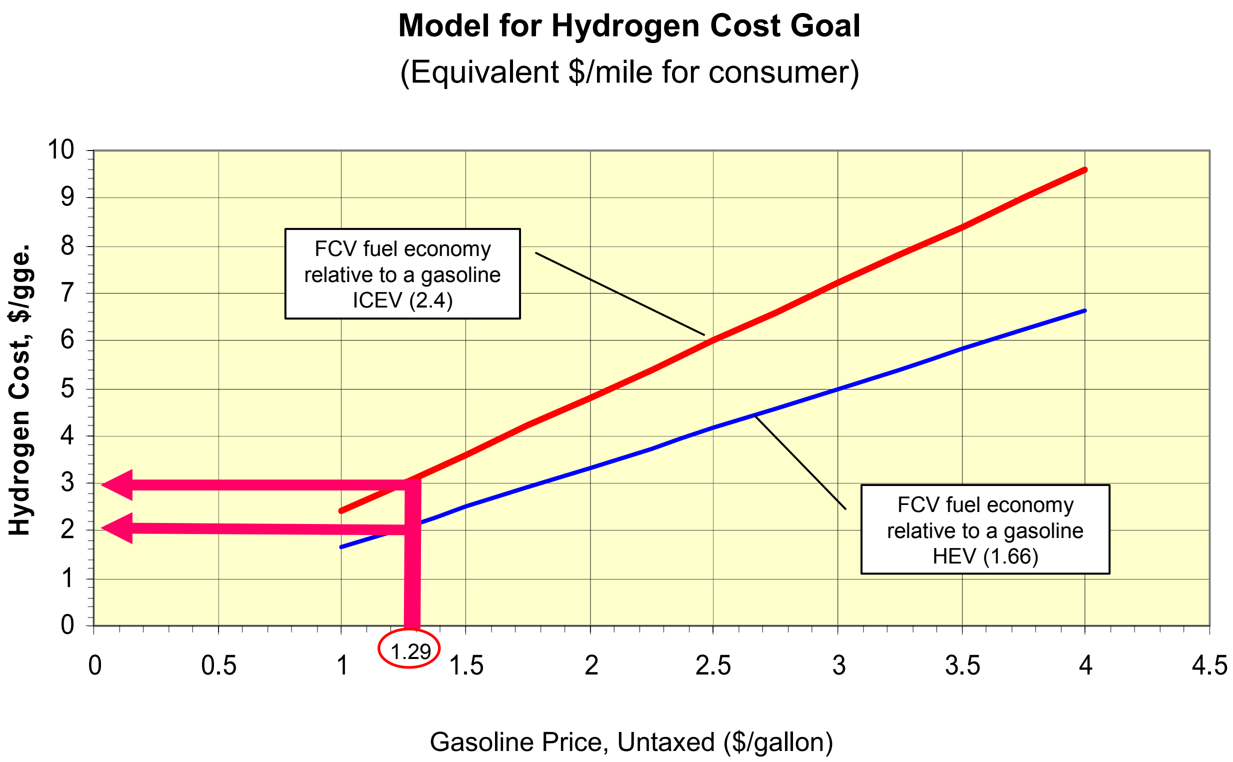
**DOE Hydrogen**
**Program Record**
**Record #:** 5013
**Date:** December 15, 2005
**Title:** Hydrogen Cost Goal
Item: $2.00 - $3.00/gge

**Originator:** Roxanne Garland
**Approved by:** JoAnn Milliken
**Date: December 21, 2005**

# Calculation




Note: FCVs are assumed to be 1.66 times more efficient than gasoline HEVs (*The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*, Committee on Alternatives and Strategies for Future Hydrogen Production and Use, National Research Council and National Academy of Engineering, 2004, p. 66) and 2.4 times more efficient than gasoline ICEVs (Ibid, p. 26). EIA projected gasoline price of $1.29 in 2015 is based on the high "A" case (*Annual Energy Outlook 2005*, Energy Information Administration, January 2005).

