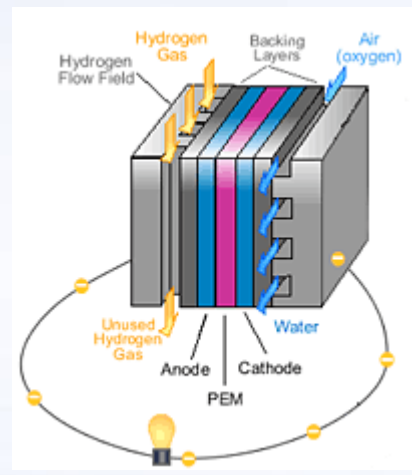




2007 Annual DOE Hydrogen Program Review Systems Analysis Session



Introduction

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Outline



- Introduction
- Analysis Strategy and Domains
- Analysis Portfolio
- Model/Analysis Application Matrix
- Systems Approach
- “Producing results”





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

Systems 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

Market/Benefits Analysis

- Example models:
 - NEMS
 - MARKAL
 - HyTrans
 - VISION



Analysis Portfolio



- **Technology Analysis**
 - Pathway & Components cost analysis
 - Hydrogen quality impact analysis
 - Well-to-Wheels (WTW) Energy & Greenhouse Gas (GHG) emissions analysis
 - Vehicle technology analysis
- **Implementation & Impact analysis**
 - Infrastructure & resource analysis
 - Consumer choice analysis
 - Vehicle penetration analysis
- **Policy Analysis**
 - National economic impact analysis
 - Policy options analysis
- **System Dynamics analysis**
- **Environmental analysis**



Model/Analysis Application Matrix



Analysis Category	Technology Analysis				Implementation & Impact Analysis			Policy Analysis		System Dynamics
	Pathway & Components Cost	H2 Quality Impact	WTW Energy & GHG Emissions	Vehicle Technology	Infrastructure & Resource Anal.	Consumer Choice	Vehicle Penetration	National Econ. Impacts	Policy Options	
Analysis Type										
Models										
H ₂ A Production Cost Model ¹	Completed									
H ₂ A Delivery Cost Model ¹	Completed									
DTI HyPRO ¹					Underdevelopment					
EEA ¹					Underdevelopment					
HyDS ¹					Underdevelopment					
NREL Infrastructure ¹					Underdevelopment					
HyDRA ¹					Planned					
PSAT				Completed						
HyTrans ¹						Completed	Completed		Completed	
GREET ¹			Completed							
Macro-System Model (MSM) ¹	Underdevelopment	Planned								
RCF Agent Based Model ¹					Underdevelopment					
NEMS								Completed	Completed	
MARKAL								Completed	Completed	
HyDive ¹										Planned
Hydrogen Logistics Model (TIAX)					Completed					

Notes:

- The models/projects funded by Systems Analysis are referenced with a "1".
- A hydrogen module is being added to the NEMS model in 2006.
- Risk analysis is being incorporated in the models. The GREET Model has risk analysis capabilities.
- The primary analysis focus of the models are illustrated in the matrix. However, the models are multi-functional and can be applied for other analyses in the matrix.

Legend

- Completed Models
- Models Underdevelopment
- Planned Models

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?
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Policy Analysis

NEMS MARKAL HyTRANS

Integrating Questions and Problems to Address with Analysis

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Technology Analysis

**H2A
Production &
Delivery
Models**

**Macro-
System Model**

**Pathways
Comp.
Cost Model**

GREET

PSAT

Implementation & Impact Analysis

DTI HyPRO

EEA

HyDS

NREL Infrastruct.

