HTAC Review
Automotive Fuel Cells

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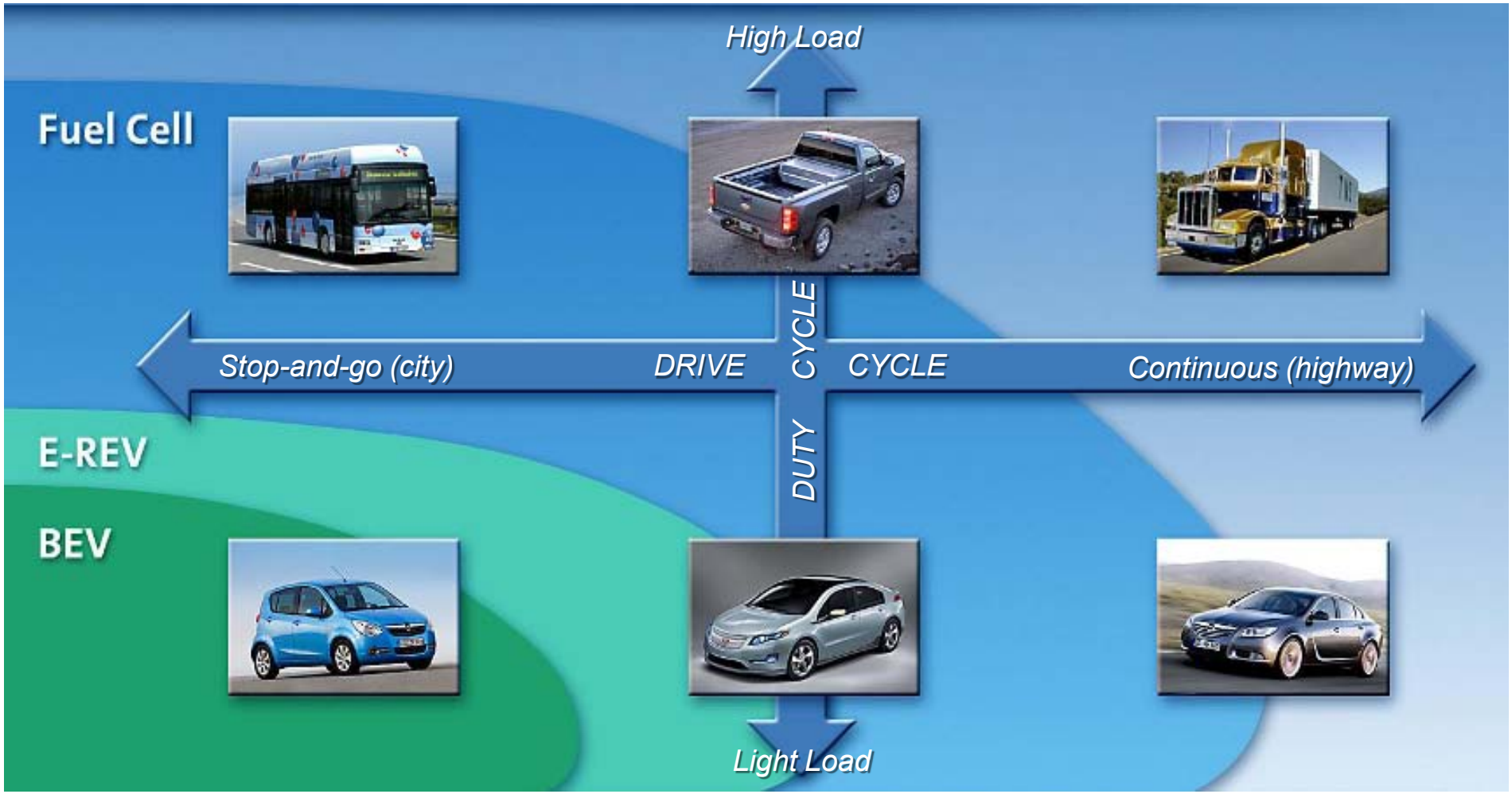
The Role of Fuel Cells in Transportation