# Reference:

## *Hydrogen Cost Goal*

Don Gardner
Fred Joseck

Presented to the FreedomCAR and Fuel Partnership Executive Steering Group
By the Fuel Pathways Integration Tech Team

April 19, 2005

# Hydrogen Cost Goal

## Why Re-Examine the Hydrogen Cost Target?

- The current hydrogen cost target of $1.50 / gge (untaxed, 2001$) for 2010 was developed in 2002.
- Represented a snapshot in time based on distributed natural gas reforming
- Was not based on comparison to a competitive benchmark
- Timeframe is not consistent with the partnership's 2015 commercialization decision point

# General Principles for Cost Goals

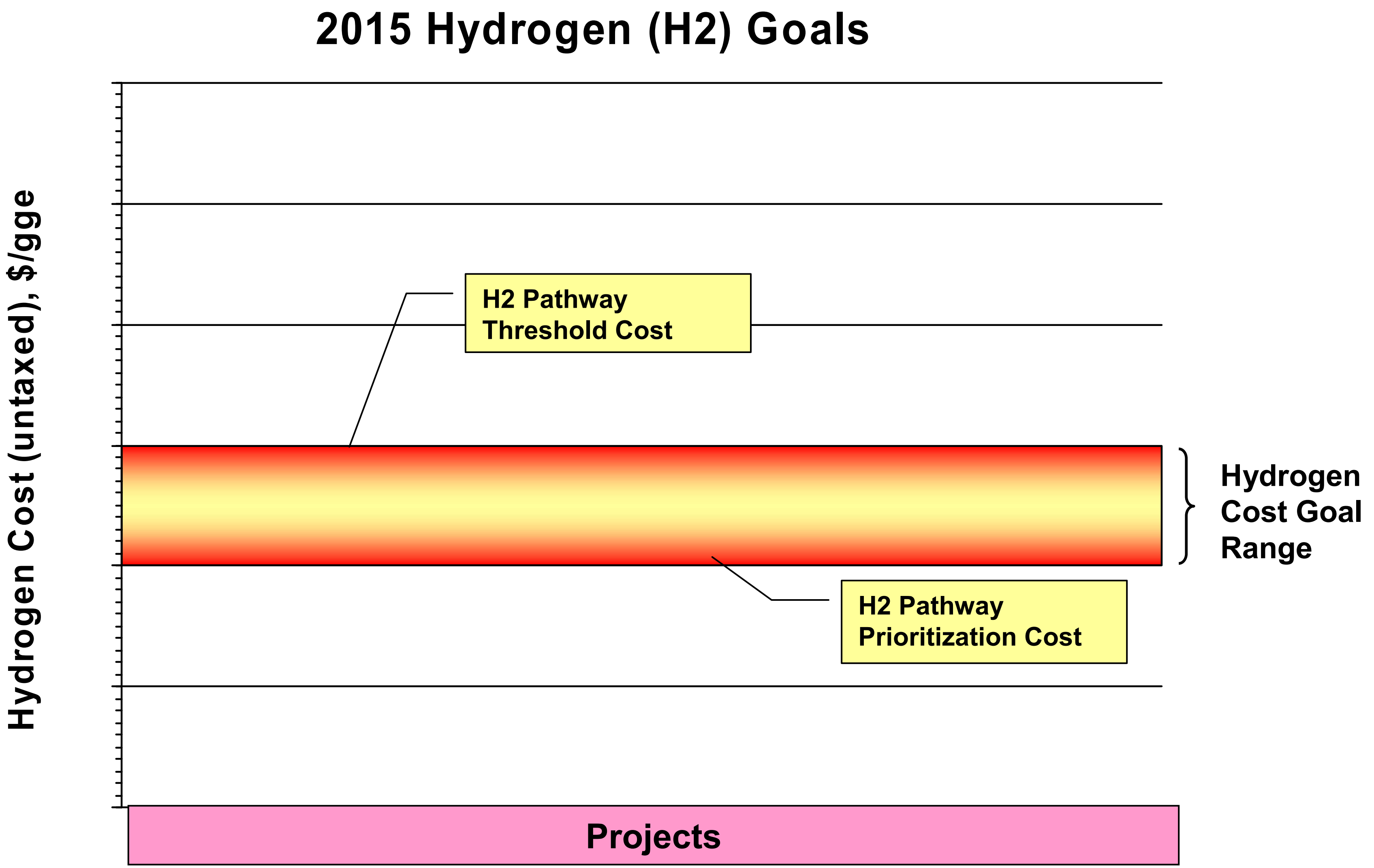
- Provide a "yardstick" for assessing technology performance
- Guide R&D programs by enabling prioritization and focusing of options
- Defined by comparison to evolved baseline or next-best technology
- Developed through a well defined, transparent process
- Reassessment based on major changes in technology or external drivers

