The Inevitable Plug: The Case for Plug-in Cars

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Plug In America

San Francisco Electric Vehicle Association

We love cars.

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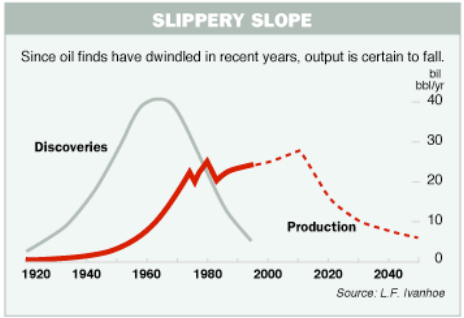
The major problem with cars today is the fuel.

- Pollution
- Global warming
- Political and economic consequences of petroleum dependency
- Peak oil



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- 99% of US motor vehicles use petroleum.
- U.S. imports 55% of its petroleum.
- Cars & trucks use more than 2/3 of all petroleum in U.S. and 1/3 of all energy.
- Emissions from cars & trucks cause 75% of smog in the Bay Area. (Bay Area Air Quality Management Board)
- Send billions overseas to buy petroleum and spend billions on our military to assure its delivery.

Sherry Boschert, *Plug-in Hybrids: The Cars that Will Recharge America,* 2006

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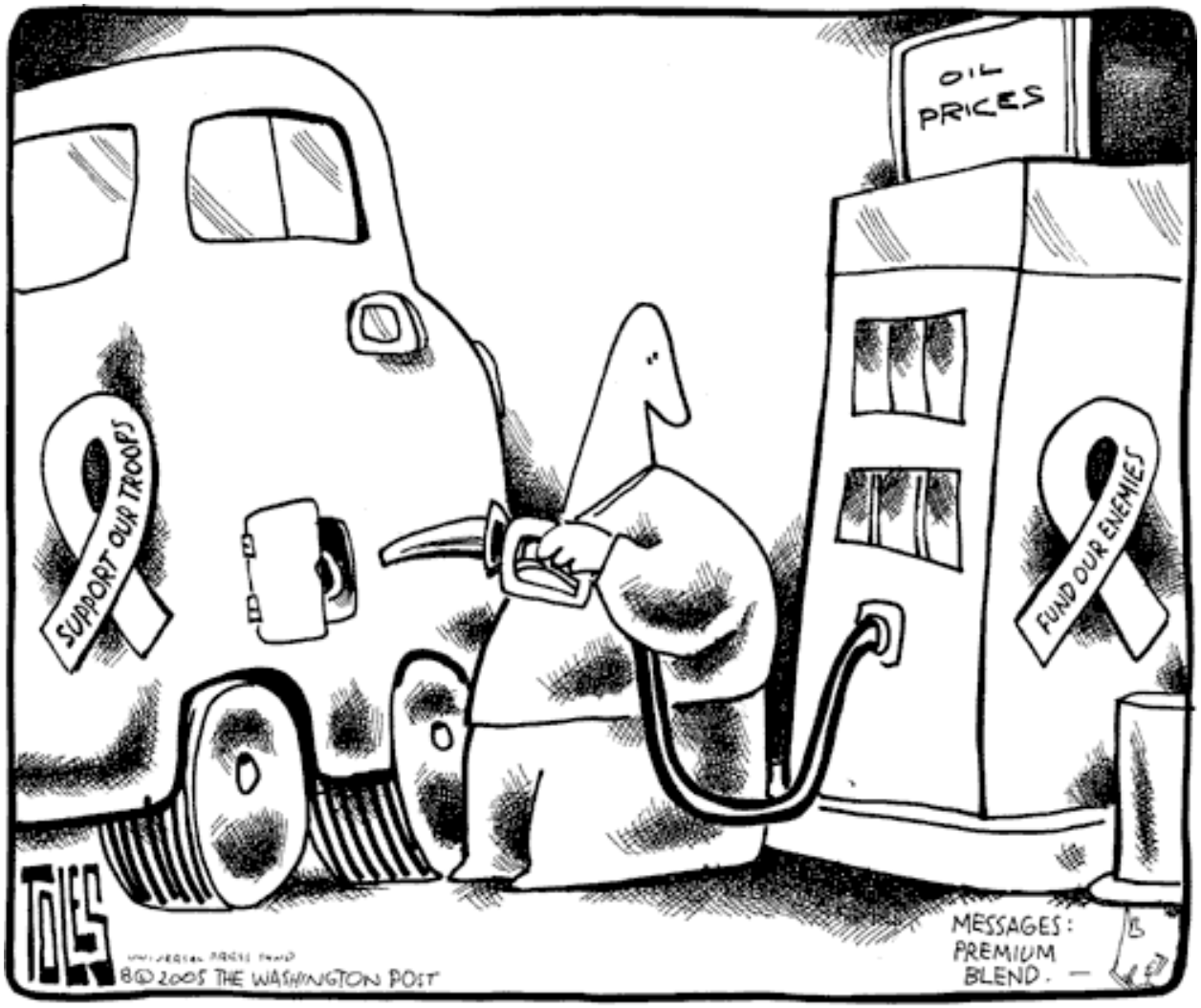

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Simply using less petroleum doesn't solve our problem. We need:

Marketable, economic, zero-emission, zero-carbon, zero-petroleum cars.

