U.S. Department of Energy
FUEL CELL TECHNOLOGIES PROGRAM

Hydrogen and Infrastructure Costs

Hydrogen Infrastructure Market Readiness Workshop

Washington D.C.

February 17, 2011

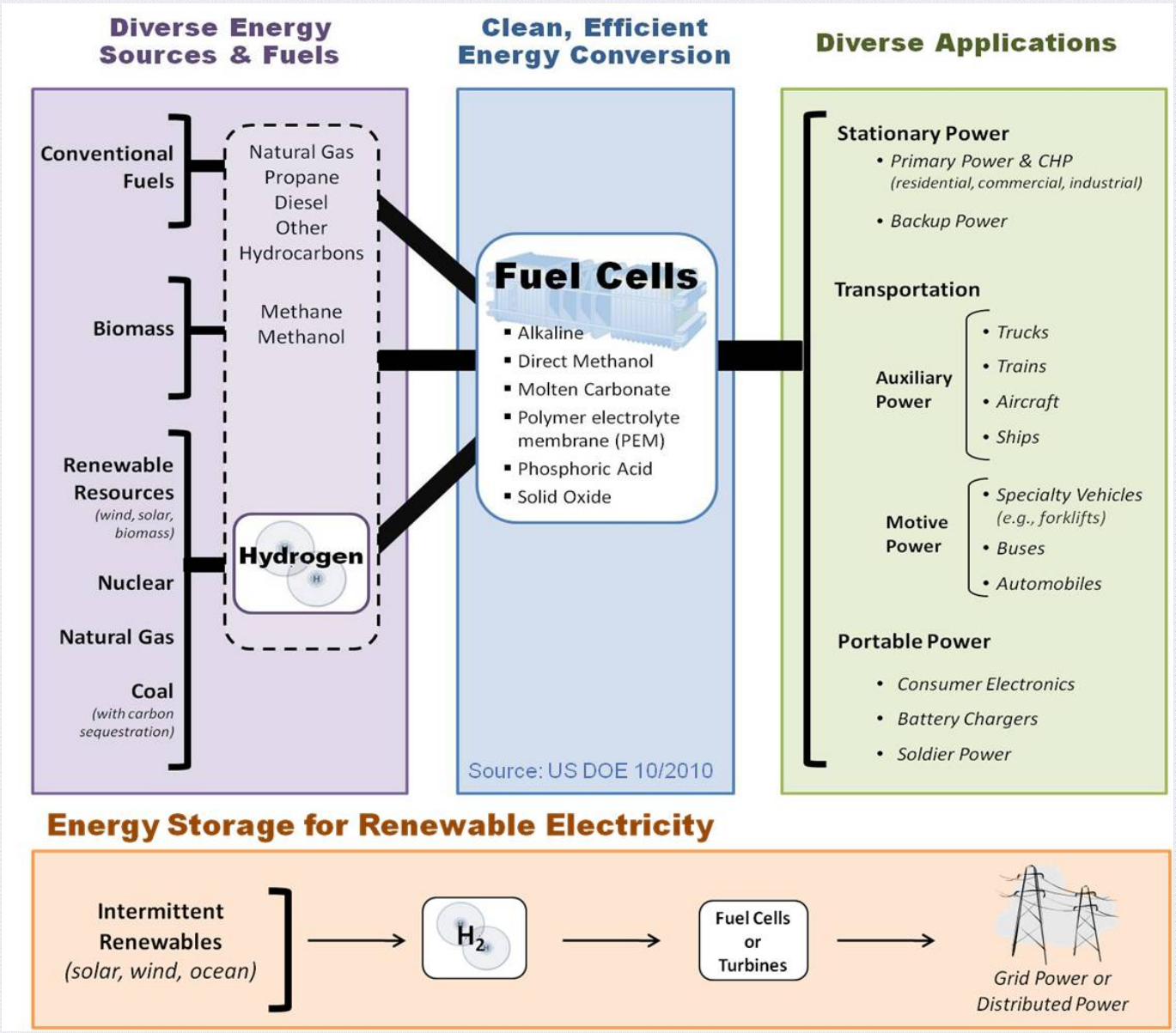
Fred Joseck

U.S. Department of Energy

Fuel Cell Technologies Program

Fuel Cells: Diverse Fuels and Applications

U.S. DEPARTMENT OF ENERGY



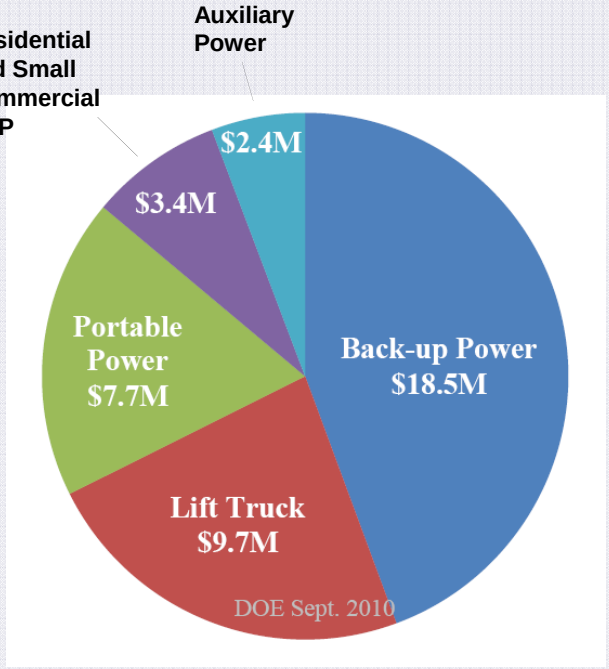
Recovery Act Funding for Fuel Cells

U.S. DEPARTMENT OF ENERGY

More than $40 million from the 2009 American Recovery and Reinvestment Act to fund 12 projects to deploy up to 1,000 fuel cells

FROM the LABORATORY to DEPLOYMENT:

DOE funding has supported R&D by all of the fuel cell suppliers involved in these projects.



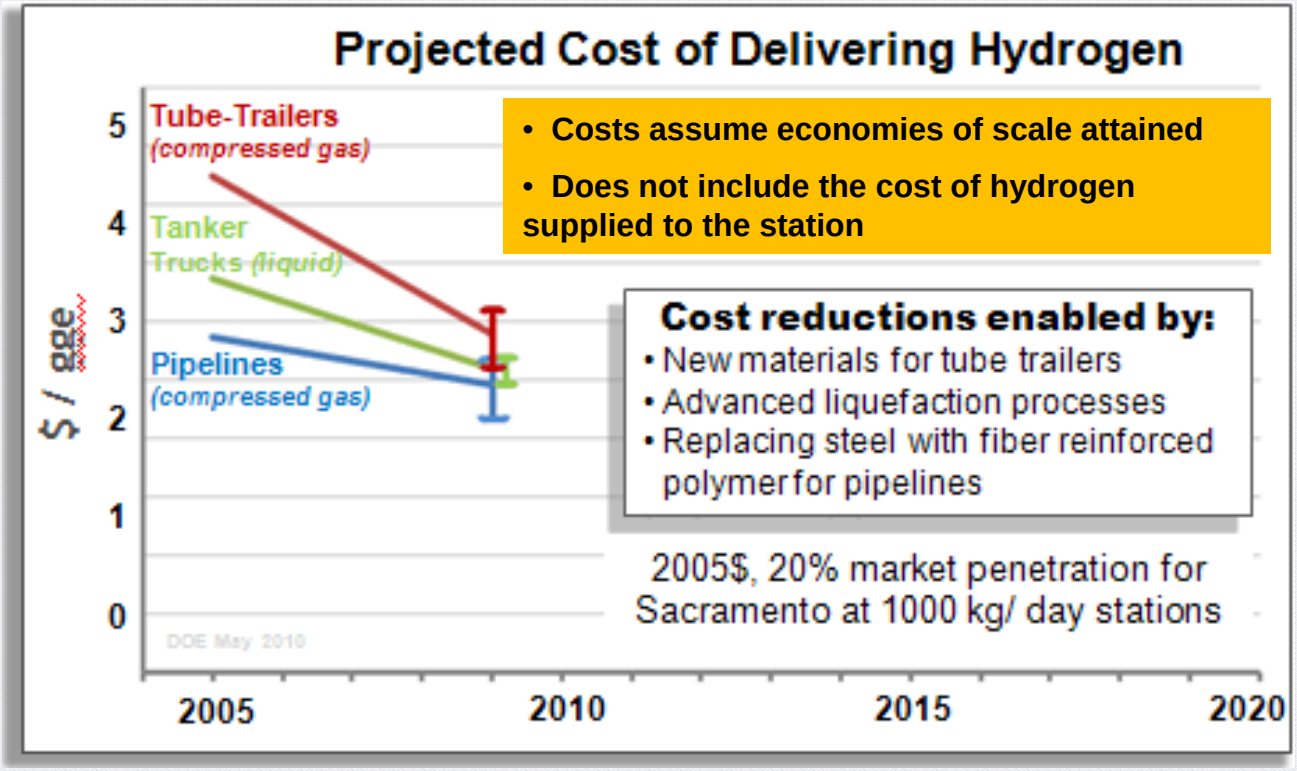
Approximately $54 million in cost-share funding from industry participants—for a total of about $96 million.

COMPANY	AWARD	APPLICATION
Delphi Automotive	$2.4 M	Auxiliary Power
FedEx Freight East	$1.3 M	Lift Truck
GENCO	$6.1 M	Lift Truck
Jadoo Power	$2.2 M	Portable
MTI MicroFuel Cells	$3.0 M	Portable
Nuvera Fuel Cells	$1.1 M	Lift Truck
Plug Power, Inc. (1)	$3.4 M	CHP
Plug Power, Inc. (2)	$2.7 M	Back-up Power
Univ. of N. Florida	$2.5 M	Portable
ReliOn, Inc.	$8.5 M	Back-up Power
Sprint Nextel	$7.3 M	Back-up Power
Sysco of Houston	$1.2 M	Lift Truck

Hydrogen Delivery R&D

U.S. DEPARTMENT OF ENERGY

The Program is developing infrastructure technologies to deliver hydrogen from centralized production facilities, efficiently and at low cost.



