Solar Energy

Photo by KAMYAR ENSHAYAN, 2006

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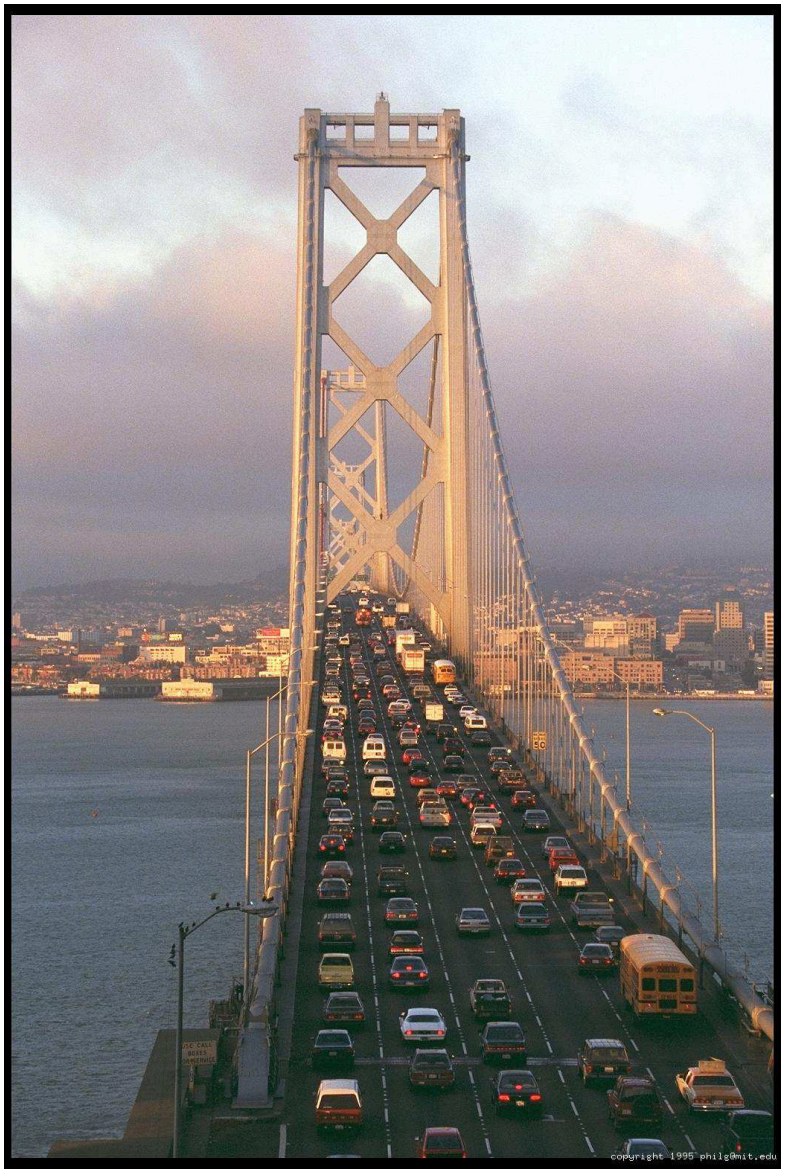
The current energy situation and the future of solar

575 Sir Francis Drake Blvd. Greenbrae, CA, October 2, 2007

Overview

Industrial agrofuels have been introduced by several nations because of

- Energy “security” (US)
- “Abatement” of Greenhouse Gas (GHG) emissions (All)
- “Sustainable” transportation systems (currently meaningless)
- Helping the “farmers” (open-ended subsidies in rich countries)



