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Fuel Cell Vehicle Technology Performance & Steps Ahead

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Honda
CARB ZEV Symposium
Sept 21 2009

Why Fuel Cell Vehicles?

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Major Issues:

Climate Change,
Energy Sustainability

FCV Technology:

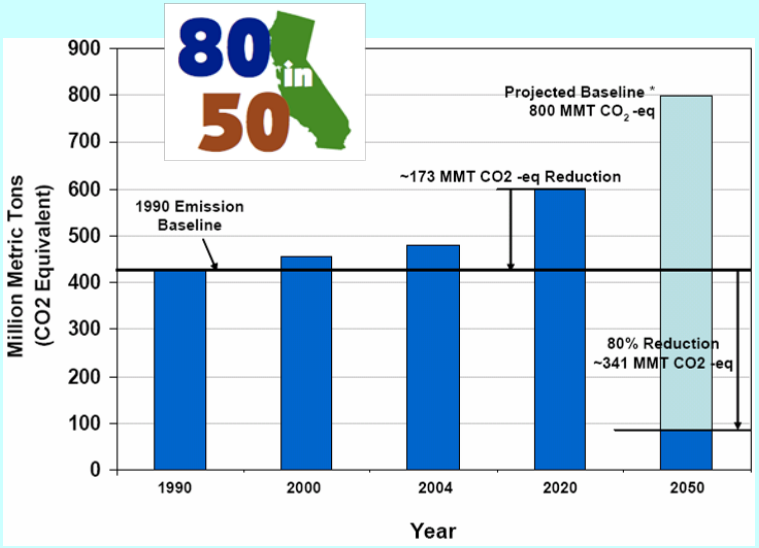
- **High Efficiency**
- **Decarbonized Fuel**

Excellent, Full Function Vehicles

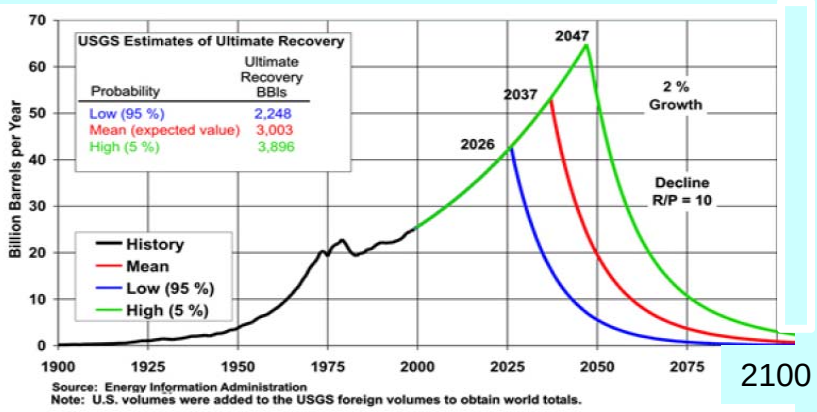
Appealing &

Compelling Vehicles

GHG Reduction (California's Target)



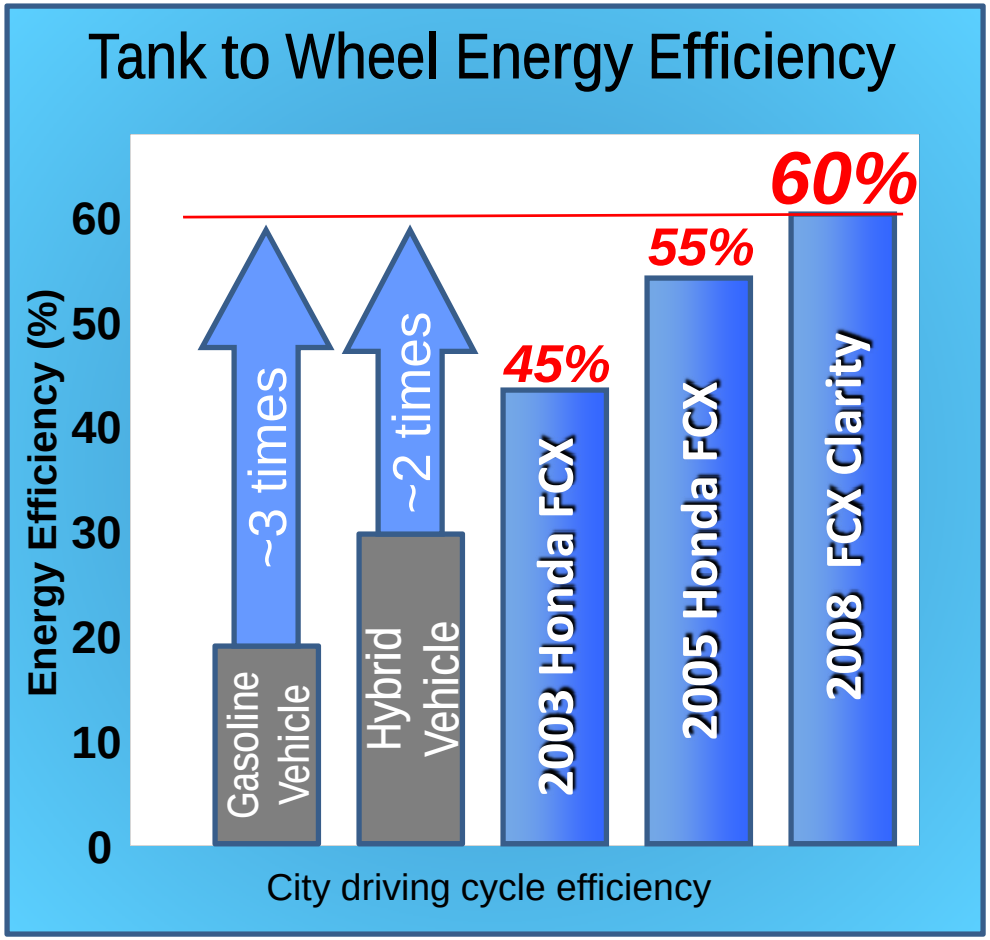
Petroleum Reduction, Sustainable Energy Supply



http://www.hubbertpeak.com/us/eia/oilsupply2004.htm

FCV Efficiency

Energy Efficiency



Fuel Economy

Definition	FCX Clarity
EPA-tested (combined)	**88 mpgge** (87 mi/kg H2)
EPA label (combined, 'real world')	**61 mpgge** (60 mi/kg H2)

