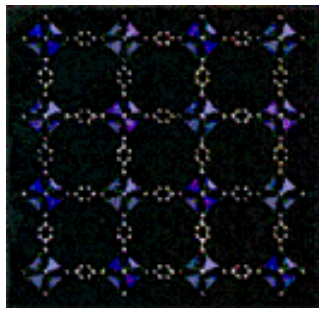
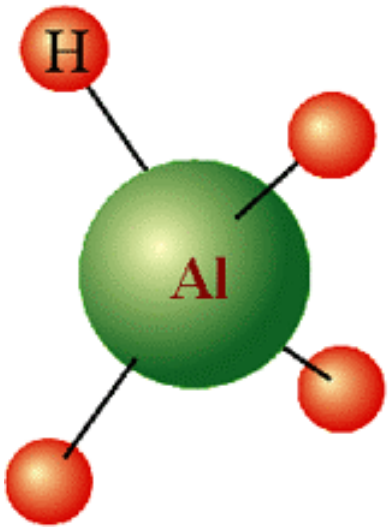
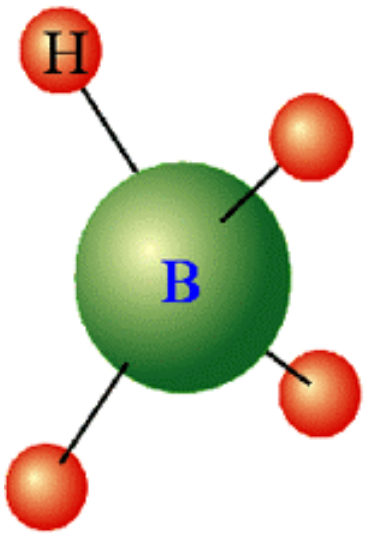
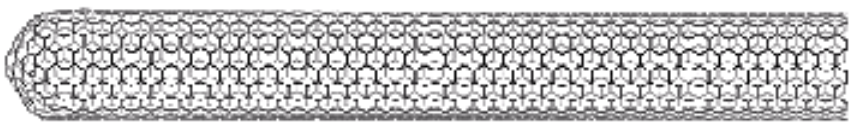




# Grand Challenge for Basic and Applied Research in Hydrogen Storage

**19 June 2003**
**Washington, DC**

**JoAnn Milliken**
**Lucito Cataquiz**
**John Petrovic**
**Carole Read**
**Sunita Satypal**

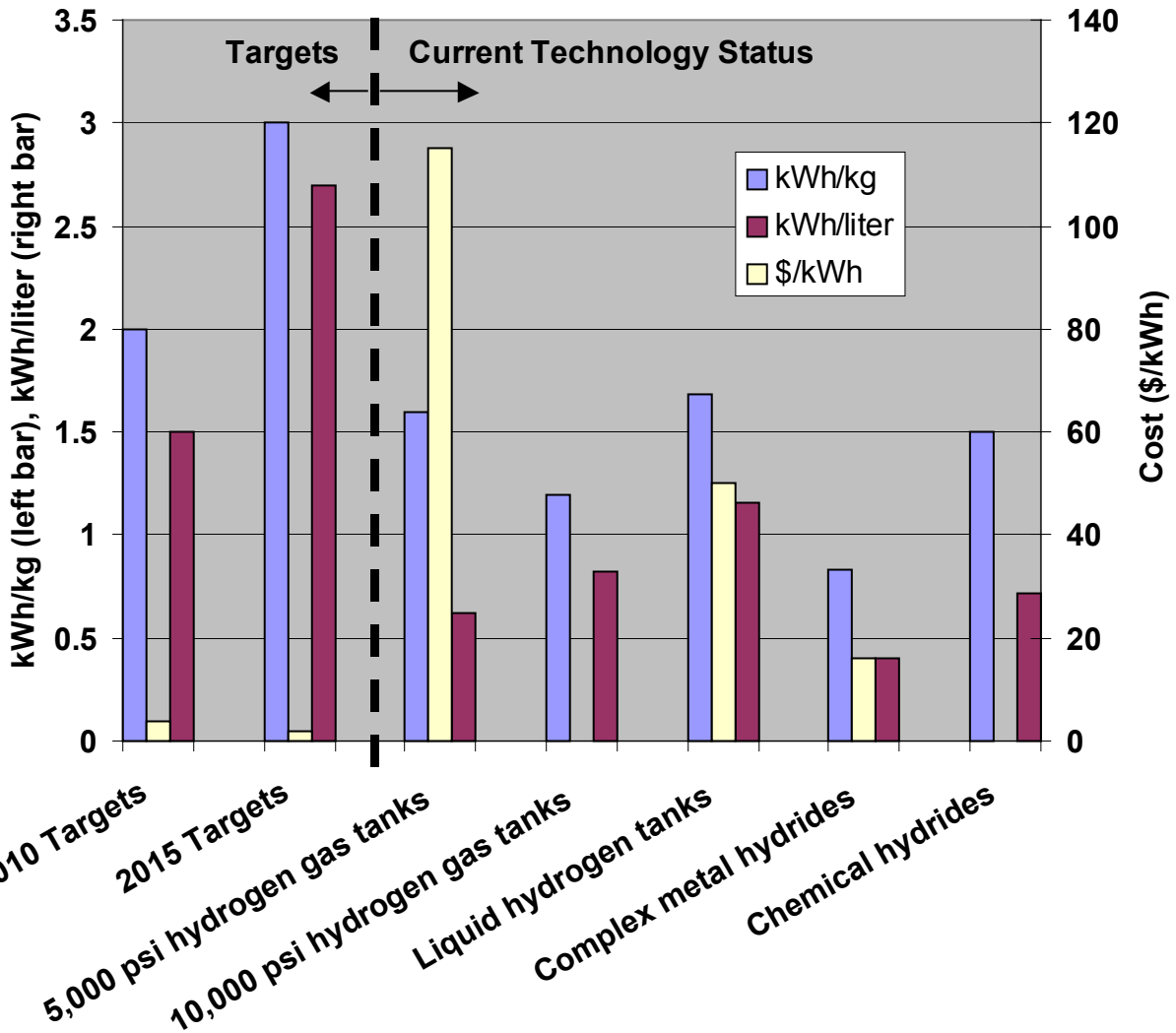
# President Bush Launches the Hydrogen Fuel Initiative

