CLIMATE AND ENERGY....

....BUILDINGS AND CARS

THE END OF OIL...PART III

March 7, 2006

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THE '800-LB GORILLAS' IN ENERGY AND ENVIRONMENT

CLIMATE

Years of conventional reserves at today's rates

OIL...and Energy security

North America
Europe/Eurasia
Africa
Asia Pacific
Central/South America

1.7
3.3
2.7
1.3
23.3

°C

Years

1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100
CLIMATE

OIL

King Kong meet Godzilla

BUILDINGS

CARS
A lot of attention has been paid to the Supply Side.
It’s the Architecture, Stupid!

Who really holds the key to the global thermostat?
The Answer might surprise you.

By Edward Mazria
Solar Today, May/June 2003
BUILDINGS USE ≈ HALF OF U.S. ENERGY

- Residential Bldgs: 22%
- Commercial Buildings: 18%
- Industrial Bldgs: 2%
- Embodied Energy in Matrls: 7%
- Non-Bldg Industry: 22%
- Transportation: 28%
  - Cars: 9%
  - Light Trucks, SUVs: 6.5%

EIA 2004
AND, BUILDINGS USE THREE-FOURTHS OF OUR ELECTRICITY
U.S. Carbon Emissions from Residential and Commercial Buildings

Million tons of Carbon


BUILDINGS
Transportation
Industry

2005 Building Energy Data Book, EIA
BUILDINGS USE ONLY 8% OF U.S. OIL CONSUMPTION:

- Passenger Cars 23%
- Passenger Light Trucks 15%
- Commercial Trucks 13%
- Other transportation 16%
- Industrial Fuel 13%
- Industrial Feedstocks 12%

TRANSPORTATION 68%

..Is this worth making a big deal about?

2000
19.7 M bbl/d
7.2 B bbl/yr
OIL FOR BUILDINGS...

.... No Big Deal?

Projected U.S. Consumption

Oil for buildings: 0.6 Bbbl/yr
OIL FOR BUILDINGS...

.... No Big Deal?

Save 30% in oil-heated buildings = ANWR

Oil for buildings: 0.6 Bbbl/yr

Projected U.S. Consumption

Arctic Refuge
8 billion bbls/40 yrs
≈ 0.2 Billion/yr
The big ENERGY loads for U.S. buildings are residential space heating and water heating, and commercial lighting.
Figure 1.13  Cat solving a problem in 2 steps.
BURR....... I'M COLD! WHAT WILL I DO?

I KNOW! I'LL GO TO THE ENDS OF THE EARTH TO DRILL FOR OIL AND DIG FOR COAL AND URANIUM AND BUILD REFINERIES AND POWER PLANTS TO RUN MY SOLID STATE ELECTRIC BLANKET!
Figure 1.14 Person solving the same problem in more than two steps.
USING THE SUN FOR DAYLIGHT AND HEAT.. Saves energy
And can be very attractive
LOTS OF INSULATION, CAREFUL ORIENTATION, GOOD WINDOWS, THERMAL MASS, EFFICIENT HEATING SYSTEM, ...

82% energy savings vs Title 24

California’s Energy-Efficiency Building Code

PG&E ACT² House  Davis, California

Comfortable in 3-day heat wave with no A/C peak 113°F
WHAT'S INSIDE THE BUILDING MATTERS TOO!

U.S. REFRIGERATOR ENERGY, SIZE AND PRICE

- Average Energy (kWh/yr) or Real Price ($)
- Refrigerator Volume (ft³)
- Energy (kWh/yr)
- Real Price ($)
- Volume (ft³)

70% energy savings, 60% cost savings, 20% bigger since 1975
ENERGY EFFICIENCY STANDARDS IN BUILDINGS HAVE BEEN VERY EFFECTIVE...

