

How Can We Zero Out America's **Need to** Import Oil at the Soonest Possible Time?

Dr. Paul J. Werbos

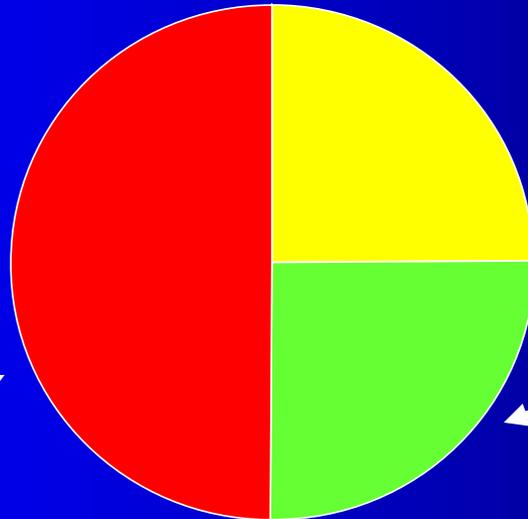
personal, **not official**, views

Sources: IEEE-USA (Edison story), IEEE, NSF, US Senate, UN State of the Future; 1979-89: EIA/DOE lead analyst for long-term energy futures.

www.werbos.com/oil.htm

WE CAN Zero Out Gasoline Dependency: A Definite Option 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

Optimal Strategy for Total Energy Security



Maximize Fuel-Flexible Plug-in Hybrid Cars



Open door to US natural gas (e.g. to trucks) while it lasts

R&D for more efficient use of diverse fuels

R&D for batteries for affordable electric cars



Minimize cost and then maximize supply of renewable electricity

Maximize supply of Alternate liquid fuels
– Not oil
– Incentives, standards and R&D

GEM Flexibly Fuel Vehicles (FFV) One Tank To Hold Them All

G: Gasoline

E: Ethanol

M: Methanol



With an FFV, you choose each day which to buy
At \$100-200/car, a more open competition, level playing field,
better unleash the power of the free market
GEM flexibility \Rightarrow use of any corrosive fuel, adaptive engine
control

Plug-in Hybrids (PHEV) : A Large-Scale Opportunity Here and Now

- Hybrids cut liquid fuel use 50% already. Plug-ins cut **50% of that**.
 - “Researchers have shown .. (PHEV) offering.. electric range of 32 km will yield... 50% reduction..” (IEEE Spectrum, July/05). Shown in working Prius.



- Battery **breakthroughs in China**: from 10/07, 10kwh batteries (larger than) cost **\$2,000**. www.thunder-sky.com. Thus an extra \$2,000 per car can cut gas dependence in half.
- **Gives economic security in case of sudden gasoline cutoff.**
- **Does not strain grid – actually strengthens it, if done right**

IEEE Computational Intelligence Society – Alternate Energy Task Force

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

- Rajashakeera, 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
- Some serious reshuffling since auto bankruptcies, endangering clean air

