

Little Green Lies: Dissecting the Hype of Renewables

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US Army Corps of Engineers
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Renewable Power Roadmap

The most difficult subjects can be explained to the most slow-witted man if he has not formed any idea of them already; but the simplest thing cannot be made clear to the most intelligent man if he is firmly persuaded that he knows already, without a shadow of doubt, what is laid before him.

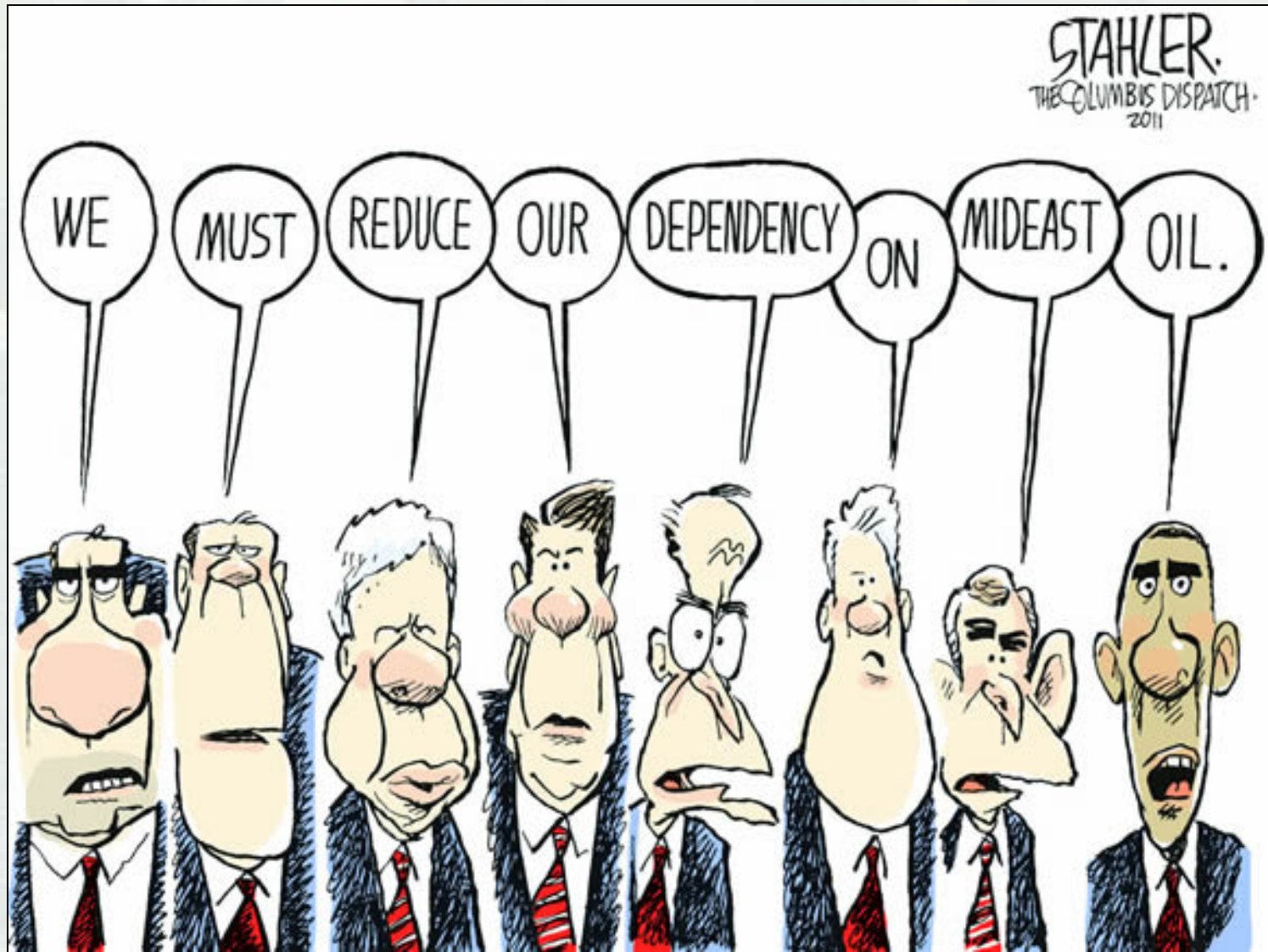
-- Leo Tolstoy

"Once people store their factual inferences in memory, these inferences are indistinguishable from hard data. The more they then use this stored information, the more central it becomes to future inferences and judgments...People constantly overrate the accuracy and reliability of their beliefs."

--University of Illinois study, James Kuklinksi, et al, "Misinformation and the Currency of Democratic Citizenship", 2000:



This Time We Mean it



Why Bother?

What's all the fuss about?

Oil Reserves:

World 1,475 bbls, 50 years (R/P ratio)

US: 28.5 bbls 18 years (R/P ratio)

Coal Reserves:

World 826 billion tons, 119 years (R/P)

US: 238 billion tons 245 years (R/P)

Natural Gas Reserves*:

World: 9,270 TCF (187.5TCM), 87.9 years (R/P)

US Reserves (Including Unproved): 2,587TCF, 124 years (R/P)

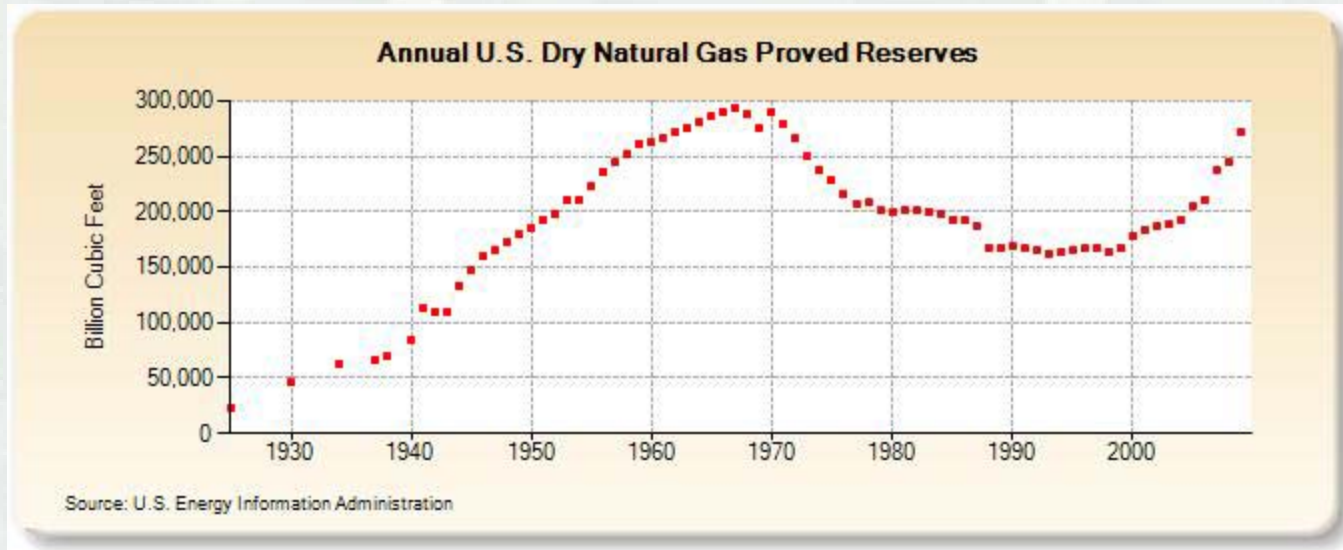
Source: 2010 BP Statistical Energy Review (Except *EIA Annual Energy Outlook, 2010)

*2011 EIA Update



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Why Bother?



