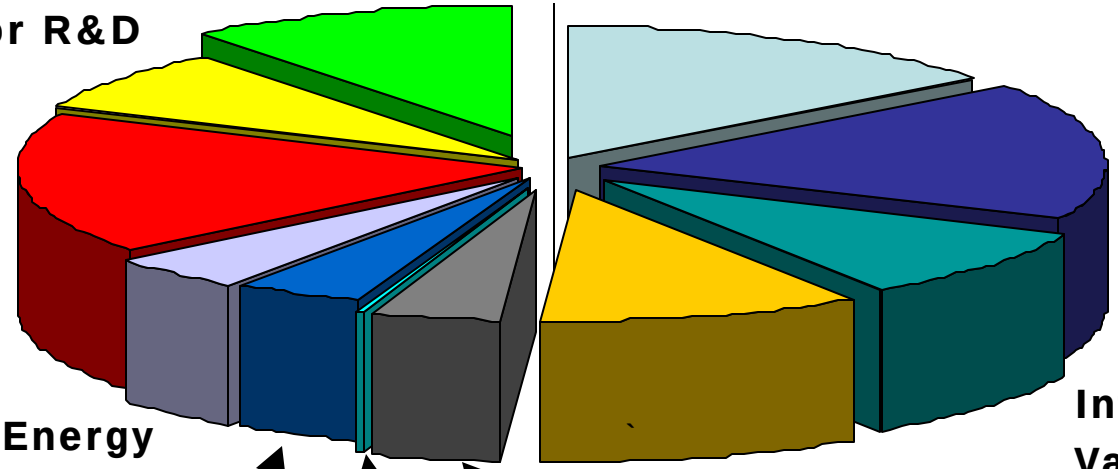
Solar Hydrogen Integration Meeting

November 11, 2004

Office of Hydrogen, Fuel Cells and Infrastructure Technologies

Pete Devlin

Hydrogen and Fuel Cell FY2005 Budget Request



Technology Validation ($18.0M)

Production/Delivery ($25.3M)

Fuel Processor R&D ($13.9M)

Stack Component R&D ($30.0M)

Storage ($30.0M)

Distributed Energy Systems ($7.5M)

Infrastructure Validation ($15.0M)

Safety, Codes & Standards and Utilization ($18.0M)

Transportation Systems ($7.6M)

Education and Cross-Cutting ($7.0M)

Technical Support ($0.5M)

Total FY-05 Request: $172.8M

Production Objectives

Research & develop low-cost, efficient H_2 production technologies from diverse, domestic sources.

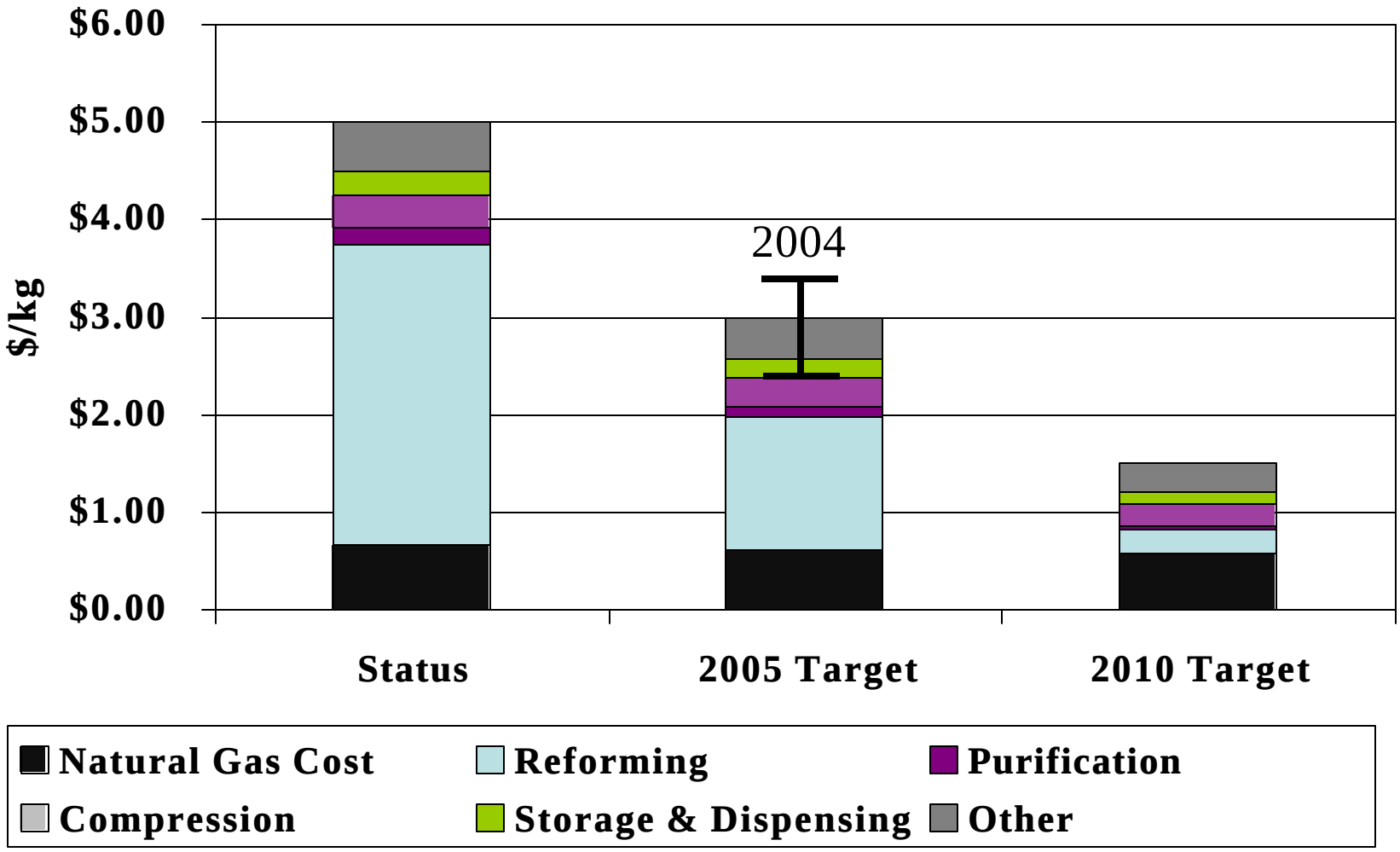
By 2010 Complete Research to Achieve:

