Hydrogen and Fuel Cell Showcase

June 2011

Board Member Briefing

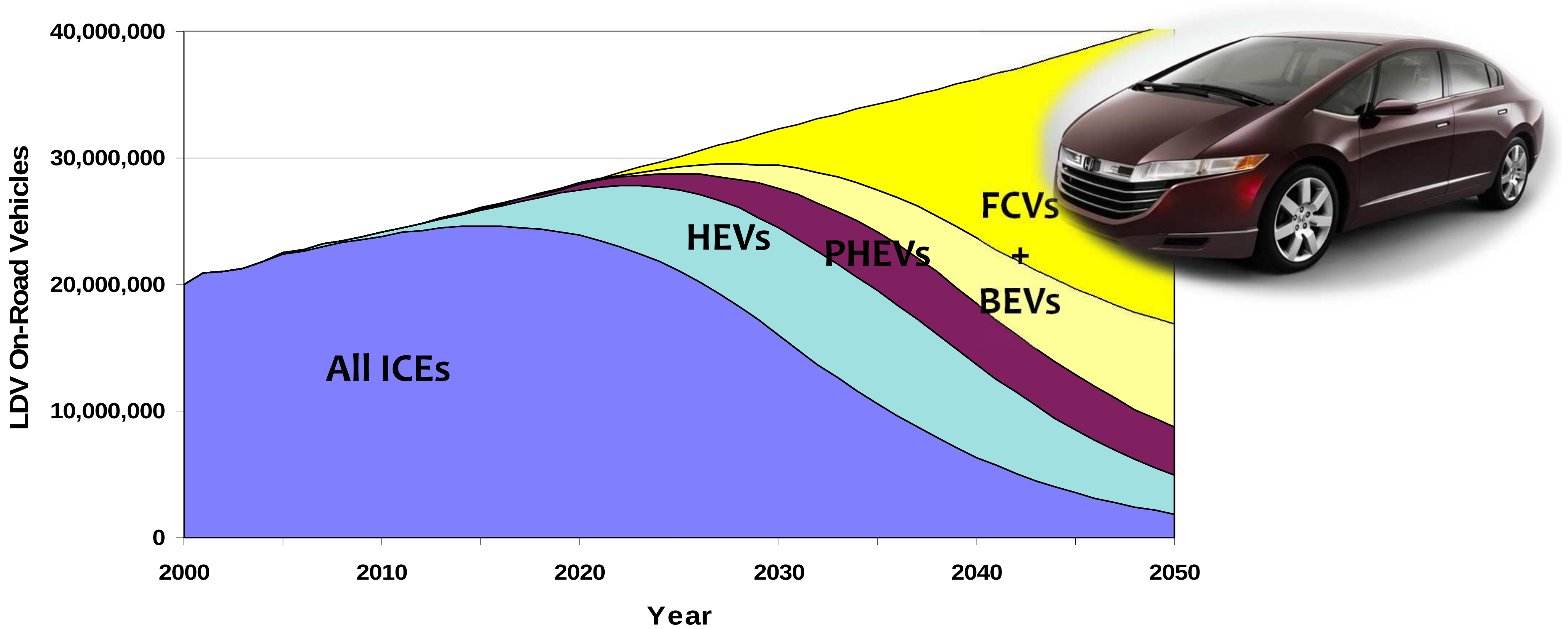
Analisa Bevan, Chief, Sustainable Transportation Technology Branch,
Mobile Source Control Division

Overview of Hydrogen and Fuel Cell Showcase

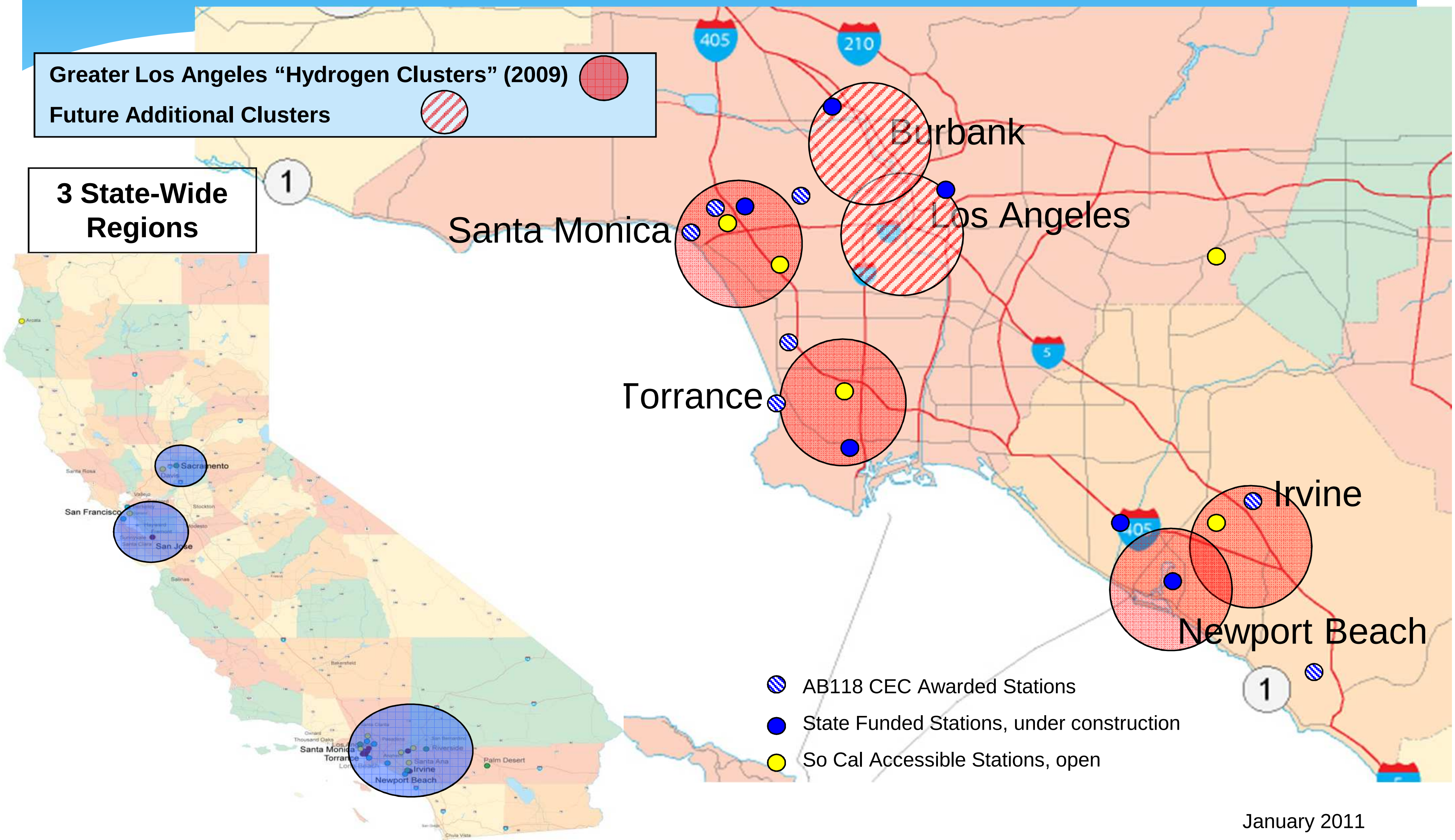
- Why hydrogen and fuel cell matter
- Industry to provide:
  - Overview of technology
  - How it works, what fuel cells are used for
  - Technology Status
  - Economic and business case
  - What is needed for success

Why Fuel Cells and Hydrogen?

* Fuel cell vehicles are the technology that allows us to reach a vehicle fleet utilizing nearly 100% electric drive



Southern California Hydrogen Highway Network
Region/Cluster Station Development



January 2011

Advanced Clean Cars

- Package of regulations to be presented in November including GHG and Criteria pollutant standards for light-duty cars and trucks
  - Zero Emission Vehicle Regulation
    - Regulation will push volumes to commercial levels by 2025
    - Fuel cell vehicles expected to fulfill a significant part of the obligation
  - Clean Fuels Outlet Regulation
    - The backstop we need to ensure success

Showcase Agenda

1. Introduction
   1. Energy
   2. Environment
2. Stationary Applications
   1. Stationary Fuel Cells
   2. Stationary Fuel Cell Case Study
3. Fuel Cell Vehicles
   1. State of Fuel Cell Technology
   2. Honda, Daimler. General Motors
   3. Alameda-Contra Costa Transit District
4. Infrastructure
   1. CaFCP Roadmap
   2. Infrastructure Modeling
   3. Linde, Air Products
5. Conclusions

Panel 1
Introduction

James Boyd

California Energy Commission

John Shears

Center for Energy Efficiency and Renewable Technology

CEERT

Fuel Cell Technology in California

CARB Board Hearing

Hydrogen & Fuel Cell Showcase

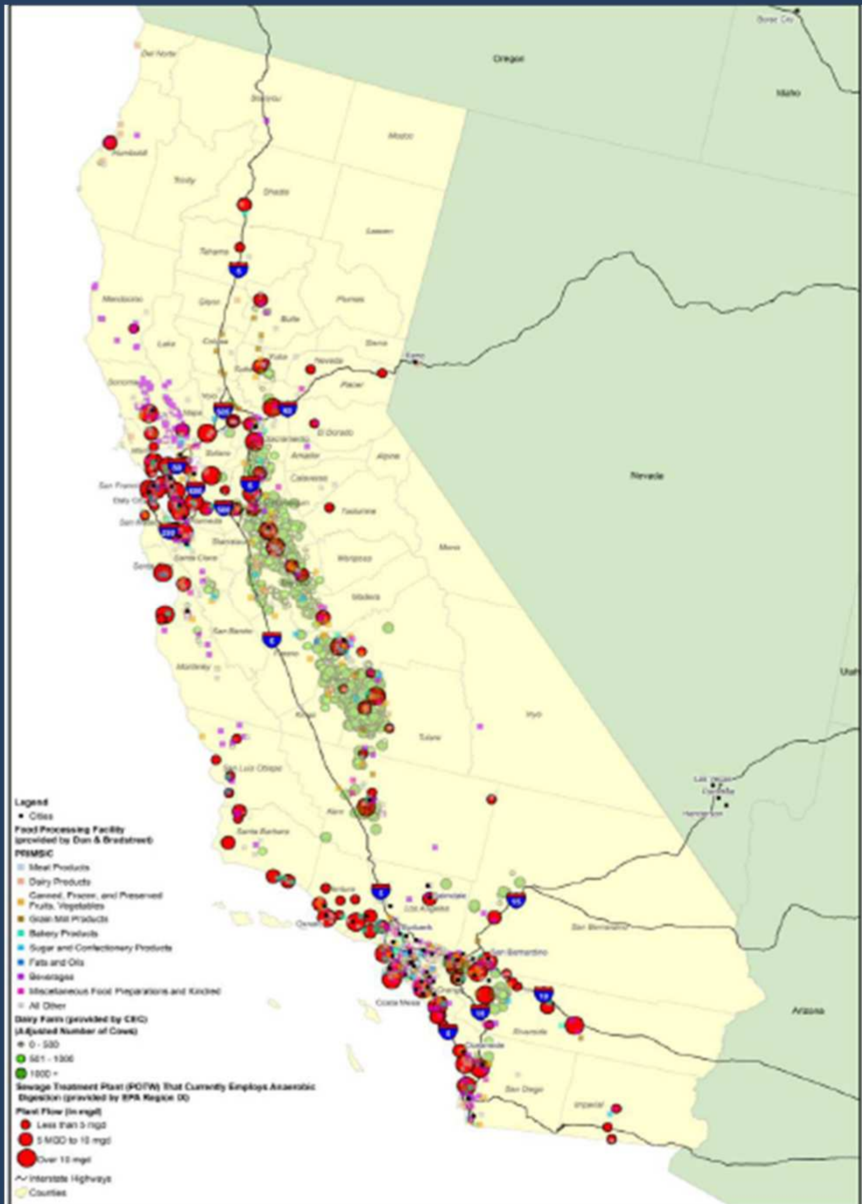
June 23, 2011

John Shears

Research Coordinator

Center for Energy Efficiency and Renewable Technologies

Potential for Synergies?



Source: CEC

Governor Brown's call for <u>12,000 MW</u> of renewable power generated from <u>Local Energy Generation Resources</u> (aka Distributed Generation)

<u>1000 MW of Potential</u>
(including wastewater & dairy waste manure)

Locations of California's

1) **Large Waste Water Treatment Plants**
2) **Dairy Operations,**
3) **Food Processing Facilities , , etc.**

2008 GHG Emissions
(*million metric tons of CO2 equivalent*)

Manure Management (<u>predominantly methane</u>)	7.6
Wastewater Treatment (<u>methane</u>)	1.9
Industrial (Food) Wastewater Treatment (<u>methane</u>)	0.7

Source: CARB GHG Inventory

Why Encourage Biogas Fuel Cells?

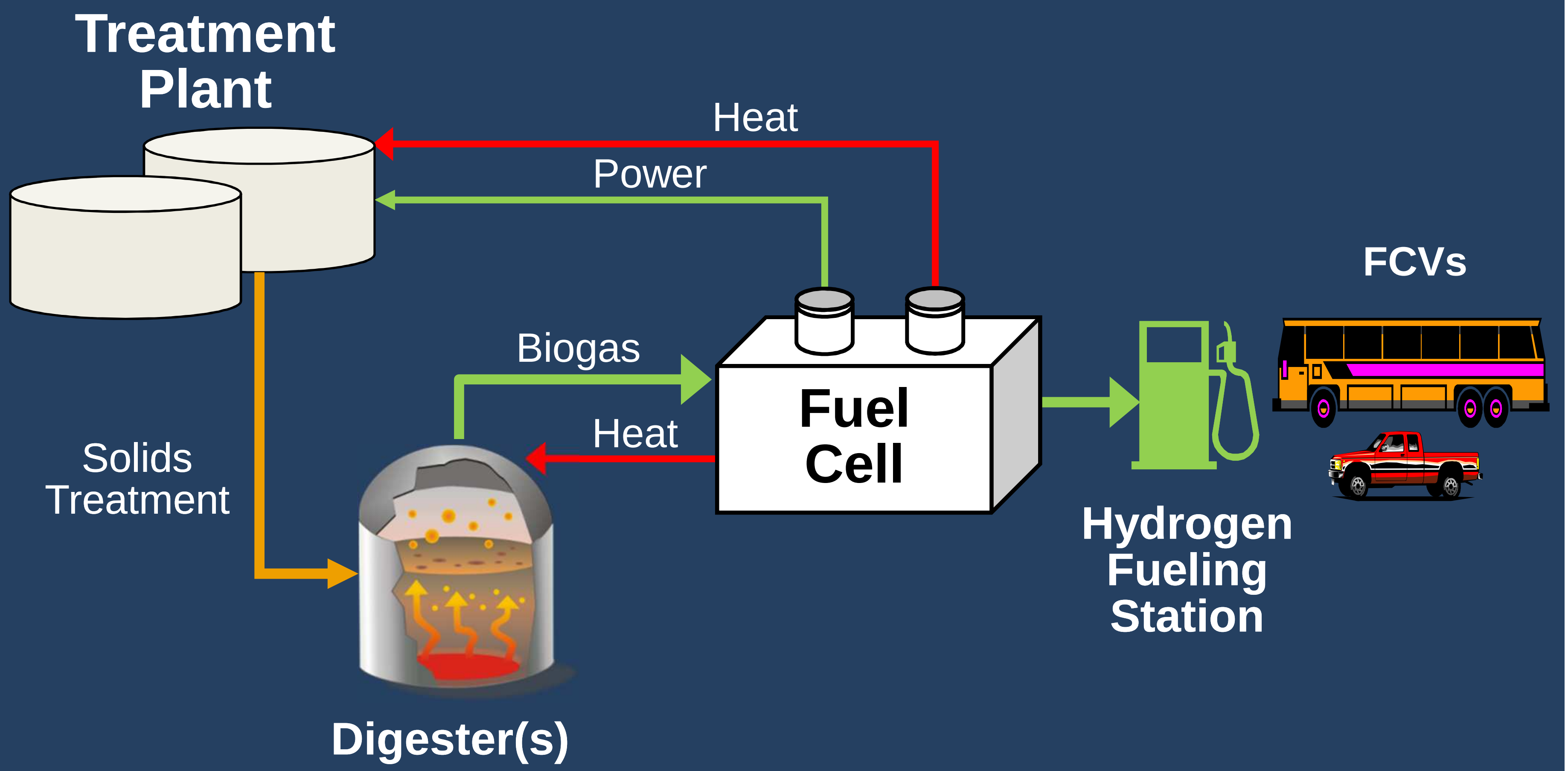
- Problem: Methane acts as a greenhouse gas with 20+ times the global warming power of carbon dioxide. Combustion of methane creates air pollutants such as Black Carbon and NOx. (Fuel Cells do not use combustion.)

- California is largest Dairy State. There are over 1.8 million producing cows.

- Solution: Biogas production and use in fuel cells can reduces the CO2E released by 95%. It is a “low hanging” renewable energy.

- Renewable energy produced by biogas digester/fuel cell projects is predictable and can be base-load or scheduled to compliment other renewables.

A Renewable H_2 Ecosystem



Source: Layne Baroldi, Orange County Sanitation District

Orange County Sanitation District (Fountain Valley)

+

Why Fuel Cell Vehicles (FCVs)?

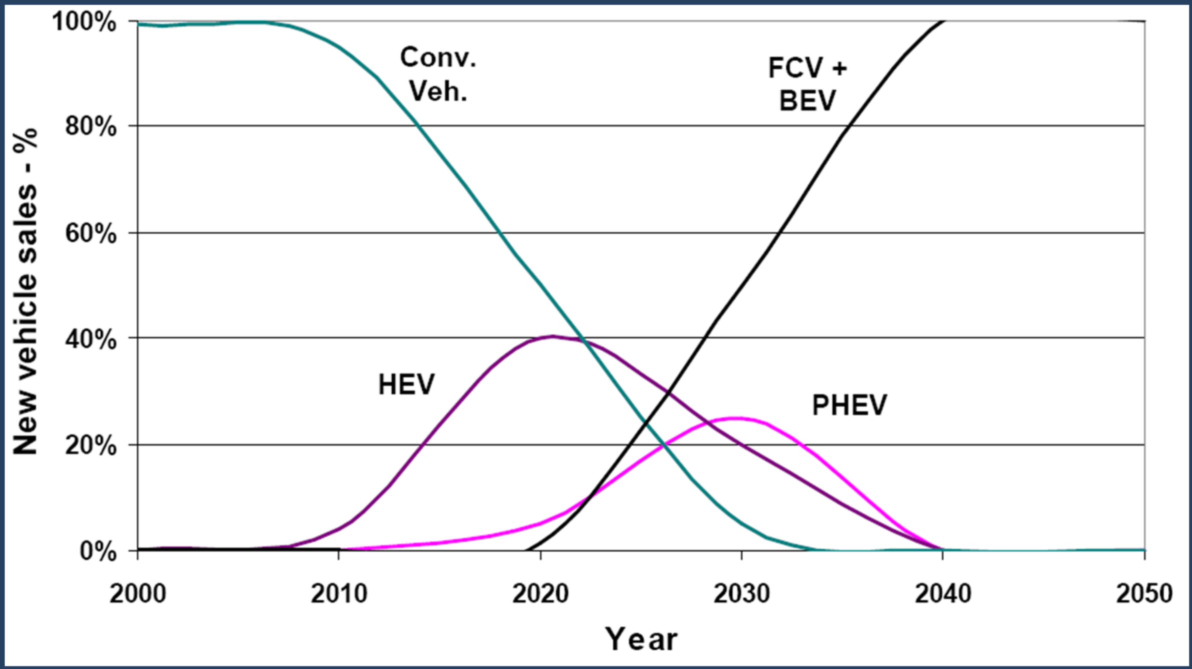
- Both Electric vehicles (EVs) and FCVs offer great promise but also face their own unique challenges
- FCVs are an important electric drive technology that will be critical to California achieving both its air quality and climate goals
- Like EVs, FCVs still face the challenges of reducing costs, size and weight (fuel stack vs battery) while continuing to improve durability … and these improvements are happening for FCVs
- BEVs are ideally suited to smaller cars and shorter trips $\leq$100miles, i.e. urban driving (including new approaches to mobility such as car sharing) due to limited battery capacity
- FCVs can achieve trip ranges similar to conventional passenger vehicles of all size classes (longer trips in larger vehicles)
    - Fueling convenience for FCVs is similar to conventional vehicles
- Fuel Cells have a broader scope of applications extending into the medium-duty and heavy-duty vehicle sectors
    - EV applications are limited to delivery vehicles and in hybrid configurations
- In recent CEC-CARB surveys automanufacturers have indicated that they will begin delivering FCVs in commercial quantities during 2015-2017
    - Total cost of ownership is expected to begin converging for all passenger vehicle technologies (ICE, PHEV, EV, FCV) by 2025

Sources: CEC, CARB, McKinsey & Co, DOE

Why Fuel Cell Vehicles (FCVs)?

- However, ensuring that there will be sufficient hydrogen fueling infrastructure available for FCVs through the initial commercial launch phase will be key to long-term market success for the vehicles … and to establishing the business conditions necessary to foster a self-sustaining market for hydrogen as a transportation fuel

The CEC and CARB need to continue to work together - with stakeholders and other agencies - to insure that their complimentary efforts will lead to a robust self-sustaining market for hydrogen fueling.



CARB Hindcasted Scenario for Emissions 80% below 1990 levels by 2050

CEERT

John Shears

916.442.7785

1100 11th Street, Suite 311

Sacramento Ca, 95814

Examples of Fuel Cells using Digester Gas in California

Los Angeles County Sanitation District,
Palmdale Water Reclamation Plant

Dublin San Ramon Services District,
Pleasanton, CA

City of Riverside Water Quality
Control Plant

Sierra Nevada Brewery, Chico

Dr. Joan Ogden

Institute of Transportation Studies,

UC Davis

UC DAVIS

SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

An Institute of Transportation Studies Program

Environmental Performance of H2 Fuel Cell Vehicles

Prof. Joan Ogden

University of California, Davis

June 23, 2011

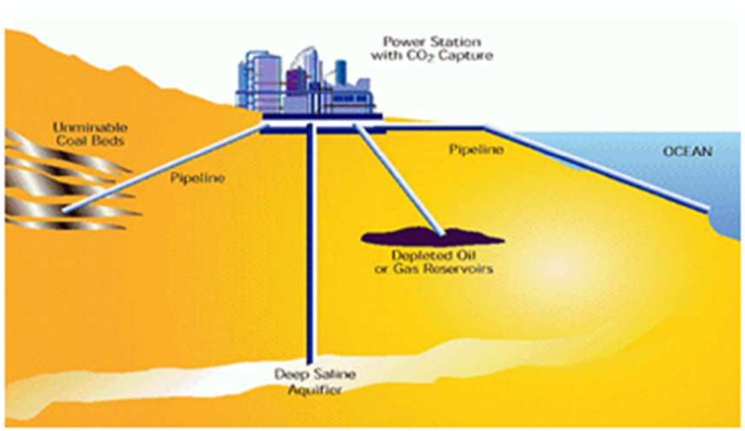
H_2 Supply Pathways

Like electricity, hydrogen is an **energy carrier** that can be produced from widely available **primary energy resources**

Wind

Solar

Biomass



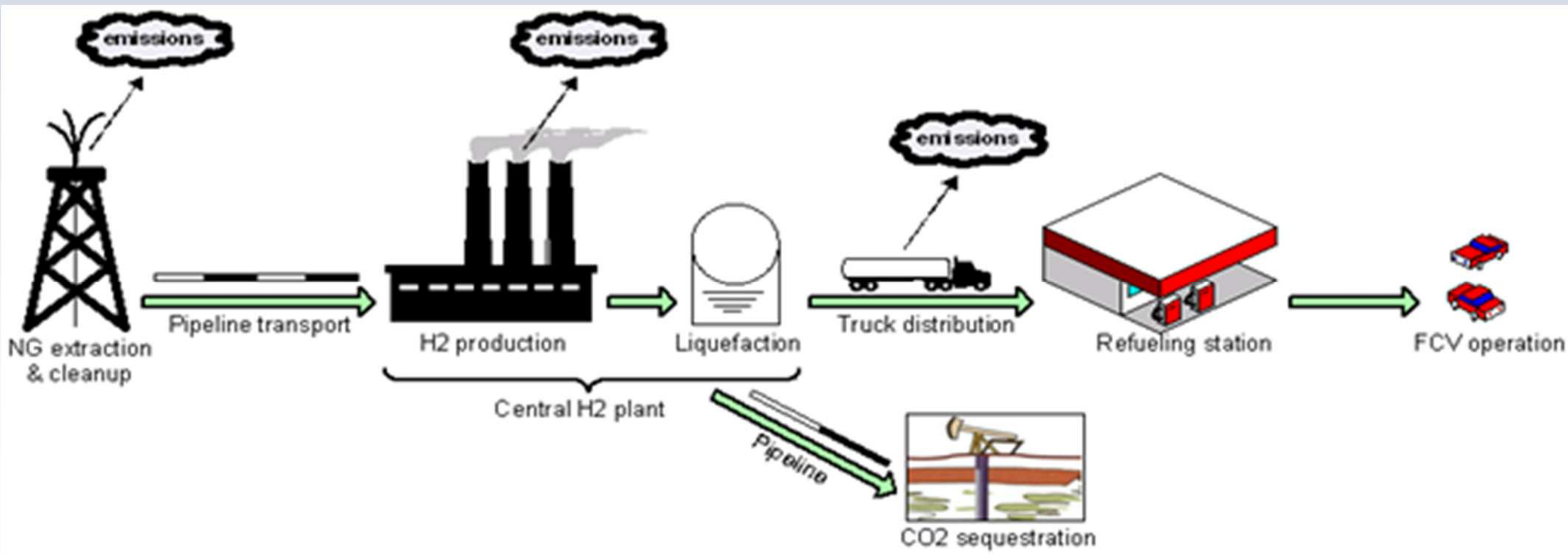
Coal w/CO2 Sequestration

Natural Gas

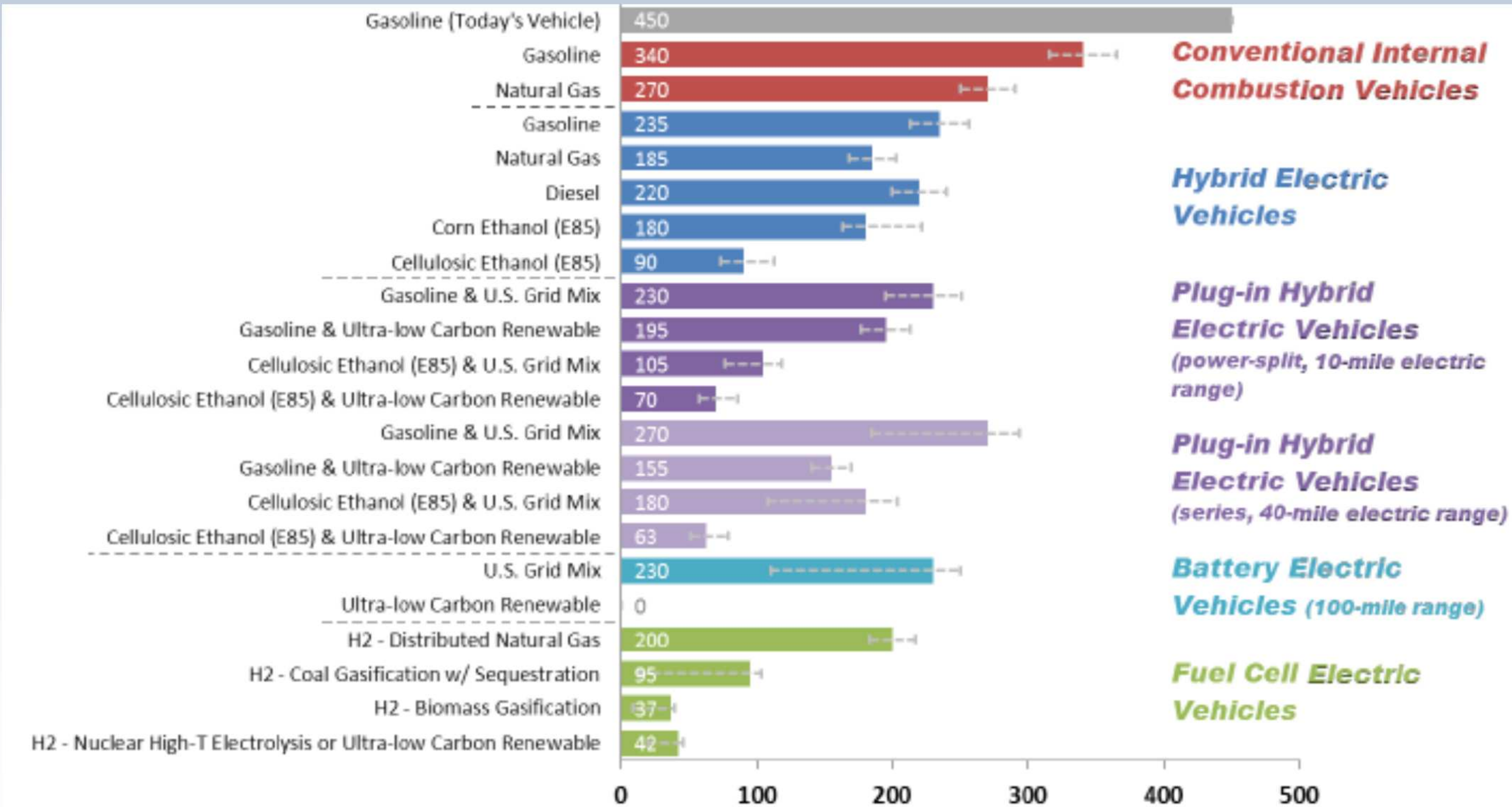
Nuclear

Emissions & Energy Use depend on the fuel/vehicle pathway

Consider "well to wheels" (wtw) incl. primary energy extraction, fuel production, transport & use



Well to Wheels GHG emissions for mid-sized cars



Source: US Department of Energy

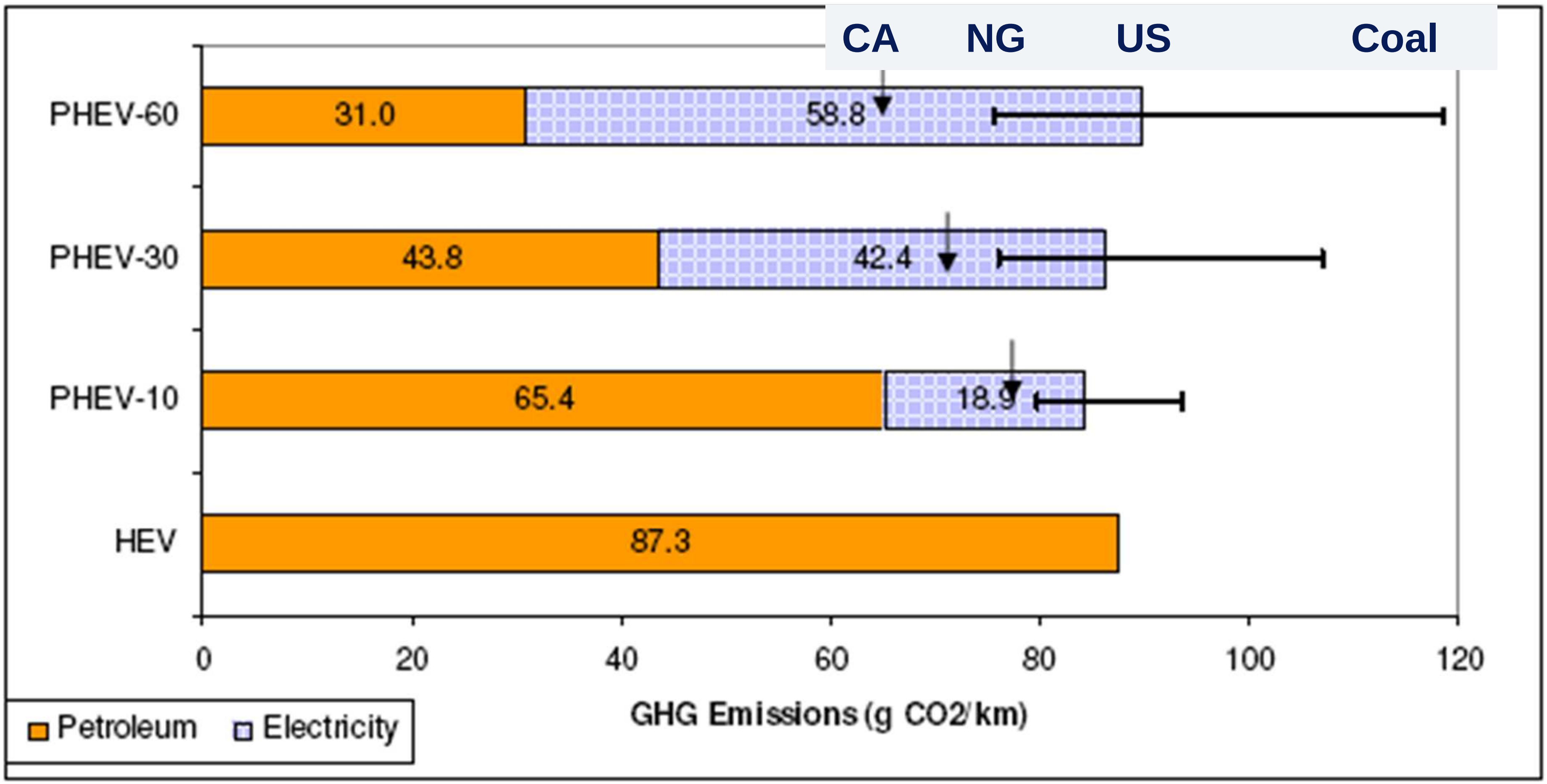
http://www.hydrogen.energy.gov/pdfs/10001_well_to_wheels_gge_petroleum_use.pdf