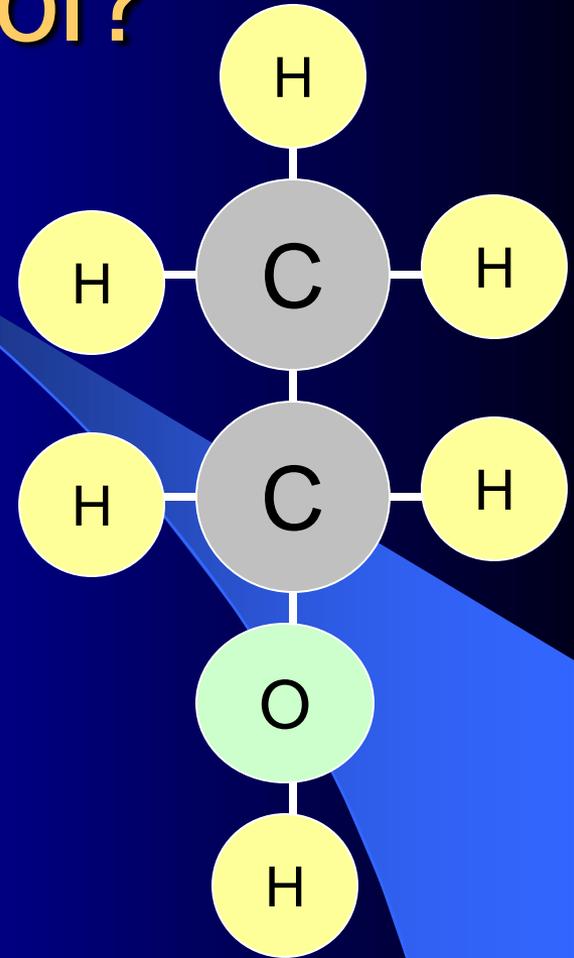
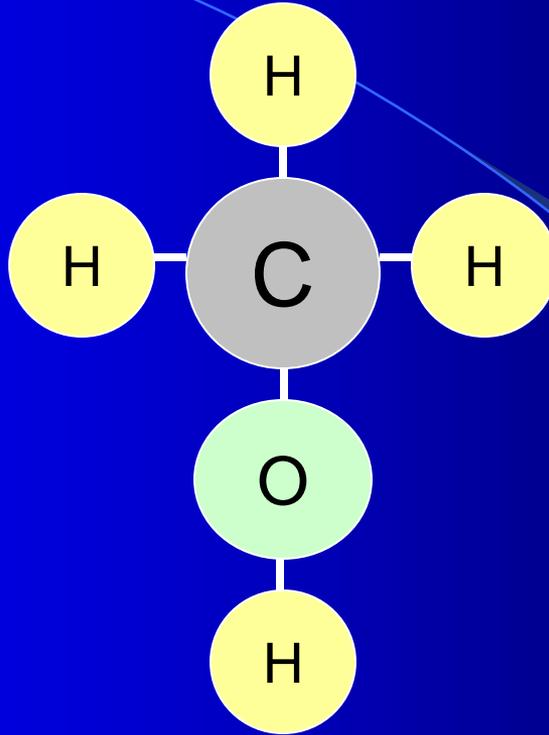
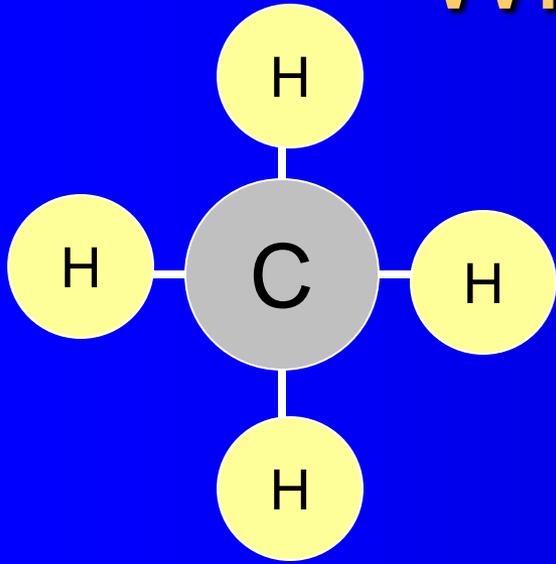
New US-China Opportunity?

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.



What IS Methanol?



Methane

Natural Gas
Scarce as Oil
Needs Special
Tank

Methanol

Good H Carrier
Can Be Bioliquid
Or From Coal, Gas

Ethanol

e.g From Corn
Drinkable

Nonfood biofuels could supply half our fuel needs using old technology – if we stop demanding purity in our ethanol/alcohol!



We need to give this guy permission to compete with Saudi Arabia and Iran for the car fuel market! He doesn't need a subsidy – only more freedom and an open door! Just give him a chance, and within 15 years...

(Also, try a google on “forest industry” methanol.)

Fuel flexibility can be brought online very quickly, much faster than hybrids merely doubling every year!



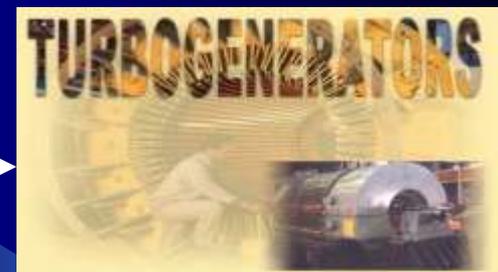
All major manufacturers which sell in US have sold such cars in Brazil!!

