U.S. Department of Energy
DOE Hydrogen Program

Systems Analysis Session

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2008 DOE Hydrogen Program
Merit Review and Peer Evaluation Meeting

June 10, 2008

U.S. Department of Energy
DOE Hydrogen Program

Introduction

What Questions Should Analysis and Models Answer?

Analysis Progression

Initial Questions and Problems to Address with Analysis

- What are the key technology drivers?
- What is the hydrogen cost of the technologies?
- Where do we focus our research i.e. which technology/ies and what area of the technologies?
- What are the resource requirements/ limitations?
- What are the hydrogen quality requirements and cost implications?
- What technologies will be needed to meet the hydrogen quality specifications?

Integrating Questions and Problems to Address with Analysis

- Which portfolio of technologies will best fit and where (cost, resource availability, infrastructure availability, etc.)
- How will the infrastructure evolve?
- What are the infrastructure requirements in cost?
- What will be the impacts on petroleum use and greenhouse gas emissions as the infrastructure and technologies are introduced?
- What and where are the infrastructure constraints to meet the technology requirements?
- Does the vehicle need to be built first or is a fueling infrastructure required first (how to manage the “chicken and egg” issue)?

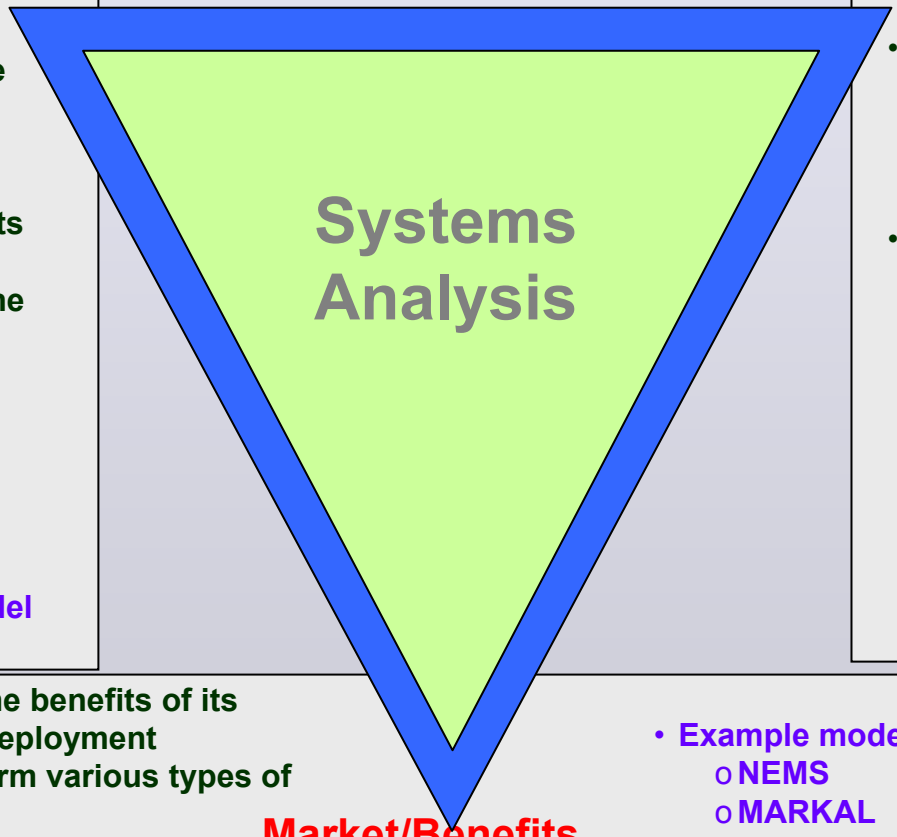
Long Term Questions and Problems to Address with Analysis

- What policies will be needed to enable hydrogen production, delivery and vehicles?
- Which policies will be more effective for vehicle introduction and for hydrogen/infrastructure introduction?
- What is the impact of switching from a petroleum based transportation fuel to a hydrogen based fuel?