We've reduced the cost of hydrogen delivery* —

~30% reduction in tube trailer costs

>20% reduction in pipeline costs

~15% reduction liquid hydrogen delivery costs

Projected cost, based on analysis of state-of-the-art technology

Infrastructure (Station with Tube Trailer Delivery) — *Progress: Cost*

U.S. DEPARTMENT OF ENERGY

The projected delivered hydrogen cost at high-volume with tube trailer delivery was projected to be ~$2.85/gge (2009)*

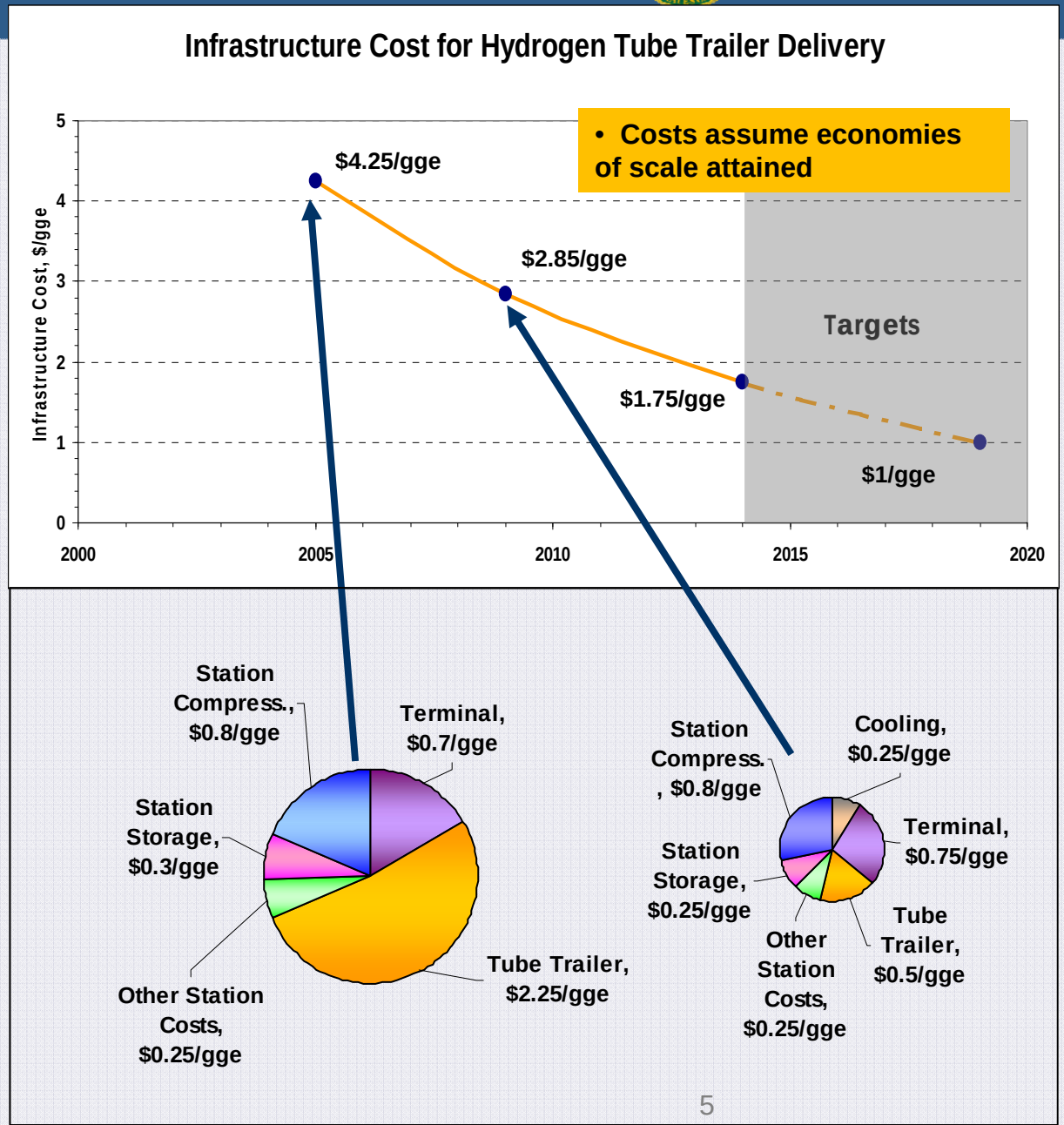
- ***More than 30% reduction since 2005***
- ***Majority of cost reduction from tube trailer advancements***

As station and delivery costs are reduced, compressor, terminal, storage components are responsible for a larger % of costs.