What are our options?
How do we get there?

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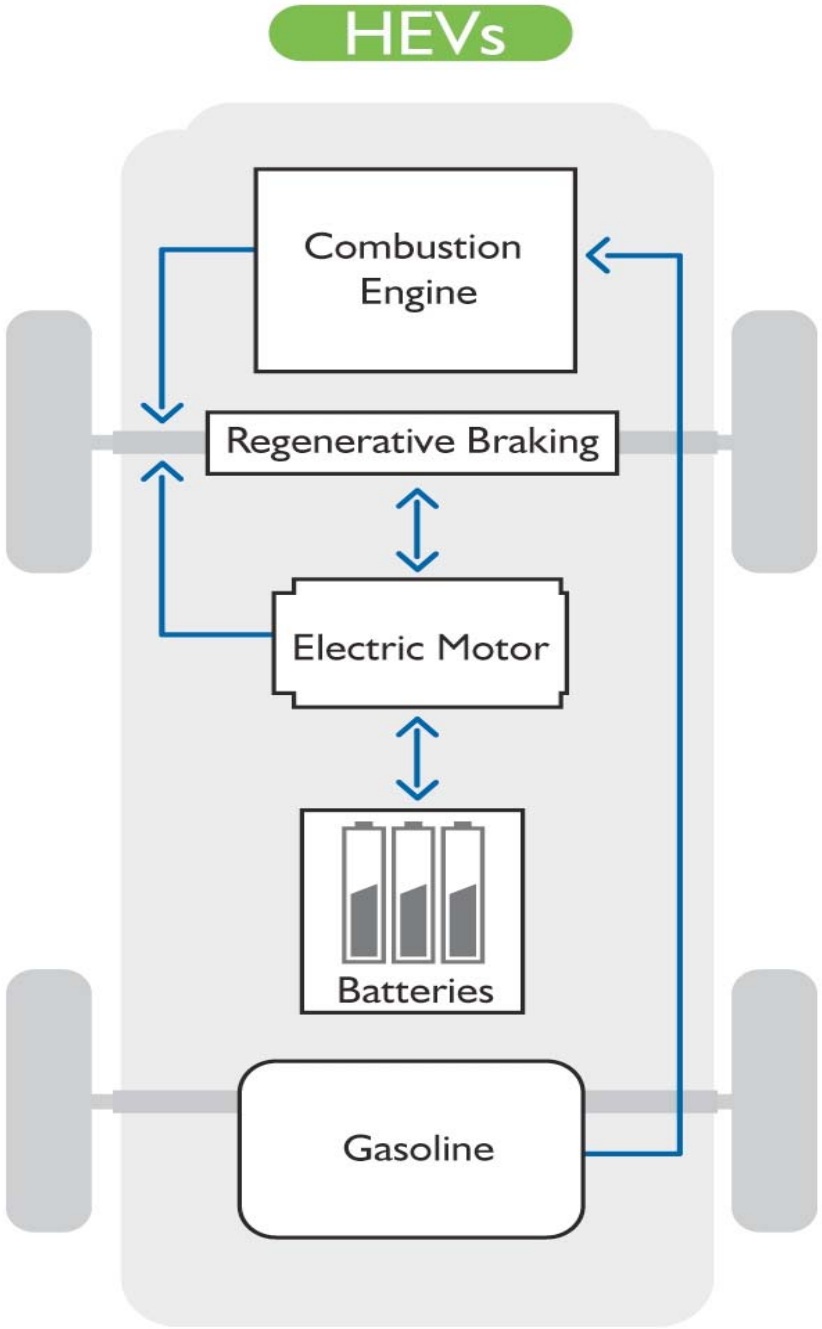
- **Internal combustion engine (ICE)**

- **Compressed Natural Gas ICE Vehicle (CNG)**
- **Bio-diesel ICE (B10; B99; B100)**
- **Ethanol ICE (E10; E85; E100)**
- **Hydrogen ICE**

- **Battery electric vehicle (BEV)**
- **Hybrid gas-electric vehicle (HEV)**
- **Plug-in hybrid electric vehicle (PHEV)**

- **Hydrogen fuel-cell electric vehicle (FCEV)**
- **Hydrogen fuel-cell hybrid (FCHV)**
- **Hydrogen fuel-cell plug-in hybrid (FCPHEV)**



