2005 DOE Hydrogen Program Review

Hydrogen Analysis Support

Marylynn Placet

Pacific Northwest National Laboratory

May 2005

Project ID # ANP5

This presentation does not contain any proprietary or confidential information

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Overview

Timeline

- Project start date: 11/04
- Project end date: 11/05
- Percent complete: 30%

Barriers

- Barriers addressed: Feedstock Cost and Availability

Budget

- Total project funding: $150K (all DOE) to date
- No funding received in FY04
- Funding for FY05: $150K

Partners

- Other national laboratories and contractors

Objectives

▶ <u>Long-term objective</u>: Support the development of tools, methods and data for the conduct of sound analysis of hydrogen production/delivery costs, markets, policy options and other key analysis topics.

▶ <u>Objectives for FY05</u>: (1) Better understand uncertainty of future oil, gasoline and natural gas prices (2) develop a protocol for collection and use of standard data and assumptions to be used in HFCIT analytical efforts

Approach

▶ Task 1 (Oil/Gas Prices): Use the PNNL-developed MiniCAM model to project oil and gas prices under a variety of assumptions.

▶ Task 2 (Data Book): Develop suggested contents and format of standard "data book" for HFCIT and begin populating it with appropriate data.

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PNNL Modeling Approach:
# Global Scale with Regional Detail

► Origins in the carbon dioxide issue – specifically studying future carbon emissions from human activities.

► Focus on energy production and consumption – the major source of anthropogenic carbon emissions.
- Requires detail on all fossil fuels and non-fossil alternatives.

► Relevant scale for energy markets and carbon emissions study is global.
- Greenhouse gas emissions have global impact and energy is traded internationally.
- Global demand for oil and other fuels affects supply availability and price.

► Regional details are critical.
- Regions vary in key drivers of energy and related emissions, e.g.,
  - Population and economic growth,
  - Fossil fuel resource bases,
 - Renewable and land resources,
  - Technology

PNNL's Top-Down Modeling Approach: Economic Market Equilibrium

► Market equilibrium modeling – model "solves" by finding the set of prices that clears all markets.

- Model finds prices that equilibrate all supplies and demands.
- Theoretically similar to optimization solution (e.g., LP).

► Equilibrium approach produces internal consistency across all model outcomes.

- Is inherently both a "systems" approach and a "life-cycle" approach in that all physical interactions and their economic impacts are explicitly considered on a consistent basis.
- Captures system feedbacks, price responses, take-backs, etc.
- Avoids double-counting of impacts. Consider substitutes and complements.

► Although we start at the top with the integrated system or economy, there is no inherent methodological limit as to how much inner detail can be incorporated.

- Regions, sectors, fuels, technologies, etc.

