

Integrated Adoption of Plug-in Vehicles with Solar and Biofuel Generation Alternatives

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America's Off-Oil Quest

- Supply vulnerabilities
- Accelerating large global demands
- Adversarial suppliers
- Supplies from least accountable most dictatorial
- Threats of climate change
- Serious adverse impacts in the developing world

Dependence on Oil

- 96% of American transportation fuel
- 24% of the world's energy
- Per capita daily consumption 2.8 gallons
- Oil accounts for 44% of U.S. CO₂eq
- **69% of US CO₂eq for transportation**
- Recognized as a problem by the public:
 - Serious 95%
 - Very serious 71%
- For 10,000 mi. of car travel, average tCO₂eq released 3.87 for new and 4.9 for all licensed

Oil to Electricity?

- Oil fuels < 3% of U.S. electrical generation
- Transmission system largely in place
- Environmentally friendly means of incremental generation are available
- Peak load rate premiums
- Electrical hybrids on the horizon

Governor Granholm Plugging Volt

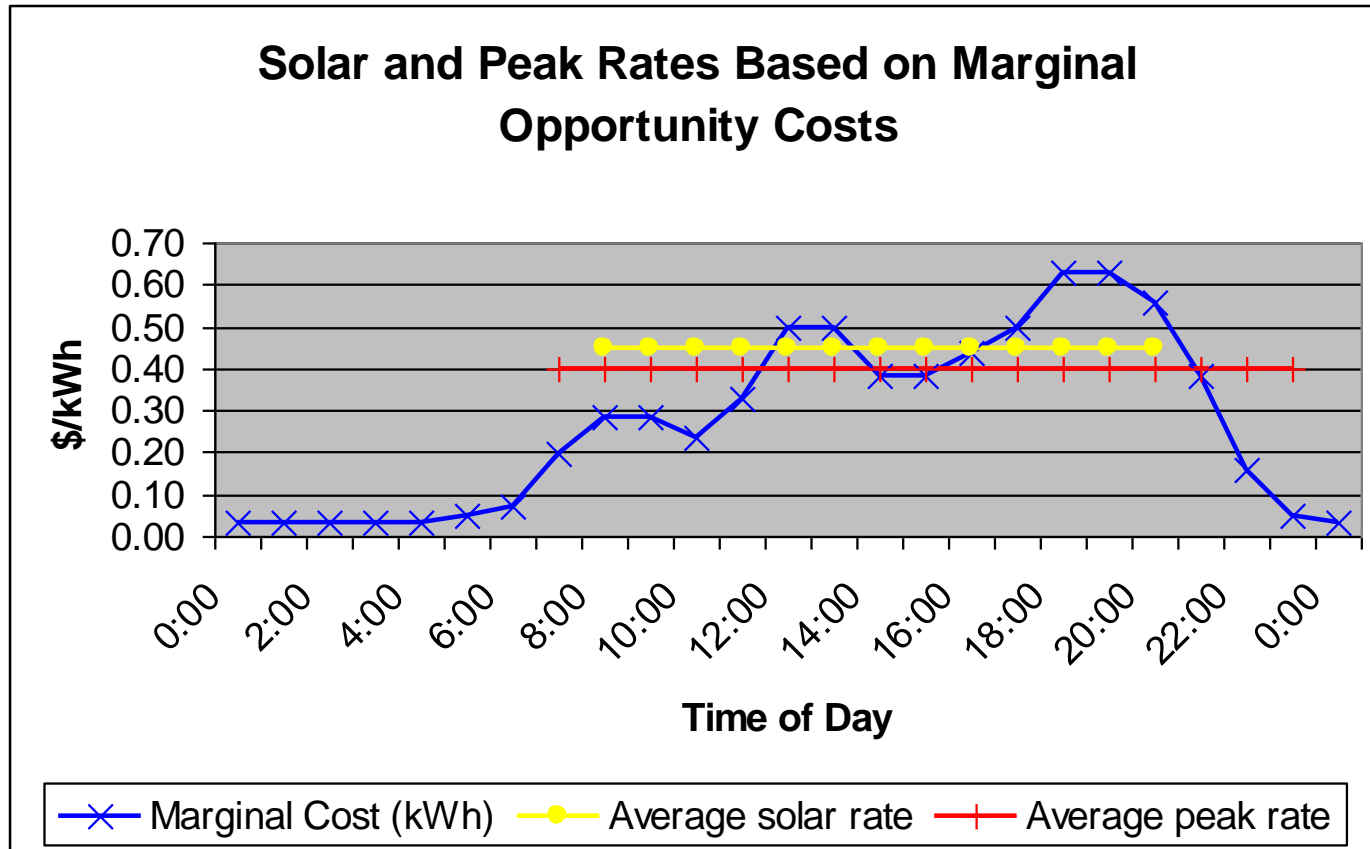


Volt Characteristics

- 16 kWh of battery storage
- Minimal electricity losses in charging
- Covers 40 mile commute
- Covers U.S. median annual miles driven
- Emits minimal amounts of hot water
- Recharged off-peak

