

# Sustainability and Energy ?

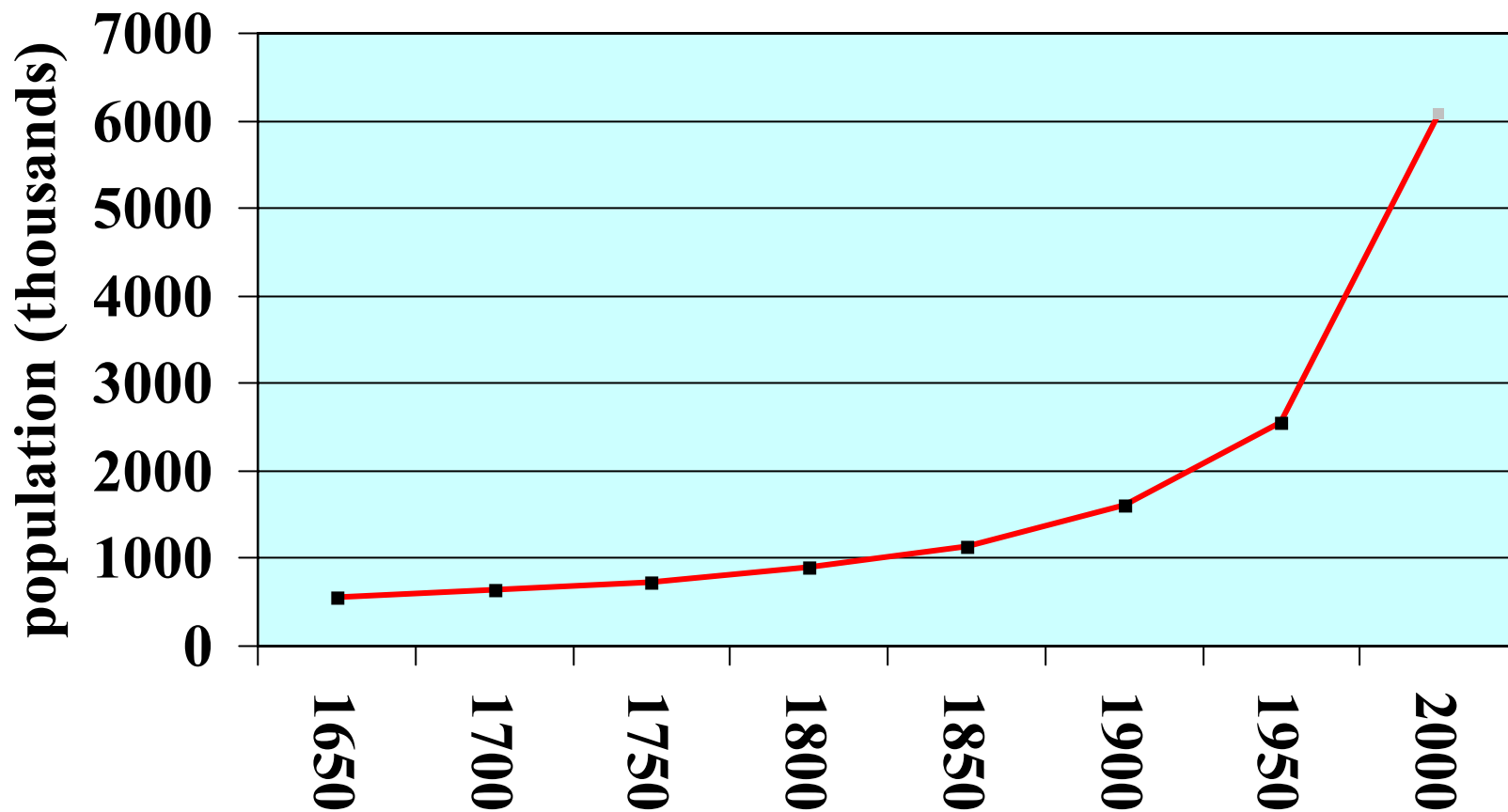
E.M. Drake, February 3, 2005



- **Is present society energy sustainable?**
- **What are the problems with present energy use?**
- **How can change be driven?**
- **Consequences of no action**