Core Elements of MiniCAM Energy Markets
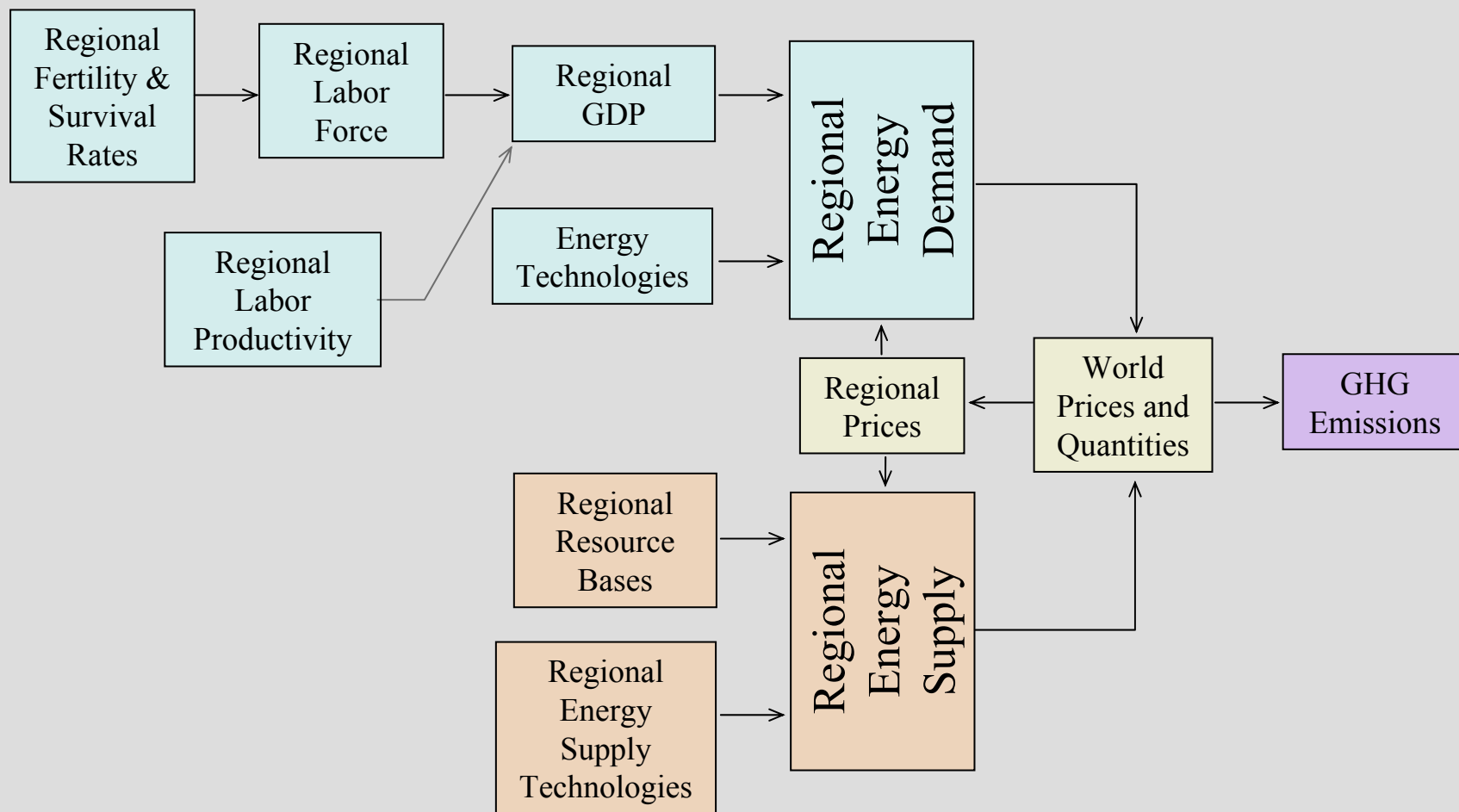
MiniCAM Energy Markets: Regional Supply and Conversion

