Plug-In Hybrids: Best of Both Worlds

Reykjavik September 18, 2007
Driving Sustainability
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CalCars
THE CALIFORNIA CARS INITIATIVE
www.calcars.org
“Nonprofit Startup”: CalCars itself is a hybrid

- Engineers
- Entrepreneurs
- Environmentalists
- Consumers/drivers
- Expanding the usual circle of decisionmakers
- Communicating messages of hope
- Approaching success!

October 2003
Expanding driver choice: new cars/line extensions

**Ford BOLDMOVES**

- **Escape XLT** $22,895*
- **Escape Hybrid FWD** $26,215*
- **Escape Hybrid 4WD** $27,820*
- **Escape Plug-In Hybrid** $30,000+*
Hybrids simplified:

- Ford Escape
- Honda Insight, Civic, Accord (cancelled)
- Lexus sedans, SUV
- Toyota Prius, Camry, Highlander
- Nissan Altima
- Many others on the way

Modified from an EDTA diagram concept
Electric “Plug-in” hybrid:

Just add batteries

Keep the freedom of the open road

Modified from an EDTA diagram concept
PHEVs: Best of Both Worlds

Cleaner, cheaper, domestic
Putting renewable electricity to best use

- Opportunity: for a world that hopes to have clean abundant energy, Iceland can show the roadmap
- Transmission -> battery -> motor, 70-80% efficient
- Hydrogen from electrolysis -> fuel cell, 20-27%; ICE, 7-9% (losses + CO₂ if reformulate natural gas)
- Worldwide, there’s never “extra” green electricity to “waste” as long as coal can be displaced anywhere
- Even as range extender fuel, hydrogen will need to surpass cellulosic ethanol on a well-to-wheel basis
- Note: ethanol used at power station is more efficient than burned in an internal combustion engine
Meeting the European Union’s 120-130 CO₂ target

<table>
<thead>
<tr>
<th>ElectGrid Location</th>
<th>EV g/kWh</th>
<th>EV g/km</th>
<th>PHEV-32 gm/km</th>
<th>PHEV-96 gm/km</th>
<th>EV as % of ICE</th>
<th>EV as % of diesel</th>
<th>EV as % of HEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calif 2004</td>
<td>236</td>
<td>39</td>
<td>101</td>
<td>65</td>
<td>18%</td>
<td>20%</td>
<td>31%</td>
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<tr>
<td>U.S. 2004</td>
<td>615</td>
<td>103</td>
<td>120</td>
<td>110</td>
<td>48%</td>
<td>53%</td>
<td>81%</td>
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<td>U.S. 2010</td>
<td>500</td>
<td>84</td>
<td>114</td>
<td>97</td>
<td>36%</td>
<td>43%</td>
<td>66%</td>
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<tr>
<td>U.S. 2050</td>
<td>375</td>
<td>63</td>
<td>108</td>
<td>82</td>
<td>29%</td>
<td>32%</td>
<td>50%</td>
</tr>
</tbody>
</table>

- **Source-to-wheels CO₂ emissions for a Prius-sized passenger car**
  - 216 gm/km, gasoline @ 9.2 l/100km (26 mpg)
  - 194 gm/km, diesel @ 7.2 l/100km (33 mpg)
  - 127 gm/km, hybrid @ 5.4 l/100km (44 mpg)
  - PHEV-20 (32 km EV range): **3.8 l/100km** at 30% EV -- with higher EV%, my PHEV-25 often gets
  - PHEV-60 (96 km EV range): **1.6 l/100km** at 70% EV 100+mpg (40km/liter or **<2.5 l/100km**)

2010/2050 grid emission projections from 2007 EPRI/NRDC Study
EV/PHEV electric miles: 16.7 kWh/100km Analysis: CalCars Tech Lead Ron Gremban, presentations at EEET-2007(see CalCars.org Downloads Page)
November 2004: “open-source” PRIUS+ demo

Hybrid-Car Tinkerers Scoff at No-Plug-In Rule

By DANNY HAKIM

DETROIT, March 31—Ron Grebhan and Felix Kramer have modified a Toyota Prius so it can be plugged into a wall outlet. This does not make Toyota happy. The company has spent millions of dollars persuading people that hybrid electric cars like the Prius never need to be plugged in and work just like normal cars. So has Honda, which even ran a commercial that showed a guy wandering around his Civic hybrid fruitlessly searching for a plug.

But the idea of making hybrid cars that have the option of being plugged in is supported by a diverse group of interests, from neoconservatives who support greater fuel efficiency for utilities salivating at the chance to supplant oil with electricity. If you were able to plug a hybrid in overnight, you could potentially use a lot less gas by cruising for long stretches on battery power only. But unlike purely electric cars, which take hours to charge and need frequent recharging, you would not have to plug in if you did not want to.