# Hydrogen Cost Goal

## Application of Principles

- Goal is pathway independent
- Consumer fueling costs are equivalent or less on a cents per mile basis
- Evolved gasoline ICE and gasoline-electric hybrids are benchmarks
- R&D guidance provided in two forms
  - Evolved gasoline ICE defines a threshold hydrogen cost used to screen or eliminate options which can't show <u>ability</u> to meet target
  - Gasoline-electric hybrid defines a lower hydrogen cost used to prioritize projects for resource allocation

# Hydrogen Cost Goal



# Hydrogen Cost Goal

## Mechanics

$$\text{H2 Cost } (\$ / \text{gge}) \leq (\text{EIA Gasoline Price in 2015}) \left[ \frac{\text{Fuel Economy H2FCV}}{\text{Fuel Economy Competitive Vehicle}} \right]^{1}$$

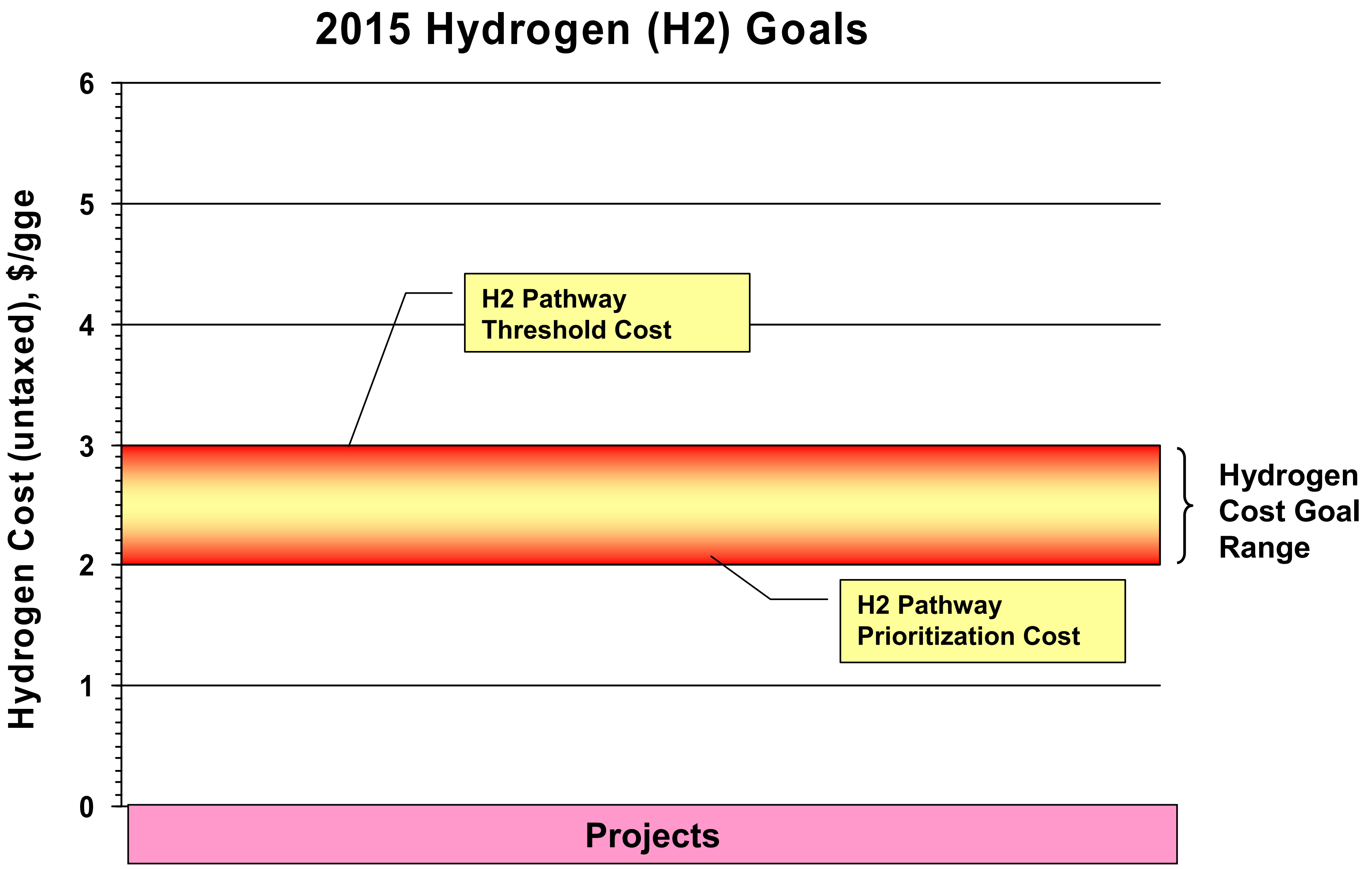
| Input | Value | Source |
|---|---|---|
| Gasoline price projection for 2015 | $1.26 / gal (untaxed, 2005 $) | EIA Annual Energy Outlook, 2005 |
| Ratio of FCV fuel economy to evolved gasoline ICE | 2.40 | NRC H2 Economy Report |
| Ratio of FCV fuel economy to gasoline hybrid | 1.66 | NRC H2 Economy Report |