# World Population (thousands)

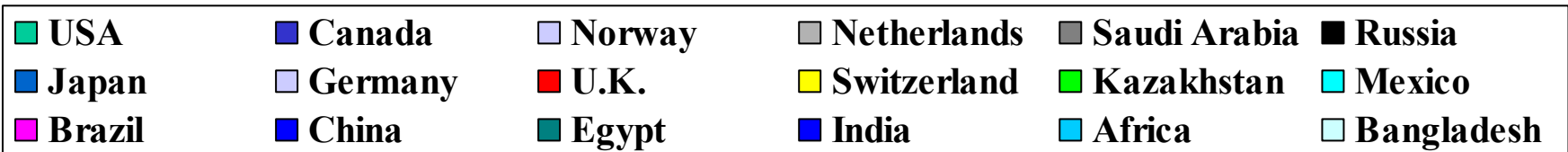
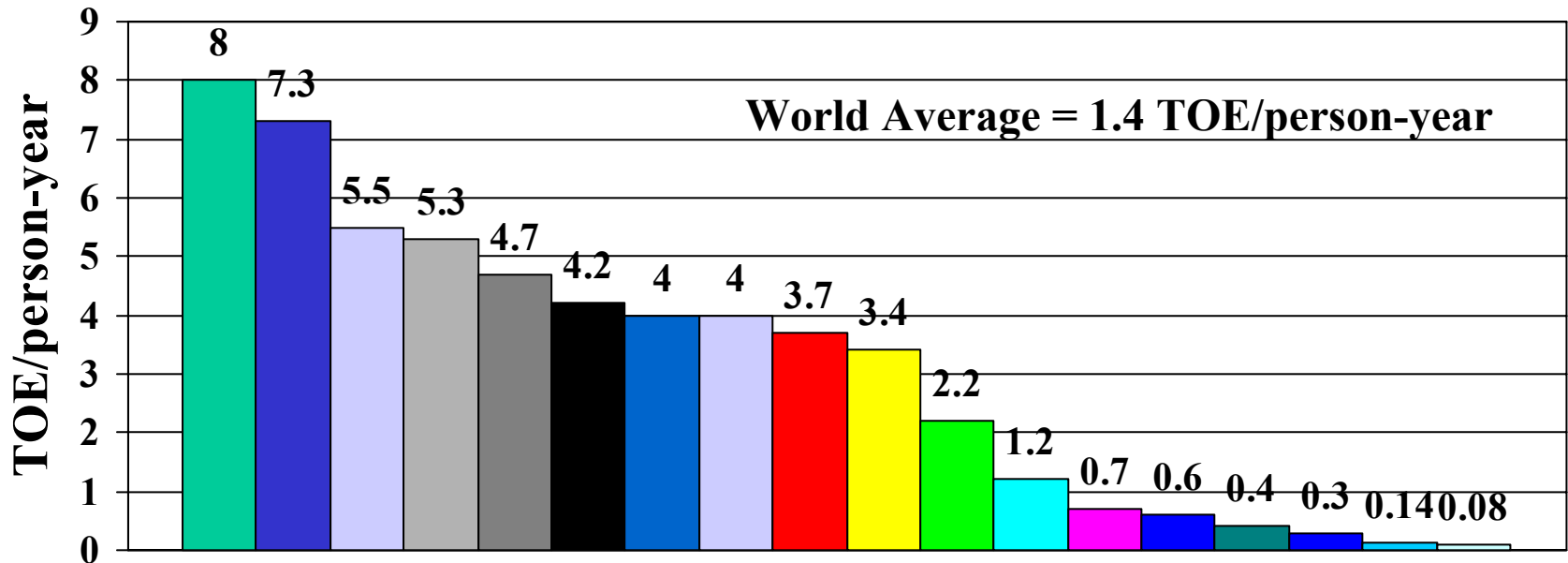


