



# **HTAC Review**

## **Automotive Fuel Cell Competitive Intelligence**

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**July 15, 2009**





# Today's Purpose

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## **Global Automotive Industry Challenges - - Energy & Environment**

- Portfolio of technologies needed

## **Global Automotive Fuel Cell and H<sub>2</sub> initiatives - - Germany & Japan**

- National Plan
- Hydrogen infrastructure
- Automotive offerings

## **Conclusions and Implications**





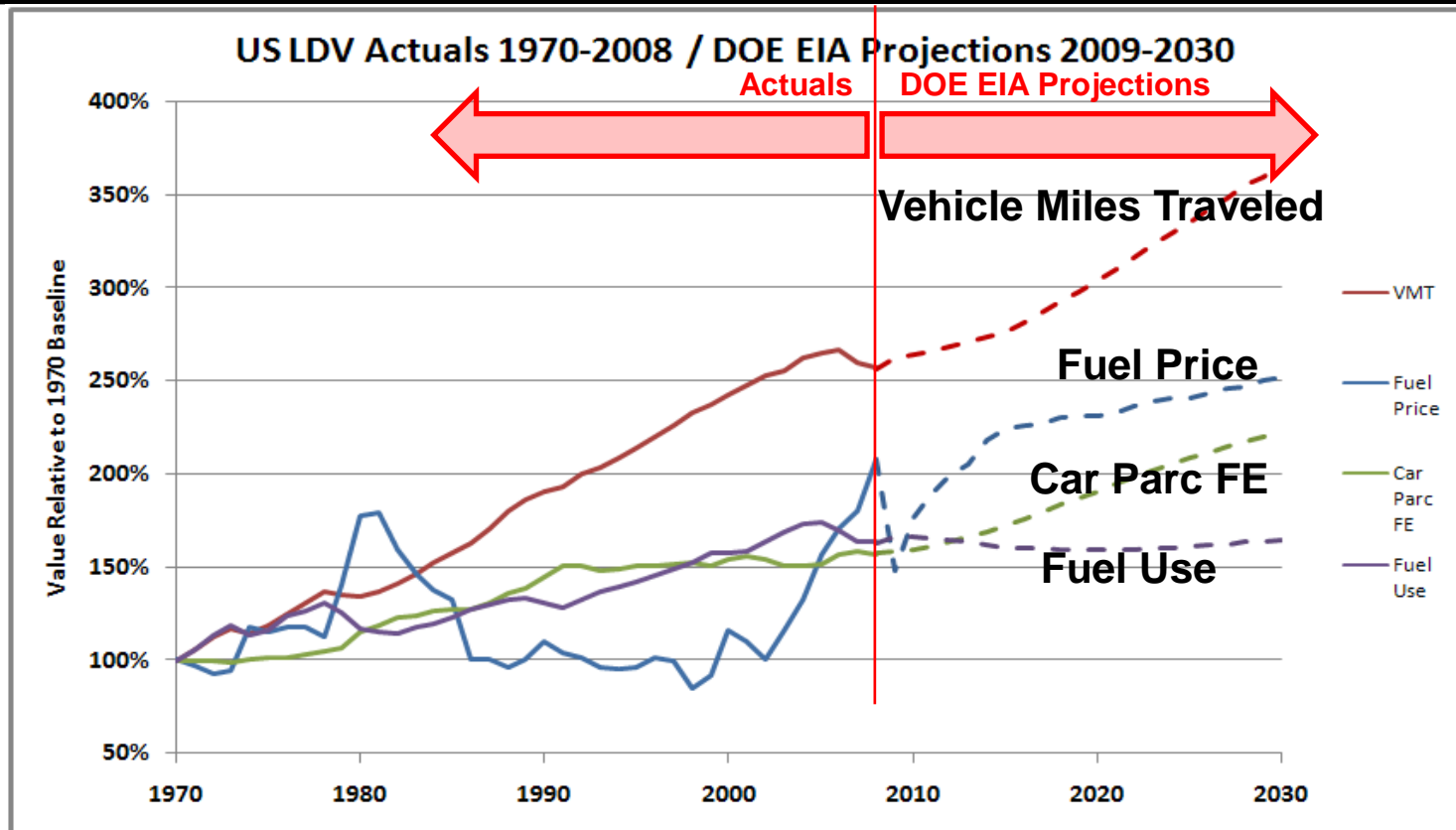
# **Automotive Industry Challenges (Energy and Environment)**

- Portfolio of technologies needed





# U.S. LDV Transportation – DOE EIA 2030 Outlook



## DOE EIA 2030 Outlook – Reference Case

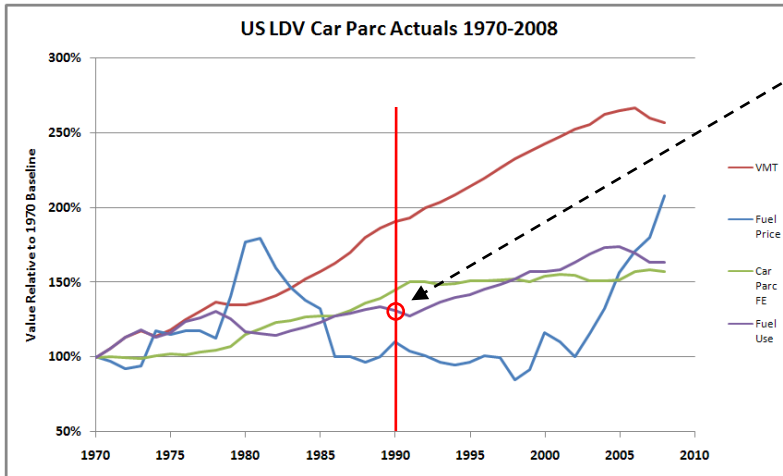
- Continued steady growth in vehicle miles traveled (VMT)
- Upward fuel price trend (highly uncertain)
- Fuel economy improvements offset growth in VMT
- Fuel use remains relatively flat (this is a break from past 40 year trend)



# U.S. LDV Transportation – 2050 GHG Reduction Goal

## U.S. goal is 80% reduction from 1990 levels by 2050

- Assuming light duty transportation must reduce its GHG footprint in equal proportion to other contributing sectors of economy:



**1990 fuel use** →

105 billion gallons

**1990 GHG**

1,220 million tons CO<sub>2</sub> equivalent

80% reduction

**2050 GHG goal**

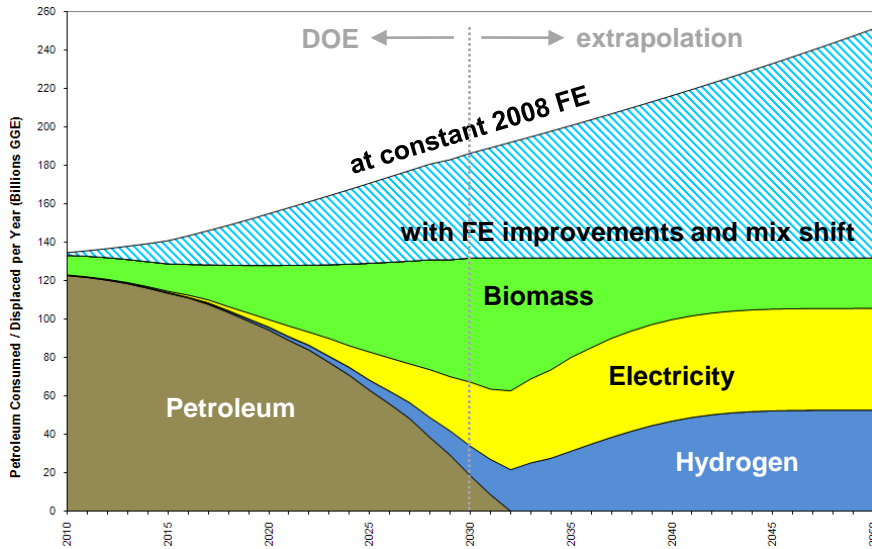
244 million tons CO<sub>2</sub> equivalent (or less)

**LDV 2050 GHG Goal is 244 million tons CO<sub>2</sub> equivalent**

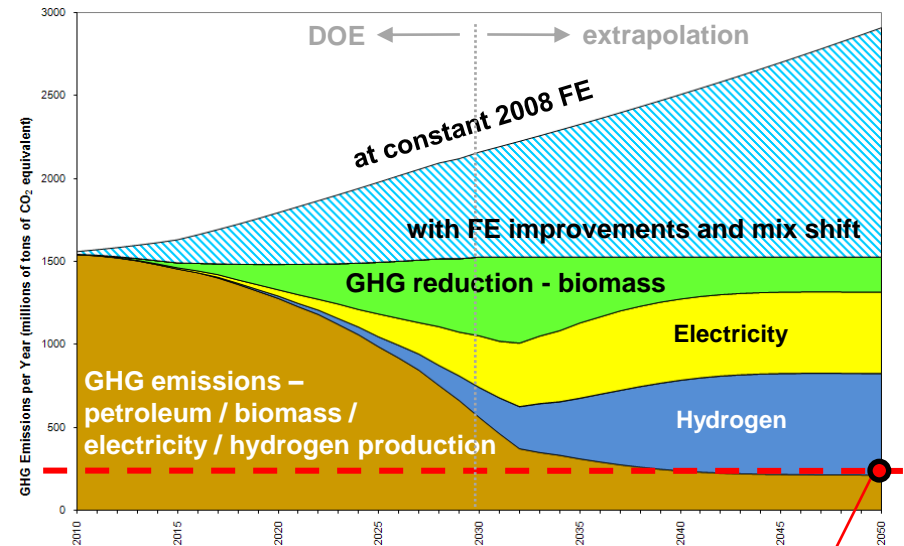


# All Options in Play – The Power of “AND”

## Petroleum Consumption



## GHG Emissions



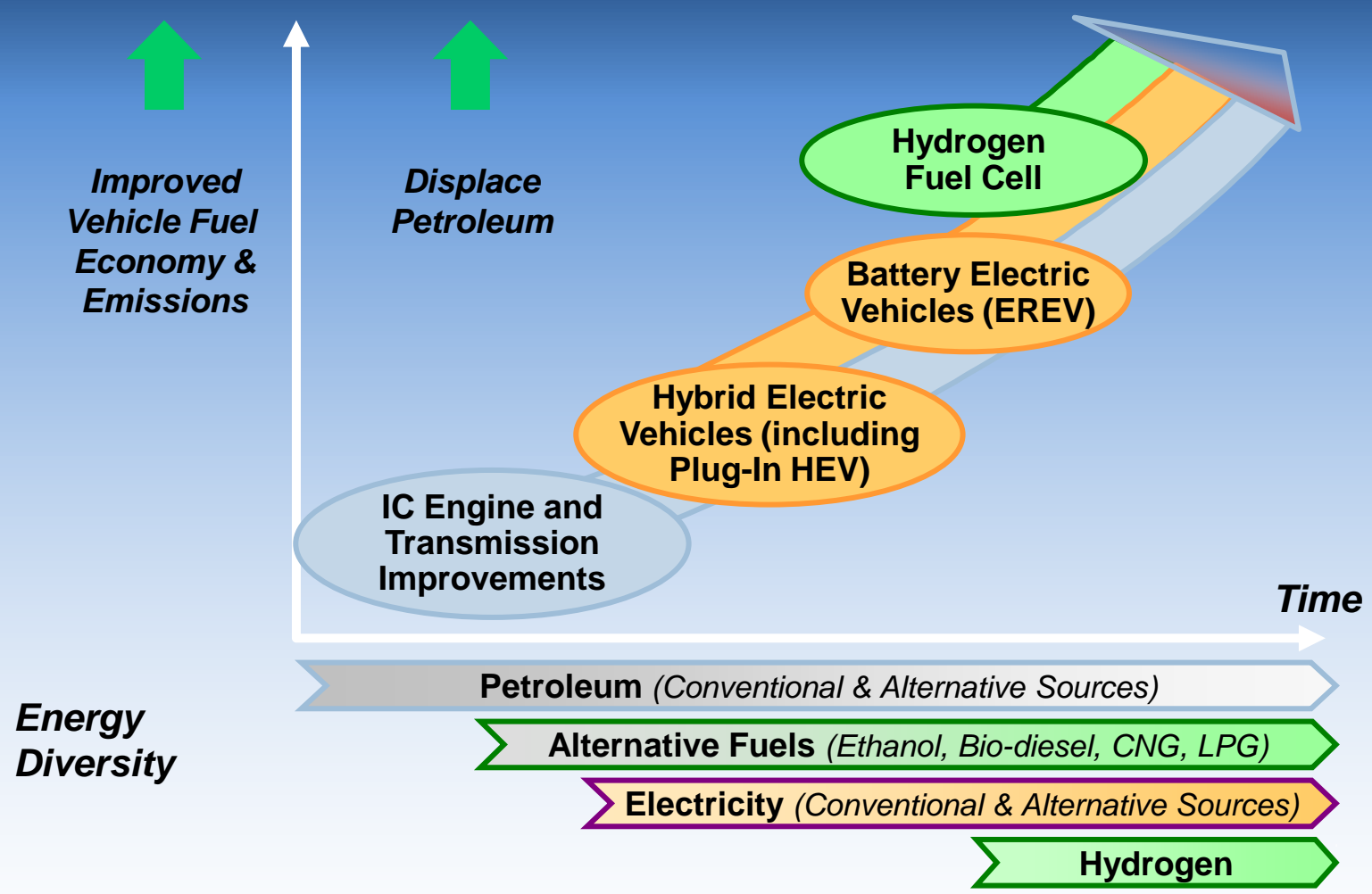
Goal – 80% reduction from 1990 level by 2050

