Sustainable Energy

Sustainable Energy Systems

Ron Johnson, ME Dept. UAF

Sustainable development was defined by the World Commission on Environment and Development (the Brundtland Commission) as development that

"meets our present needs without compromising the ability of future generations to meet theirs."

http://www.hallbarasverige.gov.se/eng/vad_ar/

Sustainable Consciousness

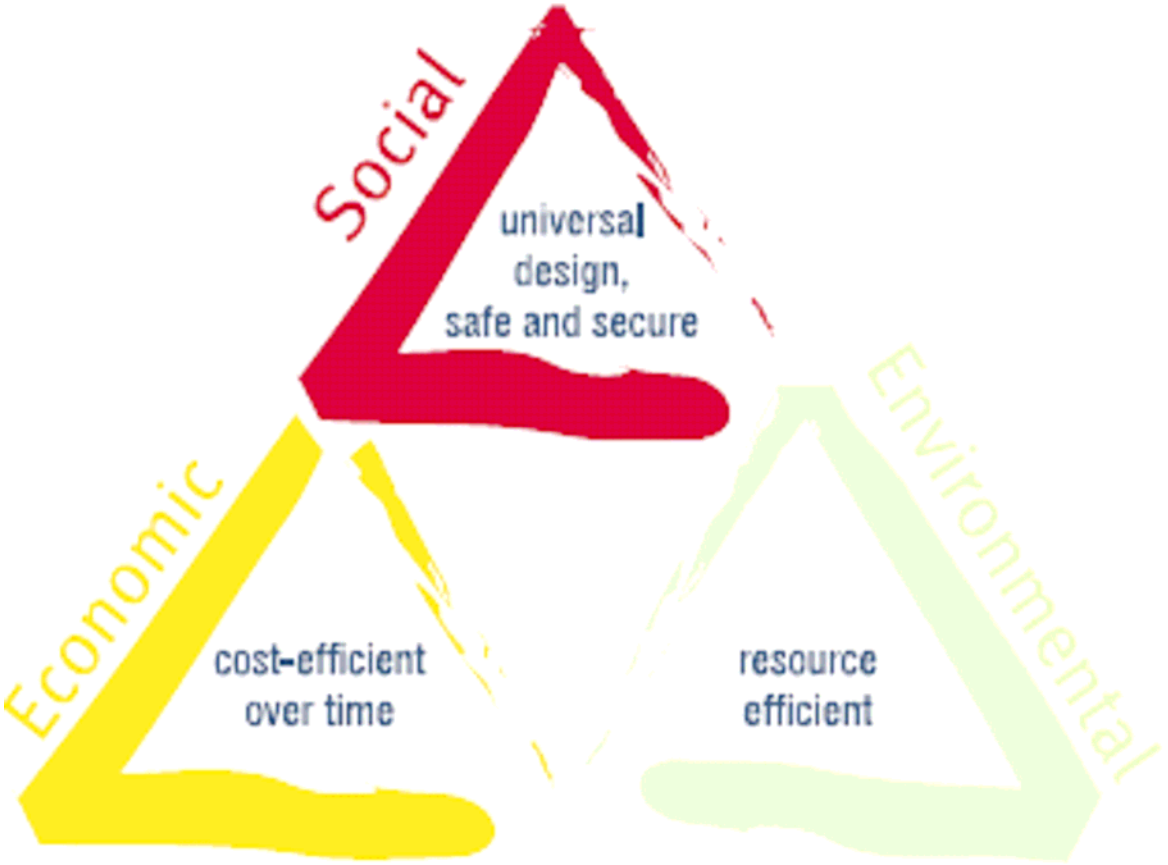
1. We are part of nature. Our existence depends on our ability to extract from finite world wo destroying natural systems.

2. Economic activity must account for environmental impacts of production. Environmental resources are capital. As we deplete them to create wealth, we are stealing from our descendents.

3. We [rich and poor alike] are all in this together

Ruckelshaus, W., 1989, Sept Sci Amer

Sustainability triangle



Towards Sustainable housing in Queensland, 2004,

Sustainability =

Environmental such as efficient water and energy use and waste minimization

Social such as considering needs of people w different abilities, universal design, and safer communities.

Economic which includes a balance between construction costs and long term operational costs.

UN Division for Sustainable Development
Agenda 21

“the major cause of the continued deterioration of the global environment is the unsustainable pattern of consumption and production”

Next slide lists some of the themes and indicators used.

http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter4.htm

Indicators

Global economic partnership	Trade	Current account deficit as percentage of GDP	Yes
		Share of imports from developing countries and from LDCs	
		Average tariff barriers against imports from developing countries and LDCs	
	External financing	Total Official Development Assistance (ODA) given or received as a percentage of GNI	Yes
		FDI inflows and outflows as percentage of GNI	
		Remittances as percentage of GNI	
Consumption and production patterns	Material consumption	Material intensity of the economy	Yes
		Domestic material consumption	
	Energy use	Annual energy consumption per capita, total and by main user category	Yes
		Share of renewable energy sources in total energy supply	
		Intensity of energy use, total and by sector	Yes
	Waste generation and management	Generation of waste	
		Generation of hazardous waste	Yes
		Management of radioactive waste	
		Waste treatment and disposal	Yes
	Transportation	Car share of inland passenger transportation	Yes
		Road share of inland freight transport	
		Energy intensity of transport	

Themes

In addition to above two themes there are 13 others such as:
poverty, health, education, atmosphere, economic development

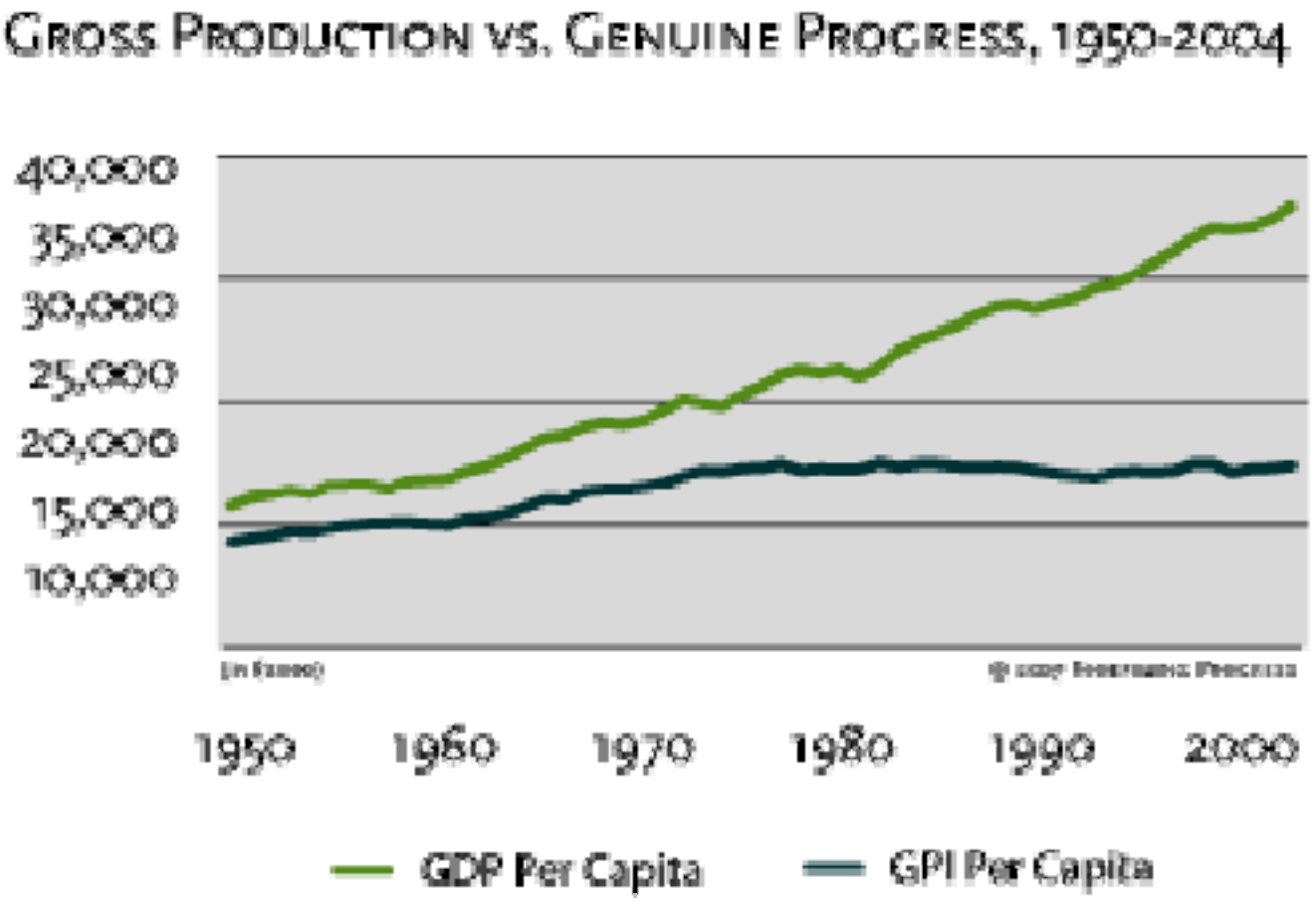
Genuine Progress Indicator

“if GPI is stable or increasing in a given year the implication is that stocks of natural and social capital on which all goods and services flows depend will be at least as great for the next generation while if GPI is falling it implies that the economic system is eroding”

Computation usually begins with estimates of personal consumption expenditures. Additions made to account for the non-market benefits associated with volunteer time (+), and other socially productive time use. Deductions for costs associated with degradation and depletion of natural capital, automobile accidents, etc. (+) cf Clinton Global Initiative

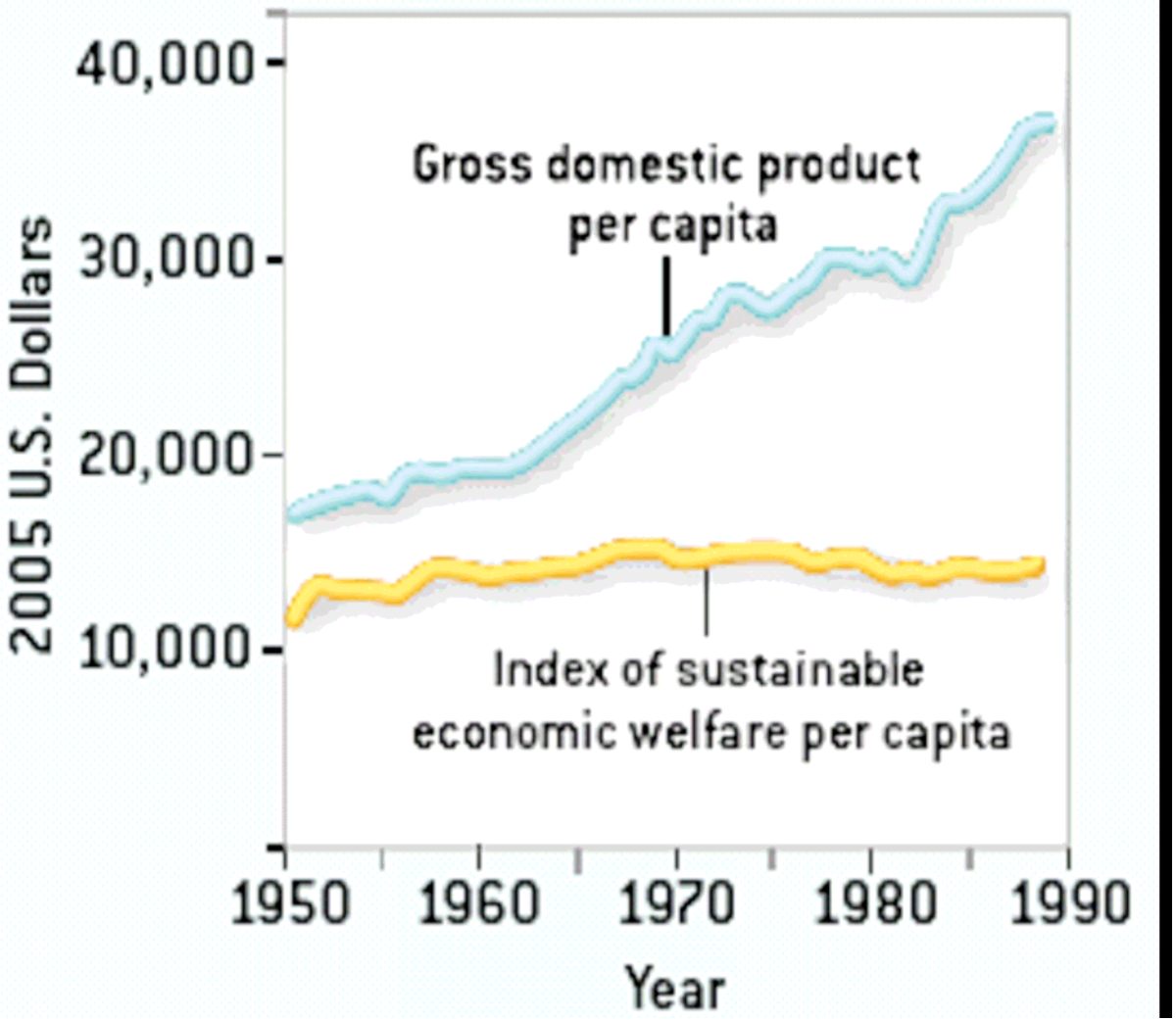
Talberth, Cobb, and Slattery, 2006, The GPI, www.rprogress.org