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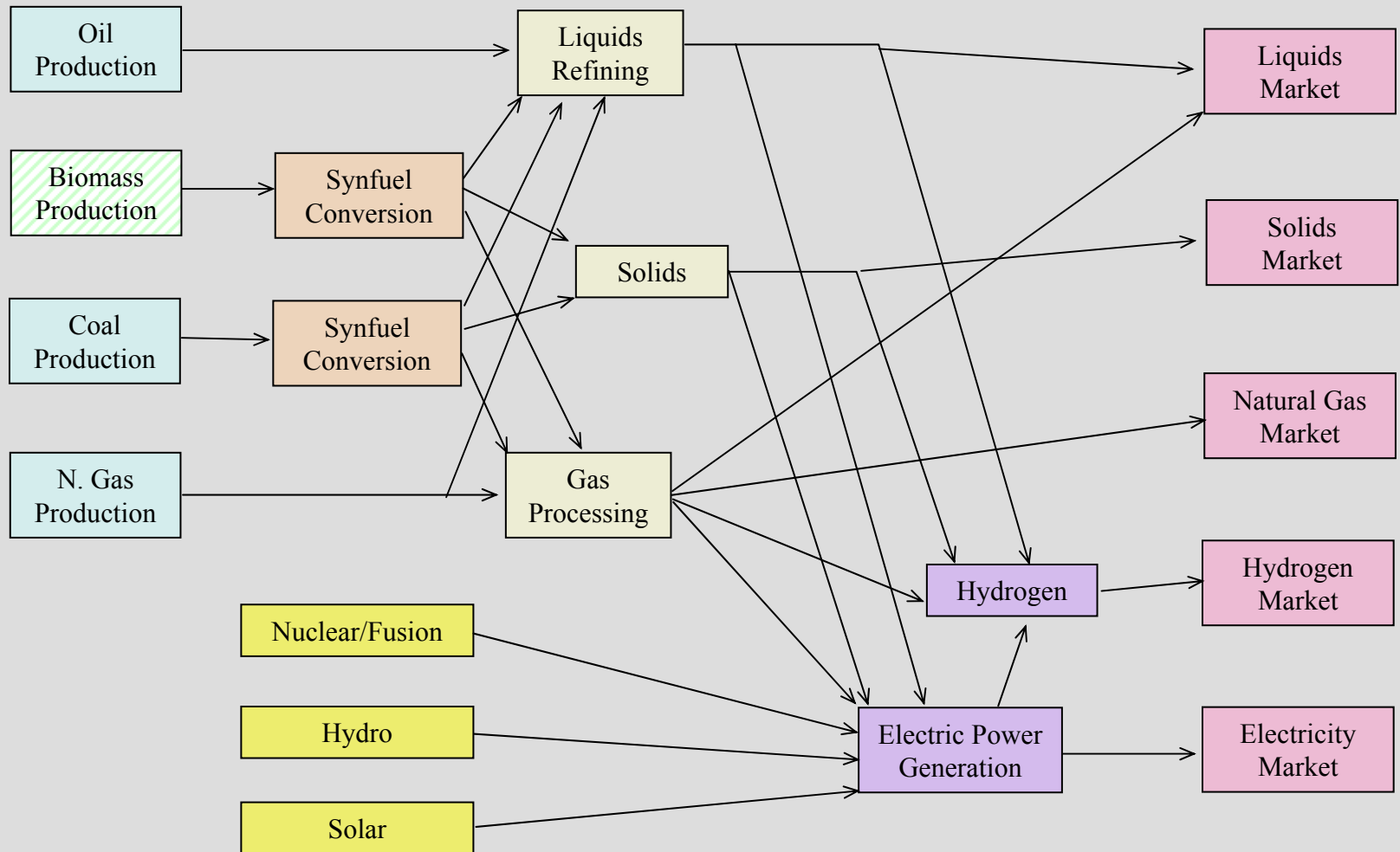
Task 2: Data Book Approach

► Develop an outline and format

► Define data categories that will be collected

► Populate the data fields

Note: Work will involve considerable interaction with HFCIT office managers and project managers to ascertain their needs and solicit opinions on key parameters important to analysis topics.

Work may also involve seeking advice of outside experts in other parts of DOE or in industry.

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Technical Accomplishments: Summary of Status

▶ Oil/Gas Analysis has been completed.

▶ Data Book design effort will be accomplished in Summer '05.

Future Price Path Case Definitions

Case	Assumed Oil Resources --Total Conventional (10^9 barrels)	Economic Growth	Additional Assumptions
1	2970	Moderate	
2	2970	High	
3	2312	Moderate	
4	2312	High	
5	3628	Moderate	
6	4286	Moderate	
7	4286	Moderate	Higher technical improvement reduces costs of production from new resources
8	2312	High	Mideast production is constrained to half of current levels in 2020 and 2035

Economic Growth Rates
(GDP, Annual Average Growth 2006-2050)

	Moderate	High
Africa	5.4%	6.2%
Australia_NZ	1.6%	2.1%
Canada	1.6%	2.0%
China	6.1%	7.8%
Eastern Europe	4.6%	5.5%
Former Soviet Union	4.2%	5.0%
India	6.1%	7.8%
Japan	0.5%	0.9%
Korea	2.8%	3.6%
Latin America	4.0%	4.8%
Middle East	4.0%	4.8%
Southeast Asia	5.6%	7.3%
USA	1.6%	2.0%
Western Europe	0.9%	1.3%