- Cellulosic biomass ramps to high volume; BEVs / EREVs make 40% of VMT electric; FCEVs penetrate to 40% of parc by 2050
  - Petroleum out of picture by 2032
  - LDV parc mostly transitioned to electric drive and ZEV solutions
  - US grid GHG modeled at 80% lower than 2008 levels
  - Hydrogen from cellulosic biomass or clean electricity

**Start soon with early options;  
finish with strongest long-term solution**



# Advanced Propulsion Technology Strategy





# Vehicle Electrification

## Hybrid & Electric Drive Types & Benefits



FUNCTIONALITY

DRIVE SYSTEM

### Internal Combustion Engine (ICE)

- SIDI
- 2-step valve
- HCCI
- Turbo boost
- 6 speed transmissions
- Active Fuel Management

### Hybrid

- Engine off on deceleration and at idle
- Mild regenerative braking
- Electric power assist

### 2-Mode Hybrid

- Full regenerative braking
- Engine cycle optimization
- Electric launch
- Limited pure electric drive
- Engine downsize

### 2-Mode Plug-in Hybrid

- Plug-in rechargeable
- More electric drive during charge-depletion
- Reduced refueling

### Extended Range Electric Vehicle

- Full-function electric drive
- Initial pure electric range
- Significantly reduced refueling

### Battery Electric Vehicle & Fuel Cell

- 100% pure electric range
- Energy storage in a battery or hydrogen tank
- No exhaust emissions



Mechanical with Electric Assist

Electric with Mechanical Assist

All Electric

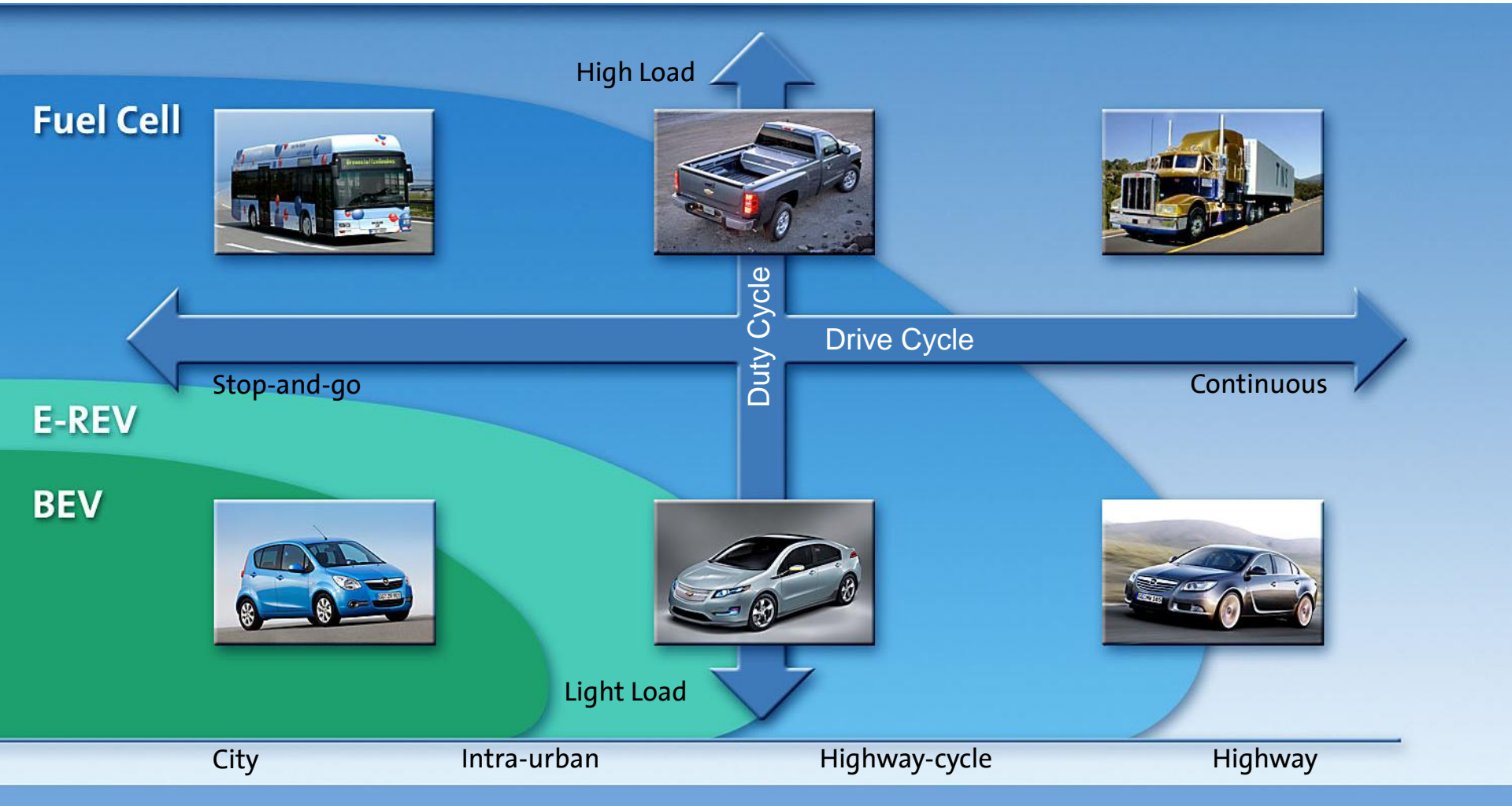


Increasing Level of Efficiency & Reduced Emissions





# Application Map





# Global Automotive Fuel Cell and H<sub>2</sub> initiatives - - Germany & Japan

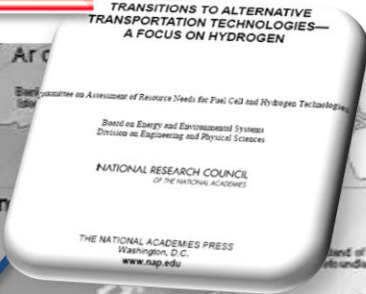
- National Plan
- Hydrogen infrastructure
- Automotive offerings



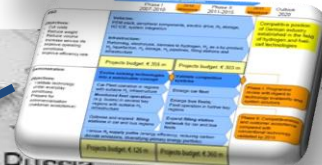
# National Hydrogen Plans



National Research Council Report



Nat. development plan



- 2015 competitiveness established
- \$1.8B project budget



METI / Japan Inc.