Biofuels Can >25% Soon IF

- Energy Independence and Security Act (EISA) 2007 **requires growth in nonfood biofuel**
- Capacity and technology **have recently grown** much faster than some thought possible. Cellulosic catalyst plant online now; butanol as easy as ethanol in the same plant; etc.
- Production **already at 10%** of US need – causing a “blend wall problem” right now. Many want 15% blend wall – and expect we would see **15% in 3-4 years** under EISA rules.
- **Stuck at 10% -- until we take action to change the cars and the gas stations and open the door to nonethanol**

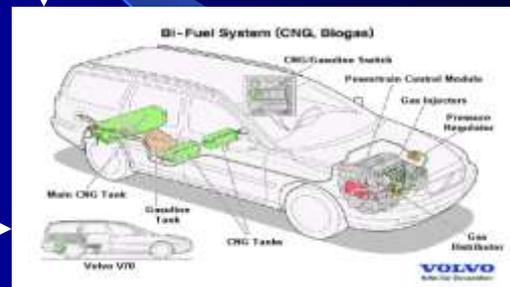
Limits of 3 Paths from Natural Gas to Cars

US
gas



Not enough

Liquefy, transport
and import (LNG)



\$6200 more per car

Remote
or nonUS
gas



Make methanol, transport

and import (\$160/ton or new
high efficiency GTL)



**GEM-flexible car: <\$200
more per car**

BUT US gas supply has grown a lot lately, deserves level playing field, and can help a lot with trucks in next few difficult decades!!

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



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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
- \$21,000 sales price, to be imported (deal with Buffet)

What would accelerate plug-ins most?



Dr. Abe, leads all of
Toyota hybrid, plug-in
& electric car
development

Me

Prof. Toshio Fukuda

- Toyota response December 4, 2008:
 - **Permanent** tax incentives (not just 4 years)
 - Promote **recharge posts everywhere** (cuts fuel use in half again, energy security, attracts consumer)
 - **Standards** for recharge posts – quicker recharge, compatibility, eventually V2G

New Legislation Is Also Essential, To Move As Fast as We Can & Should:

- Thanks to Senate Legislative Counsel: bill & explanations posted at www.verbos.com/oil.htm. All 4 together to escape “who goes first”:
- For vehicles:
 - Extend tax incentives for **all** fuel-flexible and hybrid vehicles (including plug-ins and even fuel cells) until most cars sold are “futuristic cars.” Need the extension **now** to allow new investments aimed at future. (Pryor/Inhofe.)
 - Require GEM flexibility in liquid fuel systems (open fuel standard, Brownback).
- For refueling stations (recharging or gas stations):
 - Extend tax incentives, include retrofit and public access electric recharging.
- For actual fuel use and production:
 - Modification of Waxman/Markey “Low Carbon Fuel Standards,” with penalty for oil shale removed, credit for natural gas and electricity required, and faster encouragement of new technology/fuel/combinations
 - Support prices for alternative liquid and gaseous fuels
- Aggressive new R&D:
 - \$60 million for **well-focused** new R&D living up to unmet opportunities here, through ARPA-E/NSF partnerships open to all universities, small business, etc.

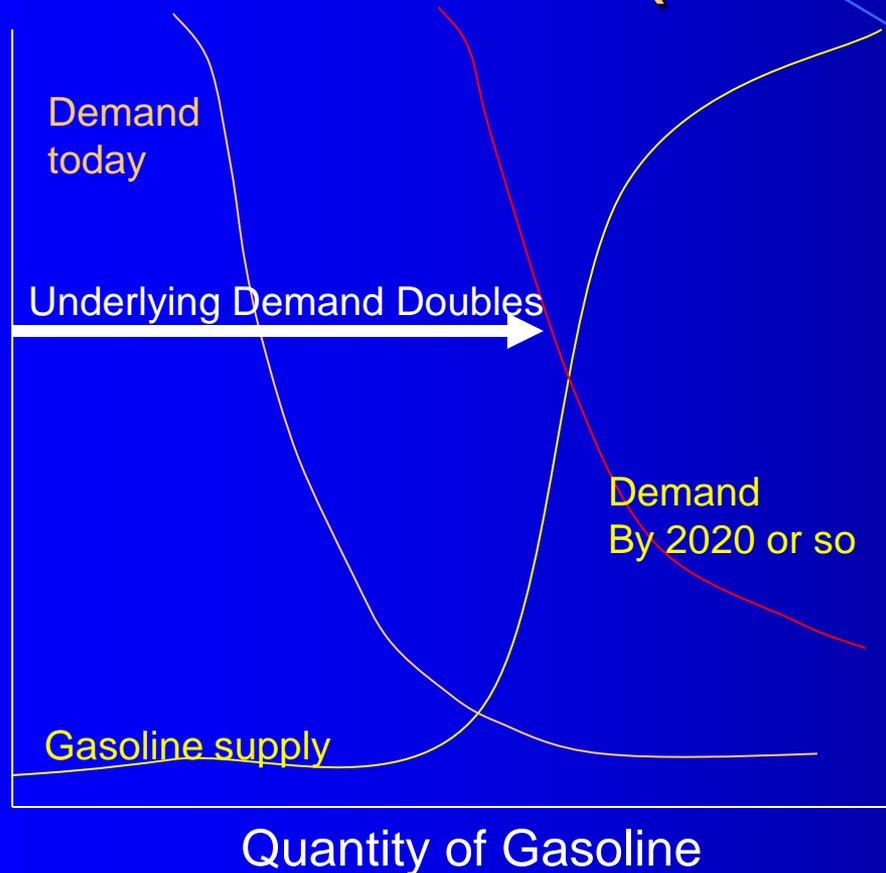
What's Important for CO₂ – Data from DOE/EIA-0573 (2007)