## Results

- **Hydrogen Cost Goal Range = $2.00 – 3.00/gge.**

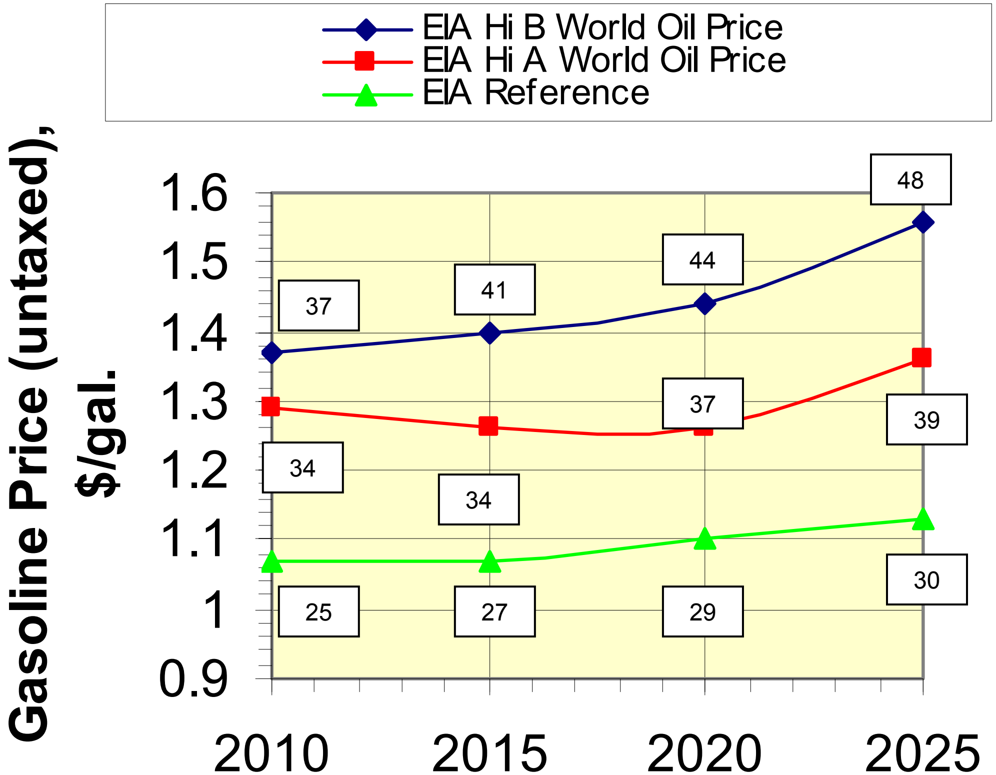
[1] Ratio of FCV fuel economy to competitive vehicle

# Hydrogen Cost Goal



# Assumptions for Cost Model: EIA Gasoline Price (Untaxed) Projections

Source: EIA Annual Energy Outlook 2005, p. 216




- Reference case - not used; relatively and stable prices, little economic case for change
- "Hi A" case – used; greater increase in future (2020-2025)
- "Hi B" case – not used; too far from best projections (Reference case)

