Energy, Economic Development, and the Environment

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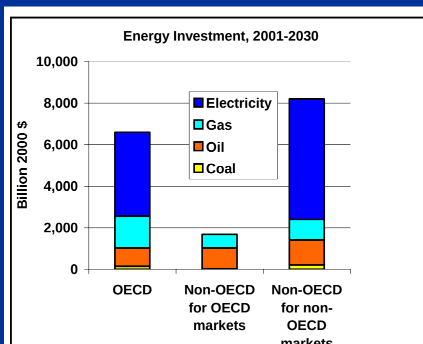
Energy Investment, 2001 – 2030 and policy

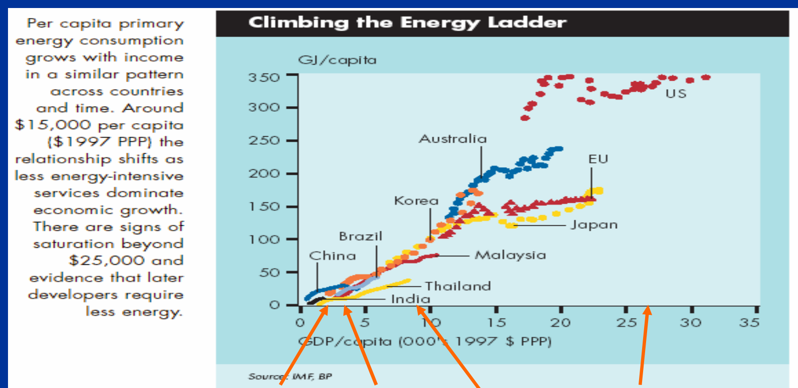
- In the OECD - $6.6 T
  - Oil and gas -$2.4 T (access, taxation, liability)
  - Electricity - $4.0 T (market structure)
- To the OECD - $1.7 T
  - Oil and gas (economic development in exporters)
- Developing/transition - $8.2 T
  - Oil and gas - $2.2 T
  - Electricity - $5.8 T
  - $250 B/y compared with current FDI of $ 50B/y



Coal	147	31	220	398
Oil	892	1,001	1,203	3,096
Gas	1,523	646	976	3,145
Electricity	4,036		5,806	9,842
TOTAL	6,598	1,678	8,205	16,481

IEA: World Energy Investment Outlook, 2003

Development & energy consumption



Income (k$/y PPP)	2.0	4.5	9.0	27
Income share	10%	20%	15%	55%
Population share	40%	35%	10%	15%

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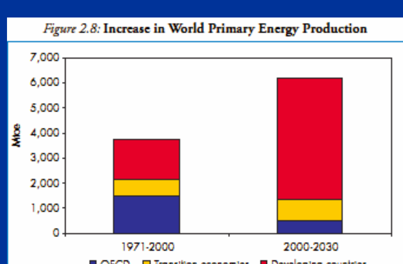
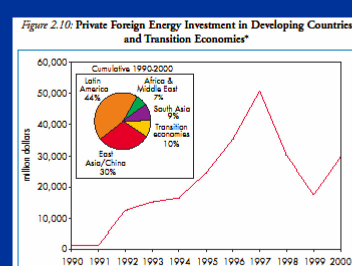
Developing country emphasis





- **Developing and transition world is the market for new energy business**
  - 80% of new energy supply in developing and transition economies
- **Investment**
  - Non-OECD requires ~ $8 trillion over next 30 years or $250billion/y
  - Foreign direct investment growing, currently at $30 billion/y

Key energy policy issue -- current governance, business, finance, and market structures cannot support this energy forecast

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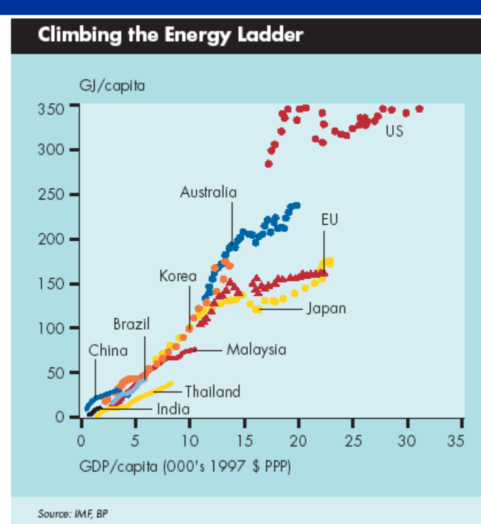
Roadmap

- Energy's next 30 years –
  demand – economic growth
  transportation and electricity
  supply – mostly conventional
- Security –
  oil market dependence and international security
  are beyond energy policy
- Economic development
- Environment - over the next 100 years,
- what's scarce is environment, not energy resources

GDP and energy consumption

Per capita primary energy consumption grows with income in a similar pattern across countries and time. Around $15,000 per capita ($1997 PPP) the relationship shifts as less energy-intensive services dominate economic growth. There are signs of saturation beyond $25,000 and evidence that later developers require less energy.