GPI



Talberth, J., C. Cobb, and N. Slattery, 2006, **The Genuine Progress Indicator,** www.rprogress.org

Index of sustainable economic welfare

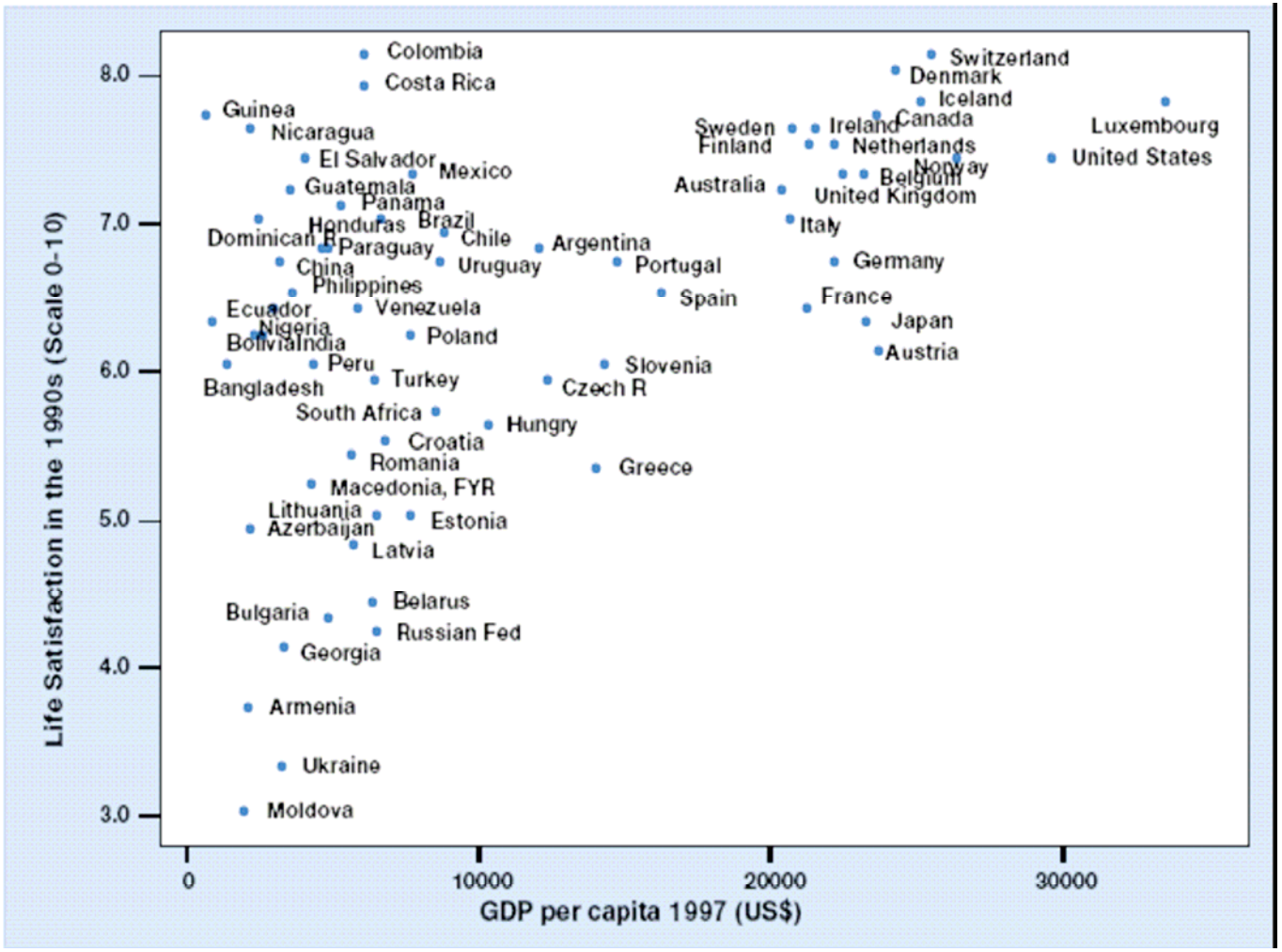


ISEW for US

ISEW 1st proposed By Daily & Cobb, 1989

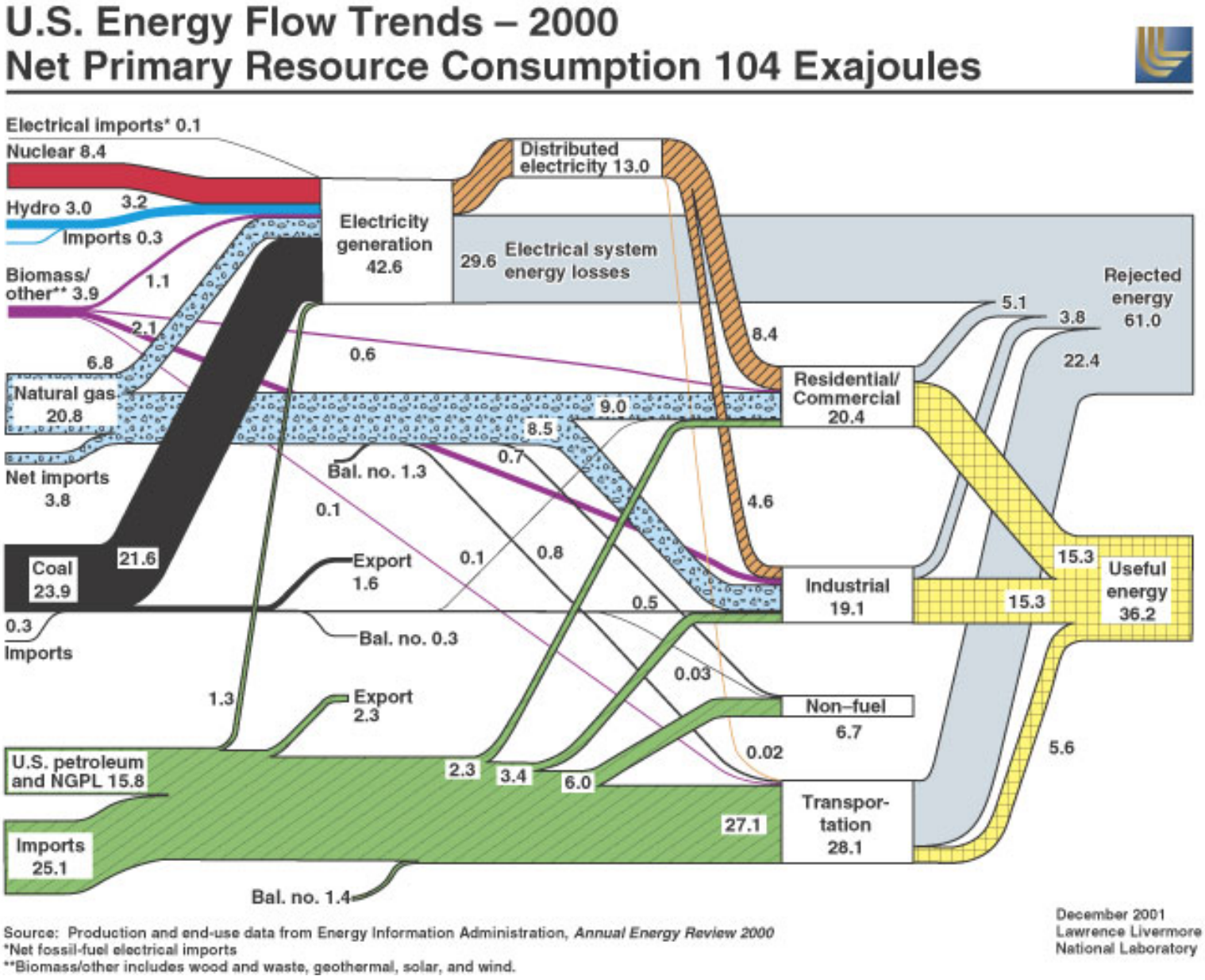
Daily, Sci Amer. Sept., 2005

Happiness vs GDP



Veenhoven, R (2003) World Database of Happiness, Catalog of Happiness Queries. Available at www.eur.nl/fsw/research/happiness