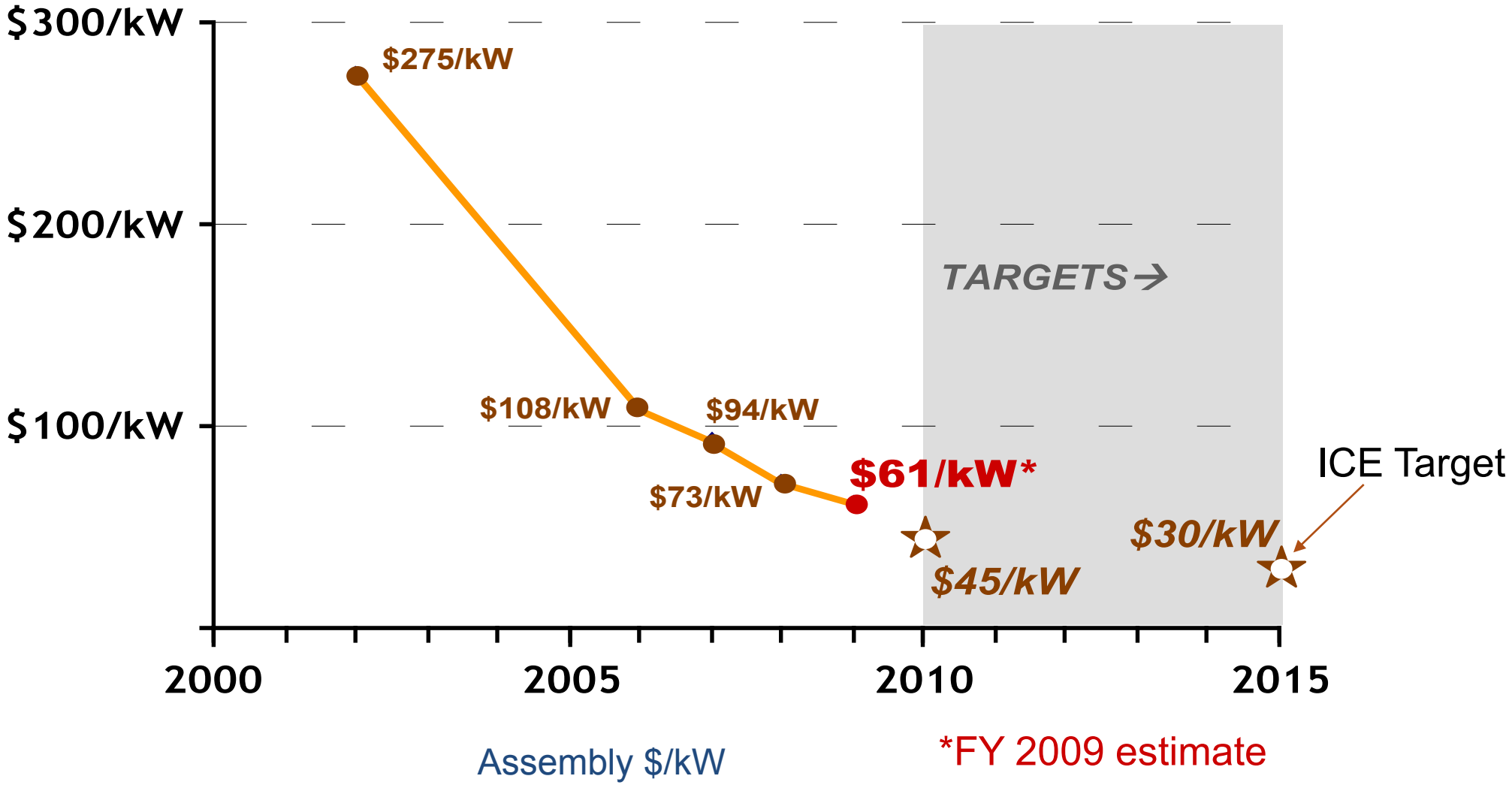
- *A variety of technologies—including fuel cell vehicles, extended-range electric vehicles (or "plug-in hybrids"), and all-battery powered vehicles—will be needed to meet our diverse transportation needs.*
- *The most appropriate technology depends on the drive cycle and duty cycle of the application.*