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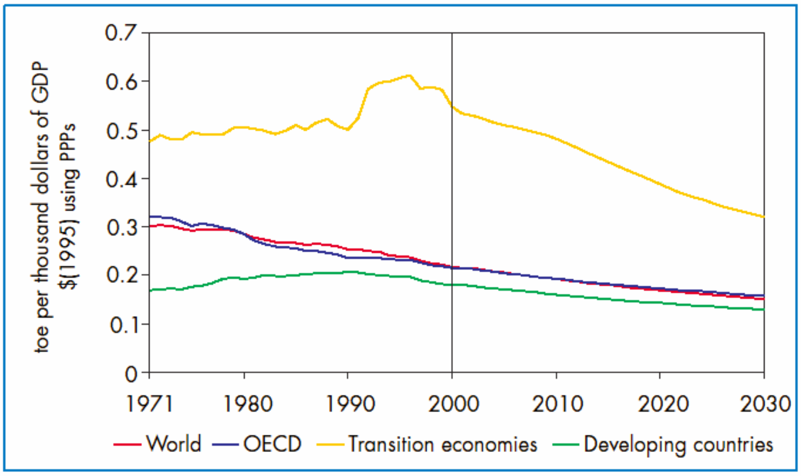
Energy “Intensity” continues to fall

Figure 2.5: **Primary Energy Intensity by Region**



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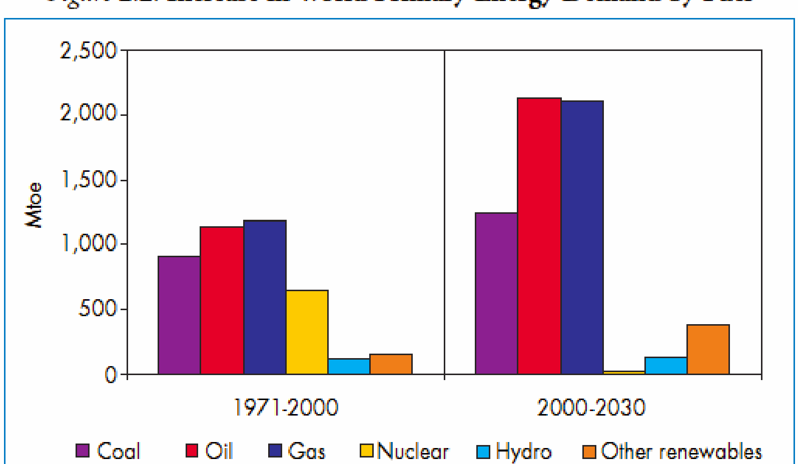
But demand grows -- mostly fossil fuels

Figure 2.2: **Increase in World Primary Energy Demand by Fuel**



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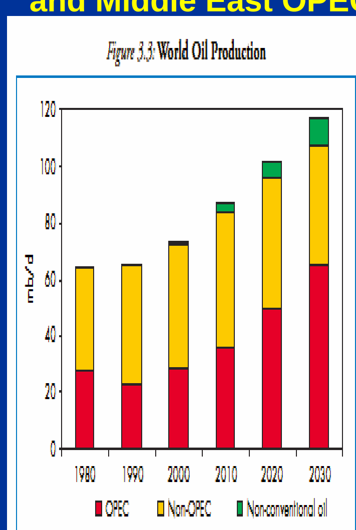
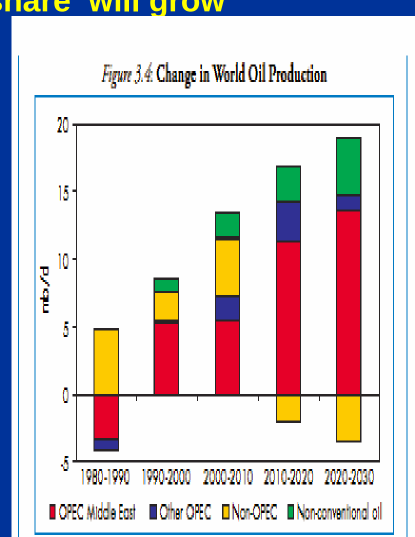
Renewables (non-hydro) – 4% share by 2030

