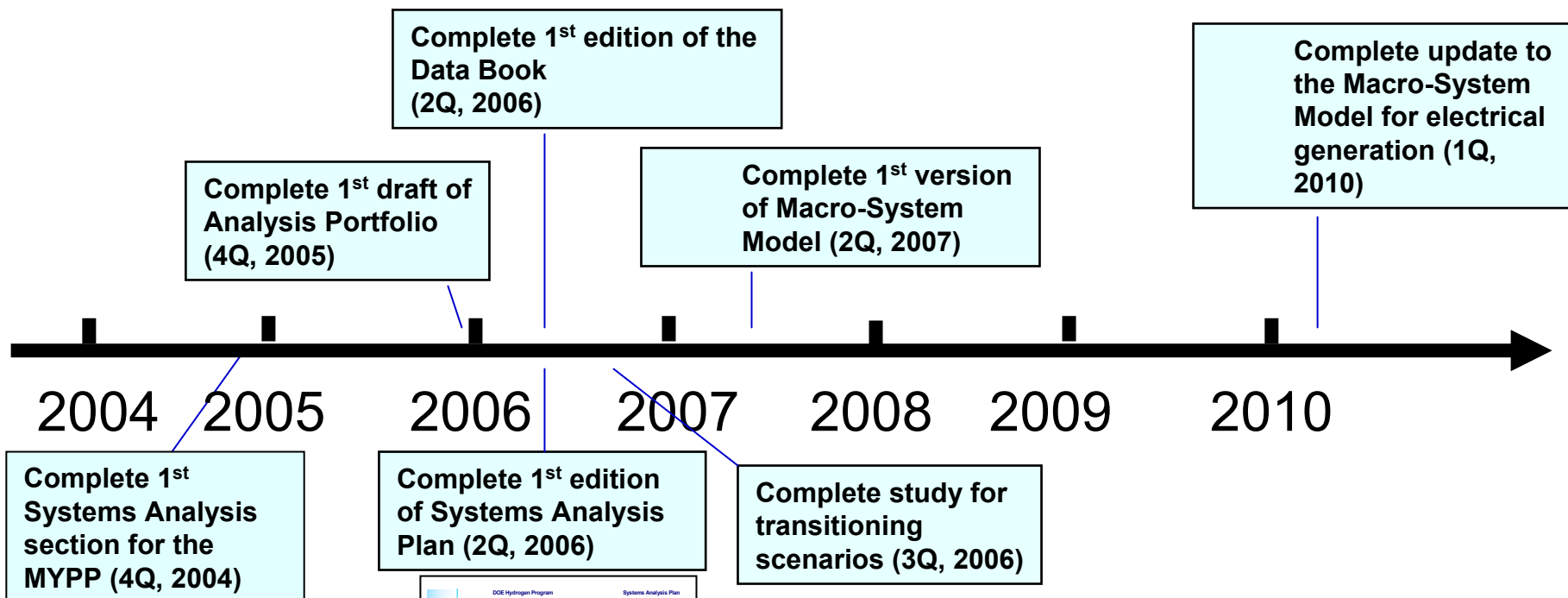


Future Directions

- Focused on resolving known “gaps”
 - Macro-System Model development
 - Transition and Infrastructure analysis
- Continue with the model development required to cover the future analytical tasks.
- Complete the transition projects with DTI, EEA, RCF, NREL and ORNL.
- Begin analyzing the requirements for incorporating hydrogen into the stationary electrical generation system.
- Begin planning for the approach to model and analyze the transition, infrastructure and ultimately the evolving hydrogen economy.



Systems Analysis Key Milestones



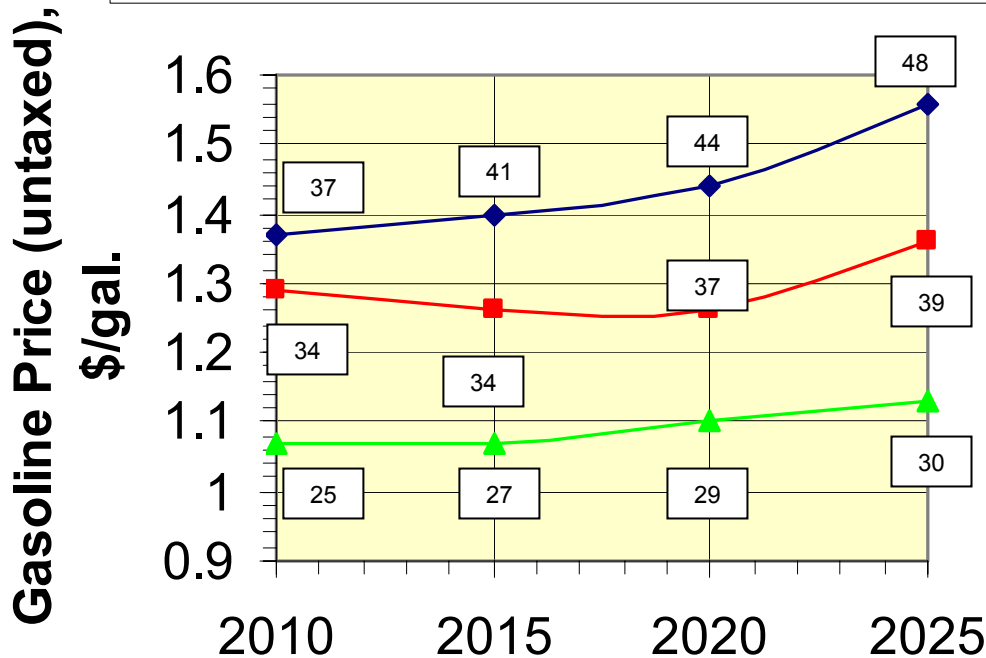


Backup



Assumptions for Cost Model: EIA Gasoline Price (Untaxed) Projections

Source: EIA Annual Energy Outlook 2005, p. 216



- Reference case - not used; relatively, stable prices; little economic case for change
- “Hi A” case – used; greater increase in future (2020-2025)
- “Hi B” case – not used; too far from best projections (Reference case)

- EIA “Hi A” case => \$1.26/gal (untaxed, at crude price of \$34/bbl)
- Note: Prices are in 2005 dollars
- The value in the box is the corresponding crude price in \$/bbl