

China, US, Japan and Korea: Who Will Win the Race towards Plug-In Cars?

Dr. Paul J. Werbos

-- personal, **not official**, views
IEEE-USA, IEEE, NSF,
UN State of the Future
1979-89: EIA/DOE lead analyst
for long-term energy futures

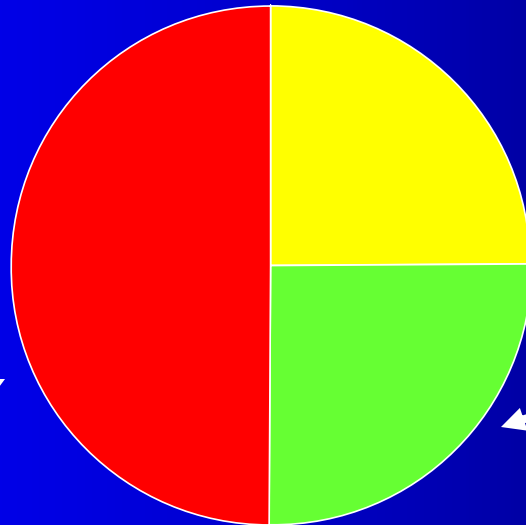


www.werbos.com/energy.htm

“Government public domain”: These slides may be copied, posted, or distributed freely, so long as they are kept together, including this notice.

How To Zero Out Gasoline Dependency: Best Near-Term Hope for 100% Renewable Zero- Net-CO2 cars & **Total Security** for Car Fuel

Highest mpg
Hybrids Cut
Gas per Mile
By 50%



With **GEM fuel-flexible** cars,
biofuels might supply $\frac{1}{4}$
of present liquid fuel
demand trends

Plug-in Hybrids
with 10kwh batteries
get half their energy
from electricity

GEM fuel-flexible plug-ins offer a 100% solution based on near-term
technology! www.ieeeusa.org/policy/positions/PHEV0607.pdf

IEEE Computational Intelligence Society – Alternate Energy Task Force

<http://iee-cis.org/isa/alternative/>

- Rajashekara, Rolls-Royce
(former Delphi hybrid leader)
- Prokhorov, Toyota
- Anya Getman, Caterpillar
- Marko, Bosch
- Feldkamp, Ford
- Javaherian, GM
- Bonissone, GE
- Zimmerman, Siemens
- Fei-Yue Wang, Chinese Academy of Science
- Chair: Werbos
- Estevez
- Fukuda
- Sarangapani
- Venayagamoorthy
- Liu
- Research for Honda, Caterpillar, ABB, others

The view from Morgan-Stanley

March 11, 2008

- “We see lithium-ion PHEVs today as akin to MP3 players in 1998. They are likely to revolutionize the automobile as we know it, but it still unclear who will develop the equivalent of the iPod”
- Projected battery costs: \$4,025 for 7kwh (20 miles all-electric) , \$5,585 for 14kwh (GM Volt)
- www.vvcars.com/pdf/PHEV_MorganStanley.pdf

Factors Which Decide Who Wins

- Who gets to mass-market first
- Who gets to low cost first
- National support and market conditions
- Rate of ramp-up in production
- But: all oil consuming nations benefit if all decent car factories shift to affordable PHEV as soon as possible! In a globalized world, collaborations will decide who really wins.

World's First Mass Market PHEV

2nd half of 2008: BYD Motors F6DM



- 20 kwh battery, 65 miles all-electric driving range
- Made in Shenzhen, China
- Follow-on in 2009: F3DM, 100 miles all-electric
- www.byd.com

Other contenders

- GM Volt, 14kwh, 40 miles: planned for late 2010, using A123 or LG Chem advanced lithium battery. **Enough for 90% of US to get to work** in case of total gasoline embargo, if employer parking lots have recharge stations.
- Hyundai: US mass-market hybrid 2009, no comment on plug-in, deal with LG Chem and massive new Korean battery program www.eetimes.eu/power/196600822
- Toyota: 2010 PHEVs to fleet owners only, a test, using **proprietary** advanced lithium-ion battery and power electronics technology GM cannot buy. Plans to keep doubling hybrid output every year.
- Chery (China) says by 2010: half of its million cars per year will be hybrids, half of them on alternate liquid fuels. 40% will be for export.
- Dongfeng Electric Car Company, and Chang' An

What limits rate of deployment of hybrids & plug-ins? Cost, cost, cost...