1990 Global Proved Oil Reserves: 1T Bbls

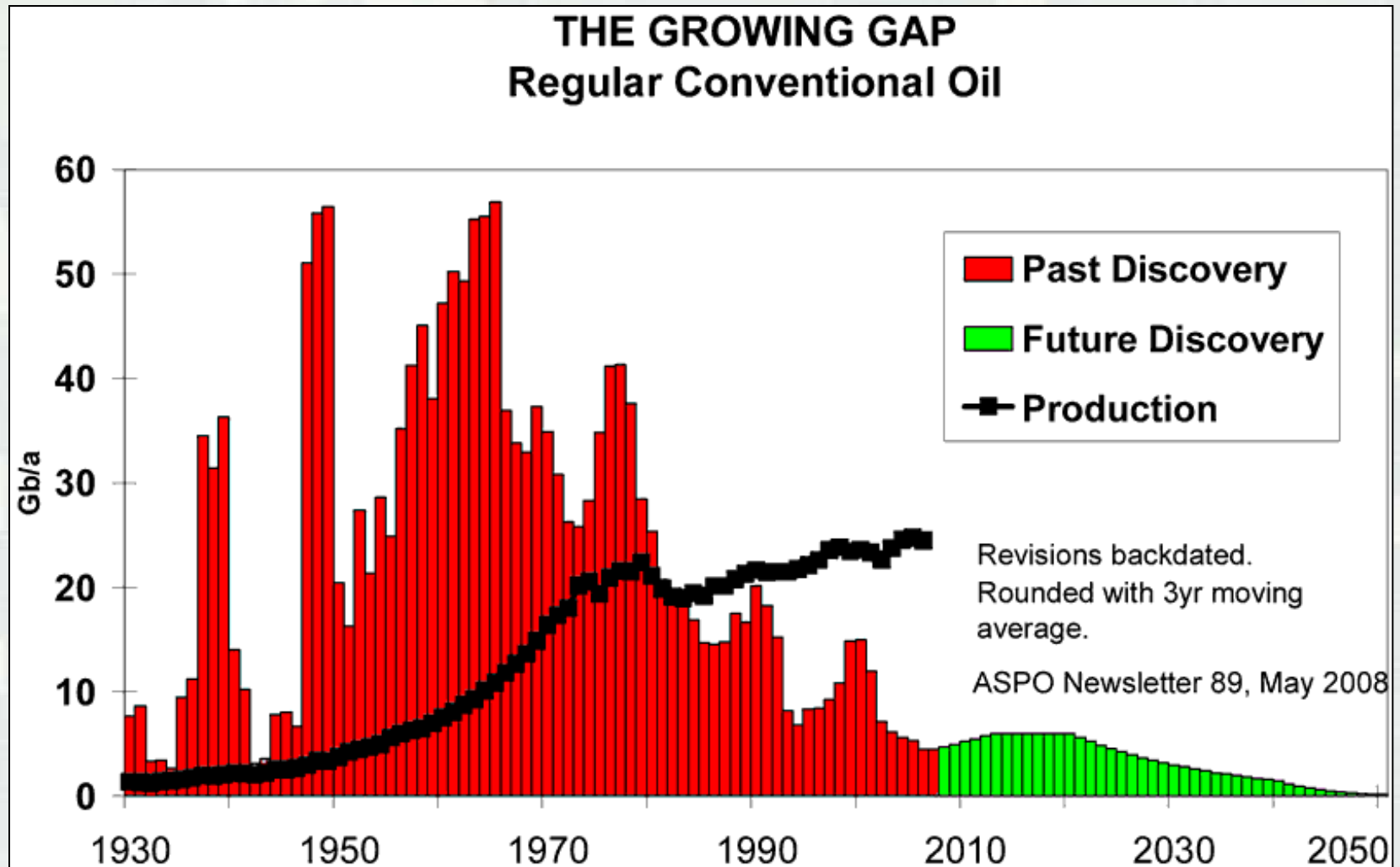
2010 Global Proved Oil Reserves: 1.5T Bbls

Oil Produced, 1990-2010: ~.5T Bbls



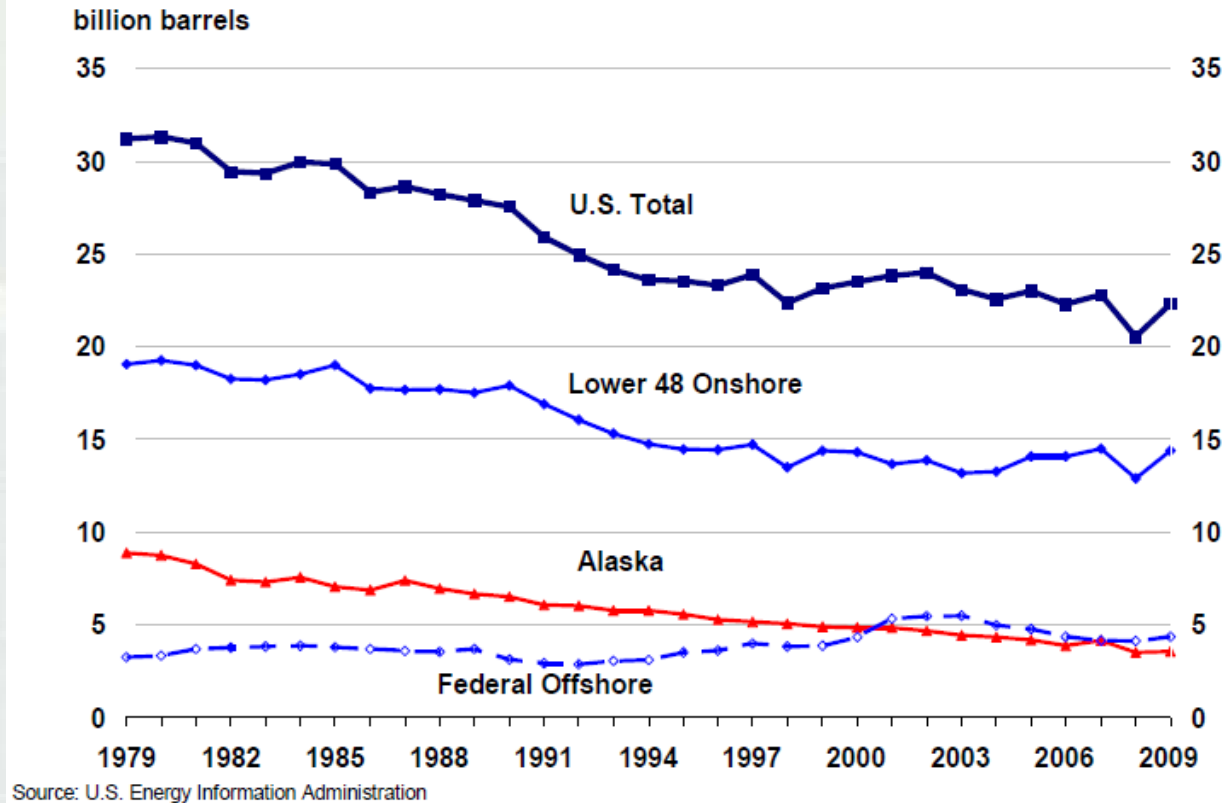
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Why Bother?