GHG Emissions Comparison: LDV

- With H2 from Natural Gas, wtw GHG emissions from H2 FCV are ~40-55%% less than gasoline ICEV, ~10-20% less than gasoline HEV; ~15-25% less than CNG vehicle
- With US grid mix and H2 from NG, Battery EVs have similar wtw GHG emissions to gasoline HEVs & greater emissions than H2 FCVs.
- With California's (low-C) grid mix, wtw GHG emissions w/battery EVs are less than those for H2 FCVs w/ H2 from NG; higher than for biomass H2

ICEV = internal combustion engine vehicle
HEV = hybrid electric vehicle
CNG = compressed natural gas vehicle
NG = natural gas; LDV = light duty vehicle;
EV = electric vehicle
FCV = fuel cell electric vehicle
wtw = well to wheels
GHG = greenhouse gas

GHG emissions from PHEVs depend on grid mix

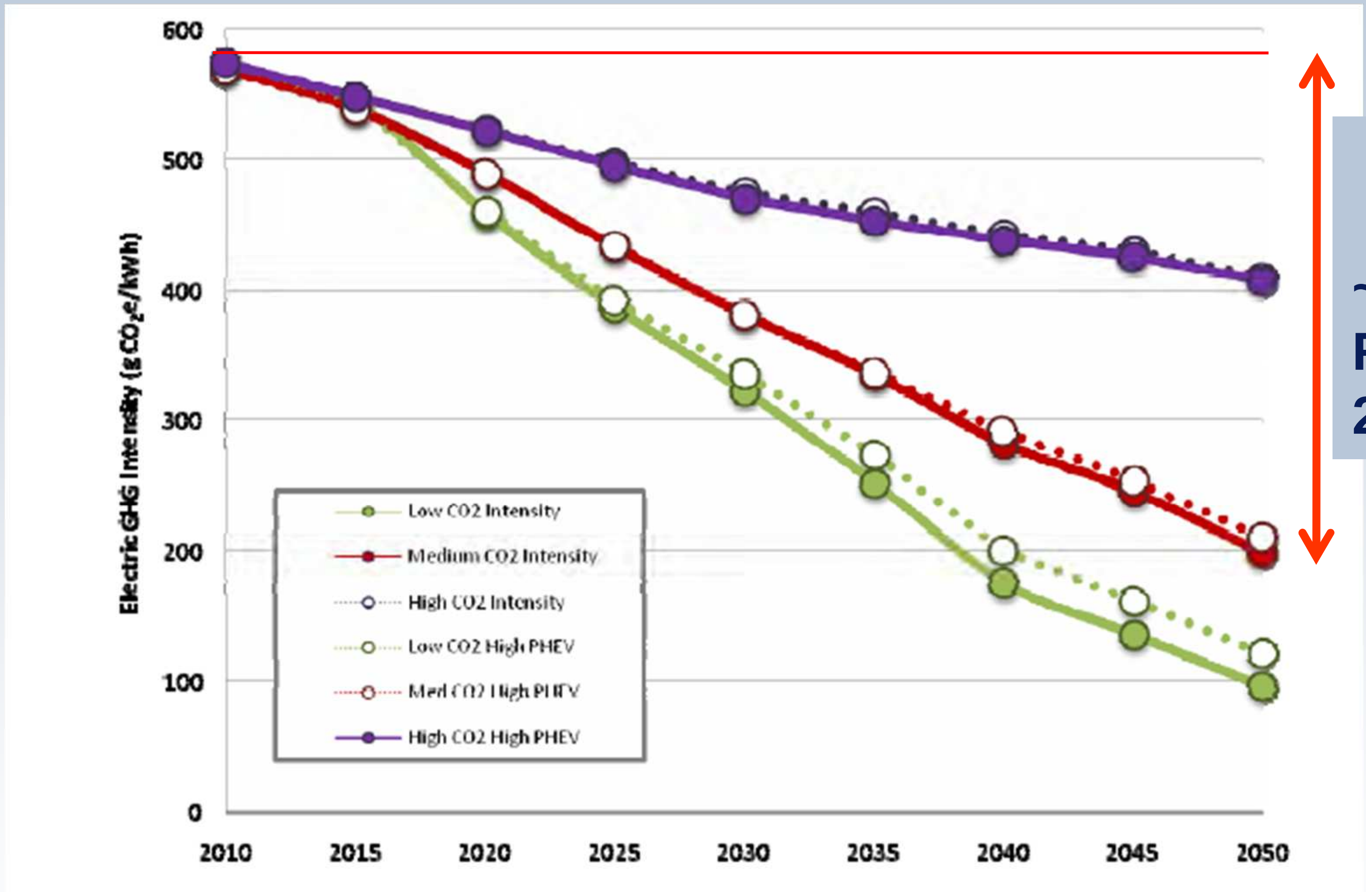


GHG Emissions depend on the primary energy source

- FCVs: Emissions depend on source of H2
- PHEVs, Pure battery EVs: Emissions depend on the source of electricity

Both EVs and H2 FCVs can reach near zero wtw GHG emissions if made from low-Carbon primary energy sources like renewables (wind, solar, biomass) or fossil w/CCS. It will take time to decarbonize primary sources.

GHG emissions Intensity for Future Low-C Grid
(gCO_2eq/kWh) (EPRI/NRDC)

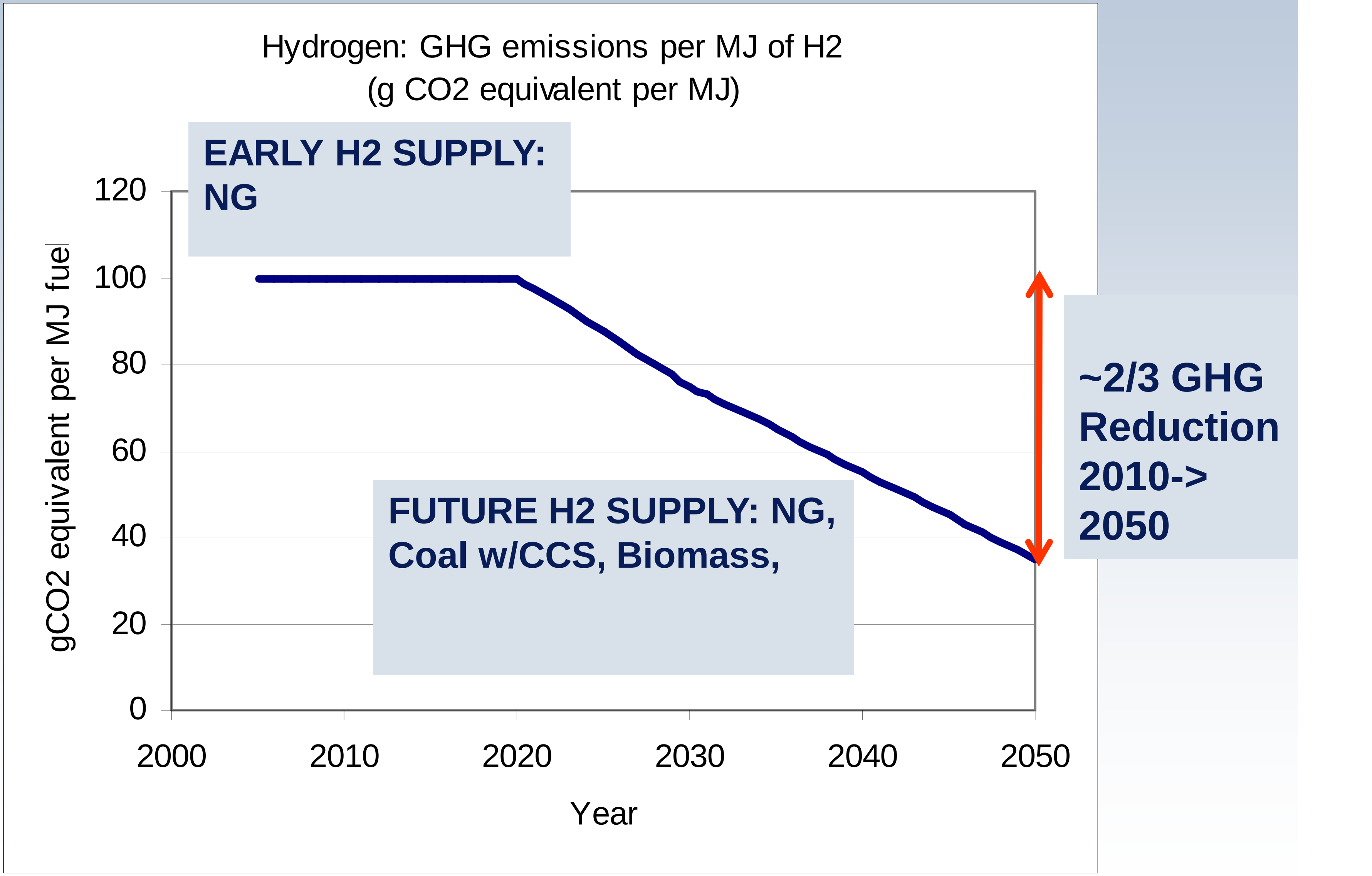


~2/3 GHG Reduction 2010-> 2050

FUTURE GRID: Coal IGCC w/CCS, New Biomass, New Nuclear, Adv. Renewables

NRC H_2 Scenario: GHG Emissions Intensity

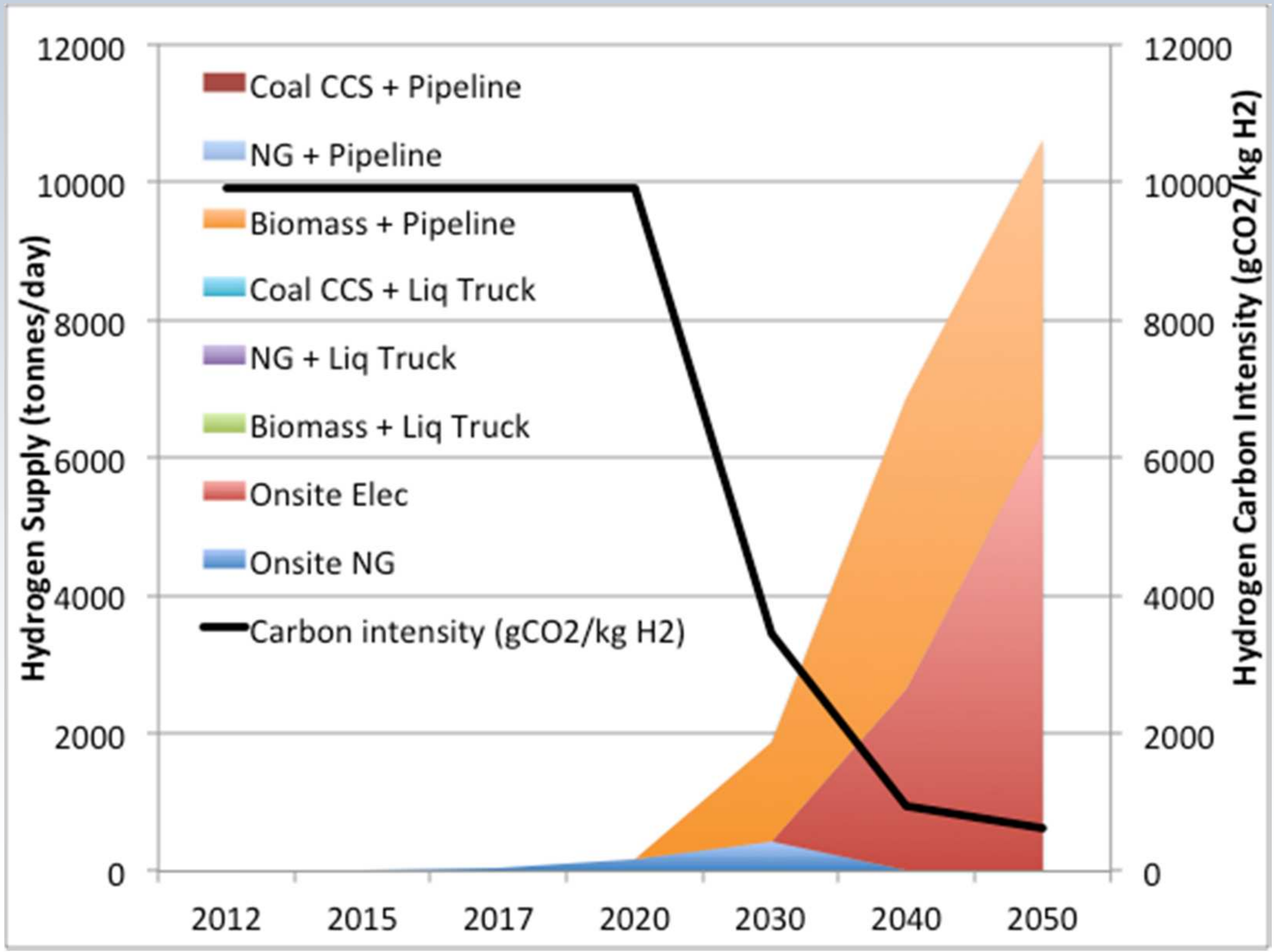
gCO_2/MJ H_2 (NRC 2008)



Scenario for Low Carbon H2 for CA

Limited Biomass, No Coal and NG (Yang and Ogden, 2011)

- NG is phased out in 2040 in order to lower H2 carbon intensity, requires lots of renewable electricity



Panel 2
Stationary Fuel Cell Applications

Katrina Fritz-Intwala

UTC Power

Stationary Fuel Cells

LARGE FUEL CELLS FOR DISTRIBUTED GENERATION

Katrina Fritz Intwala

UTC Power

June 23, 2011

CaSFCC
California Stationary Fuel Cell Collaborative

California Stationary Fuel Cell Collaborative

Co-Chairs

Mary Nichols, Chair
California ARB

Dr. Scott Samuelsen, Director
National Fuel Cell Research Center

Executive Director

Mike Tollstrup, ARB

Industry Advisory Panel

Katrina Fritz Intwala, Chair, UTC Power

www.stationaryfuelcells.org

Established 2001

- CA Air Resources Board
- CA Department of General Services
- CA Energy Commission
- CA Environmental Protection Agency
- CA Public Utilities Commission
- CA Resources Agency
- CA Trade and Commerce Agency
- CA Transportation and Housing Agency
- CA Governor’s Office
- CA Food and Agriculture

- U.S. Department of Energy
- U.S. Department of Defense
- U.S. General Service Administration
- U.S. Environmental Protection Agency

- National Fuel Cell Research Center
- LA Department of Water and Power
- South Coast Air Quality Mgt District
- Bay Area Air Quality Mgt District

Large Stationary Fuel Cell Markets
Value Proposition

Energy Challenges	Fuel Cells
Rising energy costs	• Significant Energy savings through: – 80 - 90% system efficiency – Combined cooling, heat and power • Payback in 3-5 years
Strained utility grid, unreliable power	• Assured power generated on-site: – Business continuity – Risk mitigation – Can serve emergency shelters
Sustainability and carbon reduction	• Clean, quiet & virtually pollution free: – Reduced emissions – Zero water consumption – Qualifies for LEED* points

* Leadership in Energy and Environmental Design (United States Green Building Council's rating system)

Information courtesy of UTC Power

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Large Stationary Fuel Cell Markets

Examples of Best Fit: Facilities with 24/7 Power and Heating Demand

Supermarkets

Bottling

Hospitals

Mixed Use

Hotels

Bio-tech/Industrial

Educational Institutions

Utilities

Information courtesy of UTC Power

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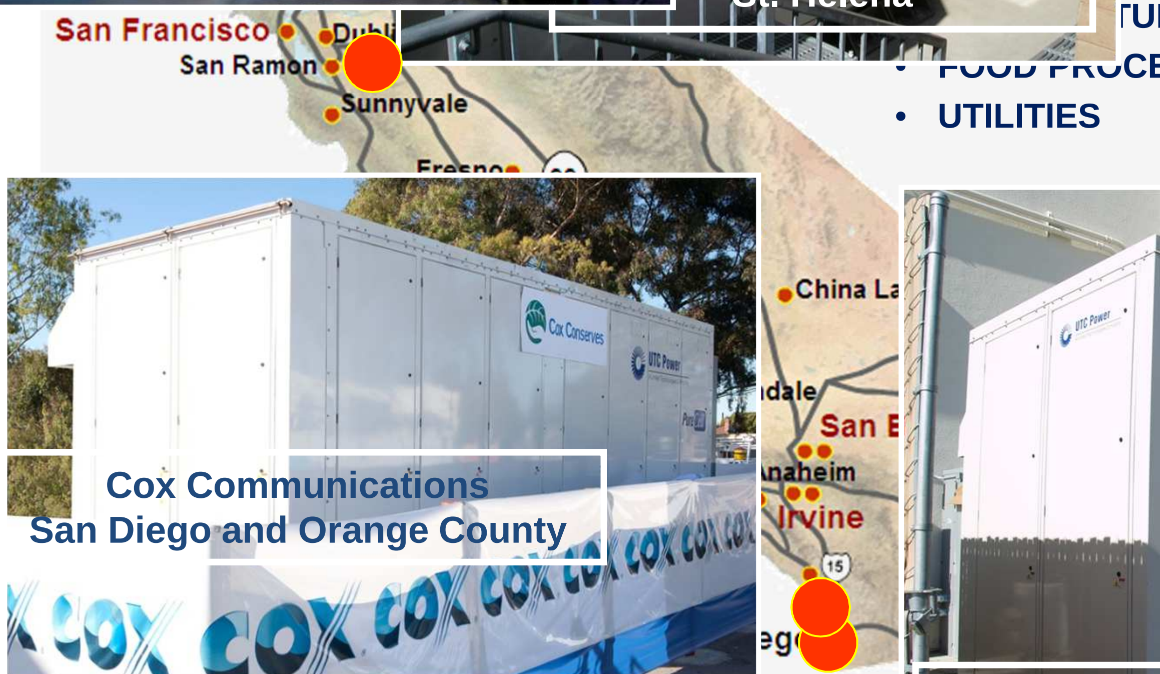
PAFC Power Plants



STATIONARY FC DEPLOYMENTS

TER TREATMENT	9.10
ENEWABLES	3.90
	2.75
ENT	2.25
S	1.00
CATIONS	0.50
STORES	1.00
IES	5.00
S	1.00
L	4.20
TURING	0.50
• FOOD PROCESSING	0.50
• UTILITIES	0.25
TOTAL =	33.00 MW

MCFC Power Plants

STATIONARY FC DEPLOYMENTS

SOFC Power Plants

STATIONARY FC DEPLOYMENTS

• WASTEWATER TREATMENT	9.10
• MOBILE RENEWABLES	3.90
	2.75
	2.25
	1.00
S	0.50
S	1.00
	5.00
	1.00
	4.20
	0.50
NG	0.50
	0.25
TAL =	33.00 MW

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Key California Enablers

- Self-Generation Incentive Program
  - Regulatory (SB412 Implementation Proceeding)
    - Most important enabler to DG fuel cells
    - Program has been suspended since January 1, 2011
    - Proposed decision expected late June/early July
    - Delays hinder CA market and cause customer concern
- Legislative (AB1150, AB864)
  - Reauthorization of collection of $80 million per year
  - Debate on length of extension
    - Program authorized through 2016
    - Assembly bill amends funding reauthorization to 2012 expiration

Key California Enablers

- CHP Feed-in Tariffs (AB1613)
  - Utilities filed updated tariff sheets and contracts for the feed-in-tariff program May 16, 2011
- Governor's Distributed Energy Goal of 12,000 MW renewable and 6,500 MW CHP
  - Include stationary fuel cells in commercial, industrial and residential applications
- Emerging Renewables Technology Program
  - Suspension delaying installations of small fuel cell replacing diesel generators

Mike Upp

ClearEdge Power

Stationary Fuel Cells

SMALL FUEL CELLS

Michael Upp

ClearEdge Power

June 23, 2011

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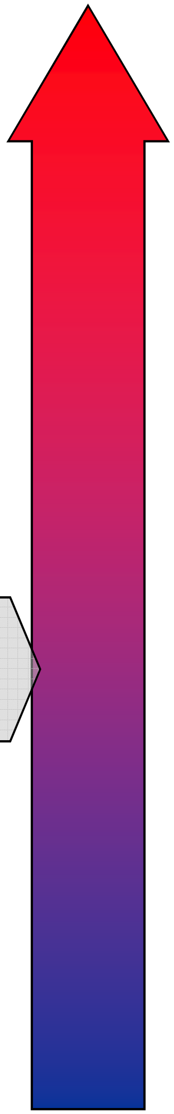
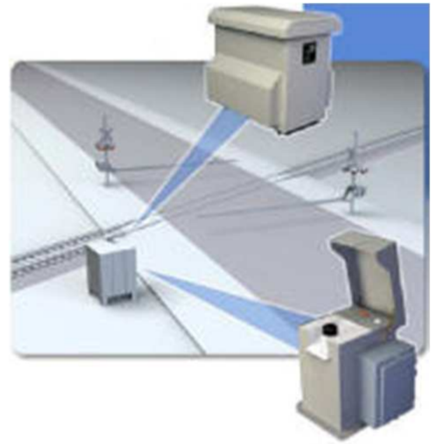
Small Scale Fuel Cell Applications

5kW to 100 kW



Backup Power



Baseload Heat and Power

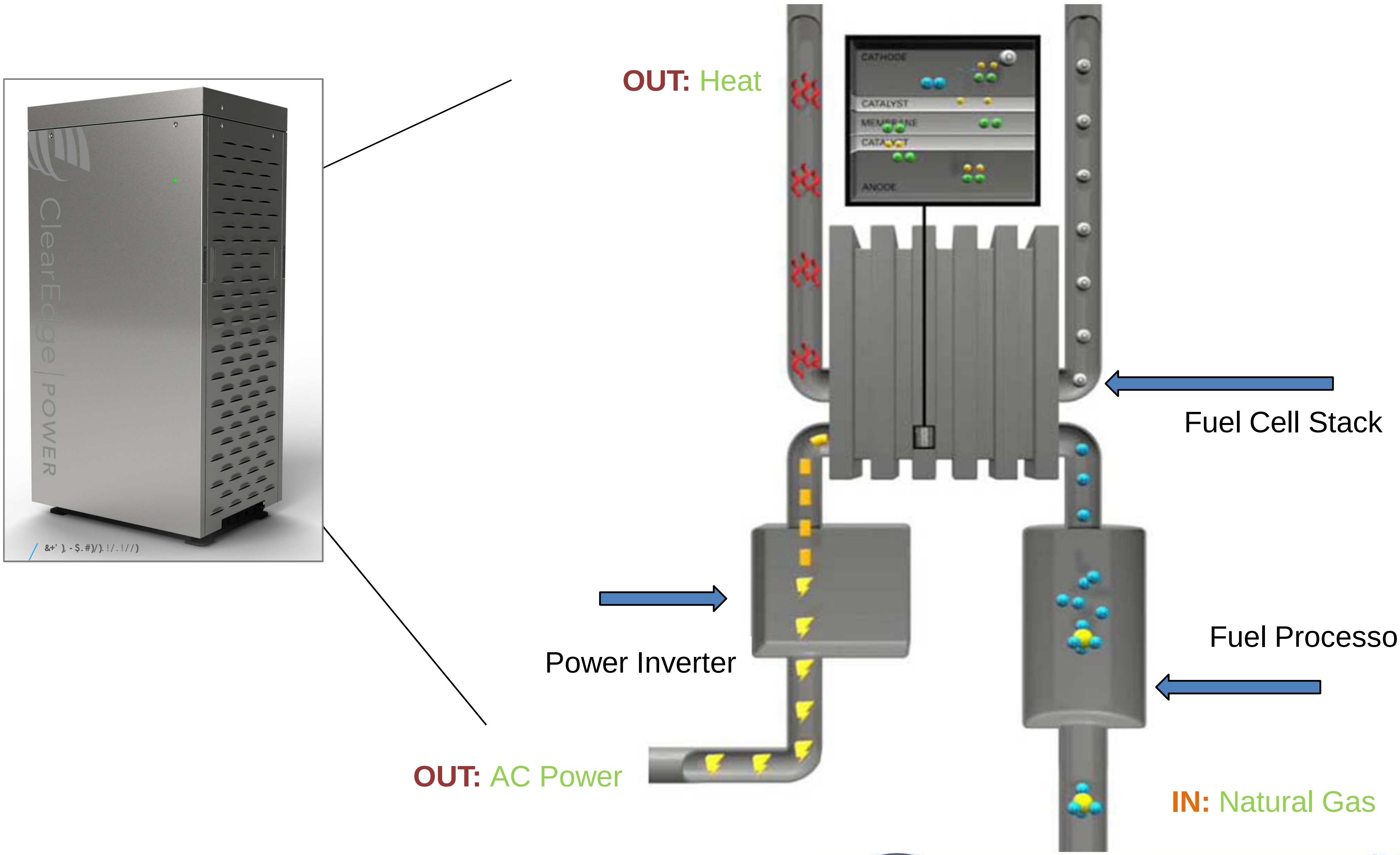
Japanese Model

Goods Movement

Autos

California Stationary Fuel Cell Collaborative

How a CHP Fuel System Works



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Cleaner Energy than the Grid

Power from the Grid

Natural Gas

Efficiency: 35%
4223 therms

Electricity → 43.8 MWh per year ← **Electricity**

Natural Gas

Efficiency: 80%

2175 therms

Heat → 51.3 MWh per year ← **Heat**

6,398 therms total

Environmental Impact
8.35 lbs CO_2 per hour
34 Tons per Annum

Power from 5 kW Fuel Cell System

Electrochemical Conversion

Natural Gas

Efficiency:
up to
90%

3,840 therms total

Environmental Impact
5.3 lbs CO_2 per hour
22 Tons per Annum

The 5 kW Fuel Cell System provides:
40% reduction in fuel and **37%** reduction in CO_2

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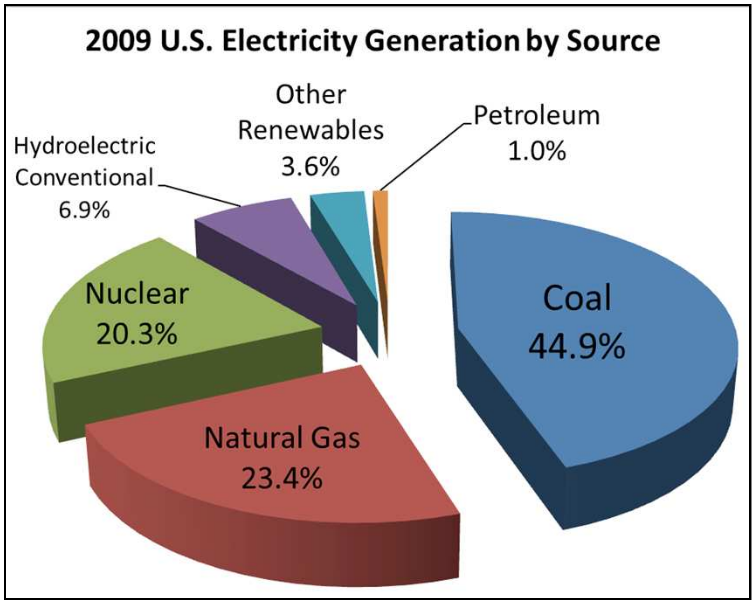
Fuel Cell Collaborative

Broad Environmental Impact

5kW CHP Fuel Cell

- Energy Production:
  - 43 MWh electricity annually
  - 51 MWh of heat annually
- Overall environmental impact using NG to fuel ***20,000*** 5kW CHP systems to produce:
  - 860,000 MWh of power per year
  - 1.02 million MWh of heat per year



GHGE	Existing Grid*	Fuel Cell Production	Reduction in GHG vs the Existing Grid	% Reduction
CO_2	680,000 tons	440,000 tons	240,000 tons	35%
NOx	1,497 tons	0	1,497 tons	100%
SOx	3,033 tons	0	3,033 tons	100%

*Source: Griffin, Jaramillo and Matthews, "Comparative Life-Cycle Air Emissions of Coal, Domestic Natural Gas, LNG, and SNG for Electricity Generation, " Environmental Science and Technology. Vol. 41, No. 17. 2007

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California Financial Return Model (w/ SGIP)

Private Residence, Santa Barbara, Calif.

(1) 5kW Fuel Cells to offset heat and power

Requirements: Power, hot water & space heating

Annual electricity usage: 123,556 kWh

Annual gas usage: 1,632 therms

Annual electric bill before implementation: $39,011

Savings with Installation of ClearEdge5

ClearEdge5 Annual Net Electric Savings	
ClearEdge5 annual net electric savings	$ 8,419
ClearEdge5 annual net avoided heat costs	$ 1,608
Total savings per year	$10,027
ClearEdge5 System Cost	
ClearEdge5 (x1) $56,000 per system	$ 56,000
Installation and Sales tax	$ 17,028
Extended Warranty	$ 3,950
SGIP	($ 12,500)
Less Federal tax credit	($ 5,000)
Net System Cost	$ 59,478
ClearEdge5 Capital Payback	4.9 years

Location and financial analysis cited for illustrative purposes only.

Environmental Impact of the fuel cell

CO_2 Reduction	36%	Offset 12 tons of carbon emissions this year
SOx & NOx	Undetectable	
Fuel Reduction	40%	

Planting
4 acres of trees

Removing
3 cars from the road

California Stationary Fuel Cell Collaborative

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Less Federal tax credit	($ 5,000)
Net System Cost	$ 71,978
ClearEdge5 Capital Payback	6.2 years

Environmental Impact of the fuel cell

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Summary of the Small Foot Print Fuel Cell

Advantages

- Highest efficiency device, most economic value
  - 90%, with over 40% as electricity
- Produces power at less than 10 cents a kWh (LCOE)
- Cleaner: Not burning of fuel
  - Addresses all areas of EPA concern

NOx	**SOx**
VOC	**Particulates**
Coal Ash	**CO_2**

- Energy generation at point of use
  - Lowers impact on the grid and future infrastructure investments
  - Picks up future loads (electric cars)
  - Reduces “choke points” on the grid

Disadvantages

- Today, runs on natural gas or directed biogas, future:
  - Renewable source hydrogen
  - Direct biogas
- Cost of Systems in Low Volume
  - Grid parity in some areas (CA/NE/HI)
  - Low volume production
  - Cost of integrating w/ heat systems
- Products relatively new to market
  - Not well understood by public and policy makers
- Need to match CHP to heat load for max efficiency

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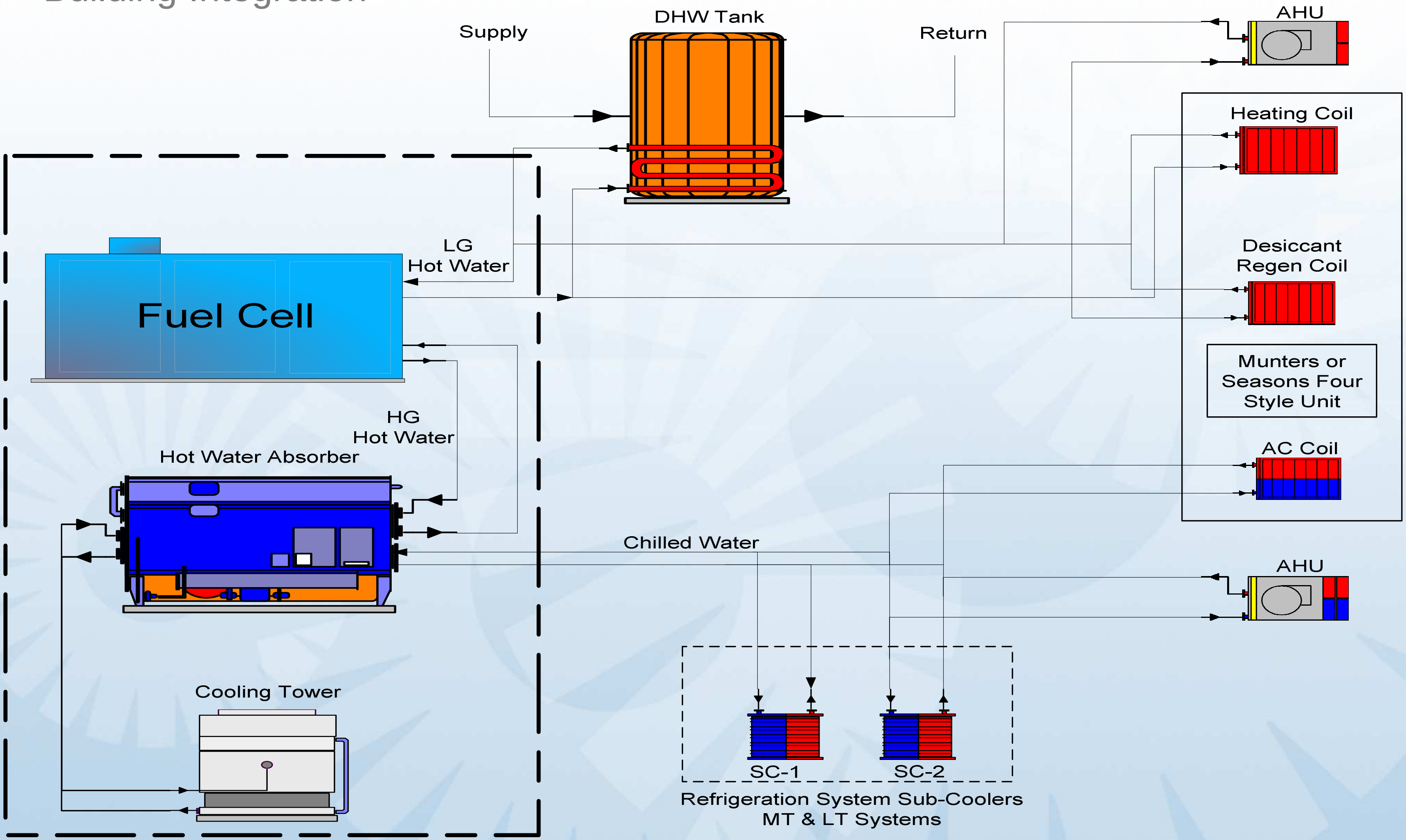
Marty Lico

Whole Foods Market

PureCell® Solution for Retail

Building Integration



WHOLE FOODS MARKET

Sustainability and Our Future

- Fuel cells are contributing to Whole Foods sustainability mission
- Additional efficiency from process heat for combined cooling, heat and power
- Ability to run in backup power mode provides greater economic benefits; stores have stayed open while other supermarkets forced to close
- Incentive enabled payback within corporate approval guidelines

SAN JOSE, CA

eGrid Sub-region:	CAMX
State:	California

Annual Emissions Balance Sheet	Energy Balance: Electricity (kWh)	Energy Balance: Fuel (MMBTU)	Emissions Balance: CO_2 (metric tons - MT)	Emissions Balance: NOx (metric tons - MT)	Emissions Balance: SO_2 (metric tons - MT)
Utility Avoided Emissions	(3,110,682)	(3,699)	(1,968)	(1.61)	(1.31)
On-Site Power Emissions	0	25,616	1,356	0.04	0.00
BALANCE	*(3,110,682)*	*21,917*	*(612)*	*(1.56)*	*(1.31)*

Environmental Benefits	Emissions Reduction: Metric Tons	Emissions Reduction: Equivalence	Emissions Reduction: %
CO_2	612	141 acres of trees	31%
NO_X	1.56	90 cars	97%
SO_2	1.31		100%
Water	433,244 gal	0.7 olympic pools	100%

Avoided Emissions & Water vs Fossil Fuel Generation

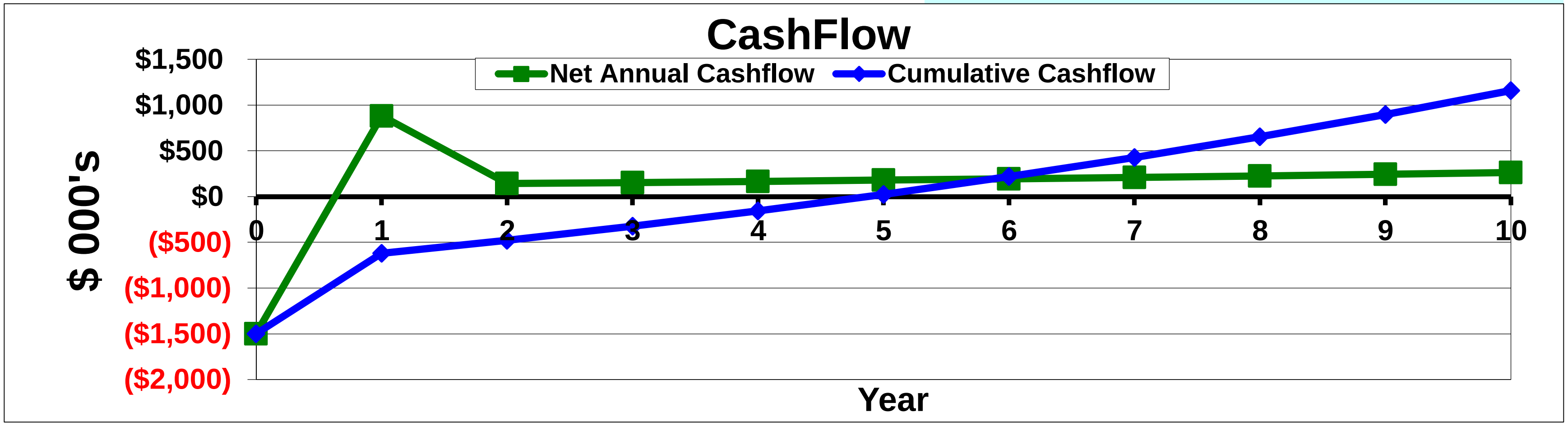
This method is consistent with the guidance of the EPA CHP Partnership and their CHP Emissions Calculator.