# Are There Limits?

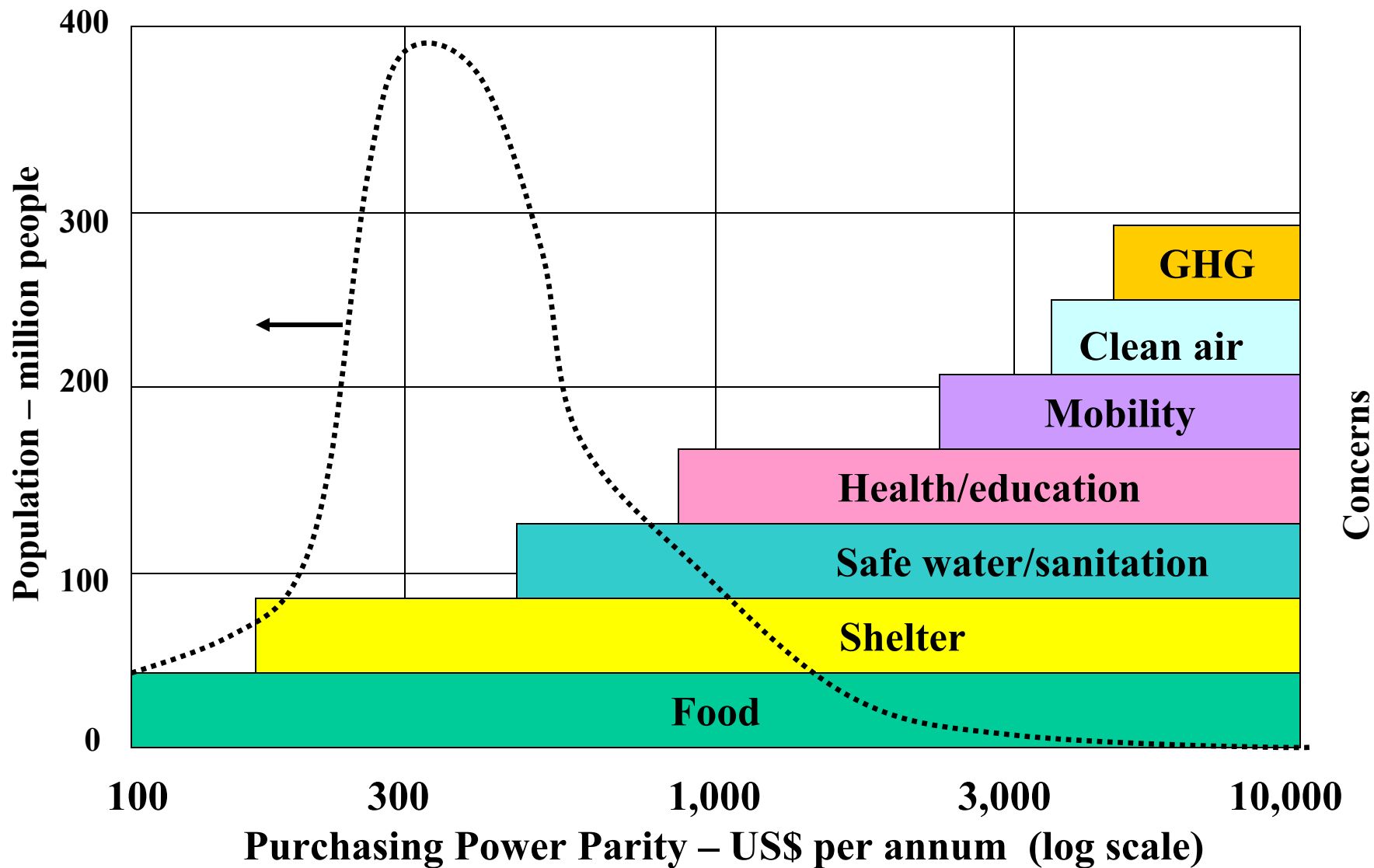
- **Malthus – 1798 – Population grows exponentially; food production grows linearly. Population growth ceases when incremental person doesn't have resources to survive**
- **Hardin – 1968 – Tragedy of the Commons**
- **Ehrlich – 1968 – Overpopulation is the problem, depleting soils and disrupting natural life support ecosystems**
- **Forrester – 1972 – Limits to Growth – potential for disaster within 100 years**
- **Meadows – 1992 – Beyond the Limits – overshoot but human ingenuity could prevent collapse**
- **Cohen – 1995 – How many people can Earth support? (maybe a trillion, more likely around 16 billion)**