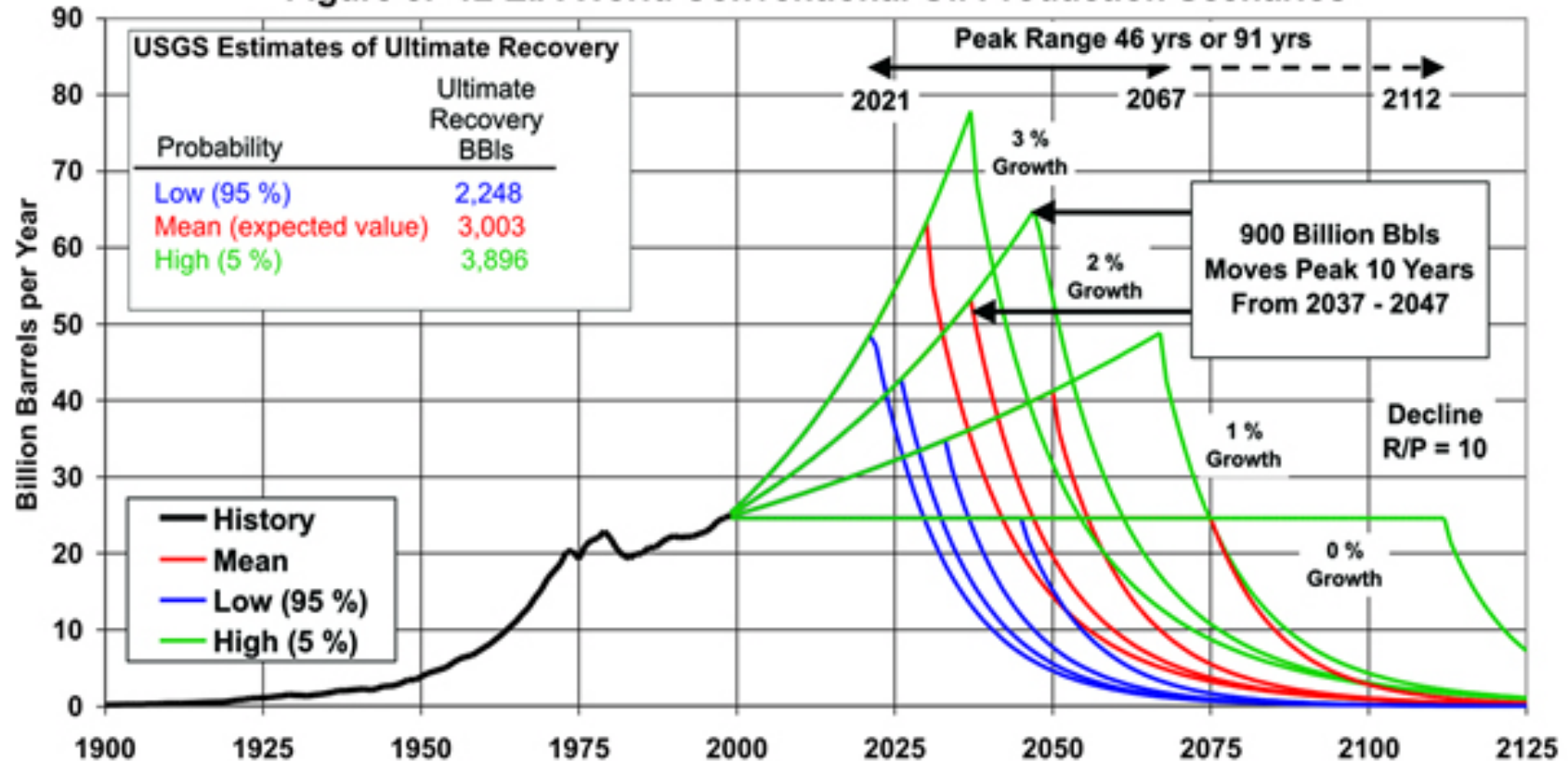
Affordable Renewable Energy Strategies

Figure 7. U.S. Crude Oil plus Condensate Proved Reserves, 1979-2009



Affordable Renewable Energy Strategies

Figure 3. 12 EIA World Conventional Oil Production Scenarios



Source: Energy Information Administration

Note: U.S. volumes were added to the USGS foreign volumes to obtain world totals.



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Population Trends

Figures in Millions	2010	2030	2050	% Increase
World	6,853	8,259	9,284	36%
Less Developed Countries	5,621	6,984	8,005	42%
More Developed Countries	1,231	1,275	1,279	4%
USA	307	373	439	43%
India	1,173	1,460	1,656	41%
Pakistan	184	243	290	58%
China	1,330	1,391	1,303	-2%
Russia	142	124	109	-23%
Japan	126	113	93	-26%
Eastern Europe	119	112	99	-17%
Sub Saharan Africa	850	1,320	1,889	122%
Northern Africa	164	212	248	51%
Nigeria	155	212	264	70%
Ethiopia	88	162	278	216%
Congo	75	131	198	164%

Source: US Census Bureau, Population Division



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Energy Trends

	Per Capita Energy Use (Kg Oil Equivalent)
World	1,819
USA	7,766
Russia	4,730
France	4,258
Germany	4,027
Japan	4,019
UK	3,464
China	1,484
Brazil	1,239
Indonesia	849
Nigeria	722
India	529
Pakistan	512
Ethiopia	290
Congo	289
Bangladesh	163

2010 Per Capita Energy Estimate:

$1,819 * 6.7\text{B people} = 12,187\text{B KG Oil Equivalent}$

2050 Per Capita Energy Forecast (1% Annual Growth):

$2,708 * 9.3\text{B people} = 25,184\text{B KG Oil Equivalent}$

2050 Per Capita Energy Forecast (2% Annual Growth):

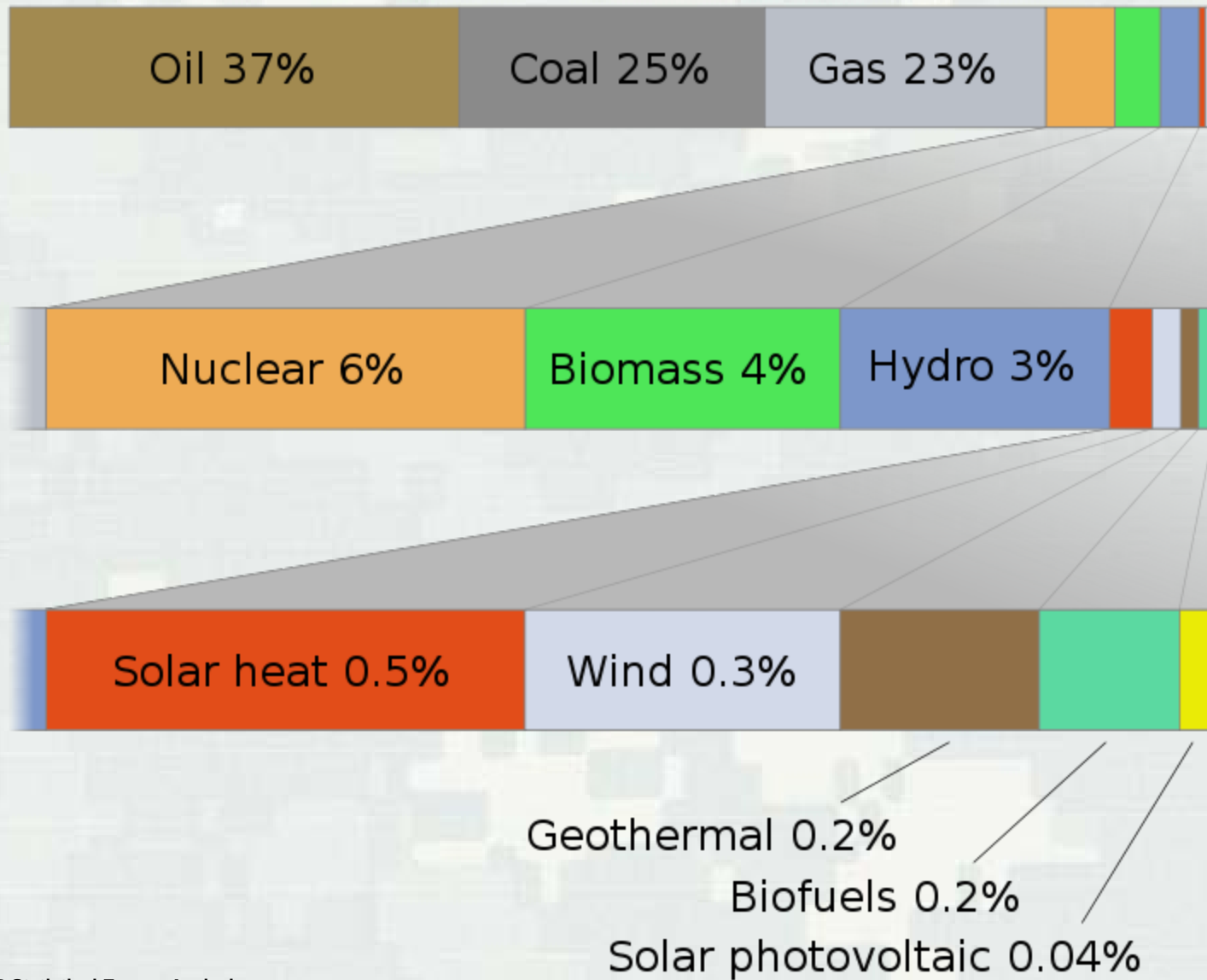
$4,016 * 9.3\text{B people} = 37,348\text{B KG Oil Equivalent}$

Sources: 2009 BP Statistical Energy Analysis, US Energy Information Administration



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Energy Trends



Sources: 2006 BP Statistical Energy Analysis



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Three-Pronged Solution

System and Building Efficiencies

Demand Reduction & Flattening

Generation and Distribution



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Three-Pronged Solution

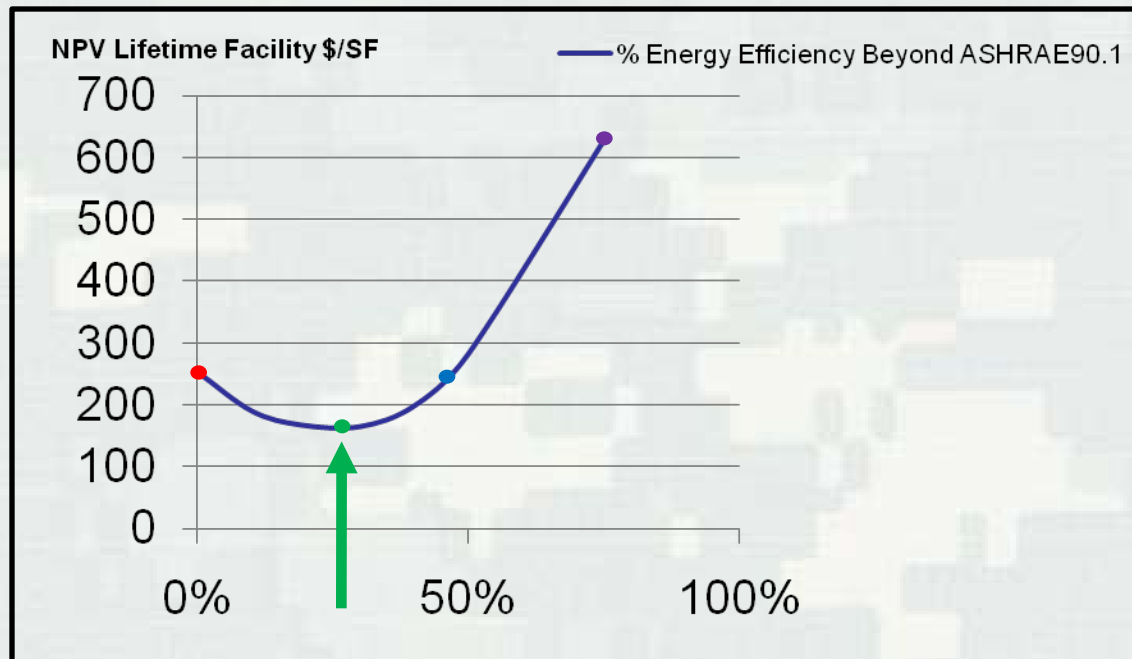
- 1) System and Building Efficiencies
 - A) Current ASHRAE & LEED Minimums
 - i. Occupancy Sensors/Timers
 - ii. Space lighting/heating/cooling properties
 - iii. Window, Roof, Envelope properties
 - B) Federal Improvement Mandates (EPA Act/EISA/EOs)
 - i. EPA Act05 / EISA07
 - ii. Executive Orders 13423, 13514
 - iii. Federal Energy Management Program (FEMP)
 - iv. Energy Star Program
 - C) Private Efforts
 - i. Utility Rebates (appliances, PV arrays)
 - ii. Dynamic Pricing