- 1.50/kg hydrogen (delivered, untaxed) for distributed production from natural gas and/or liquid fuels
- $2.85/kg with distributed grid-connected electrolysis, delivered

By 2015 Complete Research to Achieve:

- $2.50/kg hydrogen (delivered, untaxed) for distributed production from biomass-derived renewable liquids
- $2.75/kg with centralized electrolysis, delivered, from renewable electricity
- $1.60/kg hydrogen at the plant gate from biomass gasification/pyrolysis

Distributed Reforming Production Targets



Why Solar Hydrogen?

- Very large domestic solar resource
- Electrolysis hydrogen production requires low carbon electricity to reduce transportation carbon emissions
- Solar could provide distributed electricity resource to eliminate hydrogen delivery challenges
- Potential for integration of high temperature electrolysis
- Potential value for solar technologies in hydrogen transportation market
- Benefit for direct DC connection of pv and electrolysis

Solar Hydrogen Challenges

- Economic competitiveness with gasoline will require electricity at 2-5 cents per kWh from solar
- May require multi-MW electrolysis for hydrogen refueling stations
- Small scale distributed electrolysis matched with PV has very high capital costs

Renewable Hydrogen Production

Biomass Gasification/Pyrolysis

- **Lower cost of delivered feedstock**
- **Advanced and integrated gasification/pyrolysis, reforming, shift, separations/purification technologies**

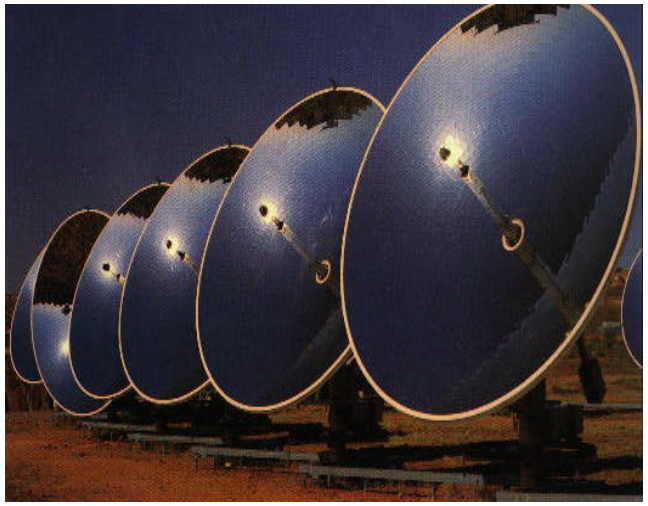
Renewable Electrolysis

- **Develop technologies for direct and grid connected integration**
- **Perform further analysis on electricity transmission and distribution scenarios for electrolysis**