Courtesy
Electric Drive
Transportation
Association

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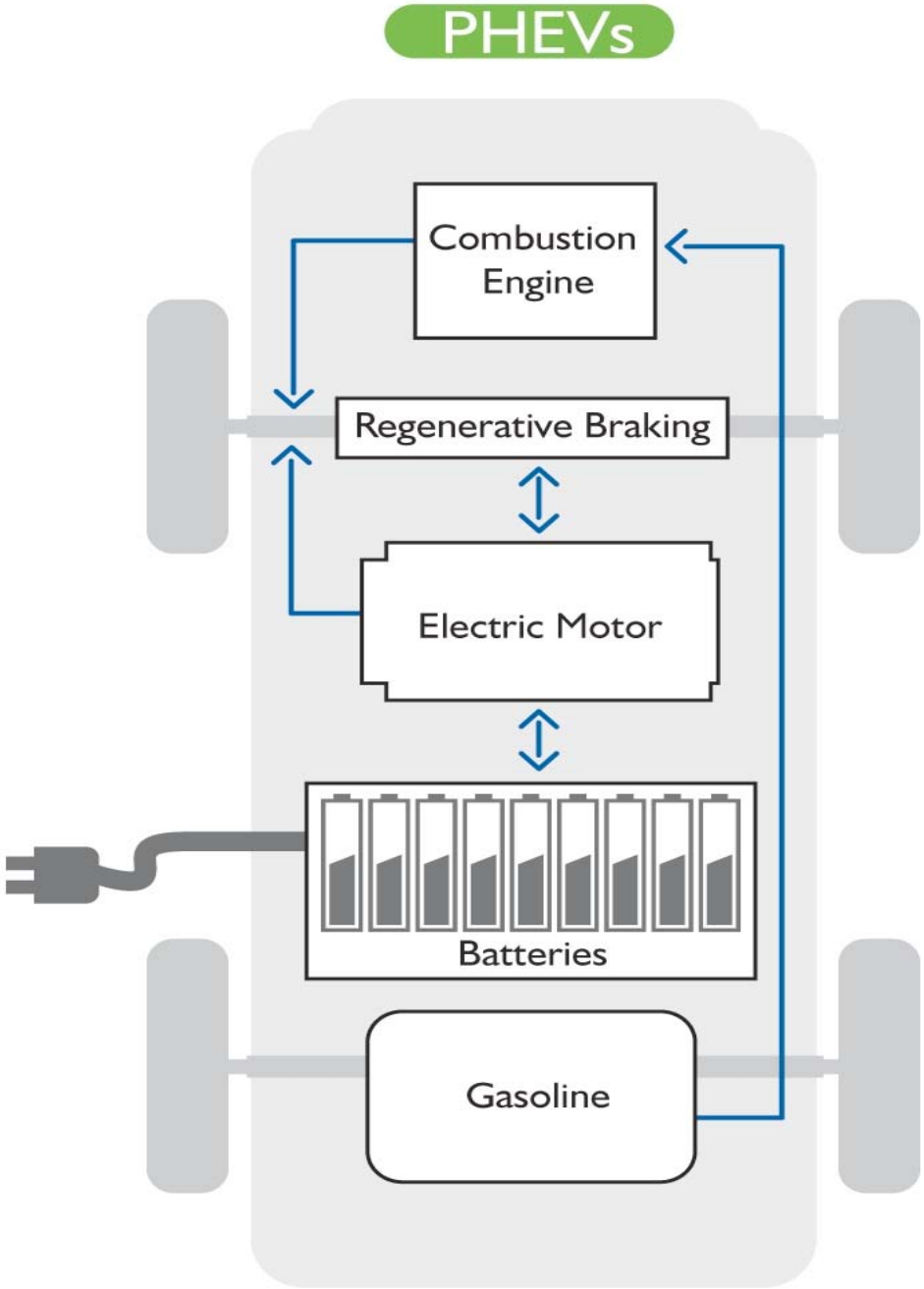

