Energy- sources, availability, demand, affordability, delivery

Sustainability and Water

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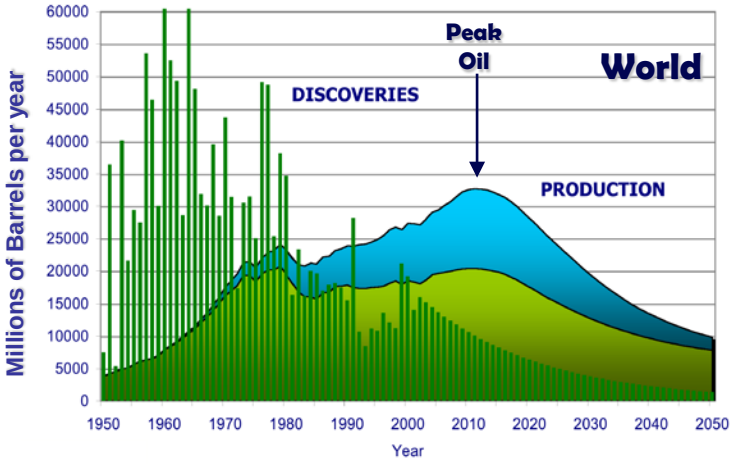
New Mexico State University

Institute for Energy and the Environment

What is the problem?



Our energy needs fall into two categories:

- **Power**
- **Transportation**

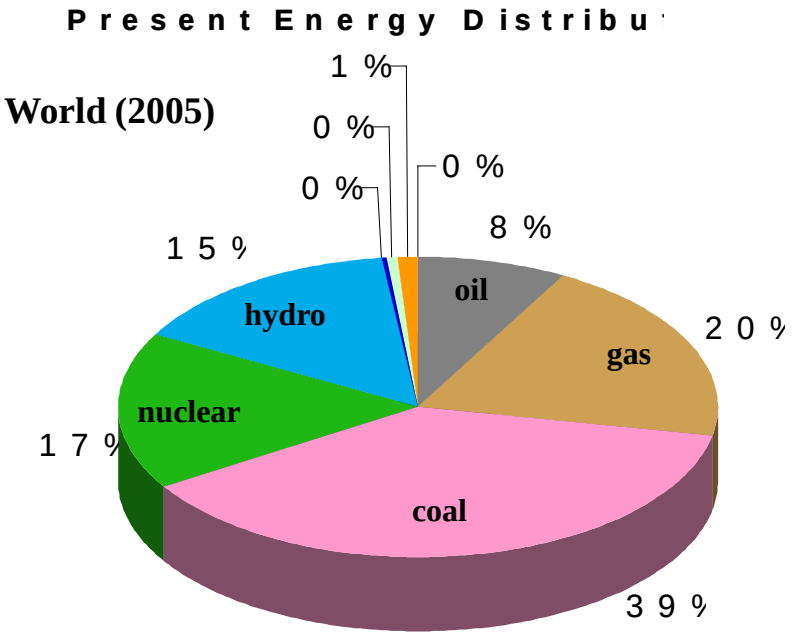
Both are presently dominated by fossil fuels but can be met with a realistic combination of fossil, renewable and nuclear.

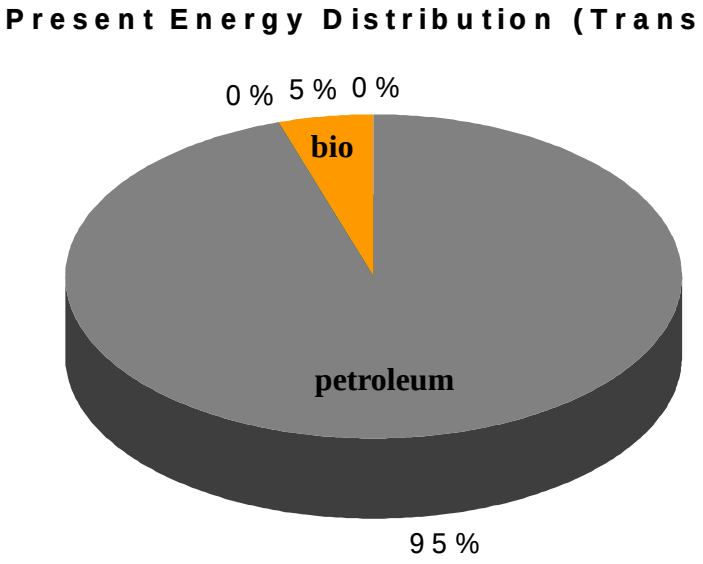
The pressing issues:

- **Adverse environmental effects of fossil fuel use, particularly the use of coal in power generation is, arguably, the most destructive activity humans can engage in, outside of large-scale war**

- **World peak oil (gas and even coal) will be achieved relatively soon**

	oil ~ 2010	(gone by 2065; unc. > 2140)
(unconventionals will change the oil and gas peaks)	gas ~ 2020	(gone by 2040; unc. > 2120)
	coal ~ 2050	(gone by 2110)





