
U.S. Department of Energy Hydrogen Program

Systems Analysis

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**2008 DOE Hydrogen Program
Merit Review and Peer Evaluation Meeting**

June 9, 2008





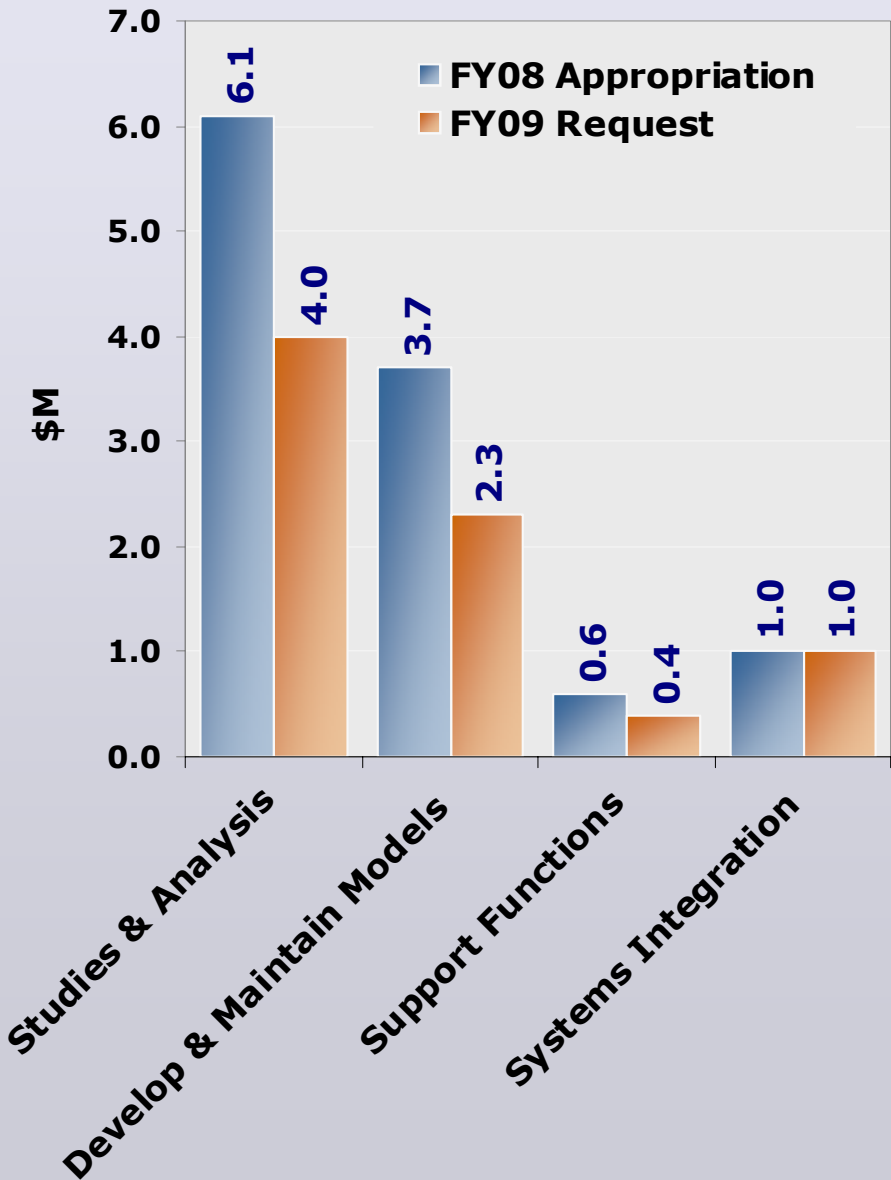
Goals and Objectives

GOAL: Provide system-level analysis to support hydrogen infrastructure development and technology readiness by evaluating technologies and pathways, guiding the selection of RD&D technology approaches/options, and estimating the potential value of RD&D efforts.

- Develop a Macro-System Model for the analysis of the hydrogen fuel infrastructure to support transportation systems by 2008; enhance the model to include the stationary electrical generation and infrastructure for long-term applications analysis by 2011.
- Identify and evaluate early market transformation scenarios consistent with infrastructure and hydrogen resources by 2009.
- Complete environmental studies that are necessary for technology readiness by 2014.
- Update the Well-to-Wheels analysis for technologies and pathways for the Hydrogen Program to include technological advances and changes on an annual basis.