*Source: DOE September 2009

Fuel Cell Costs –

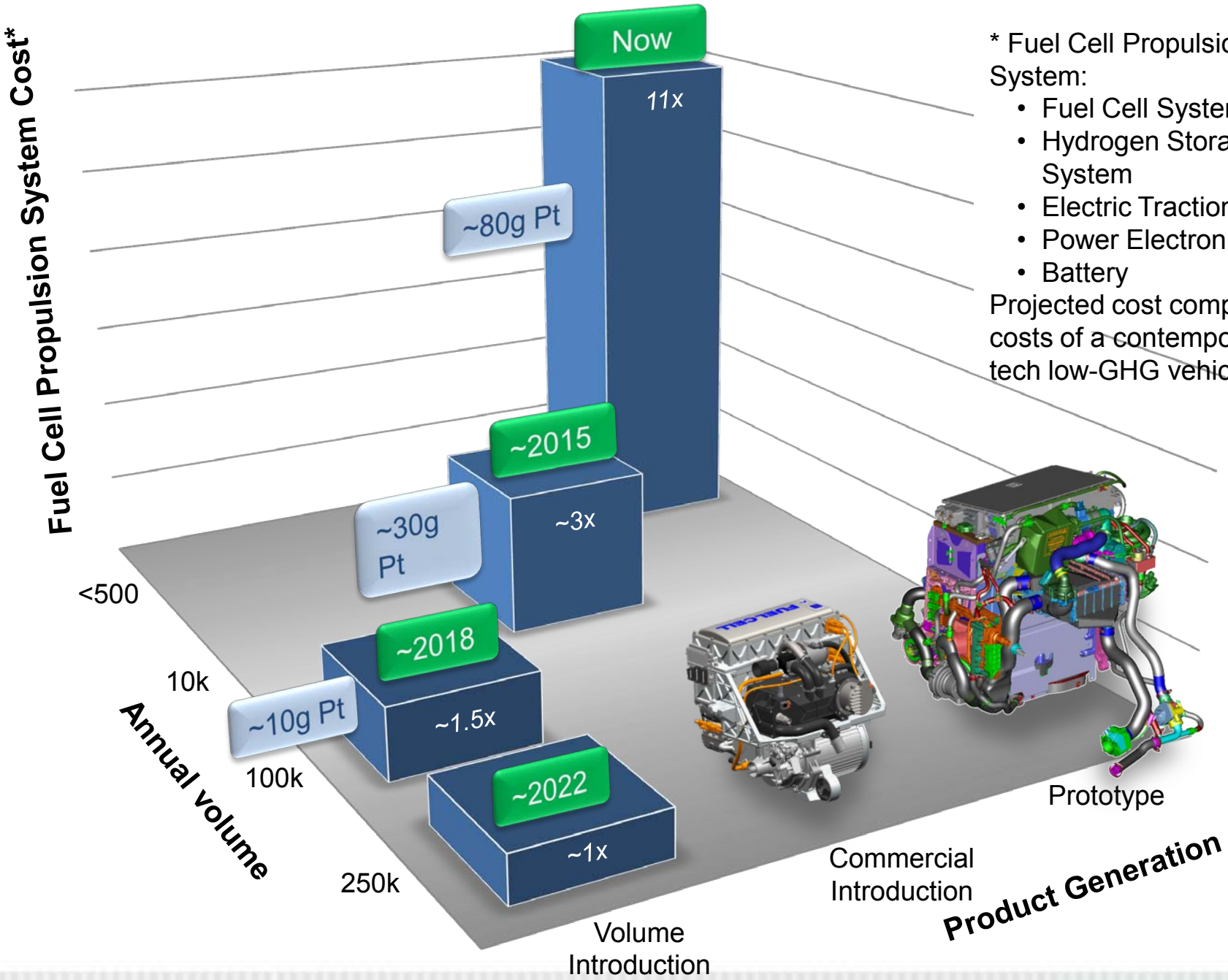
Reduced the cost of fuel cells by 75% since 2002