Oil
Gas
Coal
Nucl
Hydr
Wind
Geot
Biofu
Solar

Petroleu (includin cells)
Nuclear cells)
Biofuels
Solar (in fuel cells

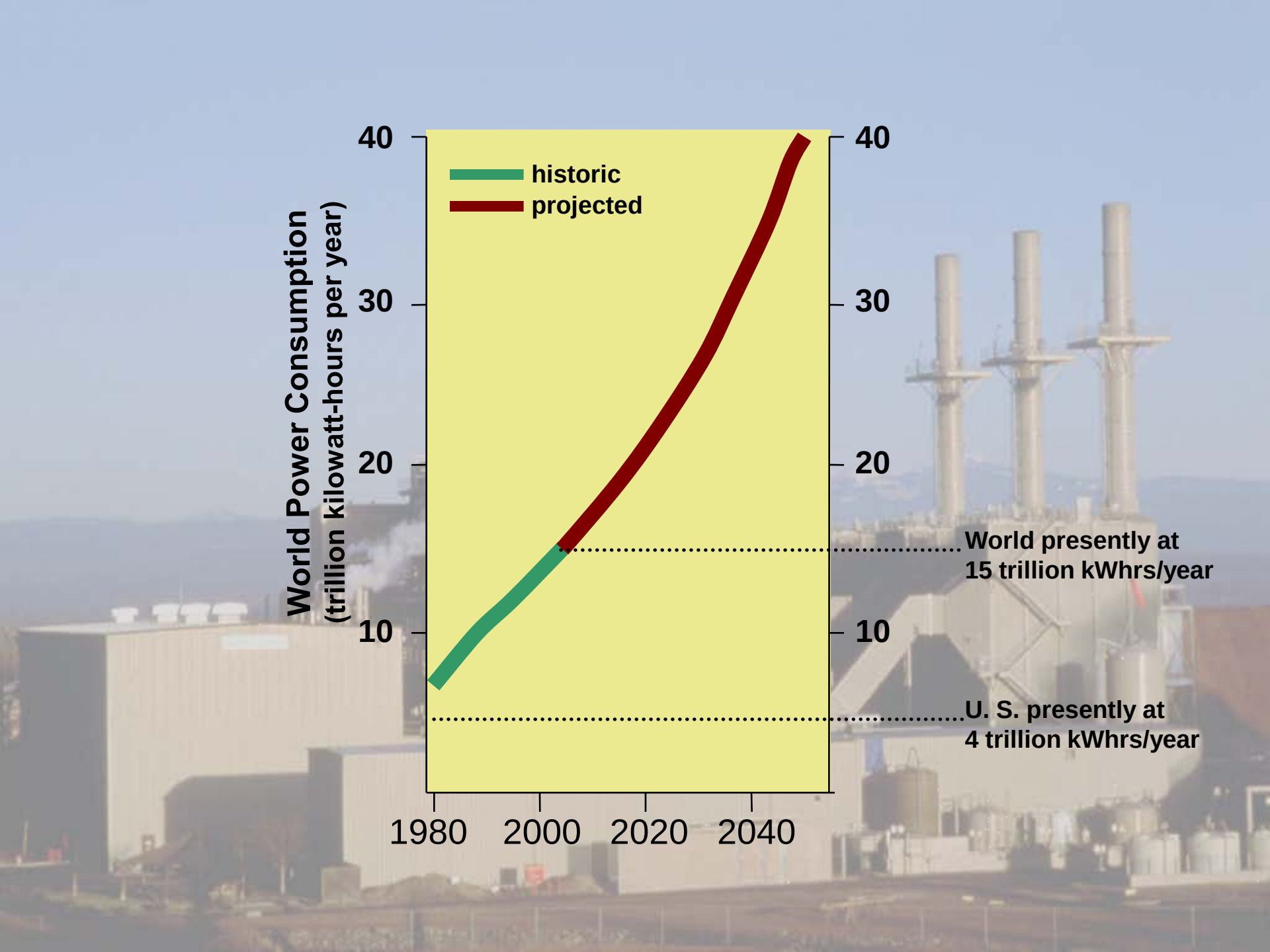
United States
50% coal
19% gas
19% nuclear
6% hydroelectric
6% other

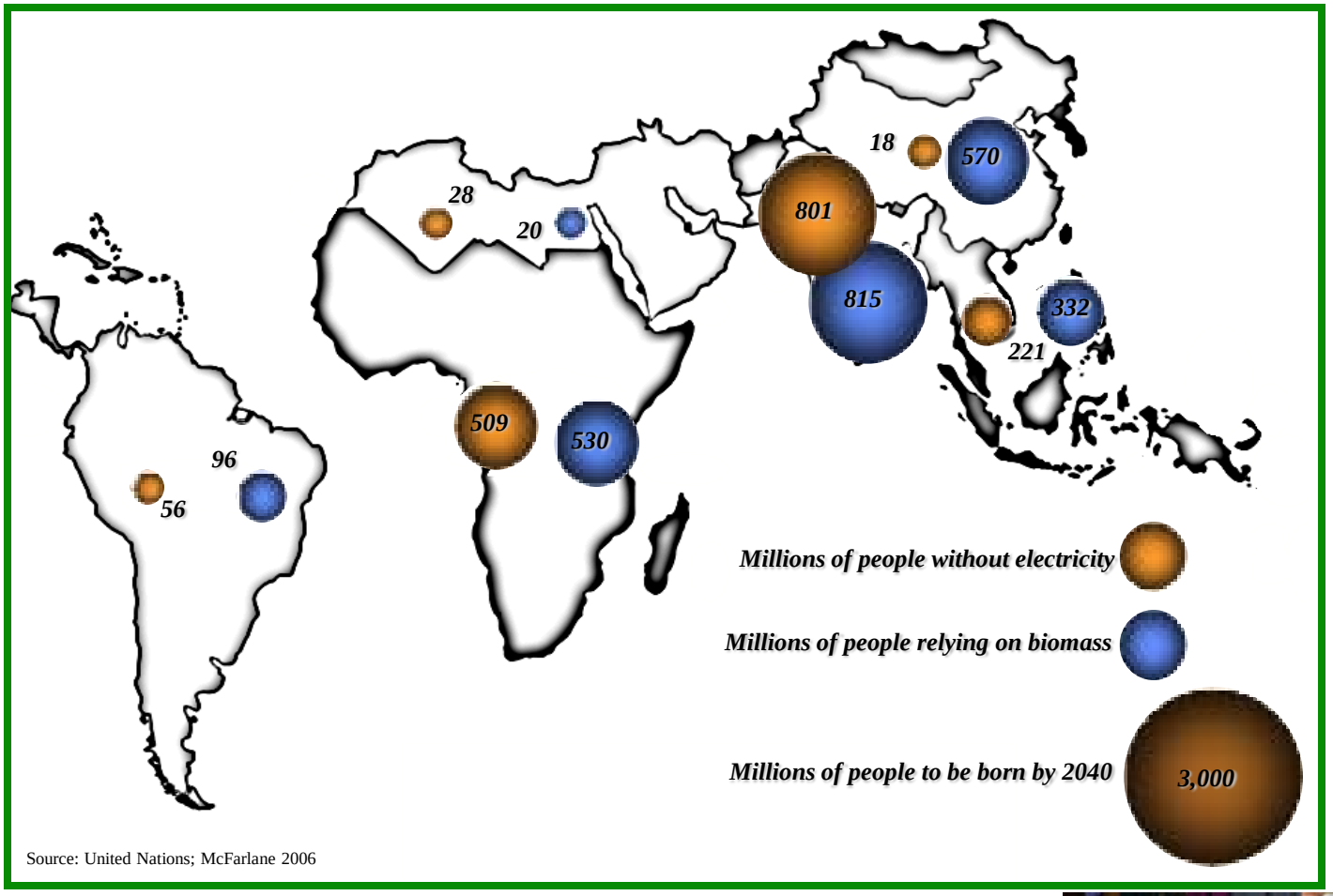
California
21% coal
41% gas
13% nuclear
17% hydroelectric
8% other