****Based on projection to high-volume hydrogen delivery.***

Does not include the cost of hydrogen supplied to the station.

Source: US DOE 10/2010



Infrastructure (Station with Pipeline Delivery) — *Progress: Cost*

U.S. DEPARTMENT OF ENERGY

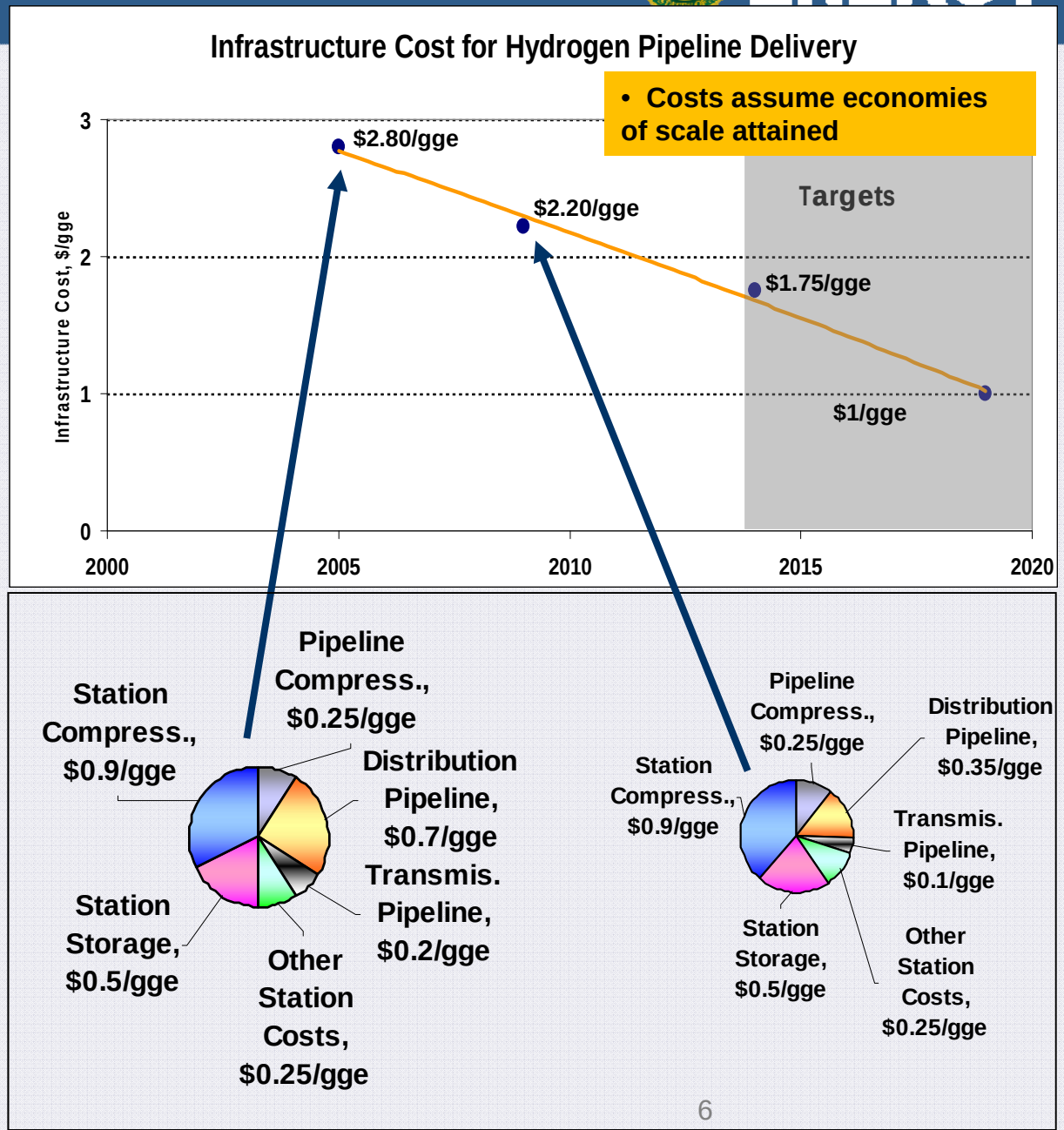
The projected delivered hydrogen cost at high-volume with pipeline delivery was projected to be ~$2.20/gge (2009)*

- ***More than 20% reduction since 2005***
- ***Majority of cost reduction from pipeline advancements***

As station and delivery costs are reduced, compressor, terminal, storage components are responsible for a larger % of costs.

Does not include the cost of hydrogen supplied to the station.