- Total US CO₂ emissions: **6096** million tons
 - **2036** direct CO₂ from transportation
 - **2433** direct from electric utilities
 - **1627** all other places, including electricity generation by industry and commercial sectors
- 1760 is the total emissions of industry (direct plus indirect)

The image features a solid blue background. A thin white arc curves from the top left towards the center. A larger, semi-transparent blue wedge shape is positioned on the right side, pointing towards the center. The word "Questions?" is written in a bold, yellow, sans-serif font, centered horizontally and partially overlapping the white arc and the blue wedge.

Questions?

How will you cut your gasoline use by 50% or more? (Gulf or hurricane...)



- If output falls, free market raises prices enough to **force** you cut your use in half or more.
- The only question: how? Lower income? Small car? Or market-friendly new technology?
- Antimarket tricks like price caps, hi interest rates, pressures on Arab states only lead to worse outcomes (Nash)

Long-term price elasticity of driving = -0.2 ; price doubling of GASOLINE only gives 14% reduction. Bigger reduction only as cars turn over, 15 years!

For example, from 2007 to 2008, average price from \$68 to \$93 (EIA), demand from 3.66b to 3.58. Peak price of \$150 was half due to high marginal cost (supply/demand), half legitimate foresight.

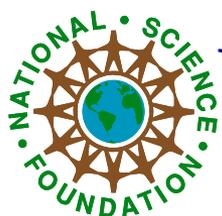
Why This Issue Calls Out for More Action

- **National Security/Vulnerability** -- It is ‘way too risky to assume “best case” or “base case” in an uncertain world
 - Gulf Institute Plans (2003)
 - Tight Link From Supply and Demand to Price
 - Big flow of money to OPEC funding threats to US
- **Likelihood of double dip recession if we do not act soon to limit oil price increases**
 - 3.6 billion barrels per year *150 == \$540b/year import bill; * \$250 = \$900b/year, >> China’s \$2t Treasury bonds
- **Big near-Term Savings possible with more open markets – methanol, natural gas, electricity**
- **Possibility of Market-Friendly Action** which opens the door to new fuels and limits price rises through greater competition, **but does not discriminate against actual use of oil.**

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



Workshop on “Drug Discovery Approach to Breakthroughs in Batteries” Sept 8-9 at MIT

- | Focus: How could new crossdisciplinary research maximize the probability of breakthrough battery designs, suitable for new plug-in hybrid cars but costing only half as much or less as what is coming already?
- | Motivation: IEEE white paper argues that fuel-flexible plug-in cars offer our best near-term hope for independence from oil imports, but the high cost of batteries for new cars like the GM Volt is the main obstacle.
- | Sponsors: ECCS. Participation from DOE, DARPA, GM. Strong encouragement from OSTP. <http://web.mit.edu/dsadoway/www/nsfworkshopMain.htm>
- | Key findings:
 - » The “design space” is huge, and poorly explored due to cutbacks in US electrochemical engineering (other than fuel cells), and the slow speed of traditional Edisonian “shake and bake” methods.
 - » Systematic exploration, using computational approaches (quantum modeling, learning from data, stochastic search) as now used in the pharmaceutical industry show great promise. Sang-Tae Kim, former OCI Director, helped build new partnerships here.
 - » The uncertainties are great, but somewhere between 2X and 10X improvements are likely to be possible, if we follow up on this opportunity. No one else is doing it yet in the US.
 - » A new EFRI topic in this area would have huge workforce benefits for the US in this key area even in the worst case where GM imports batteries from China, whose industry is now well ahead of the US industry in this area.
 - » In addition to battery design, new lifetime analysis, catastrophic safety analysis and open-source models for battery management systems are all badly needed.