New Mexico
88% coal
10% gas
2% other

European Union
30% coal
18% gas
32% nuclear
11% hydroelectric
6% oil 3% other

India
75% coal
2% nuclear
20% hydroelectric
3% other


World Power Consumption
(trillion kilowatt-hours per year)
40
30
20
10
historic
projected
World presently at
15 trillion kWhrs/year
U. S. presently at
4 trillion kWhrs/year
1980
2000
2020
2040



Source: United Nations; McFarlane 2006

Map of Global Energy Poverty

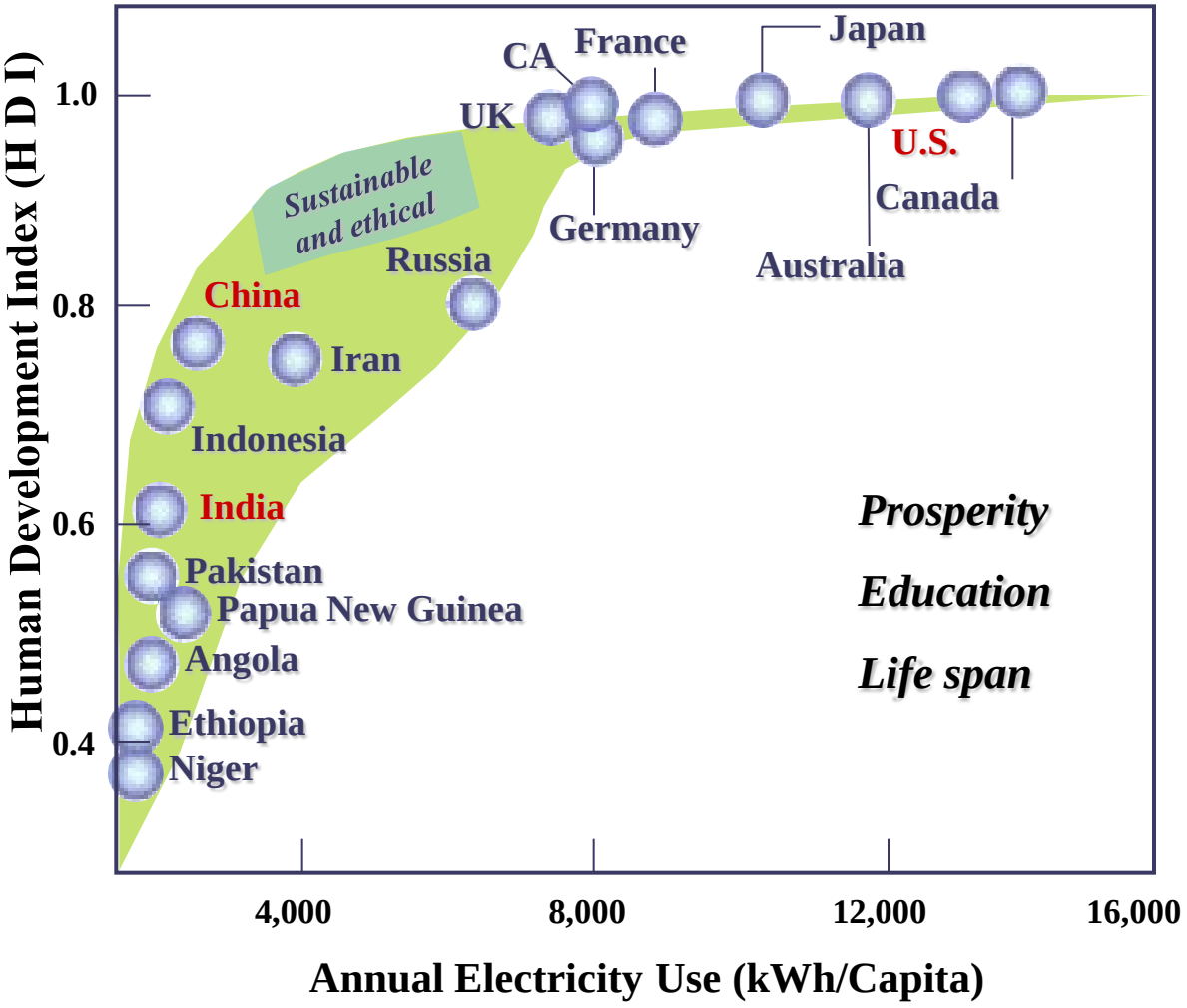
1.6 billion people have no access to electricity, 80% of them in South Asia and sub–Saharan Africa.

2.4 billion people burn wood and manure as their main energy source.