Systems Analysis Budget



FY2009 Budget Request = \$7.7M
FY2008 Appropriations = \$11.5M

- ### **FY09 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
 - Identify key cost and technological gaps

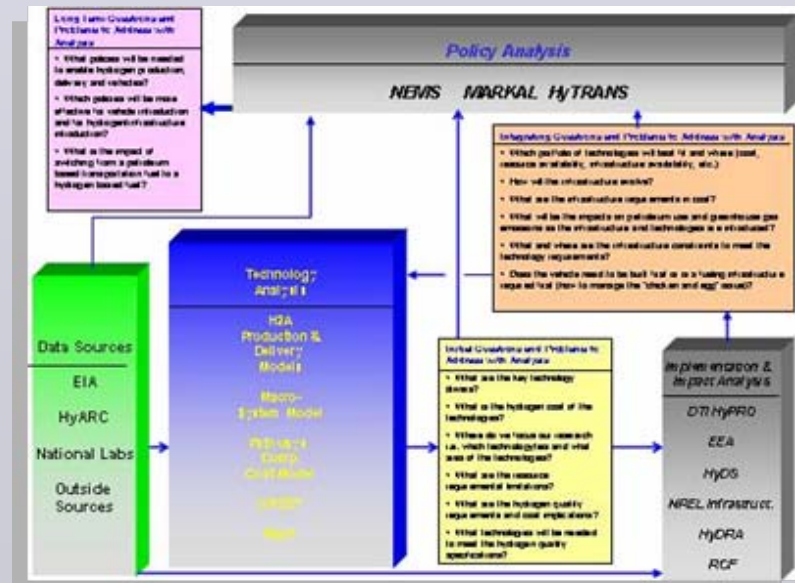


Challenges

- Establish consistent data, assumptions and guidelines for analysis tasks
- Understand behaviors and drivers of the fuel and vehicle markets
- Coordinate and integrate analysis resources and capabilities across analytical domain
- Understand vehicle, fuel and socio-economic policy impacts
- Establish and develop an integrated portfolio of models and tools



<http://hydrogen.energy.gov>





Analysis Portfolio

Programmatic Analysis

- Risk analysis of Hydrogen Program targets and goals
- Petroleum and CO₂ reduction benefits
- Analysis of integrating stationary and transportation fuel cells
- Program benefits for program-related product commercialization

Program Element Analysis

- Hydrogen production and delivery pathway analysis
- Platinum recycling impact on fuel cell cost

Environmental Analysis

- Atmospheric impacts of hydrogen
- Well-to-Wheels analysis of greenhouse gas (GHG) emissions

Policy Analysis

- CO₂ analysis
- Fuel, infrastructure and vehicle subsidy evaluation

Early Market Analysis

- Cost and GHG benefit analysis of early market applications



Systems Analysis Progress

Model & Tool Development Focused

Analysis and Results Focused

2004

2005

2006

2007

2008

2004

- Systems Analysis function established

2005

- Established process for developing hydrogen cost target
- Revised hydrogen cost target to \$2.00-3.00/gge
- Identified analytical gaps and “missing pieces”

2006

- Hydrogen Analysis Resource Center issued
- Well-to-Wheels analysis process established
- H2A Production Model issued
- Systems Analysis Plan issued
- HyDS model completed

2007

- WTW analysis completed
- Macro-System Model test version completed and validated
- Cross-Cut team established
- Scenario Analysis for Transition completed
- Resource and infrastructure analysis started

2008

- Preliminary water analysis completed
- Macro-System Model completed and issued
- H2A Production Model revised and issued
- CO₂ policy analysis completed
- Early market analysis
- Hydrogen quality analysis of impact on production and fuel cell completed
- Pt recycling cost analysis completed



