Hydrogen Delivery Analysis Plus Meeting

DTT, STT, HPTT, Other Analysts,
Invited Guests

May 8-9, 2007

Purpose/Objectives

- Present, discuss, and reach consensus on H2A Delivery Models changes and results
- Present and discuss On-Board Storage analysis
- Present and discuss H2A EE and emissions modeling/tabs
- Define a synergistic pathway forward for cost, EE, and emissions modeling for well through vehicle storage and the role for H2A tools.
- Present the HyPro and Hytrans Transition Scenario models
- Define next steps for H2A models relative to overall HFI analysis needs

Agenda

May 8, 2007

8:00	Introductions and Purpose
8:15	H2A Delivery Models Changes (Nexant/H2A Delivery Team
9:45	*Break*
10:00	H2A Delivery Scenario Model (HDSAM): New Results (Amgad Elgowainy)
11:30	Next Steps for H2A Delivery Models
12:00	*Lunch*
12:45	Carrier for H2 Delivery (Matt Hooks)
1:45	On-Board Storage Analysis Effort
	Introduction (Sunita Satyapal)
	ANL Efforts (Rajesh Ahluwalia)
	TIAX Efforts (Steve Lasher)
3:45	*Break*
4:00	WTP and W through Tank H2A EE and Emissions Model (Amgad Elgowainy
4:30	Discussion: Needs and Next Steps
5:30	*Adjourn*

Agenda

May 9, 2007

8:30	HyPro Model (DTI)
9:30	HyTrans Model (ORNL)
10:30	*Break*
10:45	H2-NEMS Model (Francis Wood)
11:45	*Lunch*
1:00	Needs and Next Steps for Modeling and Analysis
2:30	*Adjourn*

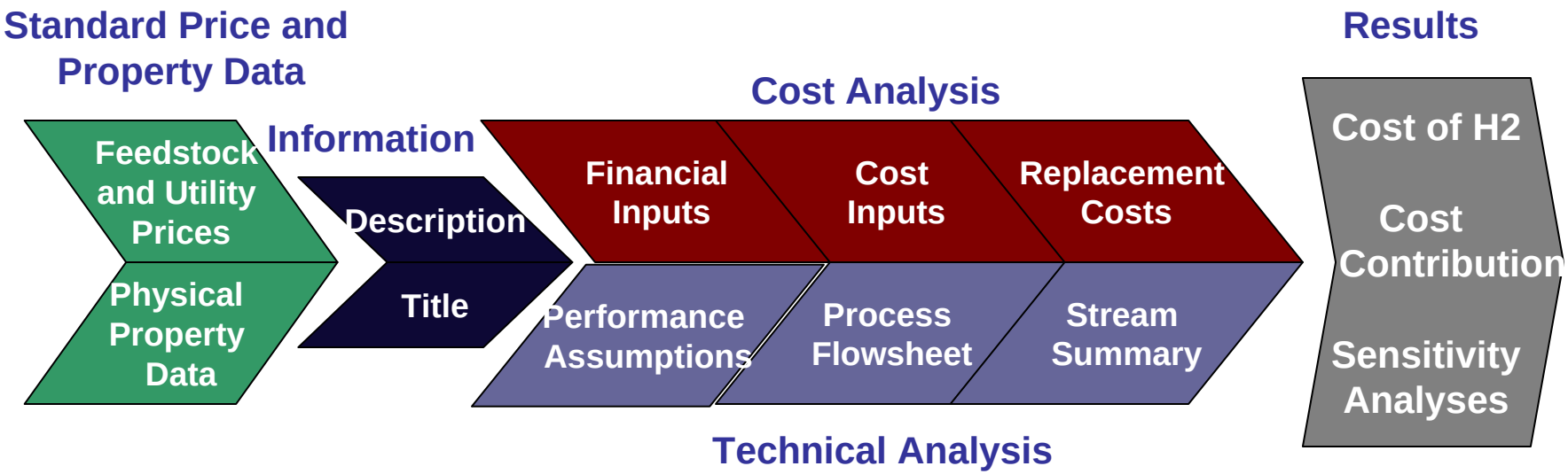
H2A Background

- Purpose
  - Improve transparency and consistency of analyses
  - Improve understanding of the differences among analyses
  - Seek better industry validation
  - Analysis portfolio development
  - Provide research direction
- History
  - Began in February 2003, financial support from U.S. DOE
  - Team of analysts from labs, industry, consulting firms, and universities
  - Use of Key Industrial Collaborators (KIC)