Utility emissions factors based on U.S. EPA eGRID2007 (year 2005 data) for average fossil-fueled generation in sub-region.
Utility water consumption based on U.S.G.S. data, 1995.

SAN JOSE PURCHASE (OPTION)

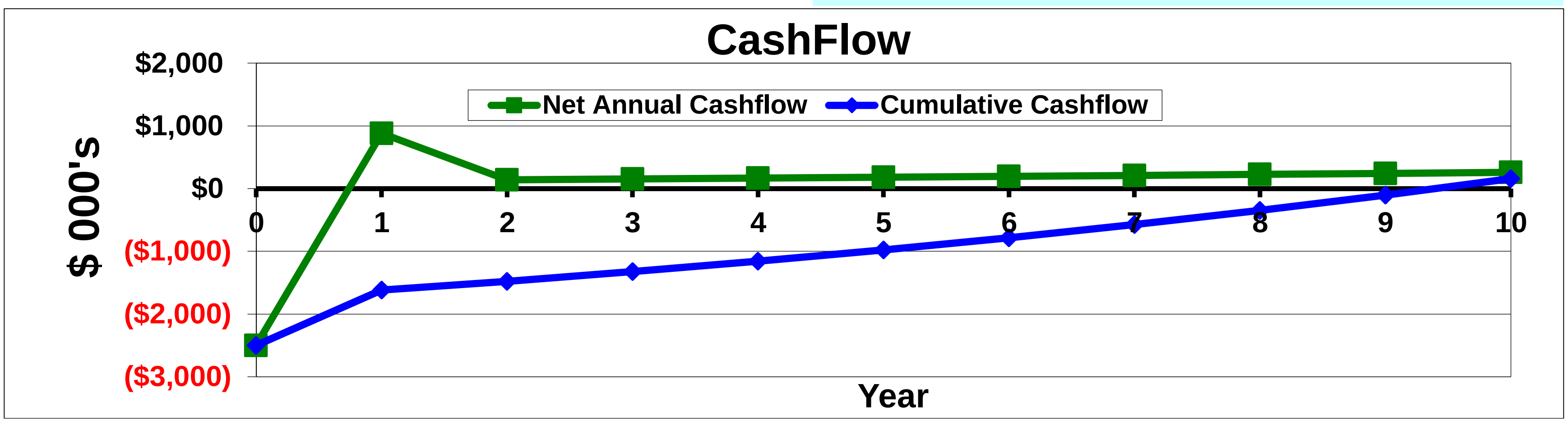
$2500/kW SGIP

Payback (years)	4.9
IRR	15.7%
NPV	$286,000



Without SGIP

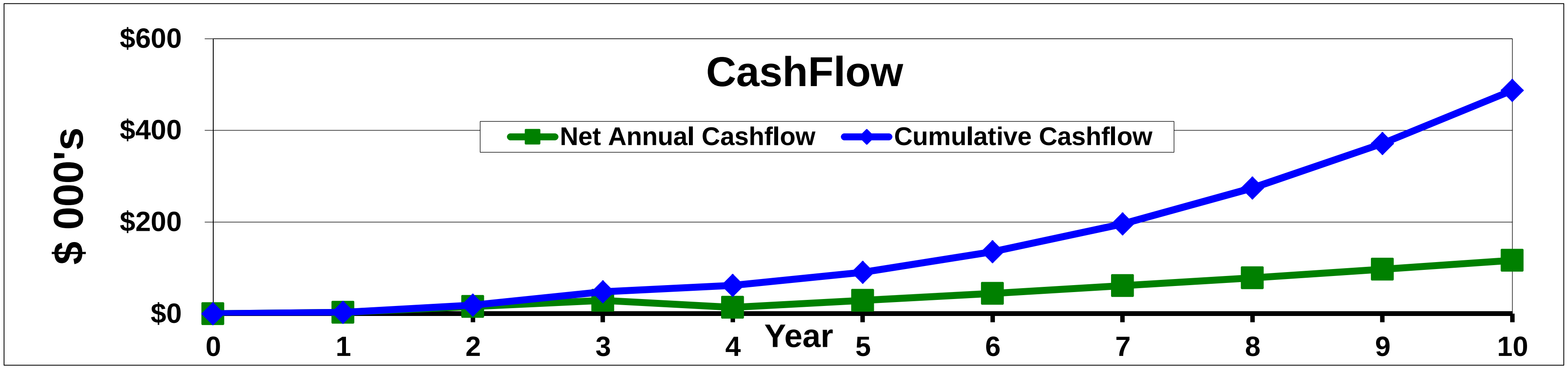
Payback (years)	10+
IRR	1.3%
NPV	($714,000)



SAN JOSE ENERGY SERVICES AGREEMENT (LEASE SELECTION)

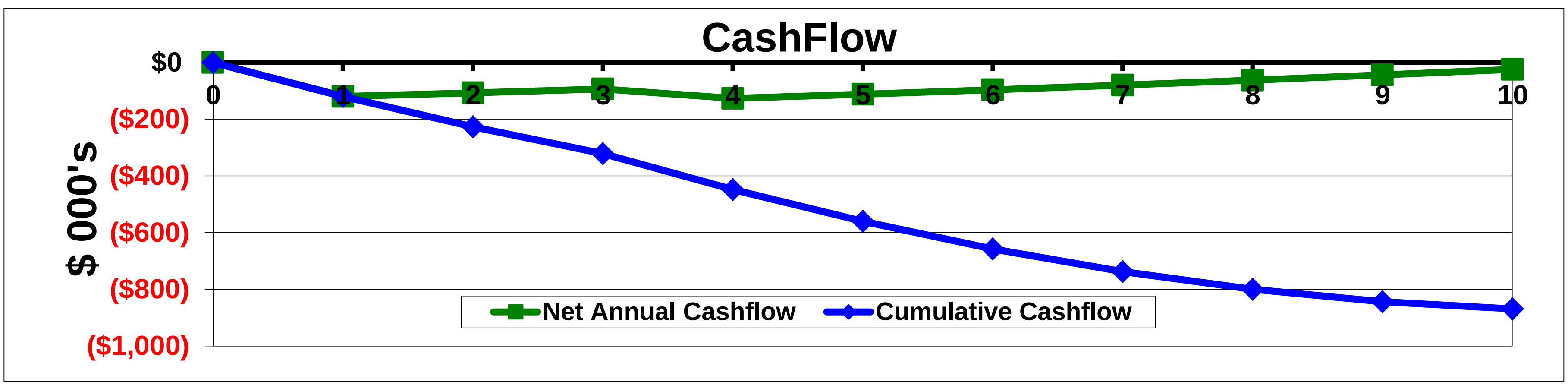
$2500/kW SGIP

NPV	$243,736
Year 1 Cost of Electric Generation	13.1 ¢/kWhr



Without SGIP

NPV	($577,885)
Year 1 Cost of Electric Generation	18.7 ¢/kWhr



SUPERVALU's Commitment to Environmental Sustainability

- To cut greenhouse gas emissions 10% by the end of 2012 (2007 baseline)
- To reduce our landfill waste by 50 percent in five years
- To build a "green" culture with SUPERVALU associates through education, communication and engagement
- To provide "green" products and services to our customers that support them in meeting their personal environmental goals

eGrid Sub-region: CAMX
State: California

SAN DIEGO, CA – Albertsons Store

Annual Emissions Balance Sheet	*Energy Balance* Electricity (kWh)	Fuel (MMBTU)	*Emissions Balance* CO_2	NOx (metric tons - MT)	SO_2
Utility Avoided Emissions	(2,649,672)	(5,185)	(1,784)	(1.46)	(1.12)
On-Site Power Emissions	0	20,808	1,101	0.03	0.00
BALANCE	*(2,649,672)*	*15,623*	*(683)*	*(1.43)*	*(1.12)*

Environmental Benefits	*Emissions Reduction* Metric Tons	Equivalence	%
CO_2	683	158 acres of trees	38%
NO_x	1.43	82 cars	98%
SO_2	1.12		100%
Water	369,037 gal	0.6 olympic pools	100%

Avoided Emissions & Water vs Fossil Fuel Generation

This method is consistent with the guidance of the EPA CHP Partnership and their CHP Emissions Calculator.

Utility emissions factors based on U.S. EPA eGRID2007 (year 2005 data) for average fossil-fueled generation in sub-region.
Utility water consumption based on U.S.G.S. data, 1995.

- Economics are similar for supermarkets
- Incentives drive decisions to use fuel cells today
- Waiting for reinstatement of SGIP in California

Panel 3
Fuel Cell Vehicles

Dr. Andreas Truckenbrodt
Automotive Fuel Cell Cooperation Corp.

AUTOMOTIVE FUEL CELL COOPERATION®

Status of Fuel Cell Vehicle Technology

Dr. Andreas Truckenbrodt

AFCC Automotive Fuel Cell Cooperation Corp.

Burnaby, Canada

ARB Hydrogen and Fuel Cell Showcase

June 23, 2011

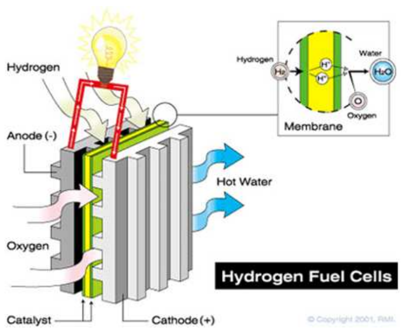
DAIMLER Ford

Meeting Climate /Customer Needs

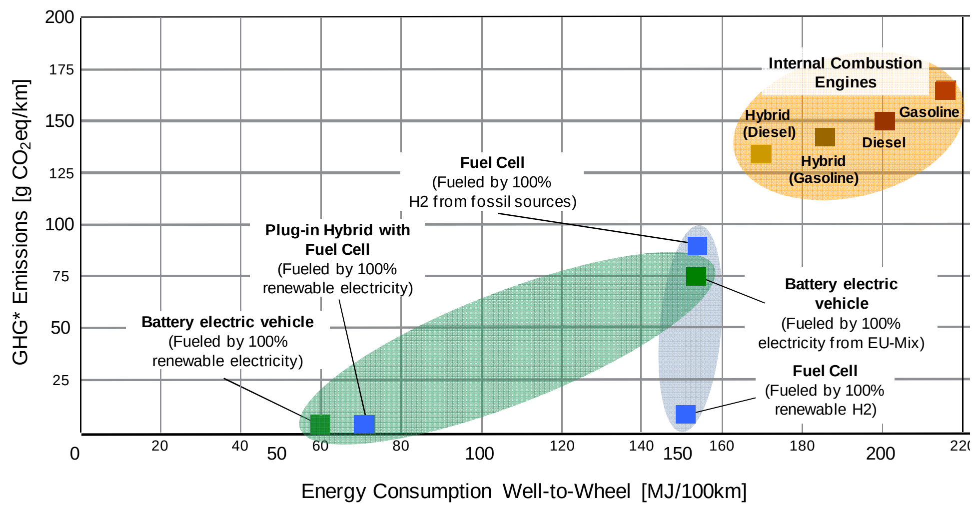
AUTOMOTIVE FUEL CELL COOPERATION ®

1

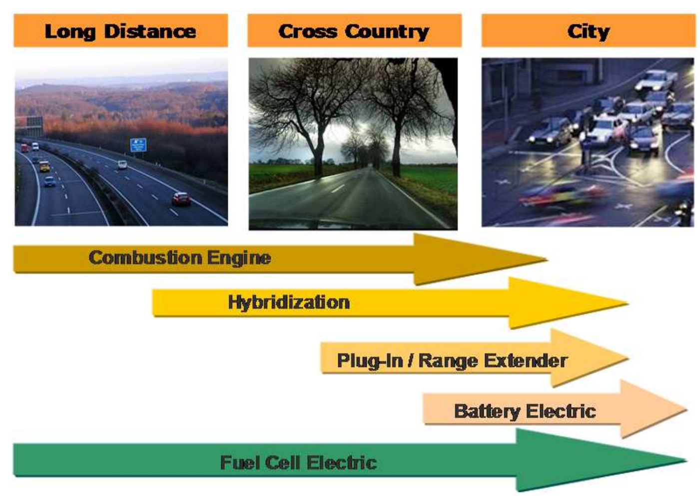
Fuel cells are an indispensible element of the mainstream automotive powertrain portfolio.



- Zero emission - end product is just water vapor and electricity
- Oil independence through use of hydrogen
- Efficiency twice as high as internal combustion engine
- No compromise in range or refill times
- Comfort and driving pleasure of electrical driving



Source: EUCAR/CONCAWE "Well-to-Wheels Report 2004
Optiresource, 2006 Reference vehicle class: VW Golf



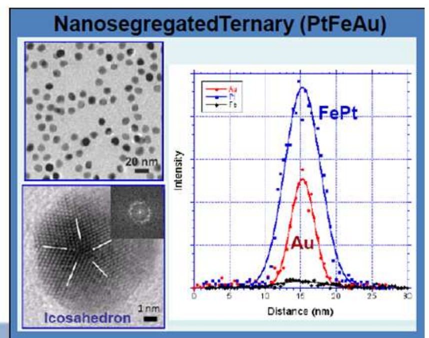
Customer Readiness

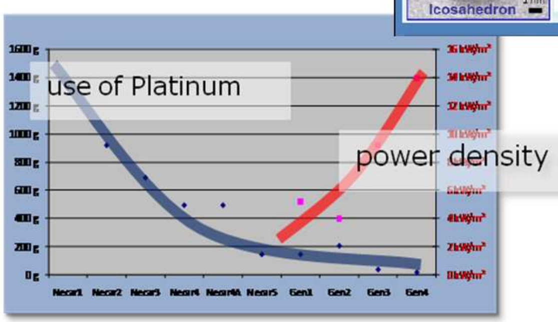
AUTOMOTIVE FUEL CELL COOPERATION®

2 Fuel cell vehicle technology has matured and is ready for the consumer.

Significant progress made in:

- Materials
- Concepts
- Analysis & simulation
- Vehicle integration





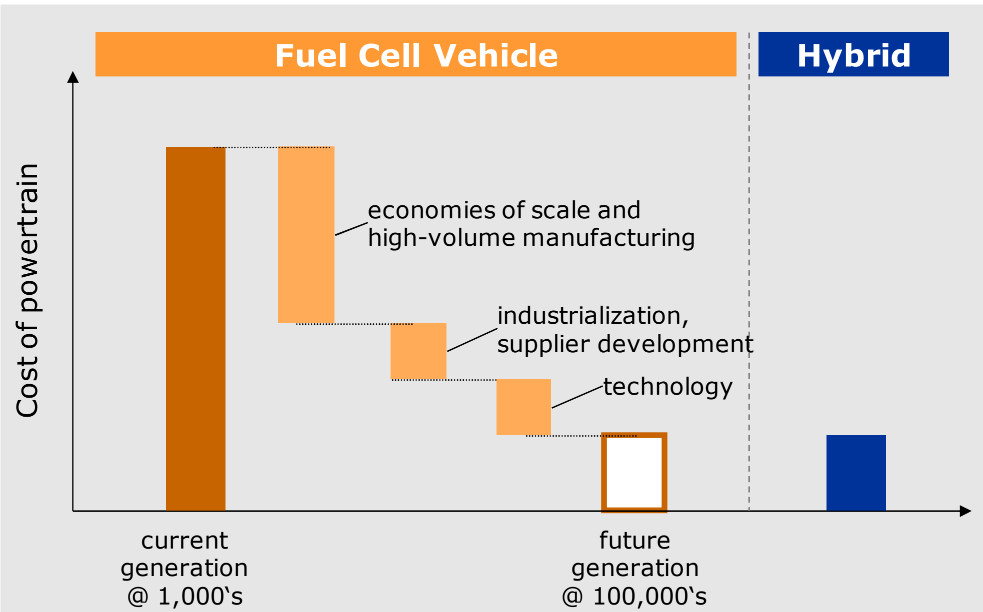
Competitive vehicle with *no* compromises

B-Class F-CELL - Main Technical Data	
Power	
Effective power fuel cell	80 kW
Effective power electric motor	100 kW
Hydrogen pressure	700 bar
Range & Consumption	
Range	Approx. 250 mi
Consumption adjusted	> 53 mpg Diesel equivalent
CO_2-emissions	0 g/100 km
Driving and Operations	
Acceleration 0-100 km/h	11.4 s
Top Speed	150 km/h
Freeze Start	< - 15 ºF (- 25 ºC)
Durability	>> 2,000 hrs (bus > 10,000 hrs)

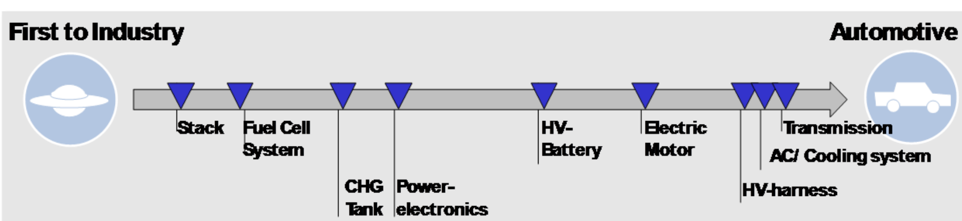
Cost Parity

3

We are on a clear and realistic path to make FCVs equal in cost to (advanced) conventional vehicles



Industrialization



Technology

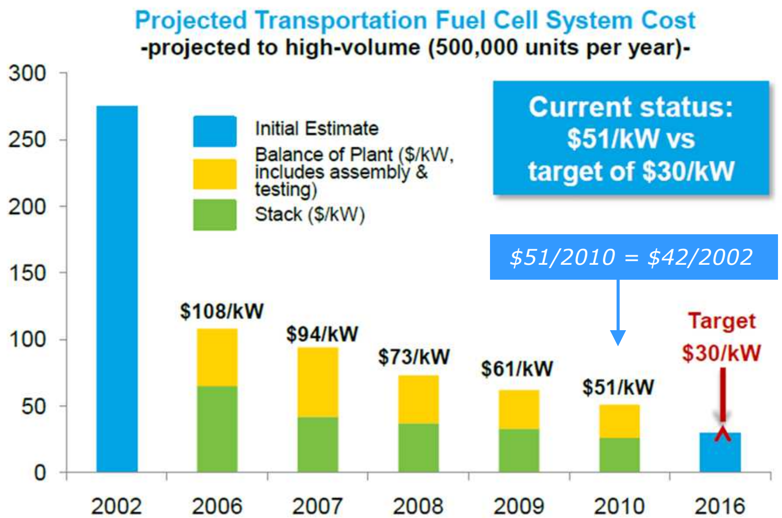
- Stack Architecture
  - Increase power density
  - Reduce active area
- Catalyst
  - Reduce platinum by >50%
  - Use alternative materials with no performance impact
- Membrane - PFSA or hydrocarbon membrane
- Bipolar Plate
  - Improve forming, joining, and coating for metal plates
  - Improve conductivity, thickness, and processing time for carbon plates
  - Adopt high volume m/f technologies
- Reduction of components
  - Eliminate cell voltage monitoring
  - Eliminate H2 recirculation
  - Reduce humidification
- Hydrogen tank
  - Improved materials
  - High volume m/f technologies
- Power electronics - Compact DC/DC converter

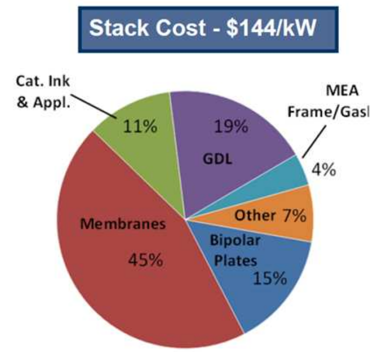
Cost Targets Achievable

AUTOMOTIVE FUEL CELL COOPERATION®

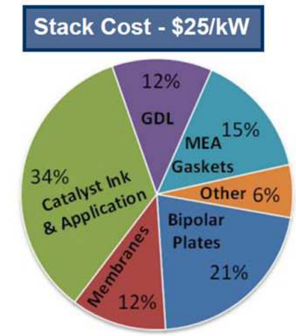
4

Cost goals can be realized - and could be even more attractive than other EV technologies



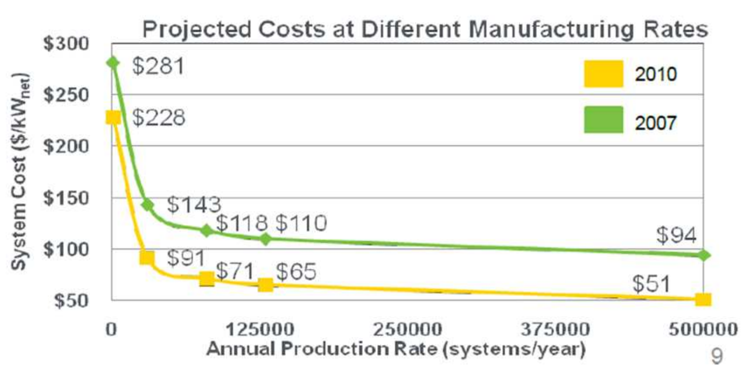


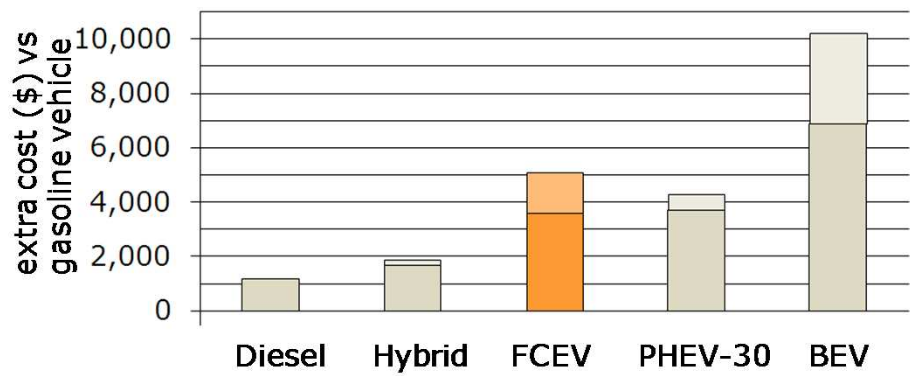
DTI, 2010 analysis, production of 1,000 units/yr



DTI, 2010 analysis, scaled to high volume production of 500,000 units/yr

Used $1100/Troy Ounce for Pt Cost





Kromer/Heywood: A comparative assessment of electric propulsion systems in the 2030 US LD vehicle fleet. SAE 2008-01-0459

Stakeholder Commitment

AUTOMOTIVE FUEL CELL COOPERATION®

5 OEMs committed to begin commercialization in 2015 - commitment now needed from *all* stakeholders

Technology development and industrialization require contributions and commitment from:

- manufacturers
- suppliers
- research institutes, universities
- Government

California Fuel Cell Partnership — Driving for the Future

CHRYSLER · DAIMLER · GM · HONDA · cdfa · ITS UC Davis · HYUNDAI · NISSAN · National Fuel Cell Research Center · NREL · TOYOTA · VW · AC Transit · VTA · Chevron · Shell · SunLine Transit Agency · Air Liquide · AFCC · Air Resources Board · Air Products · Linde · NAC · Powertech · Praxair · AQMD · BALLARD

We also need a public H2 infrastructure!

HYDROGEN

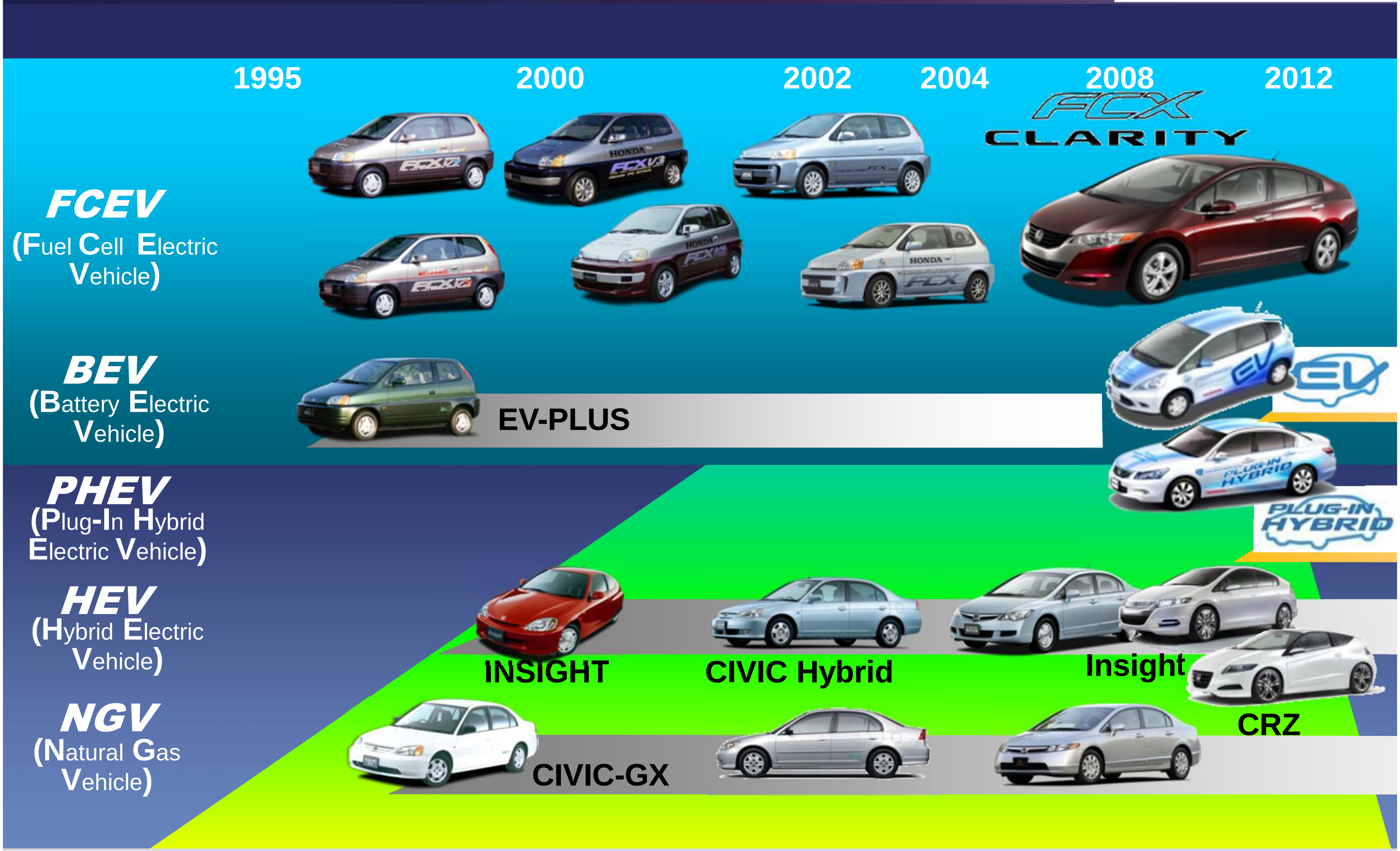
Stephen Ellis

American Honda Motor Company


HONDA
FCX
CLARITY
SF2008

Near Zero and Zero Emission Vehicles

HONDA
The Power of Dreams



Honda’s deployment of advanced & alternative technology automobiles

Why Fuel Cell Vehicles?