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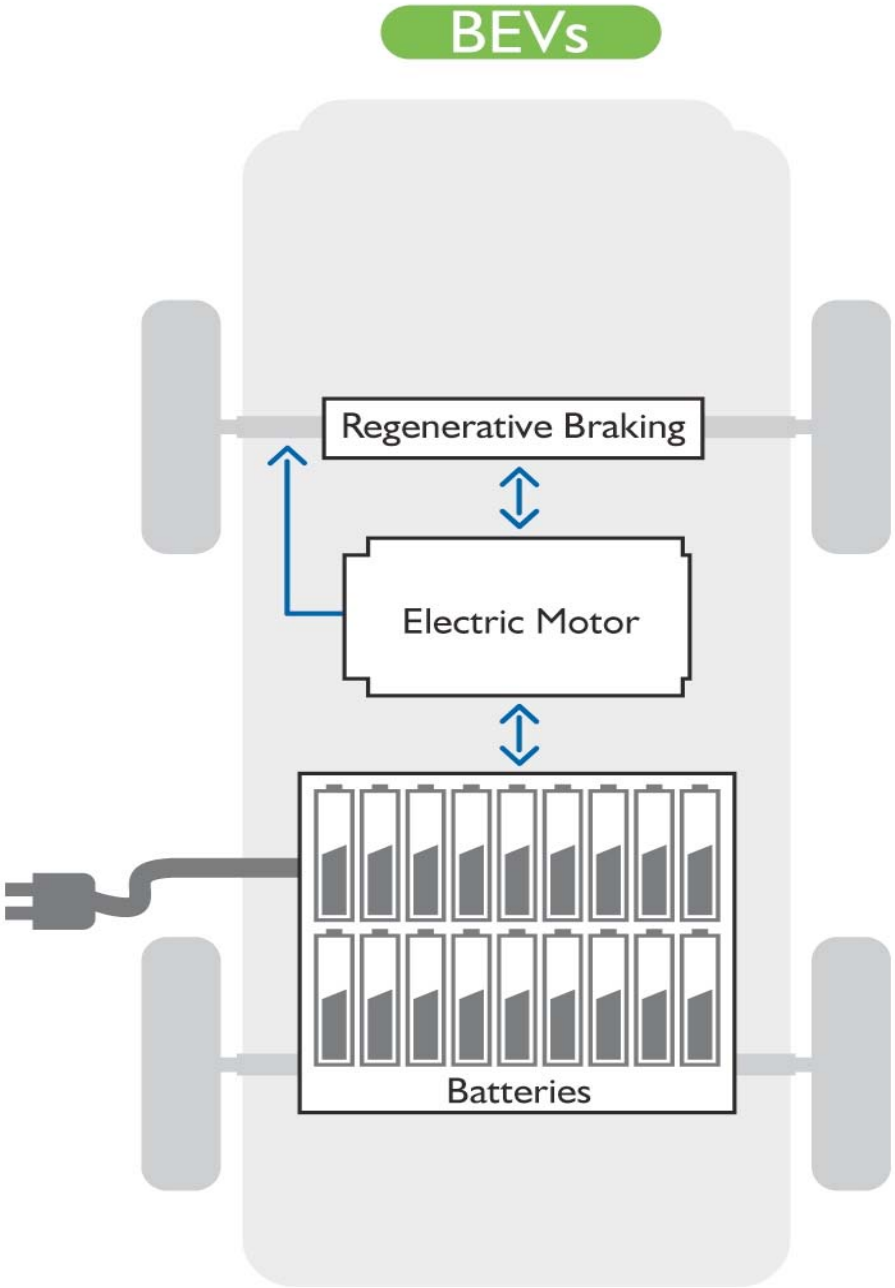

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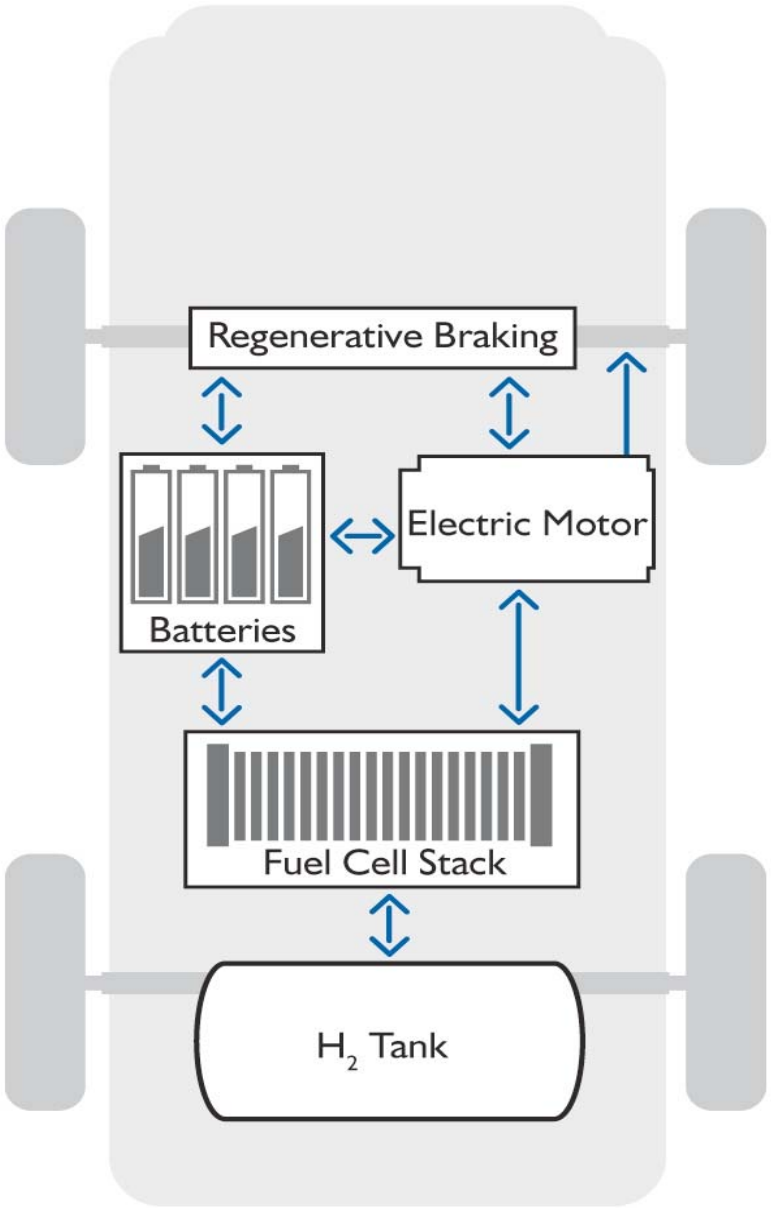
FCEVs