3 billion more people will be born by 2040

Source: ©2005 Kay Chernush for the U.S. Department of State

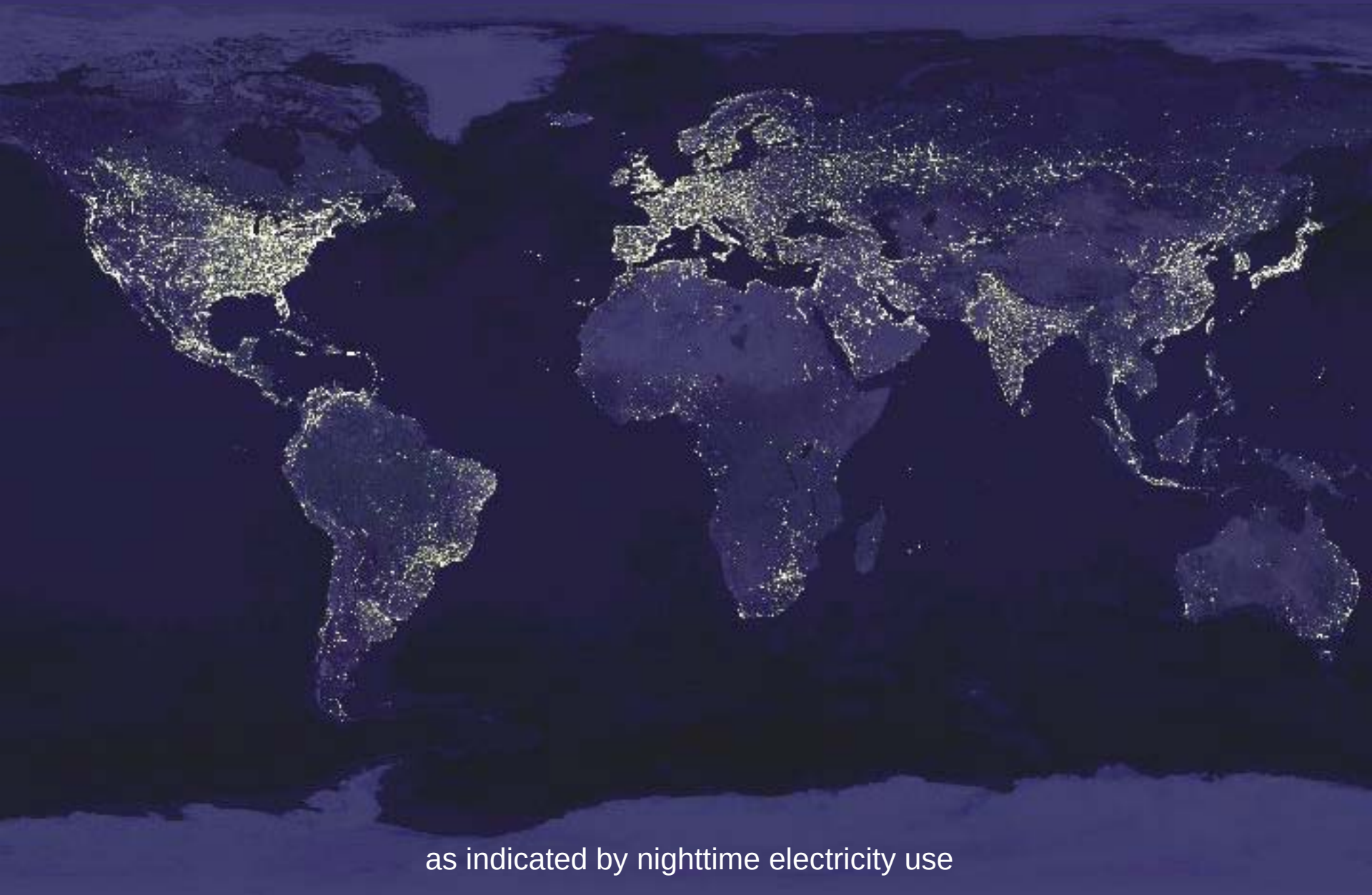
Access to energy is essential to quality of life



80% of the world's population of over 6 billion people is below 0.8 on the U.N. Human Development Index (HDI)

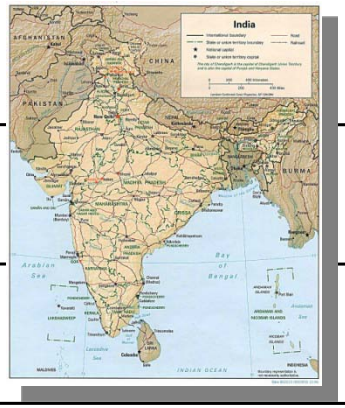
Source: United Nations Development Program; McFarlane 2006

Global Energy Distribution



as indicated by nighttime electricity use

India's planned power capacity



Fossil
Hydro
NonConv
Nuclear
Total

Installed Capacity(GWe)

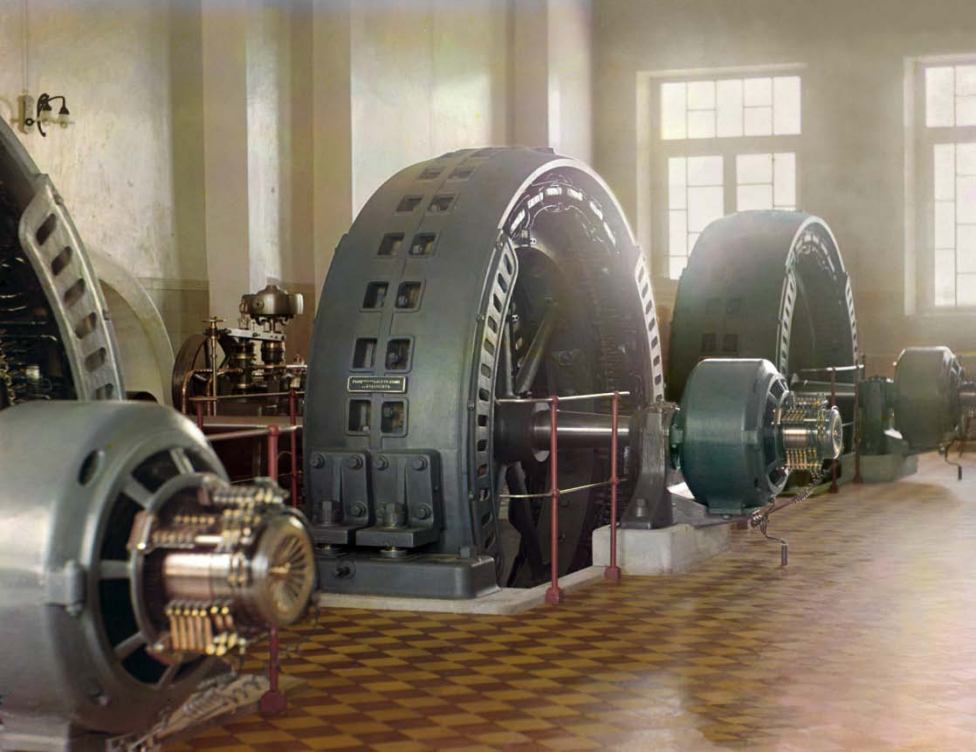
1600
1400
1200
1000
800
600
400
200
0

2002
2012
2022
2032
2042
2052

Year

138.73
104.73
27.78
3.5
2.72

1344
819
275
150
100



Energy Used for Power

Primarily electricity

- **to produce light, heat and power**

Unit: kWhr = thousand watts for an hour

U.S. = 9¢ per kWhr

CA = 12¢ per kWhr

NM = 8¢ per kWhr

TN = 5¢ per kWhr

Usually uses some energy source to turn a dynamo

- **a turbine or a big wheel that turns a metallic shaft inside a stationary metallic wrapping**

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- **photovoltaic solar, one of few sources that changes incident solar radiation into electricity through heat without a turbine.**

Some Useful Things to Remember

Crisis = 危機

Danger

Opportunity

“A crisis is a terrible thing to waste”

Paul Romer

“How wonderful that we have met with a paradox. Now we have some hope of making progress.”