Benefits of Daily Off-Peak Charging

- Generating costs lower at off-peak (11 pm – 7 am)
- Opportunity for offsetting peak electricity generation



CL&PC peak stressed

AC capacity at 3.1 of < 9 GW in CL&PC system

Buyer-take-all contracts

Sample Peak Rates (\$/kWh)

- California .39
- New Jersey .405
- Ontario .47
- CT commercial .166

Shifting to peak pricing:

- May shave peak demands
- Calls forth peak generating capacity

The Electrical Car Conundrum

- Assumes safe lithium ion batteries
- Coal generates 50% of US electricity
- Direct and indirect GHGs in grid-based electricity
- Transmission and generating constraints
- Using grid-based electricity, annual GHG reductions:
 - .59 tCO₂eq with California gas standards/vehicle @10,000 mi/yr
 - 1.41 tCO₂eq with current federal standards
- Need to subtract another tonne of CO₂eq for battery production

Solution:

Generate clean electricity as offset to increased electricity demand by plug-ins

Competing Solar Option

- Dealers install matching solar capacity to meet hybrid demands for 10,000 miles
- Deliver electricity at solar rate under fixed buyer-take-all contracts
- Hybrid owners plug-in during off-peak



Economic Analysis: Assumptions

- Installed 18 kW unit cost \$120,000
- Generates 18 kWe electricity and 18 kWw hot water
- Sufficient offset for 13 vehicles @ 10,000 mi/yr
- Operating cost \$1,000 annually
- Operating time 8 hr/day (Paper tested for 6 hr. as well)
- 70% debt financed
- Debt amortized over 20 years
- Interest rates of 0.5%/month

Years to Payout Equity: No Subsidy

GHG Credits \$50/tCO ₂ eq	Pay for Base Fuel	Peak Electricity Rates (Cents/kWh) (Rates for sum of electricity and equal energy in hot water)			
		16.62	37.80	41.70	47.00
Y	N	14.61	2.65	2.30	1.95
N	N	70.06	3.09	2.63	2.18
Y	Y	Loss	4.17	3.37	2.67
N	Y	Loss	5.39	4.21	3.13

Based on RETSCREEN results

Years to Payout Equity: Subsidy \$375/kW

GHG Credits \$50/tco2eq	Pay for Base Fuel	Peak Electricity Rates (Cents/kWh) (Rates for sum of electricity and equal energy in hot water)			
		16.62	37.80	41.70	47.00
Y	N	11.82	2.15	1.87	1.59
N	N	56.92	2.51	2.14	1.77
Y	Y	Loss	3.39	2.74	2.17
N	Y	Loss	4.48	3.35	2.54

Based on RETSCREEN results

Solar Bottom Lines

- Need at least close to CA peak rates
- Current CT subsidy alone not sufficient
- GHG credits can help
- Sales of hot water will improve results
- Manufacturers could invest and take credits to accumulate CO₂eq releases
- Vehicle owners benefit from lower cost fuel (\$365, perhaps rebated, compared to \$1,000 annually)

Electricity System Benefits

- Ideally located for peak generation:
 - Max. solar generation coincident with hot, humid, sunny summer days
 - Close to users
 - No serious transmission barriers
 - Only minor line losses
- Increased base demand
- Clean incremental electricity

Implications for Biotechnologies

- Adopted biotechnologies need to be as clean as possible
 - Bio feed stocks
 - 3.25 tCO₂eq released at CDN farm/\$1,000 shipped
 - \$2,500 of agricultural shipments average the same tCO₂eq as a \$25,000 car!
 - 5.07 tCO₂eq released per \$1,000 fertilizer shipped
 - Burning tip – Hydrogen clean at tip but what goes into it?