World Oil Price Results in Context of Historical Annual World Oil Prices
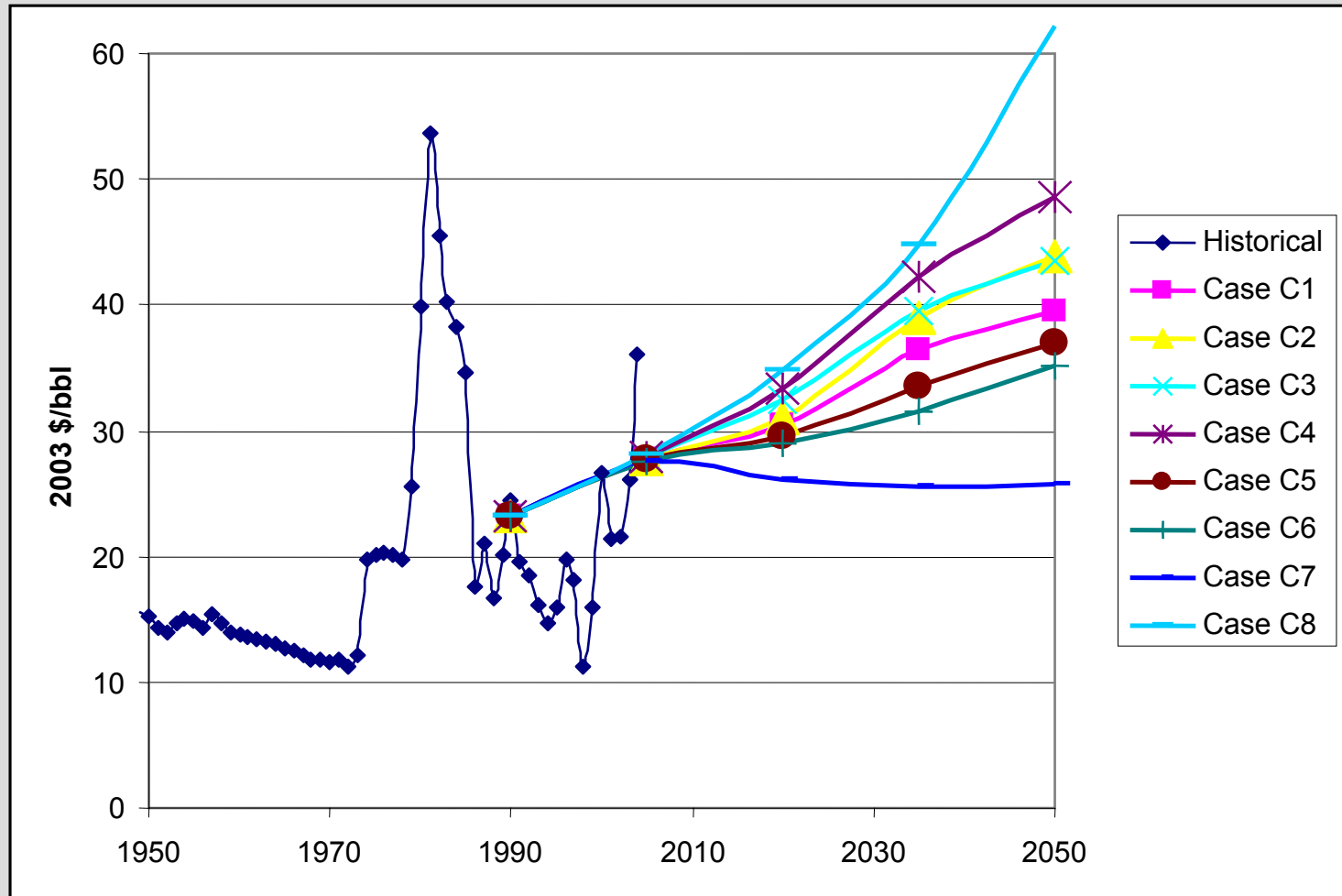
Oil Price Results: US Refiner Crude Acquisition Cost
## (EIA/AEO's Definition of World Oil Price)
2003 $/barrel

Case	2005	2020	2035	2050
1	30.3	33.0	39.0	42.0
2	30.3	33.6	41.4	46.4
3	30.4	34.9	42.1	46.1
4	30.4	35.9	44.8	51.1
5	30.2	32.2	36.1	39.5
6	30.2	31.6	34.1	37.8
7	30.2	28.6	28.1	28.2
8	30.6	37.3	47.2	64.7

US Average Delivered Unleaded Gasoline Price With Taxes
(2003 $/gallon)

| Case	2005	2020	2035	2050
1	1.63	1.69	1.82	1.89
2	1.63	1.70	1.87	1.98
3	1.64	1.73	1.89	1.97
4	1.64	1.75	1.95	2.08
5	1.63	1.67	1.76	1.83
6	1.63	1.66	1.72	1.79
7	1.63	1.60	1.59	1.59
8	1.64	1.78	2.00	2.37