Source: DOE September 2009 - cost projection validated by independent panel*

Fuel Cell Propulsion System Commercialization

Glide path to fully competitive system cost



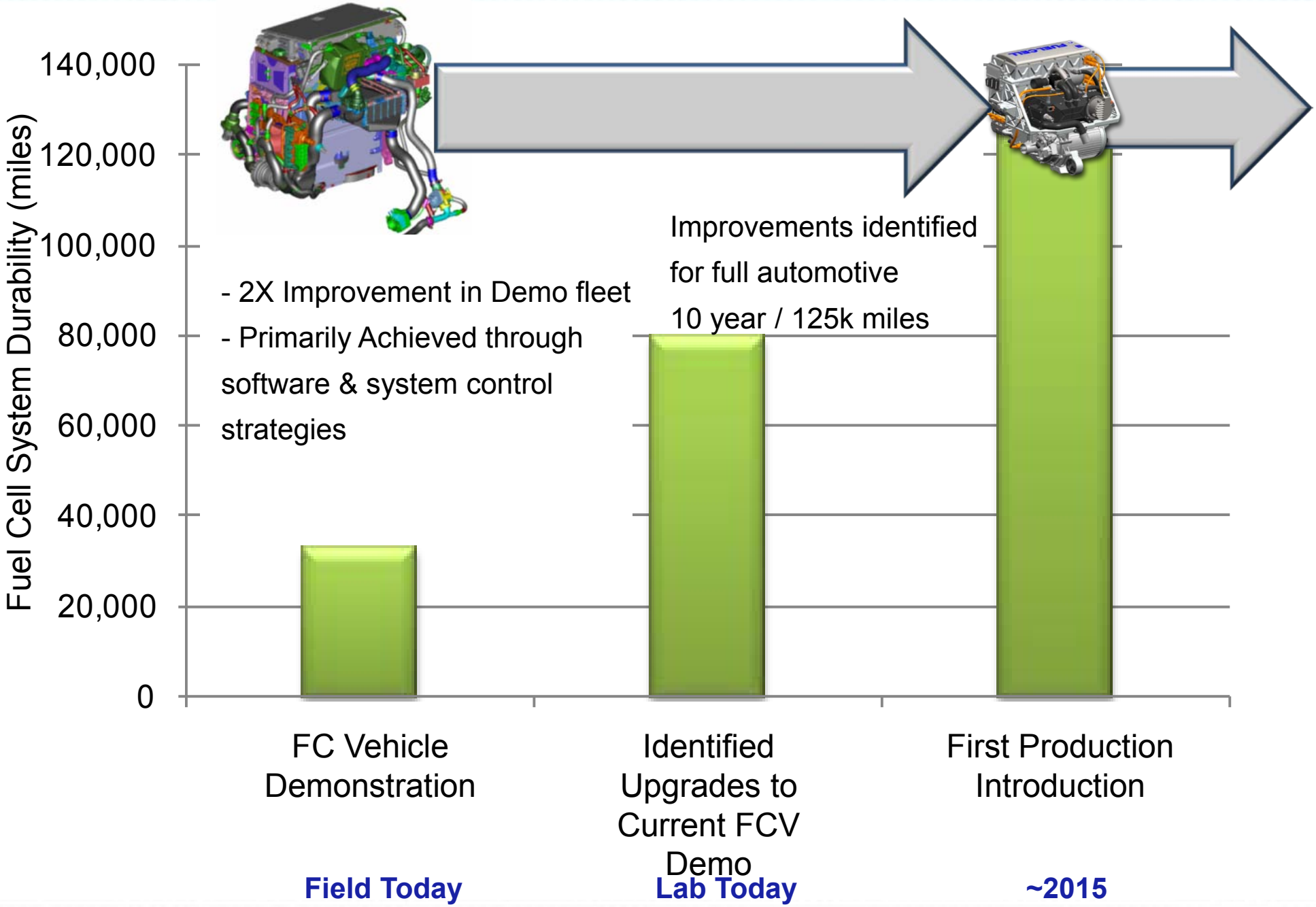
* Fuel Cell Propulsion System:

- Fuel Cell System
- Hydrogen Storage System
- Electric Traction System
- Power Electronics
- Battery

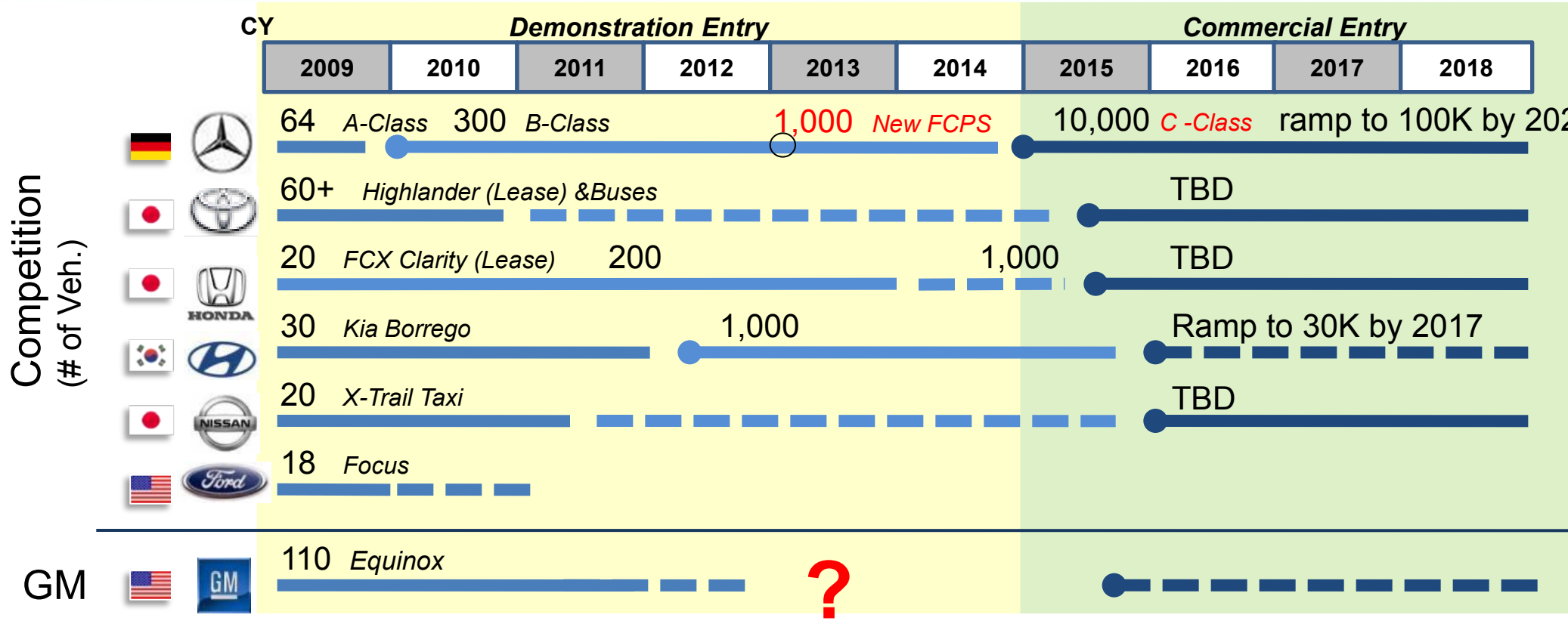
Projected cost comparison to costs of a contemporary adv tech low-GHG vehicle