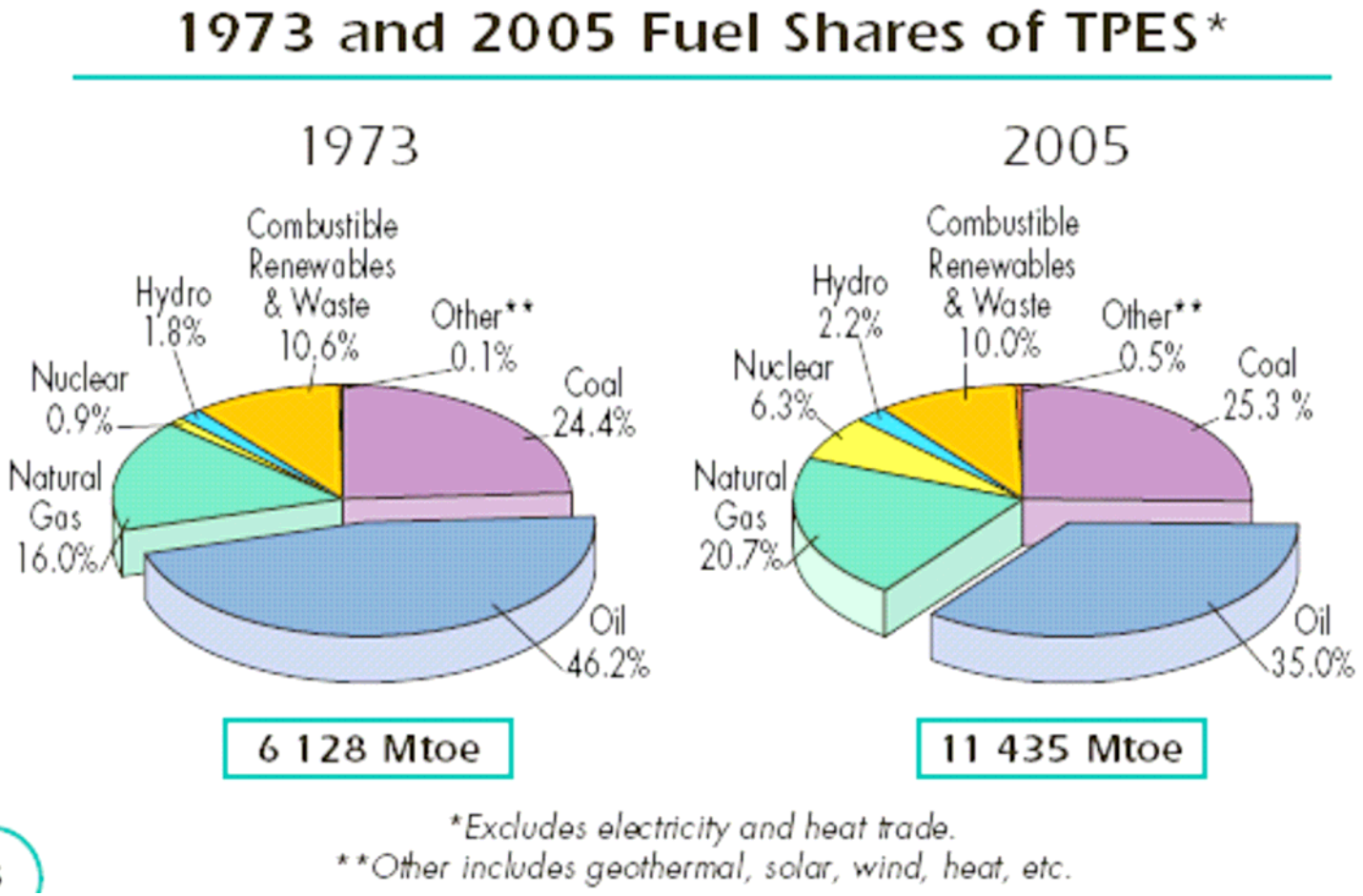
US Energy Flows



ExJ = 10^{18} J ~ Q = 10^{15} Btu

AK net extraction = 2.4 Q

World total primary energy supply



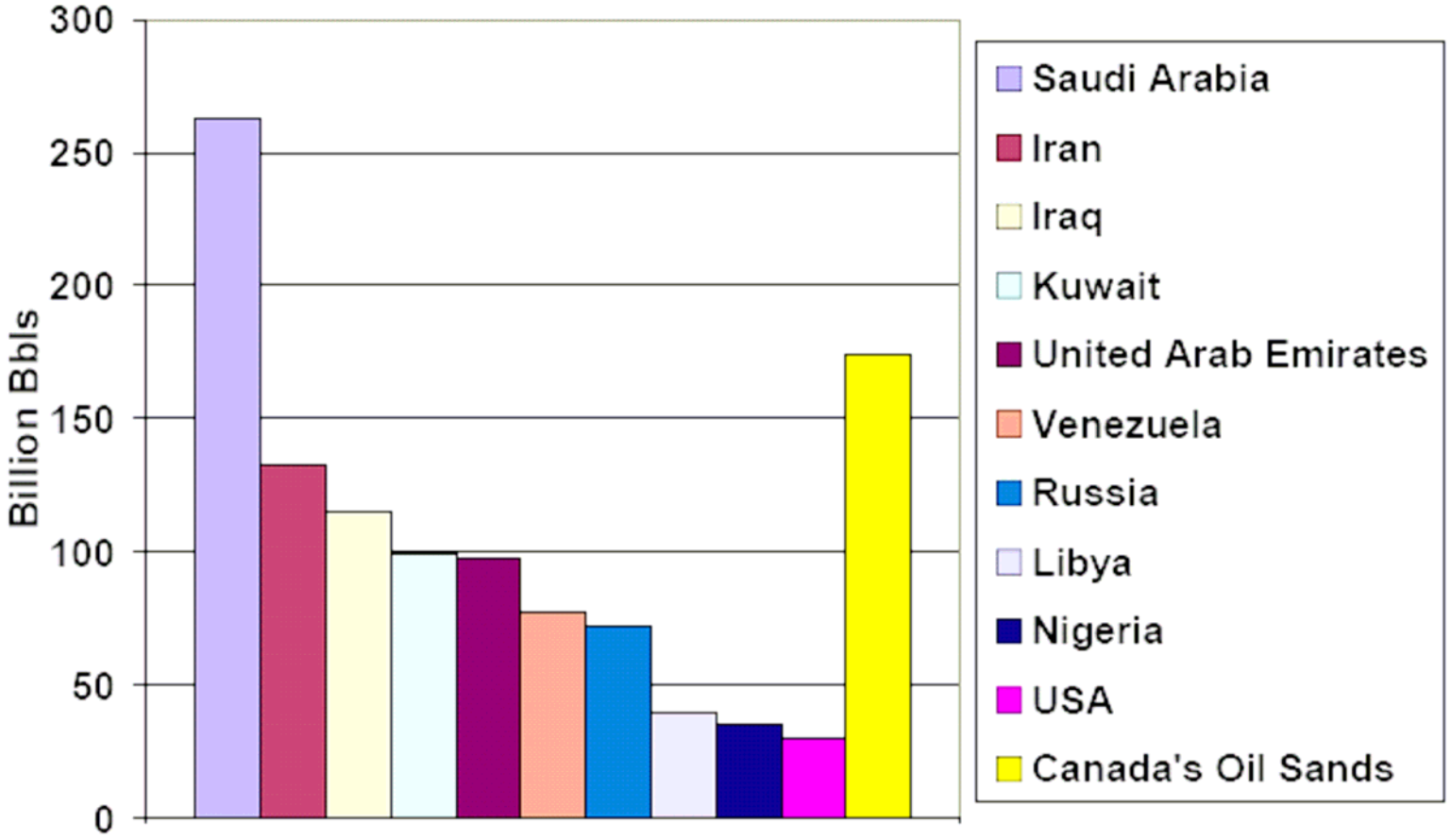
1000 M toe ~ 40 Q

Q = 10^{15} Btu

China's share doubled to 15 %

IEA Key Energy Statistics 2007

Proven oil reserves by country

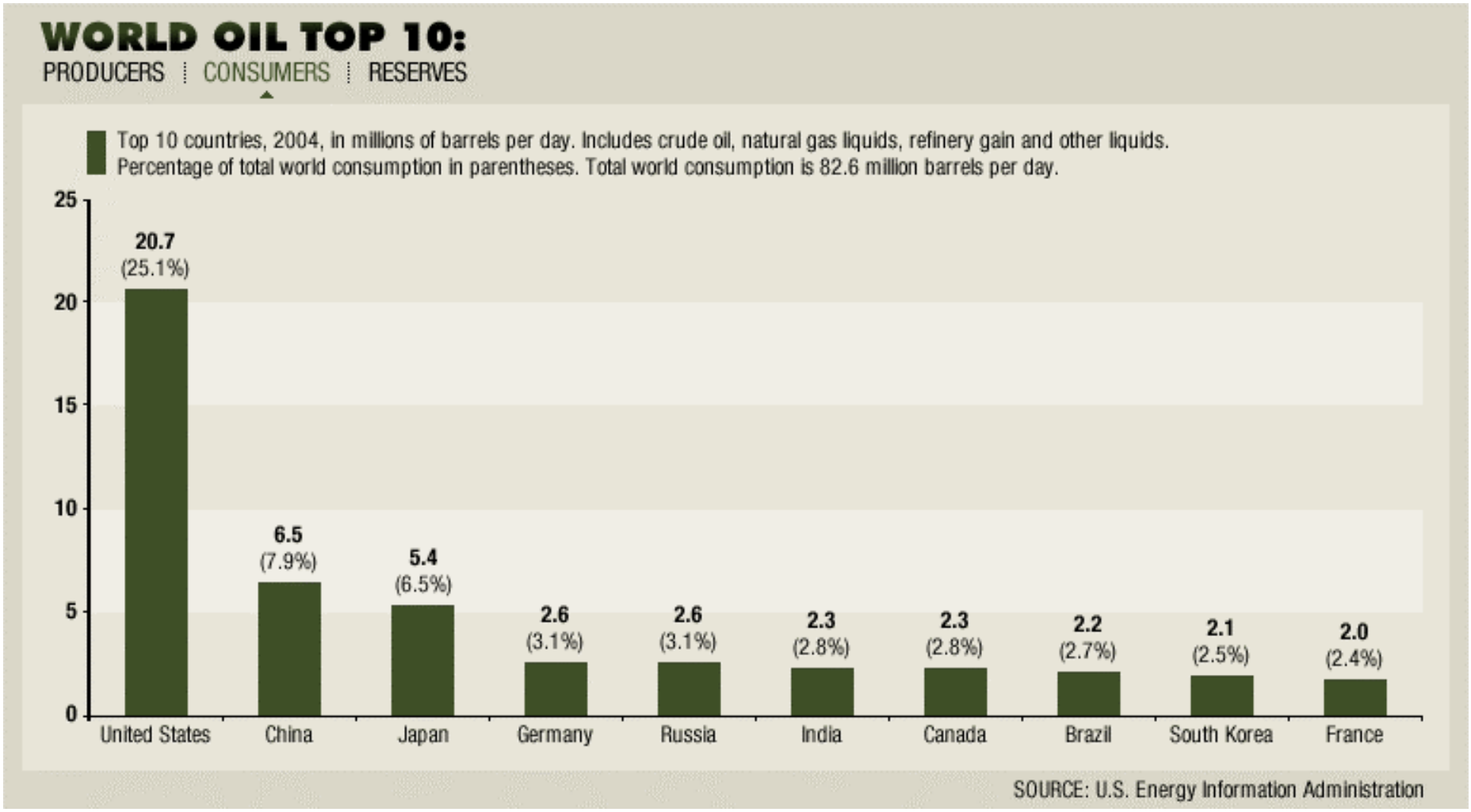


ww dmd 31 B bbl/yr in 2006, US 7 B

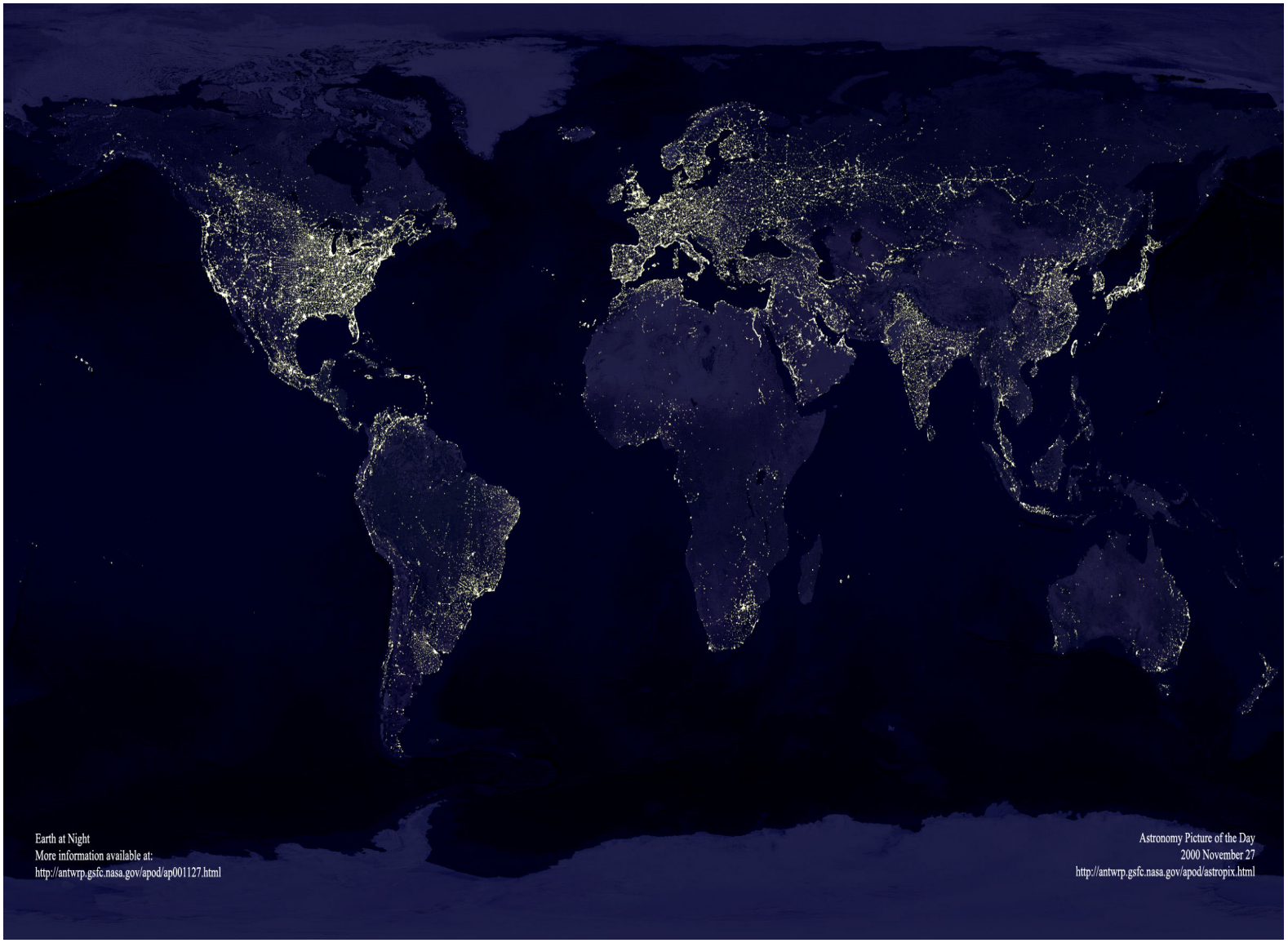
Q = 10^{15} Btu, B bbl oil = 5.5 Q
US used ~ 100 Q in 2005
for total energy supply