# 1999 Per Capita Average Energy Use for Selected Countries

Tons of Oil Equivalent per person per year



# World Income Distribution (1993) and Human Concerns as a function of Income Level

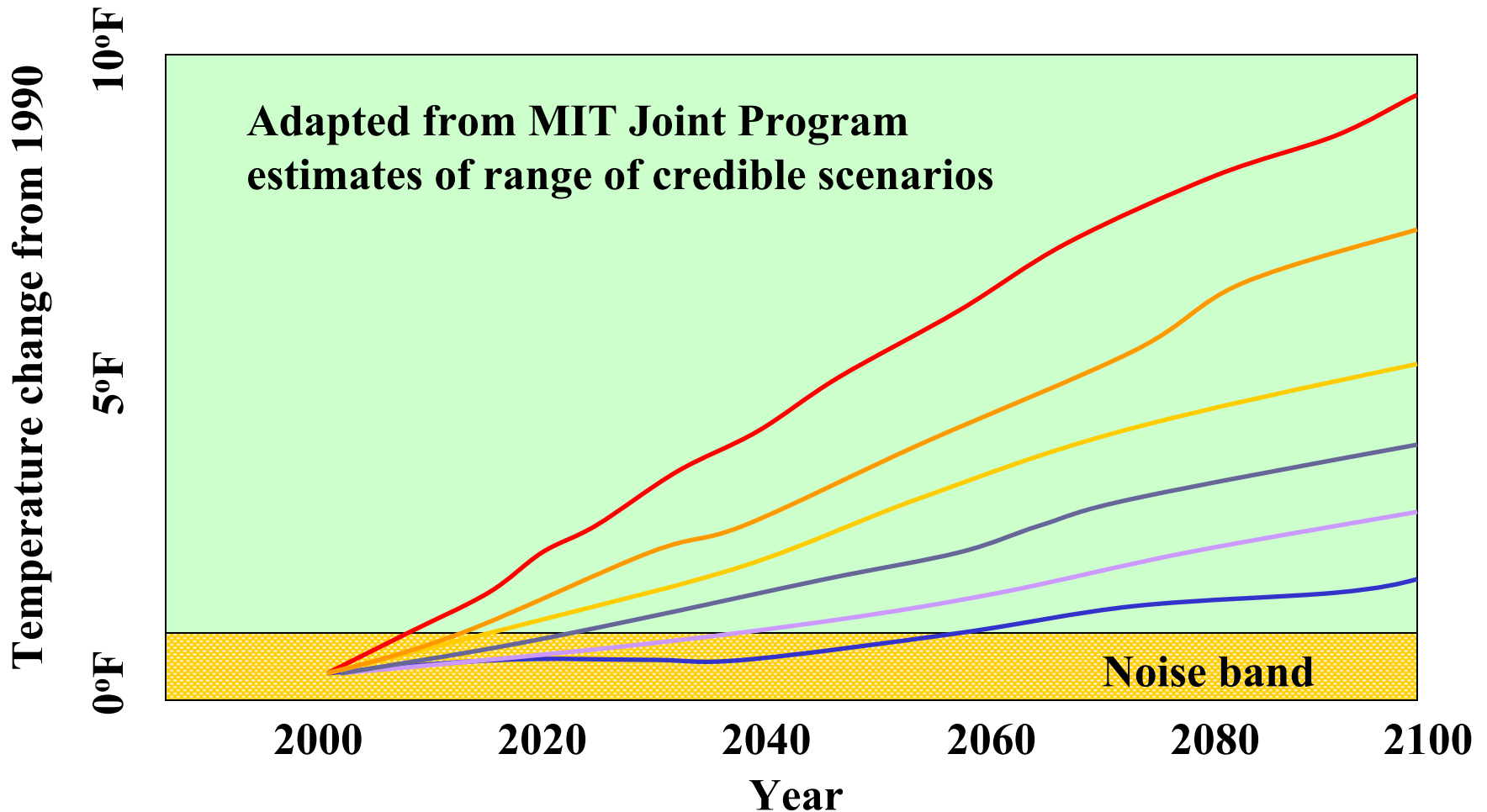


**Percentage shares of world population, world GDP, and world commercial energy consumption for selected countries.**

<b>Country</b>	<b>% of World Population 2001</b>	<b>% of World GDP 2002</b>	<b>% of World Energy Consumption 2002</b>
<b>United States</b>	<b>4.6%</b>	<b>32%</b>	<b>24%</b>
<b>Japan</b>	<b>2.0%</b>	<b>12%</b>	<b>5%</b>
<b>France</b>	<b>0.9%</b>	<b>4%</b>	<b>3%</b>
<b>Germany</b>	<b>1.4%</b>	<b>6%</b>	<b>4%</b>
<b>United Kingdom</b>	<b>1.0%</b>	<b>5%</b>	<b>2%</b>
<b>China</b>	<b>20%</b>	<b>4%</b>	<b>11%</b>
<b>India</b>	<b>17%</b>	<b>2%</b>	<b>4%</b>

# The Greenhouse Gamble

[sample forecasts of future temperature change]