Analysis Strategy and Domains

Technical Analysis

- Resource, technical feasibility, environmental, delivery, and infrastructure development analysis
- Assists in defining the appropriate slate of projects for the hydrogen research portfolio, and increasing the effectiveness of research projects
  - Example models:
    - PSAT
    - GREET
    - HyDS
    - Macro-System Model
    - HYPRO



Cost Analysis

- Analysis to assess the economic feasibility of various infrastructure and vehicle processes
- Assists in choosing research paths which offer the best possibilities of competitive costs for hydrogen production, delivery, vehicle configurations, etc.
  - Example models:
    - H2A
    - TIAX Logistics Model

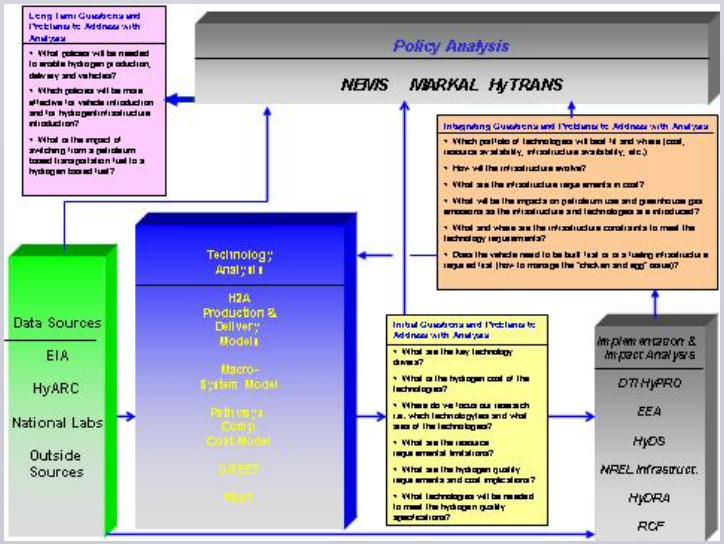
Market/Benefits Analysis

- Analysis to estimate the benefits of its portfolio of R&D and deployment programs and to perform various types of policy analyses
- Examination of the interactions of hydrogen production and consumption with the rest of the energy system
- Example models:
  - NEMS
  - MARKAL
  - HyTrans
  - VISION

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 CO_2 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**
  - ❖CO_2 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