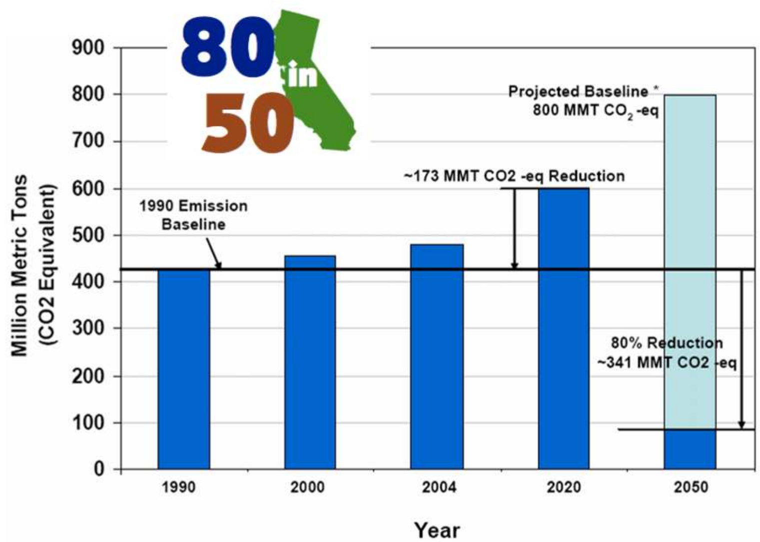
HONDA
The Power of Dreams

Major Issues: Fuel Cell EVs:

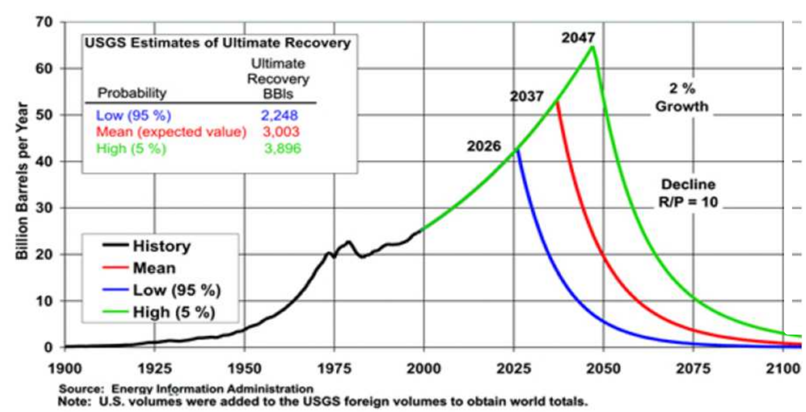
1 Climate Change, Energy Sustainability →
- **High Efficiency**
- **Decarbonized Fuel**

2 Transportation Value →
- **Compelling Full Function Vehicles**

GHG Reduction (U.S. & CA Target)



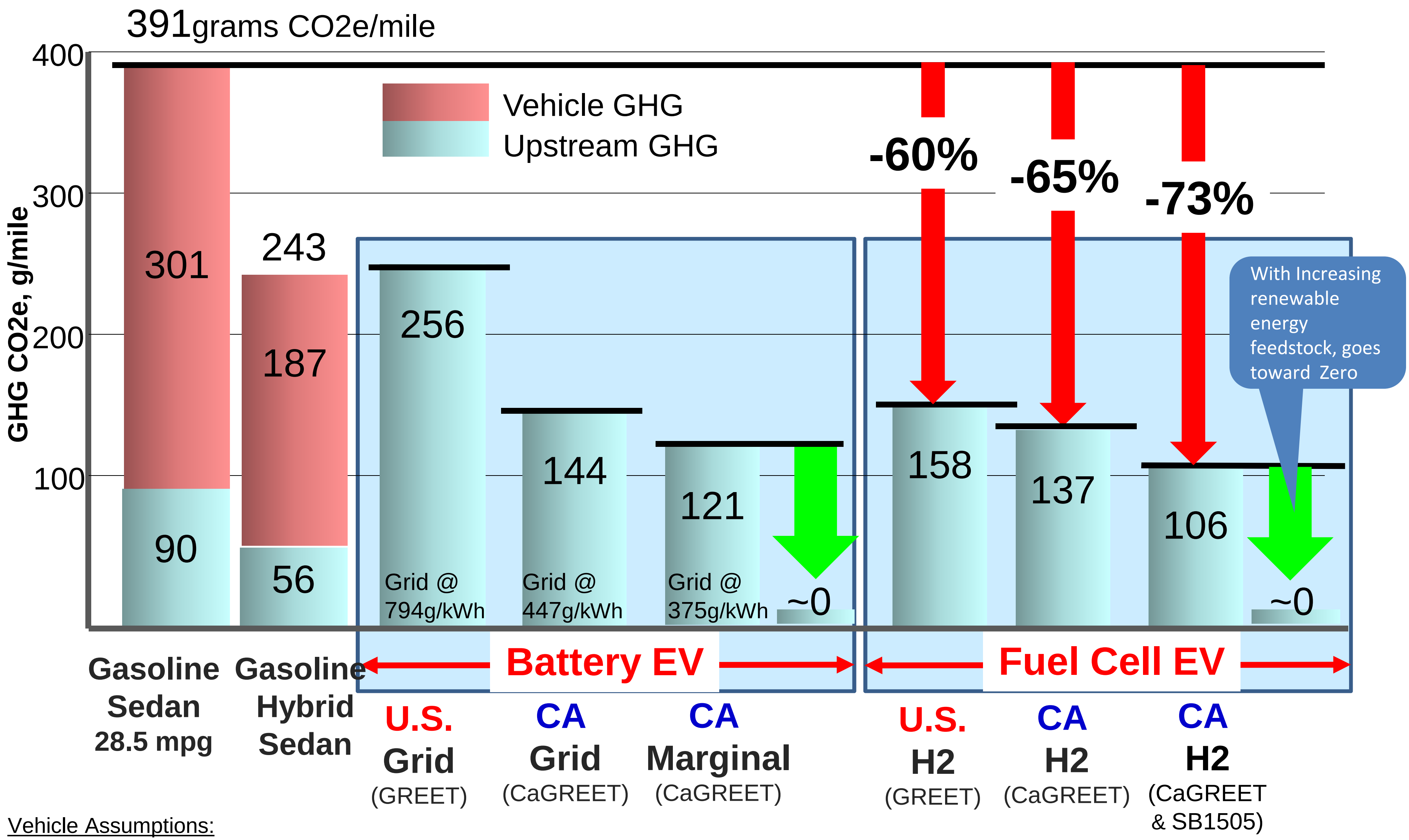
Petroleum Reduction, Sustainable Energy Supply



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

Greenhouse Gas (WTW)

HONDA
The Power of Dreams



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

Upstream Assumptions:
U.S. GREET, CA GREET (CA factors from LCFS)
GREET: DOE Argonne Nat'l Lab & University of Chicago model

HONDA

Honda Activity Today

HONDA
The Power of Dreams

Customers have been operating cars continuously since July 08 (3 years)

- "The excitement of driving has not gone away. I am so grateful to have been selected to drive this amazing car".
- "I sold my (brand X) luxury car… the Clarity is meeting all of my daily transportation needs"

  - Customers are consistently going 200 ~ 220 real-world miles between refueling
  - Varied daily commutes, several go 80 miles per day, EVERY day
  - Others "all over the LA Basin" including various trips to Victorville, Palm Springs, Santa Barbara and San Diego
  - Navigation system uses voice command to "find nearest H2 station"
    - » Honda is updating the NAVI maps after stations are commissioned, a focal point of slow station deployment
  - Collaboration with CAFCP, State of CA, Other OEM's, H2 Providers in a credible ongoing manner for H2 station planning.

Full Functionality (FCEV)

HONDA
The Power of Dreams

Range

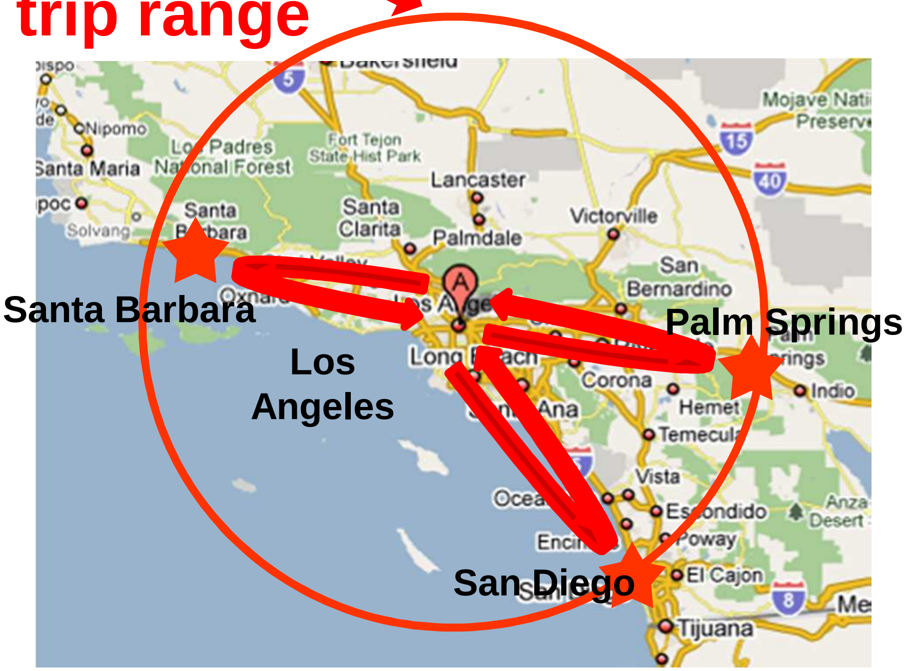
Recharge Time

240+ miles

Real World

Full in < 5 minutes

Clarity round trip range



Most recent FCEVs from OEMs ranging from 200-400+ miles
Clarity FCX range @ 240 miles label, 337 EPA miles unadjusted combined.

HONDA
The Power of Dreams

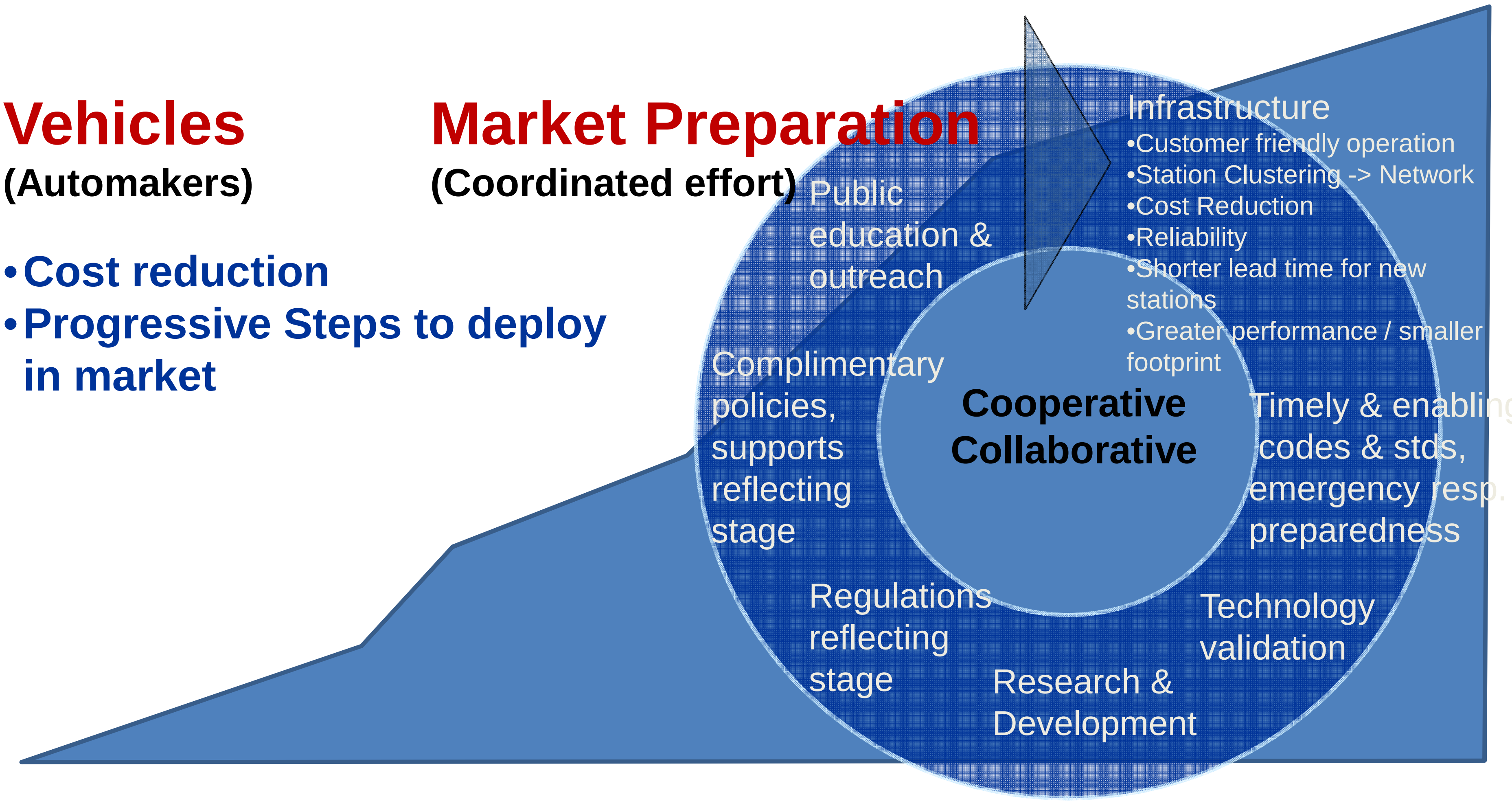
Challenges, Work in Progress

HONDA
The Power of Dreams

Vehicles
(Automakers)

- **Cost reduction**
- **Progressive Steps to deploy in market**

Market Preparation
(Coordinated effort)

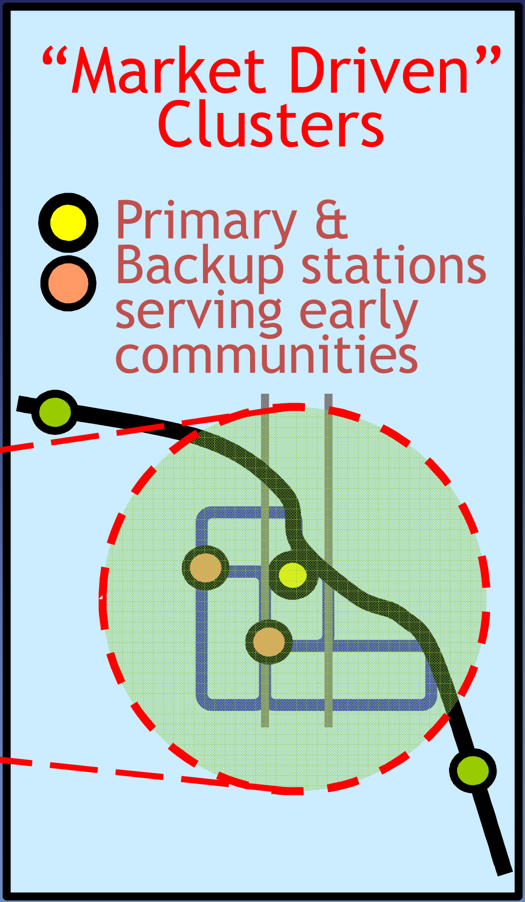


CaFCP (multi-stakeholder coordination), University (research), Energy & Infrastructure Providers, Government: Fed, State & Local (programs, policy, permitting, technology validation, emergency response, etc.), Automakers (vehicles, marketing, etc.), CHBC, etc.

Early Markets and Infrastructure

HONDA The Power of Dreams

2008-2012+ Focus on early introduction stage:
Early 'market-driven' cluster development



2012-2015+
Next Step is critical: Prepare for early commercial stage:
Early clusters → Early H2 station network in SCAB

Honda Clarity Customer Refueling

(U.C. Irvine Station)

Honda Clarity Customer Refueling

(Torrance Pipeline Station)

Dealership Deliveries Continue - Retail Consumers

Honda Summary

HONDA
The Power of Dreams

- Valuable lessons from customers leases & dealerships - 3 years with FCX Clarity
- Valuable lessons from market forces
  - Economic swings
  - Oil / Gasoline price swings
- Valuable lessons from early station diversity
  - Lower Cost, Footprint smaller, Higher Capacity
  - Value of 2-dispensers / 4 hoses with “simultaneous refueling”
- California is our focal point for FCX Clarity
  - Torrance, CA base of Research and Market operations
  - Customers, Dealerships, H2 Suppliers, Private-Public Collaboration
- Customers LOVE their cars
  - Large vehicle size WITH zero emissions (Full Function / Roomy Interior)
  - 5 minute refueling
  - 240 mile range
- Customers #1 request: More H2 Stations

- Accelerated H2 station deployment is needed
  - Trust the voice of our customers
  - Trust the collaborative effort of OEM’s and H2 providers for station needs

Rosario Berretta

Daimler

DAIMLER

June 23, 2011

ARB – Status update Daimler

Rosario Berretta
General Manager, Fuel Cell Vehicle Operation USA

DAIMLER

Daimler's Technology Portfolio for Sustainable Mobility

Optimization of our vehicles with high-tech combustion engines

BlueEFFICIENCY

CGI *BlueTEC* *DIESOTTO*

Hybridization for further increase in efficiency

HYBRID *Range Extender* *Plug-In*

Emission-free driving with fuel-cell/ battery-electric vehicles

Fuel-Cell *Battery-/E-Drive*

NGT SunDiesel

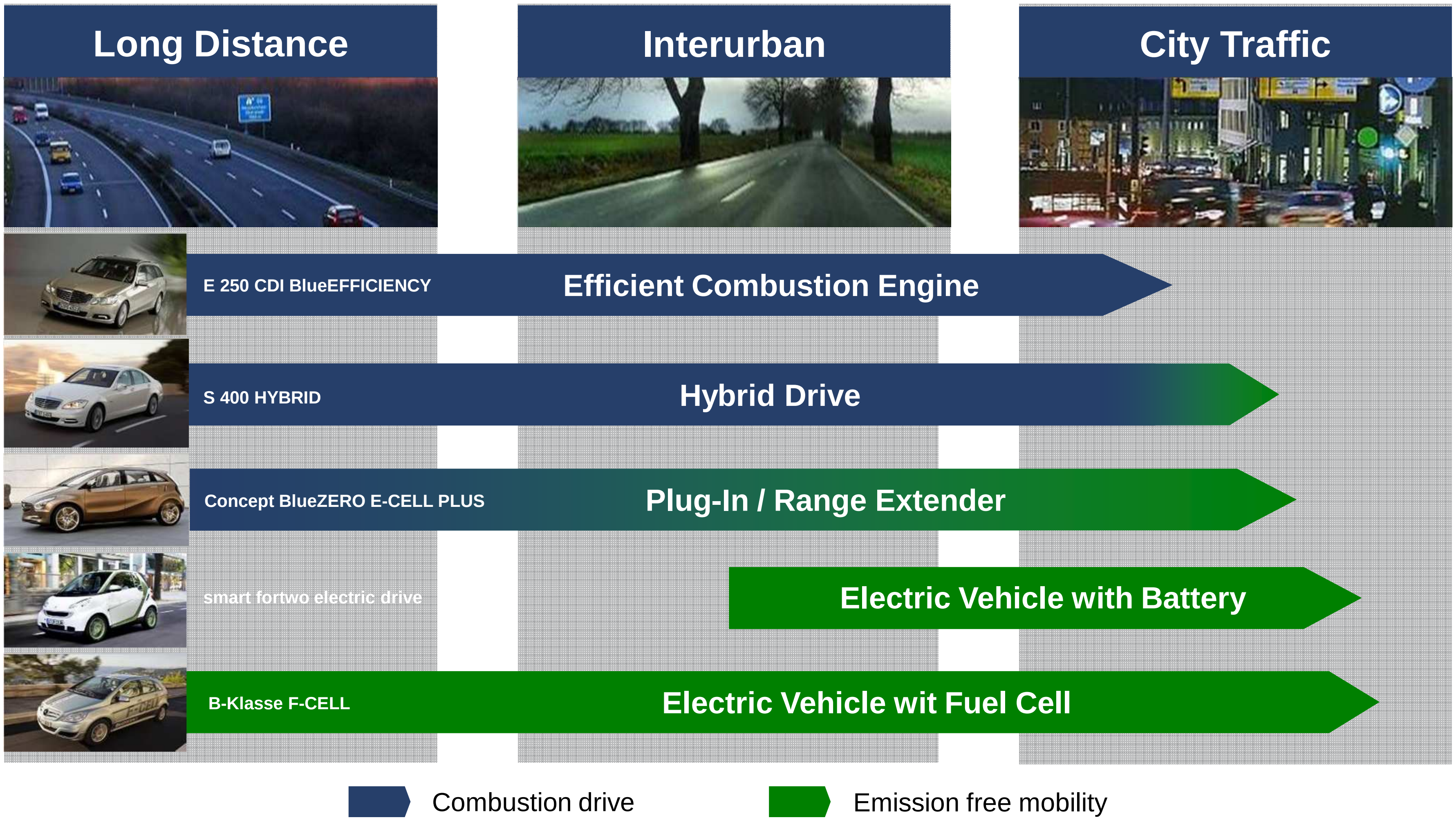
Clean fuels for combustion engines

Energy sources for the mobility of the future

Emission free driving

Drive Portfolio for the Mobility of Tomorrow

Different mobility scenarios



DAIMLER

B-Class F-CELL World Drive 2011

- **125 days**
- **14 countries**
- **approx 20000 miles**
- **Route defined through Scouting**
- **5 Legs**
- **Convoy with 24 vehicles**
- **over 50 people**
- **2 fueling Stops per day**
- **174/155 miles until fueling stop**

- First world tour with fuel cell (FC) vehicles
- The new B-Class F-CELL stands for MB as a reinvention of the mobility
- Demonstration of the technical maturity and performance of FC technology and their potentials for sustainable mobility
- Demonstration of a daily use of the FC technology in different climate
- Long local emission free range in combination with short refueling time
- Appeal to all involved partners to push the development of H_2-Infrastructure

Daimler and Linde jointly kick started the rollout
Project description – facts!

Motivation

Clear signal for the end customer that the technology is ready for real life environment and will be rolled out

Kick start roll out of infrastructure and generate addtl. Momentum within H2-Mobility

20 HRS will be built until the end of 2014

Stations

Twenty stations will be built jointly by Daimler and Linde.
The plan is to integrate them into existing gas stations, preferably with the H2-Mobility partners

Timing

The projects starts now; the first stations will be built and completed in 2012

Financing

The project is jointly financed by Daimler and Linde.
A subsidy by the German / European government is assumed.

Distribution of the stations across Germany

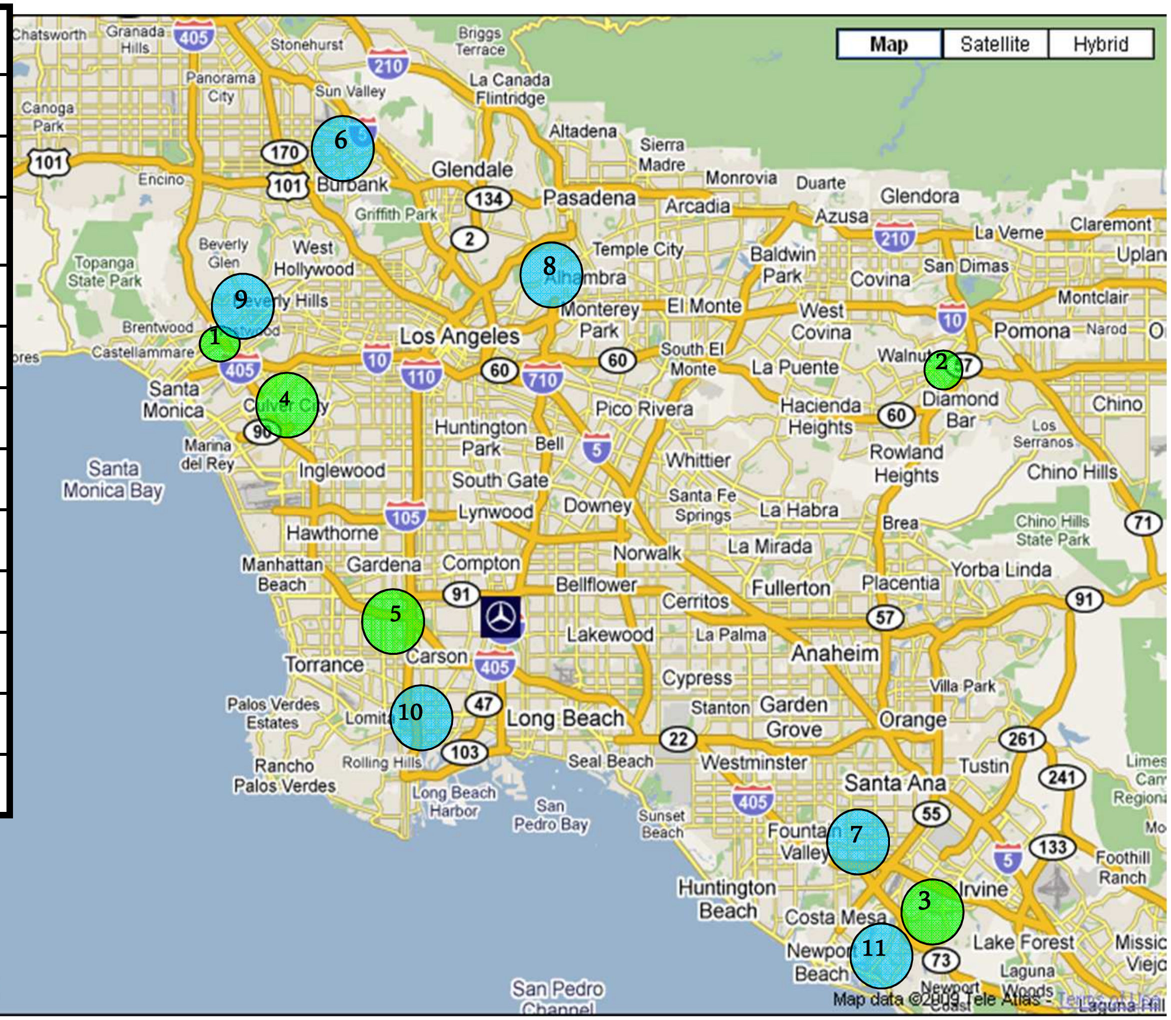
The stations shall connect existing Hydrogen clusters and at set a focus on Baden-Württemberg. The connecting stations should be highly visible and at the same time enable “cross country” travelling through select “autobahn” stations. The focus on Baden-Württemberg will enable high customer acceptance for a larger region.

Commitment to

The used Hydrogen should be as green as possible

Status Infrastructure Southern CA

35 MPa	
1	West LA
2	Diamond Bar
70 MPa	
3	UC Irvine
4	Culver City
5	Torrance
6	Burbank – mid 2011
7	Fountain Valley – **mid/end 2011**
8	CSU LA – **end 2011**
9	UCLA – **2012**
10	Harbor City – **end 2011**
11	Newport Beach – **mid 2011**

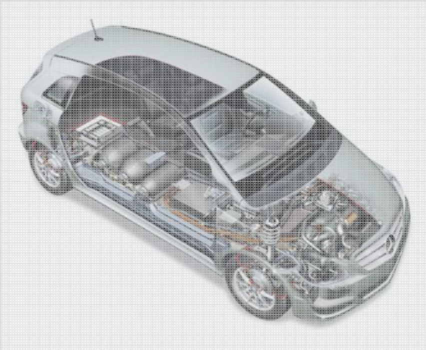


+ CEC (AB 118) funded stations

- Online (green)
- Under construction (blue)

Remaining Challenges of the Fuel Cell and Hydrogen Technology

Technology



- Power density
- Cooling system
- Hydrogen storage
- Durability

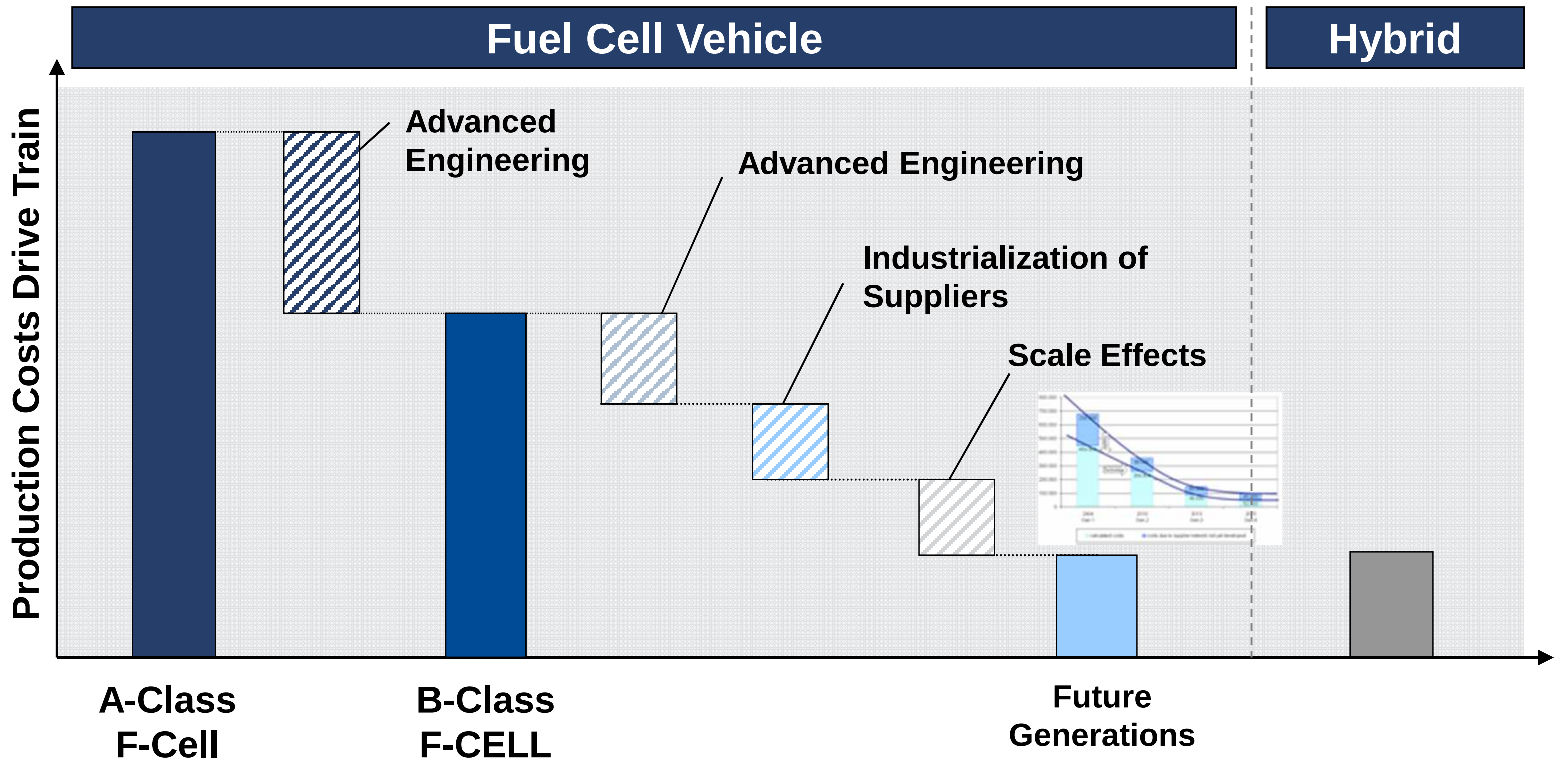
Costs

- Fuel cell system & stack
- Electric engine
- H_2 tank system
- Infrastructure
- Hydrogen costs

Infrastructure

- Reliable refueling technology
- Build-up of an area-wide infrastructure
- H_2 production at competitive prices
- Availability of renewable produced hydrogen

Cost Potentials of Fuel Cell Technology



- Production Costs can be reduced in the near future
- Total Cost of Ownership (TCO) can reach level of common hybrid vehicles

DAIMLER

Vehicles available for 24 month lease!!