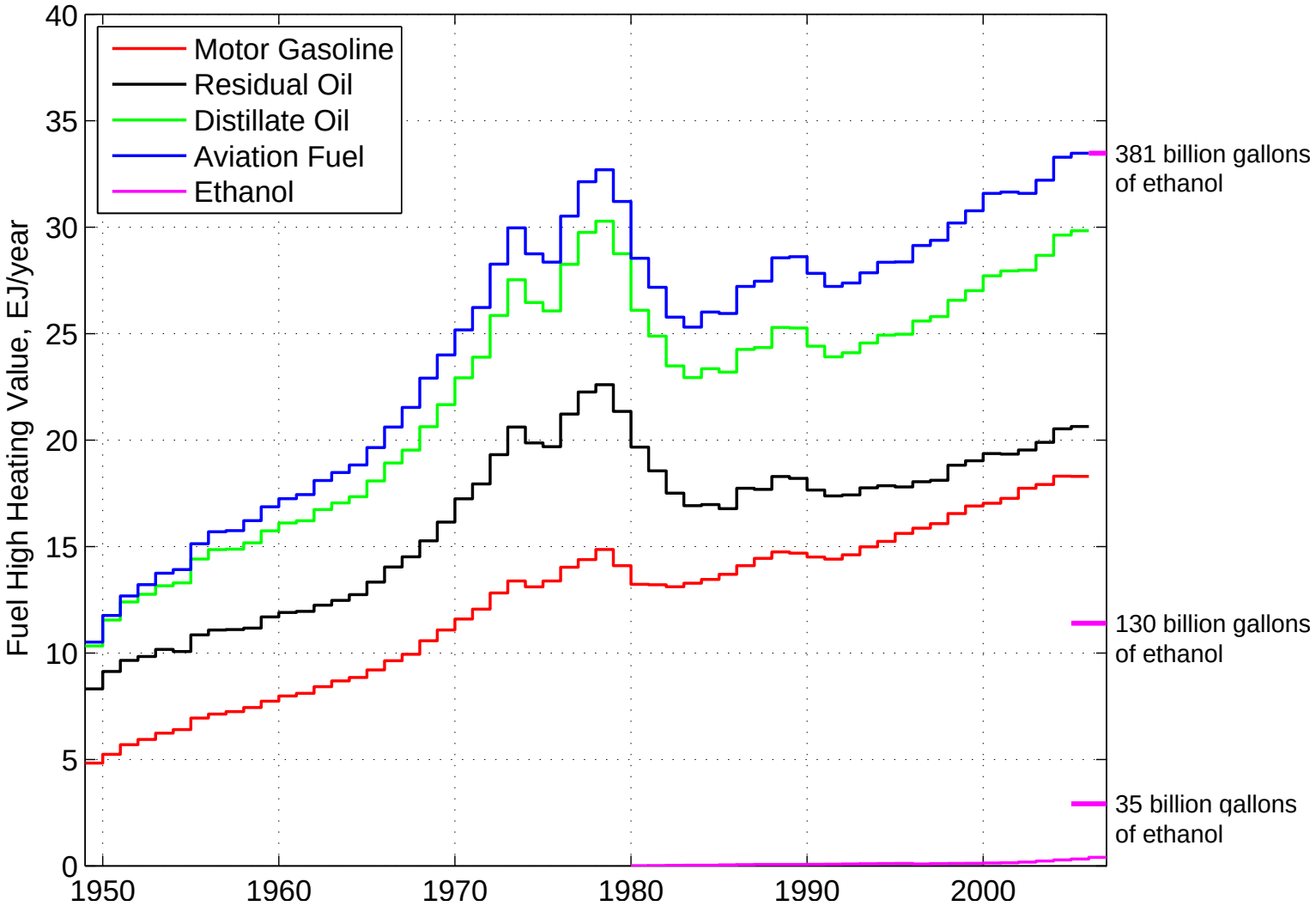
Units in My Presentation...

- The fundamental unit of energy is 1 exa Joule (EJ)

1EJ = 1,000,000,000,000,000,000 J
is the amount of metabolized energy in food sufficient to sustain the entire U.S. population for one year @100 J/s-person = 100 W/person continuously

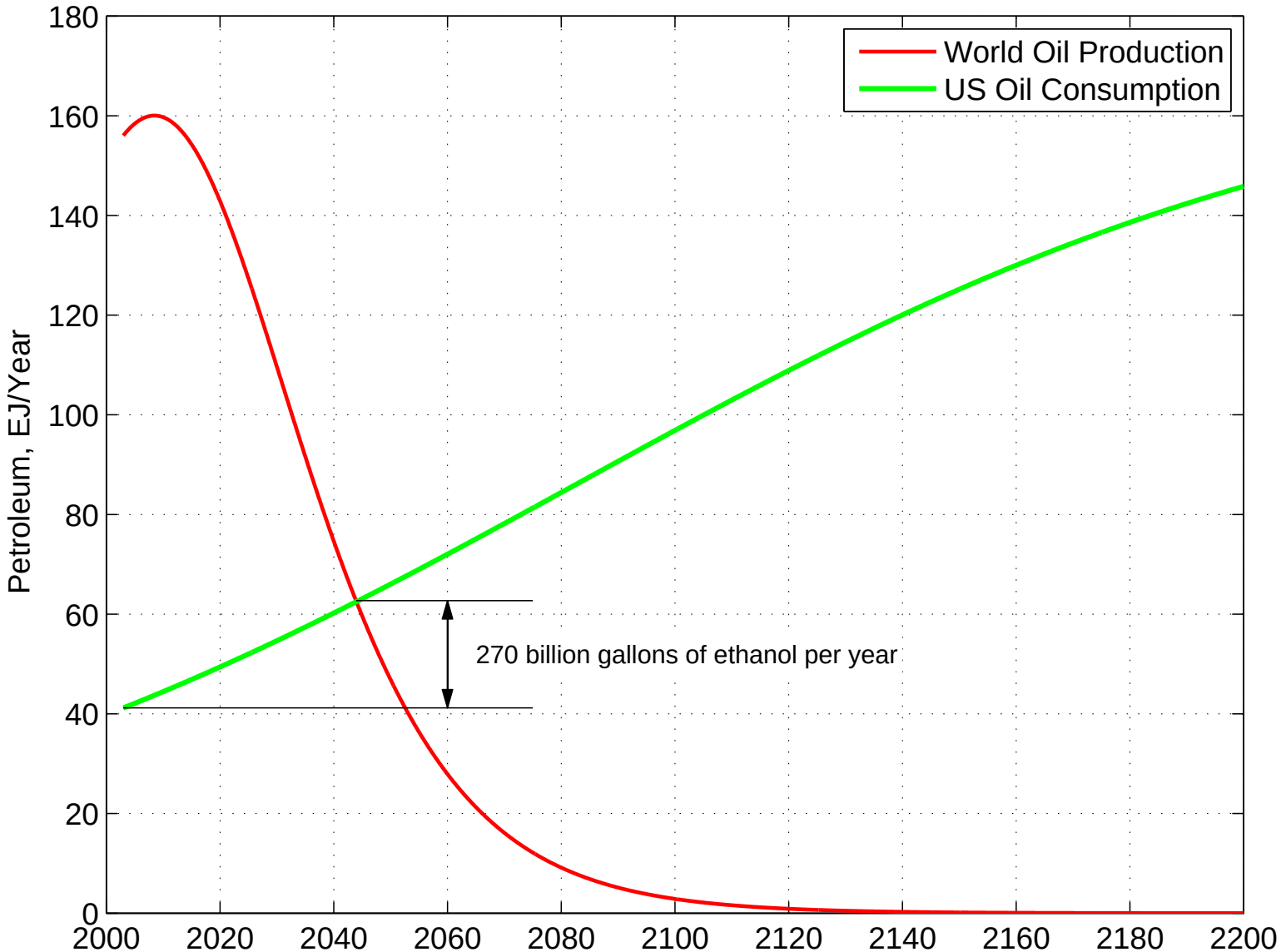
- Currently the U.S. uses 105 EJ/year; one hundred and five times more than we need to live
- If we were to metabolize this amount of energy, we would be 15 m long sperm whales, each weighing 40 tonnes. There are $\sim$300,000 sperm whales worldwide and 1000 times more Americans