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Solution: Electric drive.

Benefits of a vehicle driving on grid electricity:

- Zero emission. No tailpipe.
- Zero petroleum.
- Lower well-to-wheels emissions.
- More efficient.
- Quiet.
- Wicked quick.
- Low maintenance.

- Uses existing electric infrastructure.
- Can directly use renewable power (solar, wind, hydro).

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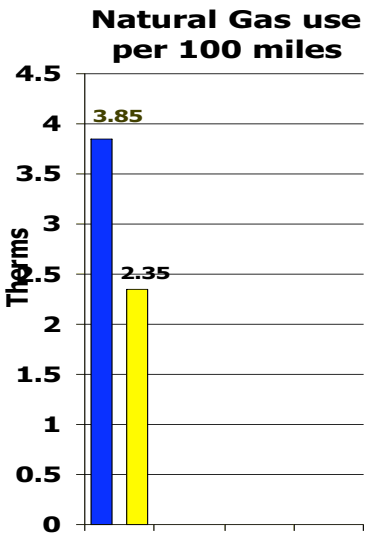
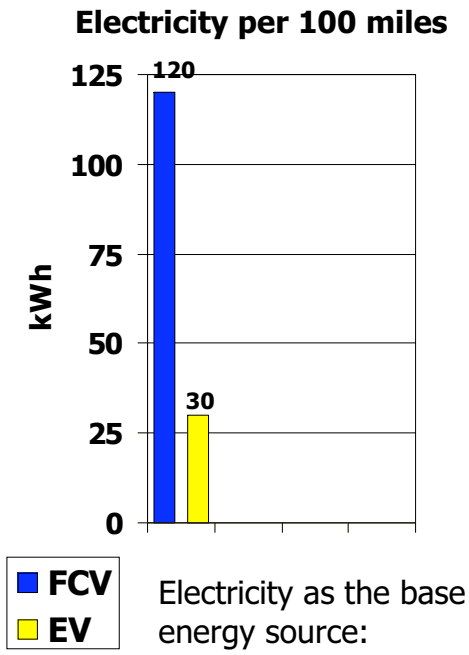
Battery or hydrogen fuel cell?

- BEV is 1.5 - 4 times more efficient than FCV.
- Hydrogen infrastructure virtually non-existent; expensive to create.
- Hydrogen storage difficult, expensive, unresolved.
- FCV - still $1 million each BEV - $40K - $100K
- Battery technology advancing more rapidly than H2 and FC.
- Publicly regulated utilities vs. multi-national corps.

Efficiency of EV vs. FCV



Natural gas as the base energy source:
H_2 from NG reformer
Electricity from power plant
64% more NG required for FCV!



Electricity as the base energy source:
H_2 from electrolyzer
400% more electricity for FCV!

Source: AC Propulsion, Dec 2002

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Everyone knows, it's about electricity.

- "I believe in the ultimate electrification of the automobile,"
- "…what started as a fuel cell project is now an electric vehicle project."

Robert Lutz, CEO, GM, in interview with Automotive News 11/06.

I have no problem picking a winner….Grid electricity or more specifically…distributed electricity… charging electric vehicles… on pure solar power.

-Pulitzer prize winning Journalist Dan Neil, LA Times, at Peterson Auto Museum panel *Is There Life After Petroleum?* 6/16/06

No New Infrastructure Needed!