BP Statistical Review of World Energy 2005. www.bp.com

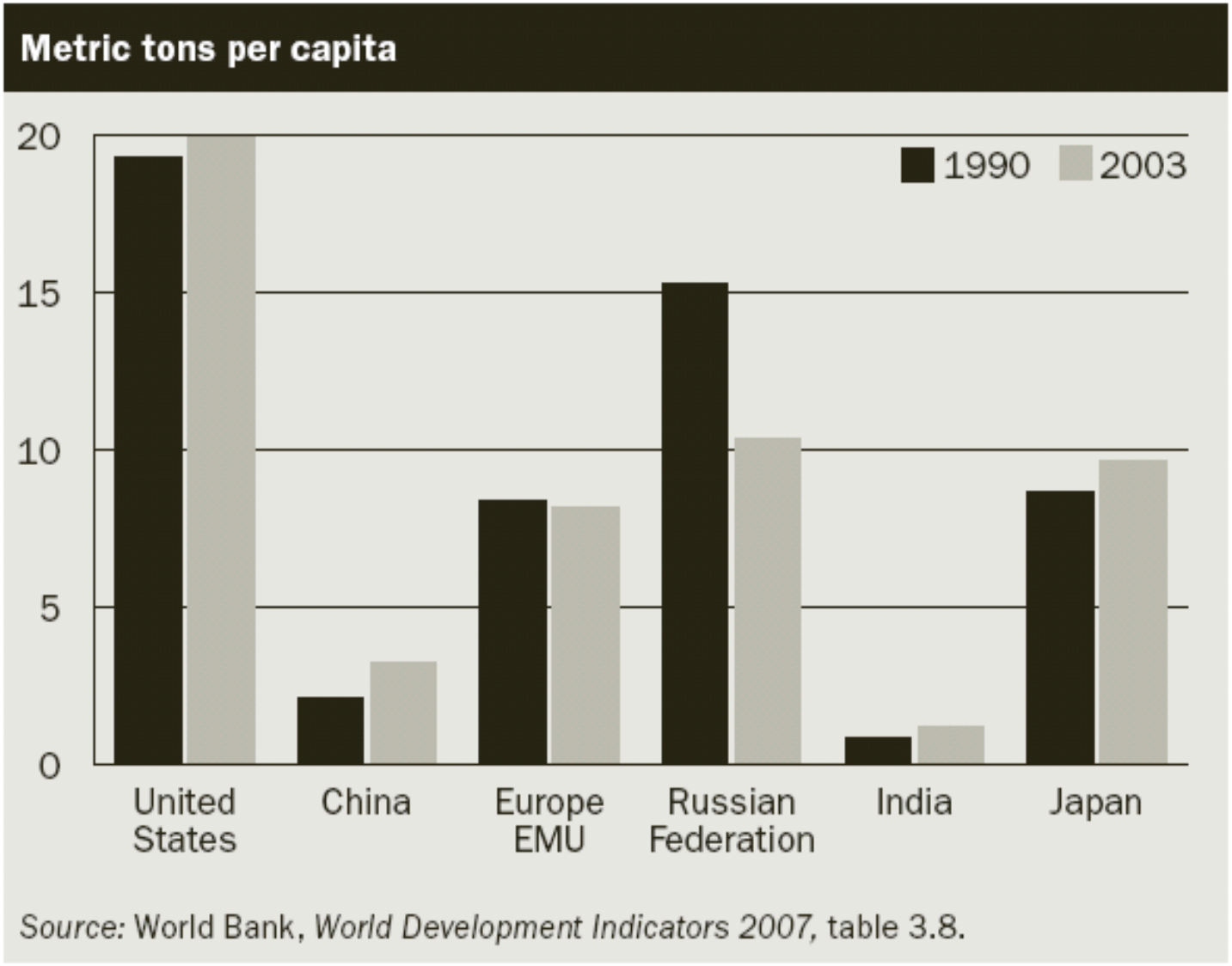
World oil consumers



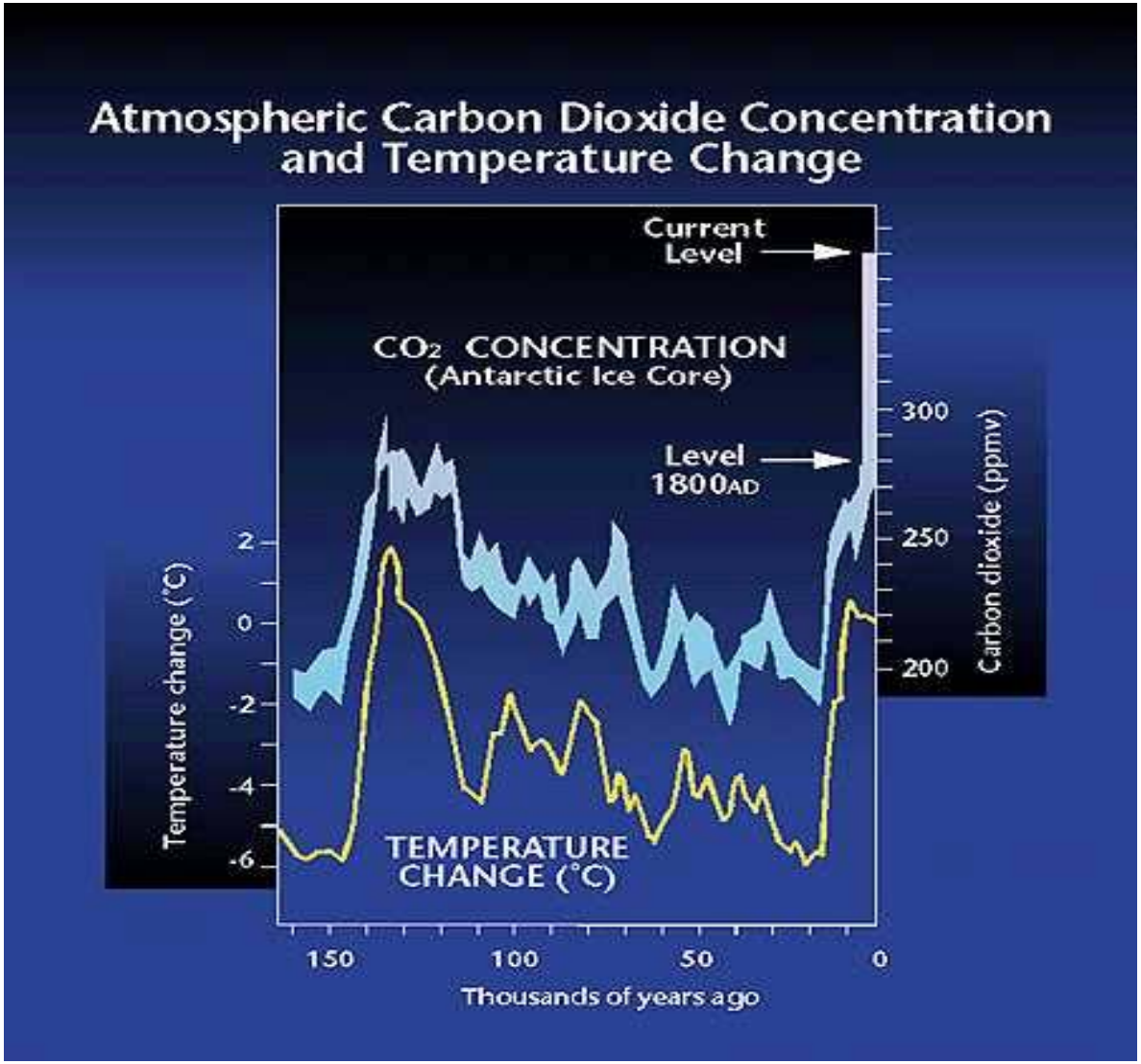
Earth at Night



World CO_2 emissions

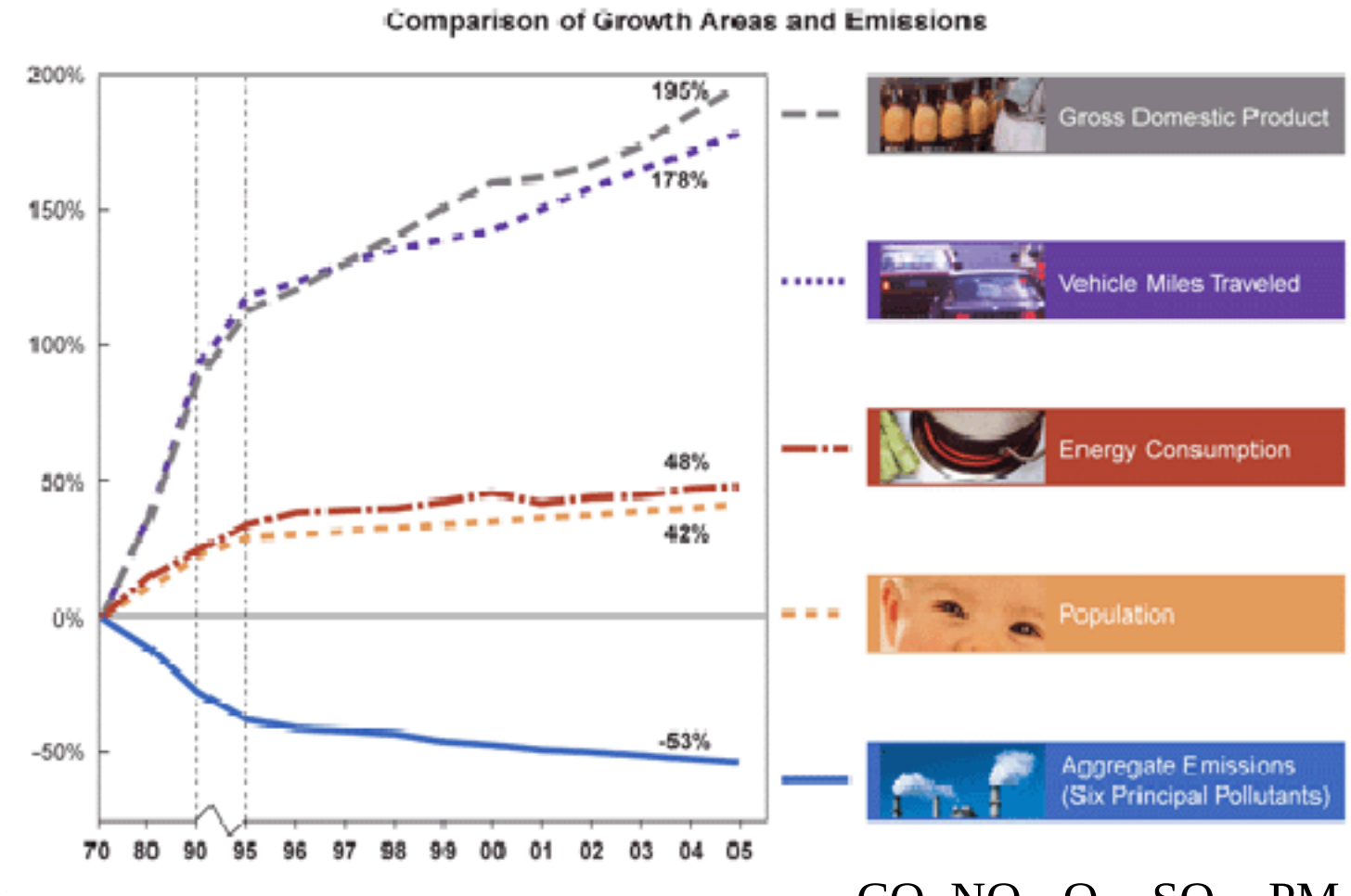


CO_2 and T vs time



Via Woods Hole **RJ 2.20**

US Emission trends



CO, NO_x, O_3 , SO_2 , PM, Pb
~ 160 M t/yr

http://www.epa.gov/airtrends/2006/econ-emissions.html

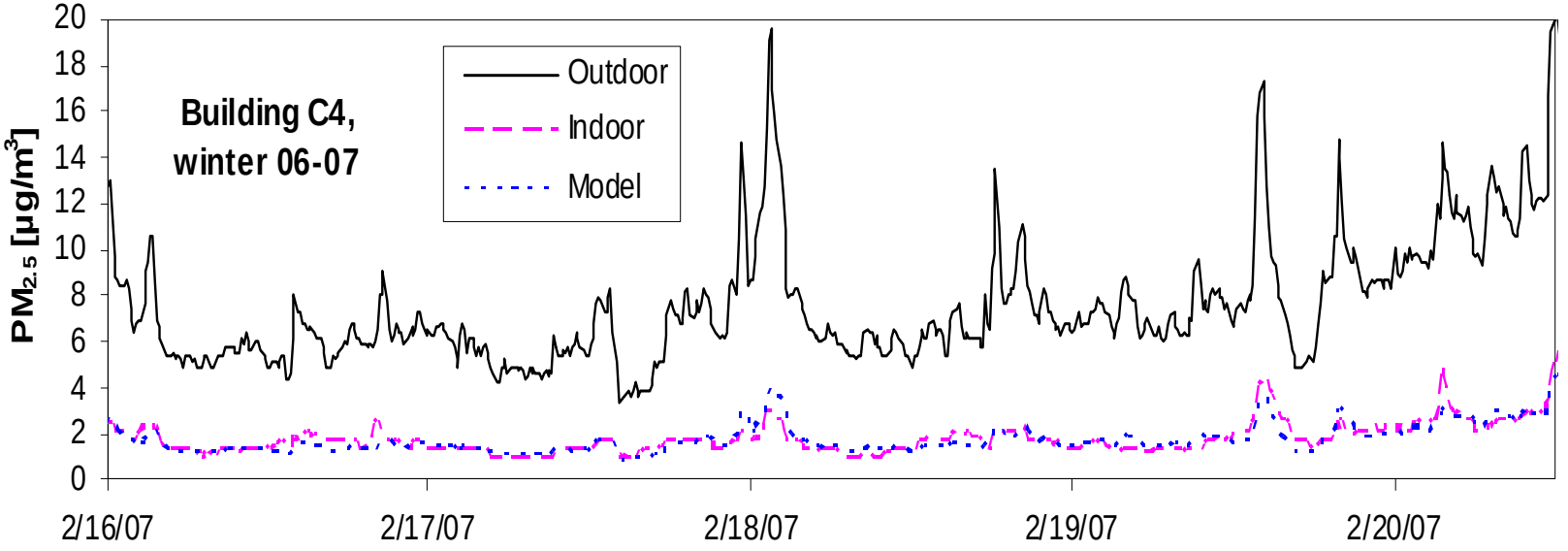
Air Polln

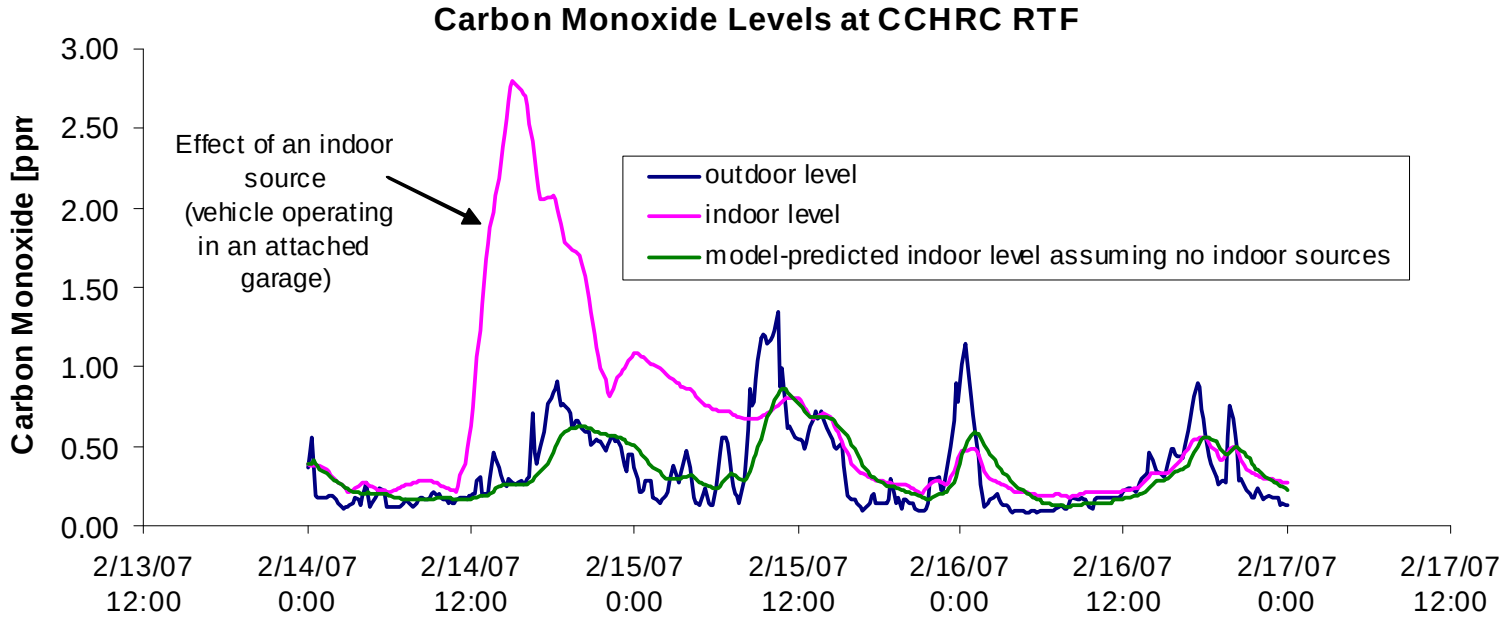
Each 10 $\mu g/m^3$ increase in long-term average ambient $PM_{2.5}$ concentrations leads to 6 and 8 % increased risk of mortality due to cardiopulmonary and lung cancer mortality respectively

[from study of 500 K adults over 16 yrs]

Pope et al, 2006, JAMA, vol 27, pp 1132- 1141

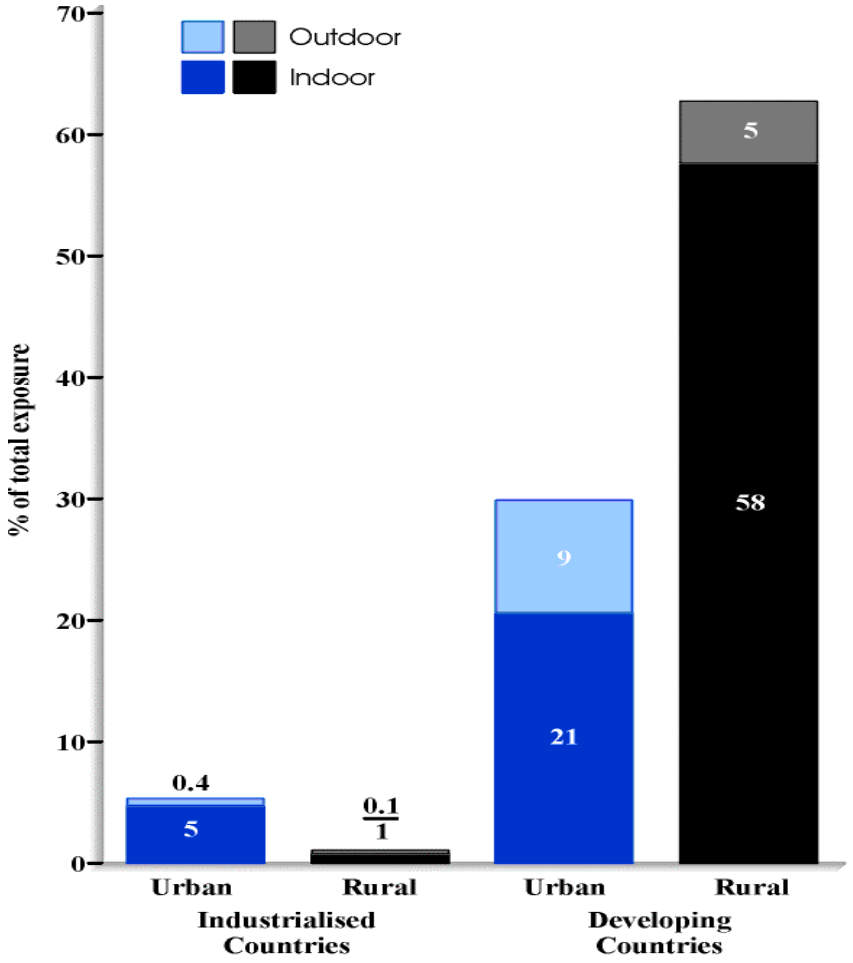
CCHRC Data