Leasing model	only
Duration	24 Month
Pricing	849 USD/Month
Full-Service¹)	included
Fuel	included
Insurance: Full Collision	included
Deployment Area	L.A. & Orange C., Bay Area & Sac.
Vehicle hand over by	MB Dealer

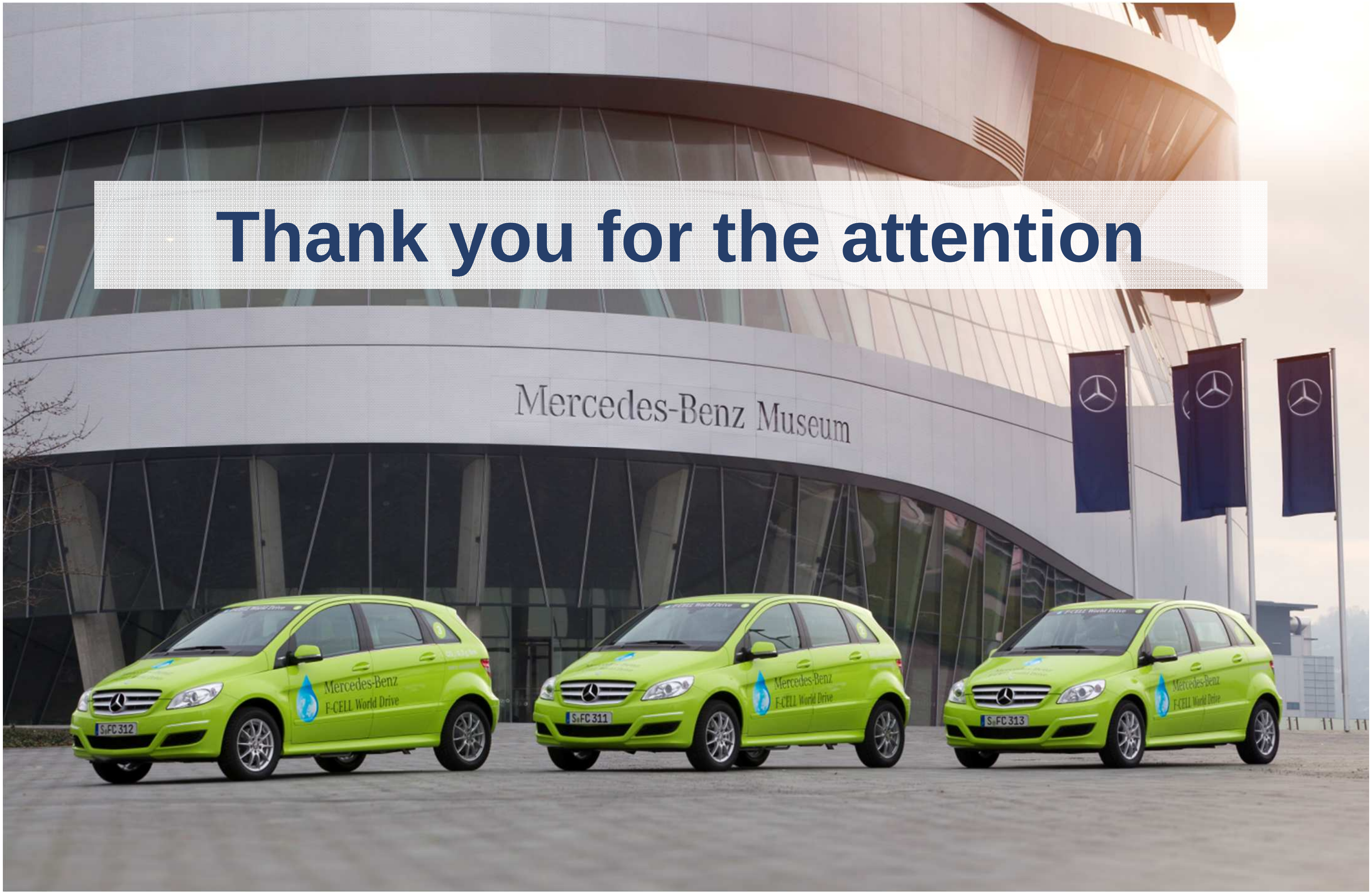
¹) Full-Service contains: maintenance, tires, wear and tear part, repairs

Technical Data	
Vehicle	Mercedes-Benz B-Class
Fuel Cell System	PEM, 90 kW (122 hp)
Engine	Output (Cont./ Peak) 70kW / 100kW (136 hp) Max. Torque: 290 Nm
Fuel	Compressed hydrogen (70 MPa)
Range	ca. 250 miles (400 km)
Top Speed	170 km/h (105 mph)
Li-Ion Battery	Output (Cont./ Peak): 24 kW / 30 kW (40 hp) Capacity: 6.8 Ah, 1.4 kWh

- **Customers are selected from a list of people who have filled out a website questionnaire.**
- **6 vehicles in customer hands and additional 20 cars will be handed–over to customer as soon more H2-stations are available.**

DAIMLER

Thank you for the attention



David Tulauskas

General Motors

Electric Vehicle Strategy:

Fuel Cells & Hydrogen Infrastructure

Air Resources Board

June 23, 2011

Sacramento, CA

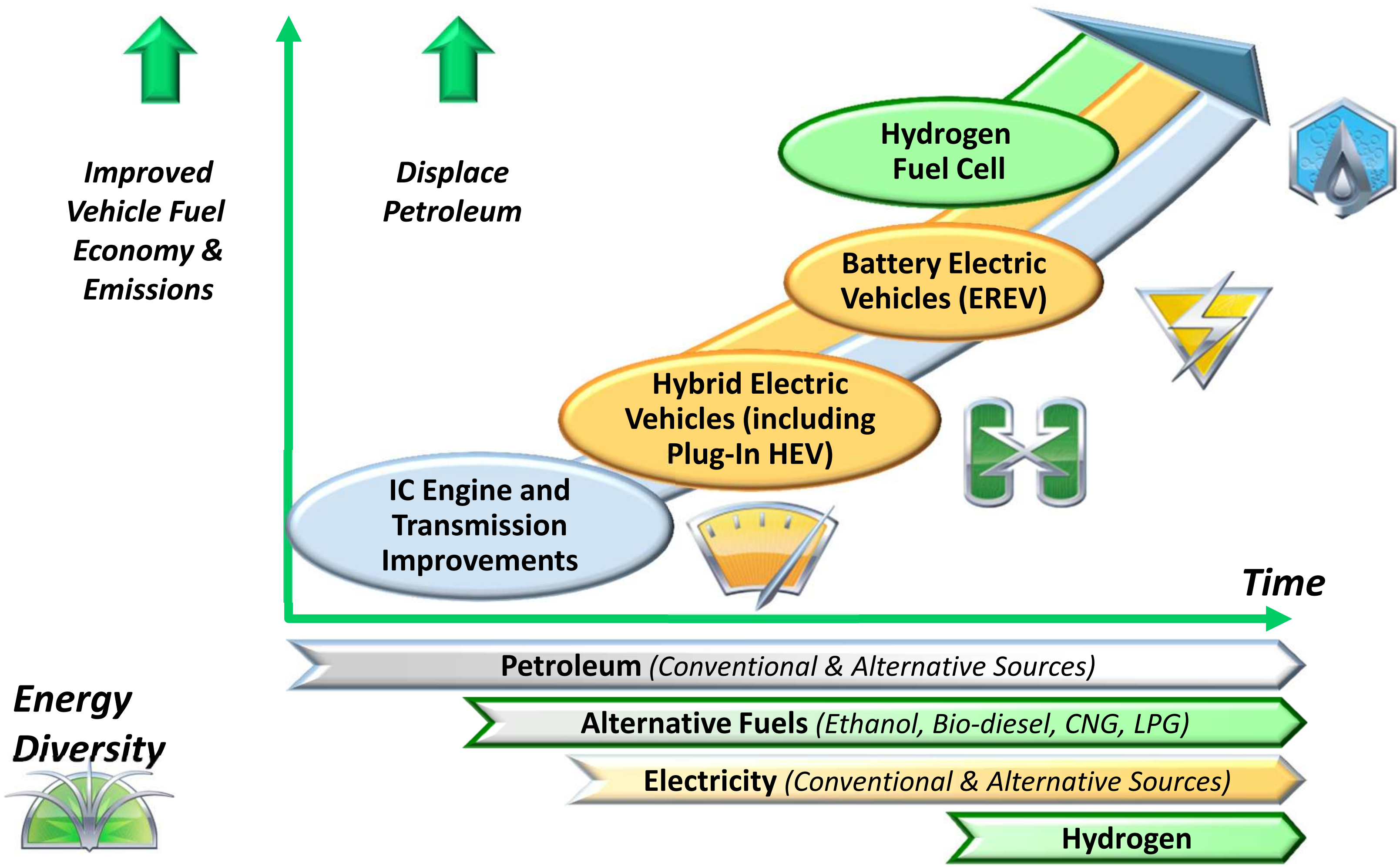
David Tulauskas

Director, State Gov't Relations

General Motors

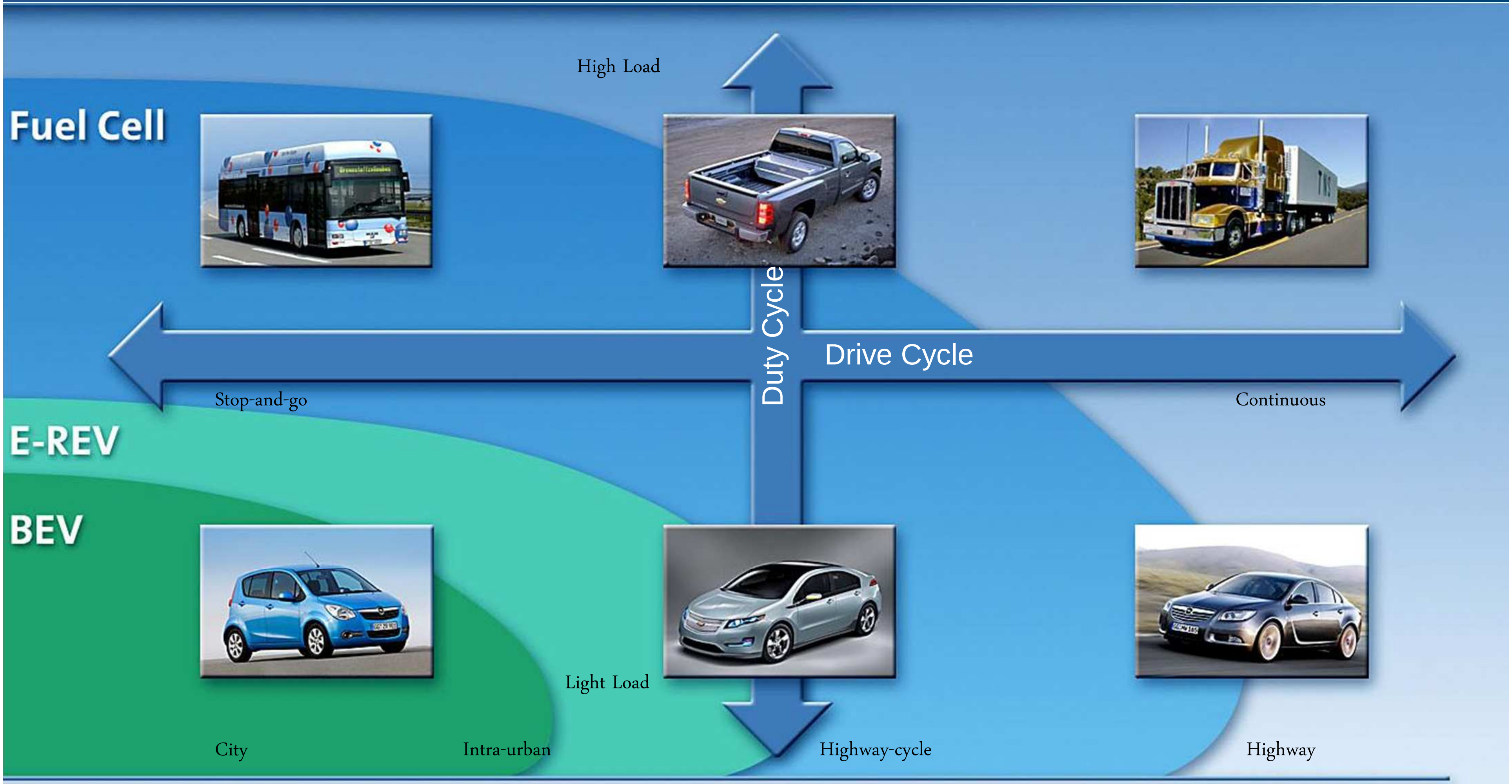
Advanced Propulsion Technology Strategy

No single silver bullet & no clear technology leader



Automotive Technology Application Map

Need to meet customer needs



Battery & Fuel Cell Technologies are both required within the portfolio

GM Project Driveway

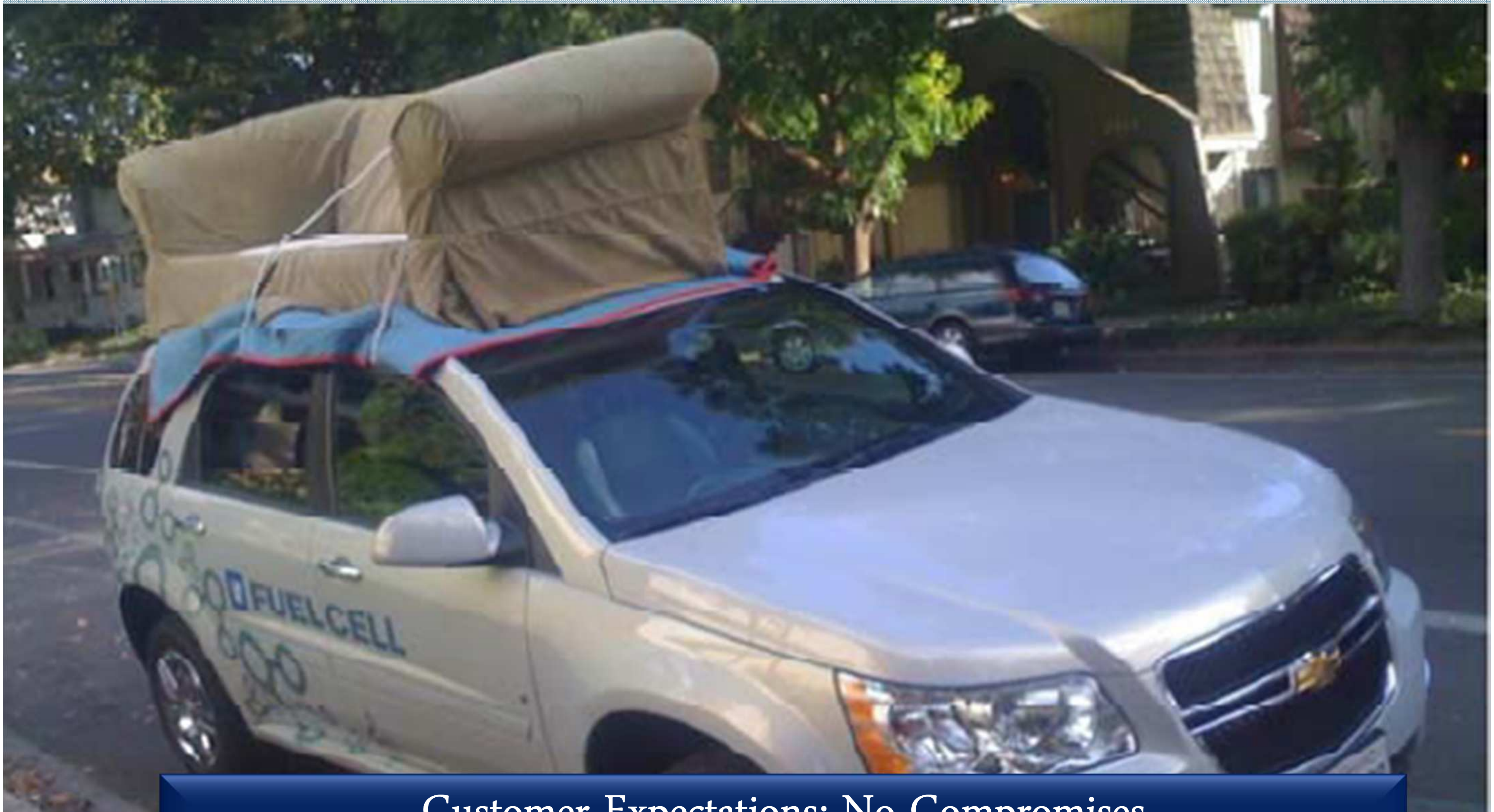
World's largest fuel cell vehicle demonstration

119 vehicles in 5 countries refueled over 25,000 times

Over 1.95 Million miles & counting

Diverse Customer Needs

Hydrogen Fuel Cell Equinox – at Work



Customer Expectations: No Compromises

GM's Advanced Technology Vehicle Center

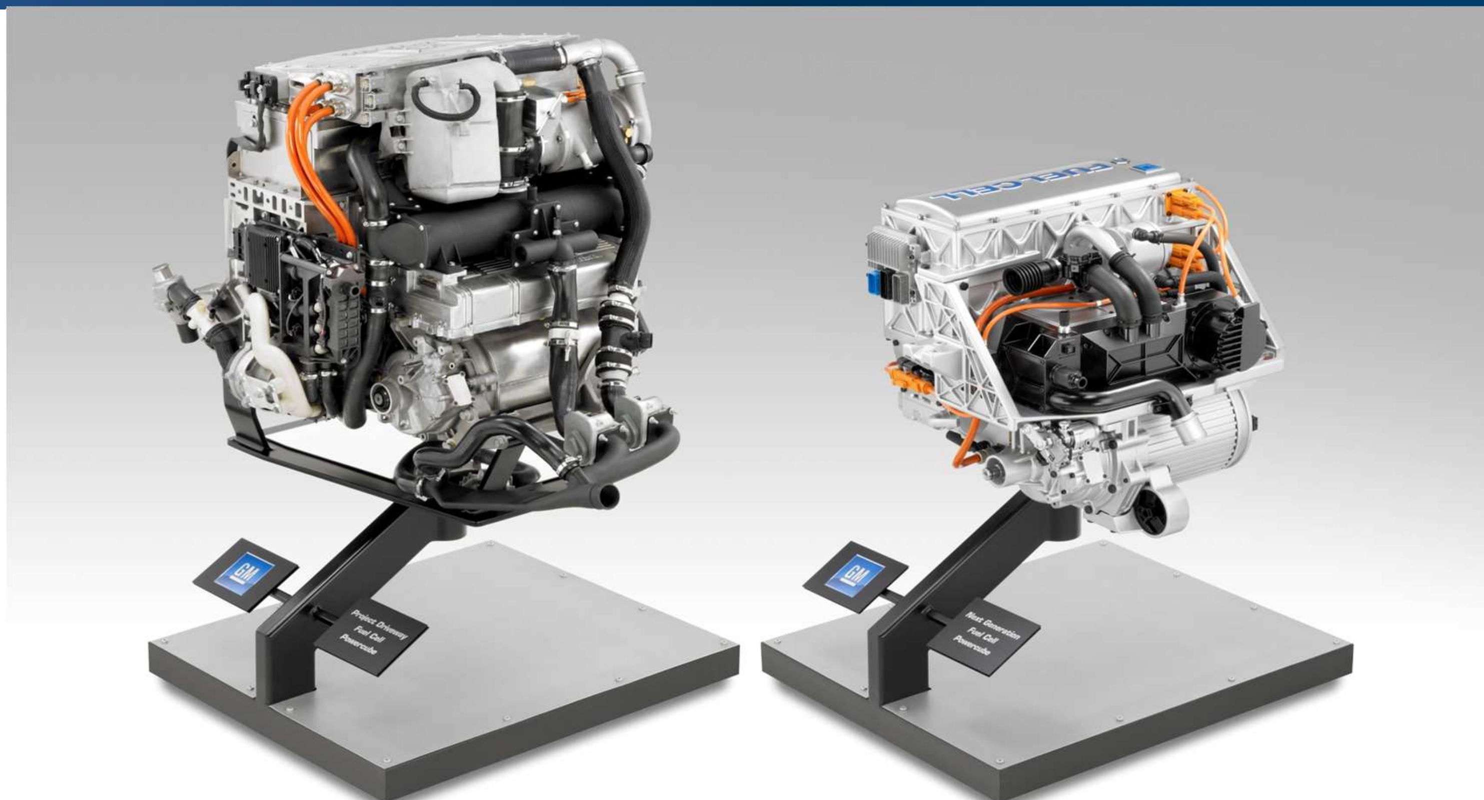
Torrance, CA

Opened June 9, 2011

- Employs up to a dozen scientists, technicians, and engineers with expertise in all aspects of advanced technology vehicle research and development
- Launch, operate, maintain and repair GM's electric vehicle activities in California
- Operates a Hydrogen Fueling station and electric charge stations to support hydrogen storage systems maintenance and development and service battery storage systems

Production Intent Design

Fuel Cell Propulsion System



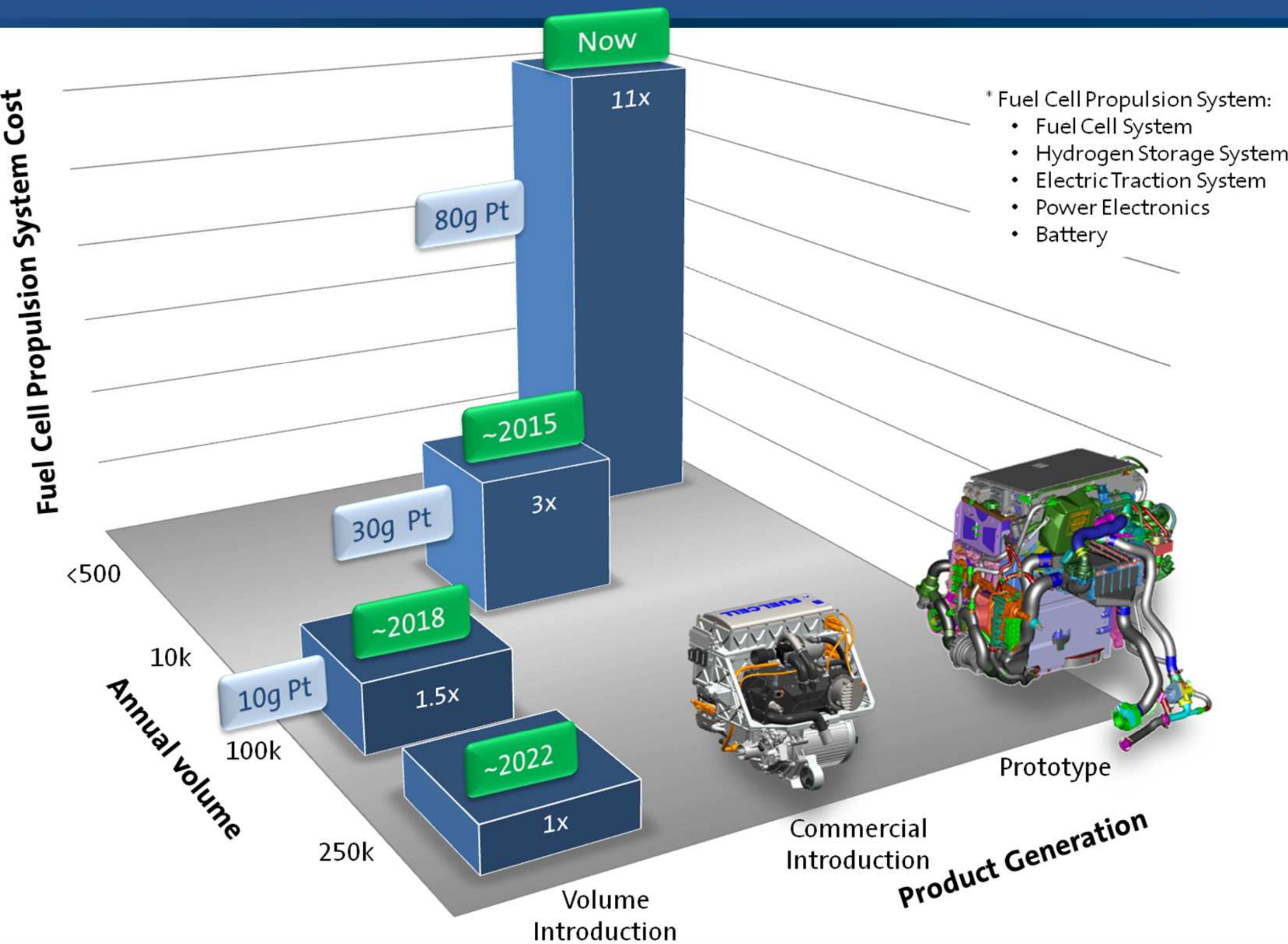
Project Driveway

- Started 2007
- 119 vehicles
- Over 6,500 drivers
- 25,000 refueling events
- 1.95 million miles & counting

Production Intent Design

- Half the size
- 220 pounds lighter
- About 1/3 the platinum
- 2X reduction in part count
- 3.7X increase in durability

Automotive Competitive Cost Glide Path



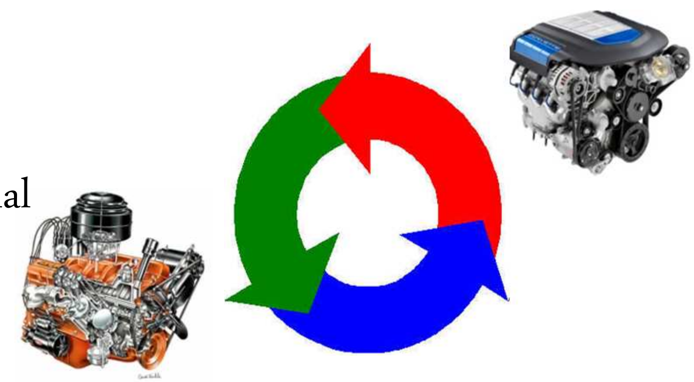
Clear roadmap to automotive competitive costs requires multiple learning cycles & scale volume

Fuel Cell Technology & Hydrogen Infrastructure

Remaining Challenges

Cycles of Learning

- 2-3 production cycles before cost effective
- Growth to scale economies required to achieve lowest cost potential



Infrastructure Investment

- Requires field infrastructure investment
- Development of manufacturing & suppliers

Government Policy

- R&D, market and infrastructure support
- Codes and standards development

Summary

H_2 Fuel cell technology is commercial ready

- Performance proven in field, durability proven in labs
- Cost pathway identified, (higher than ICE, but comparable to other adv. tech.)

H_2 infrastructure is achievable – *Must Establish & Maintain Momentum*

- Germany & Japan implementing H_2 infrastructure plans
- U.S. H_2 infrastructure is achievable, with close Government-Industry cooperation
- Develop technology & business models to drive down infrastructure costs

Stable government policy is key

- Expanded Department of Energy role to support early market introduction phases
- Germany's H_2 Mobility Template
- Codes & Standards
- Market incentives

Thank You

Jaimie Levin

Alameda-Contra Costa Transit District

Fuel Cell Transit Buses – State of The Technology

Jaimie Levin

1st Generation Bus

- >267,000 Miles
- >700,000 Passengers
- 1.6 to 2.0 Times Better Fuel Economy
- 43% GHG Reductions
  (Reforming Natural Gas;
  100% reduction with solar or wind hydrogen)

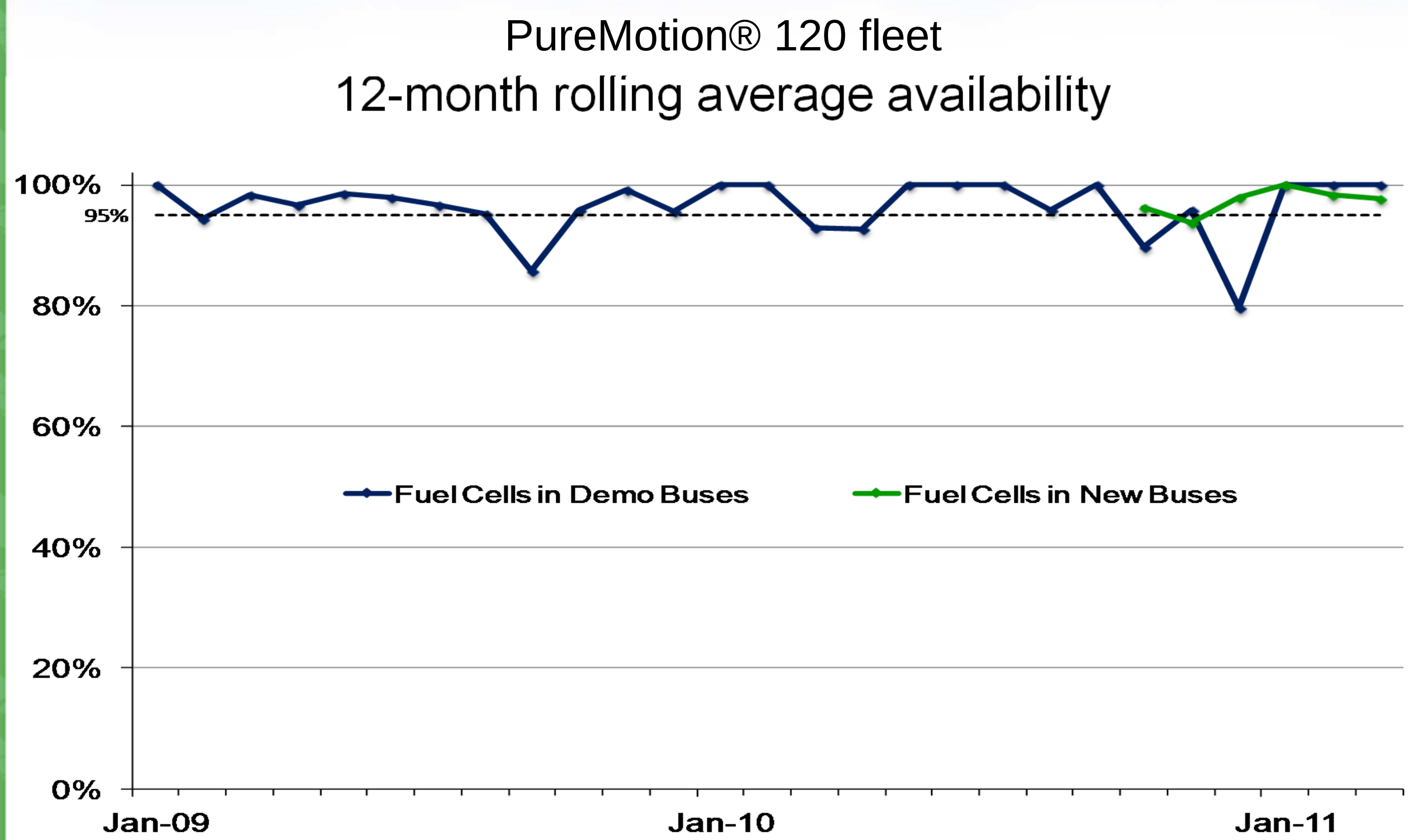
3rd Generation Design

- 5,000 lbs. Lighter
- Better Batteries
- 104,000 miles (since Aug 2010)
- > 9,400 Fuel Cell Hours

- 612,890 Miles – UTC Fuel Cell Fleet
- Over 1 million passengers in the Bay Area
- Passengers, Mechanics, and Drivers Love Them

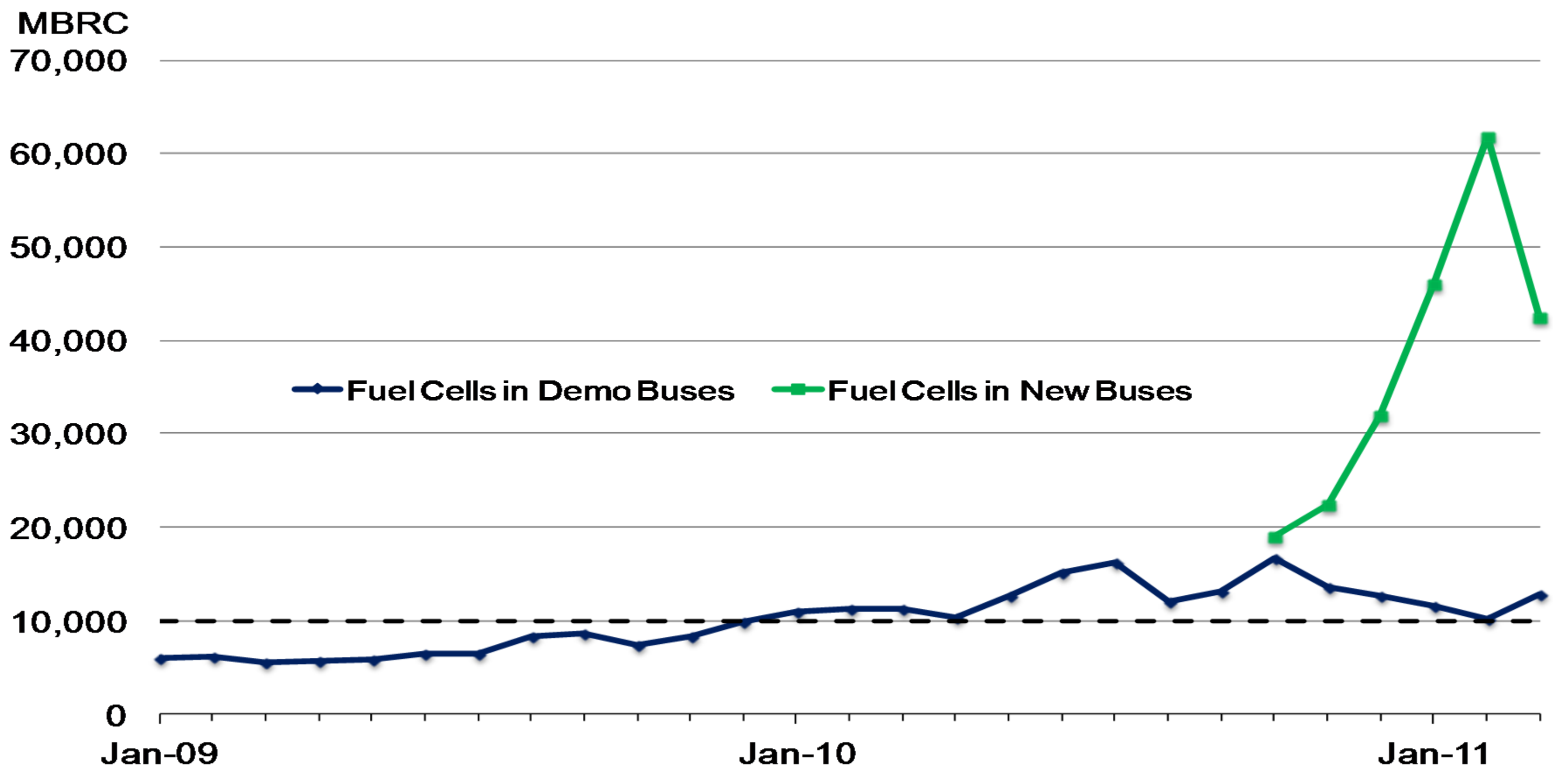
"Like Disneyland in The Real World!"