**"Tonight I am proposing $1.2 billion in research funding … so that the first car driven by a child born today could be powered by hydrogen, and pollution-free."** State of the Union Address January 28, 2003

- Provides parallel development of $H_2$ infrastructure and fuel cell vehicles with FreedomCAR.
- Enables industry commercialization decision by 2015.

➢ Hydrogen storage is a critical path technology
  - FY 2002: $6M
  - FY 2003: $11M
  - FY 2004: $30M (request)

# No Current $H_2$ Storage Technology Meets the DOE/FreedomCAR Targets



# Hydrogen Storage
## Goal & Objectives

**Goal :** Develop and demonstrate viable hydrogen storage technologies for transportation and stationary applications.

**Objectives – Develop and verify:**

- On-board hydrogen storage systems achieving:
  - 1.5 kWh/kg (4.5 wt%), 1.2 kWh/L, and $6/kWh by 2005
  - 2 kWh/kg (6 wt%), 1.5 kWh/L, and $4/kWh by 2010
  - 3 kWh/kg (9 wt%), 2.7 kWh/L, and $2/kWh by 2015
- Low cost, off-board hydrogen storage systems, as required for hydrogen infrastructure needs to support transportation, stationary and portable power markets by 2015.

# Targets
## On-Board $H_2$ Storage Systems

**Targets are system driven and were established through the FreedomCAR Partnership (DOE and USCAR).**

| Storage Parameter | Units | 2005 | 2010 | 2015 |
|---|---|---|---|---|
| Specific energy | kWh/kg | 1.5 | 2.0 | 3.0 |
| Energy density | kWh/L | 1.2 | 1.5 | 2.7 |
| Storage system cost | $/kWh | 6 | 4 | 2 |
| Cycle life (1/4 tank to full) | Cycles | 500 | 1,000 | 1,500 |
| Refueling rate | kg $H_2$/min | 0.5 | 1.5 | 2 |
| Loss of usable $H_2$ | (g/hr)/kg $H_2$ stored | 1 | .1 | 0.05 |

# Barriers
## Hydrogen Storage Systems

- **Cost**
- **Weight & volume**
- **Efficiency**
- **Durability**
- **Refueling time**
- **Codes & standards**
- **Life-cycle & efficiency analyses**