US Energy Security: Nothing



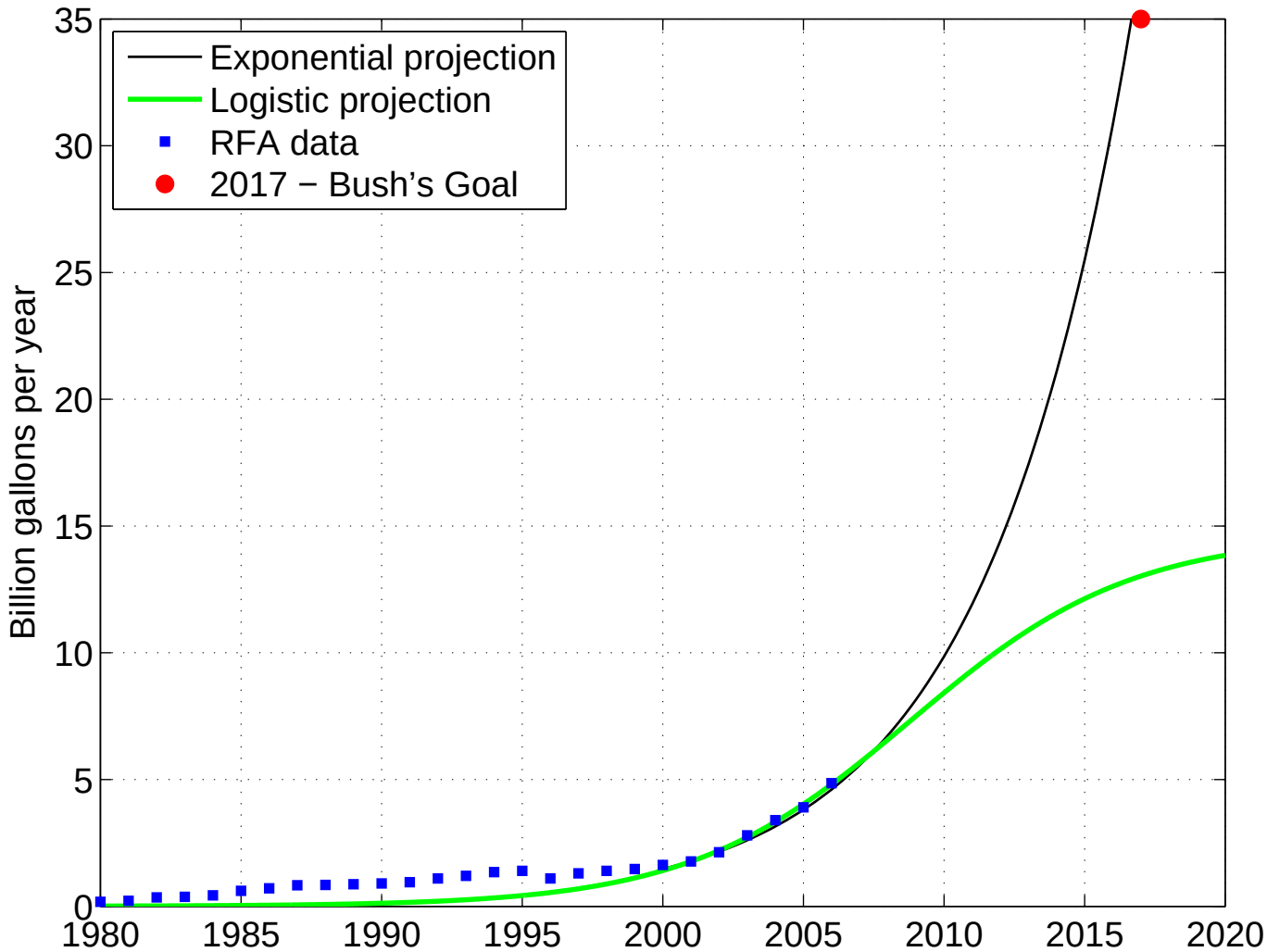
Sources: US DOE EIA, Patzek (2004)