HyDRA

RCF

Data Sources

EIA

HyARC

National Labs

**Outside
Sources**

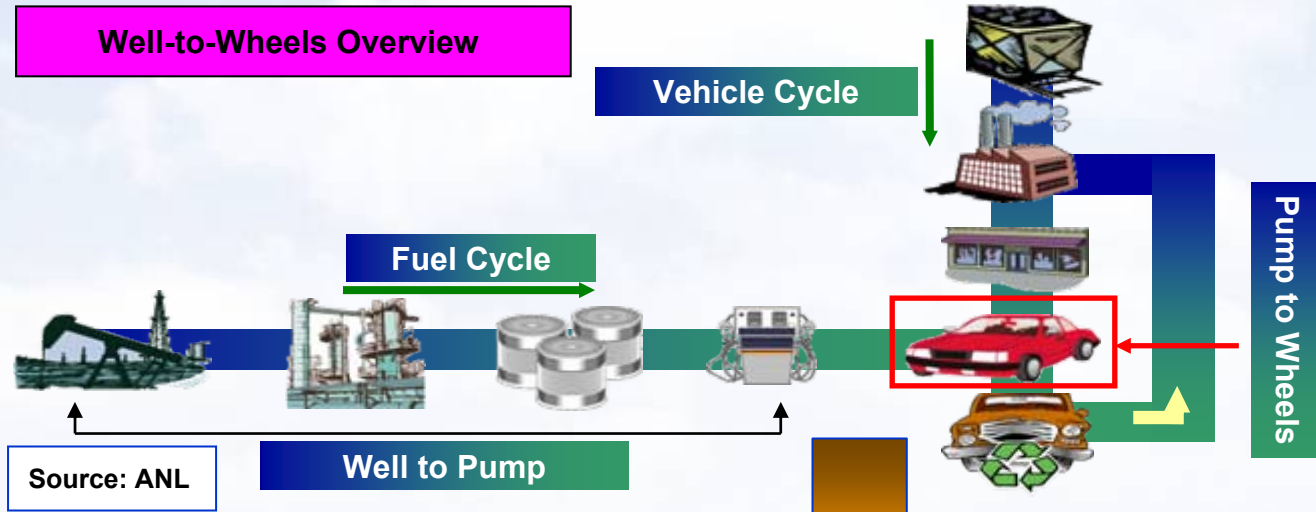


DOE Well-to-Wheels Analysis Methodology

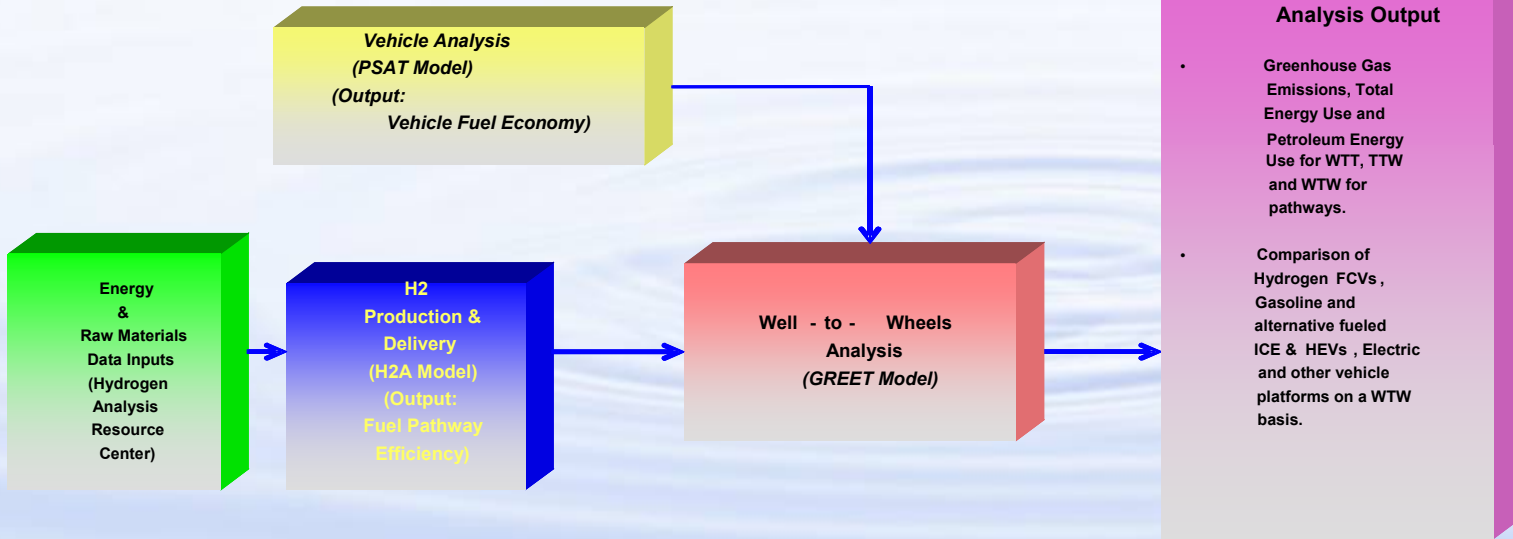
A “Systems” Approach



Well-to-Wheels Overview



Well-to-Wheels Modeling Process





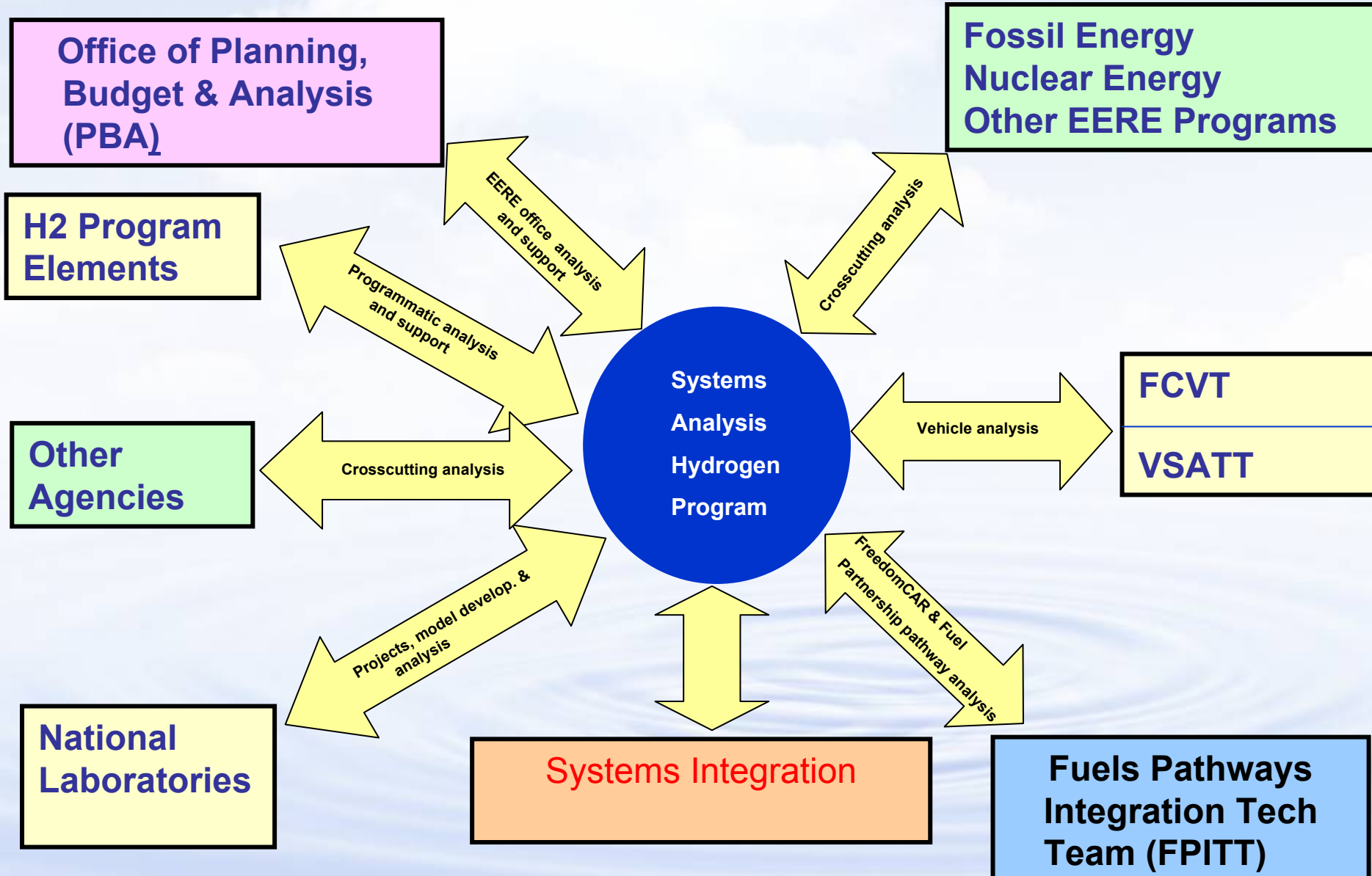
“Producing Results”



Analysis Topics	Model Utilized
Hydrogen Cost Goal	PSAT (Powertrain Systems Analysis Toolkit)
Distributed Natural Gas Reformer Independent Study	H2A Production Model (DOE)
Scenario Analysis of the Transition	H2A Production Model (DOE) H2A Delivery Model (DOE) HyPRO Model (Directed Technologies, Inc.) HyTrans (Oak Ridge National Lab)
Pathway Well to Wheels Evaluations	REET Model (Argonne National Lab)
Electrolyzer Production Technology Evaluation	H2A Production Model (DOE)
Techno-economic evaluation of Production Technologies	H2A Production Model (DOE) REET Model (DOE)
Resource Analysis: CO₂ Water Use Analysis Natural Gas Infrastructure Limitations	EEA Model H2A Production Models EEA Model
Pathway cost and WTW analysis of hydrogen leakage Pathway WTW sensitivity for production and vehicle impacts	Macro-System Model



Systems Analysis Partners





Thank You