# Planning - The National Hydrogen Storage Project

## Identify R&D Priorities and Strategy

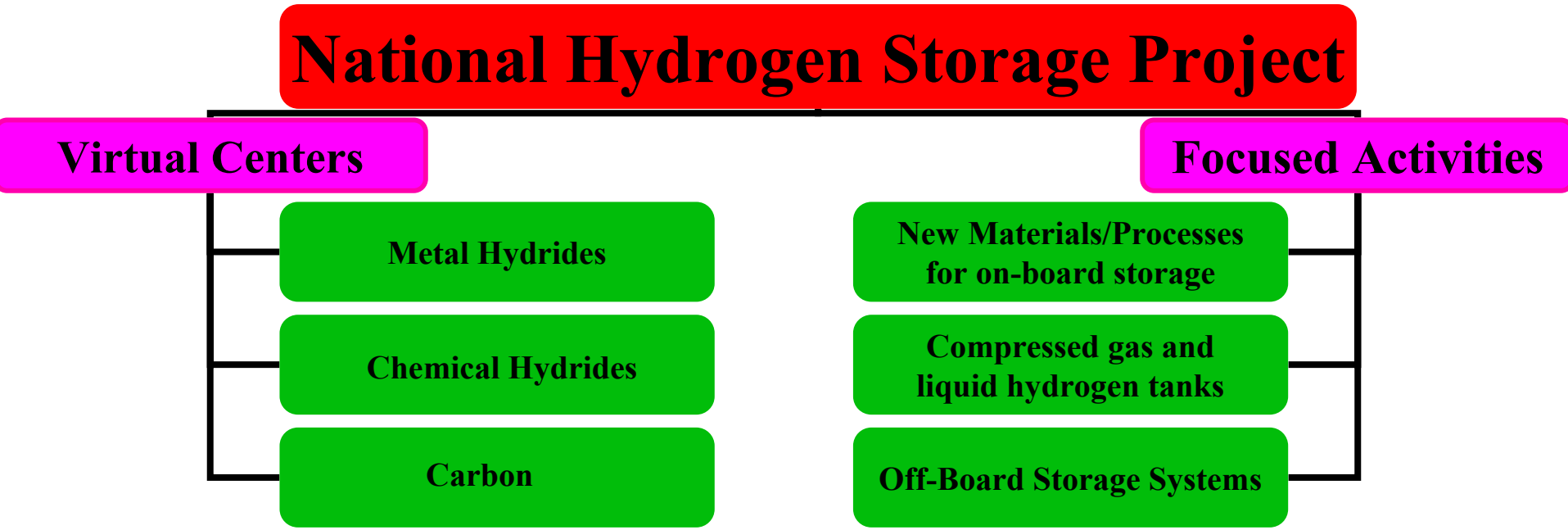
$H_2$ Storage Materials Workshop (Aug 2002)
Compressed/Liquid $H_2$ Workshop (Oct 02)
$H_2$ Storage "Think Tank" Meeting (Mar 03)
Basic Energy Sciences Workshop (May 03)

**See Websites for Proceedings:**
**www.eere.energy.gov/hydrogenandfuelcells**
**www.sc.doe.gov/bes/bes.html**

# Solicitation Topics

- **Topic 1:** Virtual Centers for Hydrogen Storage Materials Research and Development
- **Topic 2:** New Classes of Materials for Hydrogen Storage
- **Topic 3:** On-Board Compressed and Liquid Hydrogen Storage Tank Technologies
- **Topic 4:** Off-Board Hydrogen Storage Systems

# Structure


National Hydrogen Storage Project
Virtual Centers
Metal Hydrides
Chemical Hydrides
Carbon
Focused Activities
New Materials/Processes for on-board storage
Compressed gas and liquid hydrogen tanks
Off-Board Storage Systems

# Virtual Centers

# Role of Lead Laboratory

- Provide leadership and coordination of R&D, ensuring synergy, innovation, and technical cohesiveness
- Advise DOE
- Handle administrative activities
  - Reporting
  - Requests from DOE/HQ
- Facilitate technology transfer to industry

- **University and industry cooperative agreements will be executed and administered by Golden Field Office.**
- **All programmatic decisions will be made by DOE/HQ.**

# Center Funding Guidelines

- $5-6M per Center per Year for 5 years
  - 33% funding at Lead Laboratory ($1.7-2M)
    - No cost share required for Laboratory
  - 67% funding to outside partners ($3.3-4M)
    - Partnering with universities is required
      - 7 universities, each at $300K/year
    - Partnering with industry and other federal/national laboratories is encouraged
    - 20% cost share for university and industry partners
  - Go-No/Go decision after 3 years