US Petroleum Use Projection in BAU



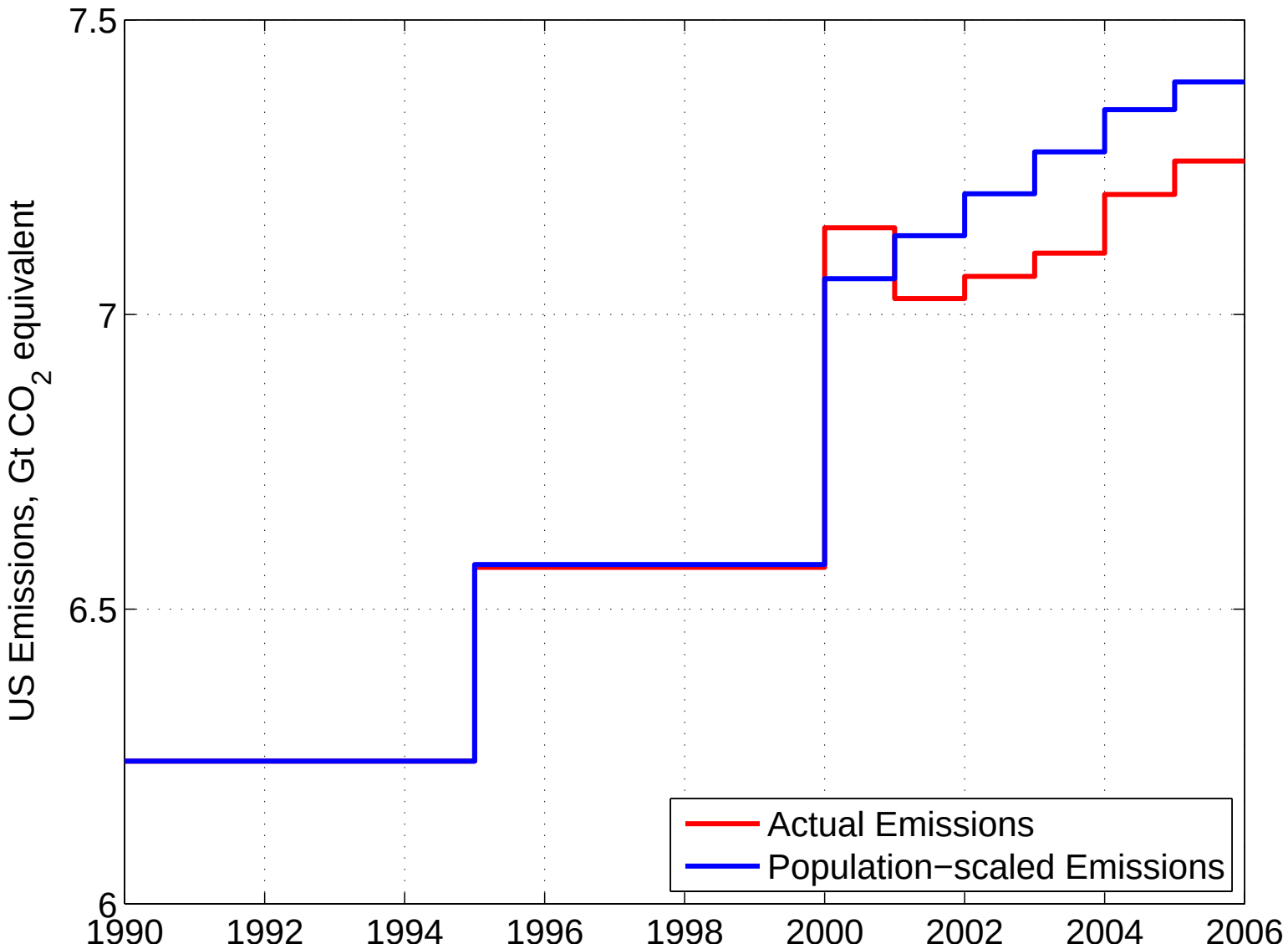
Sources: US DOE EIA, Patzek OECD (2007)