****Based on projection to high-volume hydrogen delivery.***



Source: US DOE 10/2010

Infrastructure (Station with Liquid Truck Delivery) — *Progress: Cost*

U.S. DEPARTMENT OF ENERGY

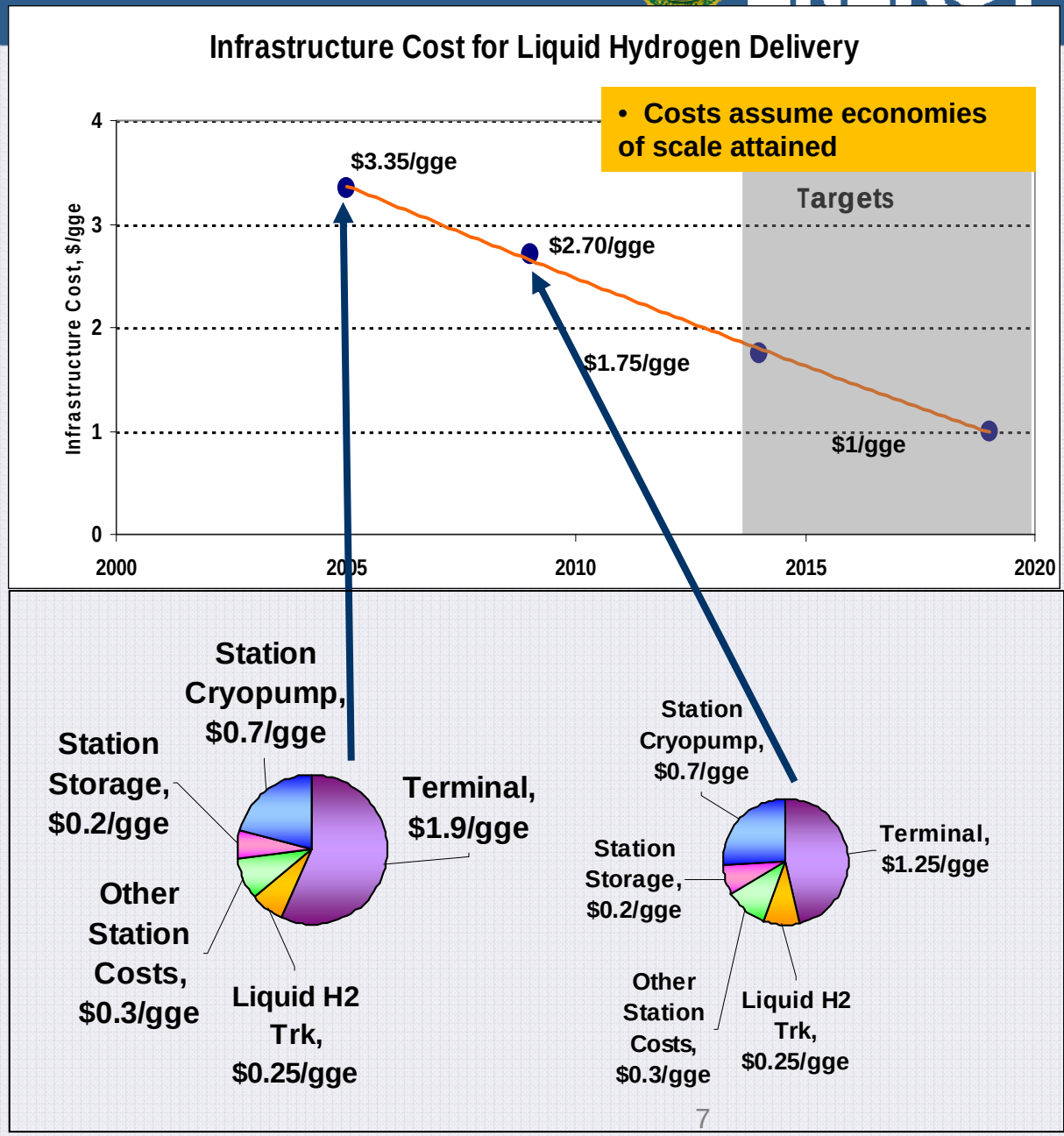
The projected delivered hydrogen cost at high-volume with liquid truck delivery was projected to be ~$2.70/gge (2009)*

- ***~20% reduction since 2005***
- ***Majority of cost reduction from treminal advancements***

As station and delivery costs are reduced, cyropump and terminal components are responsible for a larger % of costs.

****Based on projection to high-volume hydrogen delivery.***
Does not include the cost of hydrogen supplied to the station.

Source: US DOE 10/2010



Current Delivered Hydrogen Cost to the Station

Liquid H2 Pricing ($/kg)		
Delivered Volume, k g/d	**East, $/kg**	**West, $/kg**
8-24	$7.00	$10.20
24-47	$6.40	$9.30
47-79	$5.70	$8.00
79+	$4.90	$7.00
Gaseous H2 Pricing ($/kg)		
4-8	$18.40	$19.70
8-16	$17.60	$18.80
16-24	$16.70	$18.00