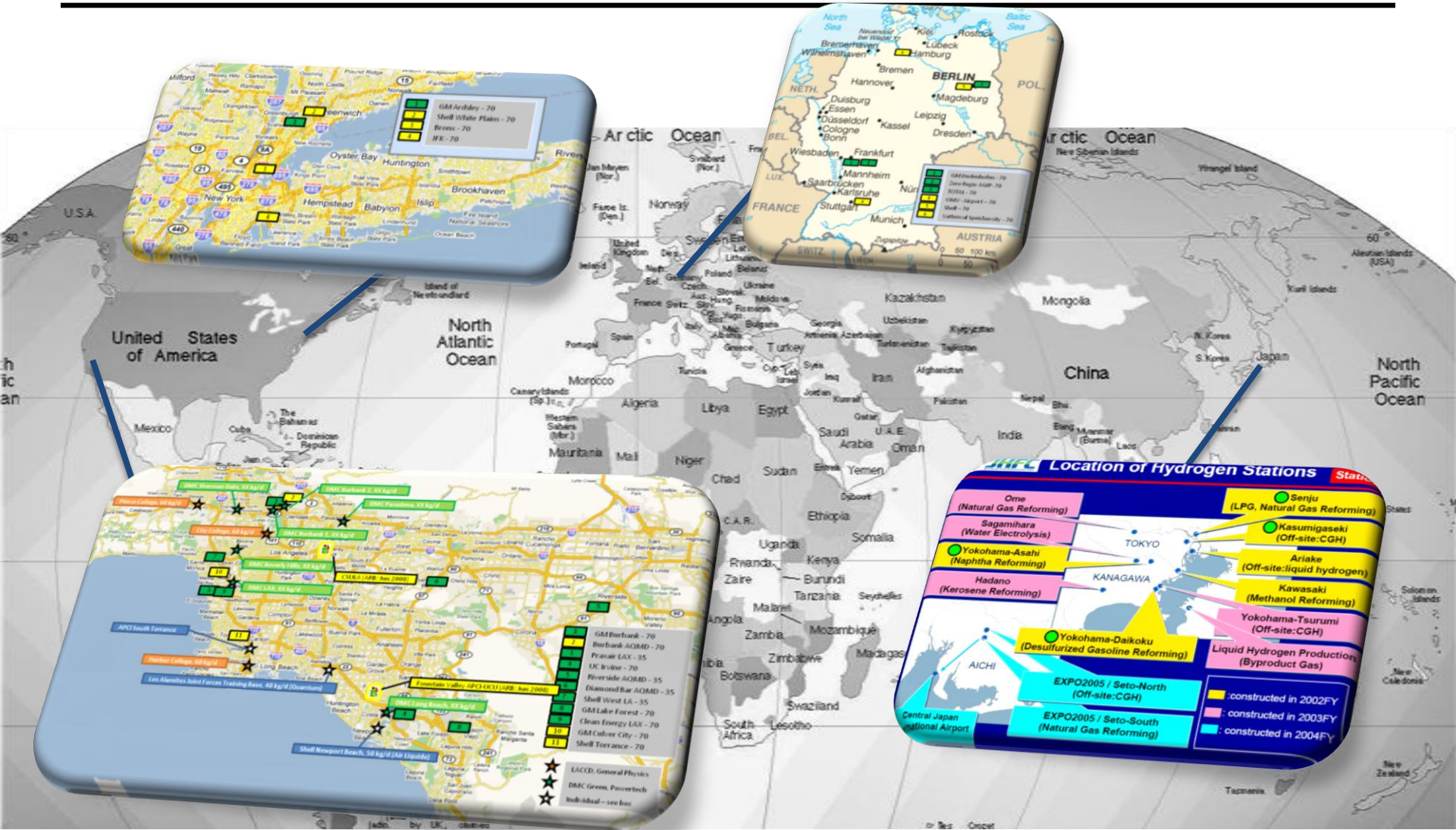
- 2015 target start commercialization
- Infrastructure leads vehicles







# Global Hydrogen Infrastructure Development (Station Locations - Main areas)



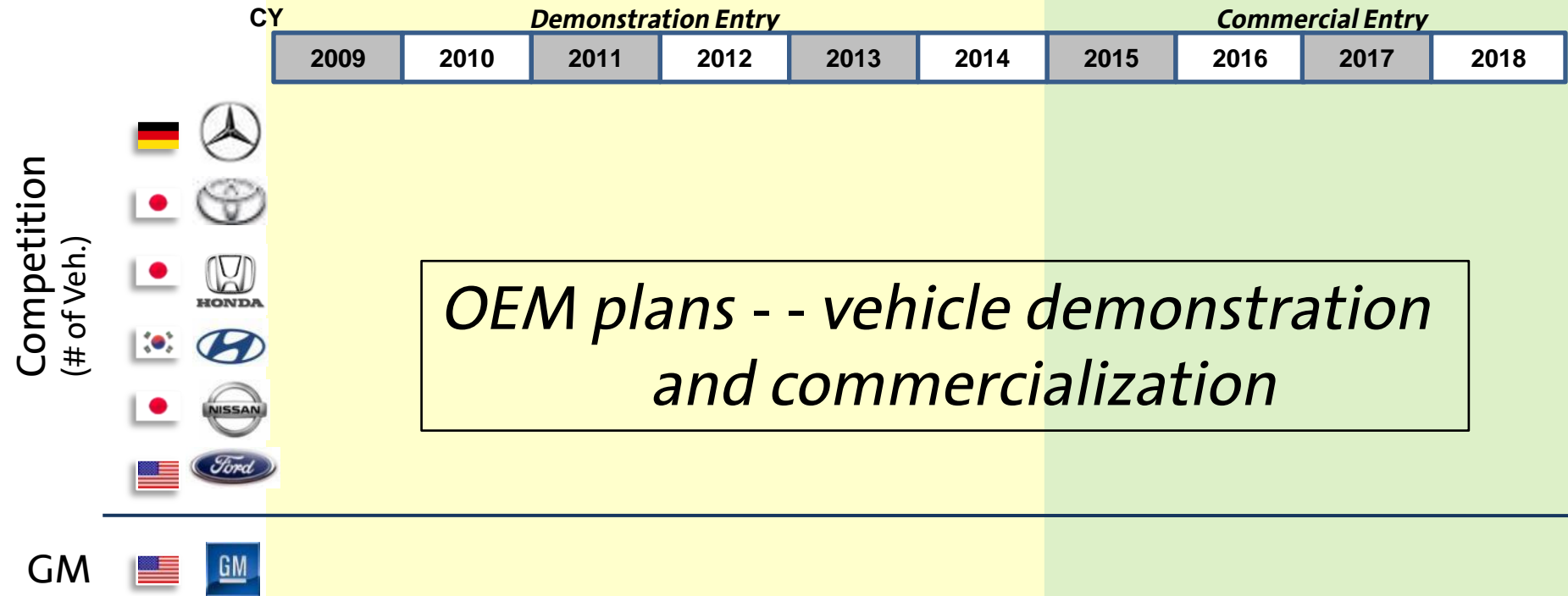


# Global Competitors





# Competitive Landscape - Summary



*Plans for H<sub>2</sub> infrastructure development*







# Germany Initiatives





# It Didn't Happen Over Night

## Verkehrswirtschaftliche Energiestrategie (VES) – [Transport Energy Strategy]



- Main Goal: Develop and implement a strategy for a long term, nationwide market introduction of hydrogen as a fuel for transport in Germany
- Launched by automotive industry and energy companies in 1999
- Supported by the Federal Government (Federal Ministry for Transport, Building and Urban Development BMVBS)
- Initiated CEP in 2002
- Delivers transportation related input for National Hydrogen and Fuel Cell Technology Innovation Program (NIP)