Building C4,
winter 06-07
Outdoor
Indoor
Model
PM2.5 [µg/m3]
20
18
16
14
12
10
8
6
4
2
0
2/16/07
2/17/07
2/18/07
2/19/07
2/20/07


Carbon Monoxide Levels at CCHRC RTF
Carbon Monoxide [ppm
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Effect of an indoor source (vehicle operating in an attached garage)
outdoor level
indoor level
model-predicted indoor level assuming no indoor sources
2/13/07 12:00
2/14/07 0:00
2/14/07 12:00
2/15/07 0:00
2/15/07 12:00
2/16/07 0:00
2/16/07 12:00
2/17/07 0:00
2/17/07 12:00

Wwide exposure to PM

Figure 2.9: Approximate Distribution of Human Exposure to Particulate Air Pollution

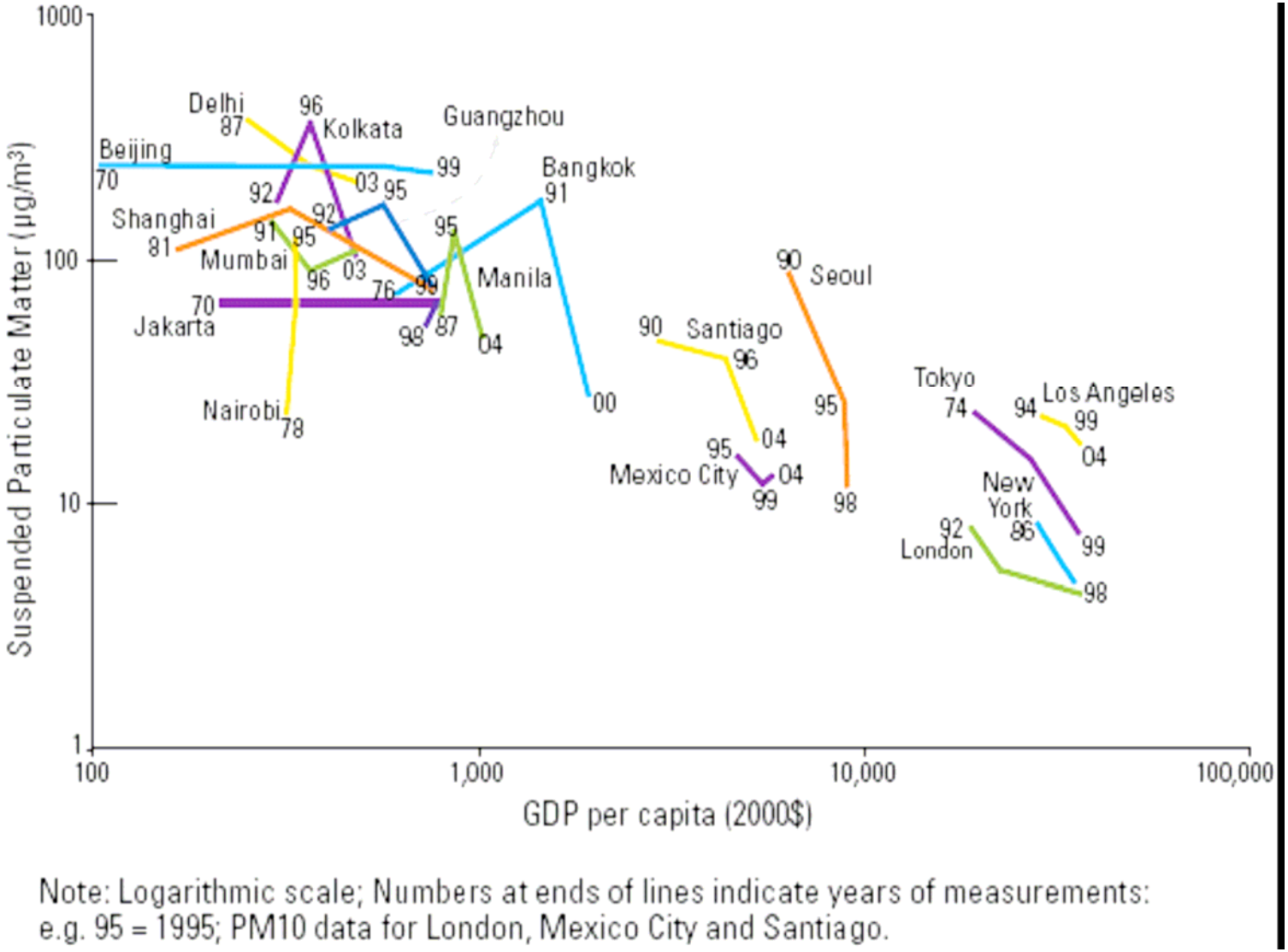


Note that more than 90 % of exposure occurs in developing countries; furthermore, two thirds of human exposure seems to occur indoors in rural areas.
Source: (Smith, 1993)