Fleet average fuel cell availability at 95% for more than 2 years



Fuel cells achieving commercial levels of reliability

PureMotion® 120 fleet
12-month rolling average miles between road calls (MBRC)



FTA United States Department of Transportation Federal Transit Administration

CALSTART

UTC Power
A United Technologies Company

Technology Demonstration → Product Improvement and Optimization → Cost Reduction and Pilot Introduction in United States → Product Commercialization

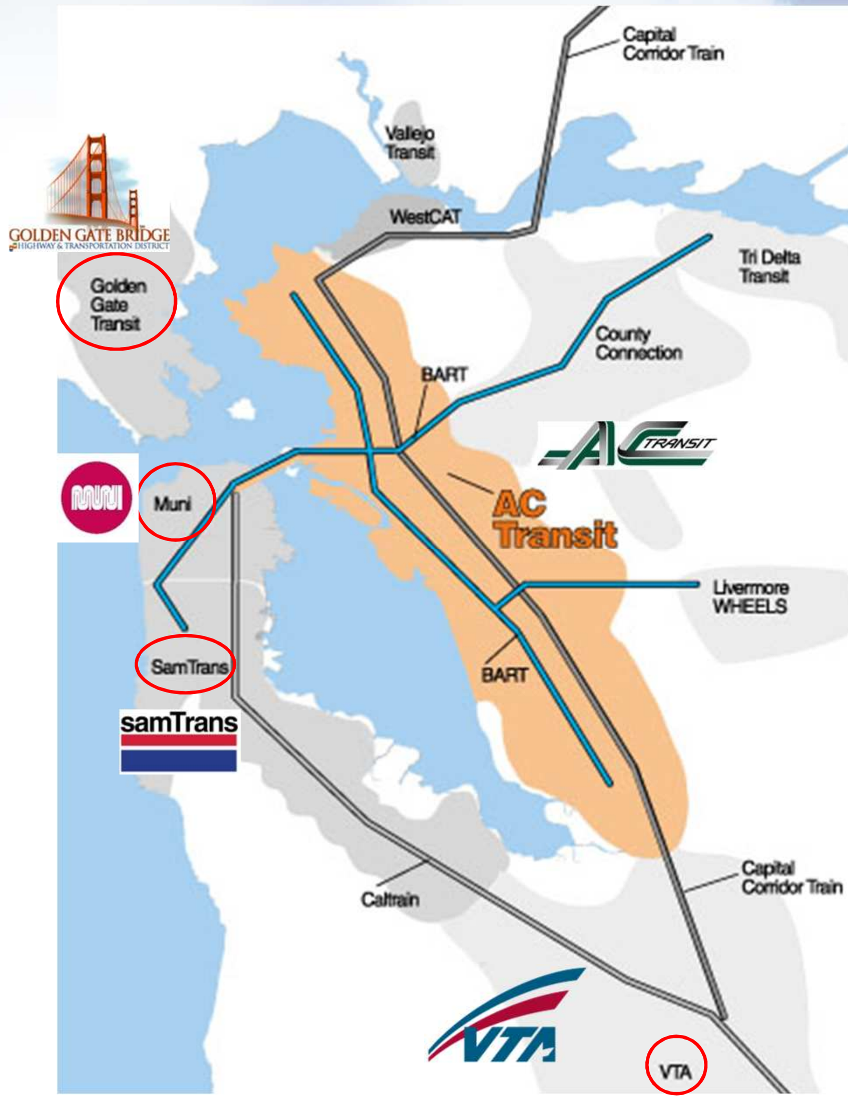
$14.2M Program for advanced fuel cell development

- Increase power density
- Increase durability
- Reduce weight, size, and cost

Focused on product optimization and cost reduction

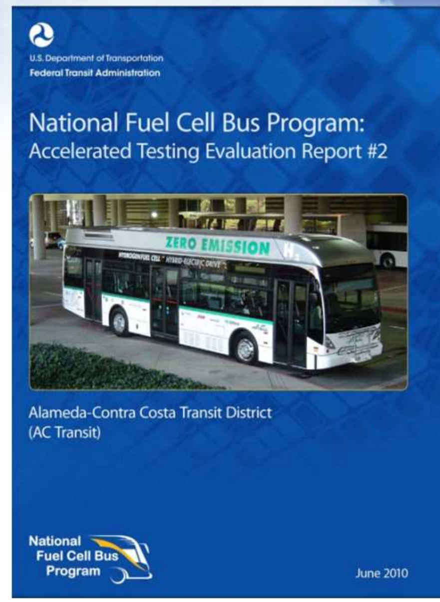
Bay Area Advanced Demo

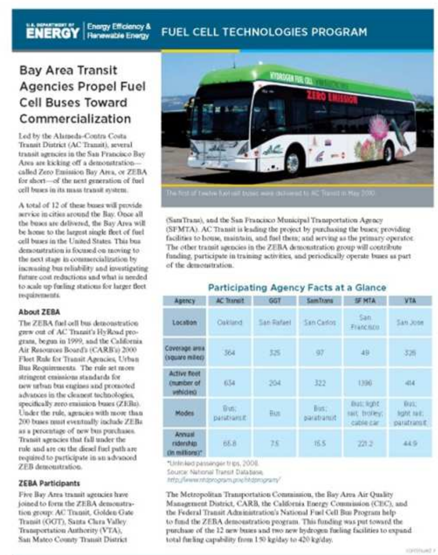
- $65 Million
- 12 New Buses
- 2 Fueling Stations
- 5 Transit Agencies (>2,500 vehicles)
- Shared Service
- Shared Training



NREL Evaluation

- In Partnership with NREL, DOE, and FTA
- **DOE has approved continued data collection** and analysis of 12 buses and new stations
- Monthly and Semi-annual Performance Reports




U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy — FUEL CELL TECHNOLOGIES PROGRAM

Bay Area Transit Agencies Propel Fuel Cell Buses Toward Commercialization

Led by the Alameda-Contra Costa Transit District (AC Transit), several transit agencies in the San Francisco Bay Area are kicking off a demonstration—called Zero Emission Bay Area, or ZEBA for short—of the next generation of fuel cell buses in its mass transit system.

A total of 12 of these buses will provide service in cities around the Bay. Once all the buses are delivered, the Bay Area will be home to the largest single fleet of fuel cell buses in the United States. This bus demonstration is focused on moving to the next stage in commercialization by increasing bus reliability and investigating future cost reductions and what is needed to scale up fueling stations for larger fleet requirements.

About ZEBA

The ZEBA fuel cell bus demonstration grew out of AC Transit's HyRoad program, begun in 1999, and the California Air Resources Board's (CARB's) 2000 Fleet Rule for Transit Agencies, Urban Bus Requirements. The rule set more stringent emissions standards for new urban bus engines and promoted advances in the cleanest technologies, specifically zero emission buses (ZEBs). Under the rule, agencies with more than 200 buses must eventually include ZEBs as a percentage of new bus purchases. Transit agencies that fall under the rule and are on the diesel fuel path are required to participate in an advanced ZEB demonstration.

ZEBA Participants

Five Bay Area transit agencies have joined to form the ZEBA demonstration group: AC Transit, Golden Gate Transit (GGT), Santa Clara Valley Transportation Authority (VTA), San Mateo County Transit District (SamTrans), and the San Francisco Municipal Transportation Agency (SFMTA). AC Transit is leading the project by purchasing the buses; providing facilities to house, maintain, and fuel them; and serving as the primary operator. The other transit agencies in the ZEBA demonstration group will contribute funding, participate in training activities, and periodically operate buses as part of the demonstration.

Participating Agency Facts at a Glance

Agency	AC Transit	GGT	SamTrans	SF MTA	VTA
Location	Oakland	San Rafael	San Carlos	San Francisco	San Jose
Coverage area (square miles)	364	325	97	49	326
Active fleet (number of vehicles)	634	204	322	1396	414
Modes	Bus; paratransit	Bus	Bus; paratransit	Bus; light rail; trolley; cable car	Bus; light rail; paratransit
Annual ridership (in millions)*	65.8	7.5	16.5	221.2	44.9

*Unlinked passenger trips, 2008
Source: National Transit Database, http://www.ntdprogram.gov/ntdprogram/

The Metropolitan Transportation Commission, the Bay Area Air Quality Management District, CARB, the California Energy Commission (CEC), and the Federal Transit Administration's National Fuel Cell Bus Program help to fund the ZEBA demonstration program. This funding was put toward the purchase of the 12 new buses and two new hydrogen fueling facilities to expand total fueling capability from 150 kg/day to 420 kg/day.

Technology Thresholds

1. Performance (Reliability and Durability)
2. Packaging (Weight and size)
3. Fuel Supply (Speed, Scalability, Renewable)

Affordability = Ownership

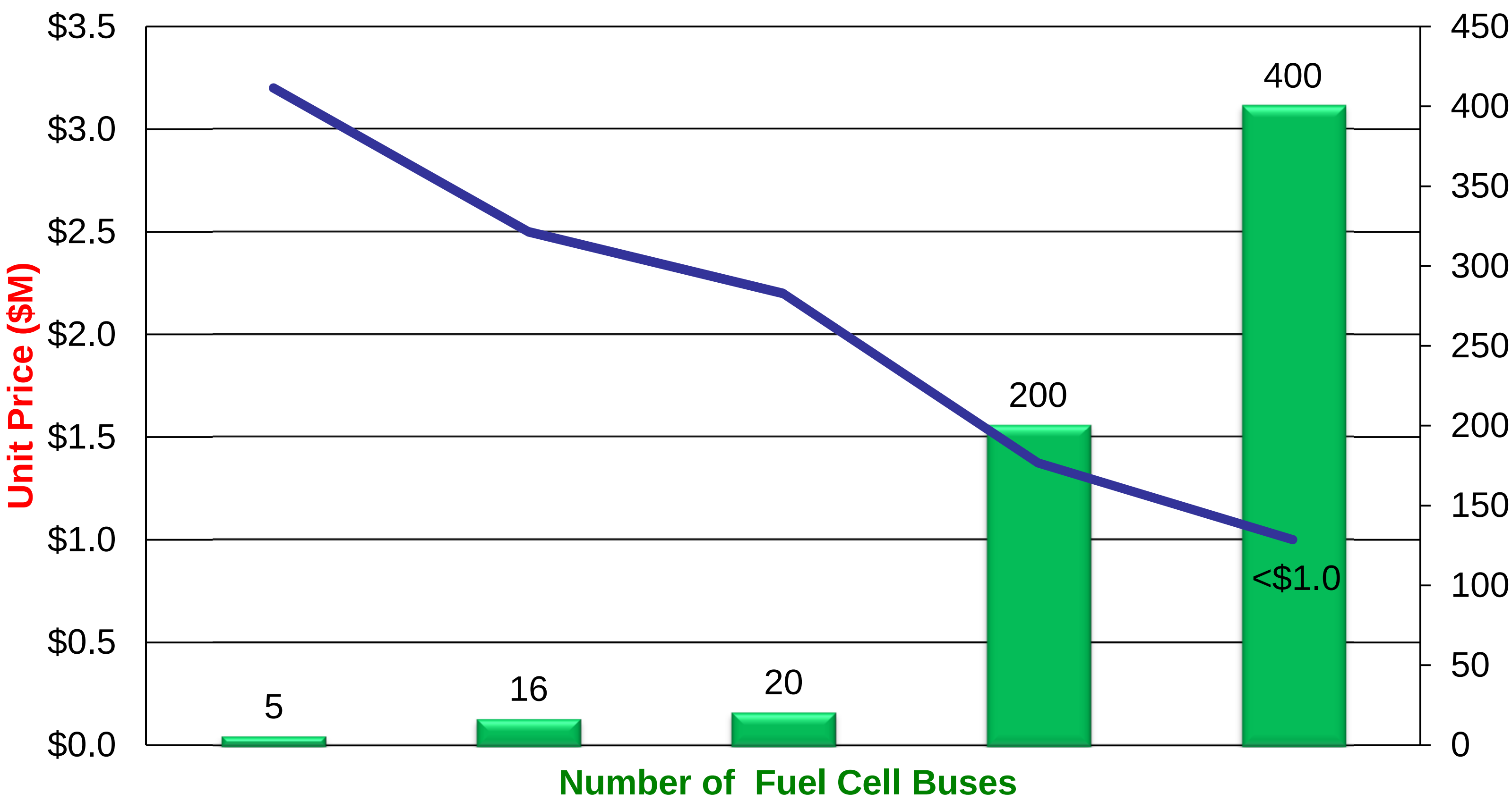
1. Can We Afford to **Buy** It?
2. Can We Afford to **Run** It?
   (Performance and Maintainability)
3. Can We Afford to **Own** It?
   (Durability and Replacement Costs)

National Program: Centers of Excellence

Next Steps	Evaluation Criteria
12 Next-Generation Buses in Regional Service by September 2011	1. Performance by different operators 2. Fuel economy 3. **RELIABILITY** 4. **HYDROGEN SUPPLY**
Four or Five Regional Centers of Excellence : Each Deploying 40 to 50 Buses (2013 – 2016)	1. Reliability 2. **DURABILITY** 3. **COST REDUCTION**

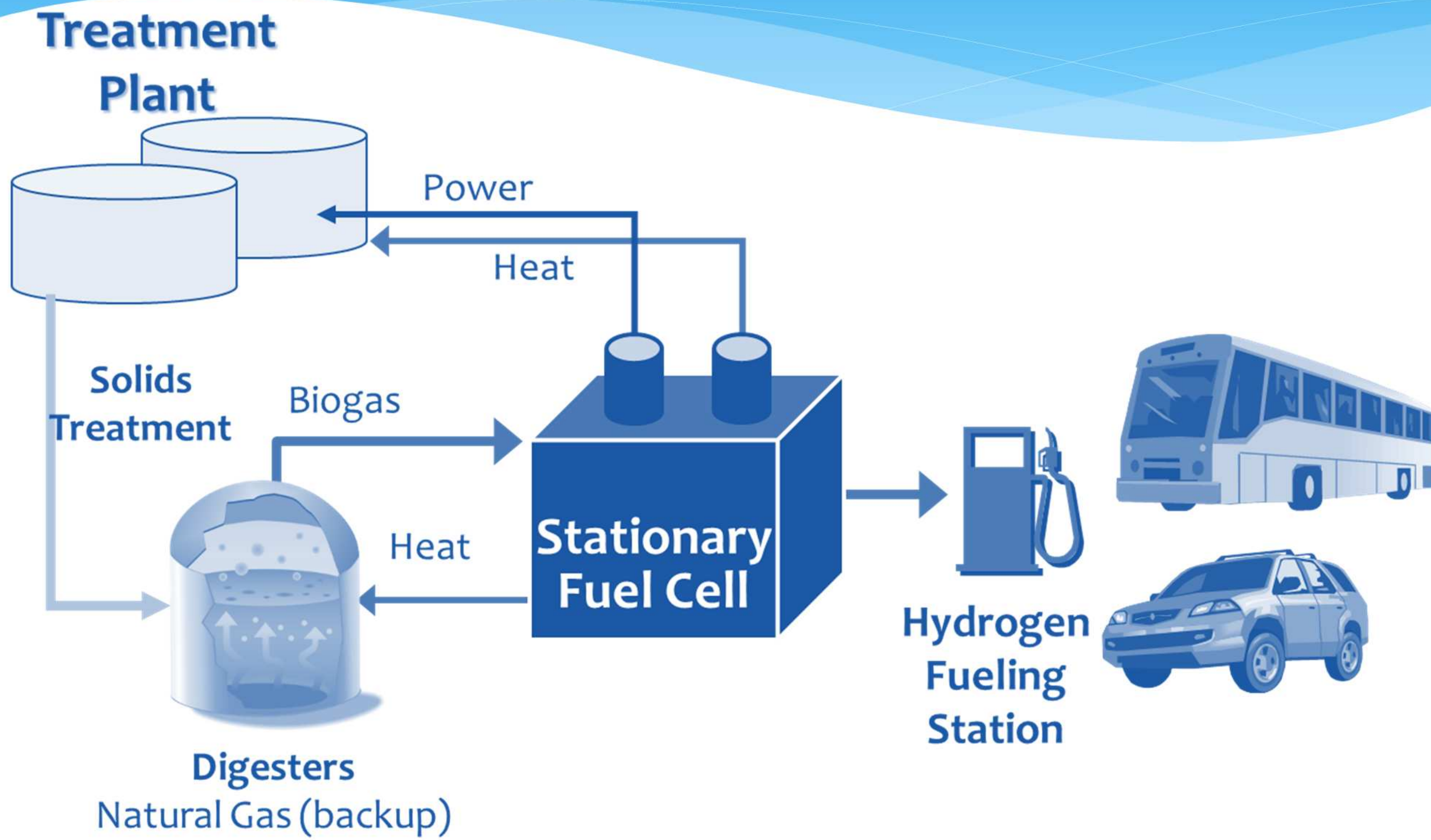
"Building a Commercially Viable National Fuel Cell Electric Bus Program," FCHEA March 2011

Commercial Cost Targets



"Building a Commercially Viable National Fuel Cell Electric Bus Program," FCHEA March 2011

Panel 4
Infrastructure



Justin Ward

California Fuel Cell Partnership

Toyota Technical Center

FCV and H_2 Station Rollout Planning

Justin Ward
Vice-Chair, California Fuel Cell Partnership
Advanced Powertrain Program Manager, Toyota Motor Engineering & Manufacturing North America, Inc.

June 23, 2011

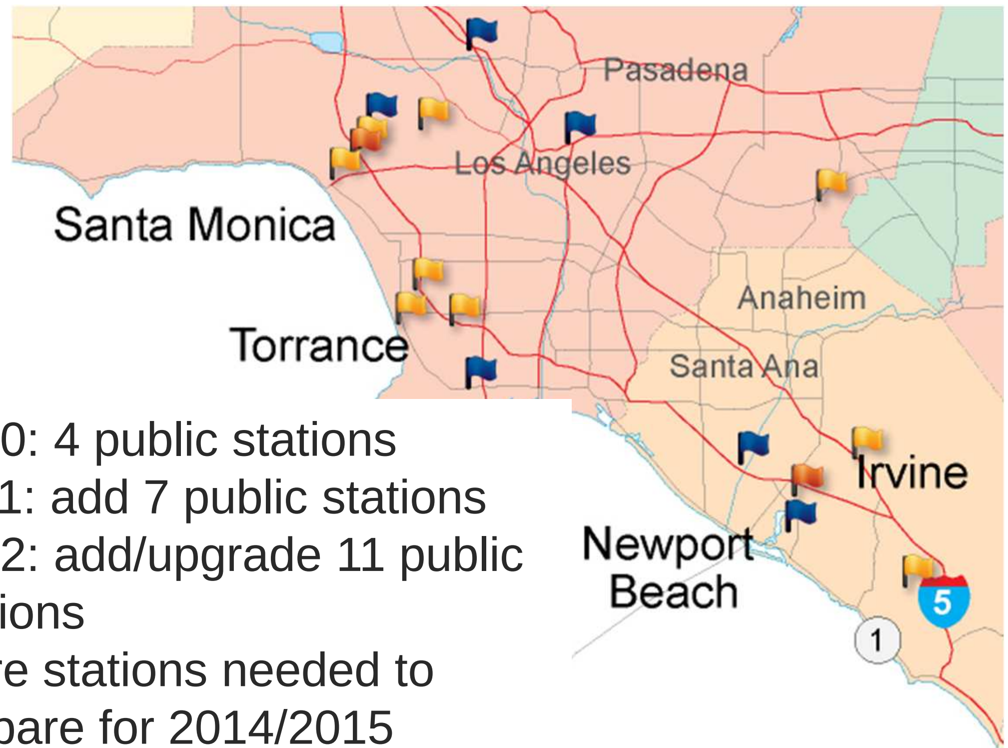
How many hydrogen stations?

- 2009 “Hydrogen Fuel Cell Vehicle and Station Deployment Plan: A Strategy for Meeting the Challenge Ahead”
  - This “Action Plan” identified the need for about 40 new hydrogen stations in order to prepare the market for the commercial launch of fuel cell vehicles (FCV).
- 2010 and 2011 Progress reports further defined station needs based on annual automaker survey results

Other supporting actions

- Finalize codes and standards for retail sales of hydrogen
  - Fuel metering, fuel quality, customer convenience
- Support business models developed by the private sector
  - How will early H_2 fuel retailers sustain their business?
- Outreach and educate early market communities
  - Including first responder training, permitting workshops, local leader outreach

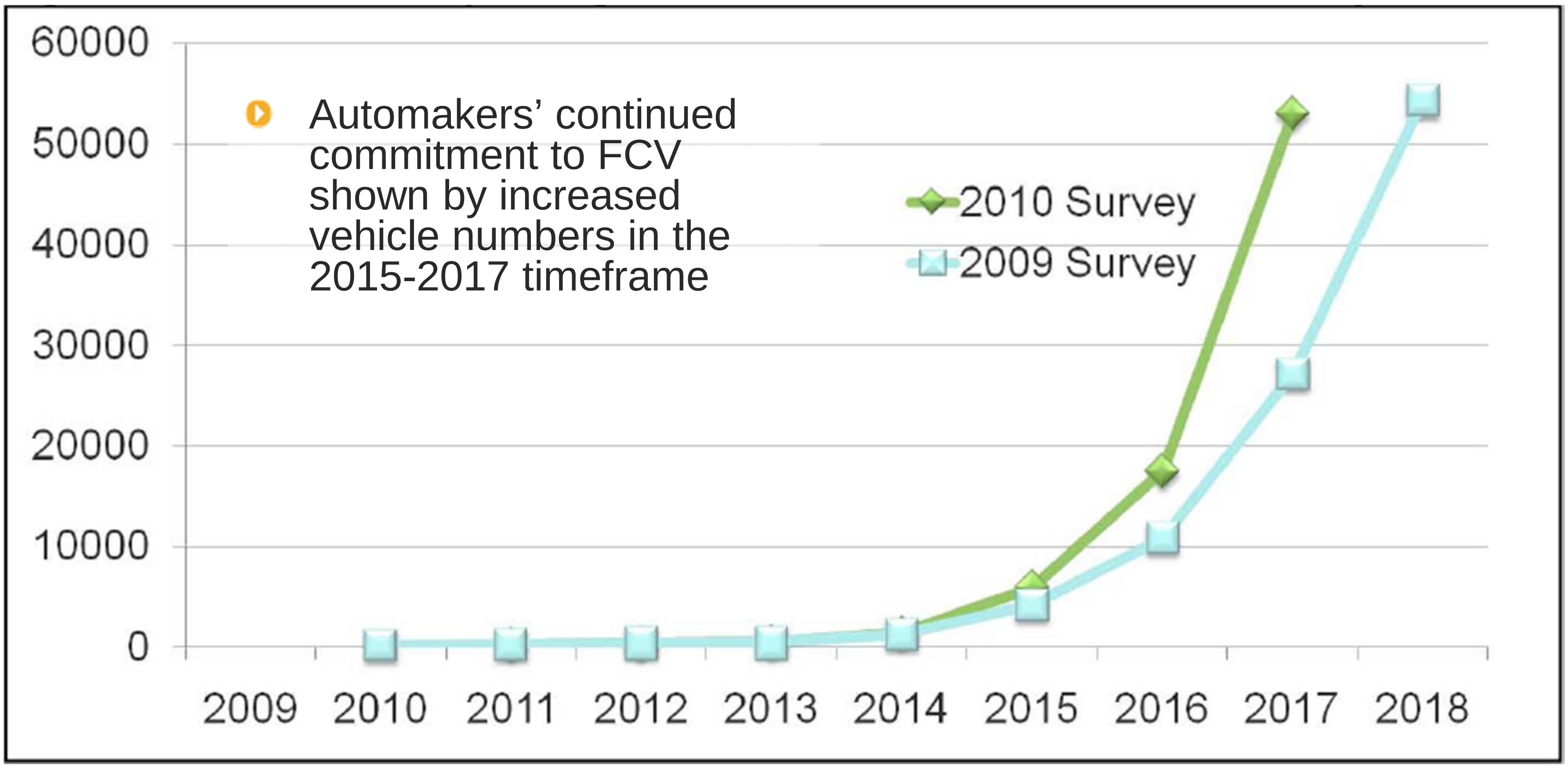
Cluster deployment in early years



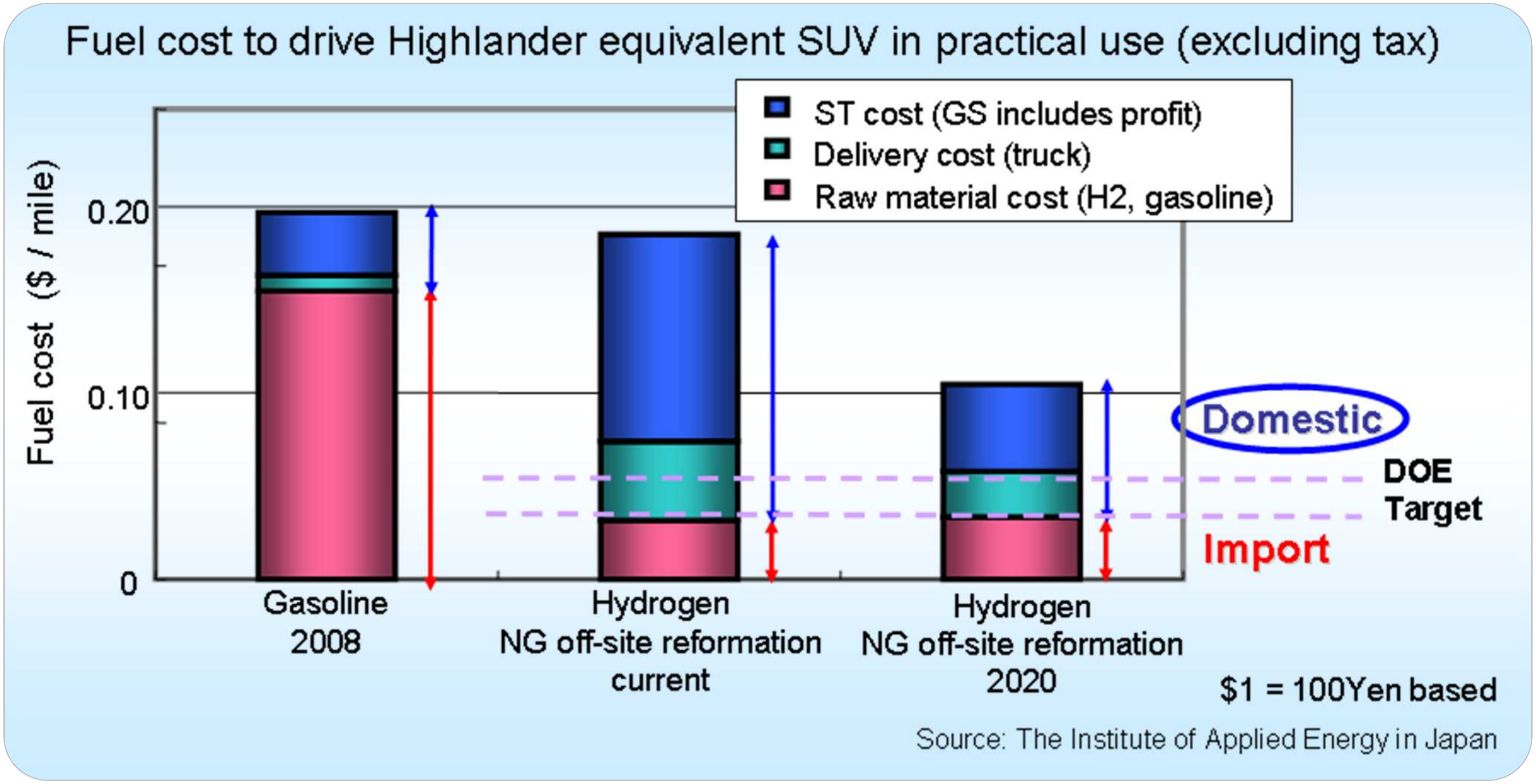
- ✓ 2010: 4 public stations
- ✓ 2011: add 7 public stations
- ✓ 2012: add/upgrade 11 public stations
- ✓ More stations needed to prepare for 2014/2015 commercial launch (tbd)

Latest Automaker FCV Survey

	Hundreds	Thousands	Tens of thousands
	Through 2013	2014	2015-2017
Total Passenger Vehicles*	430	1,400	53,000



Business Models

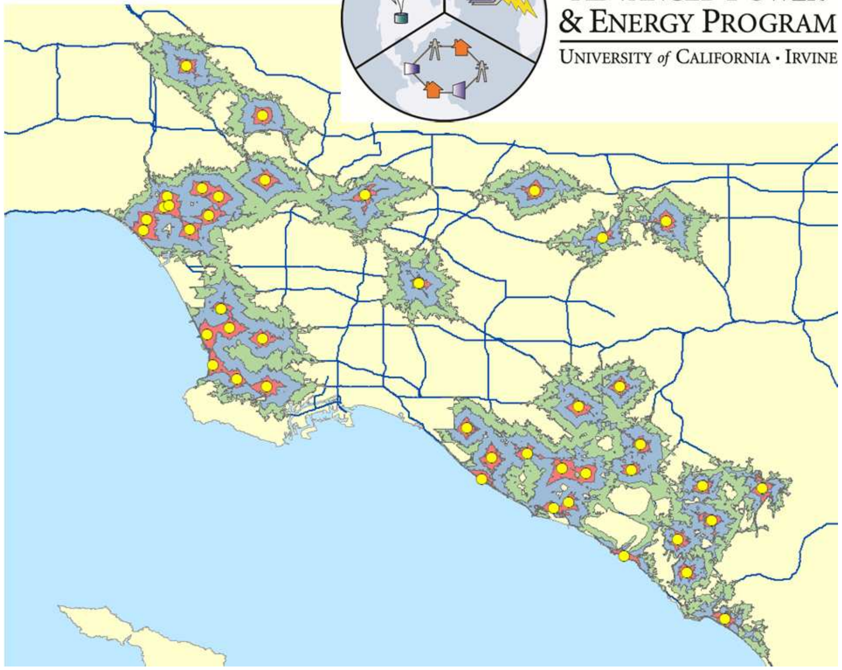


- Identify some conventional and nonconventional business models

Strategic Station Deployment

- Consider hydrogen station deployment from a more holistic point of view.
  - Identify technology needs on both the vehicle and infrastructure sides and define possible scenarios to balance the needs.
- Utilize recently developed tools / resources

  For example:
  - UC Irvine STREET (Spatially & Temporally Resolved Energy & Environment Tool)
  - Specialized CaFCP Working Groups and Task Forces



Summary

- CaFCP is committed to vehicle/station rollout planning using the latest information and tools available
- It is clear that additional collaborative work is needed to prepare the market for FCV commercialization
  - CaFCP is working to define a fourth phase to begin in 2013(current CaFCP phase concludes in 2012)

California FUEL CELL PARTNERSHIP

AUTOMOTIVE
Chrysler
Daimler
General Motors
Honda
Hyundai
Nissan
Toyota
Volkswagen

ENERGY
Chevron
Shell Hydrogen

TECHNOLOGY
AFCC

GOVERNMENT
CA Energy Commission
CA Air Resources Board
National Automotive Center
South Coast AQMD
US EPA
US DOE
US DOT

ASSOCIATE
AC Transit
Santa Clara VTA
SunLine Transit
Air Liquide
Air Products
Linde
Praxair
Ballard Power Systems
Powertech
ITS – UC Davis
NFCRC – UC Irvine
CA Dept. of Food & Ag
NREL

Thank you!
justin.ward@tema.toyota.com

Tim Brown

National Fuel Cell Research Center

UC Irvine

Using STREET* to Find the Hydrogen Infrastructure Tipping Point with Minimum Capital Investment

*Spatially and Temporally Resolved Energy and Environment Tool

ADVANCED POWER & ENERGY PROGRAM
UNIVERSITY of CALIFORNIA · IRVINE

Dr. Tim Brown
Dr. Shane D. Stephens-Romero
Yangbin Wu
Professor G. Scott Samuelsen

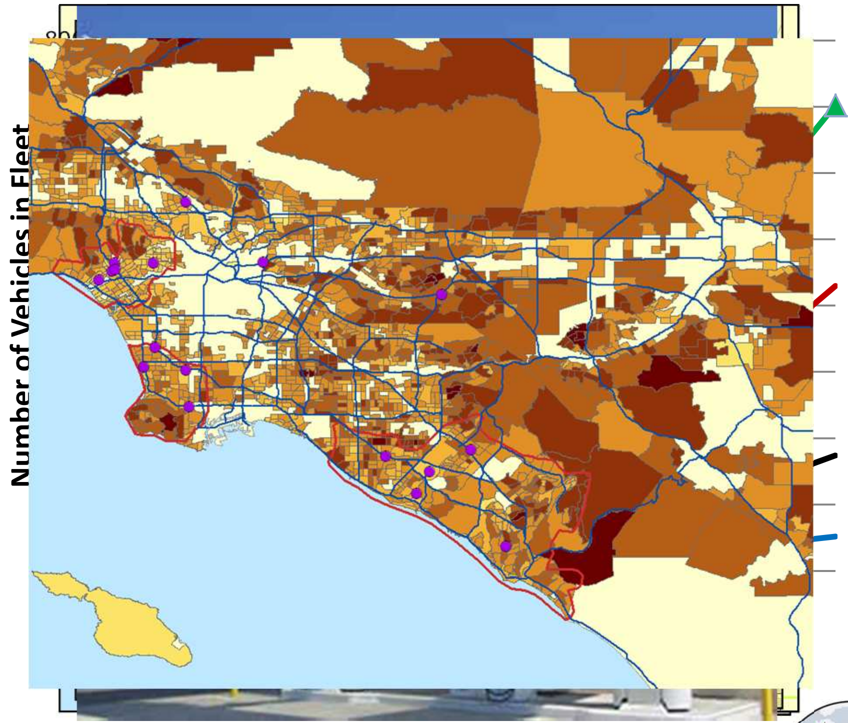
June 23, 2011

Many Factors are Considered

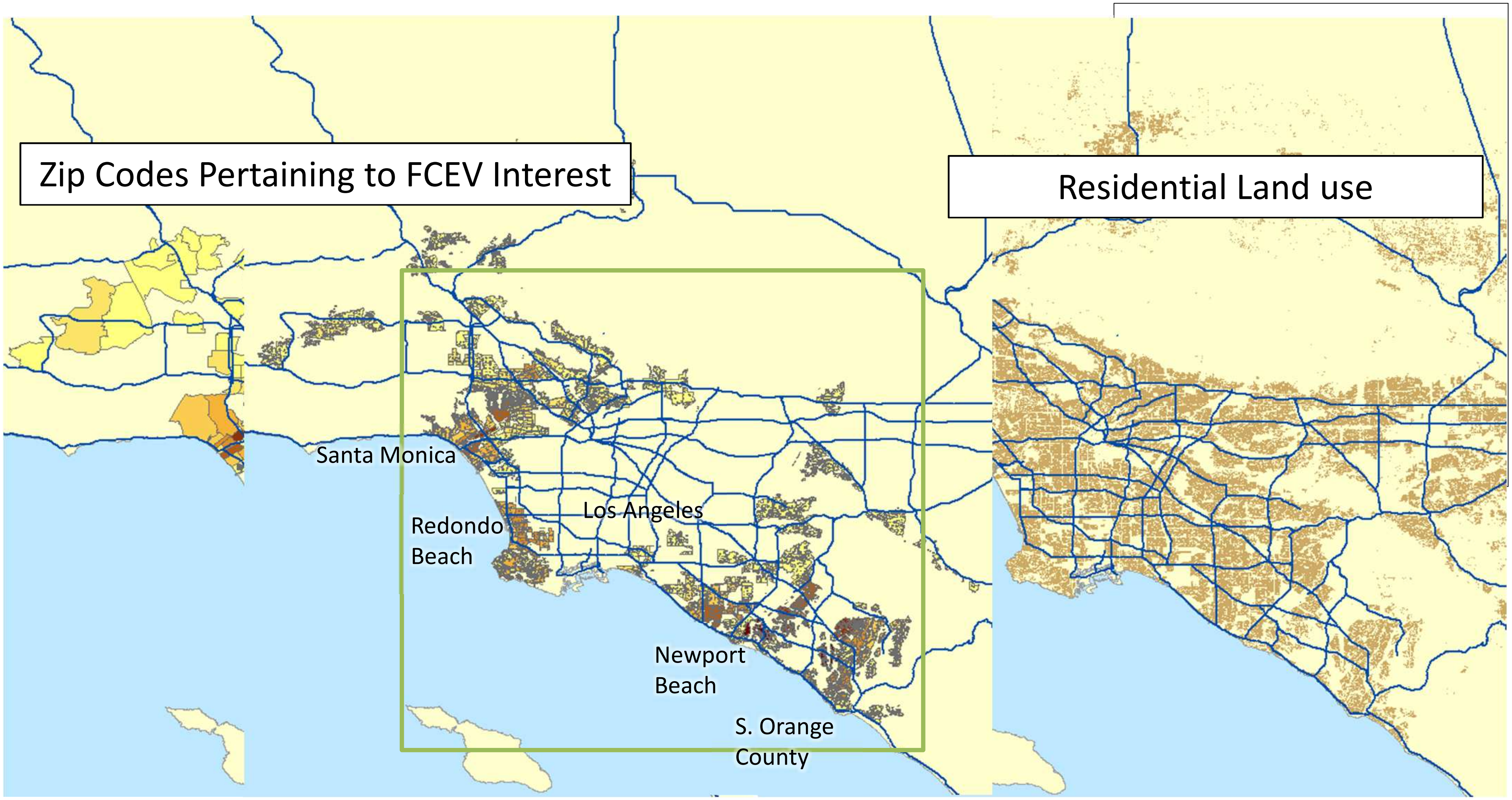
A sufficient refueling network must be established prior to commercial vehicle launch to alleviate early consumer concerns about hydrogen availability