Relatively Clean Bio Feed Stocks

- Low chemical fertilizer requirements
- Bio processing of CO₂eq
- Wastes where production CO₂eq is already embodied in products don't count (Economic parallel is sunk costs)
- CO₂eq sequestering technologies
- Co-fired pellets designed to reduce CO₂eq from coal generating stations

Bio Fuels and Peak Rates

- Stored biofuels can be used to meet peak electricity demands
- Face the need to maximize revenues from the co-production of hot water more intensively than does the solar
- Many of the same advantages of smaller scale plants
 - Close to demand (Minimal transmission)
 - Easily scaled to meet needs

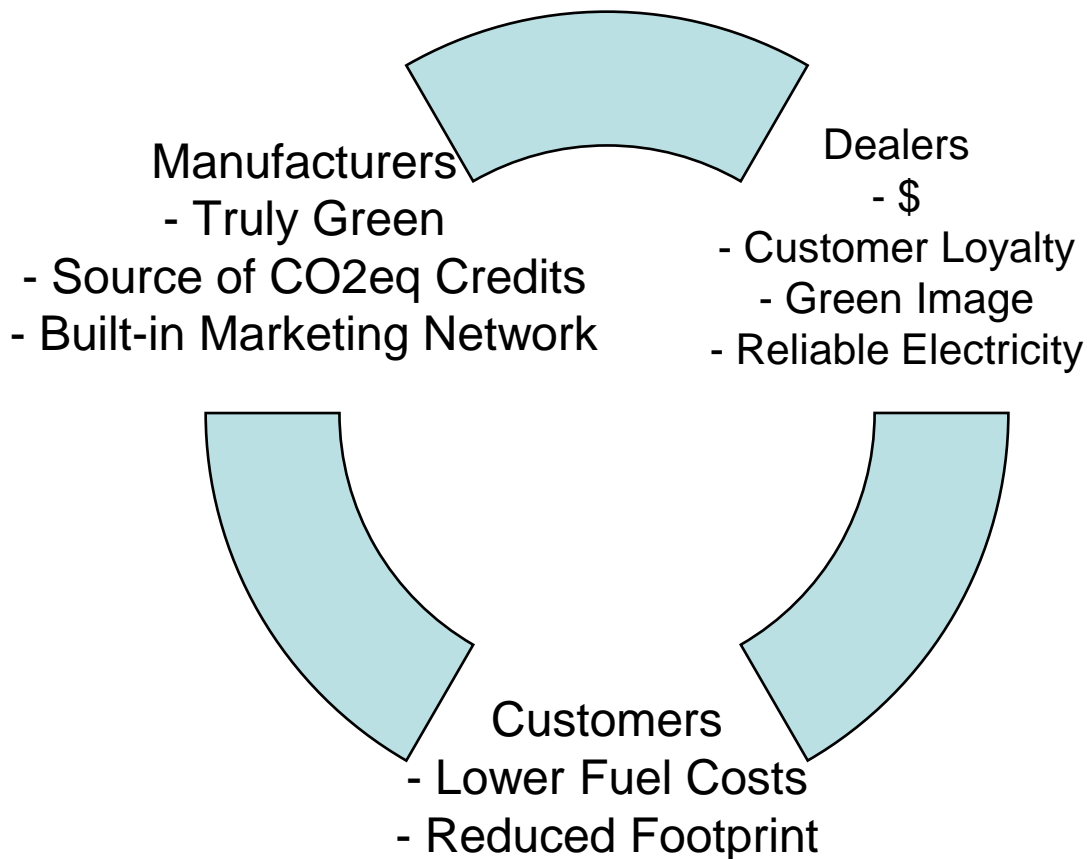
Accelerating Off-Oil

- Establish peak electricity rates
- Ensure biofuels are truly clean
- Explore biofuel delivery systems to meet peak demands
- If biorefineries, biofuels, or bioprocesses are competitive with solar, auto dealers and manufacturers have vested interest in generating or capturing tradable CO₂eq credits.

Evolutionary Scope

- 241 million U.S. motor vehicles
- 220 million cars
- 179 billion gallons of fuel consumed/year
- 1.9 billion gallons in CT
- 7% of fleet replaced annually
- 1% transition of fleet to clean plug-ins will reduce CO₂eq by 9.33 billion tonnes in the U.S. and 118 million tonnes in CT over the first 10,000 mi/vehicle fueled by equivalent clean electricity.

WINNERS



SOCIETY

- Off Oil
- Employment
- Downward Pressures on Fossil Fuel Prices
- Curtailed CO₂e_q
- Better Health
- Secure Electricity
- Quieter Vehicles
- Reduced Reliance on Adversaries
- International Growth