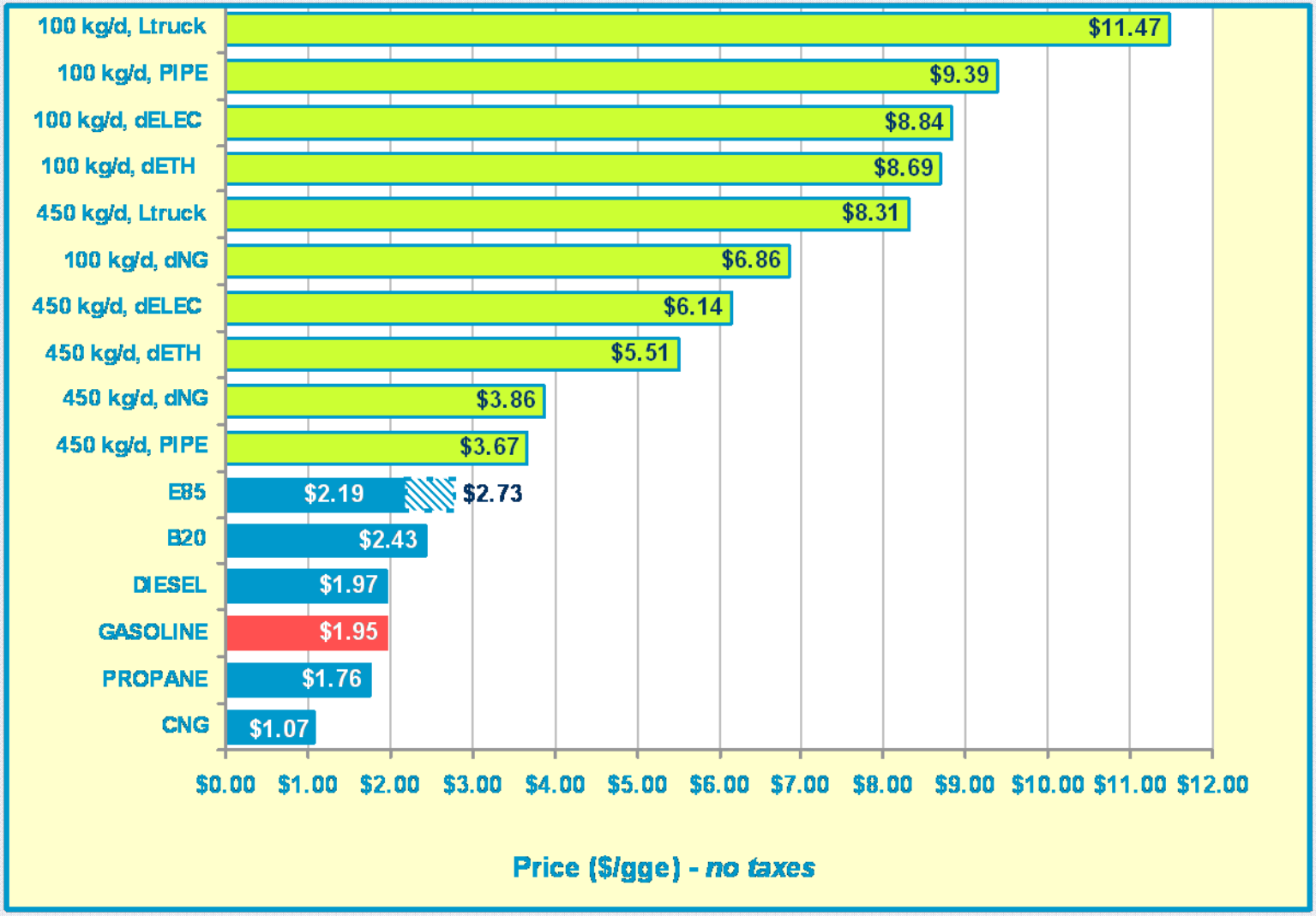
Source: TTC Hydrogen Market Study 2009

Costs are for volumes delivered by truck.

COMPARISON W/ OTHER ALTERNATIVE FUELS on $/gge basis

U.S. DEPARTMENT OF ENERGY

On a **$/gge** basis, hydrogen does not compete well. Central (450 kg/d) production from NG with pipeline delivery is cheapest hydrogen option and comes somewhat close to ethanol's price, ***if*** ethanol ***did not*** have any subsidies. Small-scale (100 kg/d) production from NG with liquid truck delivery the costliest option.