US Ethanol Production



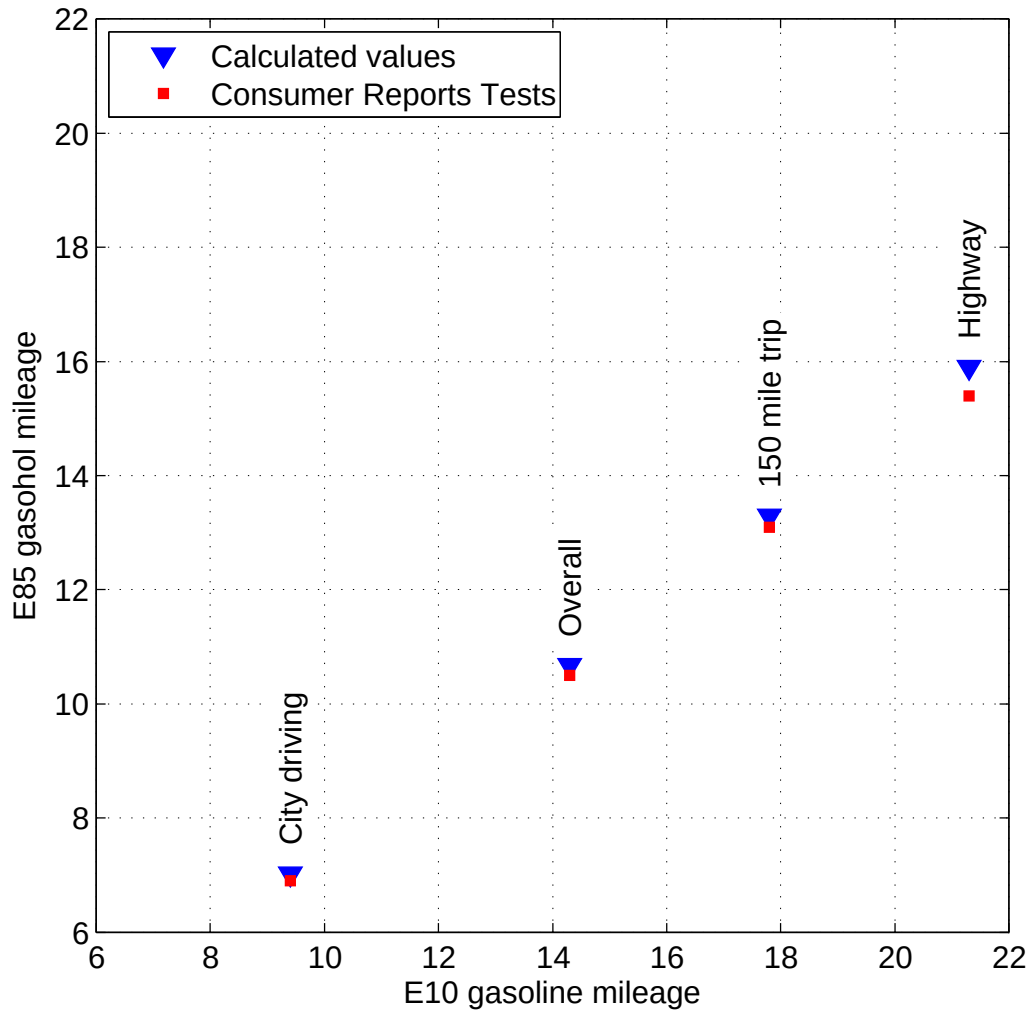
Sources: US DOE EIA, RFA, Patzek OECD (2007)

US GHG Abatement: Nothing



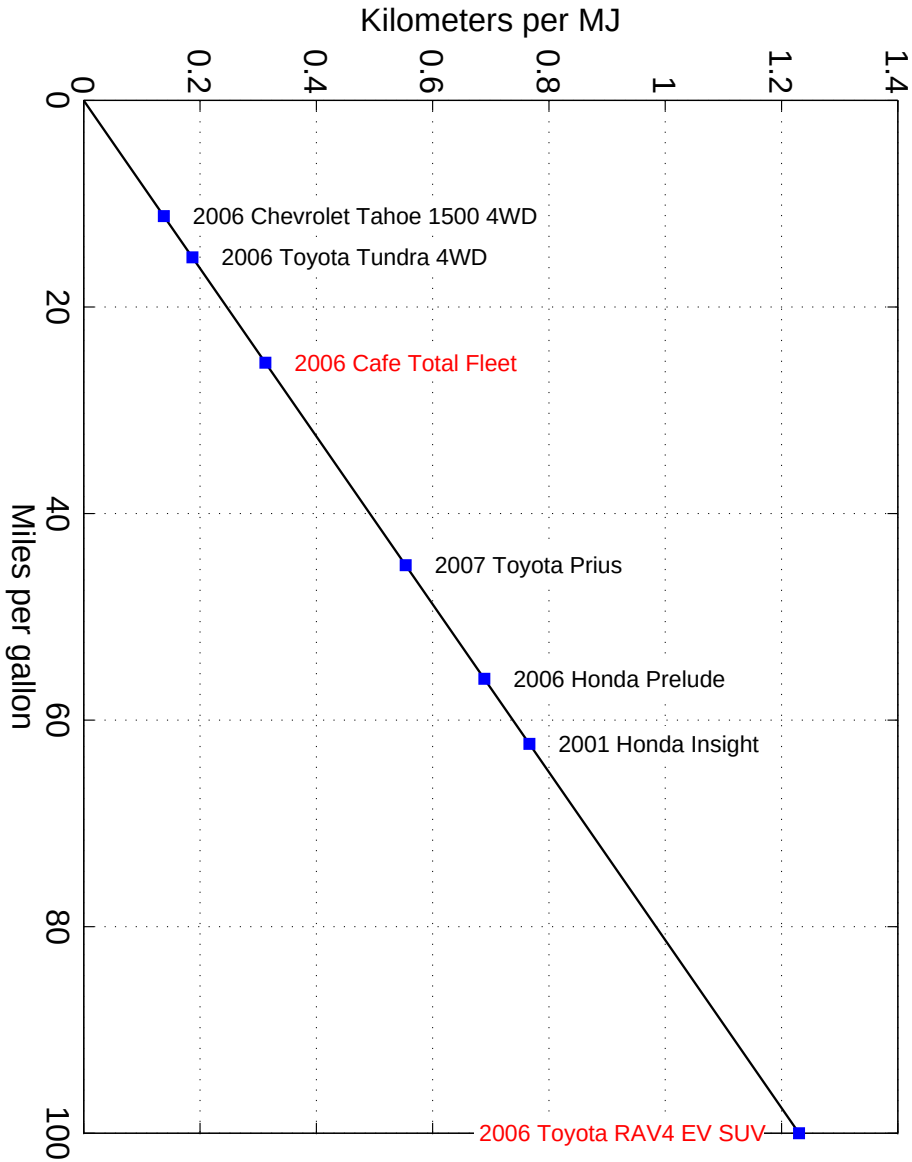
We have done **nothing** about GHG emissisons. Sources: U. S. EPA, US Census Bureau