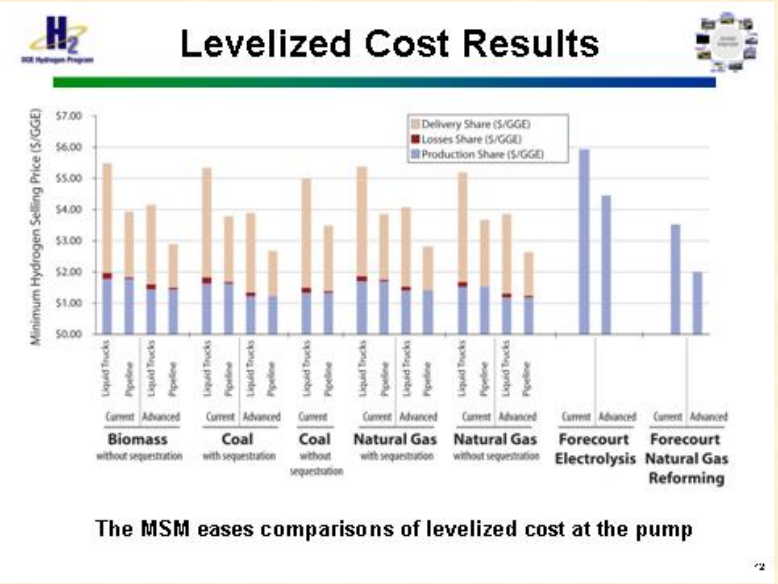
2008 Accomplishments/Results

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

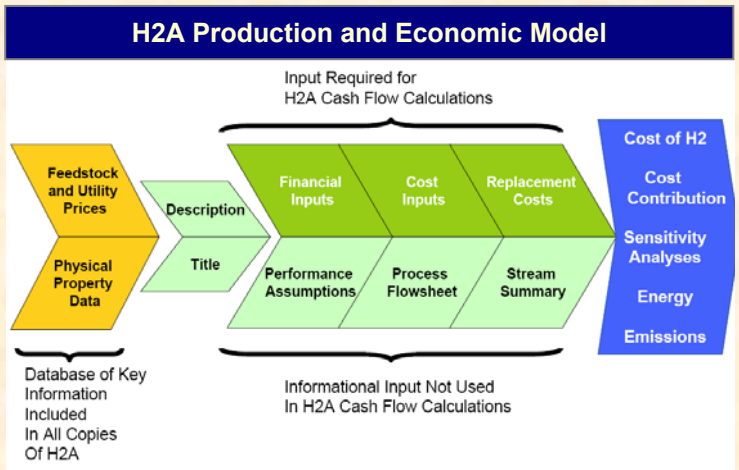


The MSM eases comparisons of levelized cost at the pump

H2A Production Model Update.

Completed peer reviewed revision of H2A model

- Added scaling feature for various production rates
- Added cost for CO_2 sequestration
  - Capital cost
  - Pipeline cost
  - Cost of CO_2 injection



2008 Accomplishments/Results

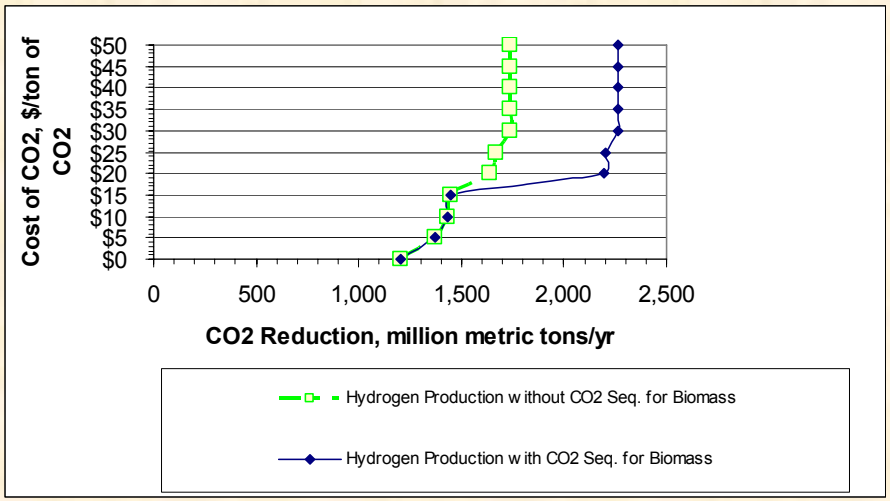
Analysis

CO_2 Analysis

Preliminary analysis shows the marginal cost of CO2 cost for hydrogen pathway policy options ~$15-20/ton of CO_2

- Preliminary sensitivity analysis of hydrogen pathways show CO_2 reduction benefits of 1.7 to 2.3 Giga tons of CO2/yr

Marginal Cost and Capture for CO_2 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