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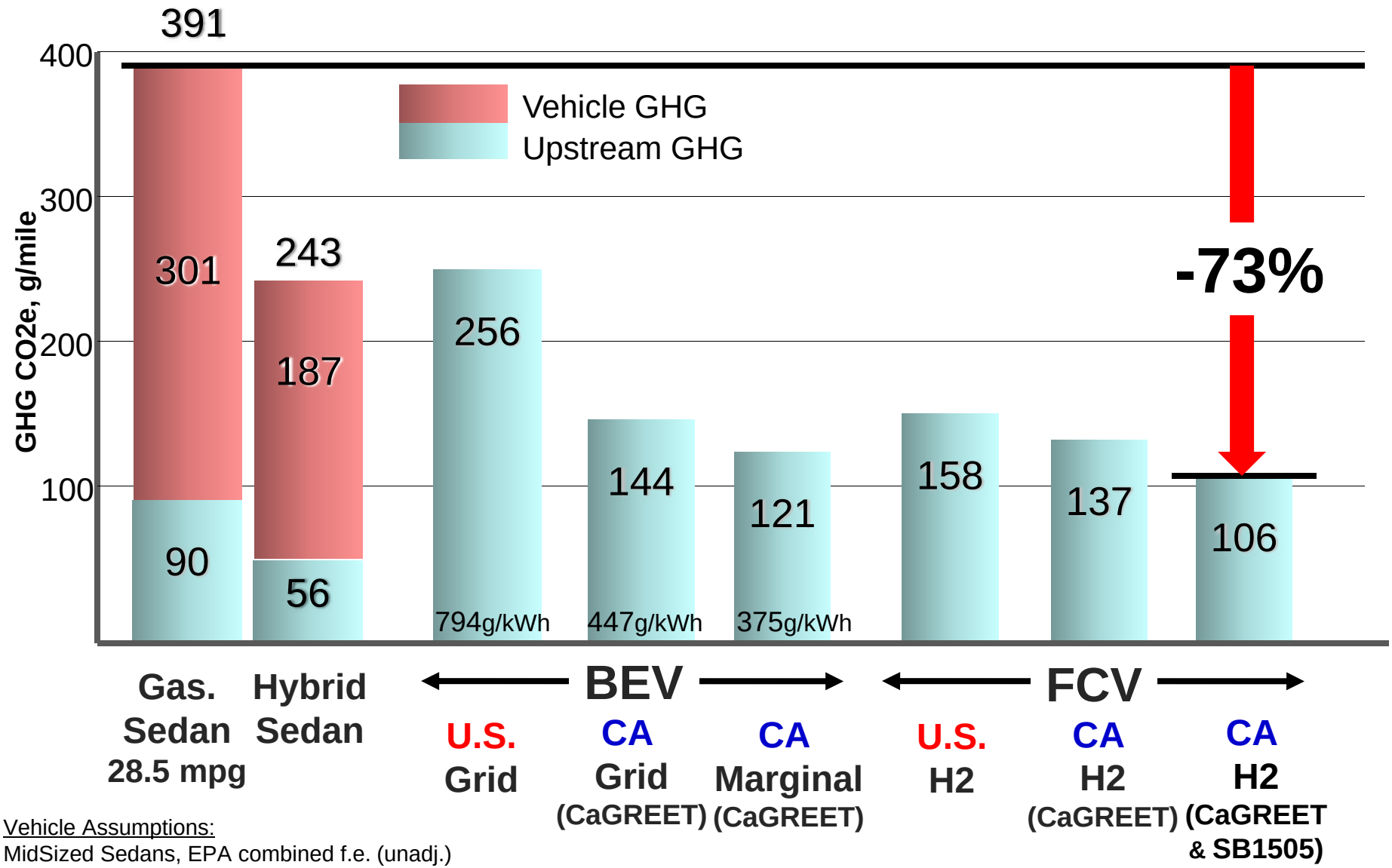
Greenhouse Gas (WTW) – midsized sedans



Vehicle Assumptions:
MidSized Sedans, EPA combined f.e. (unadj.)
BEV @3.5xEER, (100 mpgge), HEV (46 mpg)
FCV = Clarity, (88 mpgge)

Upstream Assumptions:
U.S. GREET, CA GREET (CA factors from LCFS)