Mileage = Fuel Energy Content



Under the CAFE formula a 2007 Tahoe truck would receive a CAFE rating of 21 mpg, but a 2007 Tahoe truck with an FFV engine would be rated at 35 mpg. Sources: Consumer Reports, Oct 2006; Patzek (2006)

Sustainable Transportation: Nothing



Source: www.fueleconomy.gov (2007)

Driving on Pure Corn Ethanol

Assumptions:

- Chevy Tahoe, 9 mpg, 10,000 miles/year: 1,111 gal ethanol/year
- 2.5 gallons of pure ethanol/bushel (no denaturant)
- Fossil energy output:input = 1.25

Each year, year-after-year, these are results:

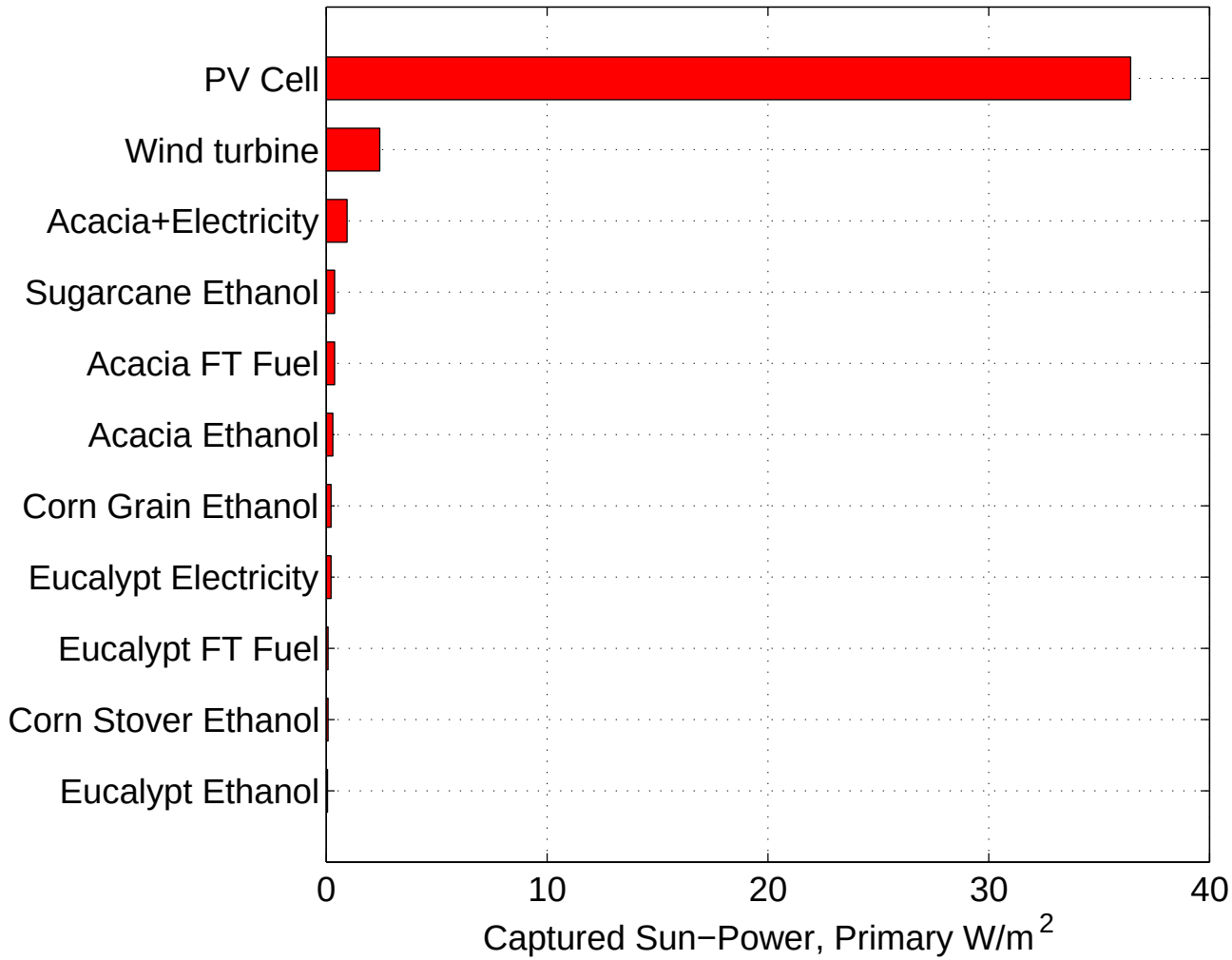
- Burn corn sufficient to feed 67 people to drive and 54 people to produce the ethanol fuel
- Consume 6700 gallons of water in refinery
- Emit up to 50 % more GHGs than from gasoline

Capture of Solar Power…

Brief Explanation

Photovoltaic Cells Win. . .