# German National Hydrogen and Fuel Cell Technology Innovation Program (NIP)

- **Main Goal: Substantially foster hydrogen and fuel cell technology**
  - **Duration: 2007 to 2016**  
**Funding volume: € 500M**
  - **Execution of the National Development Plan**
  - **Planning and execution of Lighthouse Projects**
- ➔ **The right program at the right time**





# Clean Energy Partnership (CEP) The European Lighthouse Project for Hydrogen Vehicles



- **Public-private partnership**
- **Aim to prove everyday suitability of hydrogen for transport**
- **Project duration until 2016**
- **Phase I: 2002 – 04/2008**
  - 17 hydrogen vehicles
  - 2 fully integrated hydrogen refueling stations
    - Aral/BP: Messedamm (opened 11/2004)
    - Total: Heerstraße (opened 03/2006)
  - Different methods of hydrogen production demonstrated
  - **CEP service station specialized for hydrogen propulsion**







# Clean Energy Partnership (CEP) The European Lighthouse Project for Hydrogen Vehicles



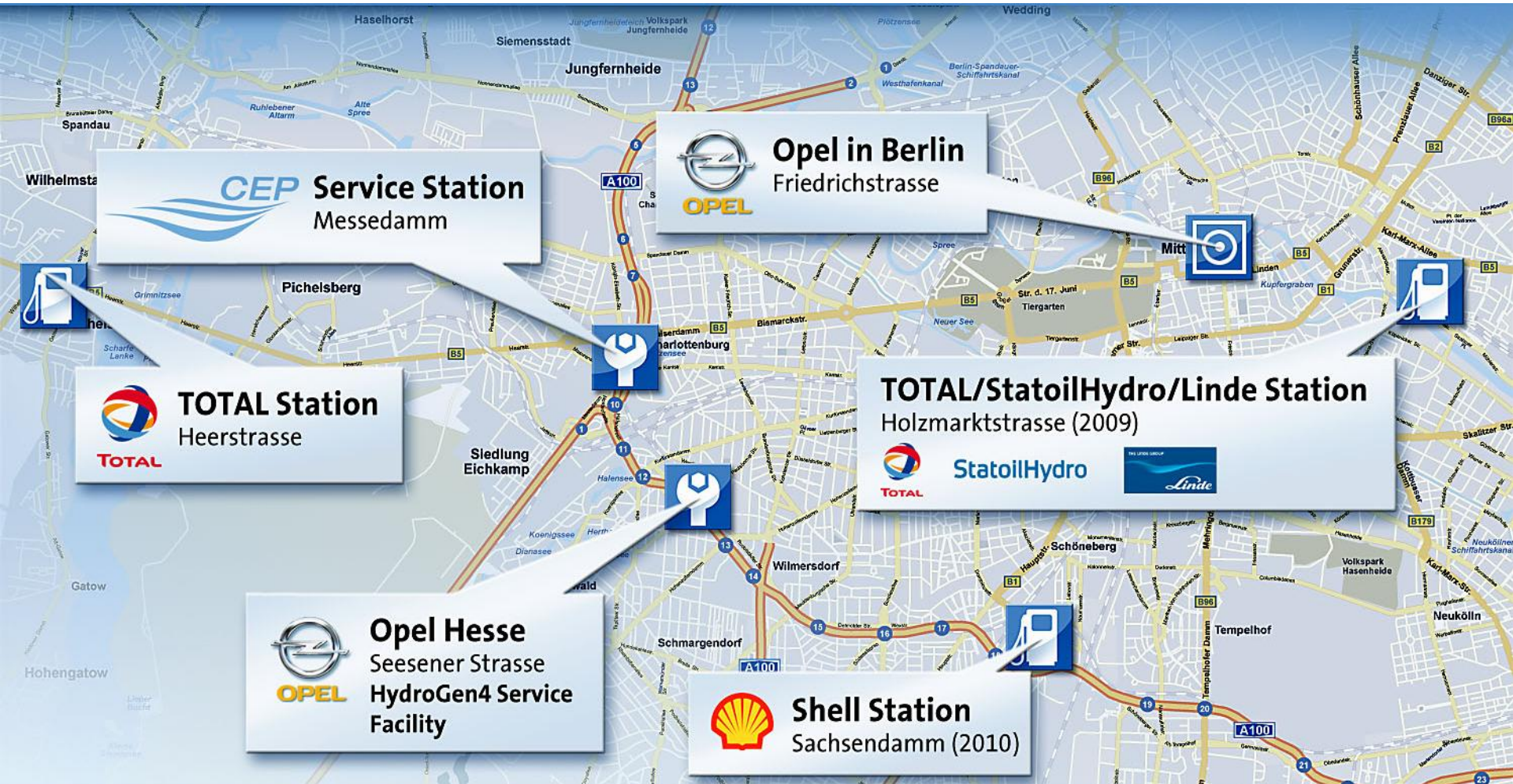
- Phase I → Phase II
  - Hamburg 2<sup>nd</sup> location
  - Aral/BP resigned
    - Messedamm decommissioned
  - Shell + Hamburger Hochbahn joined
- Phase II: 05/2008 – 2010
  - More than 40 hydrogen vehicles
  - 3 fully integrated hydrogen refueling stations:
    - Total: Heerstraße
    - Total/StatoilHydro/Linde: Holzmarktstraße
    - Shell: Sachsendamm







# CEP Refueling Station Situation



**Funding for 25 Pilot H<sub>2</sub> Stations included in 2009 Germany Stimulus**  
– Support a relative oversupply of stations during the early years





# Recent Media Articles



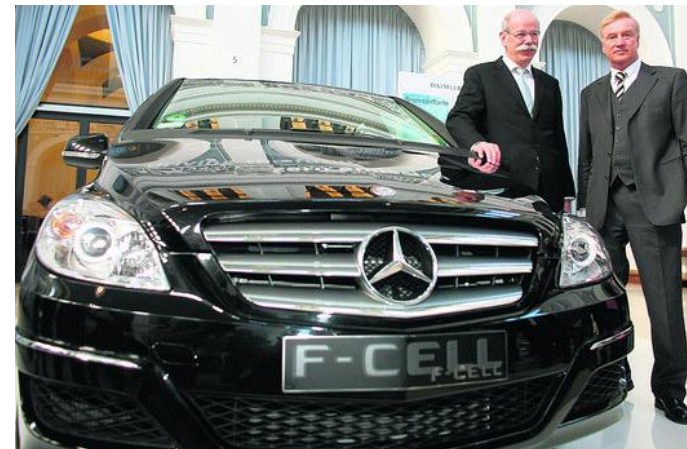
## Dr. Zetsche, Auto Motor Sport (#1 German Car magazine)