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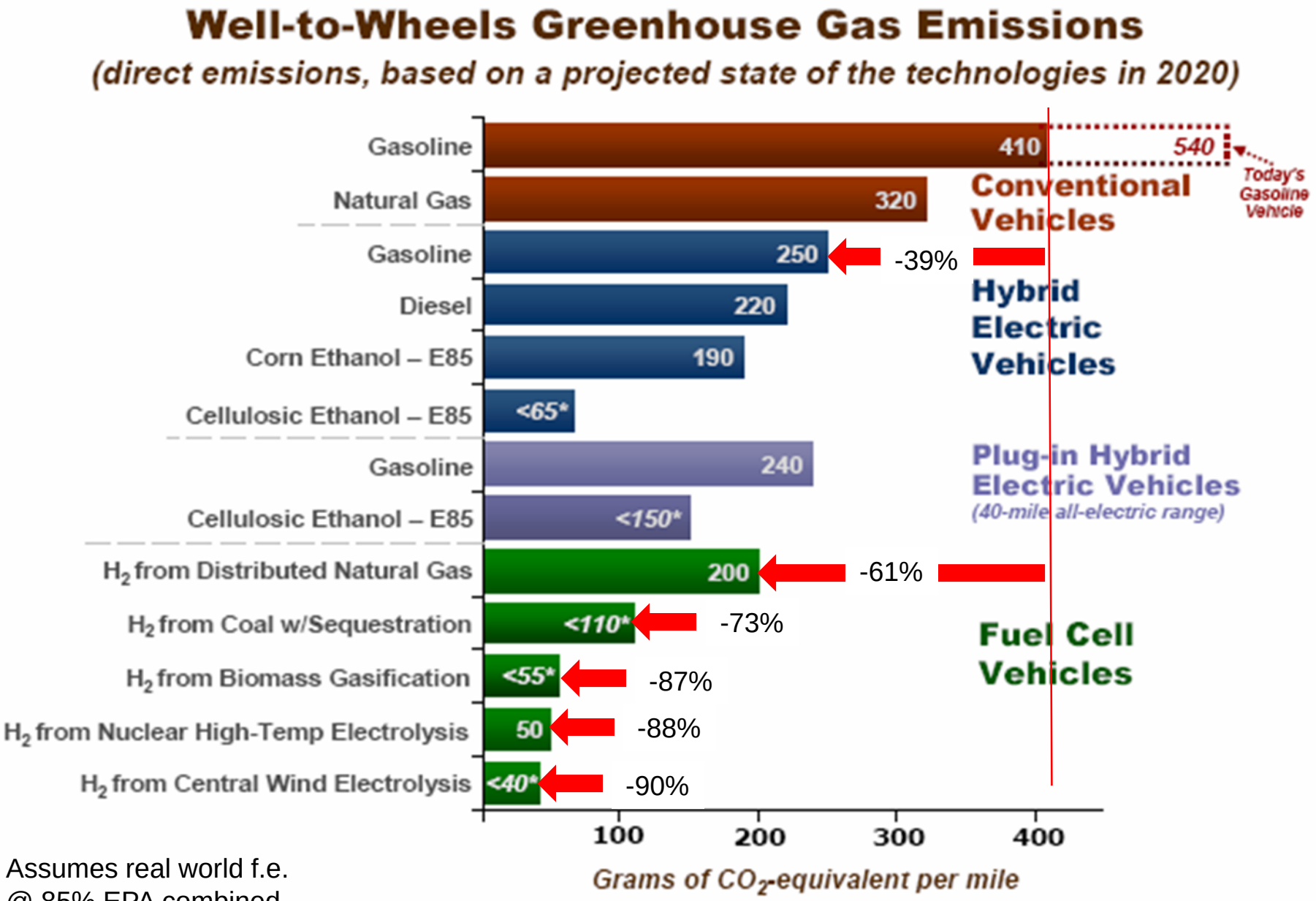
DOE GHG 2020 Projections (March 2009)