95% and 99% Probabilistic Ranges for Spot Oil Prices versus Historical Daily Spot Prices
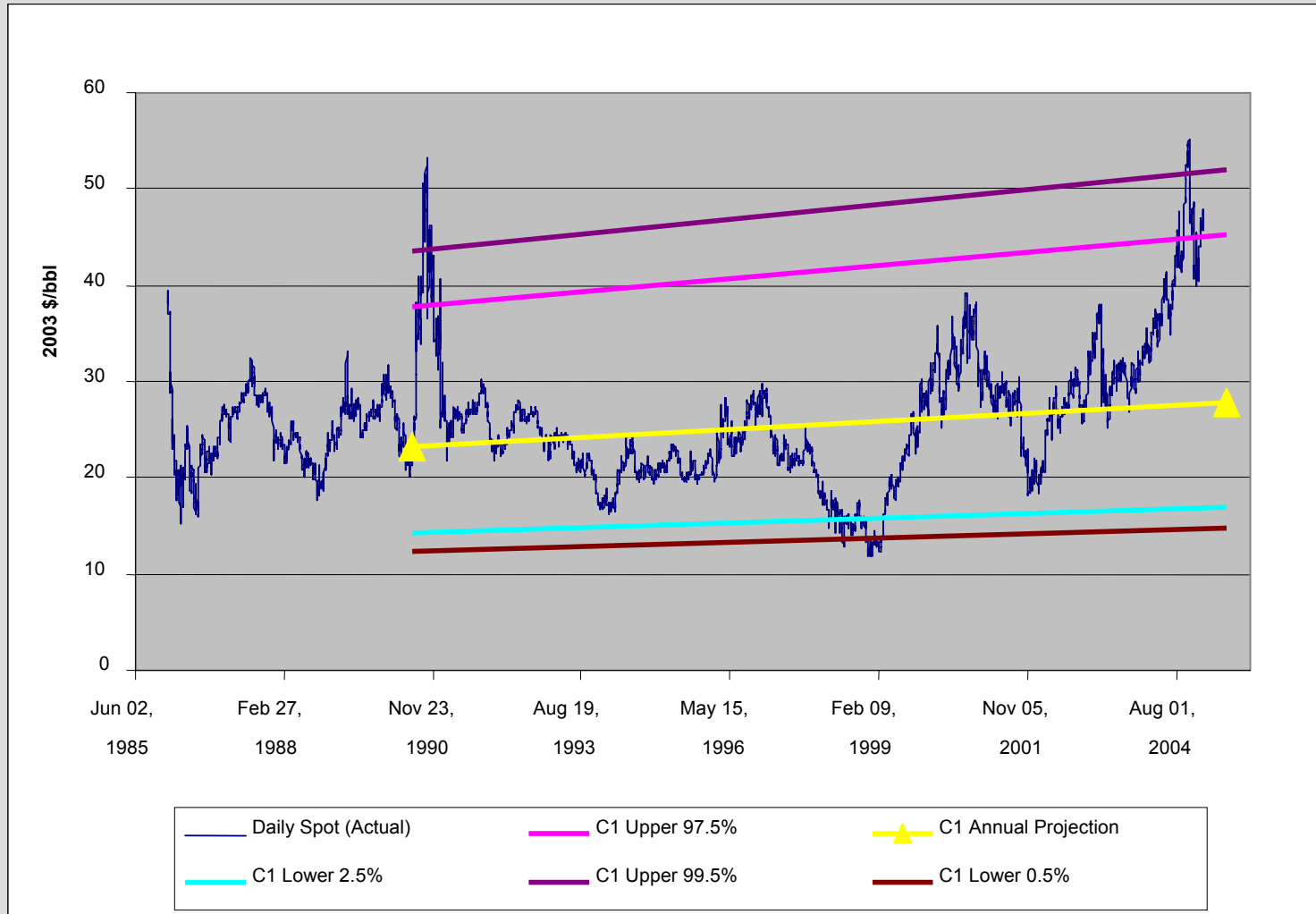
Probabilistic Ranges Applied to Case 1 Annual Projections

