The Inevitable Plug: The Case for Plug-in Cars

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San Francisco Electric Vehicle Association
We love cars.
The major problem with cars today is the fuel.

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

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?
- 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)
BEVs

Regenerative Braking

Electric Motor

Batteries

Courtesy
Electric Drive
Transportation
Association
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).
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**

![Graph showing efficiency comparison between EV and FCV](image)

- Natural gas as the base energy source:
  - H₂ from NG reformer
  - Electricity from power plant
  - 64% more NG required for FCV!
- Electricity as the base energy source:
  - H₂ from electrolyzer
  - 400% more electricity for FCV!

Source: AC Propulsion, Dec 2002
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
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*

**Carbon Dioxide**

**Carbon Monoxide**

**Volatile Organic Compounds**

**Sulfur Oxides**

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

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.


Sherry Boschert, Plug-in Hybrids: The Cars that Will Recharge America, 2006
# ZEV Mandate Produced Real ZEVs

<table>
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<tr>
<th></th>
<th>Leased/Sold</th>
<th>On Road Today</th>
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<tbody>
<tr>
<td>Toyota RAV4-EV</td>
<td>1485</td>
<td>820</td>
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<tr>
<td>Ford Ranger EV</td>
<td>1312</td>
<td>~400</td>
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<tr>
<td>GM EV-1</td>
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<tr>
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<td>Ford Th!nk City</td>
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<tr>
<td>Chrysler EPIC Mini-Van</td>
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<td>5</td>
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<tr>
<td>Nissan Altra</td>
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<tr>
<td>Nissan Hypermini</td>
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<tr>
<td>Toyota eCom</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>5599</strong></td>
<td><strong>1380</strong></td>
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</table>

Source: Various industry and private sources

1. Nationwide deployments of vehicles resulting from ZEV regulation.
2. Excludes small numbers potentially still in use by OEMs for testing.
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
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
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
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
Plug-in Hybrid: Commonsense foot in the door

President Bush at Johnson Controls, January 2006
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.
PHEVs: Real-world performance
Data compiled by CalCars.org

<table>
<thead>
<tr>
<th>Project</th>
<th>Battery Manuf.</th>
<th>Battery Model</th>
<th>Chem istry</th>
<th>Eff Ah</th>
<th>EV mi</th>
<th>Mix mi*</th>
<th>Added lb</th>
<th>In-range Mpg*</th>
<th>Orig Mpg</th>
<th>City HEV Mpg</th>
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<tbody>
<tr>
<td>World’s 1st</td>
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<td>EVP20-12</td>
<td>Lead-acid</td>
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<td>10</td>
<td>20</td>
<td>300**</td>
<td>80</td>
<td>45</td>
<td></td>
<td>-10% due to extra weight**; OEM battery not removed; hilly Marin terrain</td>
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<tr>
<td>EDrive</td>
<td>Valence</td>
<td>U1-12XP</td>
<td>Li-ion</td>
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<td>30</td>
<td>60</td>
<td>200</td>
<td>100</td>
<td>50</td>
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<td>Electro Energy</td>
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<td>24</td>
<td>48</td>
<td>250</td>
<td>90</td>
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<td></td>
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<tr>
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<td>Enax</td>
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<td>Li-ion</td>
<td>33</td>
<td>27</td>
<td>54</td>
<td>100</td>
<td>90</td>
<td>45</td>
<td></td>
<td>Increased due to even lower impedance; Anticipated</td>
</tr>
</tbody>
</table>

* Mixed city & highway driving (also uses around 130 Watt-hr/mi electricity)
** OEM battery pack unused but not removed, adding ~75 lb
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.
Media

Non-profit organizations

CalCars

THE CALIFORNIA CARS INITIATIVE

www.calcars.org

www.sherryboschert.com

www.pluginpartners.org

www.pluginbayarea.org

www.whokilledtheelectriccar.com

Businesses

EDRIVE

plug-in hybrid systems

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
PHEVs are on the way

- Rapid progress on plug-in hybrids
  - Numerous prototypes and demonstration vehicles
  - Real on-road testing underway
  - Significant durability testing already completed
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
    - George Clooney bought one
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
My Next Car: NO PLUG?
NO DEAL!

www.PluginInAmerica.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