http://www.undp.org/seed/energy/chapter2.html

UN Development Program

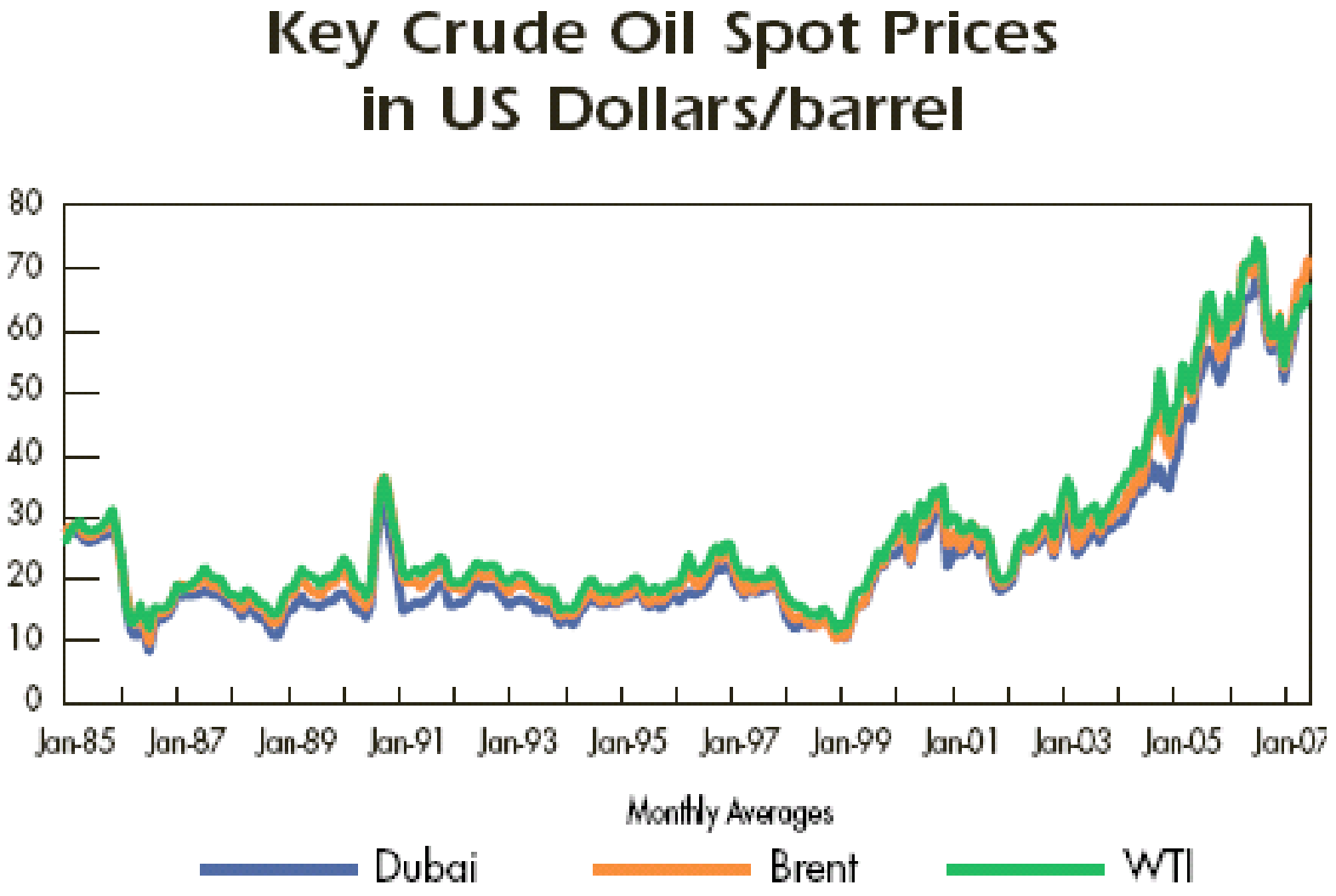
WW ambient PM_{10}



Note: Logarithmic scale; Numbers at ends of lines indicate years of measurements: e.g. 95 = 1995; PM10 data for London, Mexico City and Santiago.

UN. 2006, Trends in Sustainable development

Crude oil spot prices

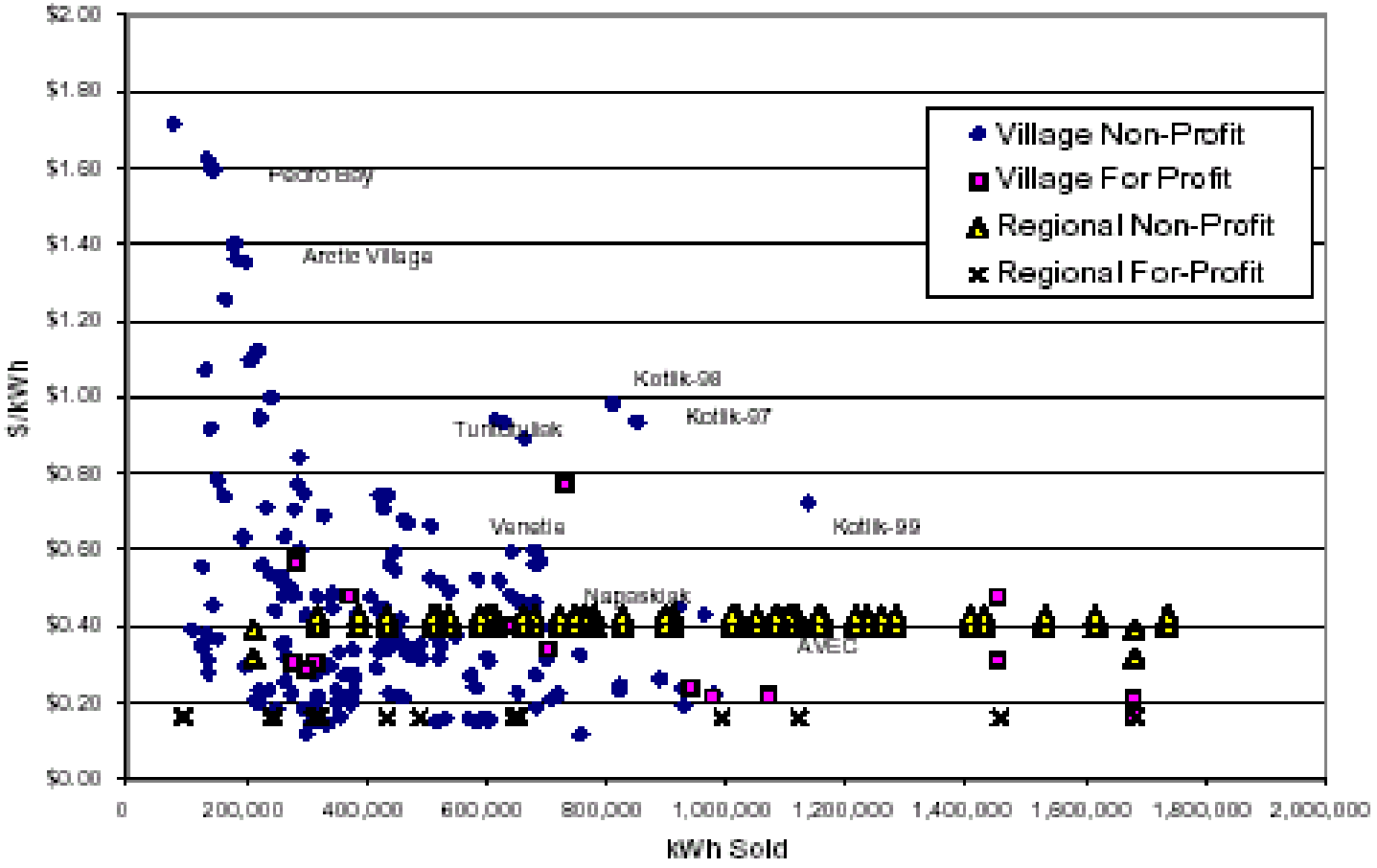


US EIA

Elec costs in rural AK

Non –fuel costs vs annual sales [max 2 M kWh/yr]

[fuel costs ~ 26% of total]



http://www.iser.uaa.alaska.edu/projects/omm/omm_review_overview.pdf

Fbks Energy Use

$ 480 M/yr spent on energy in Fbks area [not counting airport] ~ $ 5300/cap

US spends ~ $ 900 B/yr on energy or about $ 3000/cap

Kansas City has HDD + CDD ~ 6700/yr

Fbks has 14000 HDD

6700/14000 ~ 0.5 and 3000/5300 ~ 0.57

AK Energy Flows

Net extraction: 2.36 Q/yr

Primary consumption: 0.24 Q/yr

Avg rate of consumption: 13 kW

[11 kW for entire US]

Q = 10^{15} Btu with US using 100 Q/yr

1st 2 rows via Steve Colt: ISER, 2005

Worldwide Energy Use Equivalents

- **US resident uses 1021 kWh/mo elec**
- **Equiv to 2.4 Europeans**
- **Or 7.7 Mexicans or S. Americans**
- **12.6 E Asians**
- **27 Africans**