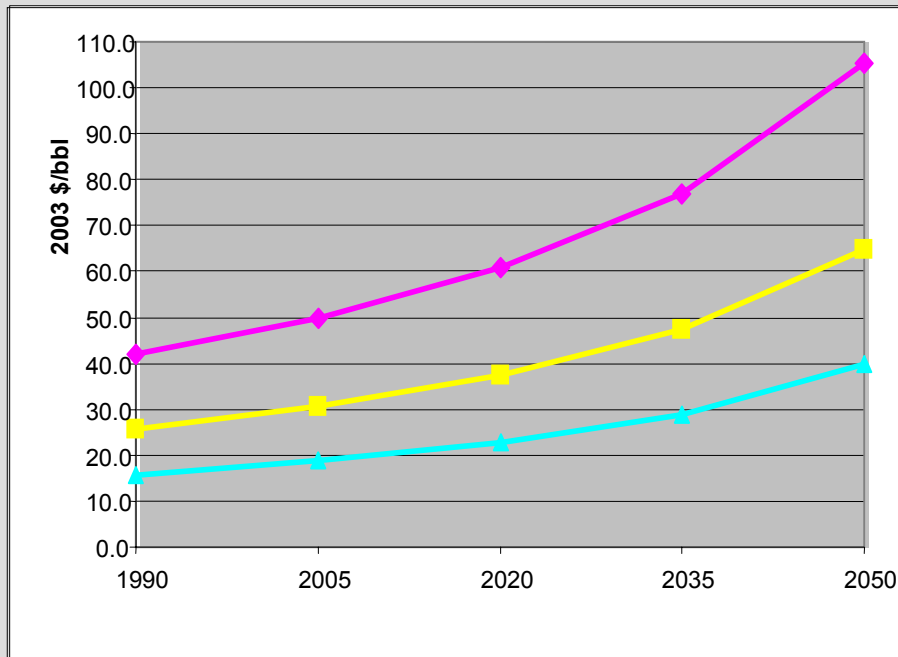**95% Probabilistic Range of Spot Prices for Refiner Crude Oil Acquisition Cost**

**95% Probabilistic Range of Spot Prices for US Average Gasoline, with Taxes**

Legend:
- C1 Upper 97.5%
- C1 Annual Projection
- C1 Lower 2.5%

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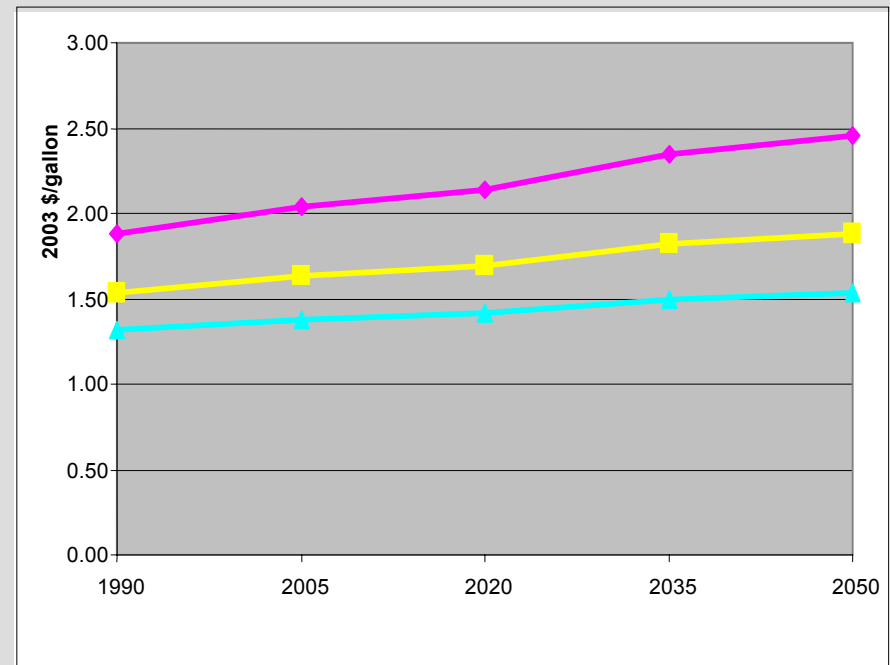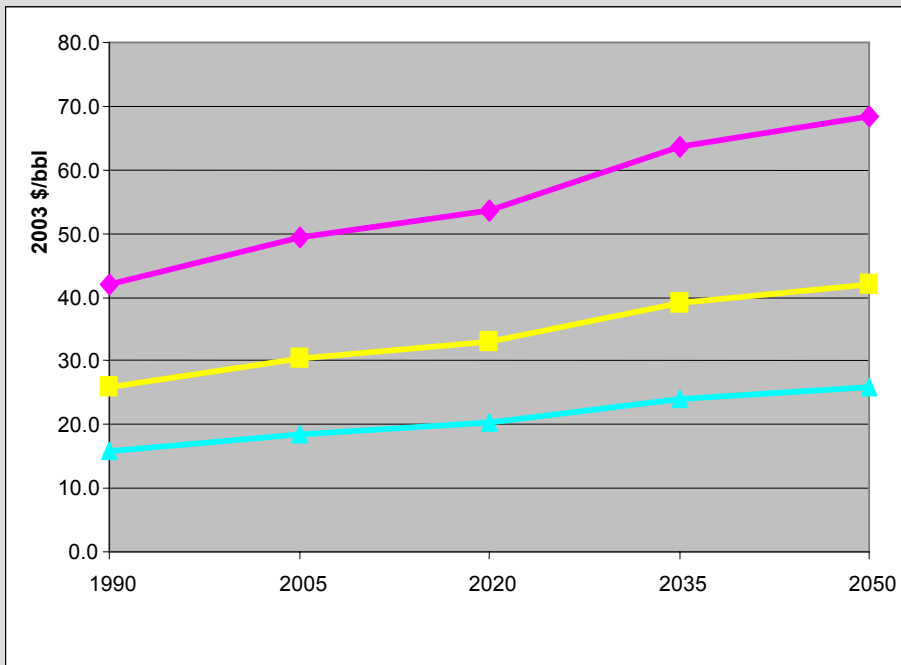
Probabilistic Ranges Applied to Case 8 Annual Projections