H2A Models Description in One Slide

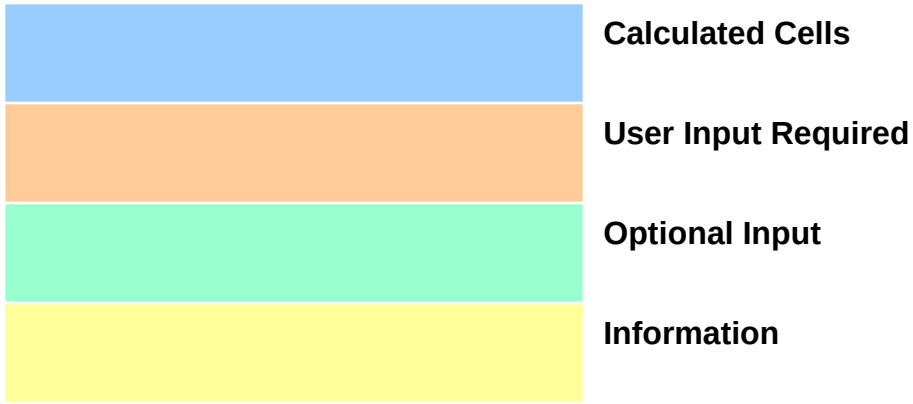
- Excel spreadsheet based
- Discounted cash flow rate-of-return analysis
- User enters:
    - Installed Capital Costs
    - Feedstock Consumption Rates/Efficiencies
    - Utilities consumption
    - O&M Costs
- Model returns:
    - Levelized price of hydrogen required to attain a specified internal rate of return $/kg)
- Central Production, Distributed Production, Delivery Models

H2A Cash Flow Modeling Tool



H2A Tool Features

- Color-coded to facilitate user input



- Yes/no toggle switches to allow for user input or H2A standard input
  - Inputs turn on/off based on yes/no toggle switch
- Error messages included to alert user when input errors are made
- Documentation is provided on website for model support

Key Financial Parameters

- Reference year (2005 $)
- Debt versus equity financing (100% equity)
- After-tax internal rate of return (10% real)
- Inflation rate (1.9%)
- Effective total tax rate (38.9%)
- Design capacity (varies)
- Length of construction period (varies according to case)
- Production ramp up schedule (varies according to case)
- Depreciation period and schedule (MACRS: varies by equipment type)
- Plant life and economic analysis period (40 yrs for central production; 20 yrs for distr. Production and for delivery
- G&A rate as % of labor (20%)
- Other parameters made consistent in approach to values

Key Cost Parameters

- **Capital Investment (installed) (itemized to extent available)**
- **Indirect Depreciable Capital**
  - Site Prep., Eng & Design, Contingencies, Licensing Fees, Permit Fees
- **Non-Depreciable Capital (land costs)**
- **Fixed O&M**
  - Labor, OH, G&A, Prop. Taxes, Rent, Annual Lic. Fees, Annual Maintenance
- **Replacement Costs**
  - Yearly schedule of major capital equipment replacement/overhaul costs
- **Variable Operating Costs**
  - Feedstock costs including utilities
  - Byproduct sales revenue
  - Royalties
  - Subsidies, Tax Incentives
  - Other variable costs
- **Working Capital (15%)**

Production Case Studies: Central Technologies

	Coal Gasification	Coal Gasification w/CO2 Sequestration	Coal Gasif w/CO2 Seq & Power Co-production	Biomass Gasification
Current	Conventional	Conventional	Conventional	Distinct
Mid term		+Membrane Separation	+Membrane Separation	Advanced Distinct
Long term		+Adv Materials	+Adv Separation	Integrated