- Wind to electricity – now economic but limited (North Sea, Cape Cod)
  - When the wind blow half the time the cost doubles
- Solar thermal – not economic w/out subsidies, needs maintenance
- Solar photovoltaic
  - 30 c/ kWh peak power = $1.00 average power + batteries where it is sunny
  - Compared to 8 to 12 c/kWh delivered by efficient power grids
- Hydrogen – not an energy source (no hydrogen wells)
  - Conversion technology raises efficiency
- Nevertheless – need research and subsidy
  - Learning
  - Leaning by doing
  - Returns to scale
  - Need better markets, esp in electricity, but also in buildings and transportation

Oil security --Total World Oil Volume and Middle East OPEC share will grow





International Energy Agency, World Energy Outlook, 2002

Security -- conclusion

- Growth of Middle East OPEC required production of 5 – 12 Mbd
- Could be reduced by extreme measures
  - Double US MPG standard   2 – 4 Mbd for a long time
  - Drill Alaskan Wildlife reserve   1 – 2 Mbd for a short time
- Dependence can't be eliminated
- Geopolitics of ME OPEC – Saudi Arabia, Iraq, Kuwait, UAE can't be "starved out"
- International security issues are political
  though potentiated by oil revenues
  and are here to stay
- Note on Iraq (recovery to 3 Mbd is ~$25 billion per year, about ½ of what were are spending)

Population and Income -- 2000

	Population (millions)	Per Capita Income (US$) (trade value)	Per Capita Income (US$) (PPP)	Share of Total Population	Share of Total Income (Trade Value)	Share of Total Income (PPP)
Income group						
Low	2,500	420	2,000	41%	3%	11%
Lower middle	2,050	1,140	4,580	34%	8%	21%
Upper middle	650	4,620	9,170	11%	10%	13%
High	900	27,510	27,450	15%	79%	55%
Total	**6,100**	**5,106**	**7,386**	**100%**	**100%**	**100%**
Regional - low middle						
East Asia & Pacific	1,850	1,060	4,120	30%	6%	17%
Europe and Central Asia	480	2,010	6,620	8%	3%	7%
Latin America & Carib.	520	3,680	7,030	9%	6%	8%
ME and North Africa	300	2,040	5,170	5%	2%	3%
South Asia	1,360	460	2,260	22%	2%	7%
Sub-saharan Africa	660	480	1,560	11%	1%	2%
	5,170	**1,237**	**3,890**	**85%**	**21%**	**45%**
High	**900**	**27,510**	**27,450**	**15%**	**79%**	**55%**

- 4.5 million (75%) people below $6,000 per capita (PPP)
- South Asia and sub-Saharan Africa very poor

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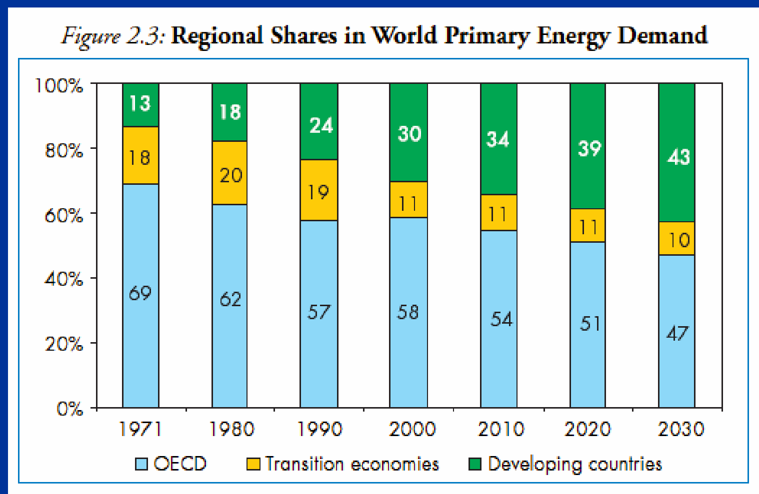
Developing world is in the high elasticity part of the energy-GDP curve