**Funding availability is subject to Congressional appropriation.**

# Hydrogen Storage R&D

- **Basic research**
  - Focused to support applied research
  - Improved understanding of hydrogen interaction in materials
- **Applied research to achieve storage system targets**
  - **Go/No-Go decisions and deliverables required**
  - Metal hydrides
  - Chemical hydrides
  - Carbon-based structures

# Focused Projects

- Projects that do not fit into the charters of the Centers
  - New materials and processes
  - Compressed and liquid hydrogen tanks
  - Off-board storage

# New Materials and Processes

- **"Outside-the-box" approaches**
  - University or industry primes
    - 20% cost share
    - Laboratory partnering encouraged
  - 4 year projects, $400K/year
    - Phase 1: proof of feasibility of concept
    - Go/No-Go decision after two years
    - Phase 2: continued development

**Funding availability is subject to Congressional appropriation.**

# On-Board Tanks and Off-Board Storage

- On-board compressed and liquid hydrogen tanks
  - 3 year projects, $300-500K/year
    - 30% cost share
  - Conformable tank concepts
- Off-board storage
  - 3 year projects, $300-1000K/year
    - 30% cost share
  - High capacity, low cost, small “footprint” approaches

**Funding availability is subject to Congressional appropriation.**

# Evaluation (Draft)

## Criteria

- Technical Quality of the Proposal
- Management Plan
- Experience, Qualifications, and Accomplishments of the PIs
- Facilities/Equipment

## Evaluators

- Government Program Managers, e.g. NSF, ONR, DOD, DOE
- National Academy of Sciences
  - ➢ No industry reviewers
  - ➢ No national lab reviewers for Topic 1

# National/Federal Laboratories

- National Laboratories
  - Ames: metal hydrides – Vitalij Pecharsky – vitkp@ameslab.gov
  - Argonne: chemical hydrides – Romesh Kumar – kumar@cmt.anl.gov
  - Brookhaven: metal hydrides – Jim Wegrzyn – jwegrzyn@bnl.gov
  - Idaho: chemical hydrides – Ray Anderson – anderp@inel.gov
  - Oak Ridge: chemical hydrides – Tim Armstrong – armstrongt@ornl.gov
  - Lawrence Berkeley: Lut DeJonghe – dejonghe@lbl.gov
  - Lawrence Livermore: chemical hydrides – Bob Glass – glass3@llnl.gov
  - National Renewable Energy: carbon – Mike Heben – mikeh@nrel.gov
  - Los Alamos: chemical hydrides – Bill Tumas – tumas@lanl.gov
  - Pacific Northwest: chemical hydrides – Moe Khaleel – moe.khaleel@pnl.gov
  - Sandia Livermore: metal hydrides – Jim Wang – jcwang@sandia.gov
  - Savannah River: metal hydrides – Ted Motyka – ted.motyka@srs.gov
- Other Federal Laboratories
  - NASA/JPL: metal hydrides – Robert Bowman – robert.c.bowman-jr@jpl.nasa.gov
  - DOC/NIST: Steve Freiman – stephen.freiman@nist.gov
  - Naval Research Lab: Bhakta Rath - rath@utopia.nrl.navy.mil

# Proposal Resources

- August 2002 Hydrogen Storage Workshop Report
- October 2002 Hydrogen Tank Workshop Report
- March 2003 Hydrogen Storage Think Tank Meeting Report
- May 2003 BES Hydrogen Workshop
- Hydrogen, Fuel Cells & Infrastructure Technologies Multi-Year RD&D Plan – See Chapter 3.3 on Storage
- Hydrogen Storage Target Explanations
- Hydrogen Roadmap