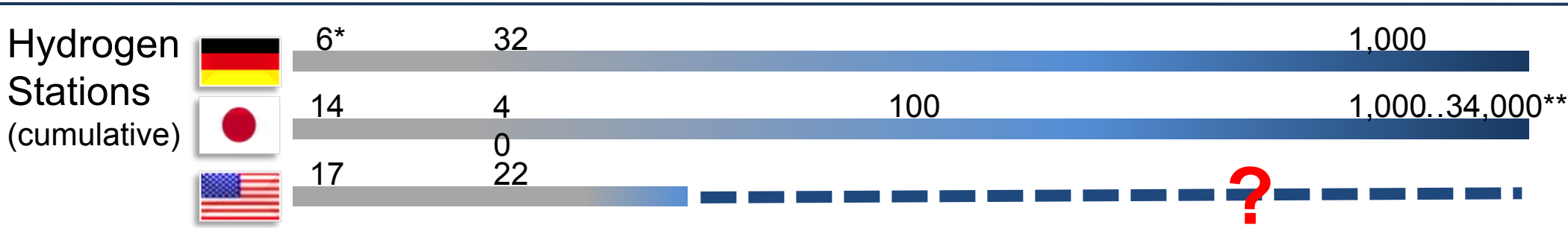
Hydrogen Fuel Cell Durability Improvement

Demonstrated Solutions for Automotive Competitive



Competitive Landscape - Summary





Legend:
Solid: publicly announced Dashed: anticipated

Notes:
* Joint funding by government, energy & gas companies, OEMs ; * * by 2050

GM Confidential

Germany Nationwide Infrastructure Agreement Sept 10, 2009

Joint Press Release of Linde, Daimler, EnBW, NOW, OMV, Shell, Total and Vattenfall

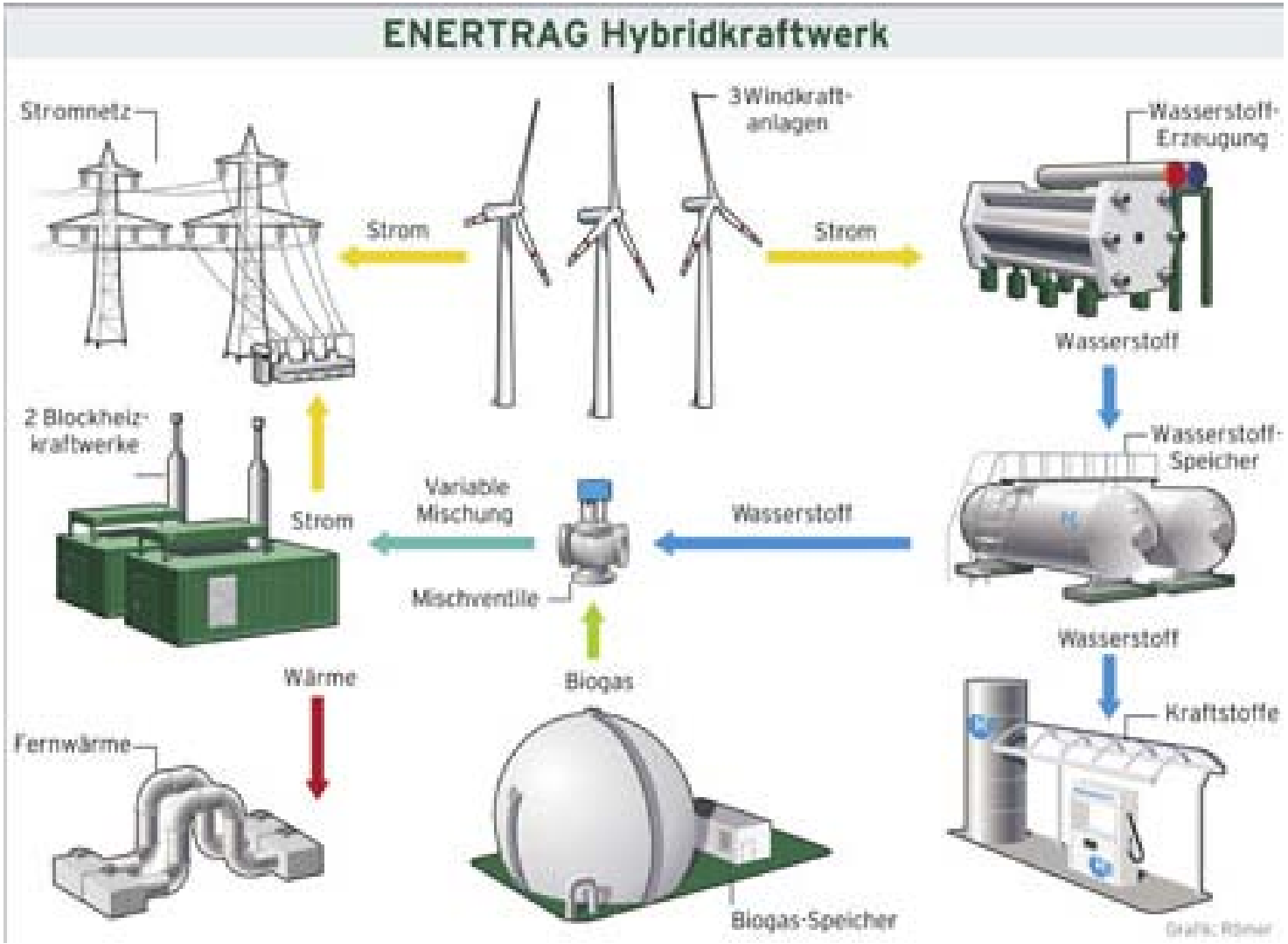
Initiative "H_2 Mobility" – Major companies sign up to hydrogen infrastructure built-up plan in Germany