# Carbon emission factors from energy use

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- $CO_2 = Pop \times (GDP/pop) \times (Btu/GDP) \times (CO_2/Btu) - Seq$ 
    - GDP/pop represents standard of living
    - Btu/pop represents energy intensity
    - $CO_2/pop$  represents carbon intensity
    - Seq accounts for sequestered  $CO_2$
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Region	Average Annual Percent Change 1980-1999				
	Population	Standard of Living	Energy Intensity	Carbon Intensity	Carbon Emissions
<b>Africa</b>	2.54%	- 0.58%	0.82%	- 0.01%	2.77%
<b>Australia</b>	1.36%	1.98%	- 0.37%	0.00%	2.98%
<b>Brazil</b>	1.61%	0.76%	1.83%	- 0.80%	3.43%
<b>China</b>	1.37%	8.54%	- 5.22%	- 0.26%	4.00%
<b>East Asia</b>	1.78%	5.00%	0.92%	- 0.70%	7.10%
<b>E. Europe</b>	0.44%	- 1.91%	- 0.14%	- 0.61%	- 2.21%
<b>India</b>	2.04%	3.54%	0.27%	0.03%	5.97%
<b>Japan</b>	0.41%	2.62%	- 0.57%	- 0.96%	1.47%
<b>Middle East</b>	2.98%	0.04%	2.45%	- 1.14%	4.34%
<b>OECD</b>	0.68%	1.73%	- 0.88%	- 0.58%	0.94%
<b>OECD-Eur.</b>	0.53%	1.74%	- 1.00%	- 1.06%	0.18%
<b>United States</b>	0.96%	2.15%	- 1.64%	- 0.21%	1.23%
<b>World</b>	1.60%	1.28%	- 1.12%	- 0.45%	1.30%

# Long-term World Energy Balance

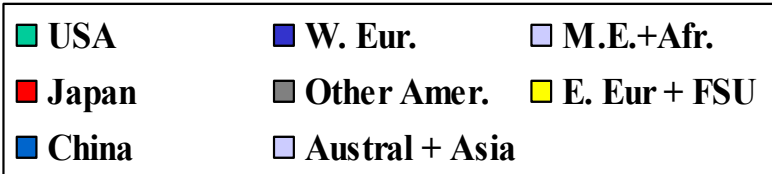
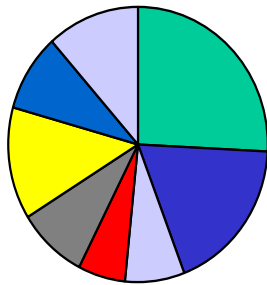
[P-R. Bauquis, *Oil and Gas Journal*, 17/2/03]

Energy Source	2000		2020		2050	
	BTOE	%	BTOE	%	BTOE	%
Oil	3.7	40	5.0	40	3.5	20
Gas	2.1	22	4.0	27	4.5	25
Coal+lignite	2.2	24	3.0	20	4.5	25
<b>Total fossil</b>	<b>8.0</b>	<b>86</b>	<b>12.0</b>	<b>87</b>	<b>12.5</b>	<b>70</b>
Renewables	0.7	7.5	1.0	6.5	1.5	8
Nuclear	0.6	6.5	1.0	6.5	4.0	22
<b>Total commercial energy</b>	<b>9.3</b>	<b>100.0</b>	<b>14.0</b>	<b>100.0</b>	<b>18.0</b>	<b>100</b>

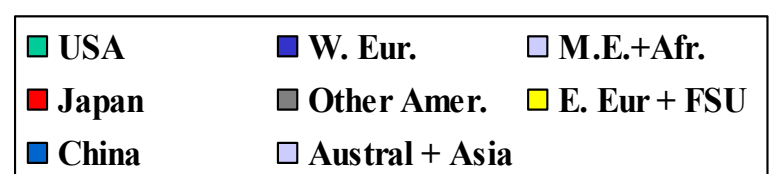
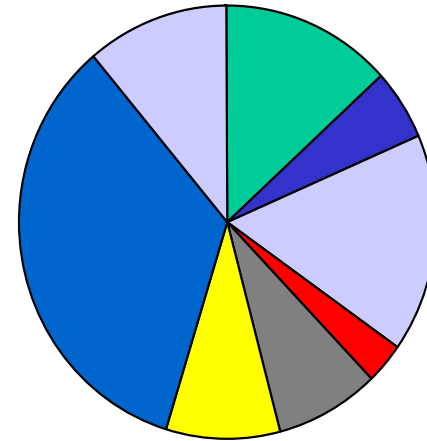
Source: Revue de l'Energie, No. 509. Sept. 1999.

# World Commercial Primary Energy Use – Now and Projected (Edmonds, BAU)

**BP data, 1999,  
8.5 bTOE**



**Edmonds, 2095,  
30+ bTOE?**



# **What is Sustainability?**

- **The ability of humanity to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. [Bruntland, 1987]**
- **Preservation of productive capacity for the foreseeable future. [Solow, 1992]**
- **Biophysical sustainability means maintaining or improving the integrity of the life support system of earth. [Fuwa, 1995]**