Electricity is our most ubiquitous and economical energy source

Grid-connected transportation is:

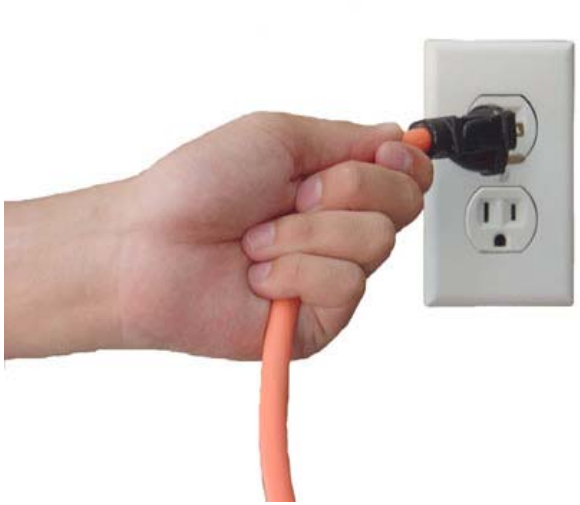
Cleaner

Cheaper

Domestic

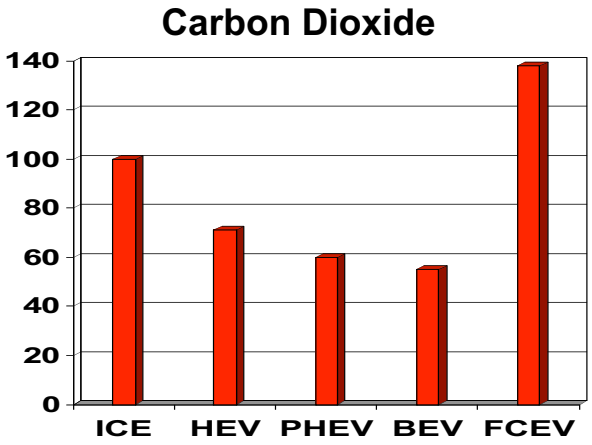
Grid-connected transportation benefits from:

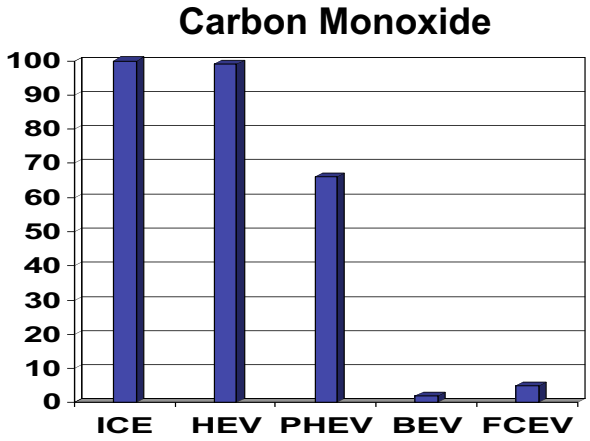
- Distributed production from multiple sources
- Direct use of renewables
- Federal and state mandates that continue to clean and green the grid

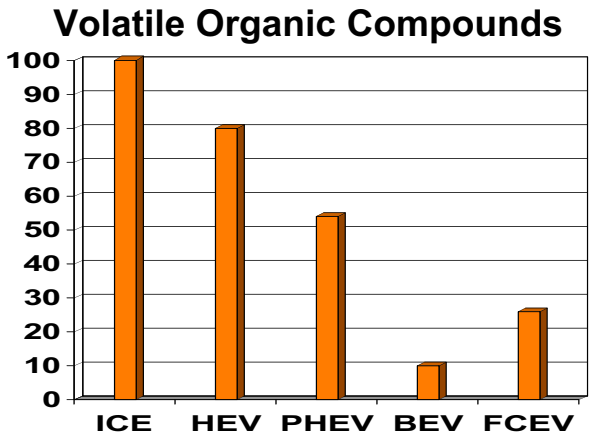


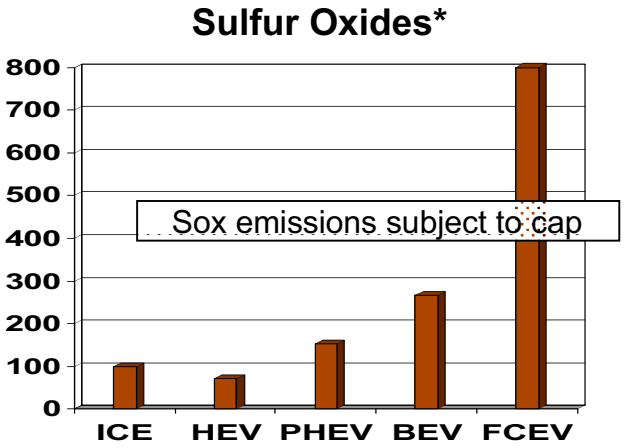
BEVs Really Do Produce Less Emissions

Well-to-wheels emissions based on total US electrical grid









*** EV Charging on US grid should not result in additional SO2 emissions due to regulatory emission caps on stationary sources already in place**

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Sources: Argonne National Labs GREET 1.6 Fuel-Cycle Model for Transportation Fuels… June 2001
FCEV based on US grid powered electrolysis fuel cycle

Effects of regulation: 1993-2004

U.S. electricity production increased, but:

- Sulfur oxide emissions fell from 15 million to 10 million metric tons per year.
- Nitrogen oxide emissions fell from 8 million to 4 million metric tons per year.