Baseline Energy Efficient Building

Present Design (~30% - 40% Beyond ASHREA90.1-2007), **Point 2**

- Improved Envelope
- Increased Insulation
- Condensing Boilers
- HE Hot Water Heaters
- Proper Building Orientation
- Double-Pane Windows
- VFD Pumps & Fans
- Cool Roofs
- Low Flow Fixtures
- ERV / Enthalpy Wheels
- FEMP / Energy Star
- Decreased Lighting Intensities



More Energy Efficient Building

LCCA Neutral (~40% - 50% Beyond ASHRAE90.1-2007), [Point 3](#)

- Triple Paned Windows
- Increased Insulation
- GSHP / WSHP
- Awnings/Overhangs/Shading
- Central Plants
- SIPs/EFIS/Styrofoam
- Daylighting & Photodimmers
- Air Conditioned Attics
- Radiant Heating
- Water Pre-Heat (Solar/Rejected)
- Floor Plan Changes:
Lighting, Ventilation, Roof Types

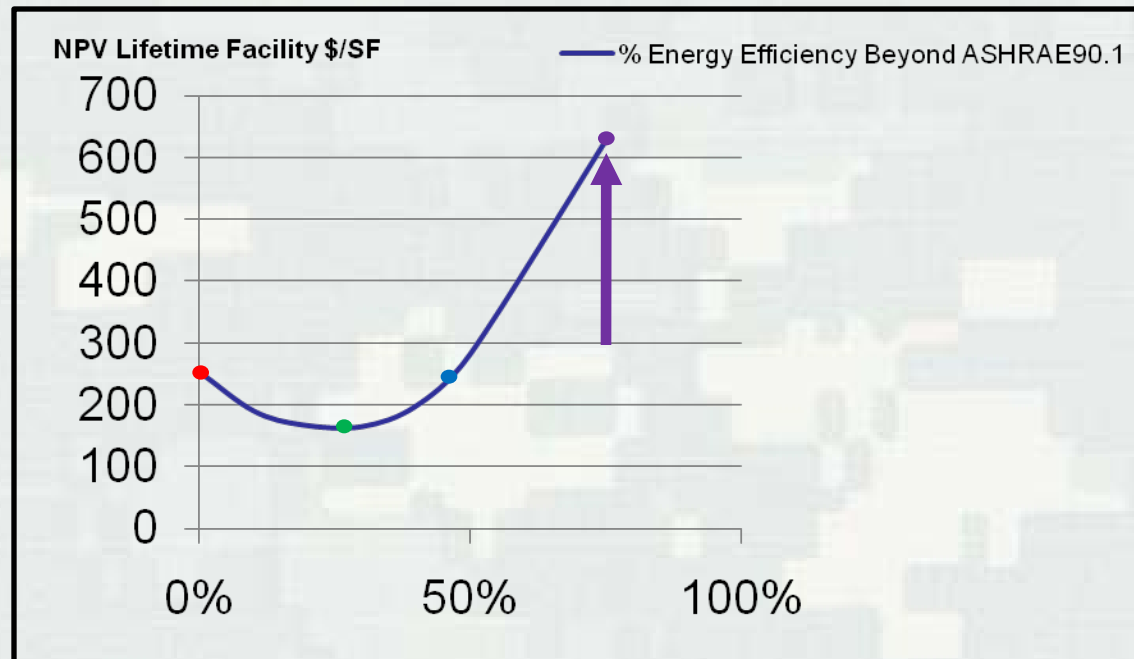


Most Energy Efficient Building

(~55+% Beyond ASHRAE90.1-2007), **Point 4**

LCCA Negative but \$\$ < Generation

- Solid State (LED) Lighting
- Superior Envelope, R-30+
- Passive / Evaporative Cool
- Night Purging
- Variable Refrigerant Volume
- Complete Building Automation
- Wastewater Heat Recovery
- Building Mass / Labyrinths
- Thermal Energy Storage*
- Trombe Walls



*Doesn't necessarily reduce energy demand, but reduces peak – thus reducing support or generation plant required.

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Federal & Department of Army Energy Efficiency



NREL Research Facility
Golden, CO

- 222KSF
- EUI Goal: 32kBTU/ft²*yr
- LEED Platinum
- \$259/SF
- 800 Occupants



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Federal & Department of Army Energy Efficiency



NREL Research Facility
Golden, CO

Cost Comparison:

City Civic Center	90KSF	\$310/SF	Silver
City Signature Ctr	186KSF	\$247/SF	Platinum
Ft. Carson BDHQ	140KSF	\$225/SF	Gold
NREL	222KSF	\$259/SF	Platinum



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Three-Pronged Solution

2) Demand Reduction & Flattening

A) Dynamic Pricing (Smart Grids & Demand Response)

- i. Tollway Minimum Speed Analogy
- ii. Avoid Unintended Consequences

B) Cultural Shifts (Load Flattening)

- i. Telecommuting
- ii. Dynamic Tollway Pricing

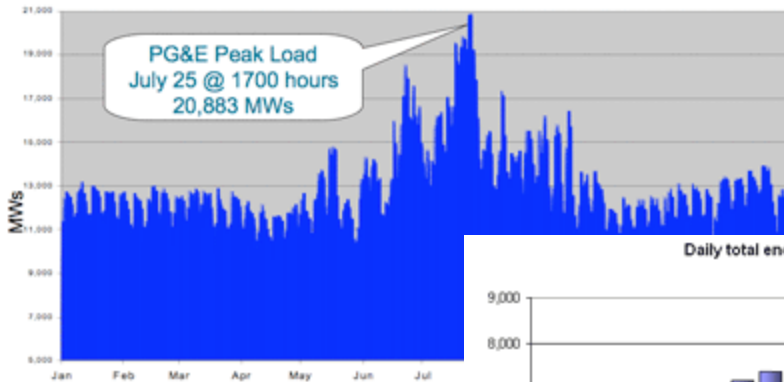
C) Equipment Selection (Load Flattening)