2008 Accomplishments/Results Modeling and Model Development

Macro-System Model

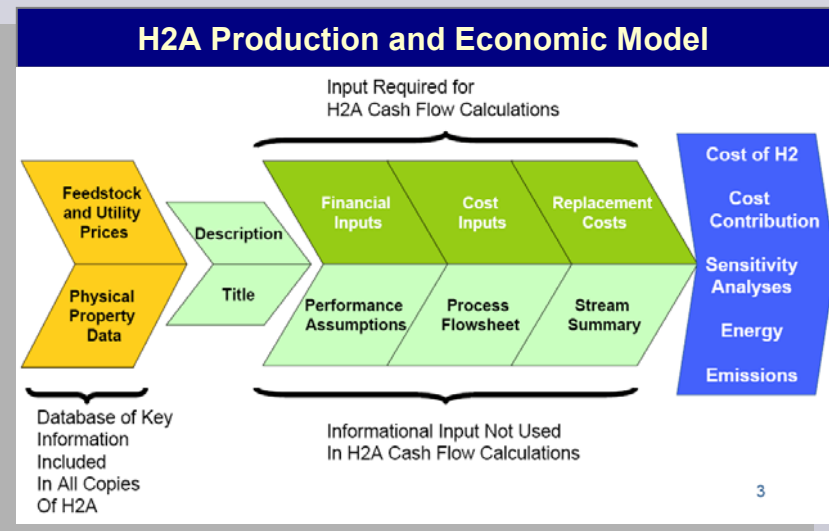
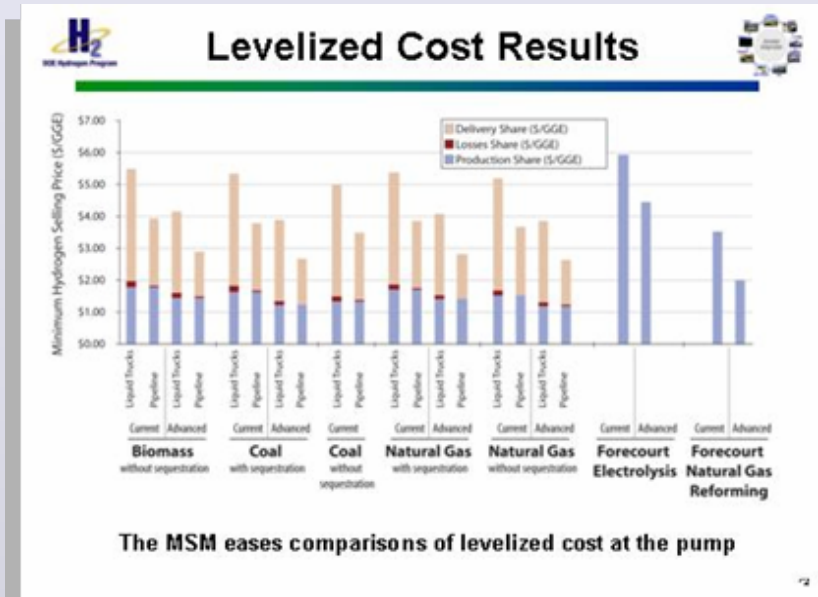
Completed first version of the model

- Completed peer review of the model
- Analyzed the hydrogen cost and greenhouse gas emissions for 7 hydrogen pathways
- Utilized model for EU/US model comparison

H2A Production Model Update

Completed peer reviewed revision of H2A model

- Added scaling feature for various production rates
- Added cost for CO₂ sequestration
 - Capital cost
 - Pipeline cost
 - Cost of CO₂ injection





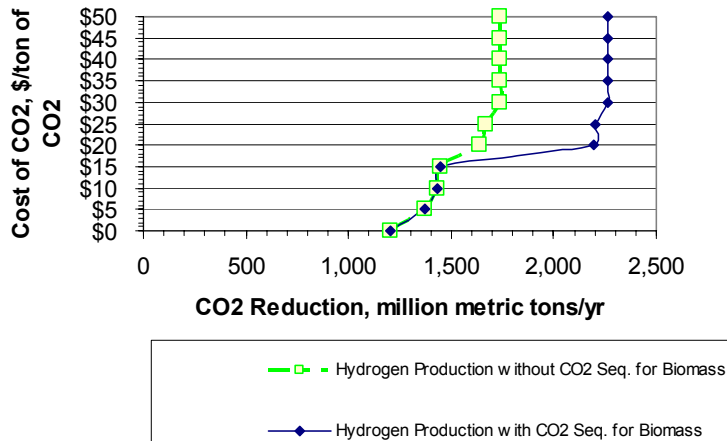
2008 Accomplishments/Results Analysis

CO₂ Analysis

Preliminary analysis shows the marginal cost of CO₂ cost for hydrogen pathway policy options ~\$15-20/ton of CO₂

- Preliminary sensitivity analysis of hydrogen pathways show CO₂ reduction benefits of 1.7 to 2.3 gigatons of CO₂/yr

Marginal Cost and Capture for CO₂ in 2050



Source: Brookhaven National Laboratory MARKAL model

Platinum Recycling Cost Analysis

Preliminary analysis of recycling platinum from the fuel cell can reduce the fuel cell cost by ~\$1-4/kW

- Currently, platinum only regarded as cost input for fuel cell analysis

Hydrogen Quality Analysis

Preliminary analysis shows the hydrogen production cost increases ~\$0.20-0.40/gge to meet hydrogen quality specifications for the fuel cell

- Preliminary analysis determined hydrogen cost to achieve quality to optimize fuel cell performance.