# Intergenerational Principles

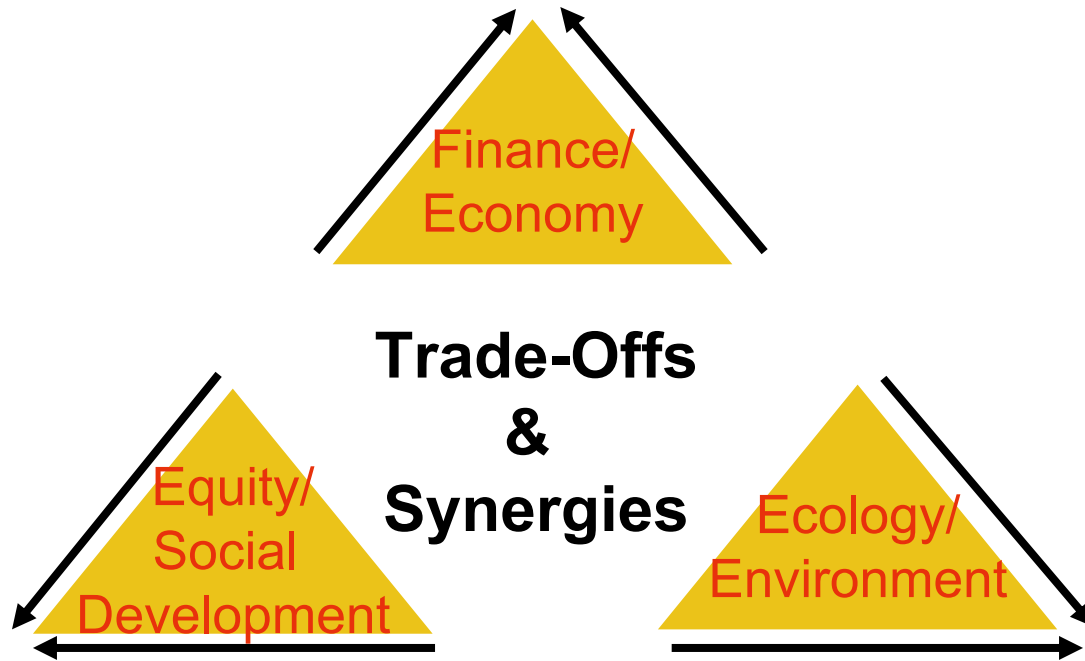
- **Trustee:** Every generation has obligation to protect interests of future generations
- **Chain of obligation:** Primary obligation is to provide for the needs of the living and succeeding generations. Near term concrete hazards have priority over long term hypothetical hazards
- **Precautionary Principle:** Do not pursue actions that pose a realistic threat of irreversible harm or catastrophic consequences unless there is some compelling or countervailing need to benefit either current or future generations

# Sustainability Issues

- **Carrying capacity of earth?**
- **Sustainable economies, societal institutions, and the environment**
- **Ecological footprints for modest European lifestyle are 2.6 hectares or about 6.5 acres per person**
  - **US average = 24 acres per person (8.8 hectares)**
  - **UK average = 5.3 hectares per person (13.3 acres)**
- **Above lifestyle applied to China suggests it could support a sustainable population of 333 million!**  
**[Optimum Population Trust, UK, 1993]**

<b>Some things we might want to sustain</b>		<b>Some trends hindering sustainable living</b>
Our standard of living		Widespread poverty
Our health and well-being		Population growth
Our food and water supply		Unnecessary or excessive consumption
The environment (climate, water quality and availability, diversity of species, natural and recreational spaces, etc.)		Social inequity (including lack of health care, education, and jobs for the poorest, widening gaps between the rich and poor)
Personal freedom		Political self interests and short term focus
International stability		Terrorism, Irresponsible industrialization
A healthy economy		Loss of habitat and species
Opportunities to improve status (individually, as a community, or a nation)		Inadequate institutional systems to manage change
Global communications and mobility		Maldistribution of resources, depletion
Etc.		Etc.