- i. Smart appliances
- ii. Heat Pump applications
- iii. TES

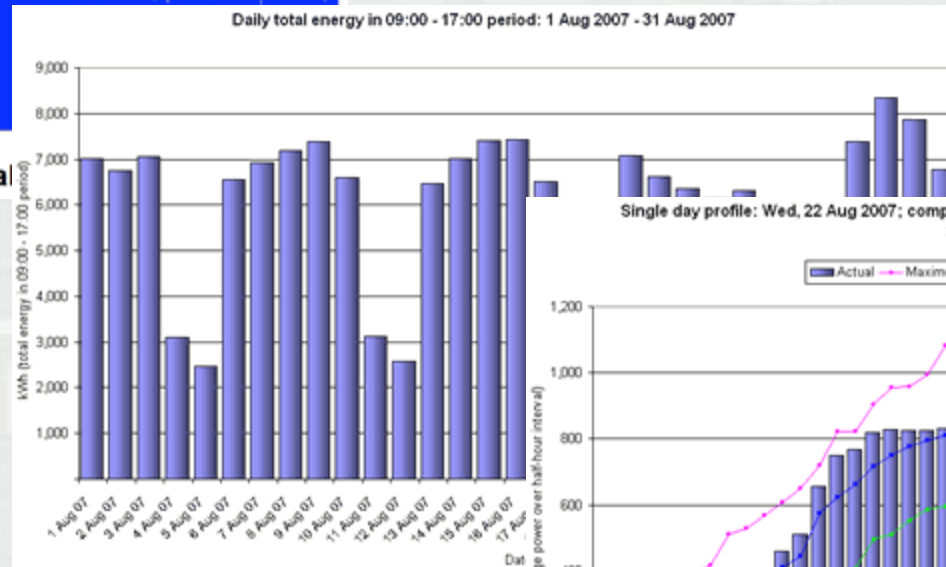


Three-Pronged Solution

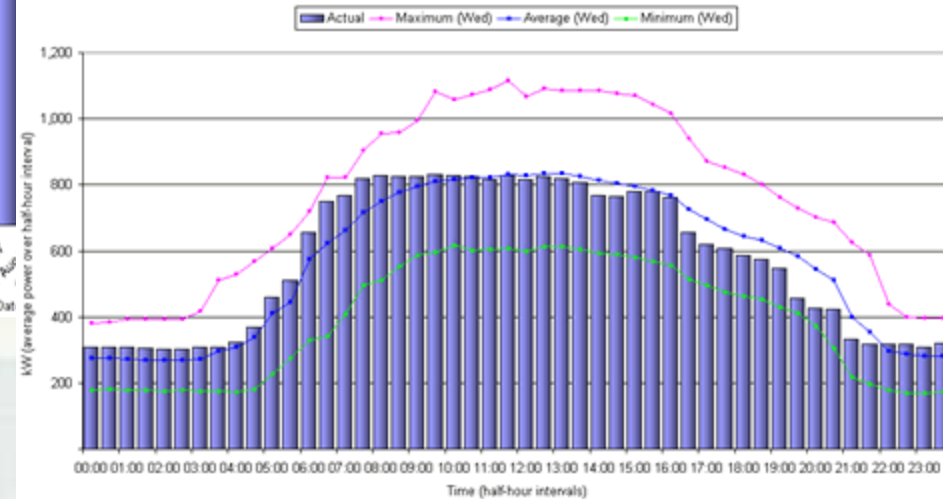
Electric Demand Is Highly Variable



2006 Annual

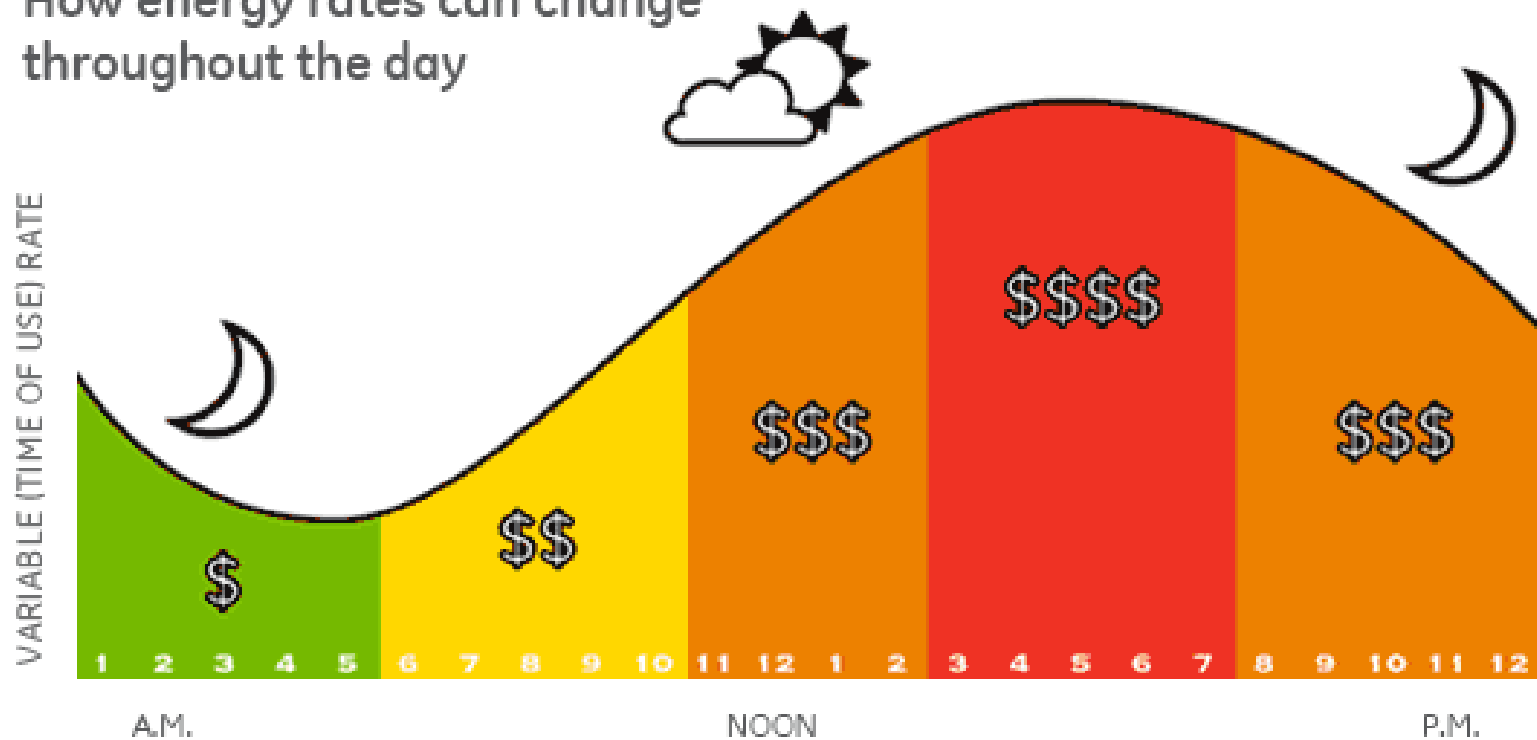


Single day profile: Wed, 22 Aug 2007; comparison data from Wednesdays between 1 Sep 2006 and 31 Aug 2007



Three-Pronged Solution

How energy rates can change throughout the day



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Three-Pronged Solution

So now we have:

1. Maximized the efficiencies within individual buildings & homes.
2. Aligned incentives for people to collectively maximize efficiencies and eschew waste and defer elective usages during peak times.
3. The last bit, barring living in a cold, dark box, requires power.