- Fuel Cell Production will begin this summer
  - Ramped up to 100,000 units within the next years
  - FCPS cost competitive to bluetec hybrid within the next 4-5 years at 100,000 units (not anticipated before)
- Hydrogen infrastructure
  - Partnered with Linde
  - Analyzed network of 1000 H<sub>2</sub> stations (max distance 35 km)
  - Investment ~1.7 billion EUR (\$2.2B) for Germany
- The end of the fossil fuel age has begun - - Chance for the German Auto Industry to win with better solutions



## Key recent media statements:

- Zetsche- - production readiness by 2015
- Wolfgang Tiefensee, German minister of Transportation
  - “We support research, development, and market preparation with 500 mio Euro”
  - “Hydrogen is the fuel of the future: efficient, emission-free, ecological”





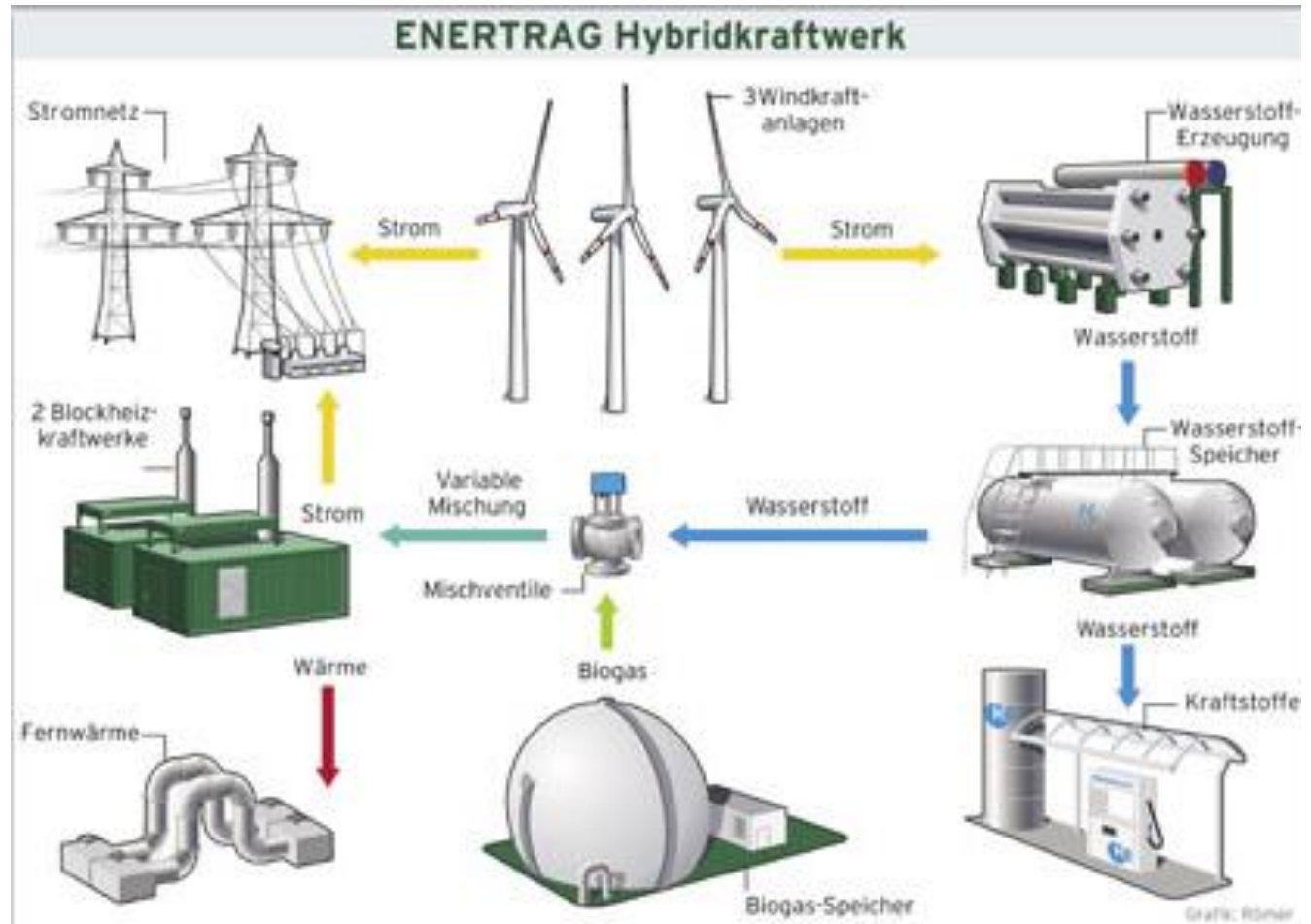


# Wind-Hydrogen-Plant Construction is Underway (21APR09) Northeastern Germany (6 MW System)

German Chancellor  
Angela Merkel @  
construction site



Minister President  
Matthias Platzeck  
(State of Brandenburg)





# Rationale for investment in H<sub>2</sub> and fuel cell Germany and Daimler



- High consumer and government awareness of environmental issues
- Industry / Governmental focused on gaining competitive advantage
  - Increase energy efficiency
  - Reducing CO<sub>2</sub>
  - Diversify primary energy portfolio (given high dependence on imported energy)
- Daimler focused on protecting core profit base (e.g. larger cars) while meeting or exceeding regulations
- H<sub>2</sub> plays a key role in integrated energy system for storage of renewable energy
- Export driven industrialized country - - high technology finished goods and equipment