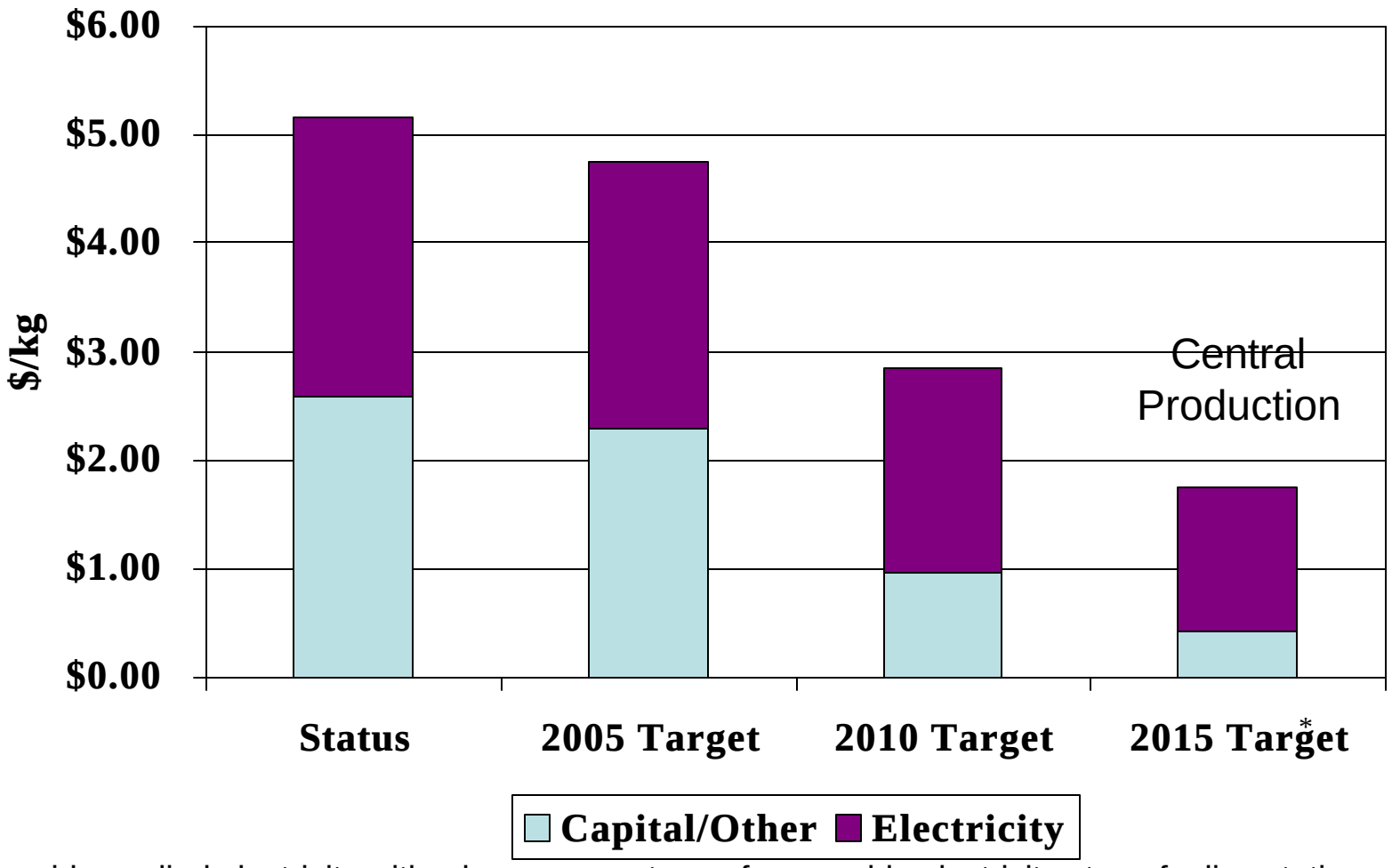
HT Thermochemical Cycles

- **UNLV Consortium: Completing database and ranking of cycles and solar concentrators**

Develop long-term renewable hydrogen technologies such as photoelectrochemical



Electrolysis Hydrogen Production Targets



* Based on grid supplied electricity with a large percentage of renewable electricity at a refueling station