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Three-Pronged Solution

3) Generation and Distribution

A) Greater Renewable Emphasis

- i. PV
- ii. CSP
- iii. Geothermal
- iv. Biomass
- v. Wind
- vi. Hydro

B) Nuclear

C) Natural Gas

D) Distributed Generation



Federal CONUS Solar PV Arrays



Ft. Irwin, 500MW: \$2B, ~\$4/W, 14K Acres

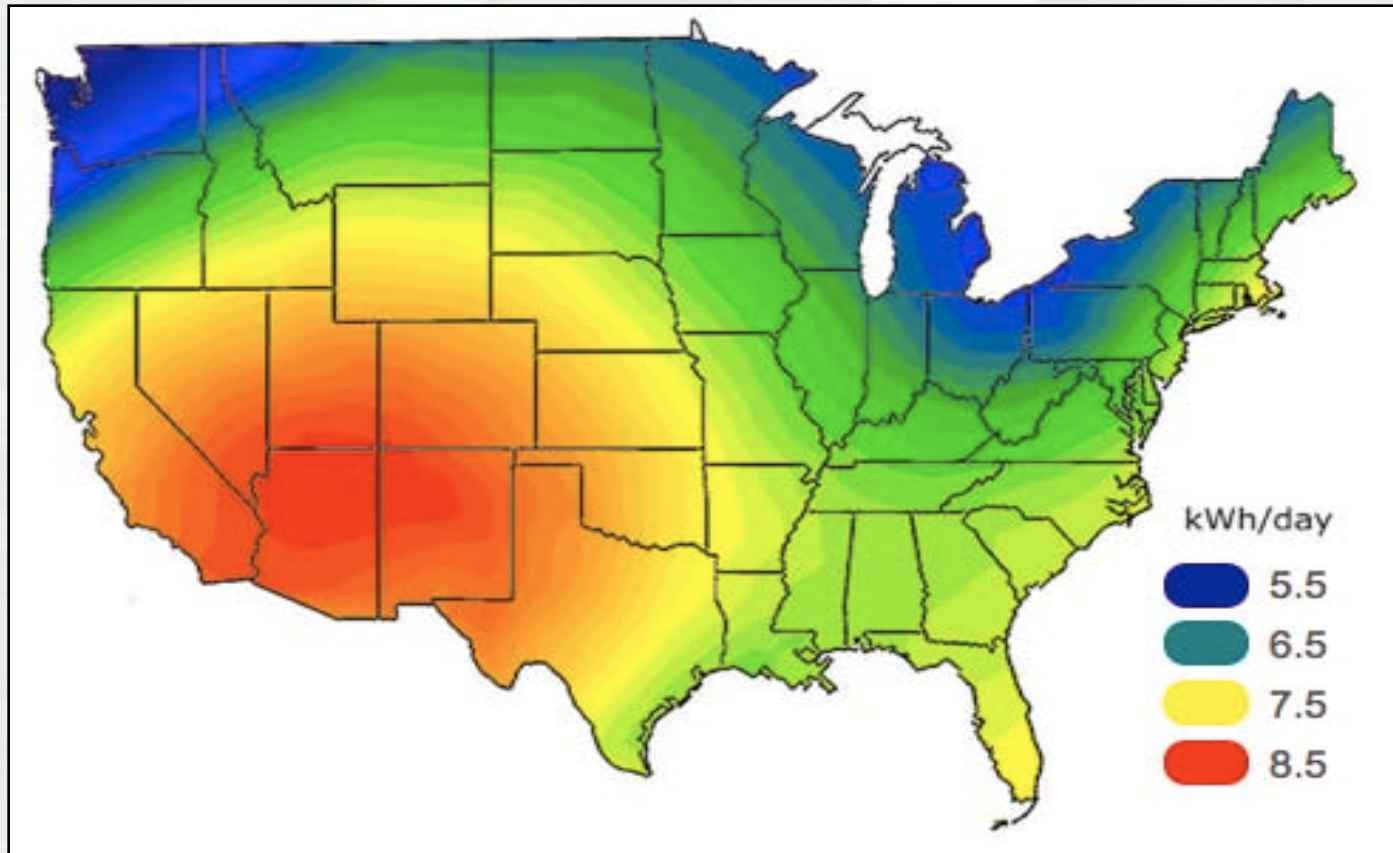


Ft. Nellis, 14MW, \$100M
(~\$7/MW), 140 Acres
CF~24%

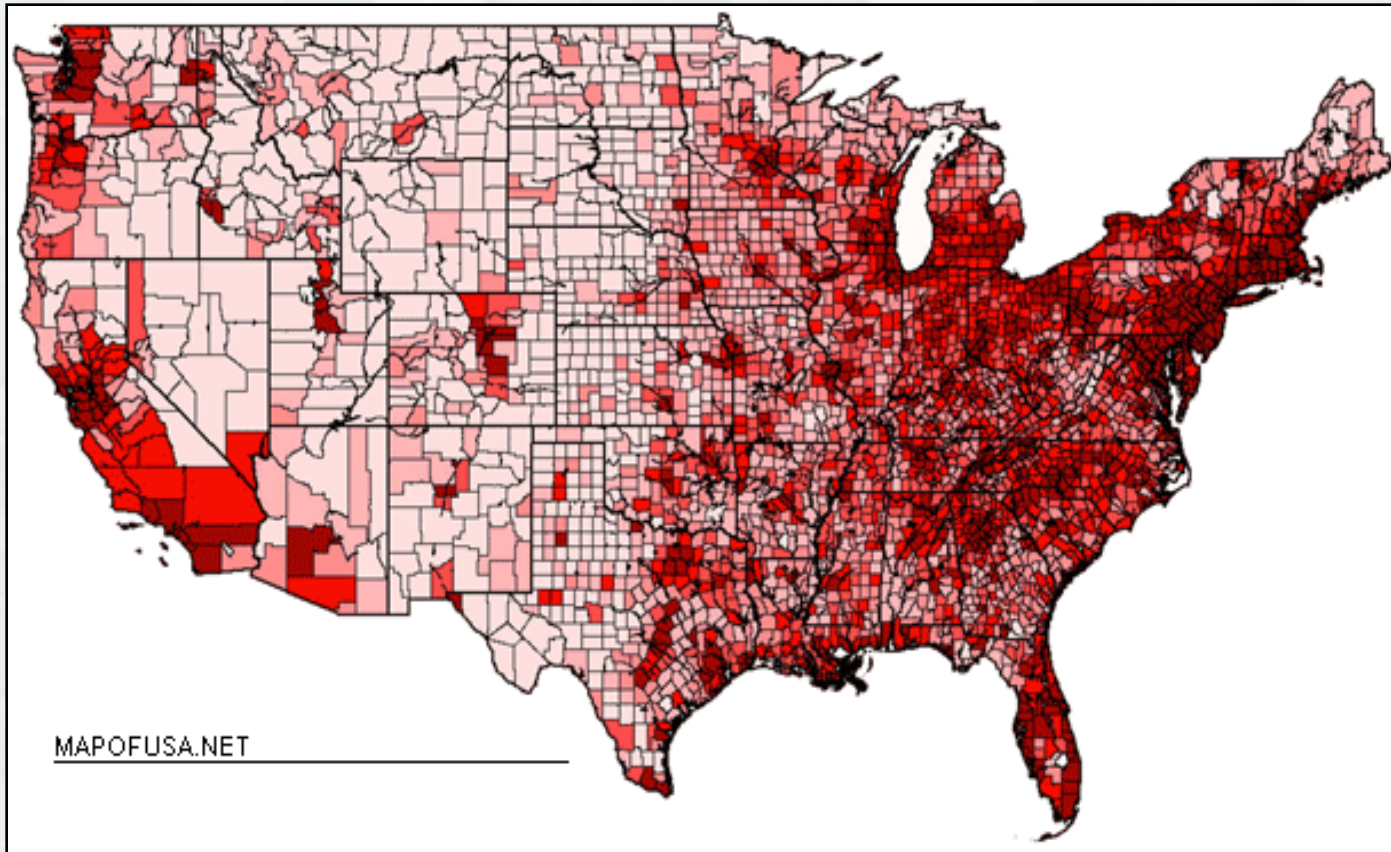
Ft. Carson, 2MW, \$13M
(~\$6.5/W), 15 Acres
CF~20%



USA Solar Resource (CSP / PV) Intensity



USA Population Density



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Wind Projects

Cape Wind Project, 468MW (130 x 3.6MW Turbines)

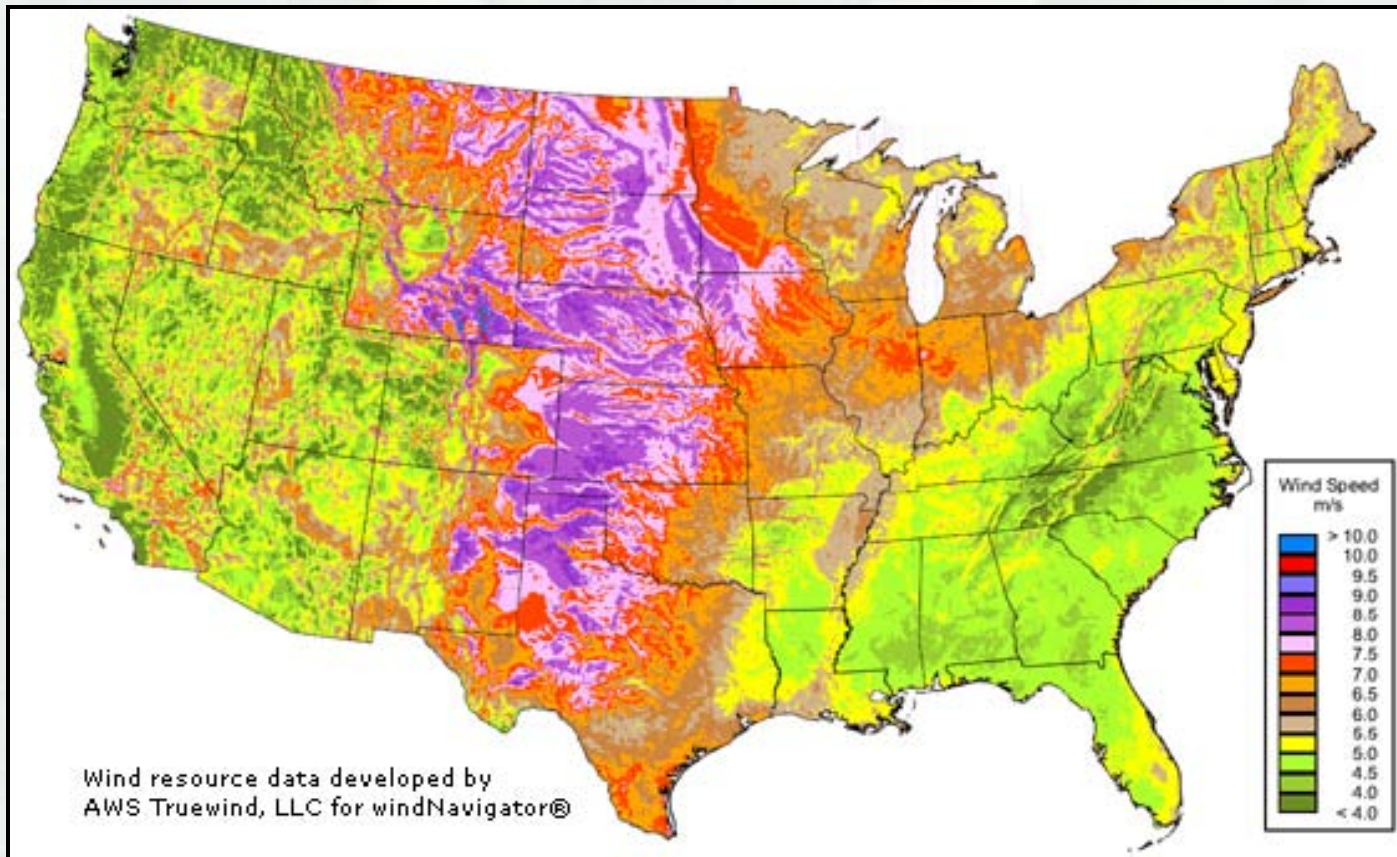
Cost: \$2B (~\$4.25/W)

14,000 Acres

CF~25%-35%



USA Wind Resource Intensity



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Problems with PV / CSP, and Wind

- Base Load Requirements
- Intermittency & Storage

	Wind	Solar	Nuclear	Natural Gas	Coal	GeoThermal
Nameplate Capacity (MW)	100	100	100	100	100	100
Acreage	3419	600	78	5	450	10K*
Construction Cost (\$10^6)	\$491	\$1,500	\$300	\$161	\$250	\$350
Capacity Factor	30%	15%	96%	95%	74%	>95**%
Annual Generation (GW*HR)	265	130	840	830	650	790
NPV (\$/KW*HR)	\$0.08	\$0.22	\$0.07	\$0.06	\$0.05	\$.035

*Well field area, not surface plant size.