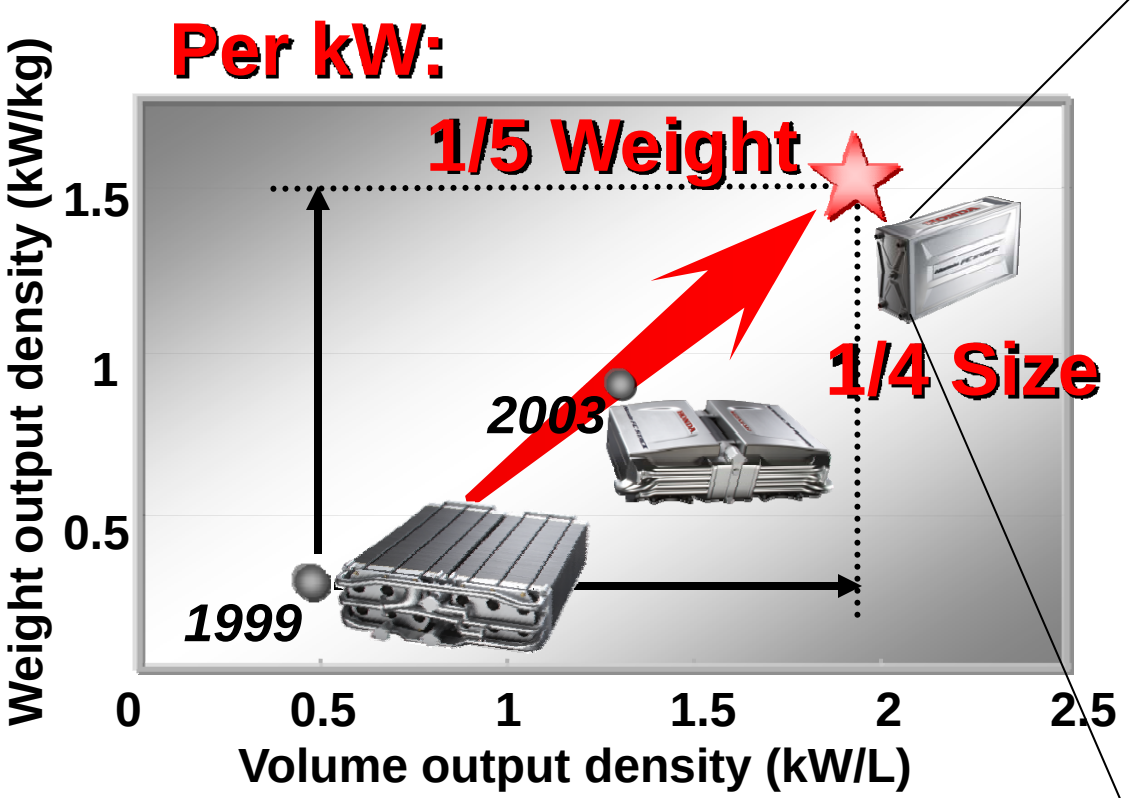


Assumes real world f.e.
@ 85% EPA combined

Fuel Cell Vehicles

Technology Performance & Innovation

Honda FC Stack Evolution



FCX Clarity

100 kW

52 L

67 kg

Aromatic electrolytic membrane

Operating temperature

-30 ℃ to 95 ℃

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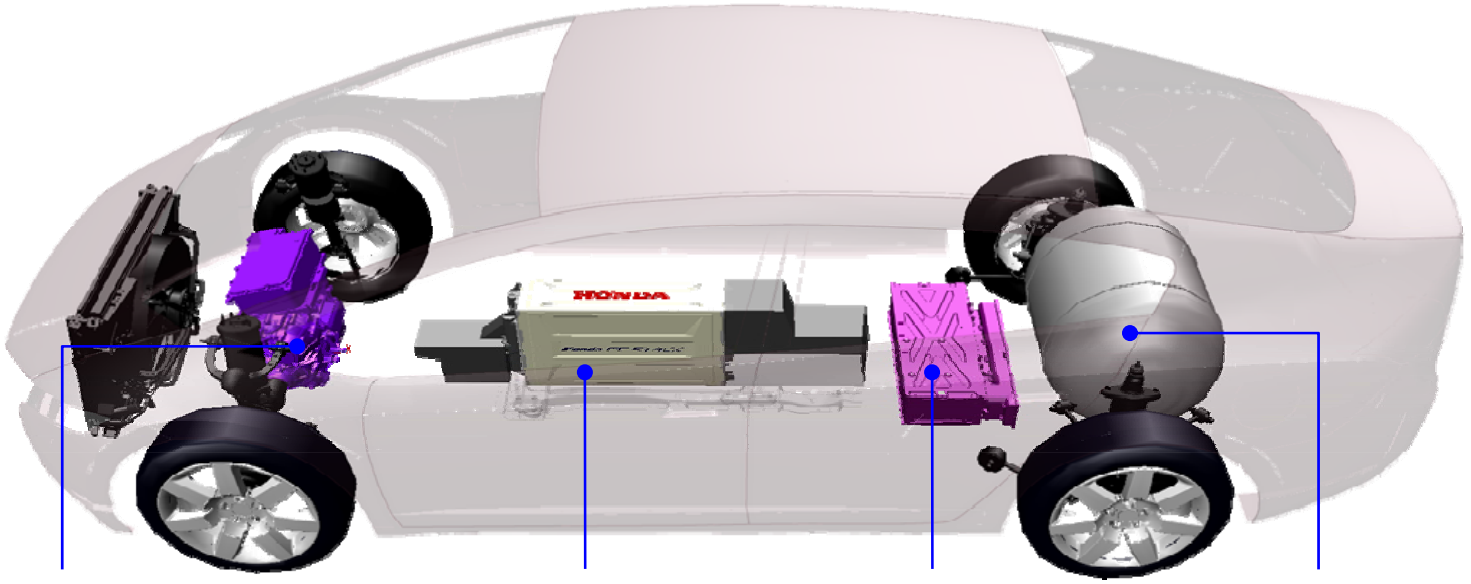
Functionality

Lightweight & Compact FC Powertrain

Enables flexible layout of compact, distributed components



Coaxial electric motor-gearbox

Compact fuel cell stack (under center console)

Lithium-ion battery

Single Hydrogen tank

- High efficiency: Weight same as midsized V-6 sedan, low CdA
- Small components: Large car cabin and good trunk capacity in short overall vehicle length

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Functionality

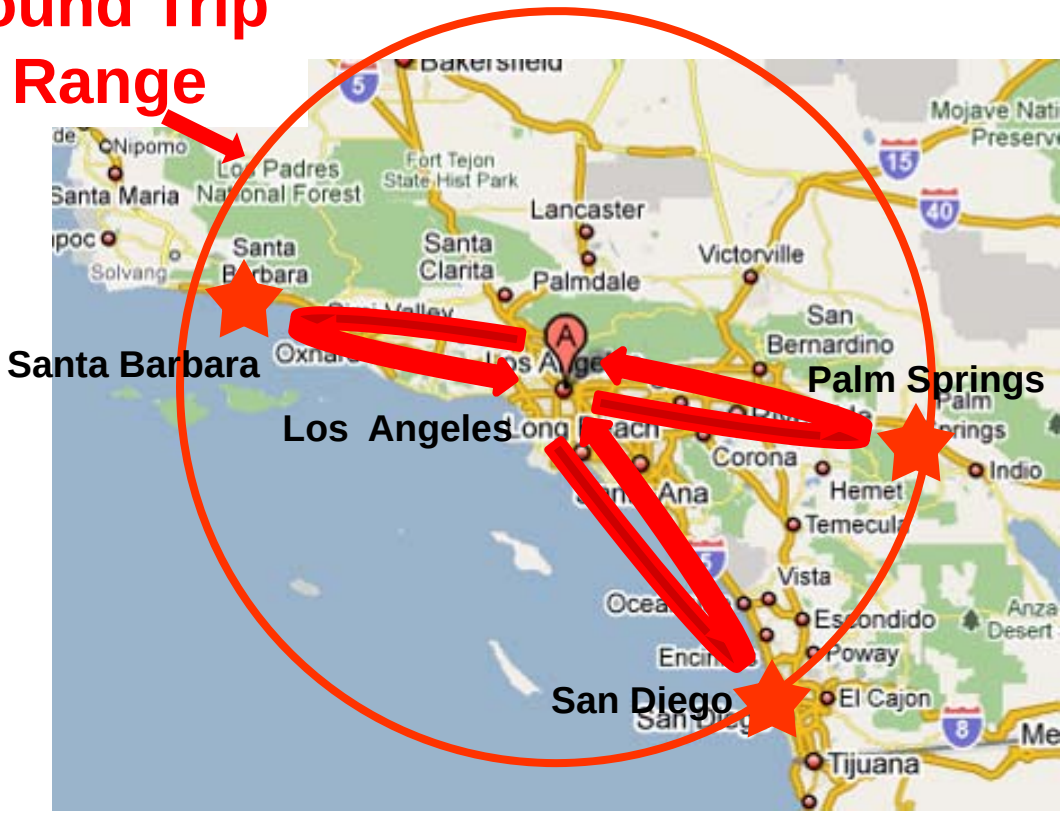
Range

240 mi. or.. **338 mi.**

(EPA ‘real world’) (unadj. FTP (city) range, for comparisons w/ BEVs)