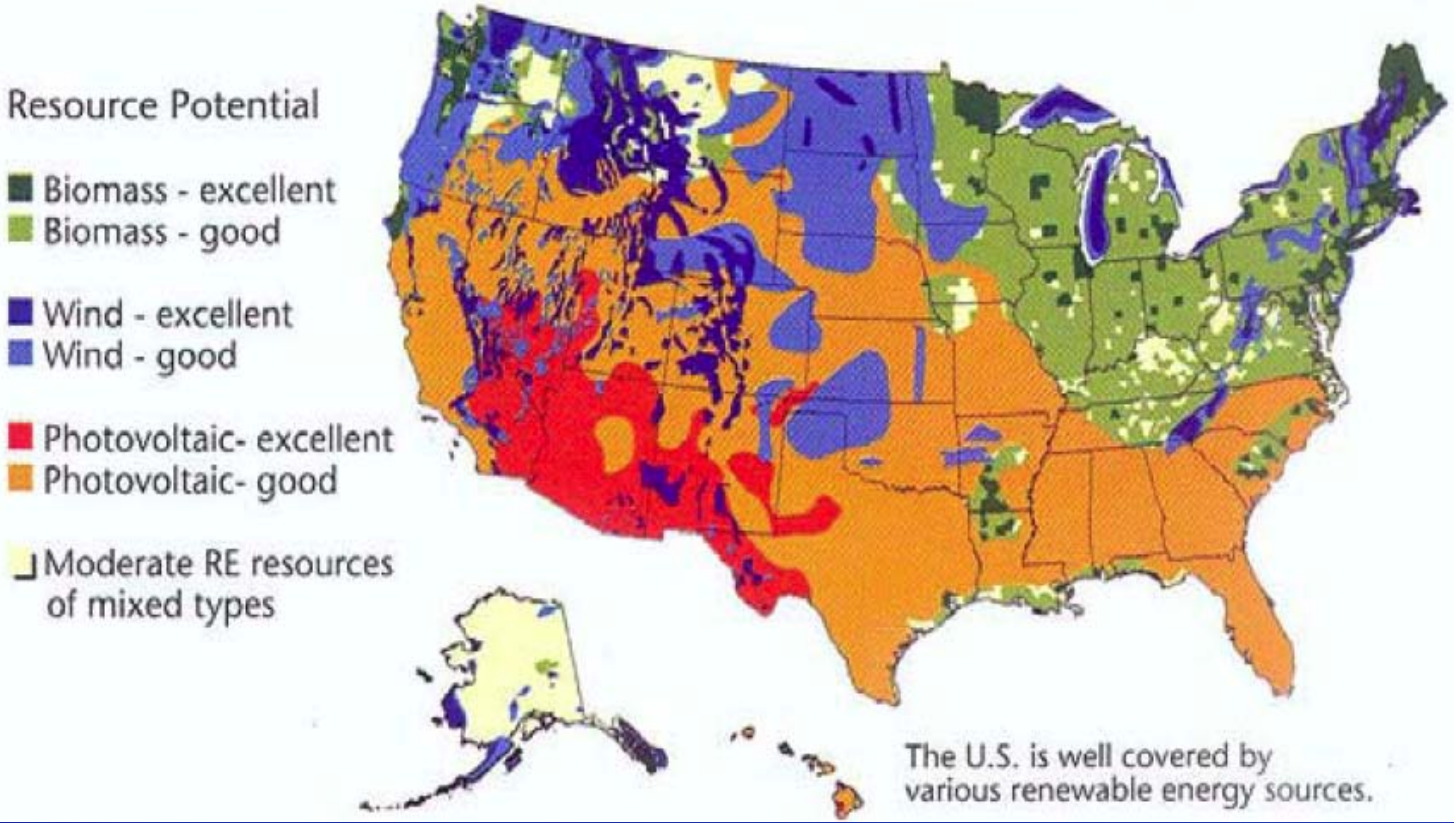
- NIELS BOHR

A vision without action is a dream,
Action without vision is a nightmare

Japanese Proverb

行為のない視野は夢、視野のない行為である不快感である

Distribution of Good to Excellent Renewable Energy Resources



The U.S. is well covered by various renewable energy sources.

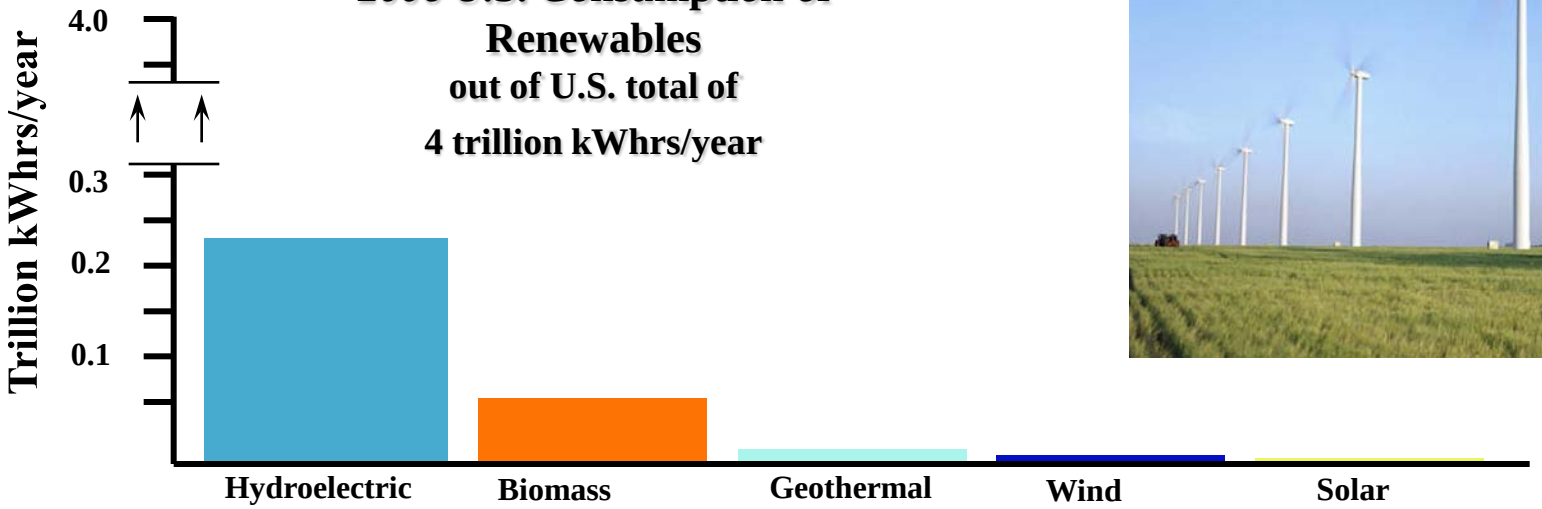
Renewables for 10 trillion kW-hrs

Can Renewables generate 10 trillion kW-hrs/yr? This is the amount of energy presently supplied by all fossil fuels.