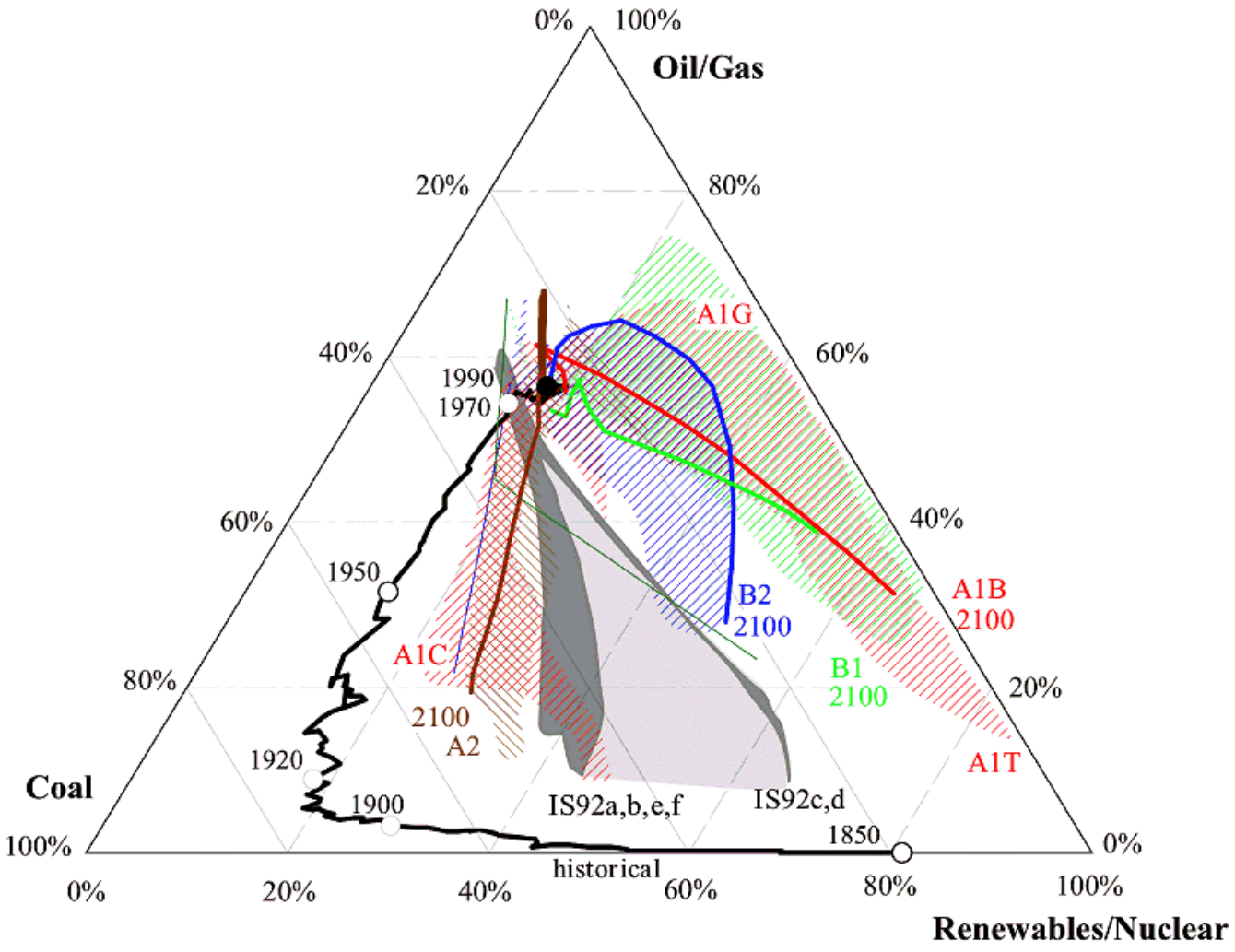
This for all elec uses incl. residential, industrial, etc.

100 Q/300M/yr ~ 11 kW at supply end

http://www.wattsonschools.com/calc-world.htm

IPCC Special Report on Emissions Scenarios

Energy Sources Triangle



http://www.grida.no/climate/ipcc/emission/2-11.htm

Bergey Excel WT

- 10 kW at 13 m/s
- 3.1 and 53 m/s are min/max
- furl at 15.5
- Permanent Magnet Alternator
- D = 7 m
- 3 Phase AC
- $17,950 to $20,475
- 18, 24, 30 m towers <= $ 8K

http://www.bergey.com/excel.html

GE 3.6 MW WT

Nominal 14 m/s

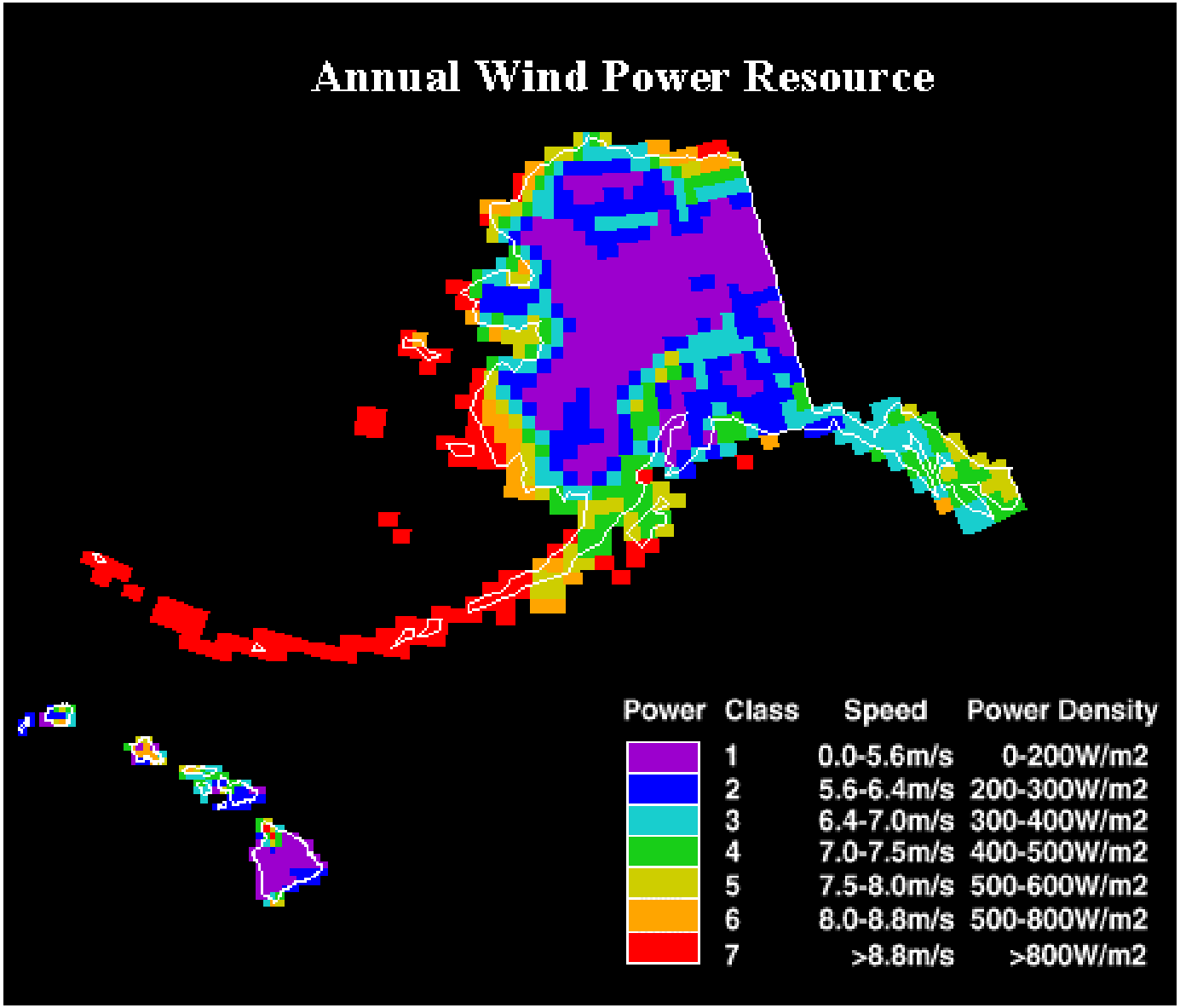
D = 111 m

8 – 15 rpm

Variable speed control

http://www.ge.com/en/product/business/utilities.htm

Alaska wind resources



http://www.nrel.gov/wind/potential.html

KEA WT installation

Via Brad Reeve

Notable AK Systems

50 Hydro Plants with B Lake @ 126 MW largest

KEA Wind Power initiated in 1997 with
10 50 kW AOC
1 Polar 100 kW
max penetration 39% as of 2004

CEC 1 MW Fuel Cell at Post Office

GVEA 40 MW [for 7 mins] battery storage

50 + MW WT TBD Fire Island, Eva Creek

Energy Conservation and efficiency

- **Conservation and storage key for use of renewables**

- **Adoption of energy efficient refrigerators $\Rightarrow$ $16 B annual savings in US**
  [yearly utility sales ~ $ 340 B with $ 68 B nuclear]

- **Denmark gets 55% of its space heating via district heating**

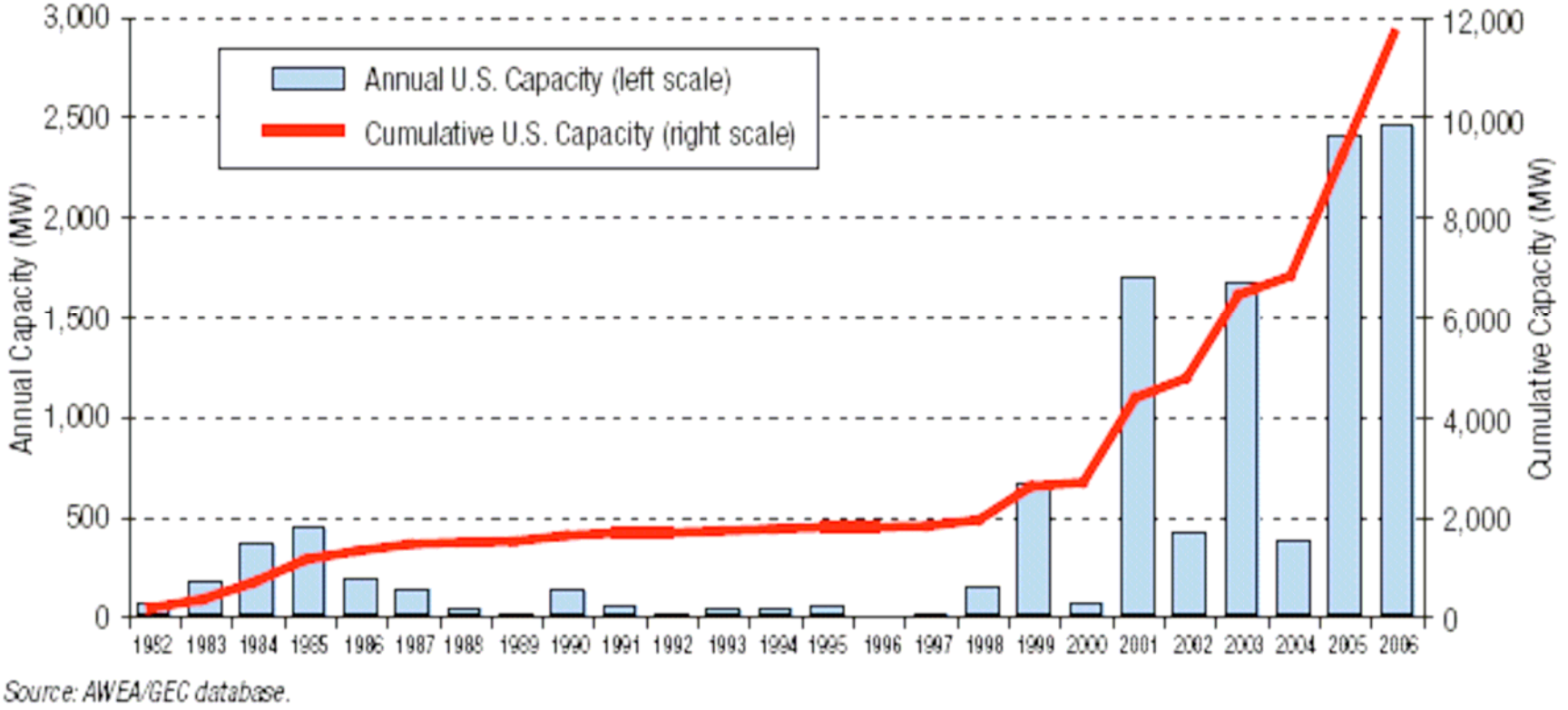
- **Customers willing to pay premium for green energy**

- **Multinational corporations spending $ billions to develop fuel cells**

- **Annual growth in wind power > 30 %/yr**

- **Space Htg energy >> electrical energy needs in Alaskan villages**
  [cogeneration worthwhile]

US Wind Power



Source: AWEA/GEC database.