Recharge Time

Round Trip Range



Full in < 5 minutes

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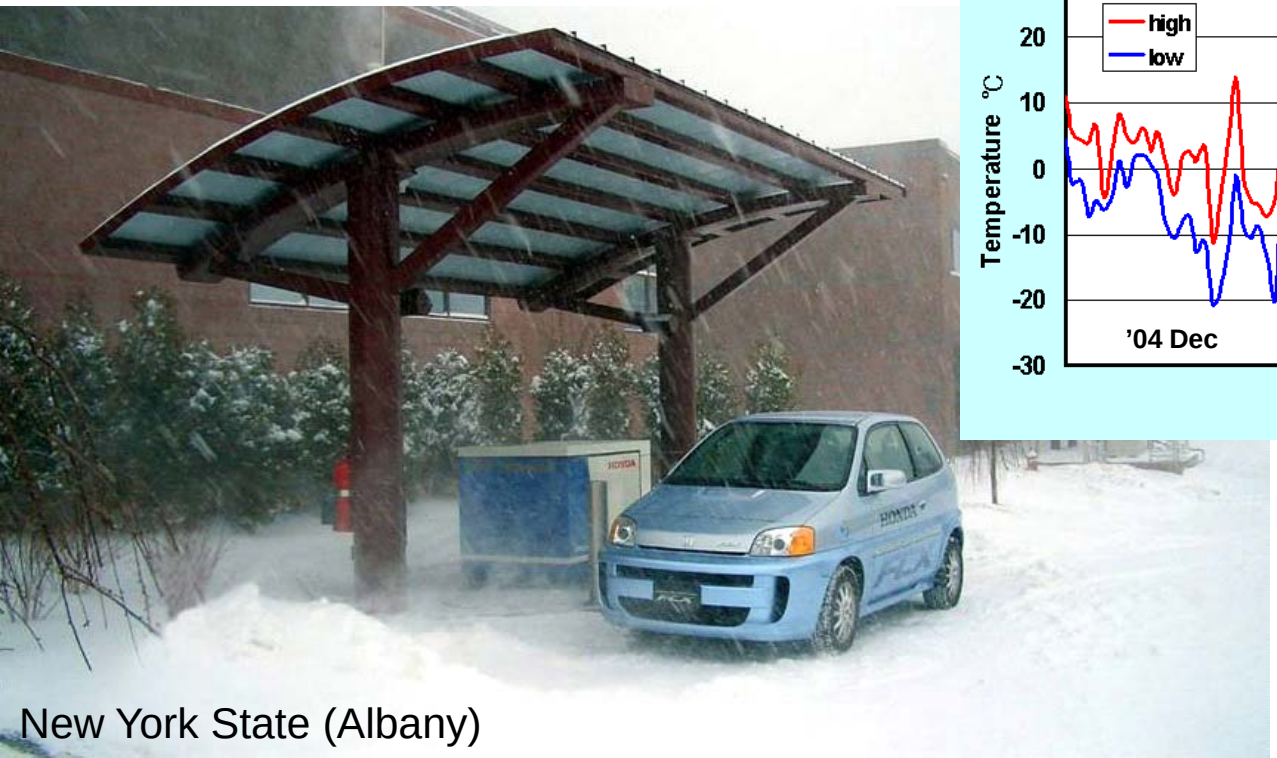
Functionality

Freezing Weather Startup and Operation

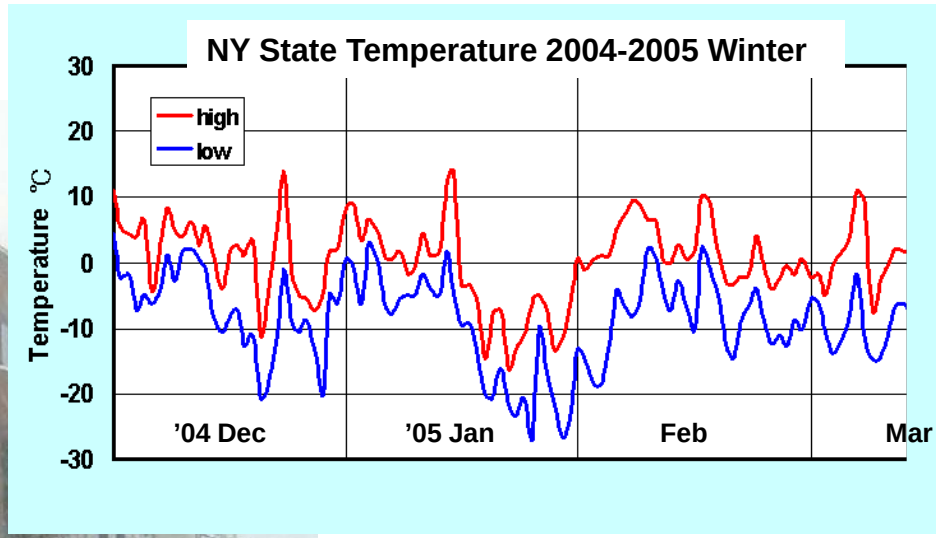
2005 FCX: **- 20C**

2008 FCX Clarity: **- 30C**

→Reduced stack mass (-40%)
→Membranes with low resistance
→Increased water drainage (gravity)



New York State (Albany)



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Challenges, Work in Progress

e.g.
cost,
durability,
range extension,
market preparation,
infrastructure development

Changes in Fuel Cell MATERIALS

Goal: ***"Automotive" parts: (low cost materials, mass producible)***

FC Stack

- ***Stamped Metal Flow Plates***

(vs. Carbon and Resin)

- ***Aromatic Membranes***

(vs. Fluorine Compounds)