2006 U.S. Consumption of Renewables

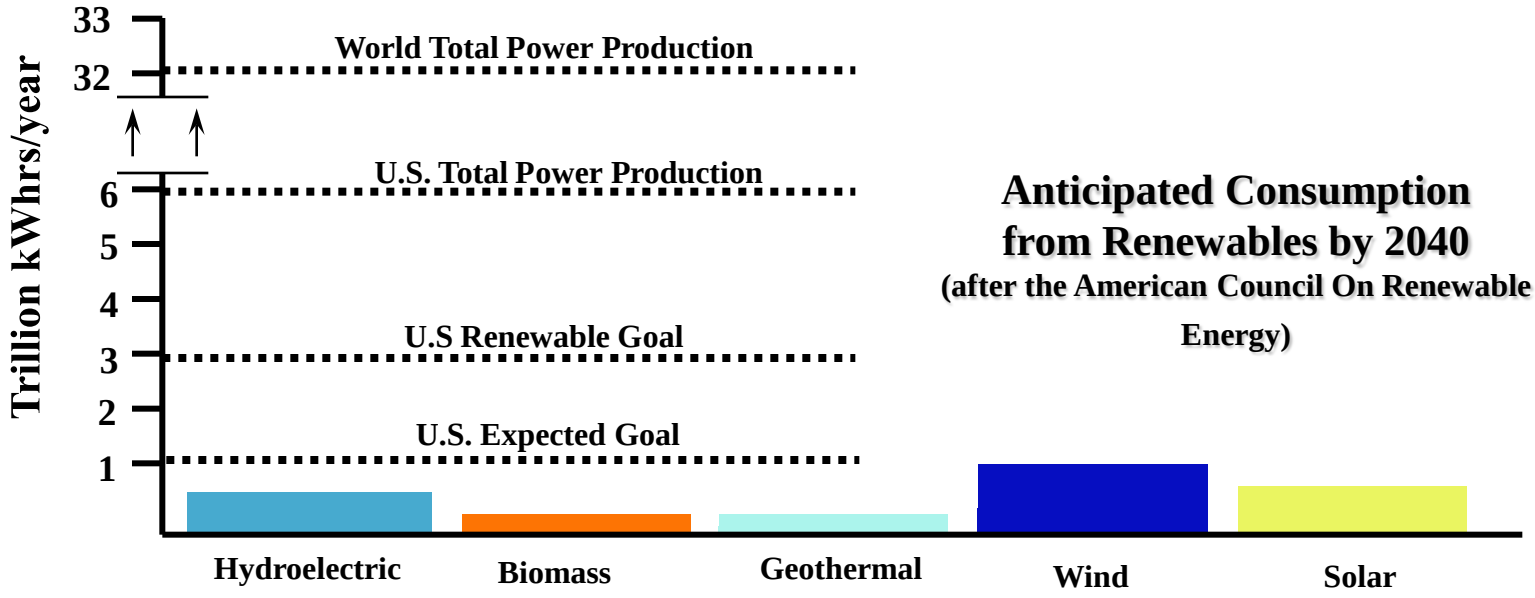
out of U.S. total of

4 trillion kWhrs/year



Anticipated Consumption from Renewables by 2040

(after the American Council On Renewable Energy)



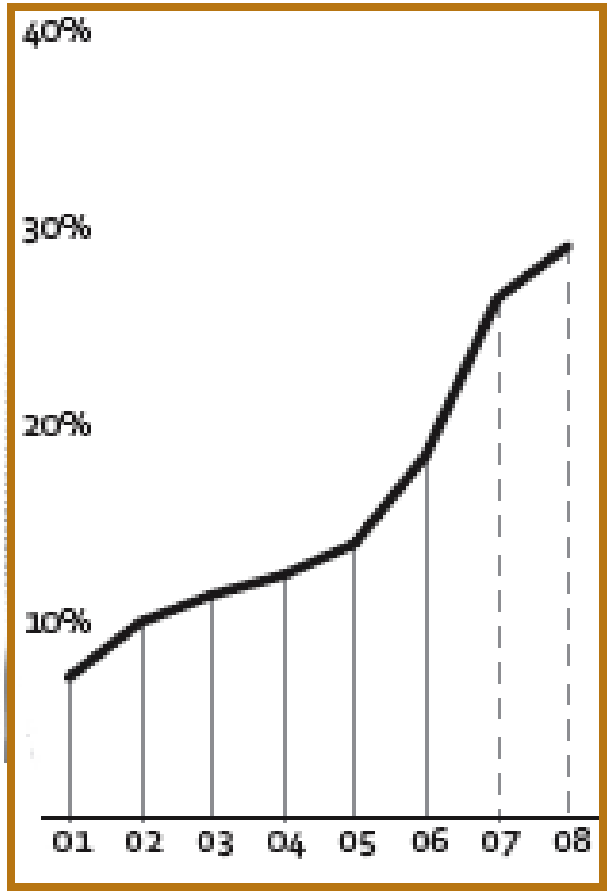
Economic competition of biofuels with food production

Food crops do not make good fuel crops

However, the infrastructure and distribution system is already in place so growers and distributors can produce now