- Leading industrial companies agree upon a built-up plan for a nationwide infrastructure
- Significant expansion of hydrogen fuelling stations network by the end of 2011
- Important milestone on the way to emission-free mobility
- Leading vehicle manufacturers pursue the development and commercialisation of electric vehicles with fuel cell. Commercialisation with several hundred thousand units anticipated from 2015 onwards

Wind-Hydrogen-Plant Construction is Underway (21APR09)
Northeastern Germany (6 MW System)

German Chancellor Angela Merkel @ construction site

Minister President Matthias Platzeck (State of Brandenburg)



National Security Issues - Defense Science Board

The Task Force concluded that DOD faces two primary energy challenges:

- Operations suffer from unnecessarily high, and growing, battlespace fuel demand which degrades capability, increases force balance problems, exposed support operations to greater risk than necessary, and increases lifecycle operations and support costs
- Military installations are almost completely dependent on a fragile and vulnerable commercial power grid, placing critical military and Homeland defense missions at unacceptable risk of extended outage.

Report of the Defense Science Board
Task Force on DOD Energy Strategy
"More Flight – Less Fuel" February 2008

Army Energy Security Implementation Strategy

Five energy security goals:

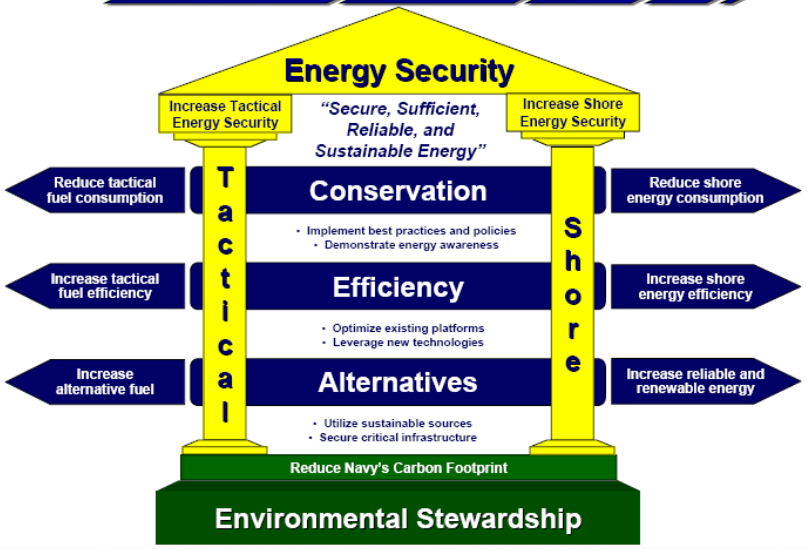
- **Reduced energy consumption** - Reduce the amounts of power and fuel consumed by the Army at home and in theatre.
- **Increased energy efficiency across platforms and facilities** - Raise the energy efficiency for generation, distribution, storage and end-use of electricity and fuel for system platforms, facilities, units and individual Soldiers and Civilians.
- **Increased use of renewable/alternative energy** - Raise the share of renewable/alternative resources for power and fuel use, which can provide a decreased dependence upon conventional fuel sources.
- **Assured access to sufficient energy supplies -** Vulnerabilities to external disruption of power and fuel sources should be minimized and the potential for industry partnerships to enhance energy security and generate net revenues for the Army should be considered
- **Reduced adverse impacts on the environment** - Reduce harmful emissions and discharges from energy and fuel use. Conduct energy security activities in a manner consistent with Army environmental and sustainability policies.

Approved by the Army Senior Energy Council on 13 January, 2009 - Similar strategies developed by the Air Force, Navy and USMC, see: http://www.energyconversation.org/conversation/us-military-energy-strategies