	Natural Gas Reforming	Nat Gas Reforming w/CO2 Sequestration	Current Nuclear Electrolysis	Advanced Nuclear
Current	Conventional	Conventional		
Mid term		+ Autothermal OTM	High Pressure	
Long term		+Advanced Separation	Steam Electrolysis	SI Thermo-chemical

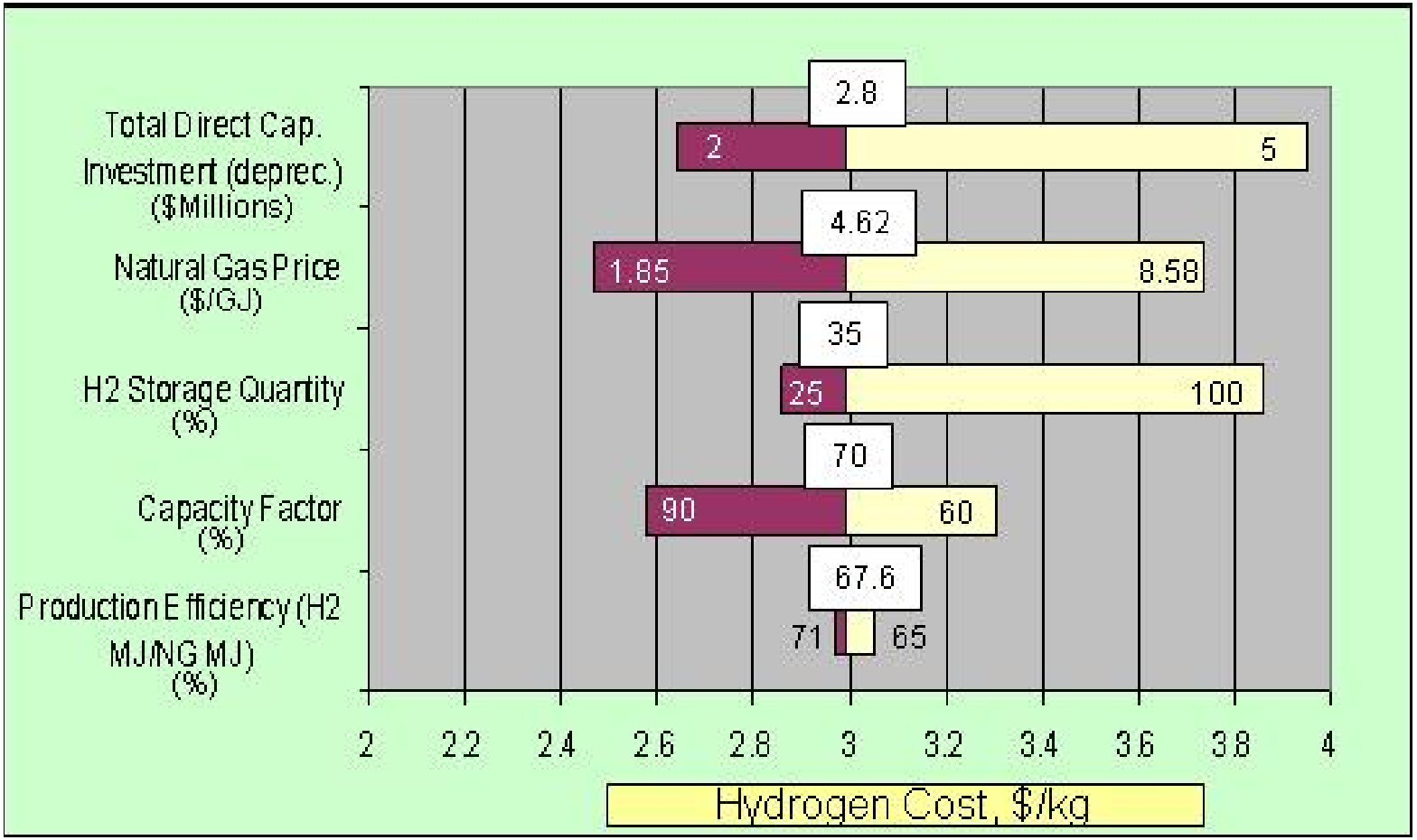
	Stand-alone Wind Electrolysis	Wind Electrolysis w Power Co-production
Current	Atmospheric	Atmospheric
Mid term	High Pressure	High Pressure
Long term	High Pressure	High Pressure