Cars Compete for Corn

Percentage of U.S. Corn production used for ethanol

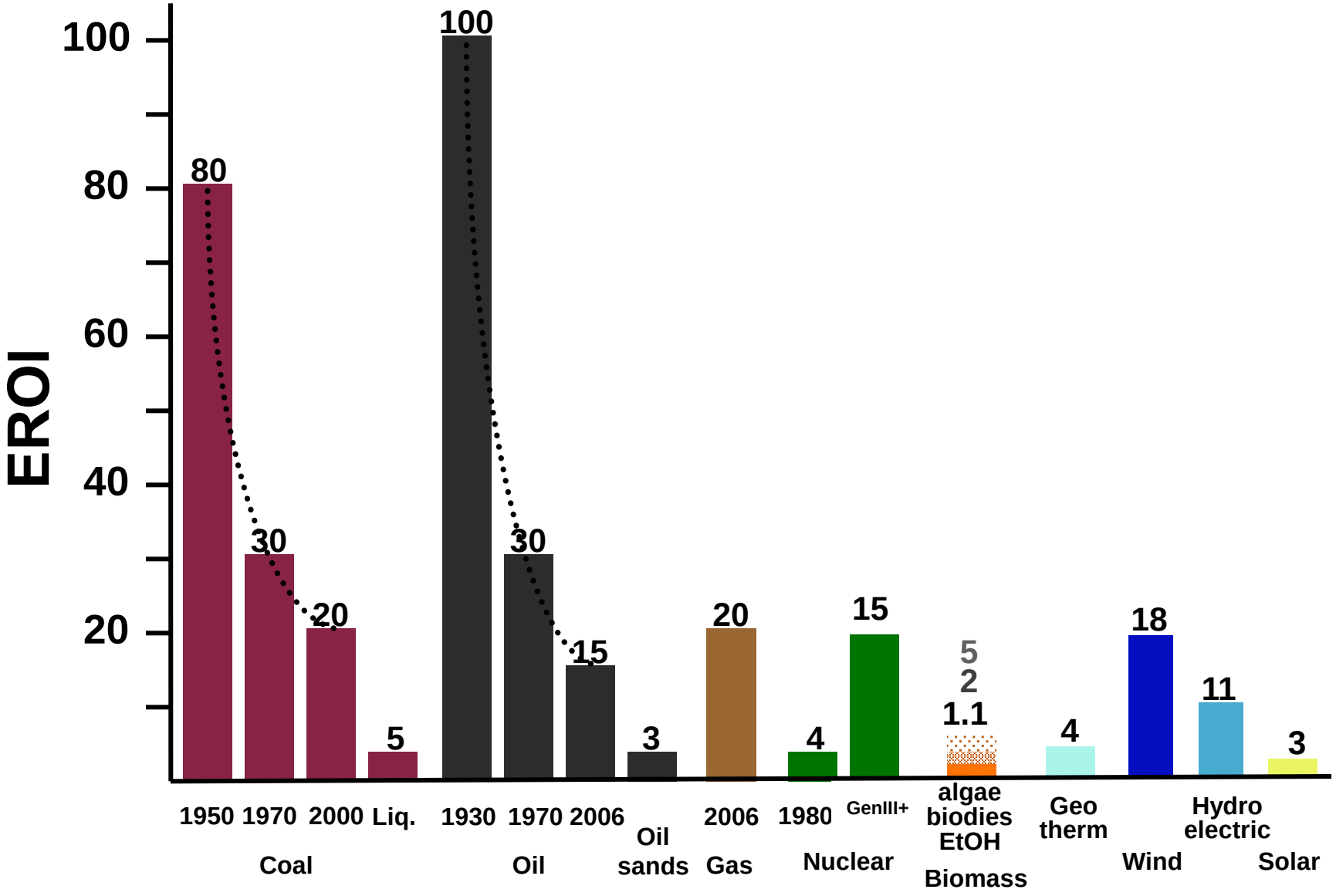


← This amount of corn, which will be used to make 5 billion gallons of ethanol next year, represents less than 3% of our fuel needs but could feed 220 million people for a year.

Raising vehicle standards to 35 mpg would do more without any adverse effects.

Energy Returned On Investment

relative to 1 (similar to the value EROEI)

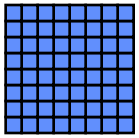


(After: Cleveland et al., 1984, 1999; ASPO 2006)

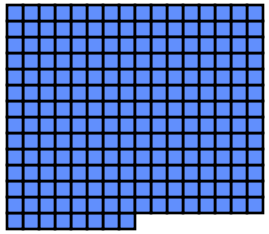
Construction costs have skyrocketed for all alternative energy sources