Annual Usage of Air Conditioning in New Homes in California

Initial California Title 24 Building Standards
California Title 20 Appliance Standards 1976-1982
Estimated Impact of 2006 SEER 13 Standards
1992 Federal Appliance Standard

BETTER HOUSES (and bigger!) AND AIR CONDITIONERS CUTING A/C DEMAND BY TWO-THIRDS..
Critical loads: Lights and Airconditioning

Building orientation
Daylighting and lighting controls
Choice of windows... transmit visible but not the infrared
Capstone 30 kW Microturbine

PowerPlus Technologies GmbH
2-4.7 kW Reciprocating engine

COMBINED HEAT AND POWER SYSTEMS SAVE 40 - 50% OF ENERGY

WhisperGen 1.2 kW Stirling Engine

Ion America 5 kW Solid Oxide fuel cell

1.2 kW ac 27,000 Btu/hr

PowerPlus Technologies GmbH
ecopower 2 kW to 4.7 kW CHP
Proposed site for the green dorm
ONE VERSION OF A ZERO CARBON GREEN DORM

THE DORM

Export electricity

Electricity Demand

Offset carbon emissions of the natural gas by exporting electricity to the grid

Buy N. Gas

Cooking

35 kW PV
200 m²

Hot Tank

5 kW Fuel Cell

30 m² Solar Thermal Collectors

Hot Water

Space Heat
ONE VERSION OF A ZERO CARBON GREEN DORM

THE DORM

- 34,105 kWh to grid
- 15,003 kWh
- 35 kW PV
- 200 m²
- 300 ft² Solar Thermal Collectors
- 54 kW Fuel Cell
- 39,420 kWh
- 270
- 80.1
- 80 MMBtu/yr
- Cooking
- 79 MMBtu
- Natural Gas
- 350 MMBtu/yr
- Electricity Demand 54,423 kWh
- Hot Tank
- 102
- 54
- 66
- 18
- Hot Water
- Space Heat
- 34,105 kWh to grid
Building stock in 30 years will be 25% old and 75% new or remodeled.

Major Remodels in next 30 yrs

- In 2005:
  - To be demolished
  - New construction
  - Remodeled

- In 2035:
  - To be demolished
  - New construction
  - Remodeled

Billion square feet
Building stock in 30 years will be 25% old and 75% new or remodeled.

Great opportunity to reduce carbon emissions...

**TARGETS FOR CONSTRUCTION DONE IN YEAR 2035**

**Serious:**
- New construction save 50%
- Major remodeling save 30%

**Aggressive:**
- New construction save 70%
- Major remodeling save 50%
BUSINESS AS USUAL SCENARIO FOR BUILDINGS

kg C/ft$^2 =$ 2

1.6
SERIOUS EFFORT TO DO BETTER BUILDINGS

kg C/ft² = 2

BAU

SERIOUS

kg C/ft²

Million tons C/yr

0 100 200 300 400 500 600 700 800

2005 2010 2015 2020 2025 2030 2035 2040 2045
AGGRESSIVE EFFORT TO MAKE BETTER BUILDINGS

Million tons C/yr

kg C/ft² = 2

BAU

SERIOUS

AGGRESSIVE

kg C/ft²

2005 2010 2015 2020 2025 2030 2035 2040 2045
CARS...

ENERGY SECURITY (IMPORTED OIL)

GLOBAL WARMING (Greenhouse gases)

URBAN AIR QUALITY (SMOG)
One way to reduce imported oil... use electricity
"PLUG-IN" HYBRID ELECTRIC VEHICLE (PHEV):

- Gasoline
- Electric grid
- Photovoltaics

E85: Bio-ethanol/gasoline?
“PLUG-IN” HYBRID ELECTRIC VEHICLE (PHEV):

- A HYBRID WITH A SMALL, EXTRA BATTERY PACK $\approx 30$ miles/day.. $100$ mi/gal of gasoline

Gasoline

E85: Bio-ethanol/gasoline?