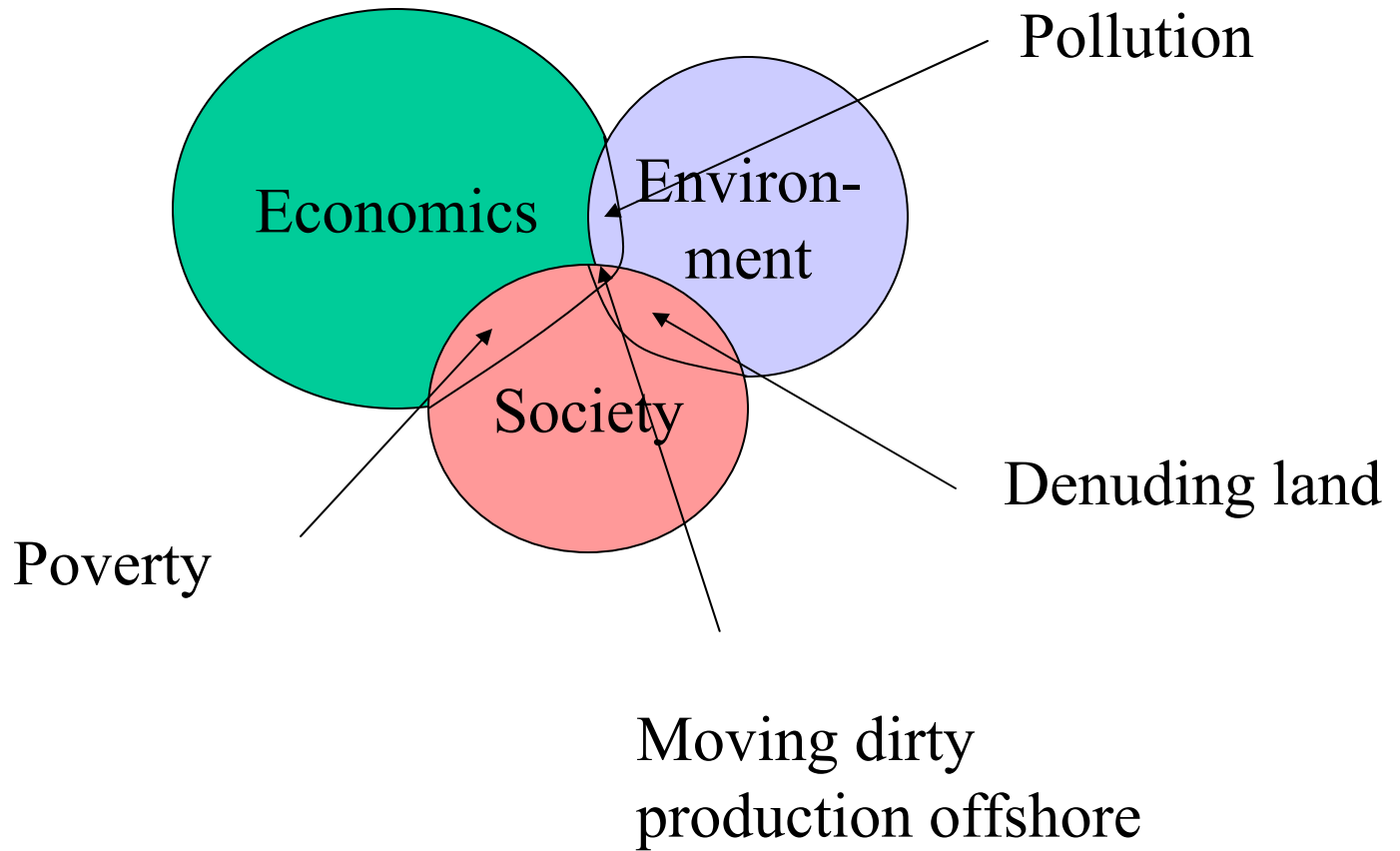
# The Three Dimensions of Sustainability



Derived from World Bank (1996)



# Balancing Issues



# The Challenge

- **If we have to change our energy technologies over a relatively short period of time, where are the best alternatives?**
- **How should we invest in developing better alternatives?**
- **What are the drivers that will encourage timely development and market penetration of these technologies?**
- **Do we also have to change behaviors?**

# Climate Change: How Far and How Fast?

- Gaming – Wait for the “other guy:”
  - Developed countries go first
  - Each country wishes to preserve or improve economic status
  - US administration backs away from the Kyoto protocol and looks to a variety of voluntary initiatives
- Result – INACTION!
- BUT: Evidence of climate change is increasing and public awareness is rising, even in the US

# Poverty: How Far and How Fast?

- **Selfishness and denial**
  - **Developed world – view that poverty is self-inflicted, limited social services aimed at reacting to problems rather than to correcting them, unwillingness to share enough domestically, much less internationally**
  - **Developing countries – graft and corruption, acceptance of large inequities, inadequate resources (human and financial) for much change, anger at the “haves” – who are more visible thanks to modern communications**

# Consequences of Inaction

- **Poverty**
  - **Subhuman living conditions for many; ill-health, addiction, crime, terrorism, mass migration, wars, etc.**
  - **Loss of human capital and environmental degradation**
- **Climate change**
  - **Shifting regional weather patterns impacting agriculture, water, storms, floods, etc.**
  - **Most impact on the poor – wealthy countries can better afford mitigation**