- ***Reductions in Catalyst Loading***

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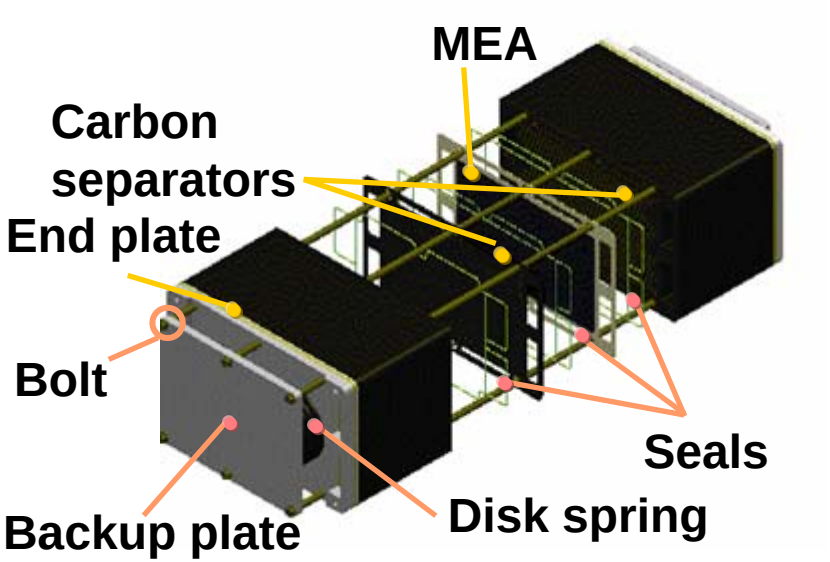
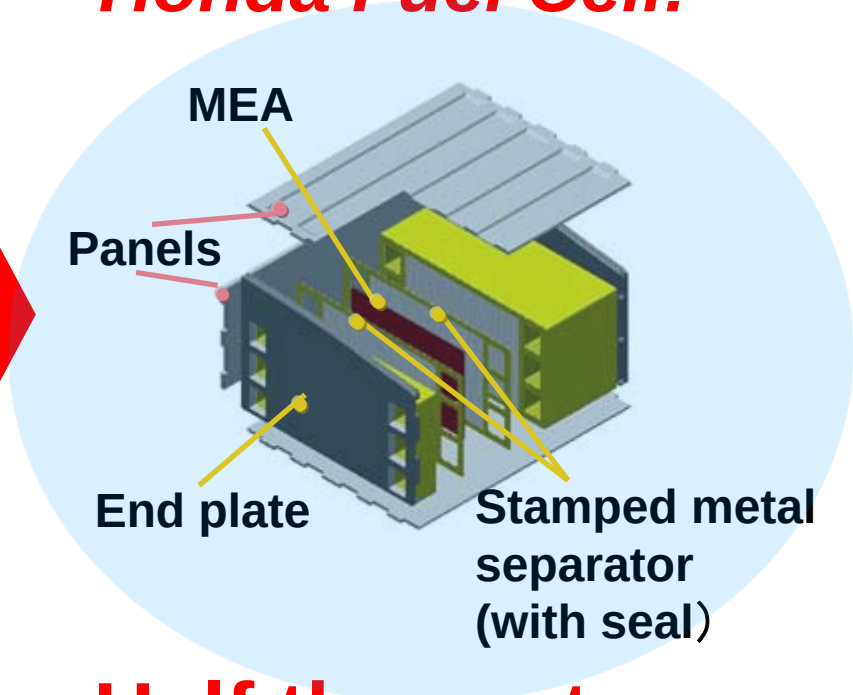
Fuel Cell SIMPLIFICATION

Earlier Fuel Cell :



Honda Fuel Cell:



- **Half the parts**
- **High recyclability**
- **Improved manufacturability**

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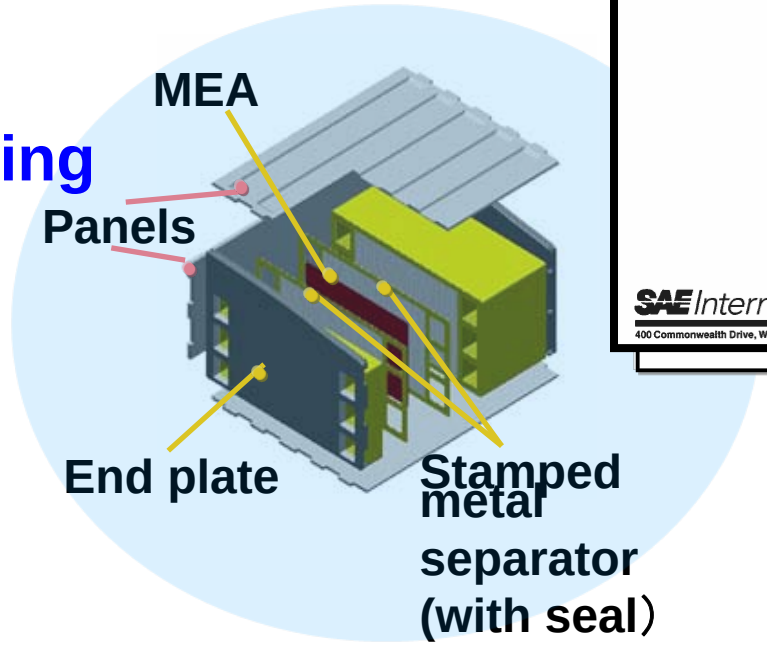
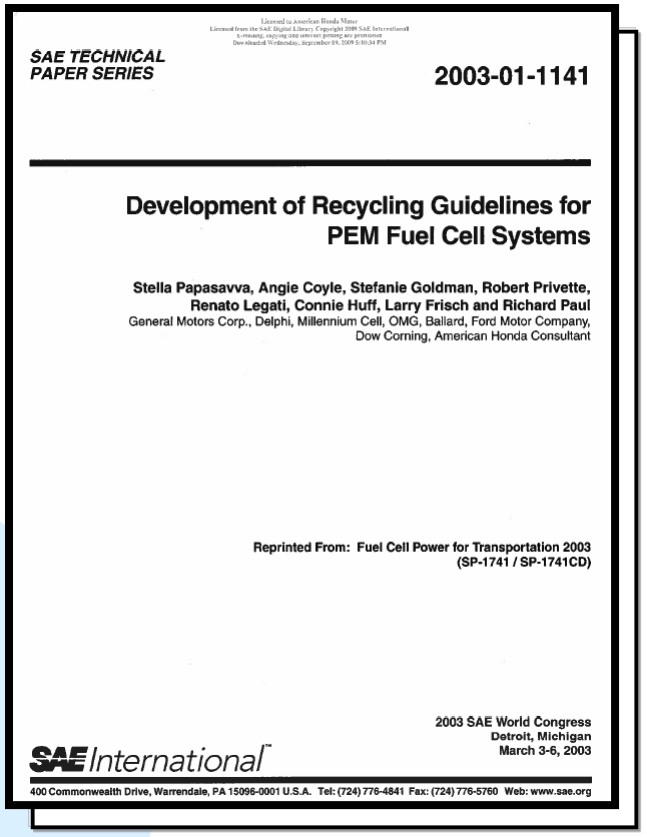
Fuel Cell RECYCLABILITY

Important factors include:

- Lightweight & compact
- Ease of disassembly
- Materials used
- Ease of Material Separation
- Ease of Reprocessing
- Re-use, Yield





SAE TECHNICAL PAPER SERIES

2003-01-1141

Development of Recycling Guidelines for PEM Fuel Cell Systems

Stella Papasavva, Angie Coyle, Stefanie Goldman, Robert Privette, Renato Legati, Connie Huff, Larry Frisch and Richard Paul
General Motors Corp., Delphi, Millennium Cell, OMG, Ballard, Ford Motor Company, Dow Corning, American Honda Consultant

Reprinted From: Fuel Cell Power for Transportation 2003 (SP-1741 / SP-1741CD)