Solar cells are up 70 - 630 times more efficient than agrofuels



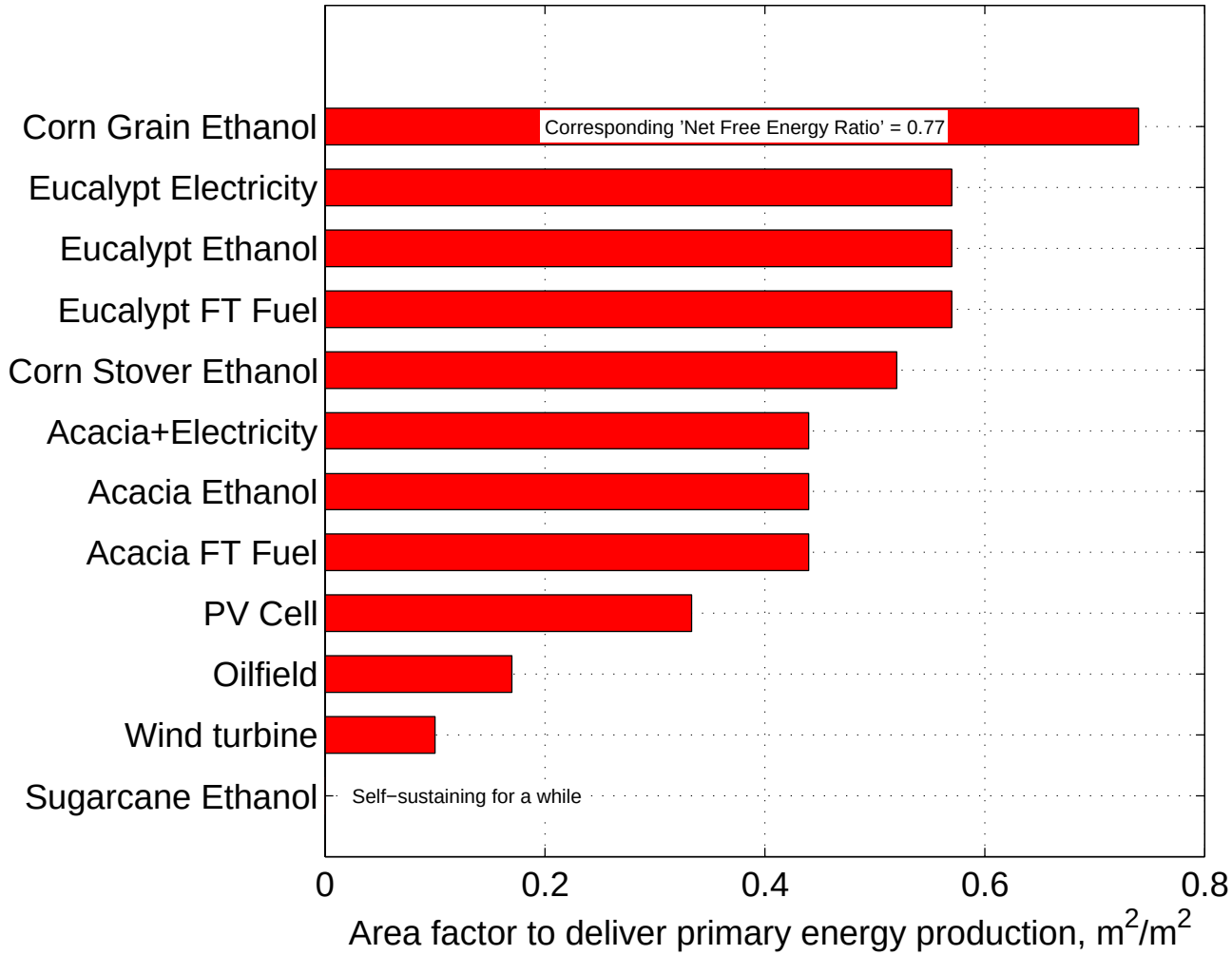
Source: T. W. PATZEK & D. PIMENTEL, CRPS **23**(6), 2004, **24**(5-6), 2005

Land Area to Drive a Car…

- Assume driving 15,000 miles/year @40 mpg in a Toyota Prius hybrid
- Alternatively, drive an all-electric car that is 2.5 times more efficient than the Prius
- Account for average energy costs of producing gasoline from crude oil (17%) and biofuels from biomass as in the slides above
- Assume energy costs of manufacturing and deploying PV panels and wind turbines, 33% and 10% of their 30-year production

Extra Area to Deliver Energy...