Case Studies: Forecourt Technologies

Type of Station	Small (100 kg/day)	Large (1,500 kg/day)	Current Technology / Design Assumptions
Natural Gas Reformer	X	X	SMR with PSA cleanup, 6250 psi piston compressors, cascade dispensing
Methanol Reformer	X	X	Comparable to SMR design, low temperature
Ethanol Reformer	X	X	Comparable to SMR design
Electrolysis	X	X	Electrolyzer, 6250 psi piston compressors, cascade storage and dispensing

Sample Sensitivity Analysis

Distributed Steam Methane Reforming



H2 Delivery Research Areas

Pathways

- Gaseous Hydrogen Delivery
- Liquid Hydrogen Delivery
- Carriers

} Including mixed pathways

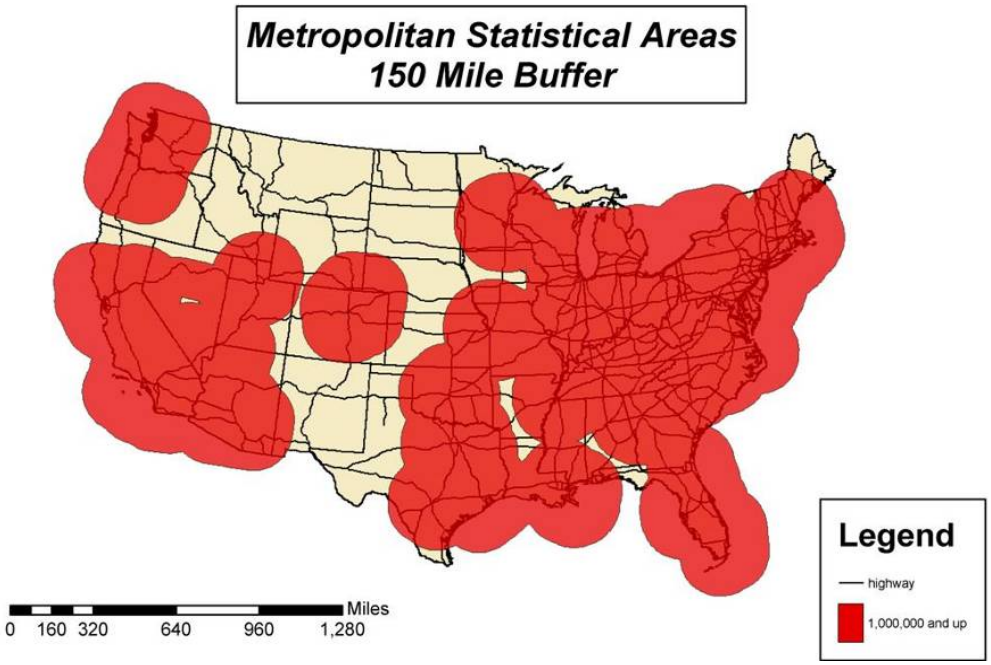
Components

Pipelines	Terminals
Compression	Purification
Liquefaction	Dispensers
Carriers & Transformations	Liquid Storage Tanks
Gaseous Storage Tanks	Mobile Fuelers
Geologic Storage	Liquid Trucks, Rail, Ships
GH2 Tube Trailers	

DOE H2A Delivery Models

- Spreadsheet model for delivery system component costs and performance: Components Model
- Delivery scenario model for set of defined Urban and Rural/Interstate markets and demand levels. Scenario Model
- Estimates the cost of H_2 delivery ($/kg)
- Assumes 2005 delivery technologies
- We can insert our Research Targets to see the impact

Hydrogen Plants can be Located Relatively Near the Market demand



Nearly all areas East of the Mississippi and West of the Rockies are within 200 highway miles (320 km) of large urbanized areas

Overview of the H2A Delivery Scenario Model

Scenario Definition

Components and Other Sub-Models

Results