Electric grid

Photovoltaics
"PLUG-IN" HYBRID ELECTRIC VEHICLE (PHEV):

- A HYBRID WITH A SMALL, EXTRA BATTERY PACK ≈ 30 miles/day. 100 mi/gal of gasoline
- CHARGE OVERNIGHT IN YOUR GARAGE USING GRID OR PV POWER
"PLUG-IN" HYBRID ELECTRIC VEHICLE (PHEV):

- A HYBRID WITH A SMALL, EXTRA BATTERY PACK ≈ 30 miles/day.. 100 mi/gal of gasoline
- CHARGE OVERNIGHT IN YOUR GARAGE USING GRID OR PV POWER
- POSSIBLY FUEL WITH E85: BIO-ETHANOL/GASOLINE ..500 mpg of gasoline
“FUEL COSTS”

25 mpg

\[
\frac{\$2.50 \text{ / gallon}}{25 \text{ mi / gal}} = 10 \text{ ¢ / mile}
\]
$2.50 / gallon \quad \frac{25 \text{ mi}}{25 \text{ mi/gal}} = 10 \, \text{¢/mile}$

$2.50 / gallon \quad \frac{50 \text{ mi}}{50 \text{ mi/gal}} = 5 \, \text{¢/mile}$
“FUEL COSTS”

25 mpg

50 mpg hybrid

EQUIVALENT COST OF ELECTRICITY FOR BATTERY-POWERED VEHICLE

(All-Electric or PHEV)

$2.50 / gallon

\[
\frac{25 \text{ mi} / \text{gal}}{25 \text{ mi} / \text{gal}} = 10 \, \frac{\cent}{\text{mile}}
\]

$2.50 / gallon

\[
\frac{50 \text{ mi} / \text{gal}}{50 \text{ mi} / \text{gal}} = 5 \, \frac{\cent}{\text{mile}}
\]

\[
0.25 \, \frac{\text{kWh}}{\text{mi}} \times \$0.09 / \text{kWh} \text{ (off peak, PG&E)} = 2.25 \, \frac{\cent}{\text{mile}}
\]
THE TRADE OFF BETWEEN PERFORMANCE AND CARBON EMISSIONS

Greenhouse Gas Emissions (tons/yr C eq)

Acceleration 0-60 mph (sec)

SLOWER

MORE CARBON
WHAT IF YOU COULD HAVE BOTH...PERFORMANCE AND LOW CARBON!

Greenhouse Gas Emissions (tons/yr C eq) vs Acceleration 0-60 mph (sec)

Focus

Prius

Prius +

FC-NG

FC-grid

Navigator

Escape

Escape h

Focus

Corolla

Lexus RS330

Highlander

Highlander H

Lexus hybrid

Acura

Corolla

Malibu

Cadillac CTS

Acura

Highlander H

Boxter

Audi RS4

Viper

WHAT IF YOU COULD HAVE BOTH...PERFORMANCE AND LOW CARBON!

ELECTRIC

MORE CARBON

SLOWER
PEOPLE ARE WORKING ON IT..
“I think we could easily double [the energy capacity of] what we have right now.

..if you had an electric car with a range of say 270 miles.. Game over… anybody who drives it will never go back to an internal combustion engine..

Prof. Donald Sadoway (M.I.T.)
IMPACT ON THE CALIFORNIA GRID WITH A BUNCH OF PHEVs AND EVs

- 20% EV
- 40% vehicle-miles EV

System load (GW)

- Noon                6 pm               MN                  6 am              Noon

SYSTEM LOAD: No EVs
WHAT IF YOU GOT YOUR ELECTRICITY FROM THE SUN?

WITH AN ELECTRIC OR PLUG-IN HYBRID... THIS PV ARRAY COULD POWER YOUR CAR FOR ≈ 12,000 MILES PER YEAR
$12,000 for 2 kWac
170 ft$^2 $ @ 17%

12,000 miles/yr

$5000 for 10kWh

PHEV WITH PVS  vs  STRAIGHT HYBRID
PHEV WITH PVS vs STRAIGHT HYBRID

$12,000 for 2 kWac  
170 ft² @ 17%

Annual Loan Payments 17k(6%, 30yr) = $1235

$14,000/16 = 14¢/kWh

$5000 for 10kWh

Utility Customer Sell Buy

12,000 miles/yr
$12,000 for 2 kWac
170 ft² @ 17%

Annual Loan Payments (6%, 30yr) = $1235

Tax deductible interest savings (MTB = 33%) = -$335
$12,000 for 2 kWac
170 ft² @ 17%  