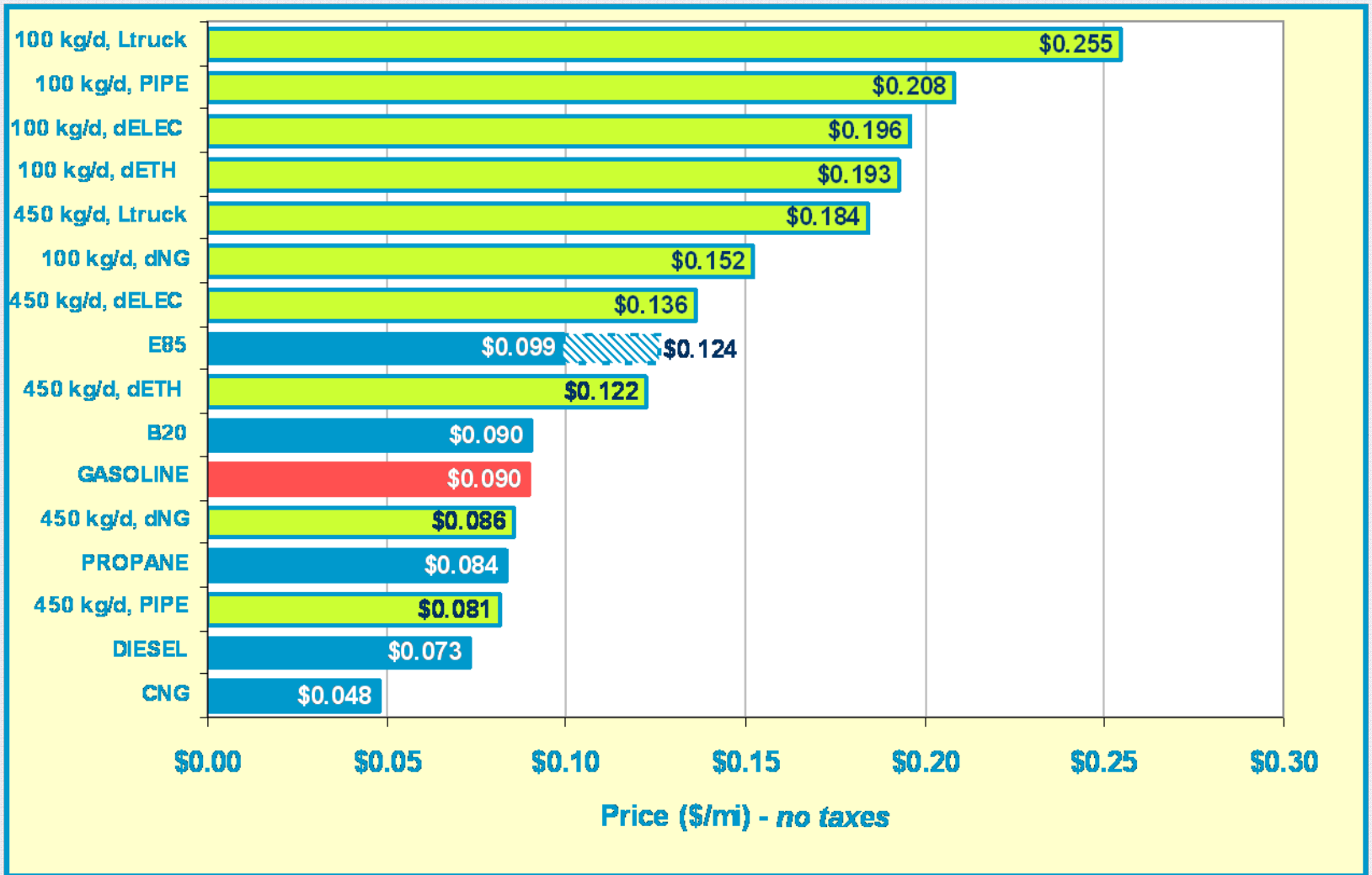


Hydrogen costs based on H2A model results

COMPARISON W/ OTHER ALTERNATIVE FUELS on $/mi basis

U.S. DEPARTMENT OF ENERGY

On a **$/mi** basis, hydrogen starts competing. Central production with pipeline delivery and distributed – both at 450 kg/d - are cheapest hydrogen options and competes with several alternative fuels and gasoline. Small-scale (100 kg/d) production from NG with liquid truck delivery still the costliest option. Distributed hydrogen from ethanol (450 kg/d) and ethanol are very close in price, especially if ethanol ***does not have*** subsidies.