Figure 1. Annual and Cumulative Growth in U.S. Wind Power Capacity

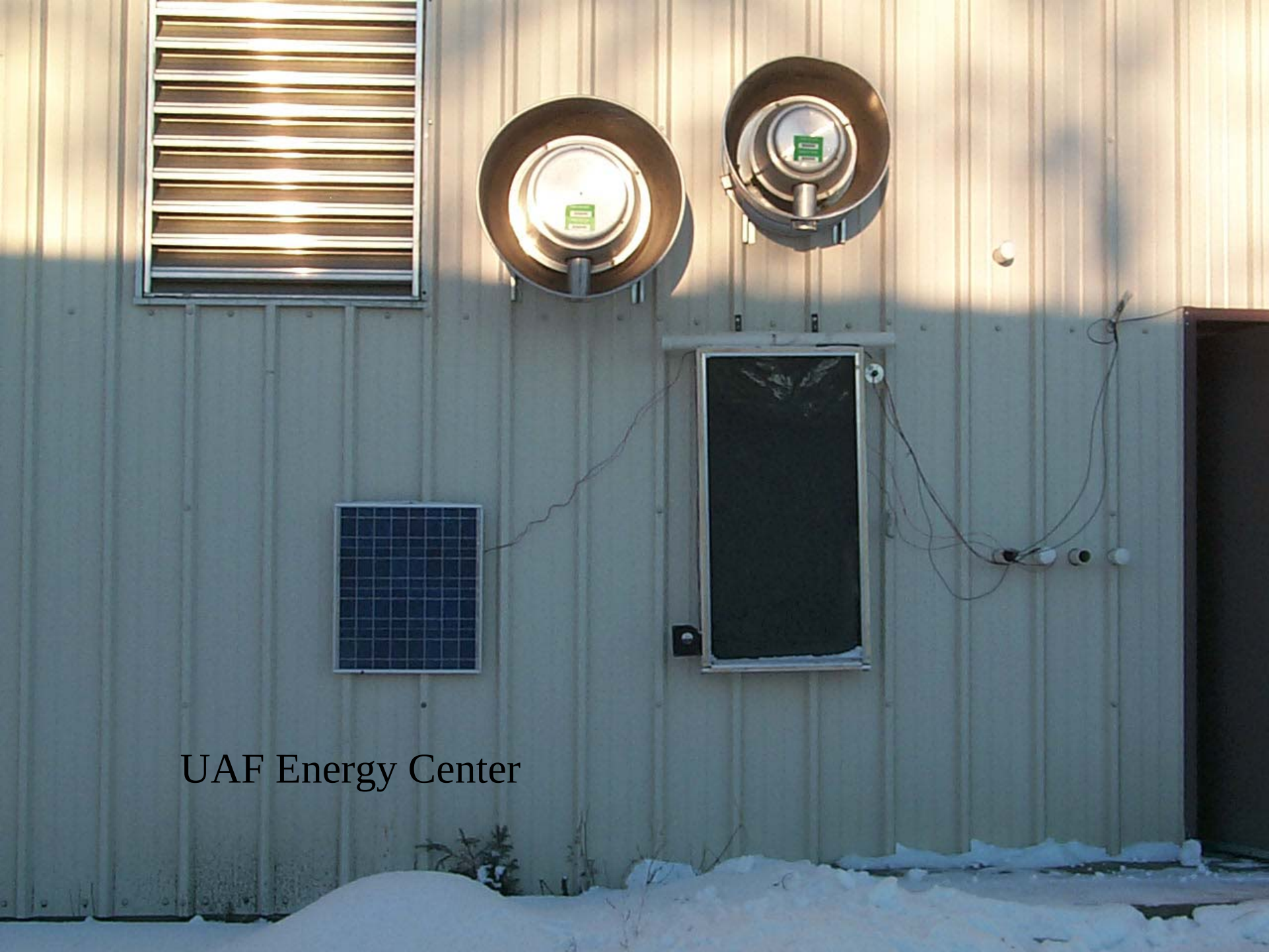
2006 Annual rpt on US wind power - USDOE

Solar Hot Water

Vancouver Int.
Airport

$ 375 K cost and annual savings of $ 67 K
100 panels heat 800 gph

http://www.solaraccess.com/news/story?storyid=5271


UAF Energy Center

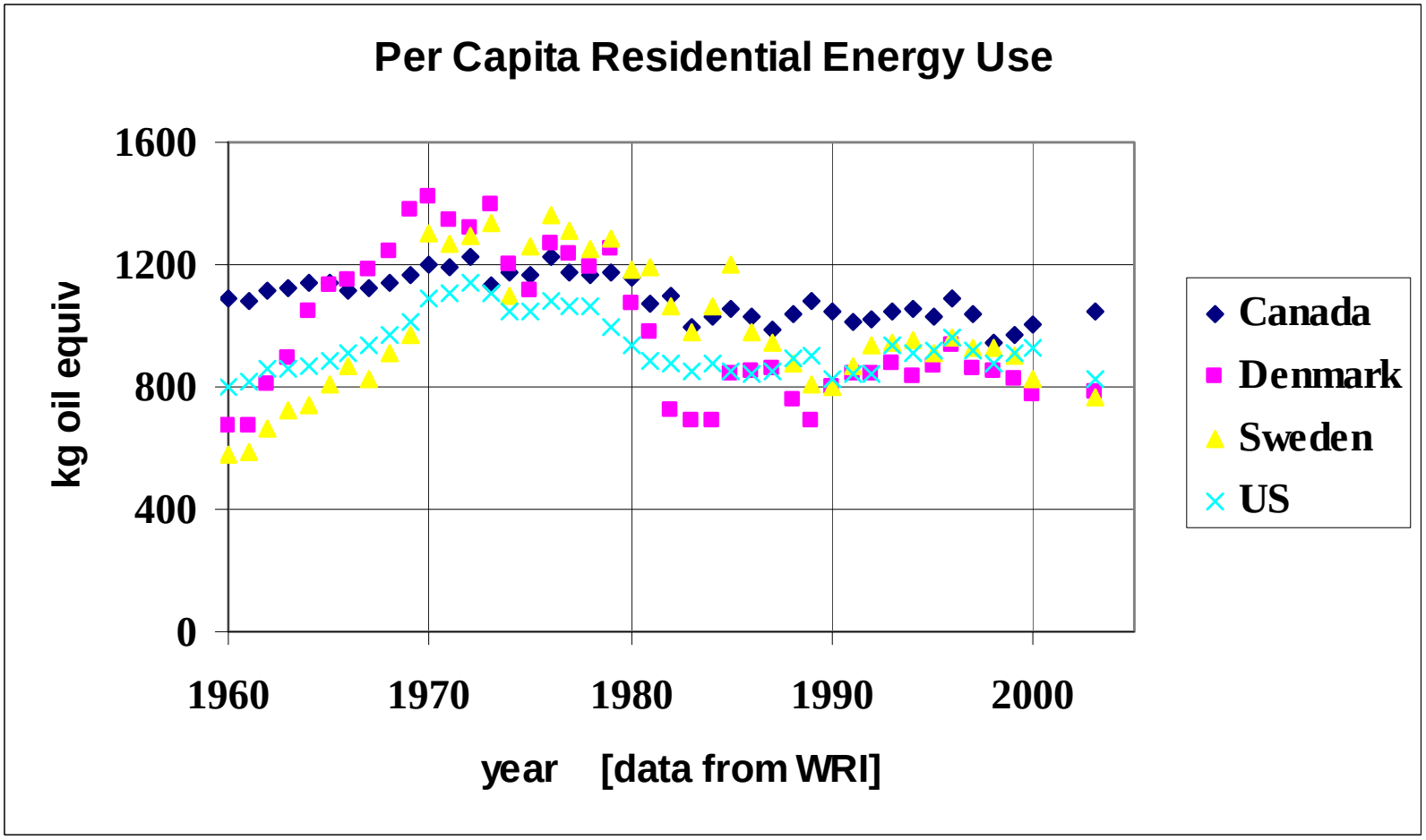
Hybrid Energy Systems

Fueled Generators:

(1) Low capital costs but high fuel cost
(2) Normally storage not required
(3) Output independent of natural cycles
(4) Noisy, air polln, fuel spills & xport

Renewable systems:

(1) "Fuel" is free
(2) No direct polln;
(3) Dependent on natural cycles
(4) Higher capital costs
(5) Need storage [resource availability not necessarily coincident with load]


Per Capita Residential Energy Use
kg oil equiv
1600
1200
800
400
0
1960
1970
1980
1990
2000
year [data from WRI]
Canada
Denmark
Sweden
US

US DOE info

$160 billion a year in US for home energy
[$ 1600/yr for avg household]

21 % of national total

17 % of US GG emissions

Predict $200 B by 2015 wo enhanced conservation

www.energystar.gov/ia/home_improvement/PHEE_Report_final.pdf

bldgs acct for 40 % of US energy use

ACEEE – State En Effic Scorecard- 2007

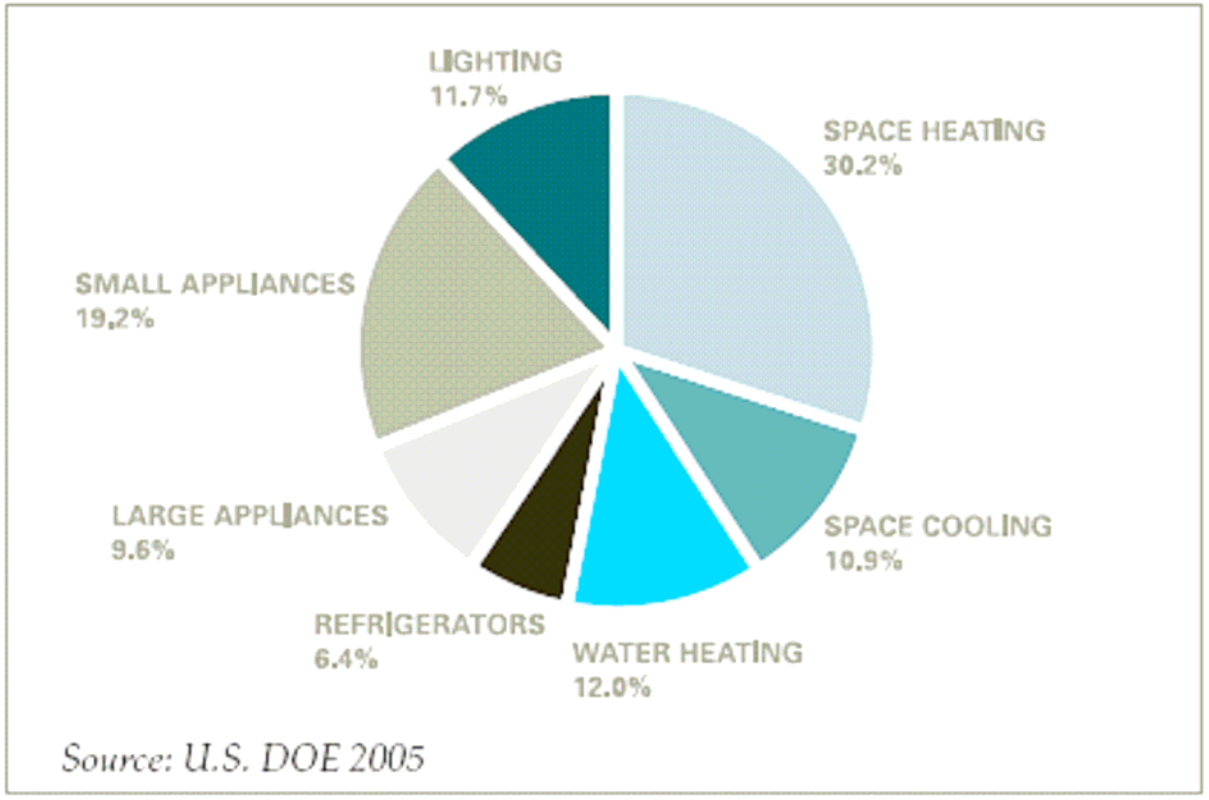


FIGURE 2. MAJOR HOME ENERGY END-USES

My home uses ~ 100 M Btu thermal and 18 M elec/yr

What can be done - residential

Overall energy use per square foot has decreased by 30 percent since 1970.
But, this has not been sufficient to overcome the increase due to the higher number and larger size of homes.

Need more emphasis on cost-effective, energy-efficient products.

Use high efficiency appliances & high efficiency lighting.

Improve bldg envelope.

Improve efficiency of heating and cooling systems

Utilize cogeneration of heat and electricity

Support GVEA SNAP program

What can be done-infrastructure

Use local resources if efficient [don't ship all petroleum and NG south]

Expand use of our abundant renewable resources [wind along coast and in mountains – solar 8 months of year in Interior- undeveloped geothermal, hydro, wave, and tidal]

Alternative technologies such as nuclear, hybrid systems

Commute by means other than single passenger car including telecommuting