Annual Loan Payments (6%, 30yr) = $1235

Tax deductible interest savings (MTB = 33%) = -$335

IF allow more than net metering... using PG&$ TOU rates:
Sell your electricity for $580, buy back for $280. Net = -$300
$12,000 for 2 kWac 170 ft² @ 17%

Annual Loan Payments (6%, 30yr) = $1235

Tax deductible interest savings (MTB = 33%) = -$335

IF allow more than net metering... PG&$ TOU rates
Sell your electricity for $580, buy back for $280.. Net = -$300

Net cost = $1235 - 335 - 300 = $600/yr

$600/yr for 12,000 miles = 5 ¢/mile
PHEV WITH PVS vs STRAIGHT HYBRID

$12,000 for 2 kWac
170 ft$^2$ @ 17%

Annual Loan Payments (6%, 30yr) = $1235

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IF allow more than net metering... PG&$ TOU rates
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$600/yr for 12,000 miles = 5¢/mile

Regular Prius

\[ \frac{12,000 \text{ miles/yr}}{50 \text{ miles/gal}} \times \frac{2.50 \text{ /gal}}{1 \text{ yr}} = \frac{600 \text{ /yr}}{5.\text{¢/mi}} \]
What About Fuel Cell Vehicles? Honda FCX
15,600 miles/yr: 5 day/wk commute @ 50 miles/day, half fwy, half city; 2 day/wk 25 mi/day city
“FUEL” COSTS FOR THE FIVE VEHICLES:

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>FUEL COST (¢/mi)</th>
<th>H2 @ $3/kg</th>
<th>Gasoline @ $2.50/gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOCUS</td>
<td>10¢</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRIUS</td>
<td>5</td>
<td>12¢ kWh</td>
<td></td>
</tr>
<tr>
<td>PRIUS +</td>
<td>3.7</td>
<td>6¢ kWh</td>
<td></td>
</tr>
<tr>
<td>ALL-ELECTRIC</td>
<td>3.0</td>
<td>12¢ kWh</td>
<td></td>
</tr>
<tr>
<td>HONDA FCX</td>
<td>5.3</td>
<td>1.5</td>
<td>Based on NG at old prices</td>
</tr>
</tbody>
</table>

H2 @ $3/kg
CARBON EMISSIONS FOR FIVE VEHICLES:

- FOCUS: 470 gCO2/mi
- PRIUS: 230 gCO2/mi
- PRIUS+: 185 gCO2/mi
- ALL-ELECTRIC: 175 gCO2/mi
- HONDA FCX: 200 gCO2/mi
- Electrolysis-Avg grid: 660 gCO2/mi

Avg US Grid
THE EMERGING “CAR OF THE YEAR” AWARD GOES TO...

- 2000: HUMMER
- 2005: HYBRID
- 2010: PLUG-IN HYBRID
- 2015: ALL-ELECTRIC
- 2020?: FUEL CELL VEHICLE
THE EMERGING “CAR OF THE YEAR” AWARD GOES TO..

2000  HUMMER
2005  HYBRID
2010  PLUG-IN HYBRID
2015  ALL-ELECTRIC
2020 ? FUEL CELL VEHICLE

THE END OF OIL...?

Good riddance
THE EMERGING “CAR OF THE YEAR” AWARD GOES TO..
"Since using hydrogen as a transportation fuel would necessitate several significant breakthroughs, other alternatives to achieve the program goals should be explored and additional research supported if such alternatives show comparable prospects for success. The committee suggests that high-energy batteries for pure battery electric vehicles might be such an alternative."

The 800-lb Gorillas
Climate and Oil
Meet Godzilla
Buildings and Cars

END OF OIL... PART III
MARCH 7, 2006

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