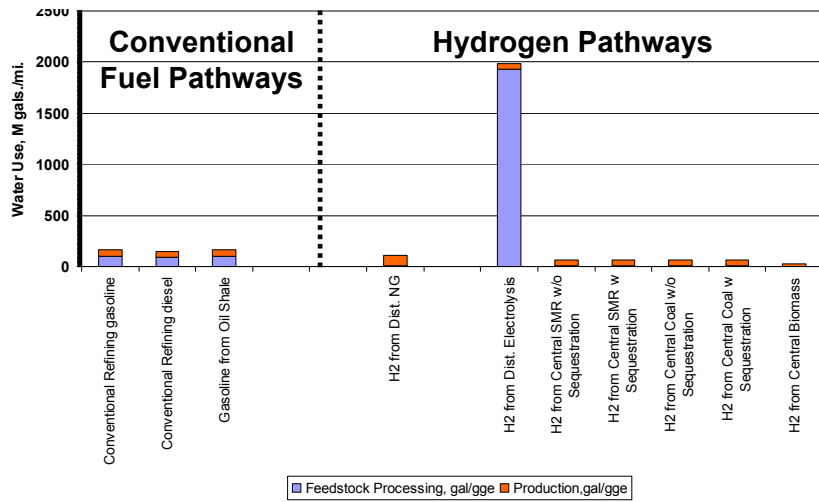
2008 Accomplishments/Results Analysis

Resource Analysis

Developed "Well-to-Wheels" analysis approach for water

- Utilized for hydrogen pathways and conventional fuel pathways analysis
- Used as a screening tool to create a Water Resource Analysis project with LLNL

Water Use for Technologies per Mile



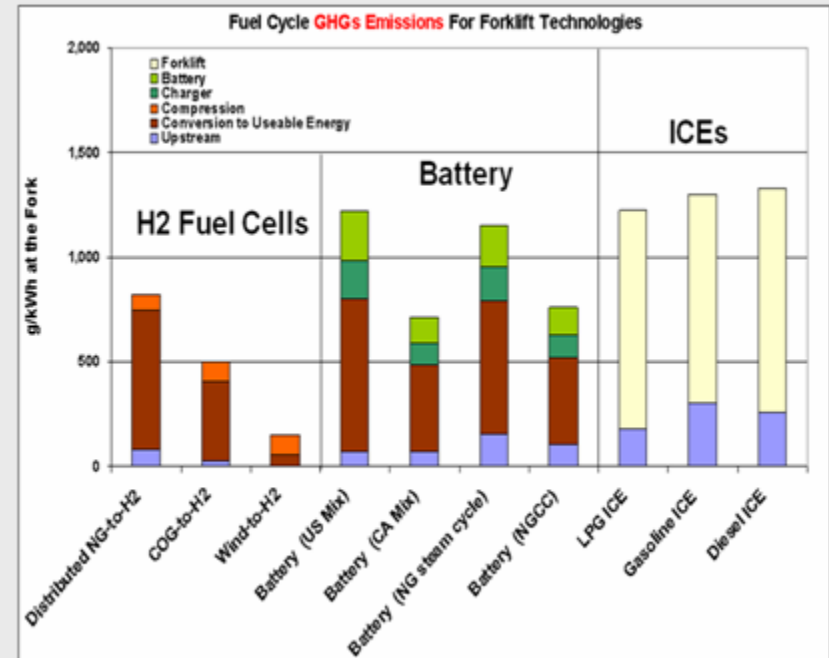
- Water requirements for hydrogen based on H2A model.
- Used ANL Water report for analysis data.
- Distributed electrolysis assumes electricity is coming from the grid.