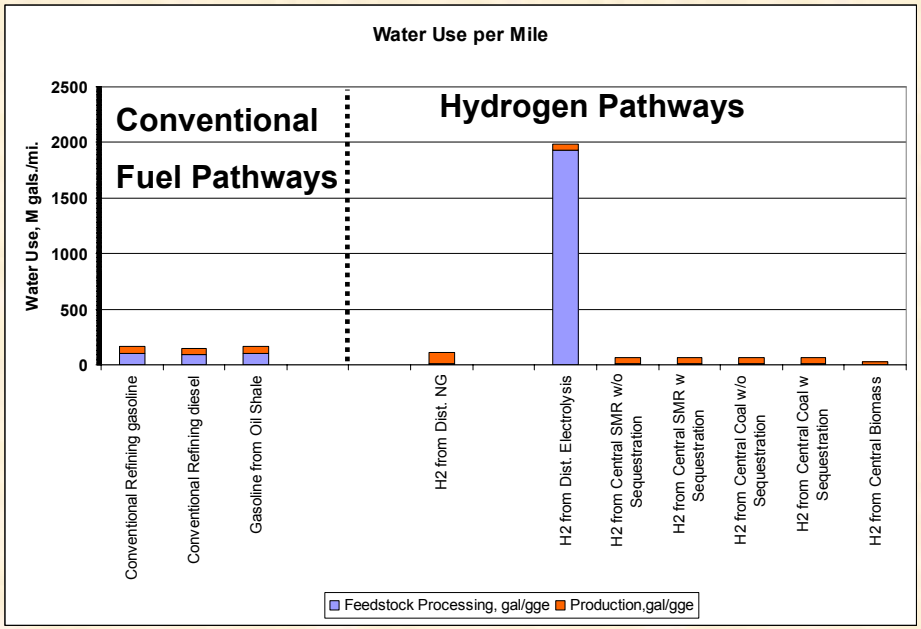
Analysis

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

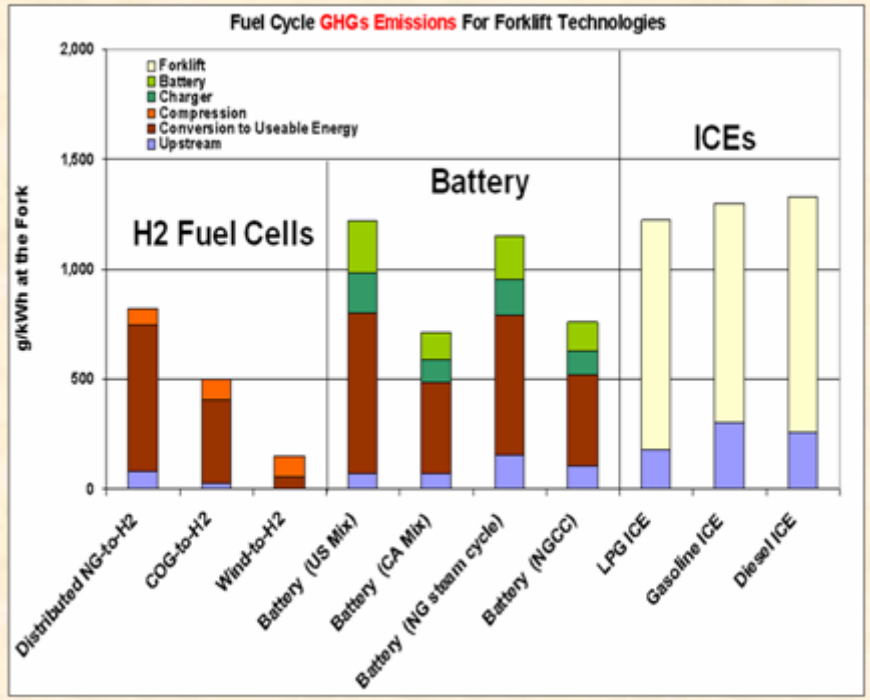


- **Water requirements for hydrogen based on H2A model.**
- **Used ANL Water report for analysis data.**
- **Distributed electrolysis assumes electricity is coming from the grid.**