2003 SAE World Congress
Detroit, Michigan
March 3-6, 2003

SAE International

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Prospects of FCV Commercialization

Demonstration stage | **Early Introduction & Pre Commercial Stages** | **Mass production stage**

2000 2010 2020

Demonstration test

- **improvement of vehicle performance**
- **Extended to cold areas**

- **Improvement of durability and reliability**
- **Extended practical range**
- **Cost reduction**

- **Cost reduction**

- **Cost, durability and reliability equal to gasoline-fueled vehicles**

Aiming at mass production by progressive efforts

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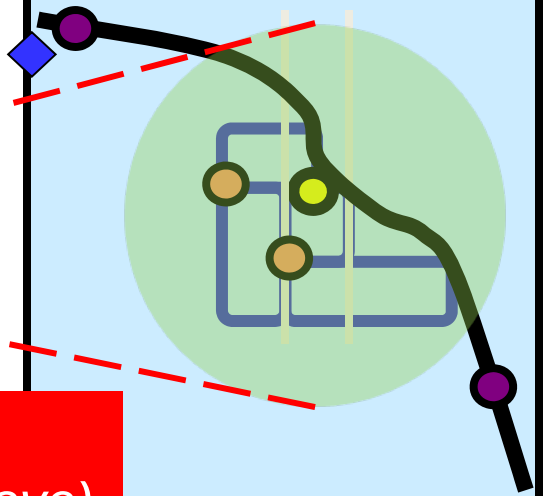
Early Vehicle Introductions to Market by OEMs
example: Markets within Southern California
3-4 primary communities/H2 station clusters

Source: CaFCP

"Market Driven" Clusters

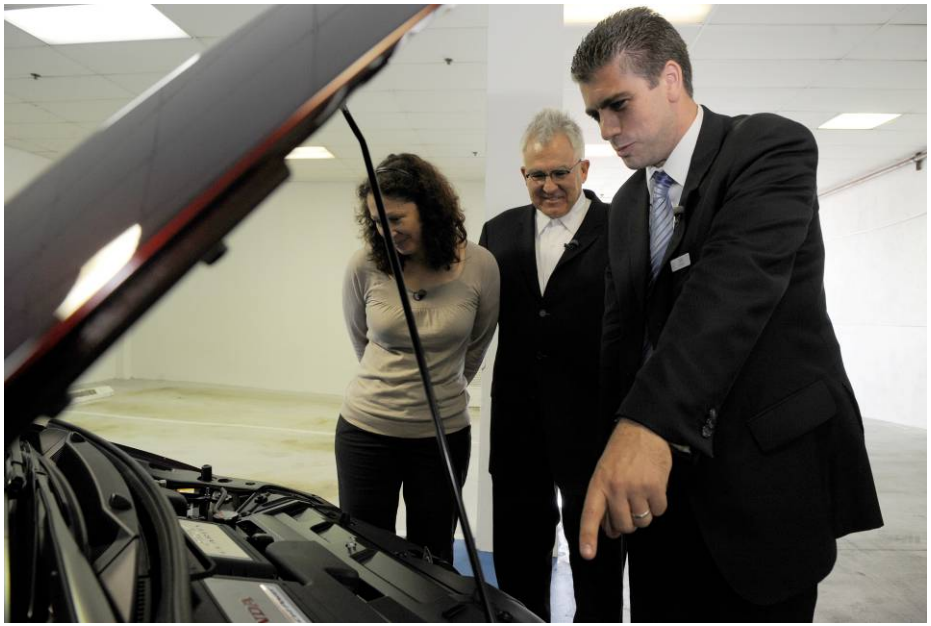
Primary & Backup stations serving early communities



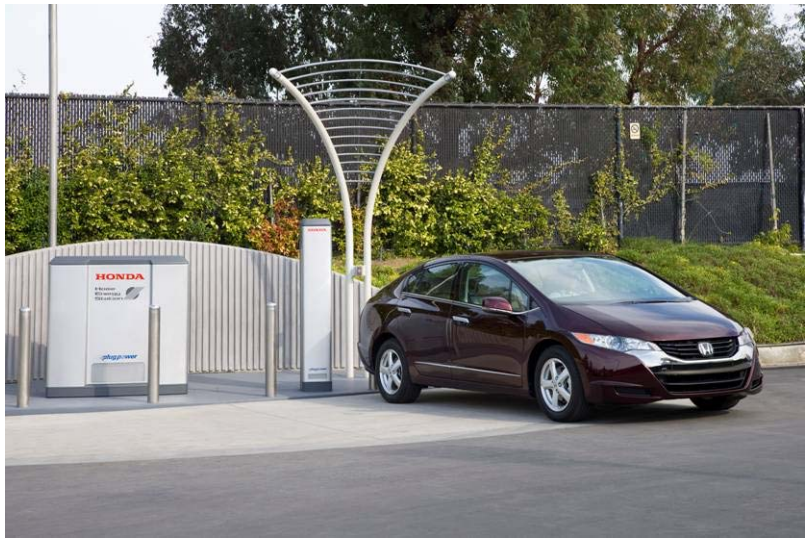
Focus on early station clusters, communities:

1. *Well-located, user-friendly stations (image shown above)*
2. *Customer access to stations in "network"*
3. *Stations (H2 supply) consistent with Vehicles (demand)*