Source: U.S. Department of Energy Electric Power Annual 2004.

Sherry Boschert, *Plug-in Hybrids: The Cars that Will Recharge America,* 2006

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ZEV Mandate Produced Real ZEVs

	Leased/Sold	On Road Today
 Toyota RAV4-EV	1485	820
 Ford Ranger EV	1312	~400
 GM EV-1	800	0 [2]
 Ford Postal Van	495	0
 Chevrolet S-10 Electric	450	55
 Ford Th!nk City	440	~100 [3]
 Honda EV Plus	300	0 [2]
 Chrysler EPIC Mini-Van	207	5
 Nissan Altra	130	0 [2]
 Nissan Hypermini	50	0 [2]
 Toyota eCom	15	0 [2]
	5599 [1]	1380

Source: Various industry and private sources

[1] nationwide deployments of vehicles resulting from ZEV regulation.
CA deployments = 4400

[2] excludes small numbers potentially still in use by OEMs for testing

[3] redeployed in Norway – none on US roads

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ZEV Mandate Experience: Real Drivers; Real ZEV miles

- BEV driver experience overwhelmingly positive
  - home charging a major benefit
    - safe, convenient, reliable
  - public charging useful for occasional longer trips
  - lower refueling and operating costs
  - less regular maintenance
    - no oil changes
    - no smog checks
- NiMH batteries have proven very reliable in real world driving over hundreds of millions of miles in BEVs and hybrids.
  - Safe, robust, predictable, durable

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Plug-in Vehicles and Renewable Energy

Only plug-in cars can be charged from renewable energy produced at home.

Plug-in cars provide a tremendous incentive to install Solar PV.

2 kW rooftop solar array provides all the electricity for typical 12,000 mi/yr

- $12 - 15,000 upfront cost
- ~200 square feet
- 6 - 8 year payback
- >30-year life

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The Straus Family Creamery

- Marin County, CA
- 2002 RAV4-EV
- 56,000 zero-emission miles
- Personal transportation and farm utility vehicle

- Farm's methane digester powers RAV4-EV and farm equipment
- No repair issues other than flat tires

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Avi Hershkovitz

- Claremont, Ca
- 2002 RAV4-EV
- 105,135 zero-emission miles

- Used as primary vehicle including 100-150 mile per day commute every working day
- No discernable loss of range after more than 100,000 miles

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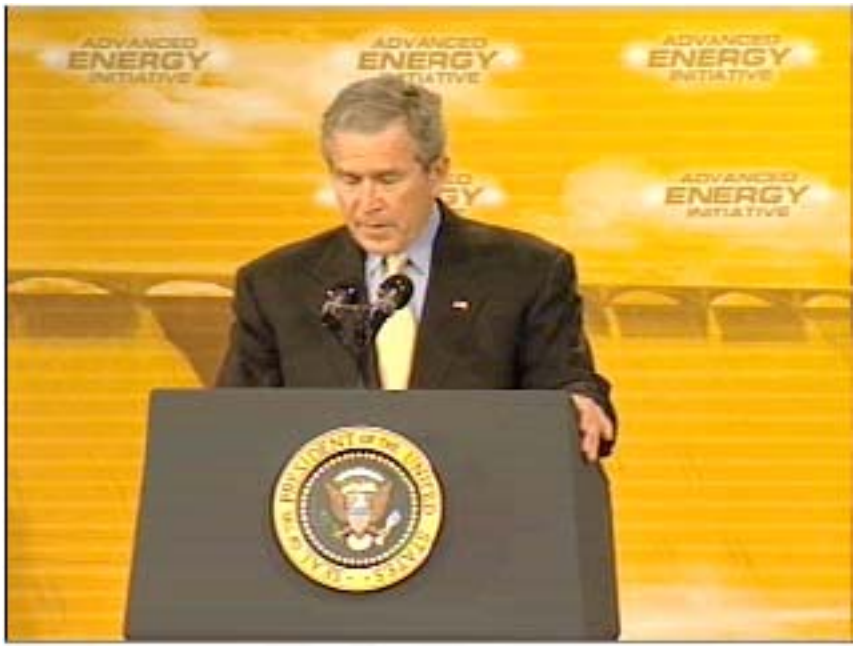
Plug-in Hybrid: Commonsense foot in the door



President Bush at Johnson Controls, January 2006

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Plug-in Hybrids:
Perfect Transition Vehicle

- Concept: EV with insurance (gas tank.)
  - All electric range
  - All-electric in town; liquid-fueled highway
  - Can use both existing infrastructures
  - ICE component could be gasoline, diesel, bio-diesel, CNG, ethanol …..even hydrogen.
  - If H2 and FC became competitive, could replace the engine/generator.