- Hybrid Prius vs. regular Prius: cost penalty = **\$3000** (2006 data Car & Driver, Financial Times) about enough to pay off at \$3-4/gallon without interest
- About **\$2000** of the \$3000 is for small fast battery, currently nickel hydride less than 1kwh.
- **\$1,000-\$2,000 tax incentive** per car, for the first million hybrids from each manufacturer, essential to speed of development, becoming cheaper, **in US**
- **Outside the US**, higher gas price bigger market now, but subsidized gasoline prices in China cheaper than US

Lithium Iron Phosphate Batteries: The One Proven Key to Breaking the Cost Barrier

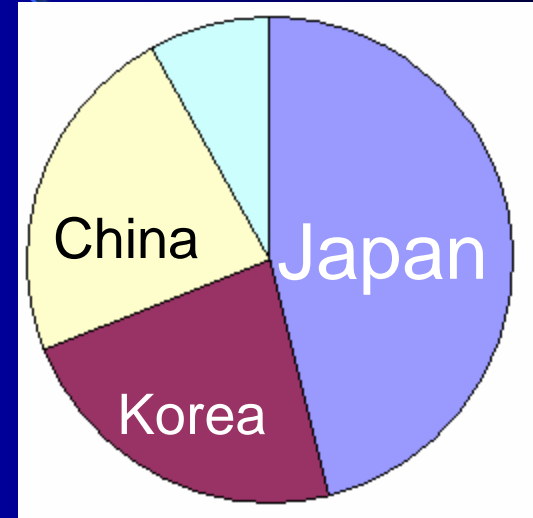


- Invented in 1997 by NSF grantee Prof. John Goodenough, U. Texas
- Winner of the Japan Prize
[www.japanprize.jp/e_2001\(17th\).htm](http://www.japanprize.jp/e_2001(17th).htm)
- Recent huge surge in production at:
 - A123, to manufacture in China
 - LG Chem
 - BYD (Shenzhen), claims to be world's #2 producer of rechargeable batteries
 - Thunder Sky (Shenzhen), safety add-on

How incentives/markets are changing the game: Better batteries are coming



Thunder Sky, China, 10kwh now \$2000
(Werbos in-depth visit June 2007)



World Li Battery Output

Toyota says it will go to Li batteries next year or so, that its new joint venture with Mitsubishi is far ahead of everyone else. But Korea's new thrust aims to beat Japan in rechargeable sales by 2012, by focusing on next generation technology.

New US-China Opportunity?

Some highlights from Shenzhen...

- Plan to get to \$1000 for 14kwh battery is in place.
- Thunder Sky says zero water runoff in manufacturing. Shenzhen says electronics, clothing, batteries, leather industries about equal as sources of pollution overall. Recycling of batteries needed, but global PHEV use would maybe double the (limited, sustainable) issue we have already from lead-acid batteries. Safety > Toyota.
- Ready now: mass production in 2007 of amazing 150-mile electric motorcycles in China. High performance!
- Can REPLACE today's hybrid batteries:
power surges are easier when the battery itself is bigger.
- For GM use, need: (1) intelligent 300-volt battery management system (computational intelligence can do it!); (2) neutral US-funded battery & system testing facility, credible to GM etc.
- US factory in NJ almost ready but twice the cost.



China Government Plan

China Daily, posted in chinaview 10/27/7

- Wan Gang, new Minister of Science and Technology & “sea turtle”, strongly supports New Energy Vehicle Key Project of the National Hi-Tech R&D Program.
- Zhen Zijian, Deputy Director:



“(this is) the priority for China’s auto industry, which is expected to become the world’s largest in 10-15 years.”

- Ouyang Minggao (Tsinghua):”.. an innovative union of private companies, research bodies & universities.. along 3 paths – hybrid, clean fuel and electric vehicles.” Also google Caijing magazine.
- Chery says the A5 hybrid 4-door sedan will be \$1,400-\$2,900 higher than conventional version which starts at \$9,975.

Needs for Action

- Restore tax credits for GEM-flexible plug-in hybrids; raise caps to 250,000 cars/year.
- More aggressive, transformative battery research
 - WTEC international battery visits
 - Joint call to all universities and small business
 - Only consider batteries at Li or more energy density
 - International partnership
 - Include computational intelligence and new chips
 - Start from (unfunded) proposals of DOE/BES, and of Sadoway of MIT, adding “drug discovery informatics”
 - Open source battery modeling to assist development of more general battery management systems
- US-funded battery testing facility under DOT
- New standards and incentives for recharge stations in employee parking lots and public parking lots serving commuters or big warehouse stores