The Advanced Power and Energy Program at UC Irvine has developed the STREET methodology to optimize infrastructure placement based on:

- *Automaker market data*
- *Travel-time algorithms*
- *Station land use*
- *Vehicle travel density*
- *Service coverage*
- *FCEV deployment*
- *Existing hydrogen infrastructure*
- *Population centers and demographics*

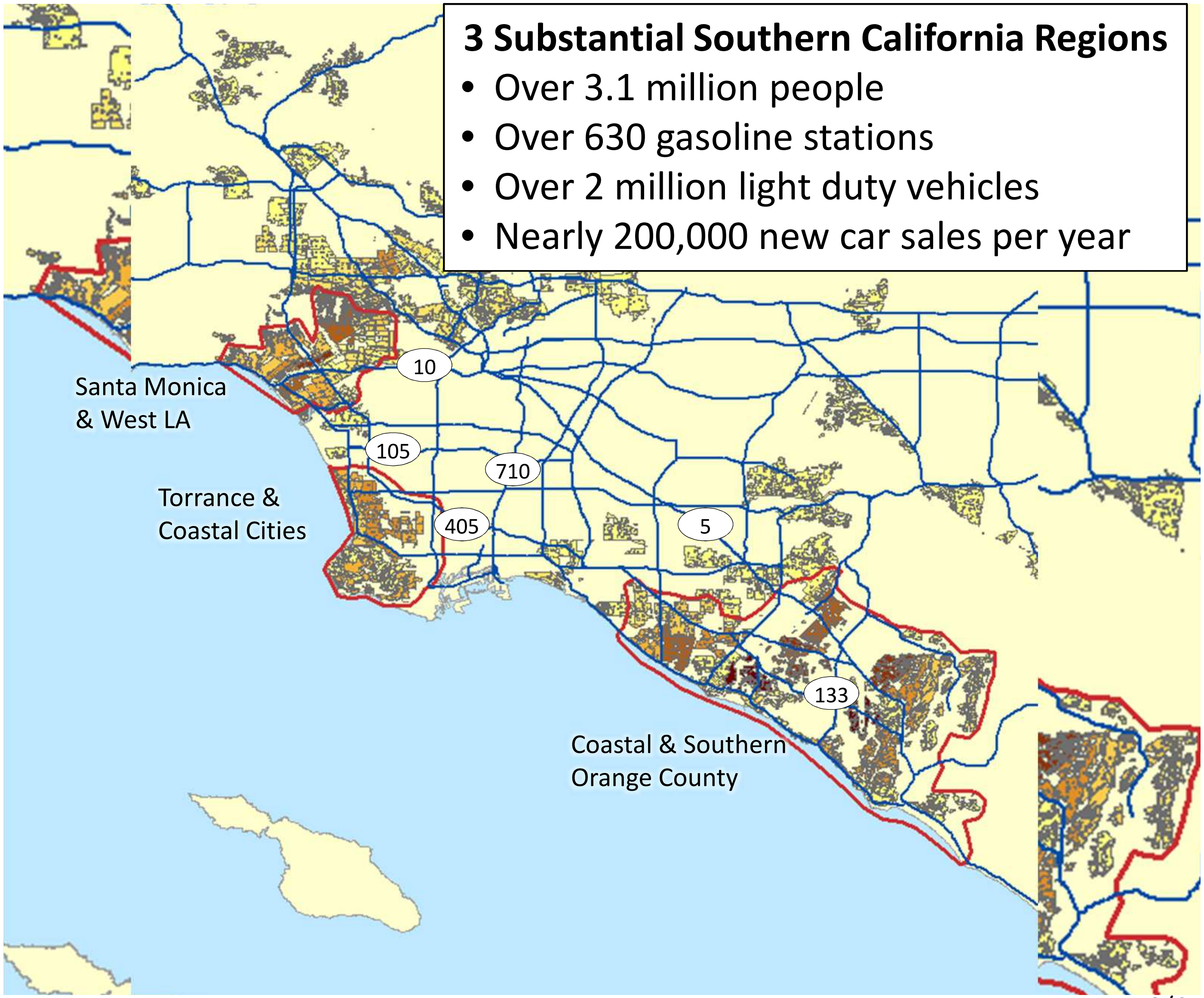


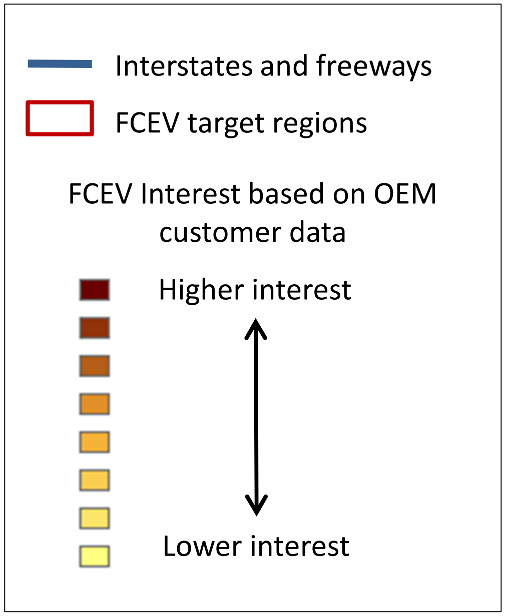
Defining FCEV Regions



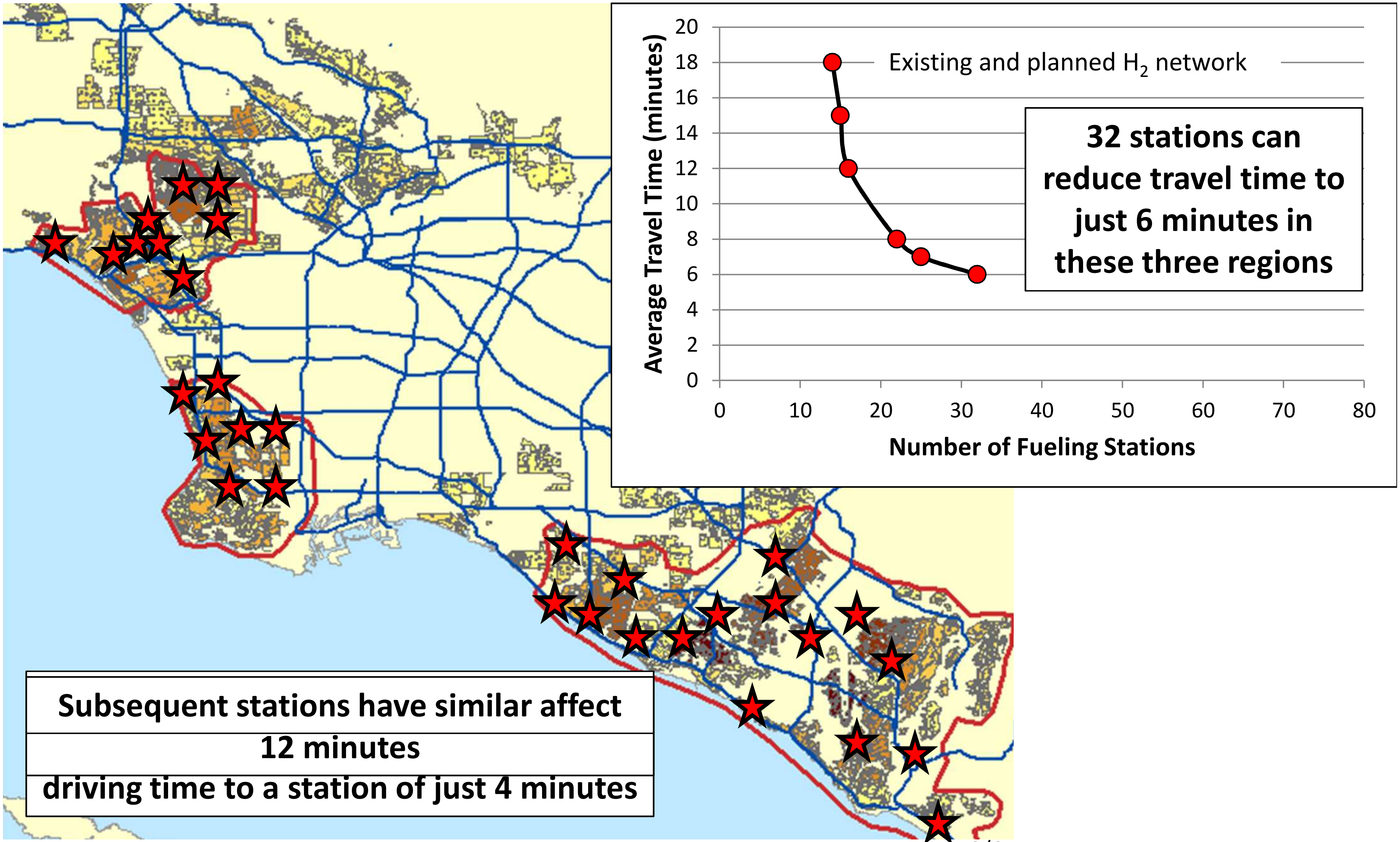
Southern California - Coverage

3 Substantial Southern California Regions
- Over 3.1 million people
- Over 630 gasoline stations
- Over 2 million light duty vehicles
- Nearly 200,000 new car sales per year



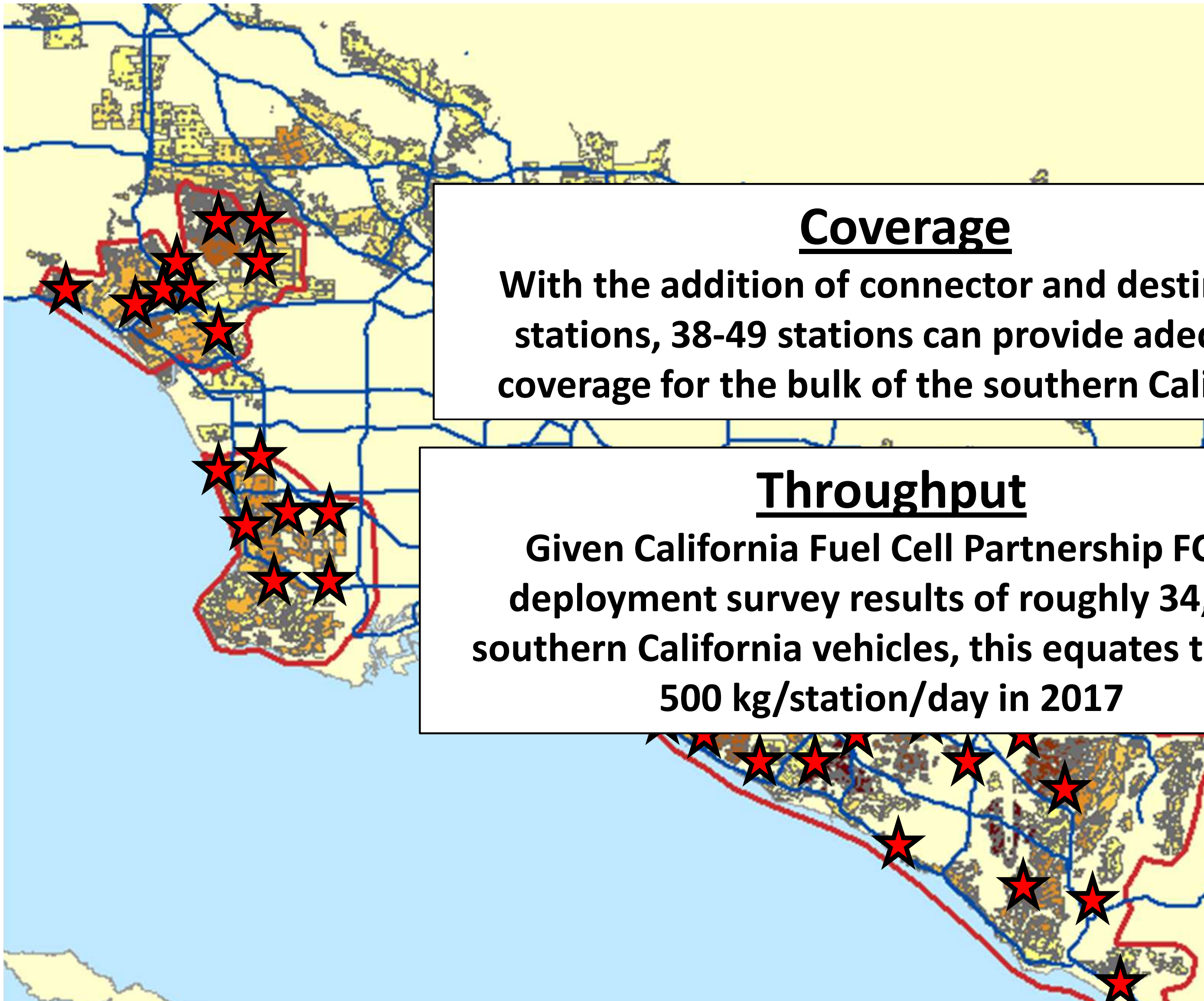


Southern California - Coverage



Subsequent stations have similar affect
12 minutes
driving time to a station of just 4 minutes

Southern California



Coverage

With the addition of connector and destination stations, 38-49 stations can provide adequate coverage for the bulk of the southern California

Throughput

Given California Fuel Cell Partnership FCEV deployment survey results of roughly 34,000 southern California vehicles, this equates to over 500 kg/station/day in 2017

Benefits of Careful Planning

Optimized infrastructure siting can:

- Reduce capital investment *(6%-7% of existing gasoline stations in target regions to achieve tipping point)*
- Increase network effectiveness *(travel time of 6 minutes)*
- Promote high fuel throughput *(over 500 kg/station/day in 2017)*

Acknowledgements

U.S. Department of Energy

California Energy Commission

California Air Resources Board

South Coast Air Quality Management District

San Joaquin Air Pollution Control District

General Motors

Air Products

Toyota

Honda

Hyundai

Mercedes-Benz

Nissan

Shell Hydrogen

Linde

Using STREET* to Find the Hydrogen Infrastructure Tipping Point with Minimum Capital Investment

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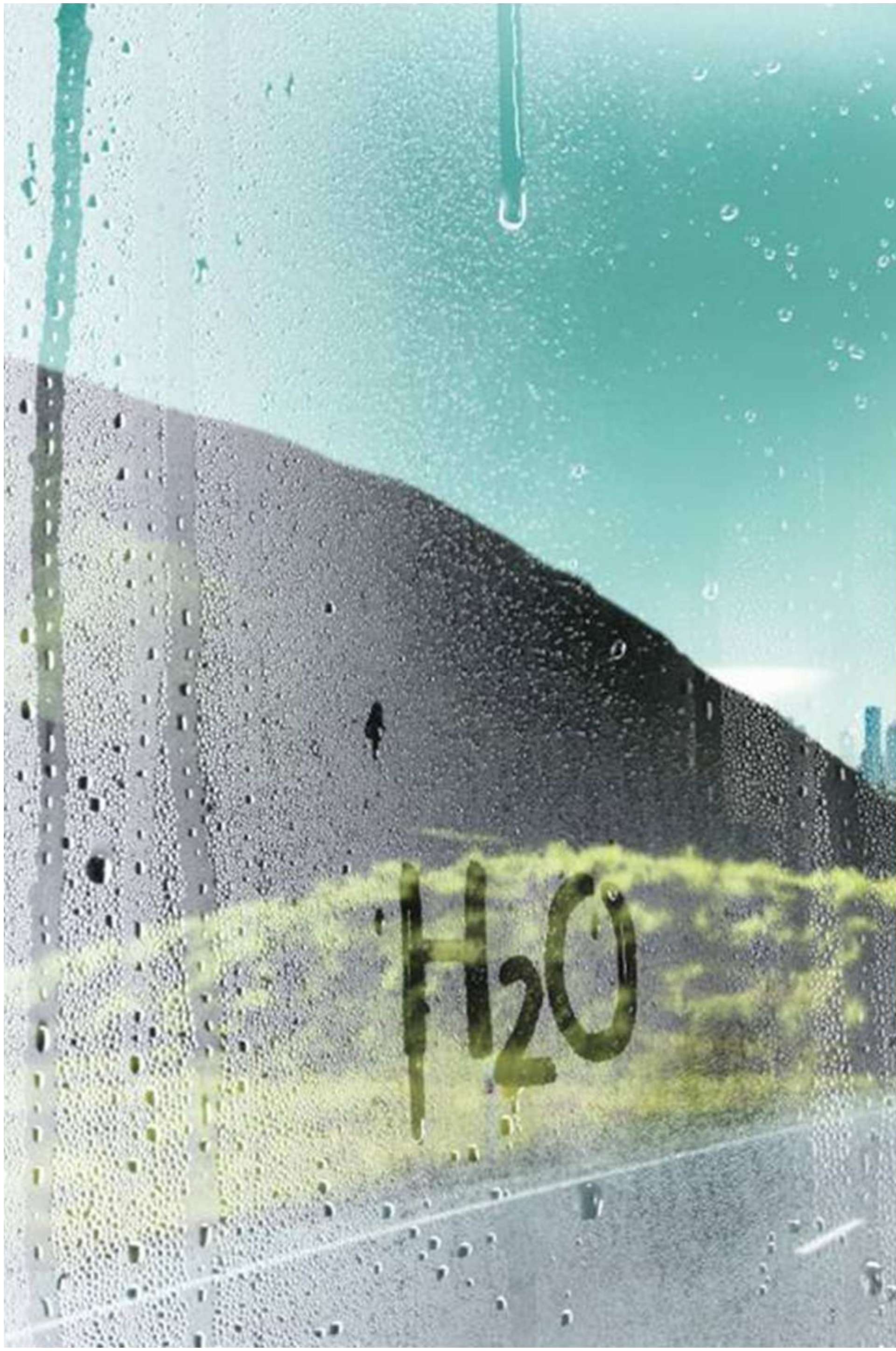
June 23, 2011

Steve Eckhardt

Linde, North America



Hydrogen and Fuel Cell Showcase

California Air Resources Board

June 23, 2011

LeadIng.

THE LINDE GROUP

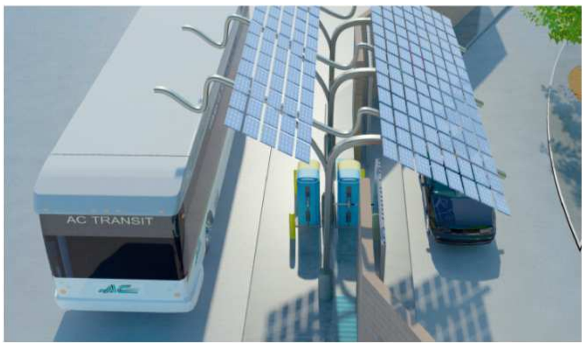
Steve Eckhardt, Head of Business Development, Alternative Energy, Linde North America

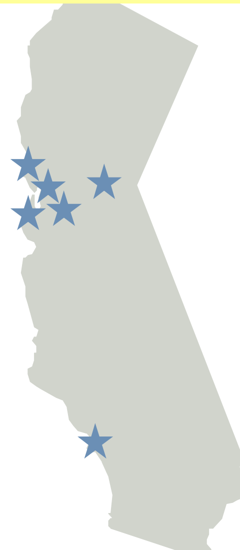
Linde's hydrogen fueling expertise

THE LINDE GROUP

Over 70 hydrogen fueling stations worldwide
Over 200,000 safe hydrogen fuelings
Auto, material handling, bus fueling
Liquid and gas hydrogen production – central & on-site

AC Transit
Ionic – high throughput gas compression





Shell Berlin
Cryogenic liquid pump, underground storage

Mobile Fueling Options
700 bar, 350 bar

Auto stations – AB118 CEC funding
High performance, compact, relocatable

Hydrogen Dispensing
Reliability, convenience, speed

Fuel cell vehicles projections for California

THE LINDE GROUP

2010 CaFCP survey of automaker passenger fuel cell vehicles

	Hundreds	Thousands	Tens of thousands
	Through 2013	2014	2015-2017
Total Passenger Vehicles	**430**	**1,400**	**53,000**

The industry must show how we can fuel these vehicles

Significant increase in hydrogen demand is near….

	2014	**2015**	**2016**	**2017**
Fuel Cell Vehicles in California	1,400	13,250	26,500	53,000
Hydrogen Demand (kg/day)	**1,400**	**13,250**	**26,500**	**53,000**

Assumptions:

1. CaFCP Feb 2011 Progress Report - 2015-2016 figures are not part of CaFCP Progress Report
2. FCV H2 consumption of 1.0 kg per day

A proposed mix of stations…..

THE LINDE GROUP

	2014	2015	2016	2017
Fuel Cell Vehicles in California	1,400	13,250	26,500	53,000
Hydrogen Demand (kg/day)	**1,400**	**13,250**	**26,500**	**53,000**

Stations (kg per day)	
Small station	100
Medium station	200
Large station	750
Very large station	1,500

Assumptions:

1. CaFCP Feb 2011 Progress Report - 2015-2016 figures are not part of CaFCP Progress Report
2. FCV H2 consumption of 1.0 kg per day

High throughput stations are an important component for FCV commercialization

	2014	2015	2016	2017
Fuel Cell Vehicles in California	1,400	13,250	26,500	53,000
Hydrogen Demand (kg/day)	**1,400**	**13,250**	**26,500**	**53,000**

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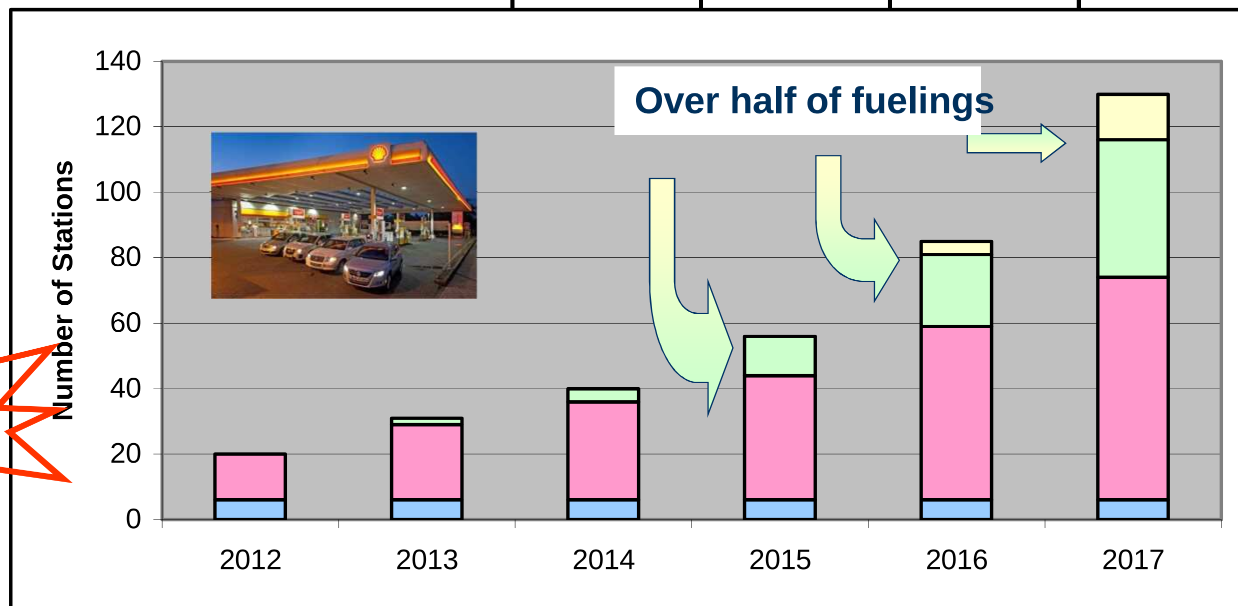
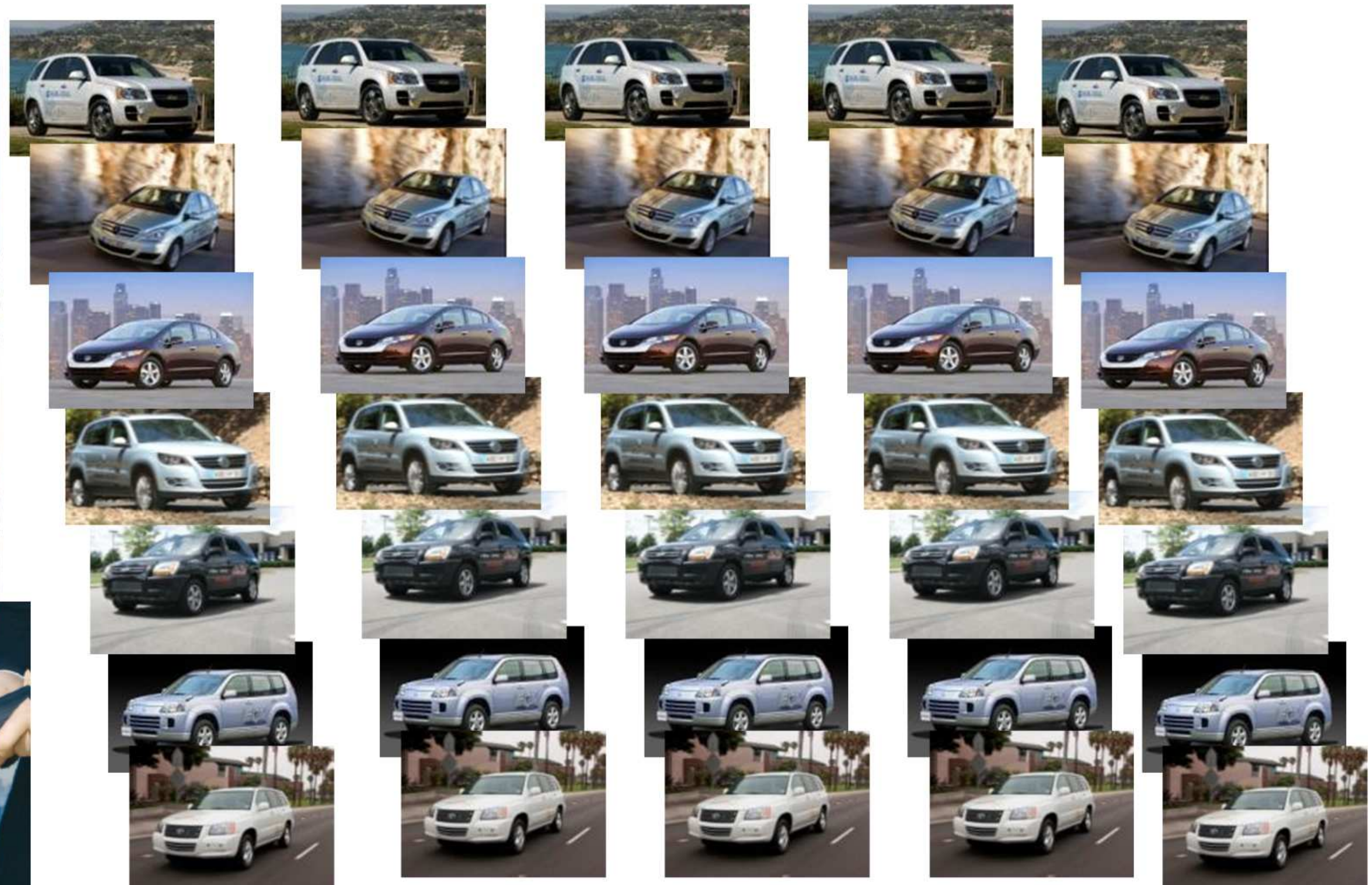


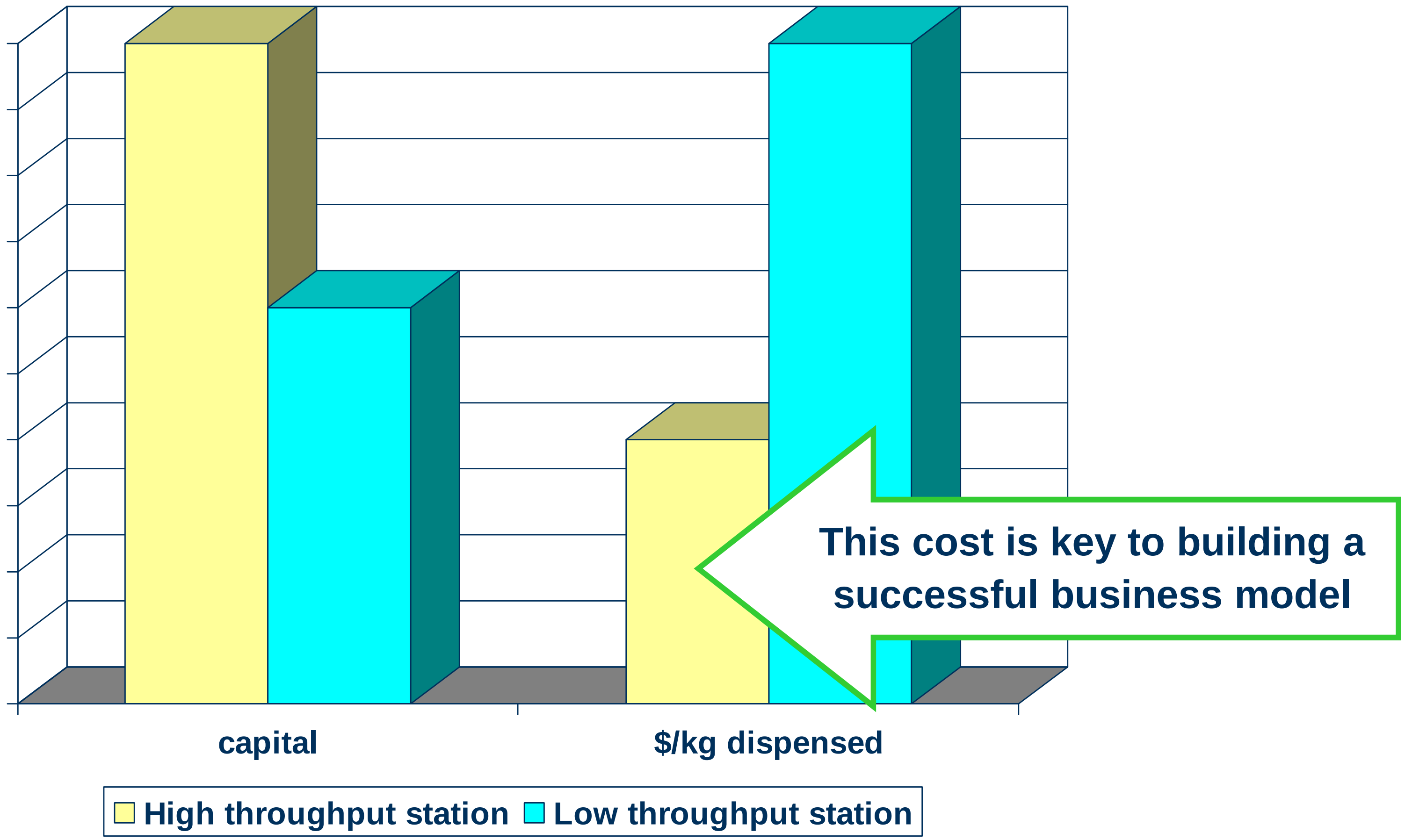
Assumptions:
1. CaFCP Feb 2011 Progress Report - 2015-2016 figures are not part of CaFCP Progress Report
2. FCV H2 consumption of 1.0 kg per day
3. Stations operate at 80% capacity utilization

Show stakeholders we can really fuel hundreds of cars a day on one site and meet driver/customer expectations



High throughput stations…….Prove economics

THE LINDE GROUP



High throughput stations…….Prove technology

THE LINDE GROUP

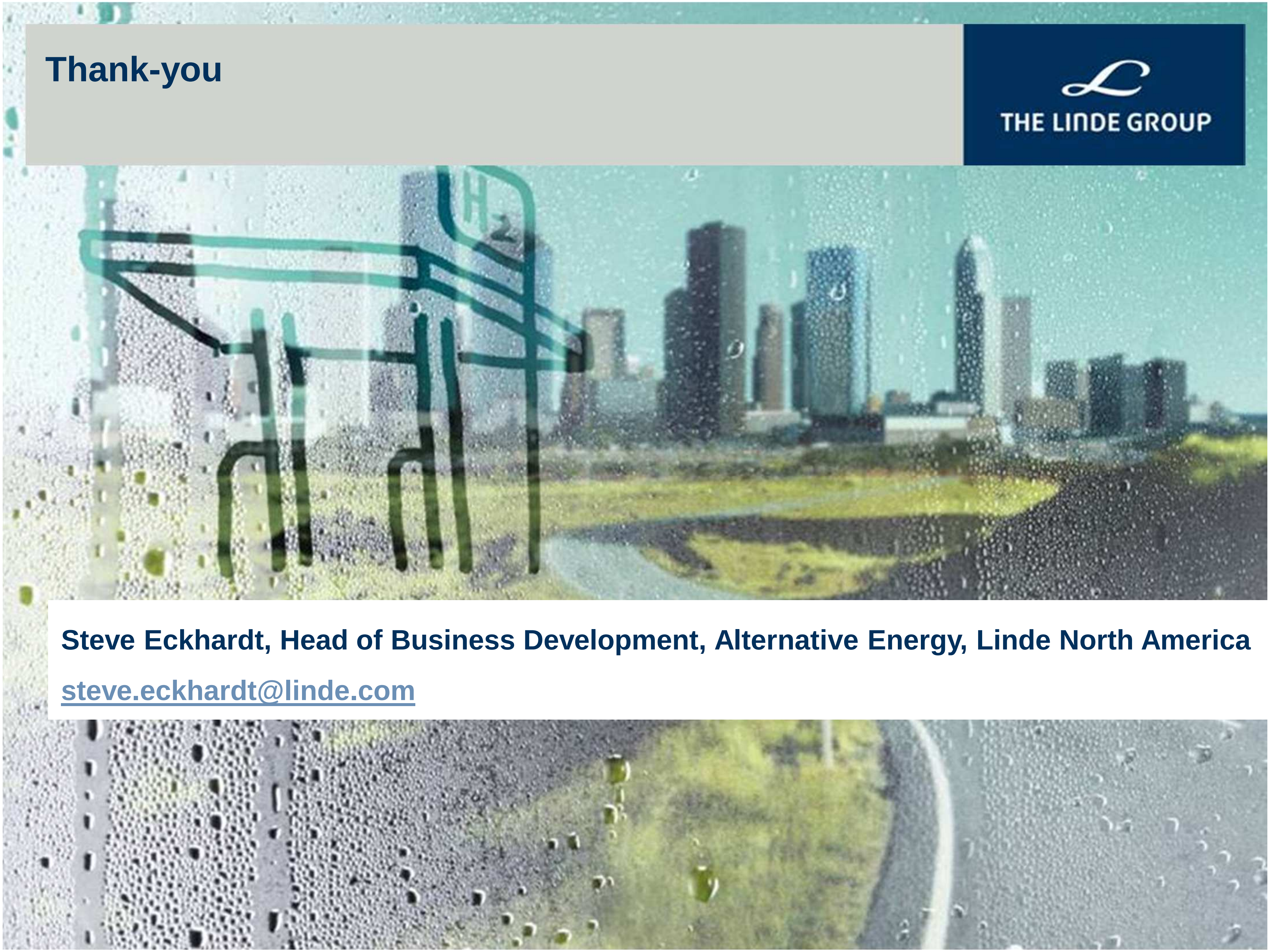
Fueling Technology

	Description	Capacity	Pressure
MF90 	Lubricant free piston compression	100-240 kg/day	450/900 bar
Ionic 	Ionic liquid as piston for compression.	500-1500 kg/day	450/900 bar
Cryo 	Efficient compression of liquid hydrogen for gaseous fueling	Over 2000 kg/day	450/900 bar

Linde high throughput station technology http://www.zeroemissionvehicles.eu/

Thank-you

THE LINDE GROUP



Steve Eckhardt, Head of Business Development, Alternative Energy, Linde North America

steve.eckhardt@linde.com

Edward F. Kiczek

Air Products and Chemicals Inc.