**Access these resources on the DOE websites:**

**www.eere.energy.gov/hydrogenandfuelcells**
**www.sc.doe.gov/bes/bes.html**

# Next Steps

**National Hydrogen Storage Project**

Start Centers/ New Projects — **February 2004**

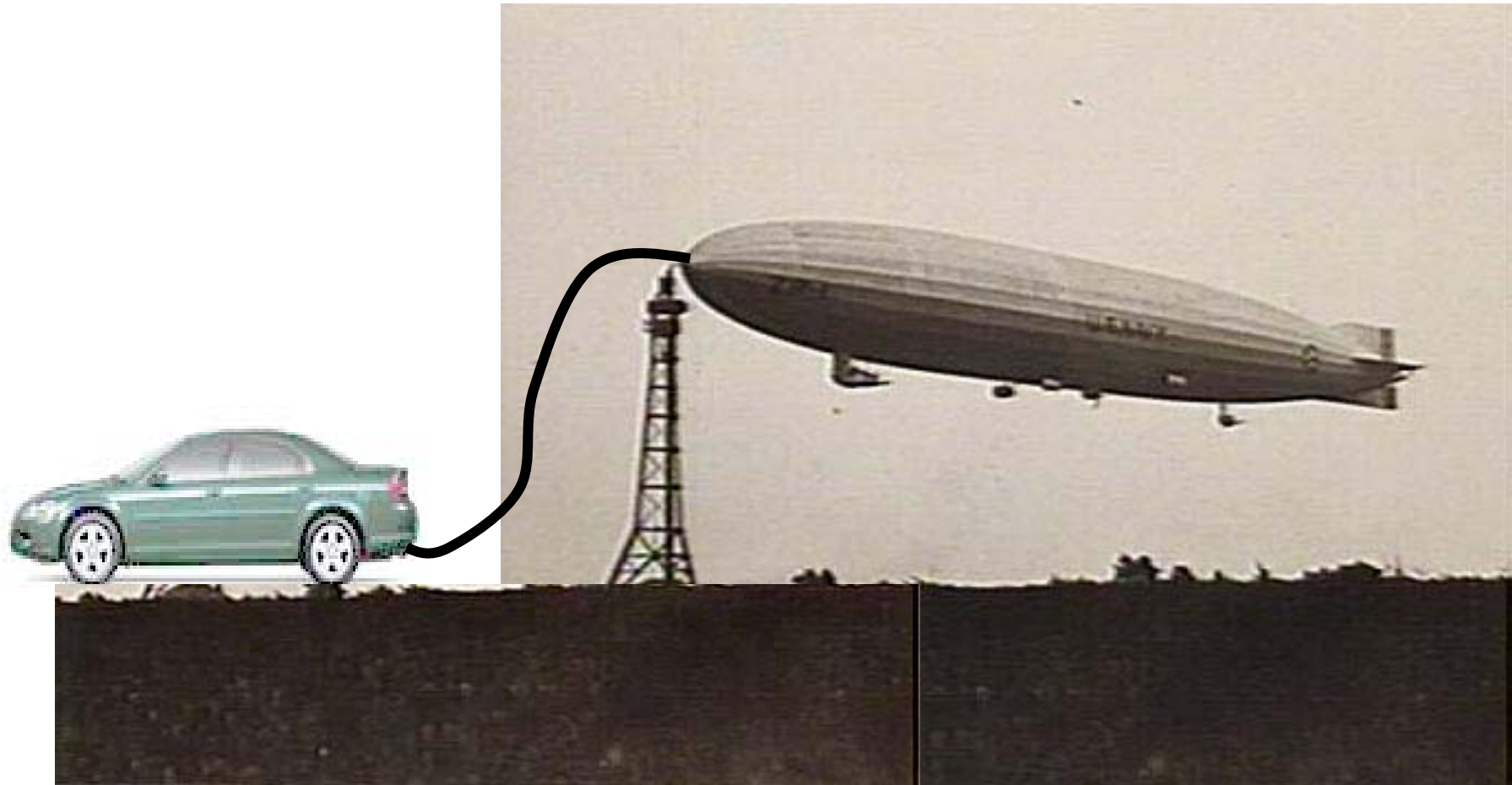
Selections — **December 2003**

Solicitation Release — **July 18, 2003**

**Applications due September 18, 2003**

Pre-Solicitation Conference — **June 19, 2003**

# Proposed $H_2$ Storage Concept



# Agenda

1:00pm Opening Remarks – Doug Hooker (Golden Field Office)

1:05pm Introductory Remarks – Steve Chalk (Program Manager, Hydrogen, Fuel Cells, and Infrastructure Technologies)

1:10pm Overview of DOE Program/Solicitation – JoAnn Milliken (Hydrogen Storage Team Leader)

1:30pm Summary of Basic Energy Sciences Workshop – Harriet Kung (DOE Basic Energy Sciences)

1:40pm DOE National Laboratory Capabilities/Plans

2:50pm Submission of questions from participants (in writing)

3:20pm Break; Participant Networking; Preparation of answers by DOE

4:00pm Questions and Answers provided by DOE (verbally)

5:00pm Adjourn