Hydrogen costs based on H2A model results

Examples of Policies Promoting Fuel Cells

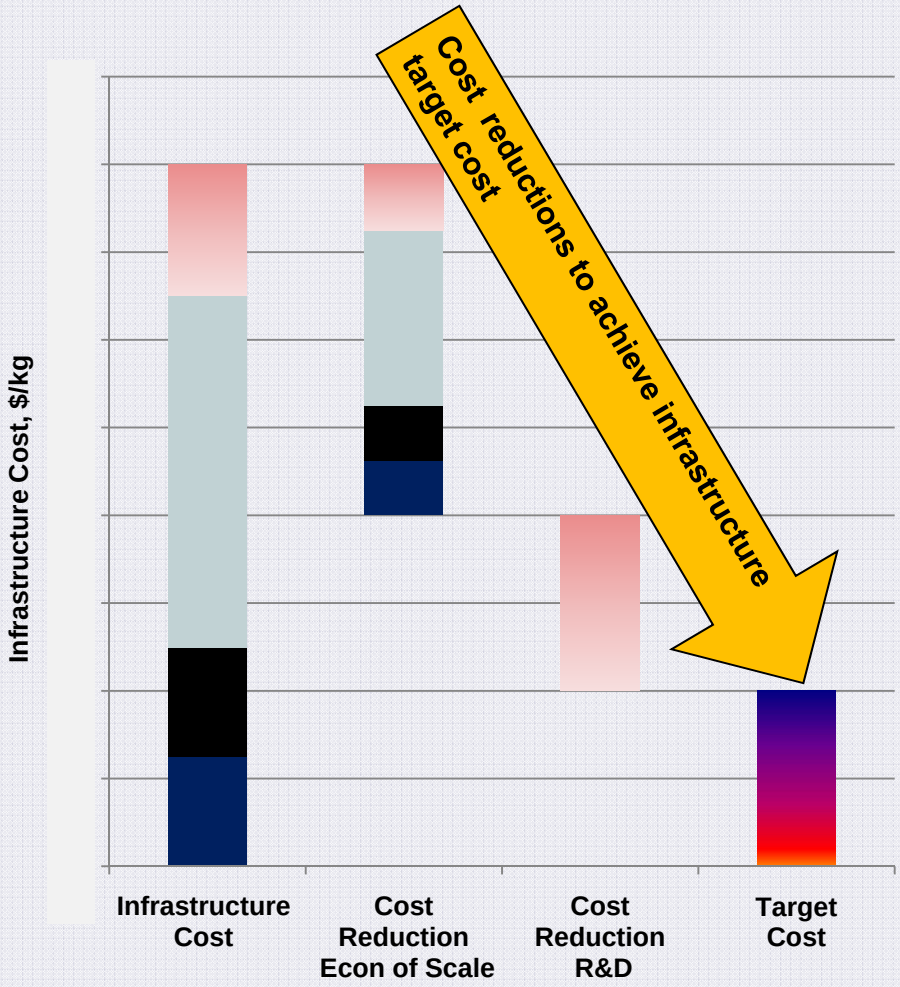
U.S. DEPARTMENT OF ENERGY

Some tax credits affecting fuel cells and infrastructure were expanded. Through new financing mechanisms, these credits can help facilitate federal deployments.

Hydrogen Fueling Facility Tax Credit	***Increases the credit for a hydrogen fueling station from 30% or $30,000 to 30% or $200,000.*** Equipment must be installed by December 31, 2014.
Fuel Cell Motor Vehicle Tax Credit	A tax credit of up to $4,000 is available for the purchase of qualified light-duty fuel cell vehicles. Tax credits are also available for medium- and heavy-duty vehicles. Expires December 31, 2014.
Fuel Cell Tax Credit (other than residential)	Offers tax credit of 30% for qualified fuel cell property or $3,000/kW of the fuel cell nameplate capacity. Feature a 10% credit for combined-heat-and-power-system property. Equipment must be installed by December 31, 2016.
Residential Energy Efficiency Credit	Raises ITC cap for residential fuel cells in joint occupancy dwellings to $3,334/kW. Equipment must be installed by December 31, 2016.
Power Generation Credit	Offers 1.8¢/kW-hr payment to the owner/operator of a qualifying advanced power system technology facility including those using advanced fuel cells. An additional 0.7¢/kW-hr shall be paid to the owner/operator of a qualifying security and assured power facility for electricity generated at such facility. Expires 2012.

Workshop Overview

Potential Infrastructure Cost Reduction



Planned Workshop Outcomes

- Identify potential infrastructure cost reductions from “economies of scale” and “learning by doing” (repetitive station installation of same design)
- Identify key areas of infrastructure cost reduction that require addition R&D

Reasons and Purpose for the Workshop

U.S. DEPARTMENT OF ENERGY

Workshop Purpose

- Identify key cost drivers for hydrogen supply infrastructure supporting light duty vehicles, buses, MHE, etc.
- Identify and quantify major cost reduction opportunities
  - Impact of economies of scale, learning by doing, redundancy of installation
- Identify actions required to achieve cost reductions

Thank you

For more information, please contact

Fred.Joseck@ee.doe.gov

hydrogenandfuelcells.energy.gov

BACK-UP SLIDES

EARLY MARKET HYDROGEN COSTS
Assumptions

U.S. DEPARTMENT OF ENERGY

GENERAL (all cases)

- Facilities are installed on existing station property.
- NO rent, land or labor costs included.
- H2A model used for all cases *except* production & delivery portion of central production with liquid truck delivery.

LIQUID DELIVERY

- (Production + delivery) cost estimate based on quote from industry, which includes the production, liquefaction, storage and liquid truck delivery cost.
- Demand - summer surge = 10%; Friday surge = 8%.

PIPELINE DELIVERY

- NO transmission and trunk pipeline – just 2 miles of *distribution* pipeline assumed.
- Pipeline inlet pressure = 400 psi & outlet pressure = 300 psi.
- Pipeline right of way land costs included.
- NO central terminal – delivery cost only includes distribution pipeline cost per kg H_2.
- Dispensing station has 2 compressors total; both operational at any time.
- Demand - summer surge = 10%; Friday surge = 8%.

BACK-UP SLIDES