# Japan Initiatives







# Government / Industry Fuel Cell and H2 Initiatives

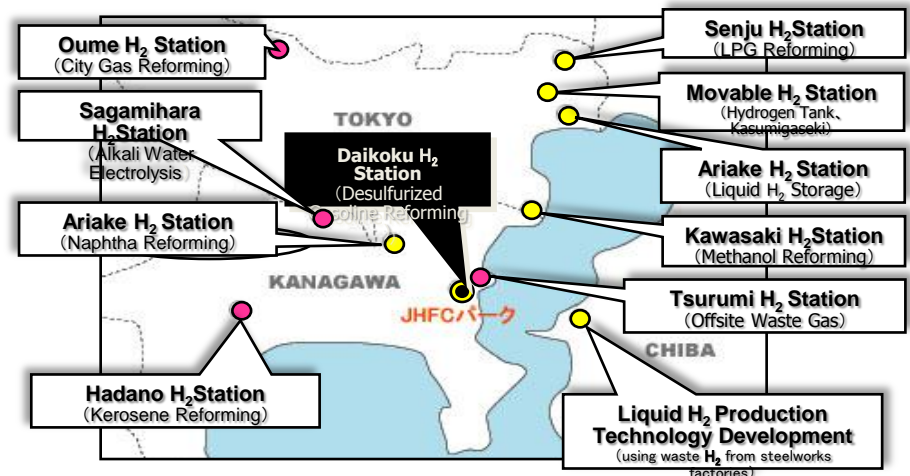
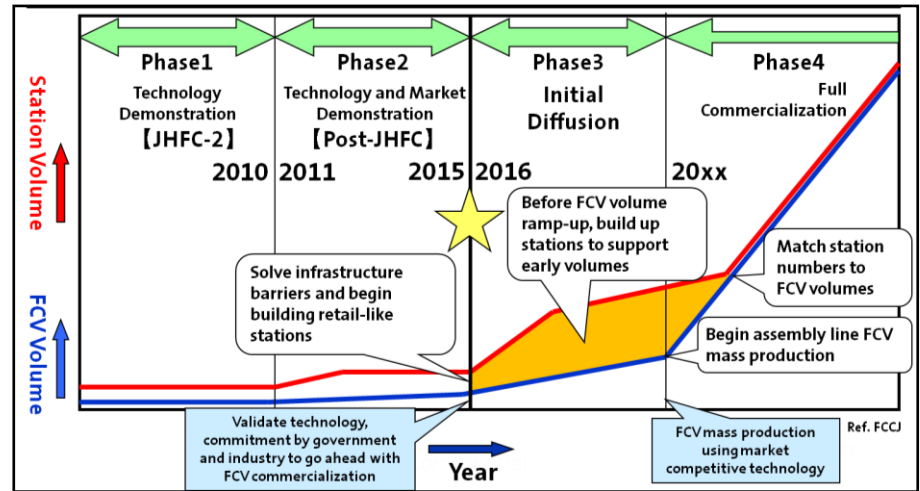
- 1992 onwards: METI has funded H2 and fuel cell development “New Sunshine Project”
- In 1997, CO<sub>2</sub> was put on high priority due to COP3 (“Kyoto Protocol”)
  - Past initiatives had been driven mainly by energy conservation
- “Millennium Project” 2000-2005 (3 major areas addressed: Information, Aging, Environment), was launched - - fuel cells and H2 were picked as key to reduce CO<sub>2</sub> emissions
- In 2001, METI facilitated Study Group consisting of representatives of industry, academia, media, national labs, semi-government organizations
- Fuel cells are relevant for vehicular and stationary application
  - Efficient energy use, Less environmental impact, Energy diversification, Distributed generation
  - **Strengthen the industrial competitiveness of a wide range of industries**
    - **21<sup>st</sup> century will be driven by energy efficient and environmentally friendly technologies**
- It was agreed that fuel cells are a “key technology” which need to be accelerated towards realization
  - Fuel Cell Commercialization Conference of Japan (FCCJ) was established





# Government / Industry Fuel Cell and H2 Initiatives

- FCCJ committee has committed to 2015 as the target for FCV commercialization
- Infrastructure should lead vehicle deployment
- Four phases defined
  - Technology Demonstration
  - Technology & Market Demonstration
  - Initial Diffusion
  - Full Commercialization
- Government sponsored program to understand various processes and feed stream sources for H<sub>2</sub>
  - 11 different H<sub>2</sub> refueling facilities with H<sub>2</sub> from 11 different feedstocks
  - Understand most economical process
  - Develop refueling equipment







# Future Products/Strategies

## Toyota Motor Corp. is counting on a huge reduction in the cost of fuel-cell stacks as it makes a bid to market a fuel-cell vehicle in 2015 -- Goal to retail an FCV in 2015

- 90% cut in cost over the next six years
- Reduced platinum use to 10% of current levels
- Reduce tank costs - - Thinner carbon-fiber layer with simplifying valve and regulator design
- 50%-100% increase in power density and stack durability
- Wide operating temperature band from -22° F to 221° F
- Technology may be applied to long-haul trucks and buses



## Toyota began leasing FCVs in 2002

- > 60 in operation in Japan (US starting 2009) Highlander FCHV-adv, including eight buses.
- 840k JPY (\$9,300) per month (for 30 months = \$279,000) lease rate to Japanese Government
- Exceeded its planned 400-mile driving range by more than 100 miles in Japanese Drive Cycle
- Almost doubling of fuel-tank capacity achieved in part by raising pressure levels to 700 bar
- Fuel economy improved 25% by reducing auxiliary system loss and increasing regenerative energy
- Automated fuel cell stack assembly line

## Percent Energy Efficiency by Powertrain Type

Powertrain	Well-to-Tank	Tank-to-Wheel	Well-to-Wheel
Fuel Cell	67	59	40
Electric Vehicle	39	85	33
Gas-Electric Hybrid	84	40	34
Gasoline-Vehicle	84	23	19

Source: Toyota







# Honda starts producing next-gen fuel cell car

- Honda continues fuel cell development and has led “retail” deployment of FCEVs
- Introduced Honda Clarity in 2008
  - World's first dedicated fuel cell vehicle platform
  - 4 Passenger sedan, 100kW Stack, 4.1 kg H<sub>2</sub>, 280 miles range
  - Deployment
    - “Retail” (lease-only) FCEV - - \$600/mo. for 36 months
    - 12 vehicles leased in Year 1
    - Total of 200 units over the next 3 years, starting in California & Japan





# Rationale for investment in H<sub>2</sub> and fuel cell Japan and Toyota / Honda / Nissan



- Very limited natural resources - - “conservation” is part of culture
- Export driven economy - - global viewpoint
- Focused on strengthening industrial competitiveness of a wide range industries
- Joint industry / government agreement - energy efficient and environmentally friendly technologies will drive 21<sup>st</sup> century
- Technology focus
  - Increasing energy efficiency
  - Reducing environmental impact
  - Diversifying energy sources
- Example: Toyota Presentation at Nagoya University, March09
  - Expect oil prices to rise significantly - negatively affect Japanese economy
  - Unrealistic assumption that electricity replaces crude oil for transportation, thus H<sub>2</sub> substitution
  - HEVs will reduce CO<sub>2</sub> by 30-40% max- - Won't solve CO<sub>2</sub> and oil issue
  - Fuel cell vehicles are moving towards realization with viable cost models
  - Fuel cell vehicle industry will create value domestically for both vehicle and hydrogen production/distribution





## Other competitors: Hyundai / Kia



- Hyundai-Kia also plans to commercialize fuel cell electric vehicles by 2012
  - 1,000 units in 2012
  - 30,000 units by 2018
  - Long-term plans for 1M units/year by 2030
- Hyundai-Kia very bullish on the prospect of FCEVs for the South Korean home market
  - Almost half the population lives in very condensed Seoul metropolitan area
  - Nearly all energy sources are imported
  - Only 100 H<sub>2</sub> stations needed to serve Seoul area