** Lund, Bloomquist, Boyd, and Renner, "The United States of America Country Update", World Geothermal Congress, 2005



Geothermal Projects

Neal Hot Springs, OR (35MW)

Cost: \$105M (\$3/W)

5440 Acres

CF~88%

Blue Mountain, NV(50MW)

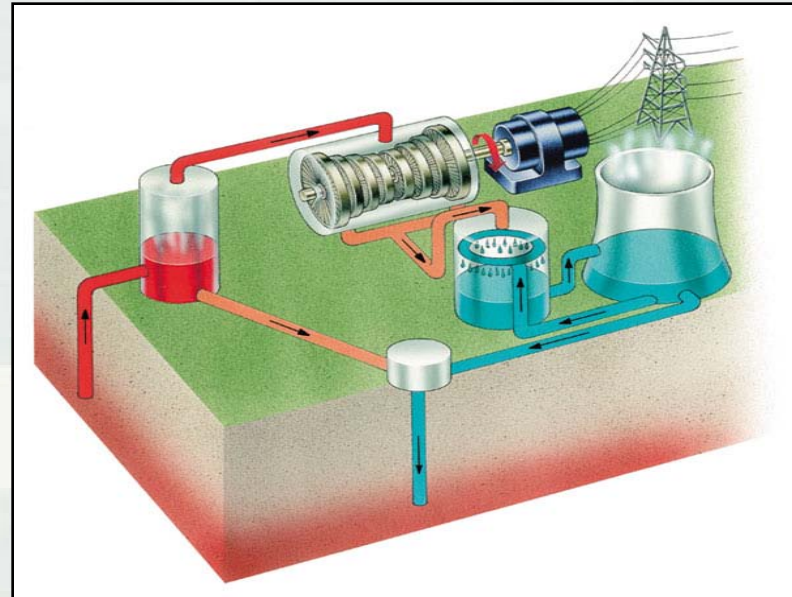
Cost: \$180M (\$3.6/W)

CF~92%

San Emidio, NV (37MW)

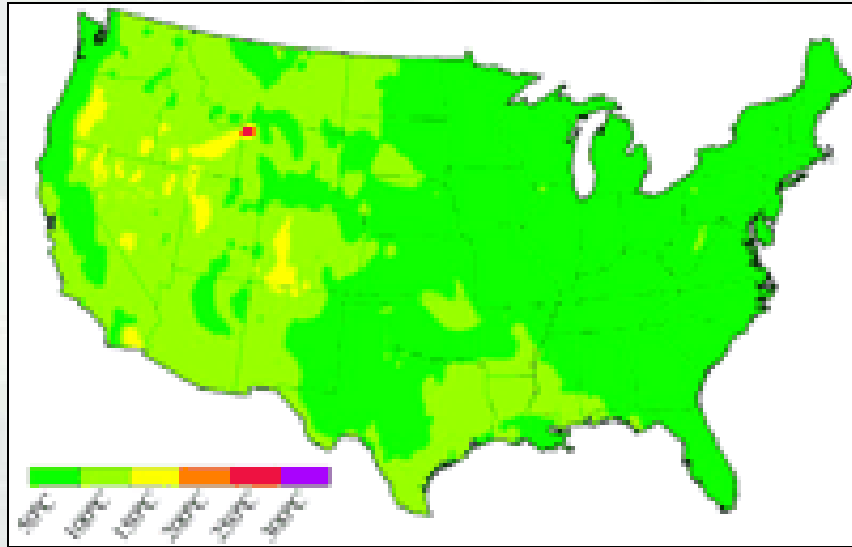
Cost: \$200M (\$5.4/W)

CF~85%

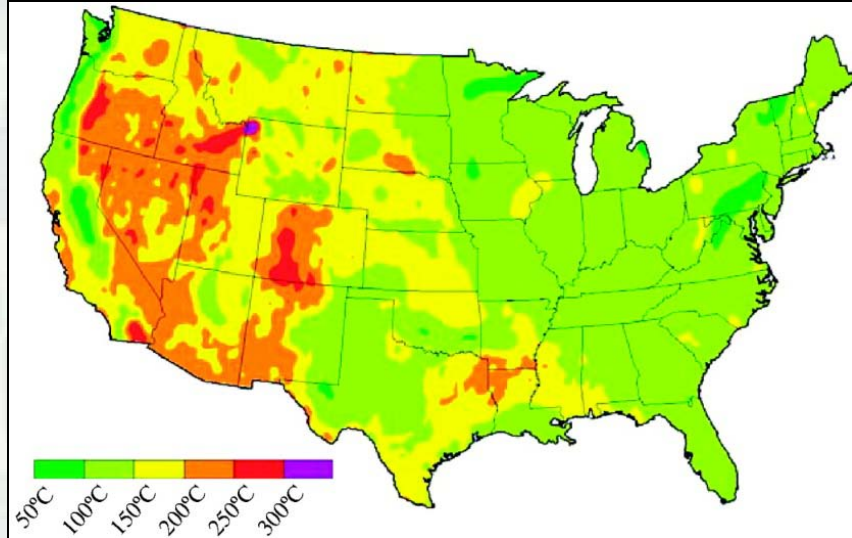


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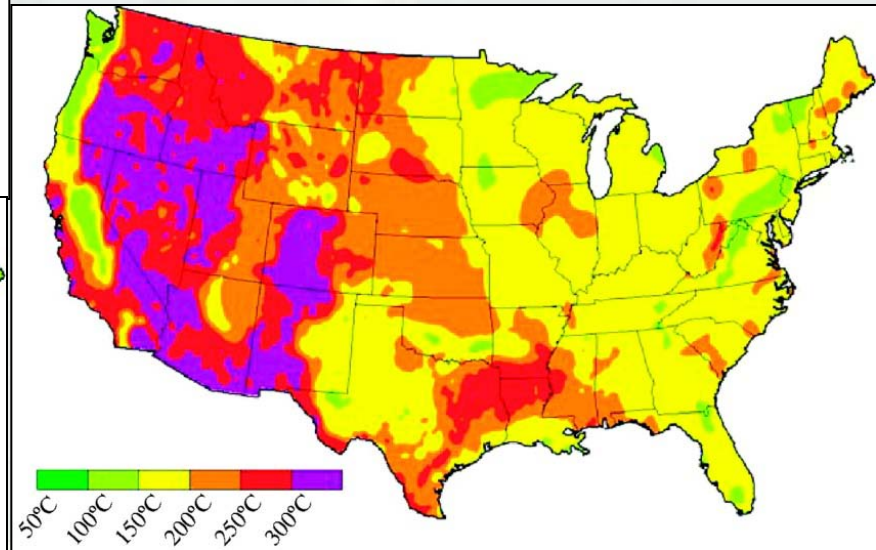
USA EGS Resource Maps



Temperatures at 3.5km



Temperatures at 6.5km



Temperatures at 10km



Geothermal

Geothermal:



1. Ubiquitous
2. Prolific
3. Credit Suisse study: better long-term pricing than coal
4. Power, Direct Heating, and Adsorption Cooling