Additional Land Area Needed to Cover Energy Production Costs



Source: T. W. PATZEK & D. PIMENTEL, CRPS **23**(6), 2004, **24**(5-6), 2005

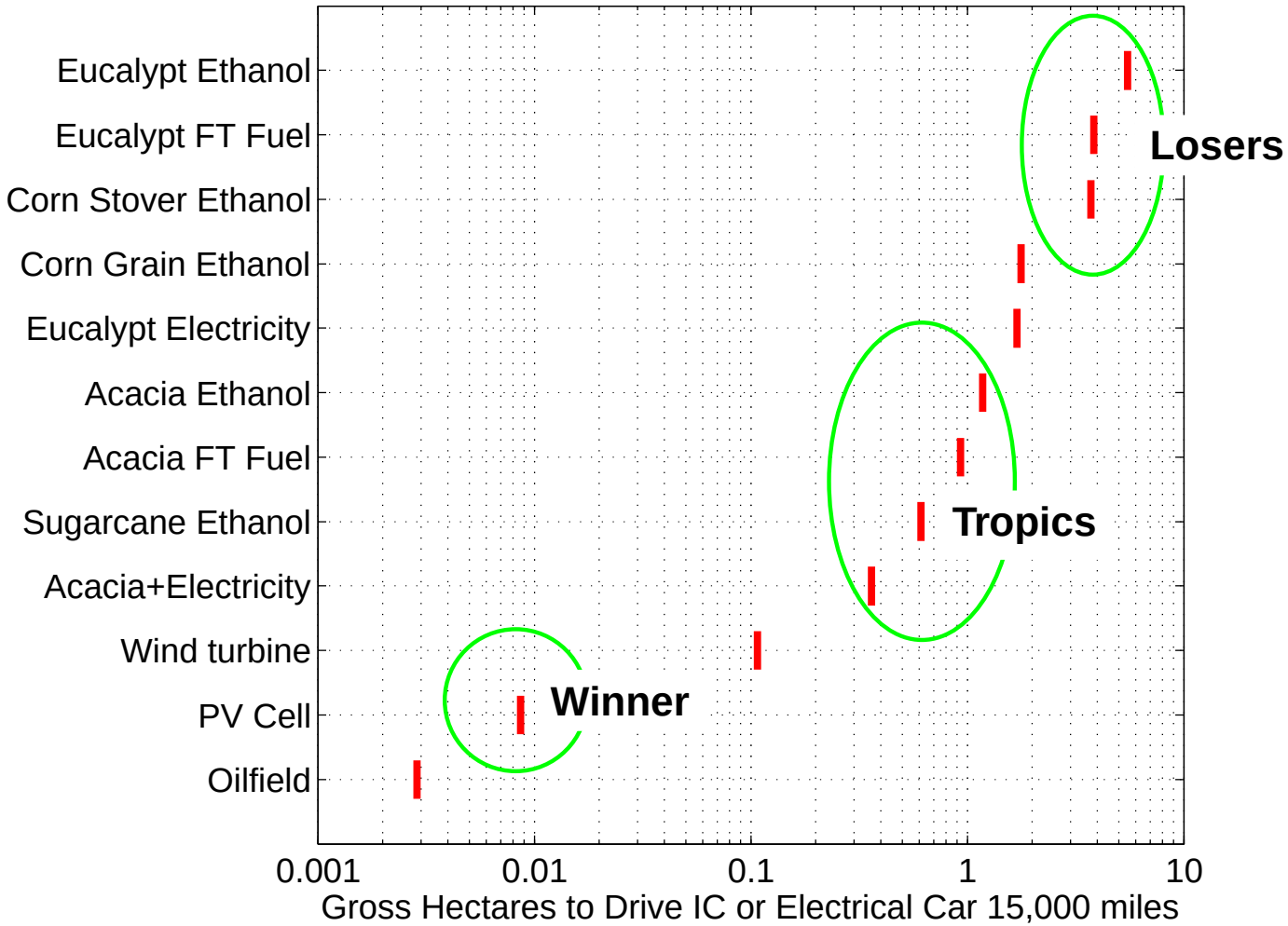
Areas Relative to Oilfield...

Oil field area to drive the Prius is 330 square feet (30 m^2)

Technology	Net Ratio	Gross Ratio
Oilfield	1.0	1.0
PV Cell	2.7	3.0
Wind turbine	39.8	37.4
Acacia+Electricity	102.0	125.5
Sugarcane Ethanol	250.0	213.7
Acacia FT Fuel	263.2	323.9
Acacia Ethanol	333.3	410.3
Eucalypt Electricity	416.7	593.0
Corn Grain Ethanol	441.9	619.7
Corn Stover Ethanol	1000.0	1299.1
Eucalypt FT Fuel	1000.0	1341.9
Eucalypt Ethanol	1428.6	1917.0

Gross Acres to Drive a Car…

Solar cells and 85%-efficient electrical car are clear winners



Source: T. W. PATZEK & D. PIMENTEL, CRPS **23**(6), 2004, **24**(5-6), 2005

Conclusions

Thirty million hectares (75 million acres) covered with:

Corn = 16 million Priuses from grain + 8 million Priuses from stover – for a while

Sugarcane = 47 million Priuses – for a while

Solar cells = 3000 million electric cars

Wind turbines = 270 million electric cars

We need to invest is solar cell and electricity storage technologies, *not* in agrofuels