Dealership Delivery – Market Foundations



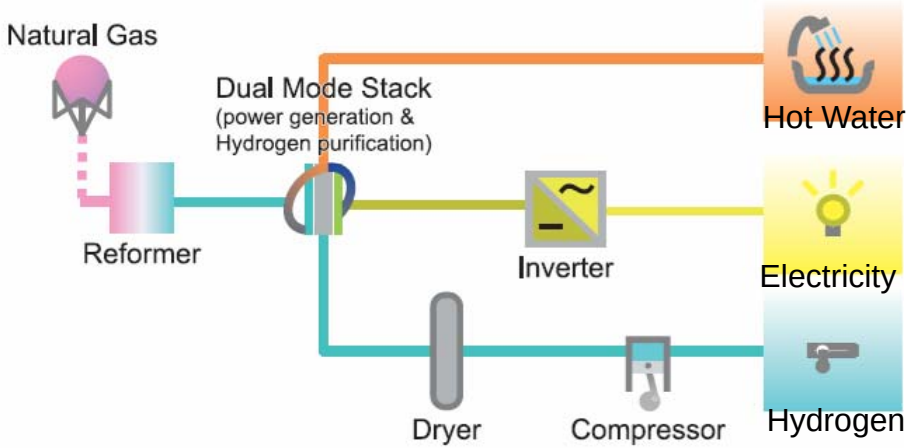
Honda's Hydrogen Station R&D



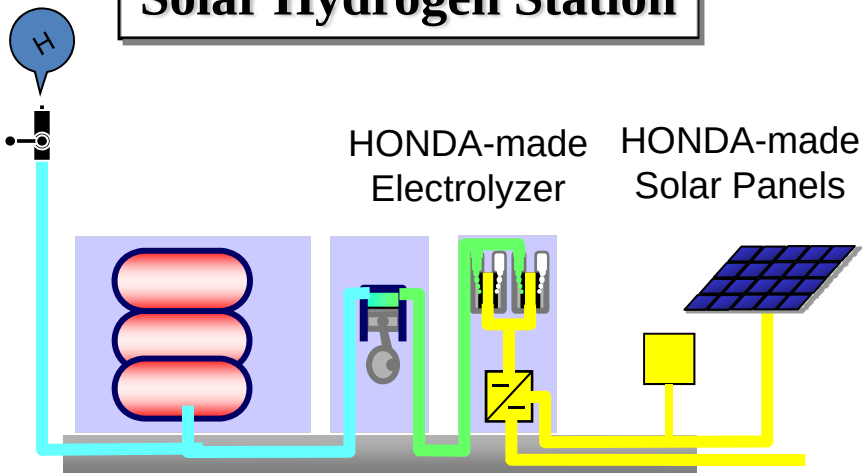
Torrance, California

Torrance, California

Home Energy Station



Solar Hydrogen Station



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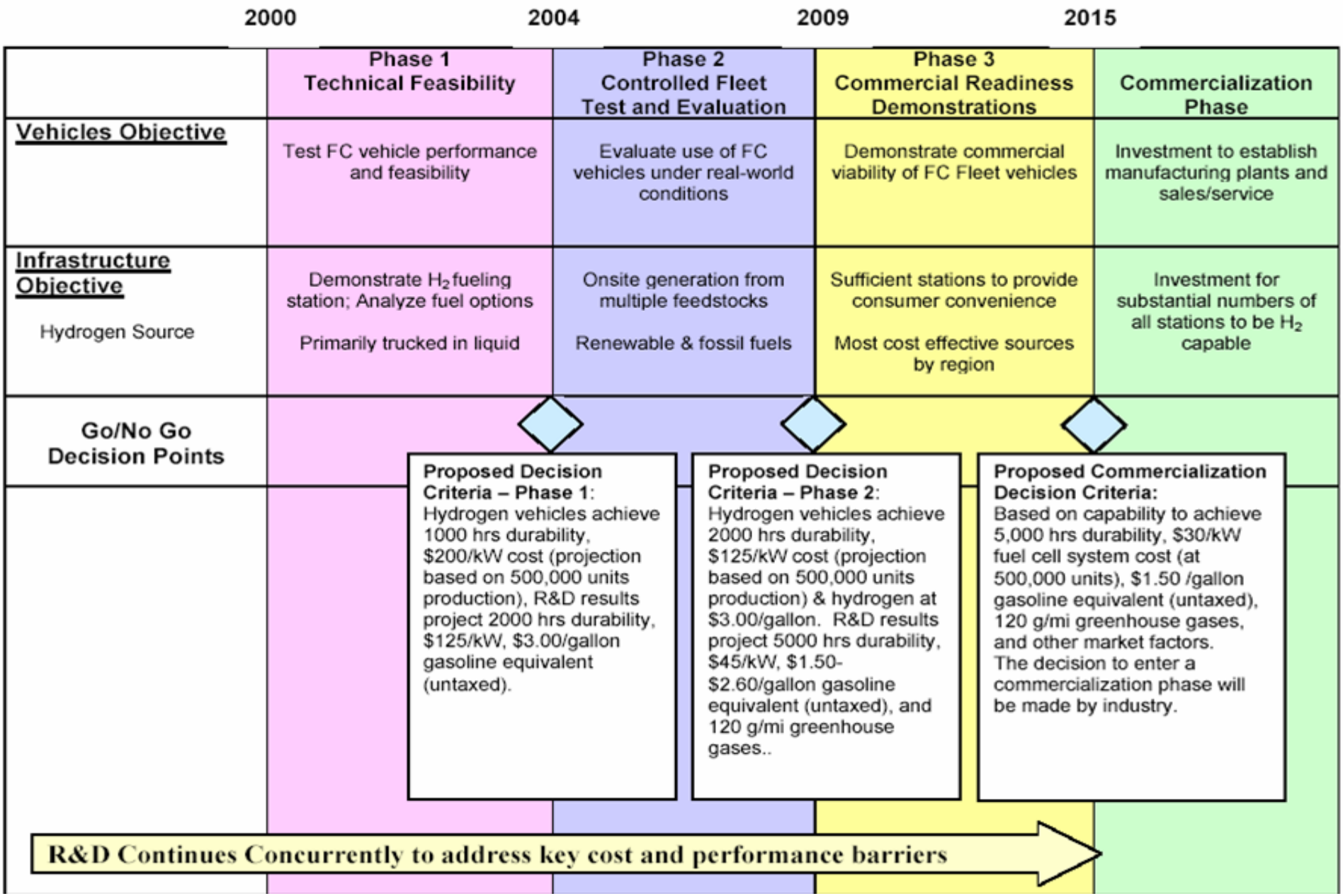
DOE H_2 & FCV Timeline, Milestones



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Advanced Vehicle Technologies (Current Status)

Path	Social Values				Marketability			
	Air Quality	GHG	Energy Sustain.	Energy Security	Infra-structure	Vehicle Cost	Full Function	Appeal
Bio Fuels (Current)								
Bio Fuels 2nd Gen								
Diesel								
CNG								
Down Sizing								
Improved ICE								
HEV								
PHEV								
EV								
FC								

Very Good

Good

Fair ~ Good

Challenging

Extremely Challenging


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Mt. Shasta