AFFORDABLE HYDROGEN FROM NEW APPROACHES TO HYDROGEN INFRASTRUCTURE

23 June 2011

Edward F. Kiczek
Global Director - Hydrogen Energy Systems

For: CARB- Hydrogen and Fuel Cell Showcase
Sacramento , CA

50+ Years of Hydrogen Experience

- World's largest merchant supplier
- H_2 production equivalent to fueling ~8 Million cars/day. Three major facilities in California.
- Bulk, liquid and pipeline distribution
- H_2 Energy projects since 1993
  - >130 hydrogen station projects
  - >350,000 fuellings/yr
- Stations in 19 countries
- Parlayed material handling, cell tower and DOD experiences

AIR PRODUCTS

Commercial Markets, Today !

Forklifts

Planes ,UAV's

Distributed Power

Cell Towers

Submarines, UUV's

AIR PRODUCTS

Breakthrough Supply Platforms

HP Composite Bulk Storage. Multi-capable Liquid trailer.

- New high pressure composite trailer* and dual phase tankers* have cut the cost of dispensed H2
  - – Deliver vs. generating high pressure onsite
  - – On the road in the U.S. and E.U.
- Dispensed priced competitive with gasoline !

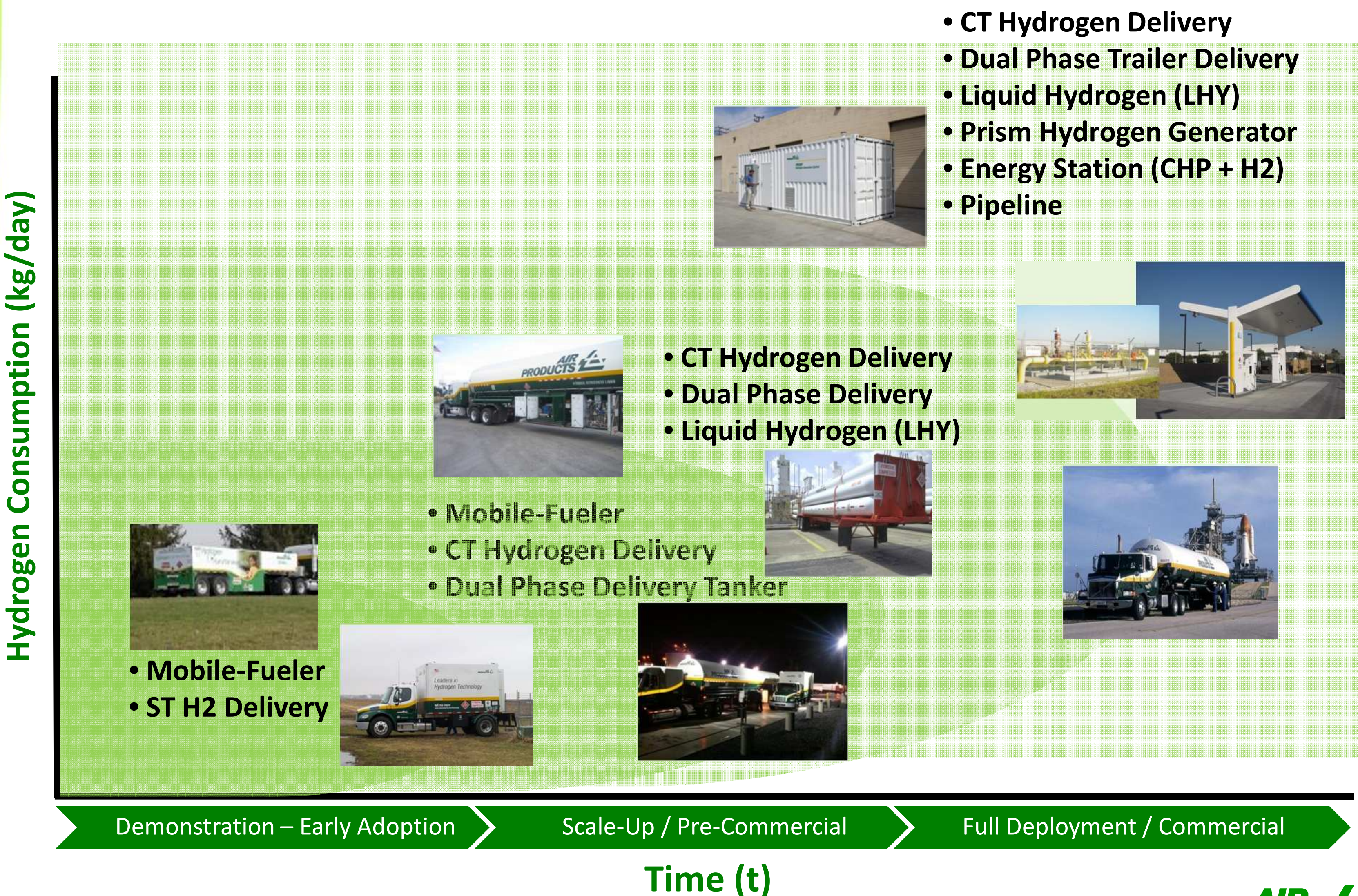
Composite Trailer

Dual Phase Trailer

*AP patented/patents pending

AIR PRODUCTS

Air Products Offers Unmatched Hydrogen Supply Capabilities to Most Effectively Serve Customers Throughout the Complete Transition to Hydrogen



AIR PRODUCTS

CARB/CEC H2 Fueling Station Award

- Deploying 9 stations with this platform
- Supported by CEC, CARB and SCAQMD funding
- Harbor City in Construction and supported via CARB
- Collaborating with the OEM's for station placement
- Can be located at most existing stations
- Station is modular, expandable, redeployable.
- AP has a portfolio of products from100kg/day to mega stations via proprietary patented technologies
    - Manages the customer thru the demand cycle

Harbor City

AIR PRODUCTS

Immediate Impact to California

- Economic benefits
  - Hydrogen sourced from upgraded CA facilities
  - Delivery systems sourced from CA suppliers
  - Station construction
- Supports ~240 jobs

AIR PRODUCTS

Challenges

- Business case for early deployments
  - Lack of volume
- 30-40 early "subsidized" stations in a region should develop the sustained business case per UCI STREET modeling.
- Sustained business case could attract:
  - $150-300MM of investment in SoCal (by 2020)
  - ~$900MM for all of CA station infrastructure
  - ~$300M in commensurate H_2 production facilities

Summary

- New approaches to hydrogen distribution are enabling market development of fuel cell markets. Reconfigured supply chains "fit for purpose" to supply fuel cell vehicle markets.
- Hydrogen infrastructure capital cost have been lowered to spur early commercial market development.
- Total cost of ownership of hydrogen fuel is affordable to gasoline for large percentage of light-duty vehicle market.
- Programs are underway to demonstrate robustness of our new business model and continued support is required to achieve commercial sustainability.

AIR PRODUCTS

Tell me more !

www.airproducts.com/H2energy

Dr. Scott Samuelsen

National Fuel Cell Research Center

UC Irvine

Orange County Sanitation District
Energy Station

National Fuel Cell Research Center

University of California, Irvine
http://www.apep.uci.edu

Scott Samuelsen, Director
June 23, 2011

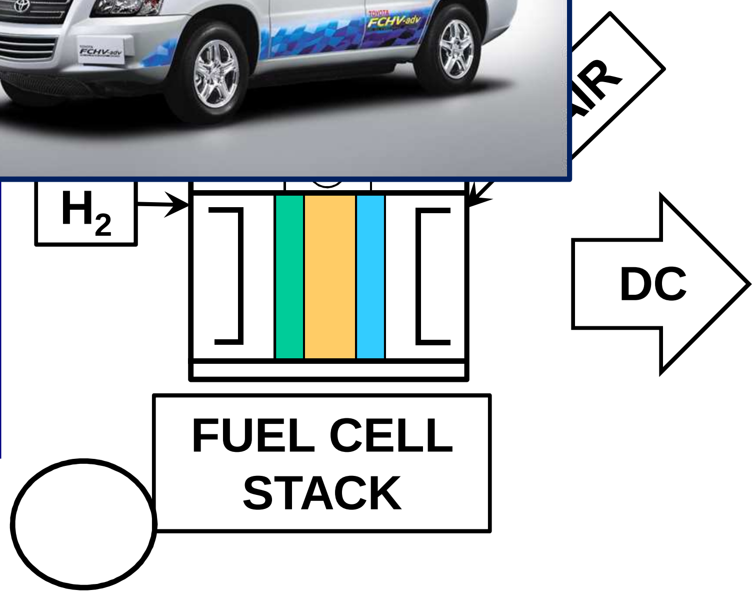
California
FUEL CELL
PARTNERSHIP
DRIVING FOR THE FUTURE

CaSFCC
California Stationary
Fuel Cell Collaborative

NEXUS: ELECTRICITY and HYDROGEN

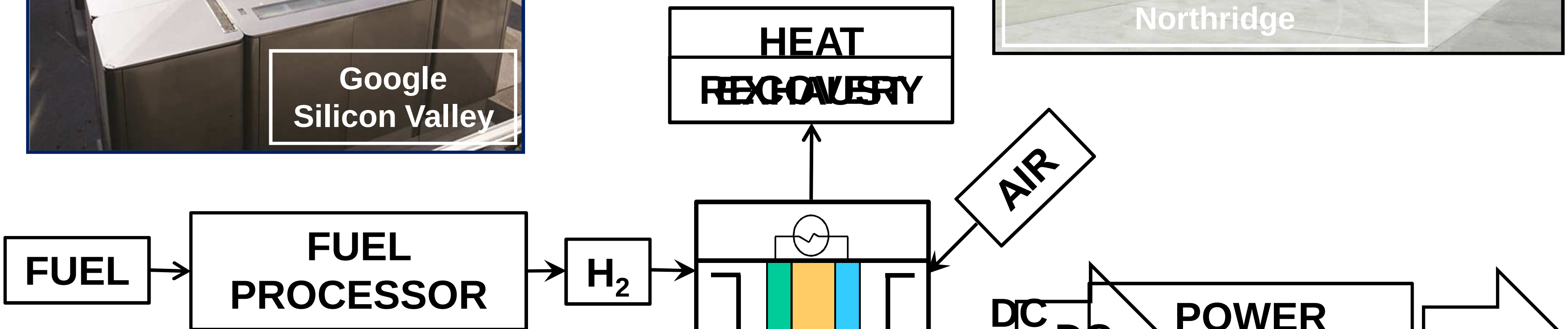
NFCRC

FUEL CELL



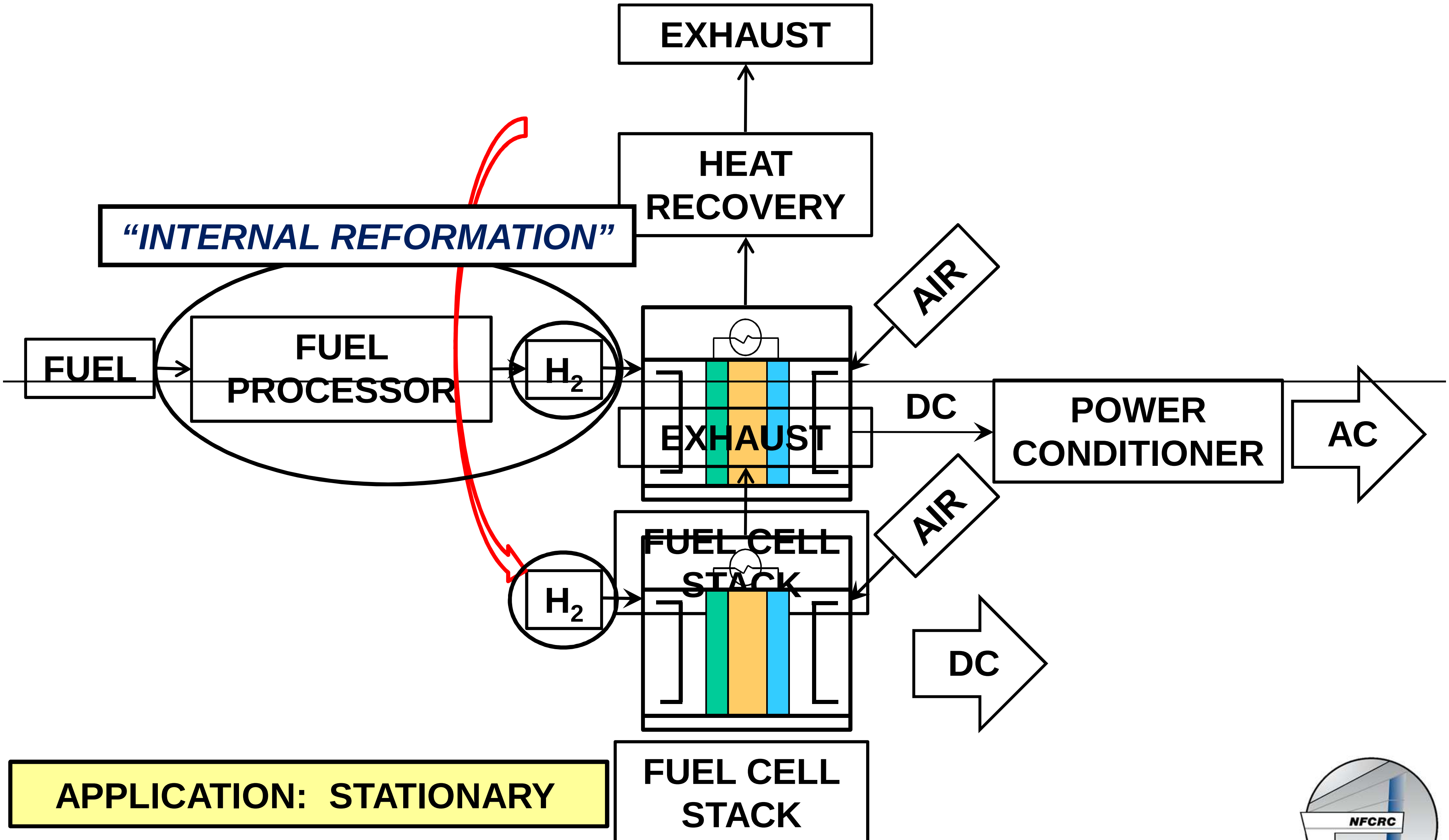
APPLICATION: AUTOMOBILE

FUEL CELL



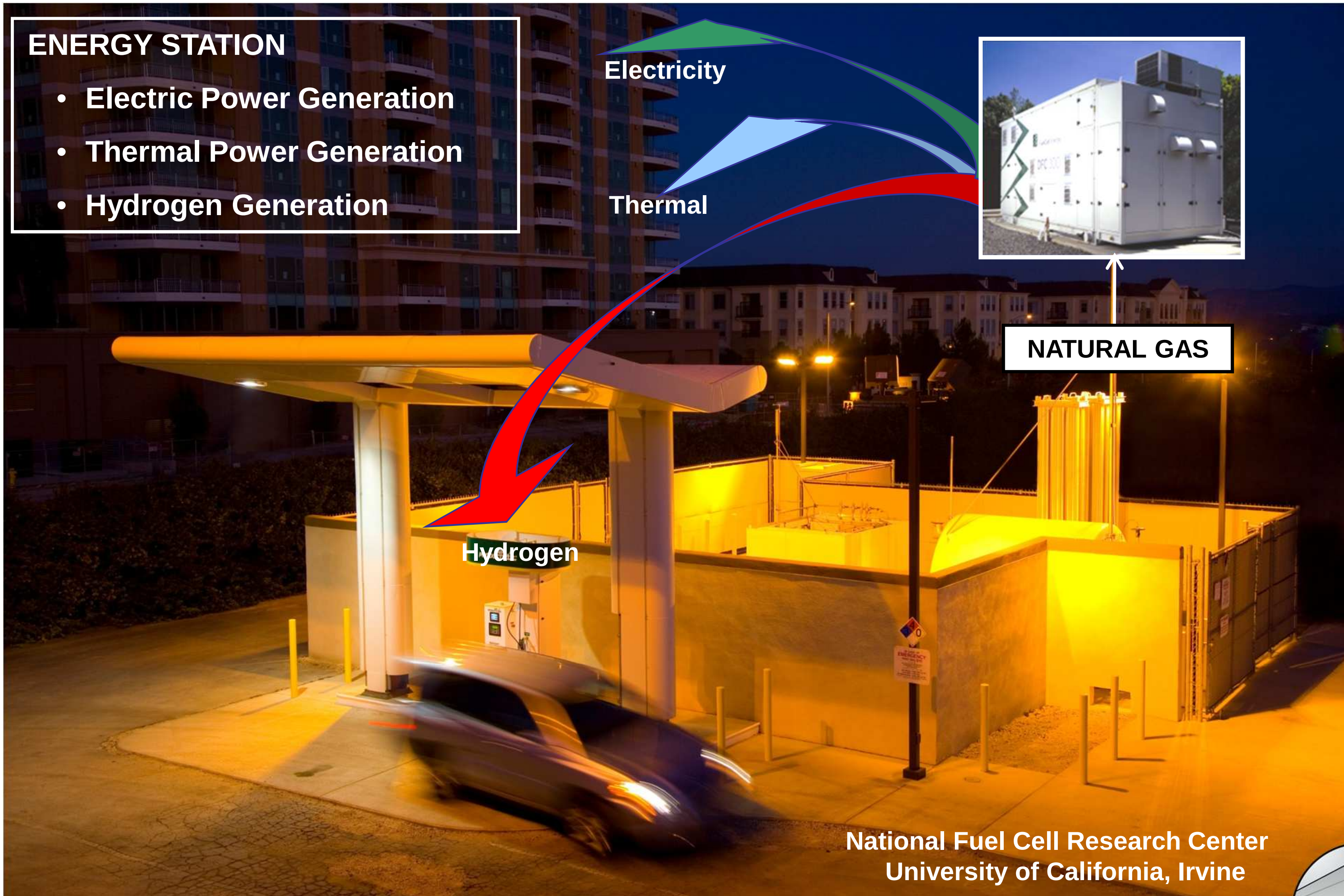
APPLICATION: AUTOMOBILE

HIGH-TEMPERATURE FUEL CELL (HTFC)

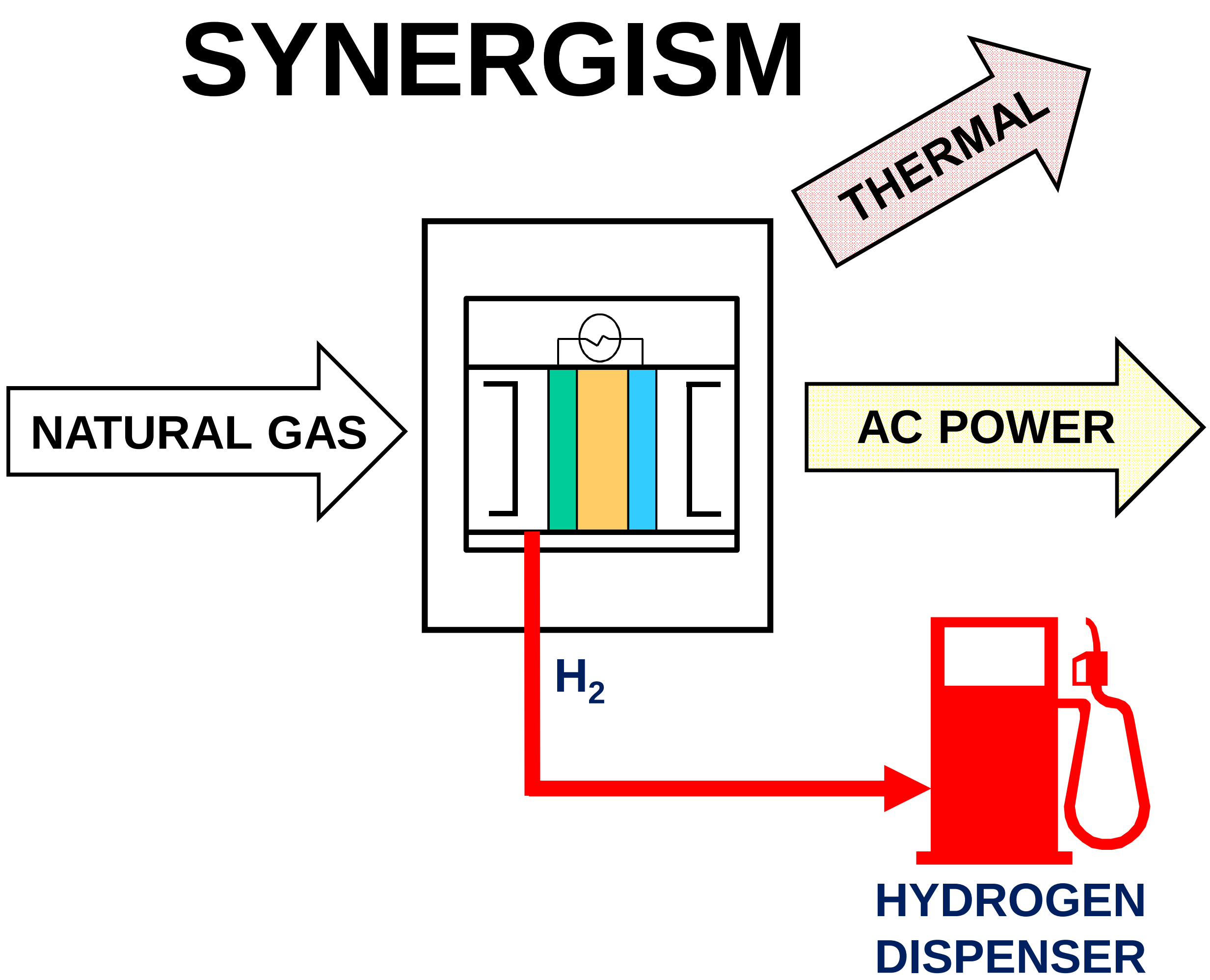


APPLICATION: STATIONARY

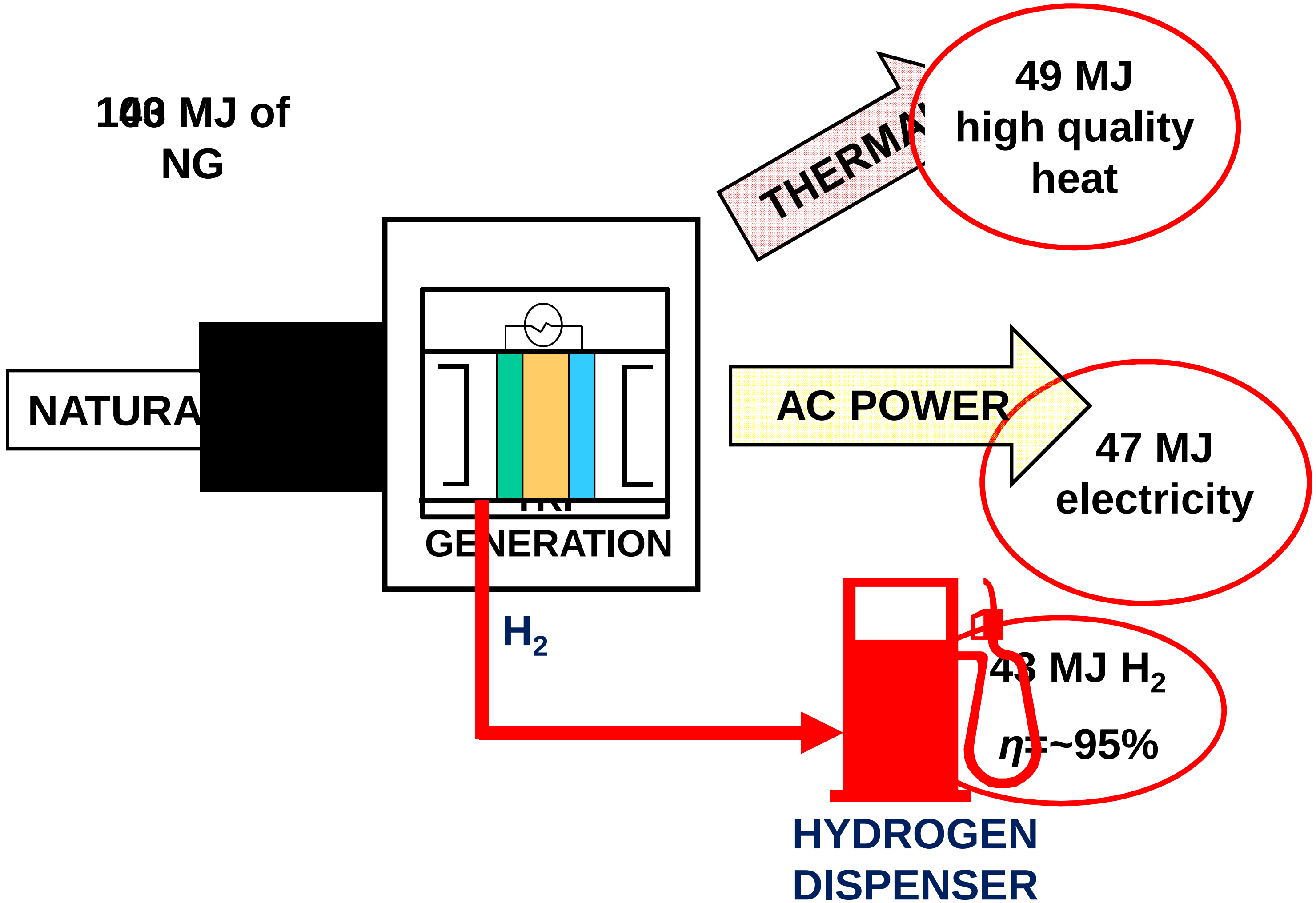
HTFC WITH H_2 TRI-GENERATION



HTFC WITH H_2 TRI-GENERATION

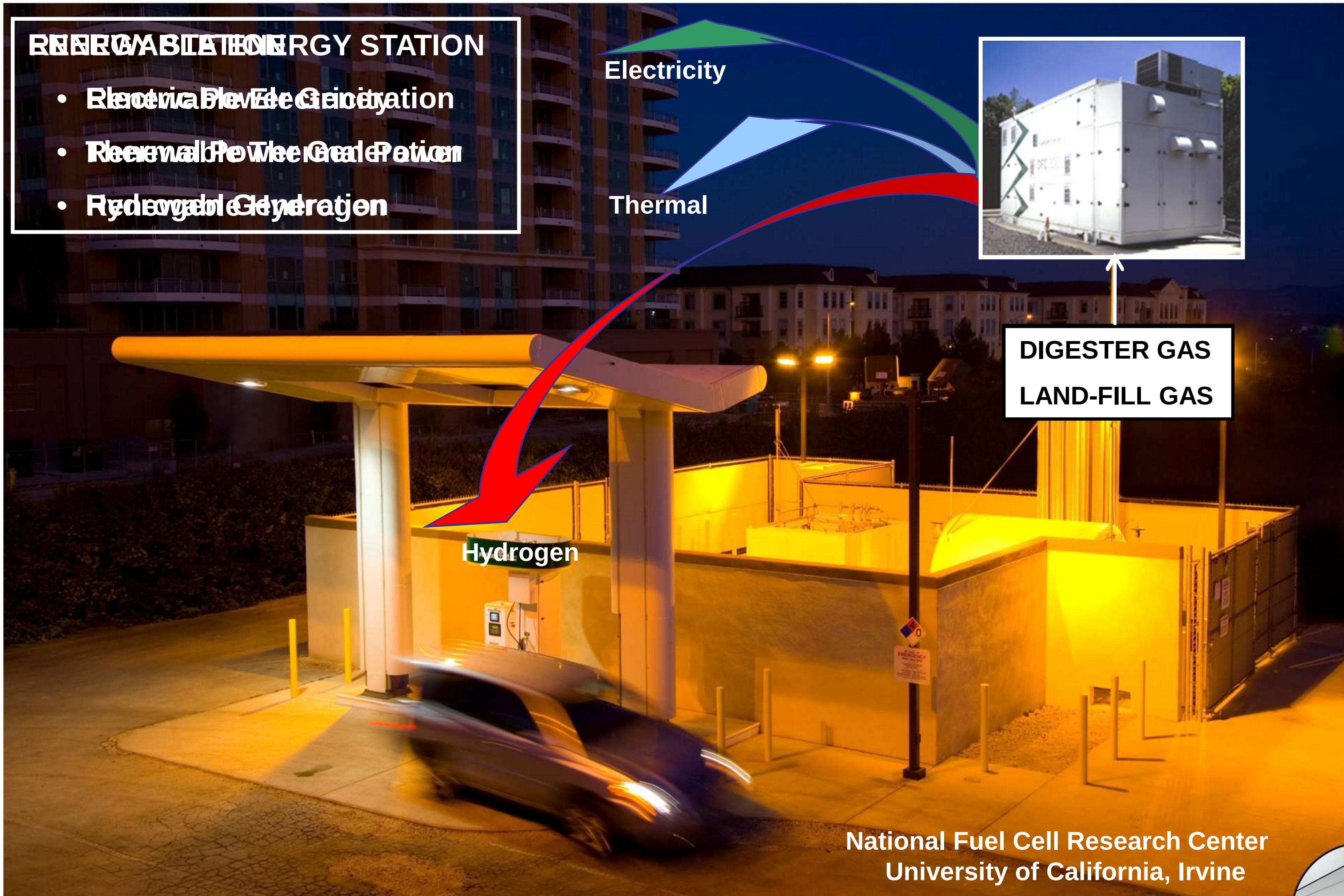


SYNERGISM



NG
NATURA
GENERATION
THERMAL
49 MJ
high quality
heat
AC POWER
47 MJ
electricity
H_2
43 MJ H_2
η = ~95%
HYDROGEN
DISPENSER

HTFC WITH RENEWABLE H_2 TRI-GENERATION



HTFC WITH RENEWABLE H_2 TRI-GENERATION

Orange County Sanitation District Energy Station

National Fuel Cell Research Center

University of California, Irvine
http://www.apep.uci.edu

Scott Samuelsen, Director

June 23, 2011

Hydrogen and Fuel Cells in California

* Fuel cells and hydrogen are ready for commercialization in California