Manhattan Island

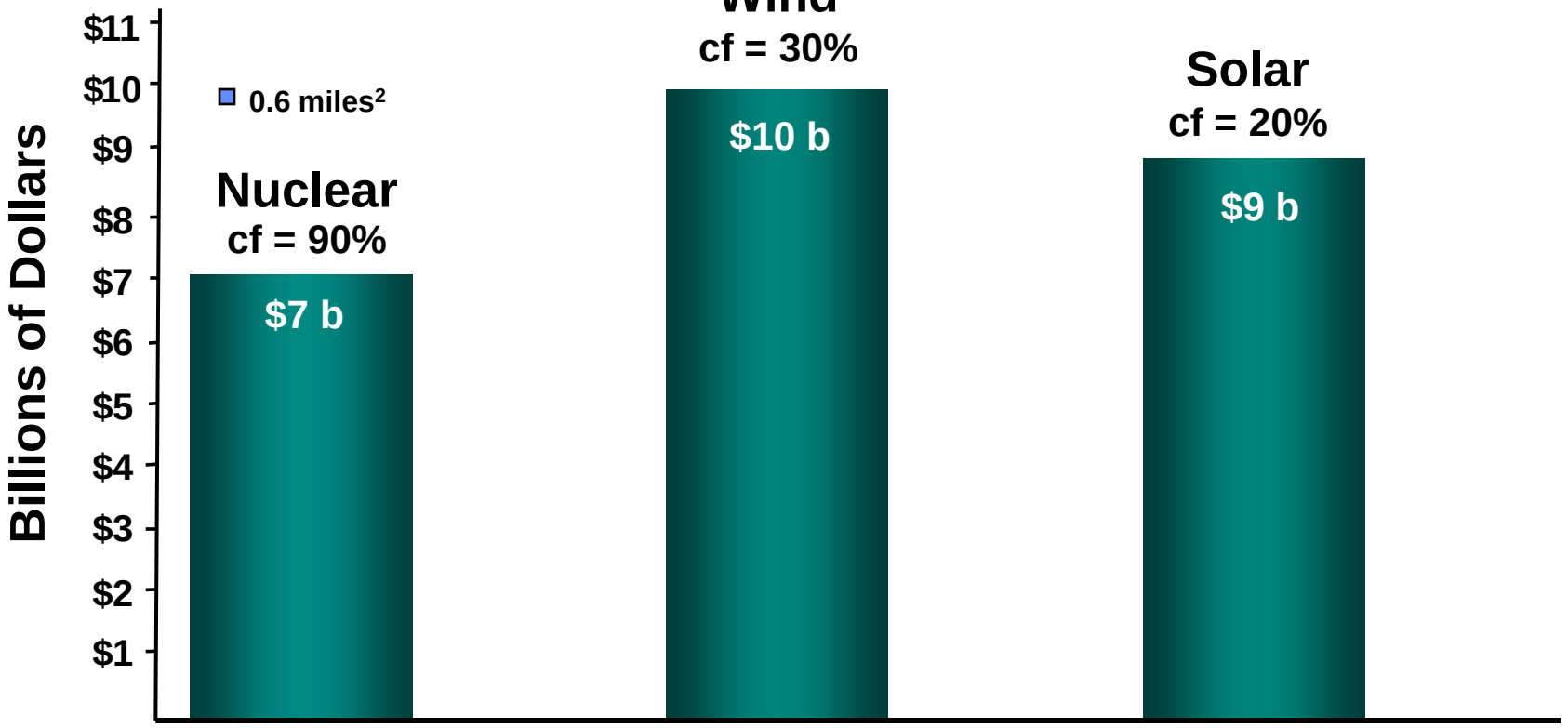
= 59 miles^2



36 miles^2



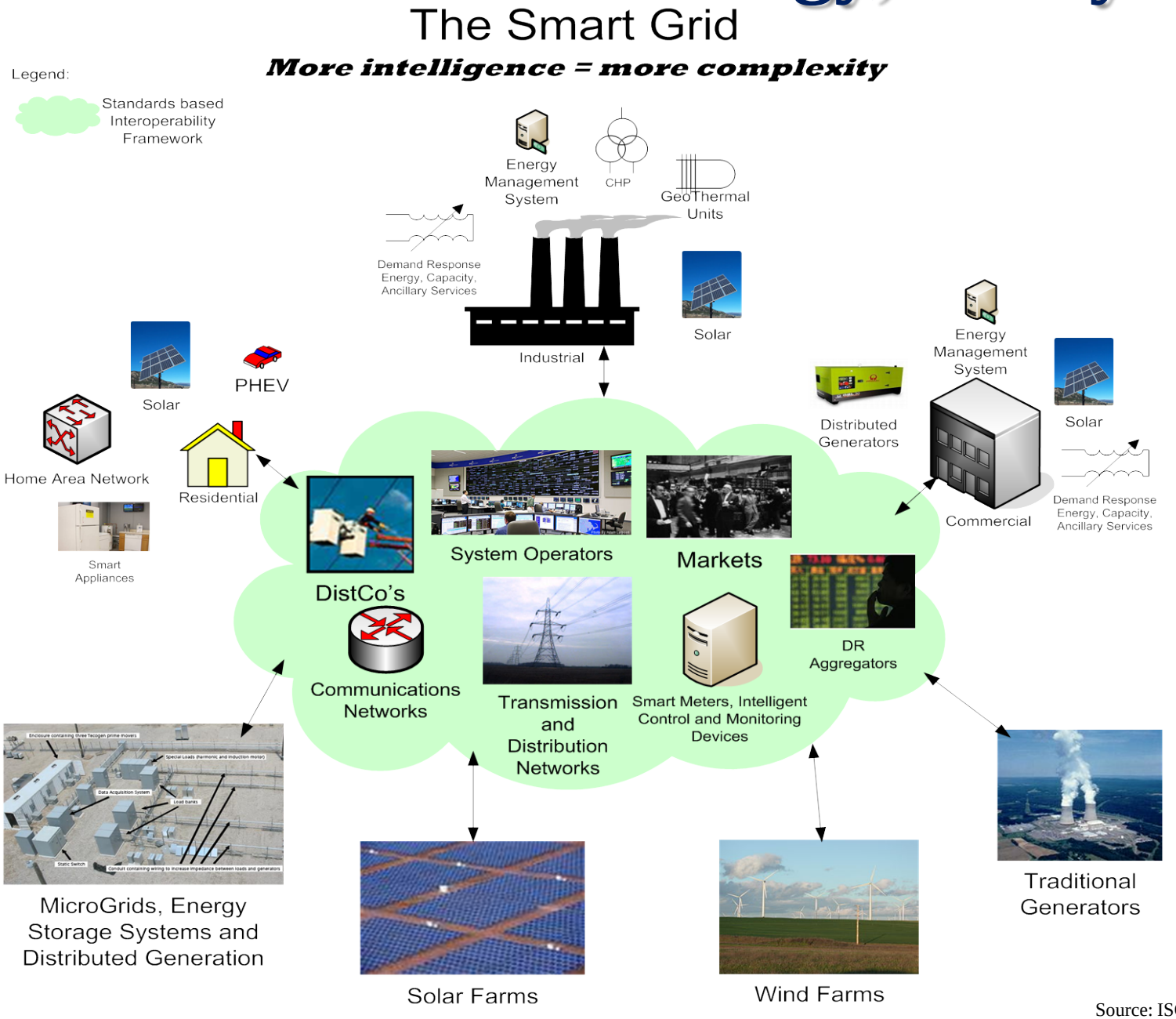
124 miles^2



2008 Construction Costs and Footprint to produce similar power

installed capacity x capacity factor (cf) = 1200 MW average production

Smart Grid = Technology, Policy…



Source: ISO New England

In the United States

- **Increase efficiency and conservation - 1 tkWhrs by 2020**
- **Increase CAFE to 50 mpg by 2015 - not 35 mpg by 2020**
- **develop plug-in capabilities - fully-electric cars**
- **Embrace green building practices and new urbanization strategies that localize essential production, and reduce energy use and transportation - culture change**
- **Dramatically increase electric grid and distribution development - new transmission infrastructure**
- **Plan resource stockpiling, e.g., steel, copper**

<u>by 2040, for energy security and economic stability, we need:</u>

- 100,000 3+ MW wind turbines totaling 0.8 trillion kWhrs/year

- Concentrated and ordinary solar arrays totaling 0.5 trillion kWhrs/year

- 200 GenIII+ nuclear reactors, depending upon plug-in vehicle demand (~ 2 trillion kWhrs/year)

- 10 bbl/yr of biofuels from algae, cellulosics and high-efficiency biomass

- 0.8 trillion kWhrs/year from other geothermal, wave, tidal and biogas

- no new coal- or gas-fired power plants

New Mexico power consumption changes - two futures

(assuming a 3% growth rate per year and concerted conservation efforts)

2007	*2015*	*OR*	*2015*
	with all anticipated goals met for renewable and NGas development		*with a single 1,500 MW Gen III+ reactor*
20 billion kWh	**25 billion kWh**		**25 billion kWh**
85% coal	**76% coal**		**24% coal**
12% natural gas (NG)	**20% NG**		**20% NG**
2% hydro	**1% hydro**		**1% hydro**
<1% renewables	**3% renewables**		**3% renewables**
0% nuclear	**0% nuclear**		**52% nuclear**
33 million tons of CO_2 emitted per year	**36 million tons of CO_2 emitted per year**		**16 million tons of CO_2 emitted per year***
1.8 million tons of hazwaste per year	**1.7 million tons of hazwaste per year**		**0.5 million tons of hazwaste per year°**

***NM would be able to export significant amounts of energy for carbon tax credit**

° health cost savings would be significant, primarily from decreases in respiratory illness from particulates associated with coal-emissions (~11%; *The 1998 ICAP Report*)