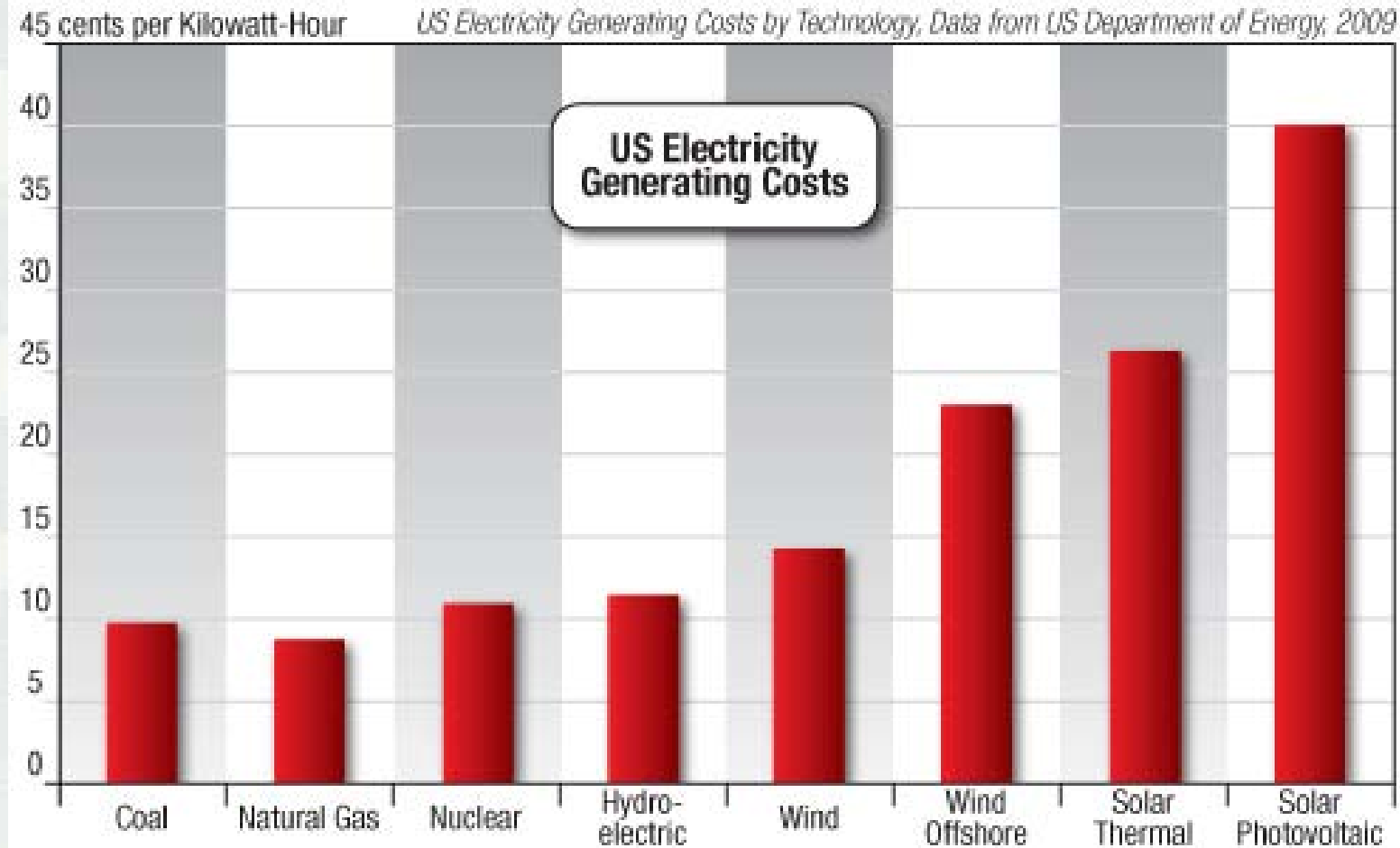


1. Favors Western US
2. R&D still required
3. Price competition will not be realized until widely implemented



Electricity Generation \$\$\$

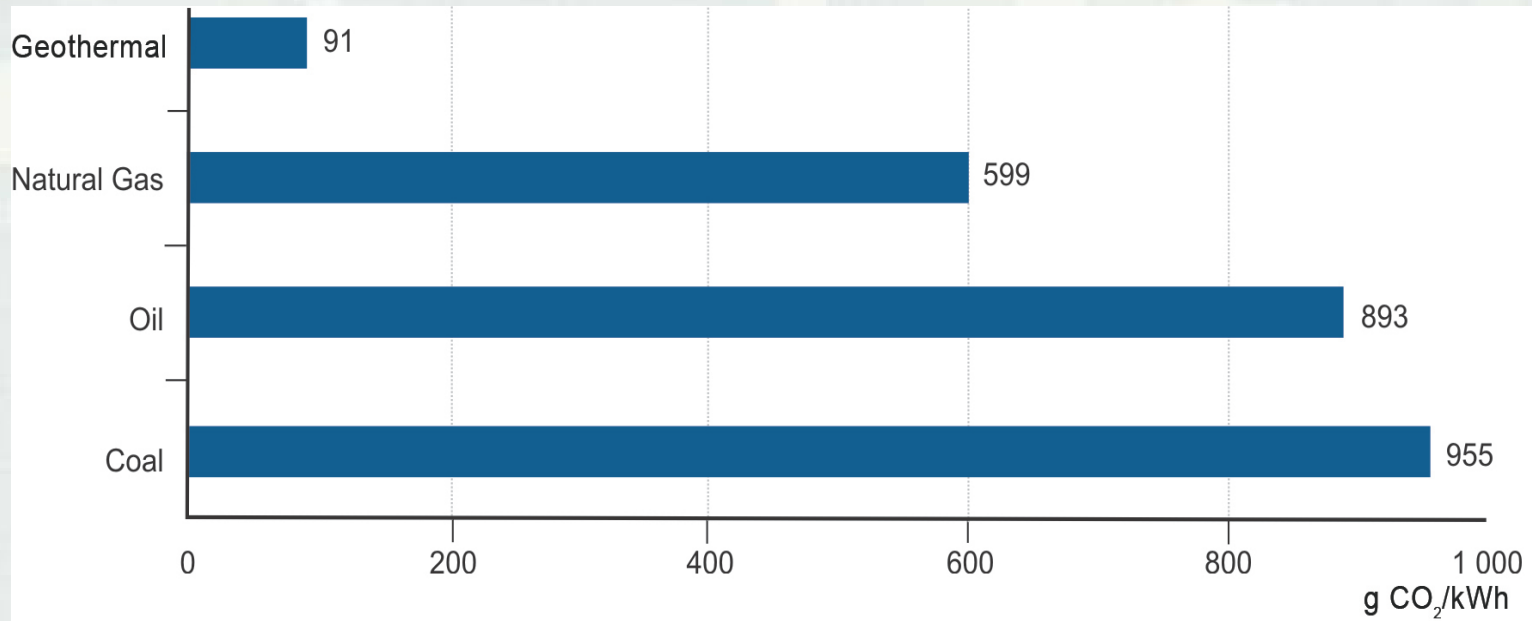
- A 2009 Credit Suisse report indicates that geothermal (\$.036/kW*Hr) electricity can be had more cheaply than coal (\$.055/kW*Hr) electricity can!



Electricity Generation GHG Emissions

Geothermal energy

Comparison of CO₂ emissions from electricity generation



Source, World Energy Council, 2008



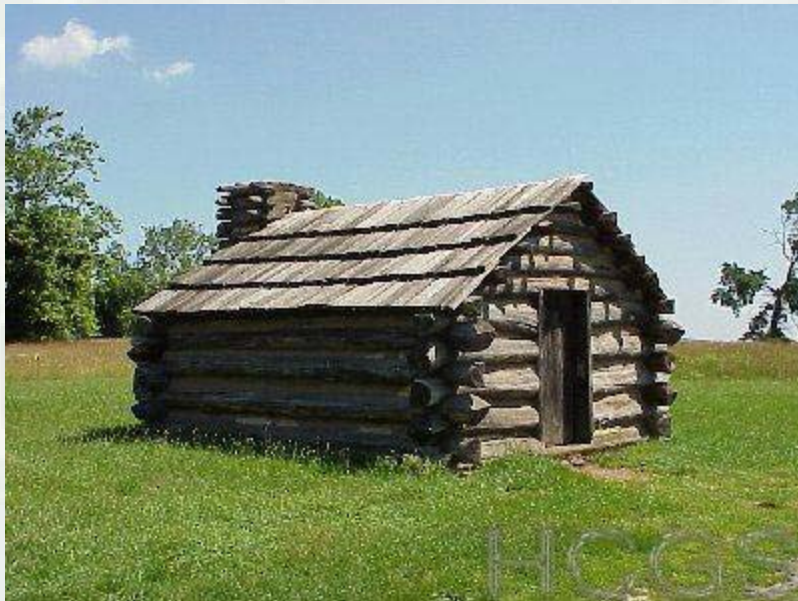
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Renewable Power Roadmap

- Geothermal
 - Power Generation
 - Heating
 - Adsorption Cooling
- Biomass
- Solar / Wind
 - Complementary
 - Niche Applications
- Disruptive Technologies
 - Bloombox
 - JTEC
 - Chlorophyll-based Thin-Film PV Cells
 - Micro Nuclear (<300MW)



Net Zero Buildings (v1.0)



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Net Zero Buildings (v2.0)



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Questions and Comments



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Thank you!

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