“I’ve gotten anywhere from 85 to over 100 miles per gallon,” said Mr. Grebhan, an engineer at CalCars, a small nonprofit group based in Palo Alto, Calif. He gets 40 to 45 miles per gallon driving his normal Prius. And EnergyCS, a small company that has collaborated with CalCars, has modified another Prius with more sophisticated batteries; they claim their Prius gets up to 180 m.p.g. and can travel more than 30 miles on battery power.

“If you cover people’s daily commute, maybe they’ll go to the gas station once a month,” said Mr. Kramer, the founder of CalCars. “That’s the whole idea.”

Conventional hybrid electric cars already save gas. But if one looks at growth projections for oil consumption, hybrids will slow the growth rate of oil imports only marginally. Depending on when they actually are introduced, the potential savings of hybrid makers have been estimated at 40 percent of the total gasoline consumption. But fuel-reinvention technology to make electric cars is available.

Building them in garages. “All of the relevant technology is at hand,” said Frank Gaffney, founder of the Center for Security Policy and an assistant defense secretary in the Reagan administration. His group was among a coalition of right-leaning organizations that released an energy plan this year promoting plug-ins as one way to increase fuel efficiency in light of the instability of the Middle East.

“If you’re thinking about this as an environmental issue first and foremost, you’re missing the point,” Mr. Gaffney said. “Cursing dependence on foreign oil is the agenda.”

Hybrid cars for prime time.

“Crude oil will not last forever. What is this the next great American innovation?” asked Ray Johnson, an executive engineer at Southern California Edison. “Electricity is really better at localizing power and transmission. If it expands their market, it expands their agenda.”

Plug-in hybrid is not just for the garages of enthusi-
Plug-in hybrids go to Washington 2006

“Amazing breakthrough...”

“You pull in and you plug it right into the wall...”
2005-2007: 11 books with major focus on PHEVs

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HybridsPlus

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EDTA

JOBS & FACTORY CONVERSIONs

Editorial: Minnesota lays a bet on cars of the future
ApolloAlliance

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Plug In America
Friends of the Earth
NRDC

UTILITIES & FLEET BUYERS

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PG&E
EDISON
Plug In BAY AREA
SMUD

NEO-CONS / GEO-GREENS

RechargeIT

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PHEVs: Best of Both Worlds

7 carmakers interested; race to be first; still no timetables (CalCars “Carmakers” page tracks statements)

“Maybe not first but best” – start with Plug-in HV

“Within 5-10 years” – Volvo may be sooner

Daimler Sprinter PHEV; Chrysler: new electric division

Saturn Vue possible 2009
Chevy Volt: mass production 2010 goal; Opel Flextreme follows

Interest from Nissan, Honda, Visionary Vehicles, Tesla
Automakers still holding out for perfect batteries

- **40 mile range/life of vehicle/price-competitive**
- **NiMH**: Proven in hybrid, RAV4 EV (100K+ miles)
- **Lithium-Ion (50-75K+ miles)**
  “Good enough” for Version 1.0 demo fleets
PHEVs: Best of Both Worlds

Disruptive forecasts: CARB & Alliance Bernstein

Int’l Energy Agency: “Niche”
Alliance-Bernstein: “Mainstay”
2015: HEVs 50% new car sales

2030 Hybrid/PHEV Share
Vehicle Base: 0.7% vs. 72.0%
New Vehicles: 1.0% vs. 85.0%

CA Air Resources Board: Staff Report, ZEV Technology Symposium, April 2007 (excerpt)
“The Emergence of Hybrid Vehicles” 50 pp. June 2006 (download at CalCars.org)
“Perfect” products start as “good enough”

Prius version
1.0 1997:
Japan only
v. 2.0 2001:
acceptable
v. 3.0 2003:
best-seller
Demo PHEVs
2004-07
Plug-in HV: pilot
2007-08

GM Impact
1990-1995
GM EV-1
1996/1999
AC Propulsion
tZero 1997/2003
Tesla Roadster
2007: market
success
Volt series PHEV 2010:
GM hoping to build it
Iceland’s role in creating sustainable PHEVs

- Ideal test-bed: island/commuter driving
- “Soft” buy order (hundreds)
- Buyer/seller incentives
- Promote “level playing field” for multiple energy solutions ("silver buckshot" not "silver bullet")
- Internationally, connect domestic geothermal know-how, R&D on “enhanced geothermal” (EGS) and steps to electrify transportation
CalCars website as a resource

Today’s presentation:
• At About/Downloads

Links at home page:
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• What Carmakers are Saying
• How to Get a Conversion