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PHEVs: Real-world performance

Data compiled by CalCars.org

Project	Battery Manuf.	Battery Model	Chem -istry	Eff Ah	EV mi	Mix mi*	Added lb	In-range Mpg*	Orig Mpg	City HEV Mpg	Comments
World's 1st	BB Battery	EVP20 -12	**Lead-acid**	12	10	20	300**	**80**	45	-10% due to extra weight**	OEM battery not removed; hilly Marin terrain
EDrive	Valence	U1-12XP	**Li-ion**	36	30	60	200	**100**	50	Unchanged due to lower impedence	Flat Los Angeles driving
Electro Energy	Electro Energy	N/A	**NiMH**	30	24	48	250	**90**	45	Unchanged due to lower impedence	Project nearly complete
Another Li-ion	Enax	N/A	**Li-ion**	33	27	54	100	**90**	45	Increased due to even lower impedence	Anticipated

* Mixed city & highway driving (also uses around 130 Watt-hr/mi electricity)

** OEM battery pack unused but not removed, adding ~75 lb

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Can the electric grid handle PHEV Energy Requirements?

- Average unused capacity = 505 gW (more at night)
- Average charge requirements per PHEV: 1.5 kW (max from 120V, 15A outlet)
- Average unused capacity could simultaneously charge 337 million PHEVs
- NREL study revealed that these cars, each equipped with a 9 kilowatt-hour battery, could reduce overall CO_2 vehicles emissions by half. They could also save owners more than $450 in fuel costs each year compared to a traditional combustion engine vehicle.

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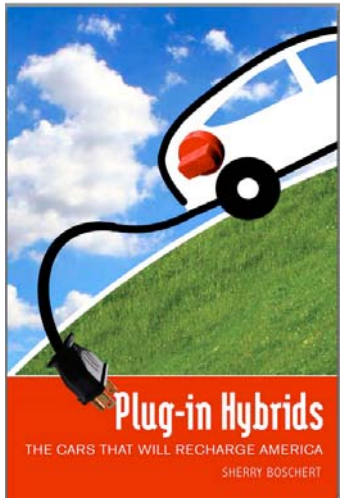
Media



www.sherryboschert.com

Non-profit organizations

CalCars
THE CALIFORNIA CARS INITIATIVE

www.calcars.org

Plug-In Partners
National Campaign

www.pluginpartners.org

Plug In BAY AREA

www.pluginbayarea.org

www.whokilledtheelctriccar.com

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Businesses

www.edrivesystems.com

www.hymotion.com

www.hybridsplus.com

Vehicle to grid (V2G)

- Average car driven 3 hours, parked 21 hours
- Peak sun or wind into car, later tapped for peak load, load leveling, grid regulation.
- 1 million V2G = 20 average power plants

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PHEVs are on the way

Saab 9-3 PHEV Biopower Convertible

Chevy Volt Serial Hybrid

Daimler-Chrysler Plug-in Hybrid Sprinter Van

- Rapid progress on plug-in hybrids
  - Numerous prototypes and demonstration vehicles
  - Real on-road testing underway
  - Significant durability testing already completed

Plug-in Prius by eDrive Systems

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New Life for Battery Electrics

- **Tesla – Roadster**
  - **250 mi range**
  - **0-60 mph in 4 sec**
  - **Charging - std 110 or 220v outlet**
  - **First 100 units sold out in <30 days**
  - **www.teslamotors.com**

- **Redesigned Th!nk City**
  - **www.think.no**

- **AC Propulsion – eBox**
  - **Based on Scion xB**
  - **140-180 mi range**
  - **Charging - std 110 or 220v outlet**
  - **www.acpropulsion.com**

- **Commuter Cars – Tango**
- **100 mile range, PbA**
  - **Geoge Clooney bought one**

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Plug-in Vehicles
Practical, Proven, Ready

- Over 150 million emission-free *consumer* miles driven
- Cleanest personal automotive alternative available
- Only option that allows fueling from home-based renewable energy sources

- Consumer demand already demonstrated
- Continued battery advancements promise longer range BEV and PHEVs
- Plug-in hybrid vehicles provide lower cost entry point for plug-in vehicles and potentially wider initial market

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My Next Car:
NO PLUG?
NO DEAL!
www.PlugInAmerica.com

Plug-in car resources

- Plug In America - pluginamerica.com
- CalCars - calcars.org
- Plug-in Partners - pluginpartners.org
- Plugs and Cars Blog - plugsandcars.blogspot.com

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