95% Probabilistic Range of Spot Prices for Refiner Crude Oil Acquisition Cost

95% Probabilistic Range of Spot Prices for US Average Gasoline, with Taxes

Legend: —◆— C1 Upper 97.5% —■— C1 Annual Projection —▲— C1 Lower 2.5%

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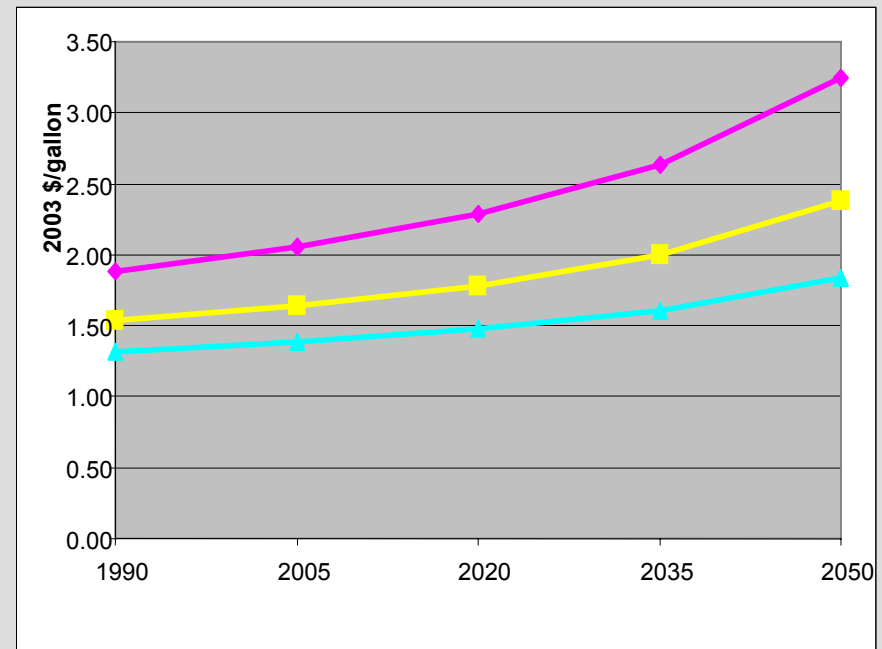
Future Work

▶ Task 1: Conduct analysis of hydrogen markets using Mini-CAM model (see next slide)

▶ Task 2: Continue and update Data Book

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Anticipated Future Work:
Update Previous PNNL analyses of hydrogen (see below) using new H2A technology characterizations