## Automobile

### Kia's Big Fuel Cell Plans

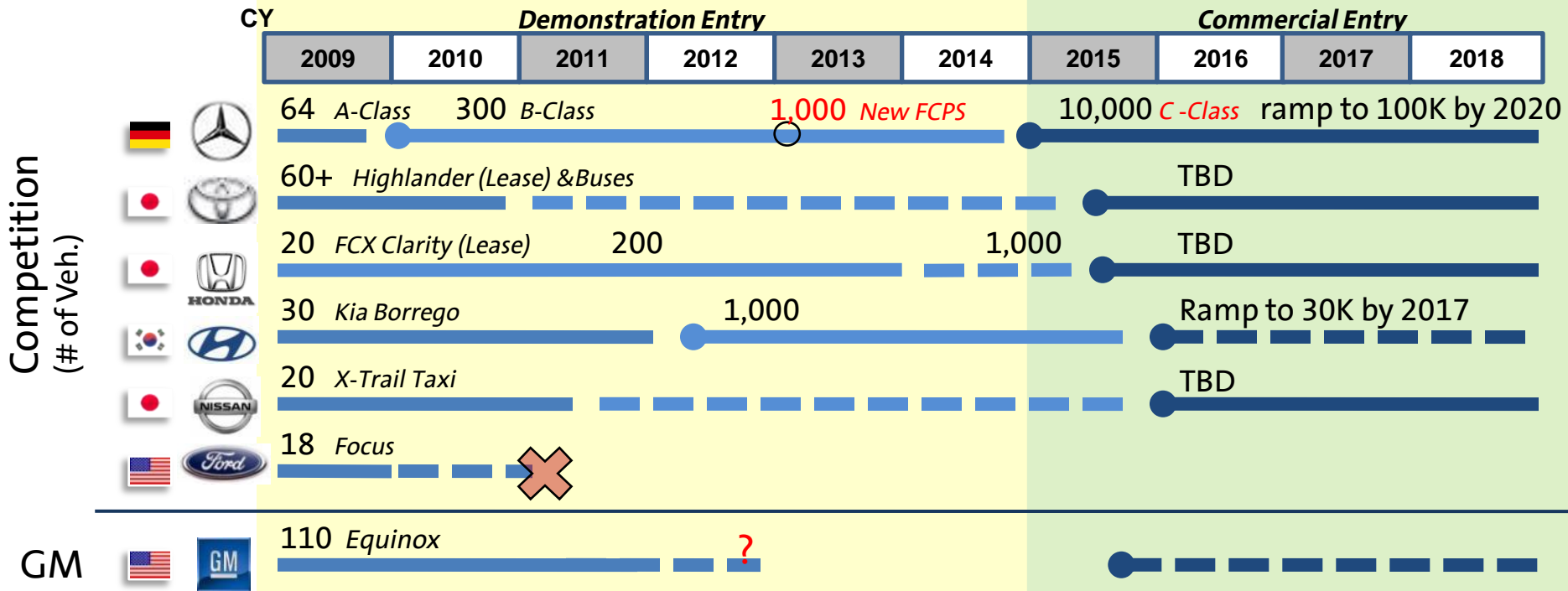
Kia reveals next generation Borrego fuel cell vehicle and production Soul

November 22, 2008  
By Le Guide de l'auto

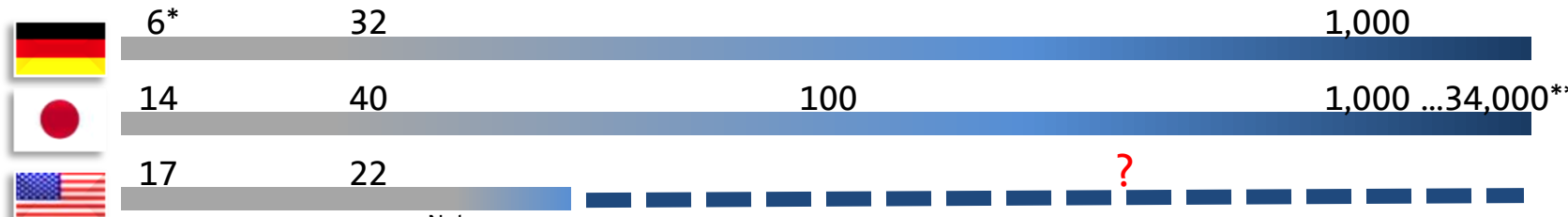




# Competitive Landscape - Summary



## Hydrogen Stations (cumulative)



Legend: Solid: publicly announced Dashed: anticipated Notes: \* Joint funding by government, energy & gas companies, OEMs; \*\* by 2050

**GM Gen2 goal is to be "among the few Fuel Cell Leaders" - - Great Product Execution on track to Automotive competitive fuel cell vehicle offering**





# Fuel Cell Technology: Government & Competitive Landscape Summary

## Germany & Japan:

- Long term government / industry collaborations (Auto, Energy) to improve domestic competitiveness & energy security
- High volume H<sub>2</sub> fuel cell vehicle introductions by 2015
  - Addressing CO<sub>2</sub> & energy independence challenges
  - Developing infrastructure to support fuel cell growth
- Daimler, Toyota and Honda are executing aggressive plans for fuel cell technology
  - Leverage learning cycles to mature technology

## China & Korea

- Chinese companies are developing internal fuel cell capability
- Korean government & Hyundai are working together to ensure competitiveness by 2015

## Other U.S. OEMs:

- Ford scaled back to an R&D project (Technology was from Daimler)
- Chrysler not an active player

### PLAN REPORTS



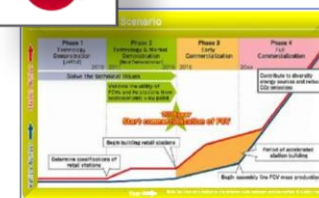
Nat. development plan



- 2015 competitiveness established
- \$1.8B project budget



METI / Japan Inc.



- 2015 target start commercialization
- Infrastructure leads vehicles



# GM Competitive Position in Fuel Cell Technology

**GM is the only domestic OEM with in-house automotive experience**

- GM developed a leadership position
  - GM has over 20 years experience & invested >\$1B
  - GM is operating world's largest fuel cell vehicle fleet (Project Driveway)
  - GM established technology strength in electrochemistry, materials, systems engineering, modeling and packaging
- In total, U.S. Government & Companies invested over \$3B
- Given co-dependence of high volume vehicle introduction & refueling infrastructure, GM has invested to remain among the fuel cell leaders
  - Need consistent and long term government policy supporting fuel cell and hydrogen commercialization
  - Need funding initiatives (Fuel cell and H<sub>2</sub> infrastructure development) in light of significant economic challenges

## Fuel Cell Technology Competitive Position

**Leader**

**Among the Leaders**



**Followers**





**Thank You**