- EIA "Hi A" case => $1.26/gal (untaxed, $34/bbl)
- Note: Prices are in 2005 dollars
- The value in the box is the corresponding crude price in $/bbl

# Hydrogen Cost Goals

## Recommendation to ESG:

- The Hydrogen Cost Goal should be revised expressed as a range (untaxed in 2005$)/gge for 2015.
  - ❖ The Hydrogen Threshold Cost of $3.00 will be a guideline and one factor used to screen R&D projects
  - ❖ The Hydrogen Prioritization Cost of $2.00 will be used as a guideline to prioritize the R&D projects (highest resource allocation).
- The Hydrogen Cost Goal should be reevaluated in the event there is a major change in technology, markets, and/or other external drivers.

## Next Steps if Receive Approval:

- The Hydrogen Cost Goal will be changed in the Partnership Plan
- JOG will work on communications plan

# ***Backup Slides***

# Summary of EIA Cases & Hydrogen Cost

| EIA Case | 2015 World Oil Price, $/bbl | 2015 Gasoline Price (untaxed), $/gal. | Hydrogen Threshold Cost, $/gge. (Gas ICEV) | Hydrogen Prioritization Cost, $/gge. (Gas HEV) |
|---|---|---|---|---|
| High "B" World Oil Price | 41 | 1.40 | 3.36 | 2.32 |
| High "A" World Oil Price | 34 | 1.26 | 3.02 | 2.09 |
| Reference Case | 27 | 1.07 | 2.57 | 1.78 |

The Hydrogen Threshold Cost is based on a Vehicle Fuel Efficiency Improvement Factor of 2.4 from the NAS.

The Lower Hydrogen Threshold Cost is based on a Vehicle Fuel Efficiency Improvement Factor of 1.66 from the NAS.

# EIA Case Descriptions

***EIA Reference Case***
Baseline economic growth (3.1 percent per annum), world oil price falling to about $25 per barrel by 2010 and rising to $30.31 per barrel, and technology assumptions.

***High A World Oil Price***
Reference case assumptions except that the world oil prices are $39.24 per barrel in 2025, compared with $30.31 per barrel in the reference case.

***High B World Oil Price***
World oil prices remain high and are $48.00 per barrel in 2025, compared with $30.31 per barrel in the reference case.

**Note:**
The source of this information is the EIA Annual Energy Outlook 2005 on page 216.

# Hydrogen Cost Goal Methodology

- $$\text{¢/mi}\Big|_{\text{Any Fuel System}} = \frac{\text{Fuel Cost [\$/gge]}}{\text{Fuel Economy [mi/gge]}}\Bigg|_{\text{Any Fuel System}}$$

- $$\frac{\text{Cost}^{1}\ H_2}{\text{Fuel Economy } H_2\text{FCV}}\Bigg|_{2015} = \leq \frac{\text{EIA Gasoline}^{2}\text{ Price}}{\text{Fuel Economy Competitive Vehicle}}\Bigg|_{2015}$$

$$\text{H2 Cost}\Big|_{2015} \leq (\text{EIA Gasoline Price in 2015}) \left[\frac{\text{Fuel Economy H2FCV}}{\text{Fuel Economy Competitive Vehicle}}\right]^{3}_{2015}$$

[1] Untaxed

[2] EIA Price is untaxed; able to reference

[3] NRC fuel economy ratios cited; able to reference

# Assumptions for Hydrogen Cost Method: Fuel Economy Ratios for Competitive Options[1]

- 1: Gasoline internal combustion engine (ICE) vehicle – no hybridization

$$\left.\frac{H_2FCV}{\text{Gas ICEV}}\right|_{\text{Fuel Economy}} = 2.40$$

[NRC H2 Economy Report, p.26]

- 2: Gasoline hybrid-electric vehicle (HEV)

$$\left.\frac{H_2FCV}{\text{Gas HEV}}\right|_{\text{Fuel Economy}} = 1.66$$

[NRC H2 Economy Report, p.26; derived using Gas HEV to Gas ICE ratio of 1.45]

[1] 1%/yr improvement in fuel economy assumed in both cases