# Some considerations...

- There is no right or wrong – it is a matter of balance
- Each one may contribute in a different way
- Selfishness and materialism are OK in moderation, but may block other rewarding human values like feeling part of a community, self respect, love, and compassion
- We can only control our behavior – not other people's (Though it is possible to be an example)

# Barriers to Change

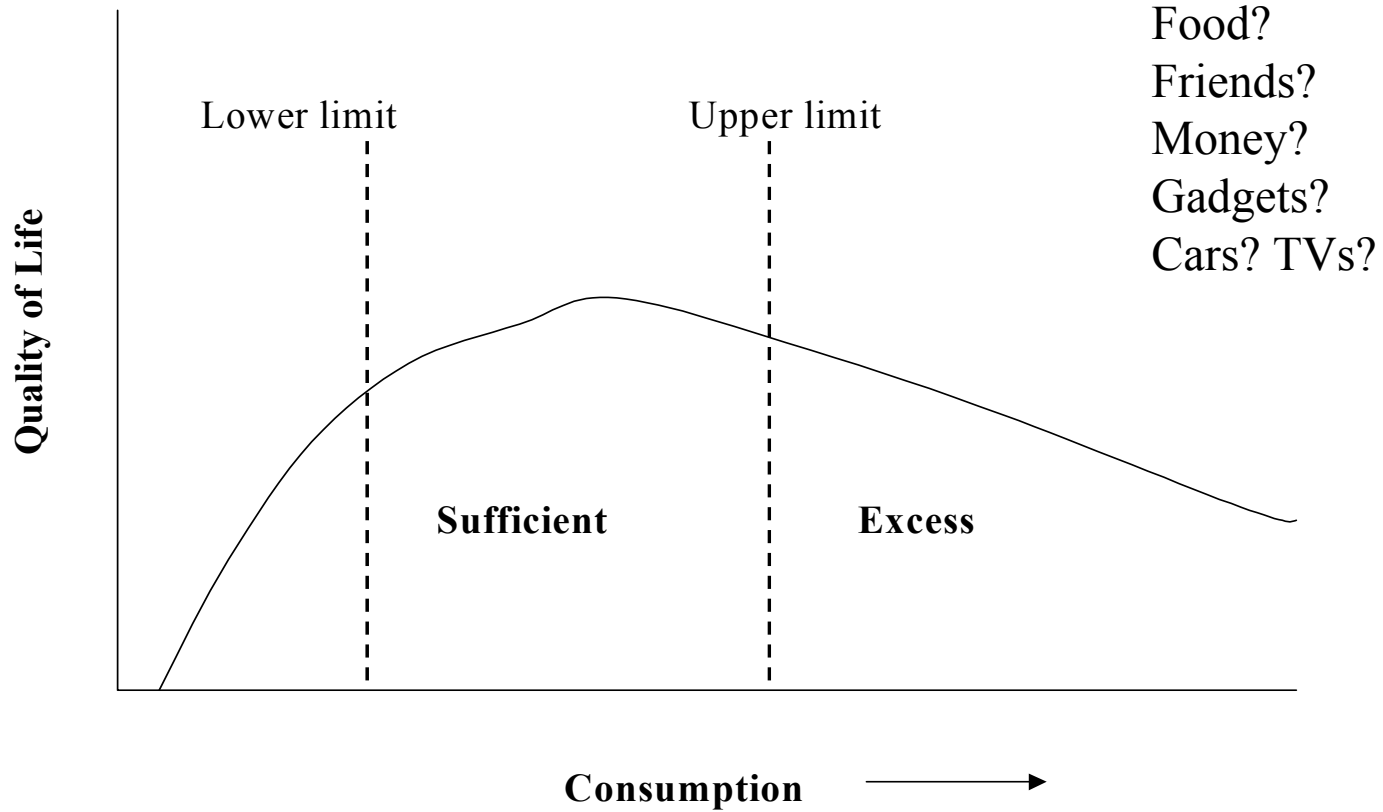
- Money, health and intelligence
  - “Haves” – we want even more, we want to be better than our peers, and to not see poverty
  - “Have-nots” – we want all this, but it seems out of our realm of possibility – others have made the rules and we cannot win - we resent or hate them, though we may pity them as human beings – we would love to take what they have!

# Rewards of Action

- Perhaps a better quality of life with enough to meet our needs – not our wants!
- A different business paradigm – not mass production, but life cycle service production with careful regard for externalities
- Greatly reduced social inequity and improved societal stability
- Appreciation and care for nature and diversity, both human and environmental



# Thring's model



# What can we do?

- In choosing careers?
- In our professional lives?
- As private citizens?
- As national citizens?
- As global citizens?

*How much are we willing to do?*