Early Market Analysis

- Preliminary Well-to-Wheels analysis for GHG emissions for early market shows H₂ forklifts lower than fossil fuel pathways



Fuel-cell Forklift:
(Source: Toyota)



Source: ANL GREET model



International Collaboration

International Partnership for the Hydrogen Economy

- Issued findings of the EU HyWays and US modeling and analytical comparison
 - EU approach focused on social benefits
 - US approach focused on business/ financial benefits



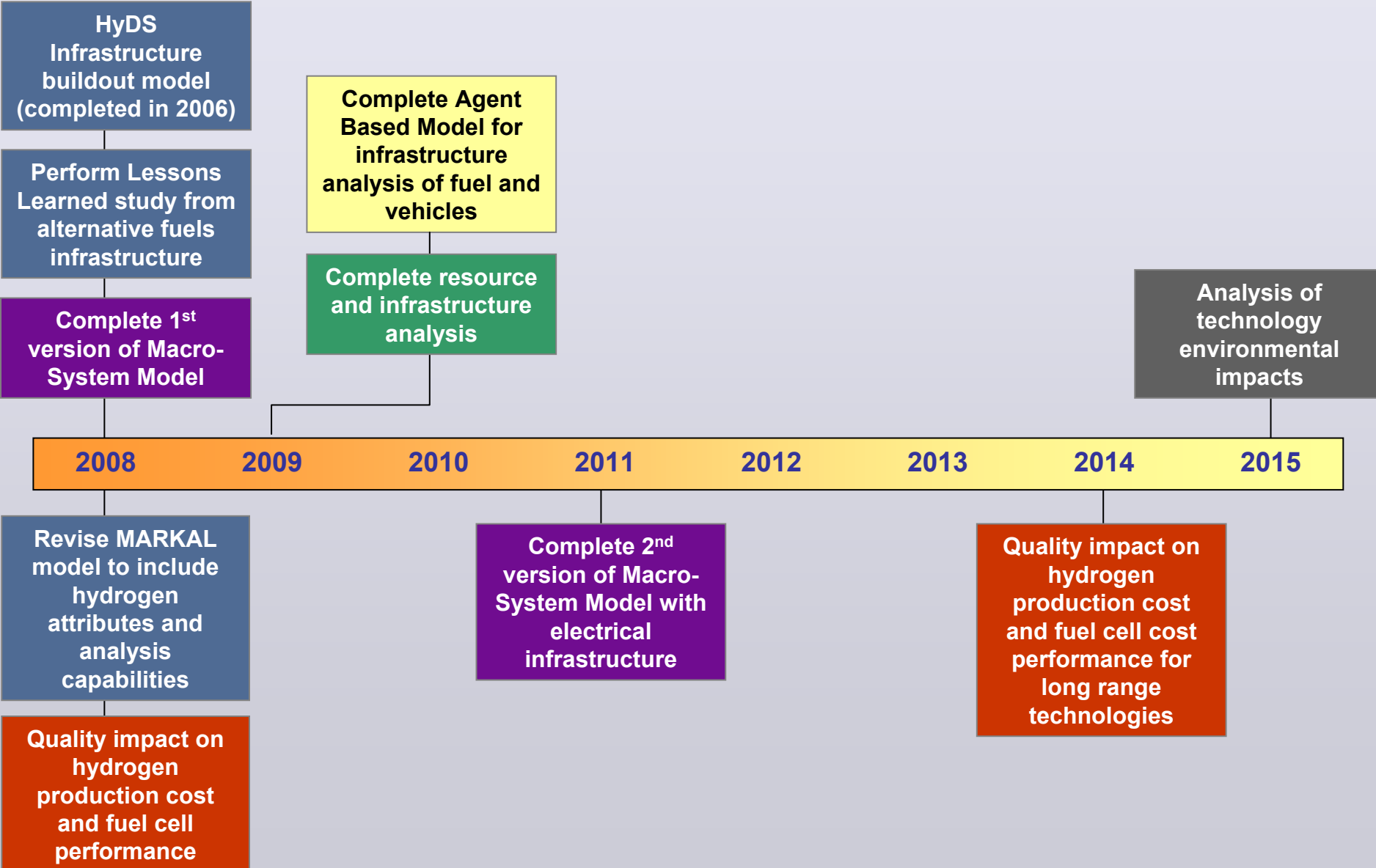
www.hyways-iphe.org

Analysis and roadmapping workshops will be held with other IPHE countries in Australian and China during 2008.





Future Plans





Thank You

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