Early Market Analysis

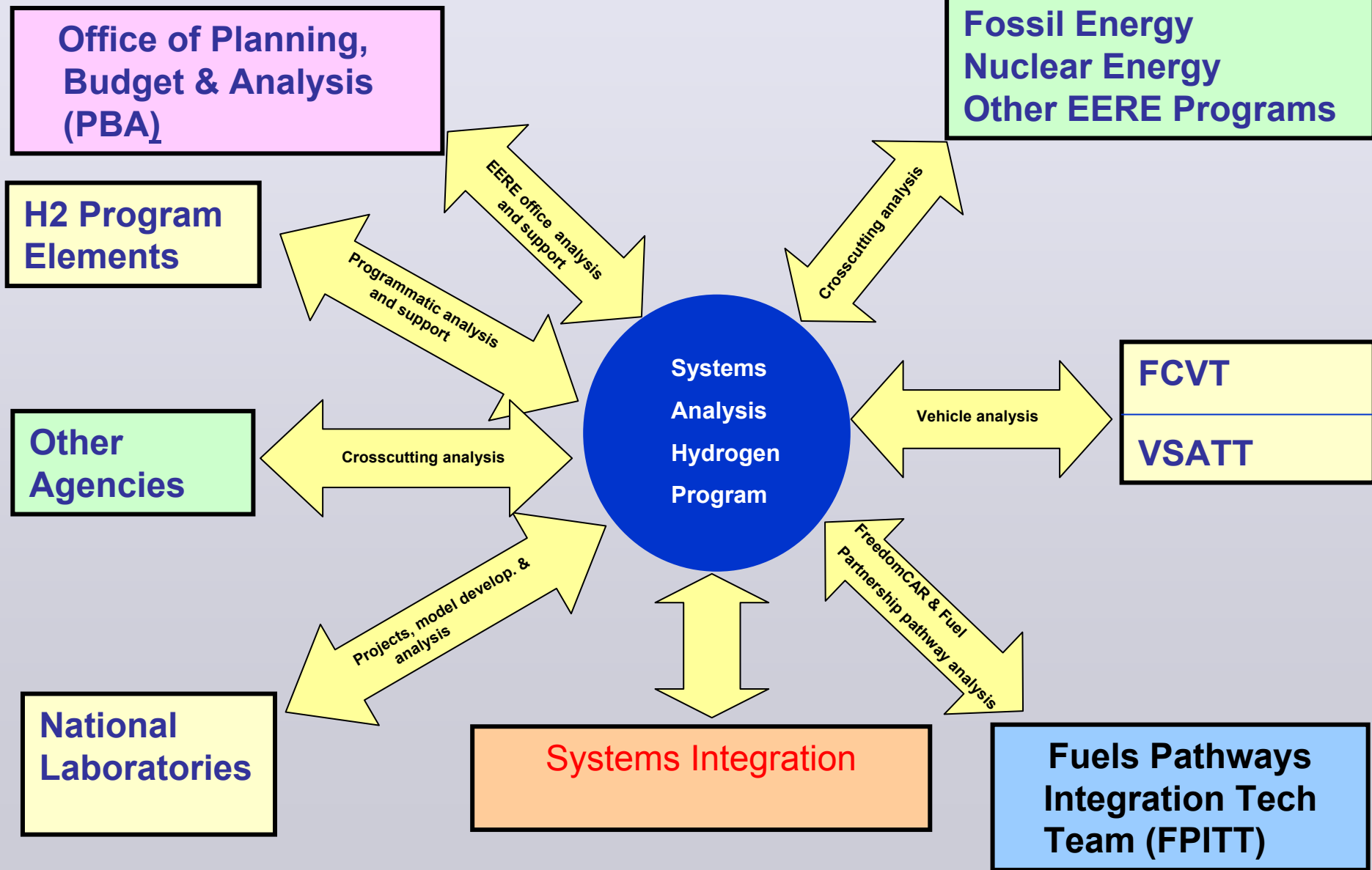
- Preliminary Well-to-Wheels analysis for GHG emissions for early market shows H_2 fork lifts lower than fossil fuel pathways

Fuel-cell Forklift: (Source:Toyota)



Source: ANL GREET model

Systems Analysis Partners



Systems Analysis

Session Schedule

Analysis Sessions will be held EVERYDAY!