DOD doctrine in place – moving to implementation

ENERGY SECURITY

Navy Energy Strategy



Air Force Energy Plan

U.S. AIR FORCE

3-Part Strategy

Reduce Demand

Increase Supply

Change the Culture

Currently in final coordination

Vision

Make Energy A Consideration In All We Do

Integrity - Service - Excellence

Commandant's Intent

Vision and Strategy 2025

"Improve aggressive research, development, acquisition, fielding and sustainment of equipment that:

- *Has inherent force protection capability,*
- ***Is lighter, easier to maintain, and promotes energy efficiency, and***
- *Ensures interoperability with and between naval platforms and joint systems".*

August 09 Energy Summit

"Reorganize HQMC to establish Service Level Energy Office"

Lighten The Load!

Summary

- Automotive FC technology is real, viable, and offers unique solution to challenges faced by other electric drive vehicle architectures
- Automotive FC technology will be in the marketplace – likely by ~2015
  - First mass scale commercialization likely in Germany and/or Japan
  - Both have coordinated infrastructure and FCV commercialization plans
  - US does not currently have this model in place
  - Some states are trying to step in to fill this role
- Automotive FC technology costs are falling rapidly and will fall further
  - In line with other low-GHG automotive technologies in the ~2020 timeframe
- Automotive FC technology offers unique characteristics to address key energy security challenges facing the military
  - And deployment of automotive FC technology to address energy security needs of military installations can act as anchor for civilian deployments

Conclusions for HTAC Consideration

- This is a critical time in the race to deploy automotive FC technology, and the U.S. focus on fork lifts is a potentially fatal distraction from the prize
- The U.S. needs a (Japanese-style) focused effort at overcoming the barriers to vehicle commercialization of automotive FC technology
- The U.S. needs a German-style coordinated approach to hydrogen infrastructure
- The U.S. could benefit from greater cooperation with our international partners – particularly on deploying a German-style infrastructure plan
- The military's need to implement its energy security strategies offers a potential avenue for beneficial cooperation among DOE, DOD and the automotive fuel cell industry
  - Rapid implementation
  - Early application of automotive FC technology
  - Accelerated commercialization
  - Green Jobs

Thank You