Electrolysis Development

Key Challenges

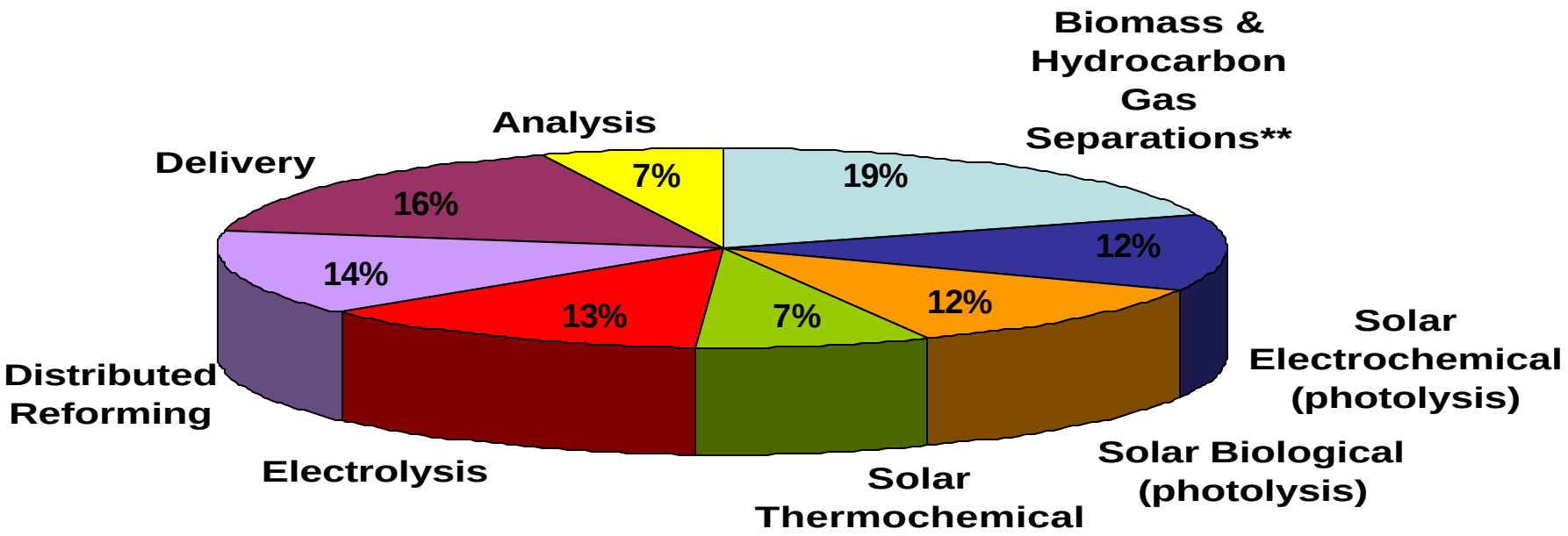
- Reduce electricity cost of hydrogen production
- Increase scale to match larger refueling demands
- Develop systems that provide benefits to electric grid
- Integration with large supply of domestic renewable electricity sources

Technical Approach

- Lower capital costs through new system designs ($700 kW to <$300 kW)
- New cell materials and systems for higher energy efficiency (60% to 75%)
- Develop high temperature electrolysis technologies to reduce electricity requirements

Hydrogen Technology* Award Funding

Total with Cost Share = $102.5 Million (Federal Share = $77.4 Million)



* Hydrogen Technology: Production, Delivery, and Analysis

** Hydrocarbon separation research co-funded with the Office of Fossil Energy

Major DOE Hydrogen Production Projects FY-05:

Distributed Reforming
- *Air Products*
- *General Electric*
- *H2Gen*
- *BOC*
- *Praxair*
- *Virent Energy Systems*

Electrolysis
- *Giner*
- *Proton Energy*
- *Teledyne Energy*
- *General Electric*
- *Cerametec*
- *Arizona State University*
- *SRI International*
- *Stirling Energy Systems*

Separations and HT Thermochemical
- *Praxair*
- *NETL*
- *SNL*
- *University of Colorado*
- *University of Nevada*
- *Media & Process Technologies*
- *Pall Corporation*
- *University of Cincinnati*

Photolytic
- *UC, Santa Barbara*
- *UC, Berkeley*
- *ORNL*
- *University of Hawaii*

Biomass
- *NREL*
- *PNNL*
- *Gas Technology Institute*
- *United Technologies*

FreedomCAR and Fuel Partnership

ChevronTexaco

bp

FreedomCAR & Fuel Partnership

Ford

ConocoPhillips

ExxonMobil

DaimlerChrysler

GM

Shell

New Energy Company/DOE Technical Teams

- Production
- Delivery
- Fuel Pathway Integration

New Joint Auto/Energy/DOE Technical Teams

- Codes and Standards
- Storage

Questions for Meeting

- How much solar electricity will be integrated with the electric grid in the future?
- Can distributed/home scale electrolysis be economically feasible?
- Can high temperature electrolysis be integrated with solar technology for higher efficiency and lower cost?
- Can solar achieve 2-5 cents per kWh electricity production cost?