2008 DOE HYDROGEN PROGRAM MERIT REVIEW AND PEER EVALUATION MEETING BLOCK SCHEDULE

Schedule as of: 19-May-08

Session	Monday June 9	Tuesday June 10	Wednesday June 11	Thursday June 12	Friday June 13
Salon		A: V&VI; B: IV; C: III; D: I&II	A: V&VI; B: IV; C: III; D: I&II	A: V&VI; B: IV; C: III; D: I&II; D&E	A: V&VI; B: IV; C: III; D: I&II
8:15				Reviewer Orientation Meeting	
8:30					
8:45					
9:00		PD / ST / FC / AN	AN / ST / FC / BES	PD / AN / FC / ED	PD / ST / FC / AN
9:30		PD / ST / FC / AN	AN / ST / FC / BES	PD / AN / FC / ED	PD / ST / FC / AN
10:00		PD / ST / FC / AN	AN / ST / FC / BES	PD / AN / FC / ED	PD / ST / FC / AN
10:30		Break	Break	Break	Break
11:00		PD / ST / FC /	PD* / ST / FC / BES	PD / ST / FC / ED	PD / / FC / AN
11:30		PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / ED	PD / / FC / ME*
12:00		PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / ED	FC / MF
12:30		Lunch (Awards)	Lunch (EC Address)**	Lunch	FC / MF
1:30					
1:45	Plenary	PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / ED	MF
2:15	Plenary	PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / SCS*	
2:45	Plenary	PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / SCS	
3:15	Break	PD / ST / FC /	PD / ST / FC / BES	PD / ST / FC / SCS	
3:45	Plenary	Break	Break	Break	
4:15	Plenary	PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / SCS	
4:45	Plenary	PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / SCS	
5:15	Plenary	PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / SCS	
5:45	Reviewer Orientation Meeting	PD / ST / FC / TV	PD / ST / FC / BES	PD / ST / FC / SCS	
6:30	POSTER SESSION I: Storage, Analysis, SC&S, Manufacturing, Market Transformation, Technology Validation	US Fuel Cell Council Reception Room G-50 Dirksen Senate Office Building, 6:30 – 8:30 PM (see map on H2 AMR Web site)	POSTER SESSION II: Fuel Cells, Production & Delivery (including Basic Energy Science) H2 EDUCATION EXPO (6:30-9:00)	Reviewer Feedback Meeting	
7:00				Free Night	
7:30					
8:00					
8:30					
9:00					

H2 EDUCATION EXPO

FC: Fuel Cells
TV: Technology Validation
ST: Storage
PD: Production and Delivery
AN: Analysis
BES: Basic Energy Sciences
ED: Education
SCS: Safety,Codes&Standards
MF: Manufacturing

*: 15 minute talk, starts 15 minutes after listed time.

**Raffaeli Liberali, Director for Non-Nuclear Energy in the Directorate General for Research, Technology and Development (DG-RTD) of the European Commission

Systems Analysis

Session Schedule

Analysis Sessions will be held EVERYDAY!

Tuesday, June 10

Start: 8:45 AM **Focus: Modeling and Fuel Cell Vehicle in Transportation**

- Systems Analysis Introduction
- AN 1: HyTrans Model: Analyzing the Transition to Hydrogen-Powered Transportation by David Greene
- AN 2: Fuel-Cycle Analysis of Hydrogen-Powered Fuel Cell Systems with the GREET Model by Michael Wang
- AN 3: Discrete Choice Analysis of Consumer Preferences for Refueling Availability by Marc Meliana

Wednesday, June 11

Start: 9:00 AM **Focus: Modeling and Analysis of Hydrogen Production**

- AN 4: Macro-System Model by Mark Ruth
- AN 5: Analysis of the Hydrogen Production and Delivery Infrastructure as a Complex Adaptive System by George Tolley
- AN 6: Updates to the H2A Hydrogen Production Discounted Cash Flow Model (H2A version 2.0) by Darlene Steward

Systems Analysis

Session Schedule (cont)

Analysis Sessions will be held EVERYDAY!

Thursday, June 12

Start: 9:00 AM **Focus: Hydrogen Resource Requirements and Infrastructure**

AN 7: H2-W The Production Value of Water in a Hydrogen Economy
by Richard White

AN 8: HyDRA: Hydrogen Demand and Resource Analysis
by Mitt Sparks

AN 9: Lessons Learned for Fueling Infrastructure
by Marc Meliana

Friday, June 13

Start: 9:00 AM **Focus: Fuel Cell Analysis and Environmental Impacts of Hydrogen**

AN 10: Hydrogen and Fuel Cell Analysis: Lessons Learned from Stationary Power Generation
by Mr. Dogan

AN 12: Hydrogen Quality Issues for Fuel Cell Vehicles
by Romesh Kumar

AN 13: Update on Platinum Availability and Assessment of Platinum Leasing Strategies for Fuel Cell Vehicles by Matt Kromer

AN 14: Evaluation of the Potential Large-Scale Use and Production of Hydrogen in Energy and Transportation Applications by Don Wuebbles

AN 15: Potential Environmental Impacts of Hydrogen- Based Transportation and Power Systems
by Tom Grieb

Thank You

For More Information

Systems Analysis

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