Final Energy Use by Energy Carrier (EJ/year)
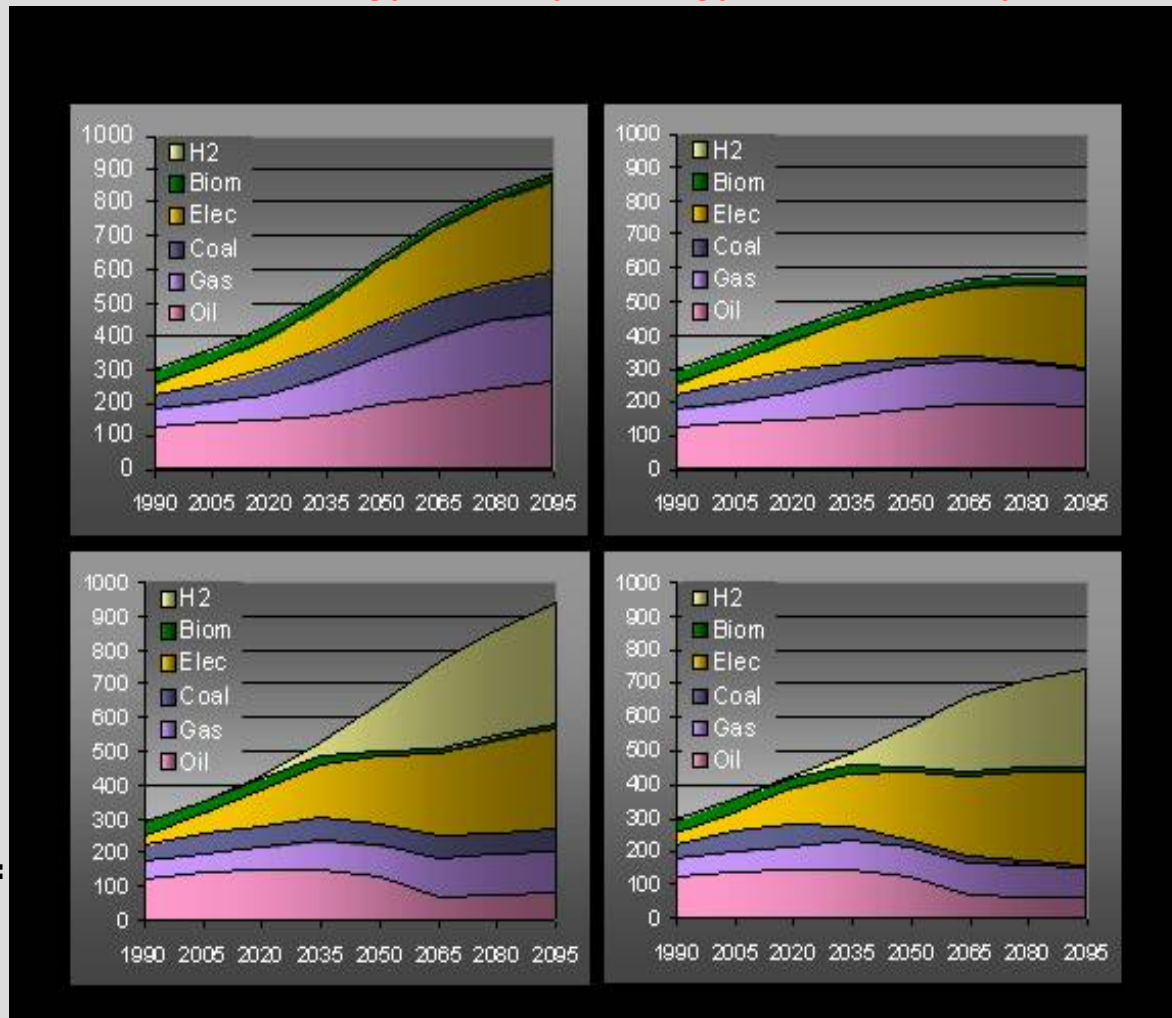
No carbon policy & no advanced technology = no hydrogen

Carbon constraints & no technology improvements = no hydrogen

No carbon policy, but dramatic technology improvements = hydrogen penetration

Carbon constraints & dramatic technology improvements = hydrogen penetration

Supplemental Slides

Publications

"Scenario Analysis of Future Oil and Gas Prices", by Marshall Wise, Jae Edmonds, and Marylynn Placet. Draft Final Report, Pacific Northwest National Laboratory, April 2004

Hydrogen Safety

The most significant hydrogen hazard associated with this project is:

None