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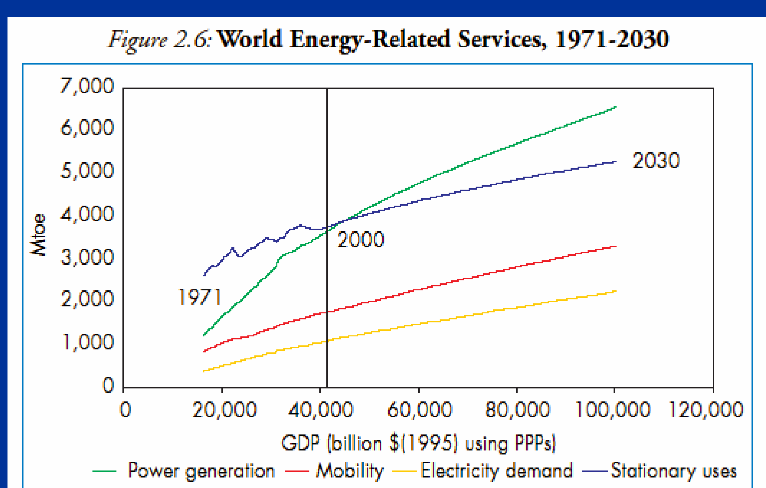
Energy services vs income
-- transportation and electricity are the big pieces



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What to do?

- 2.5 billion very poorest
  - need reliable electricity connection
  - Need cooking fuel for health and women's empowerment
  - Consumption is so small that key must be cost not environment
  - Better grid electricity is often the answer – efficiency, maintenance, quality, cost

  Can't solve the environment problem on the backs of the poor

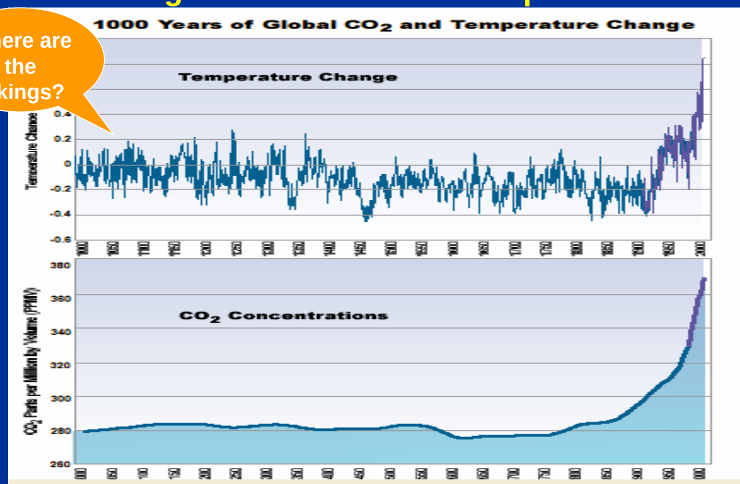
- The rest can participate in global market solutions to environmental problems if we find the way

Environment -- Global warming linkages

Energy consumption => more CO2 (anthropogenic CO2)	***No doubt, about 80% of greenhouse gases***
Atmospheric CO2 has risen	***No doubt***
Current temperatures are at unprecedented highs	***Huge controversy***
Anthropogenic CO2 causes warming	***Huge controversy***
Warming causes economic damage	***Mixed effects (see Russia pullout)***
Kyoto will fix the problem	***No***

Global Warming and CO2 – "scientific proof!"

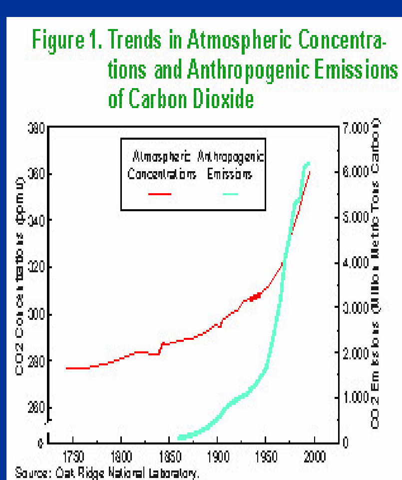
Where are the Vikings?



Climate Change Impacts in the United States, *The Potential Consequences of Climate Variability and Change, National Assessment Synthesis Team, US Global Change Research Program, Published in 2000*

Problem

- No doubt about the CO2 data



- Big doubt about the temperature data McIntyre-McKitric at http://www.multi-science.co.uk/mcintyre_02.pdf

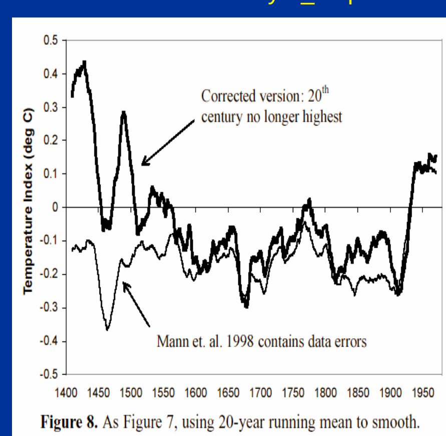
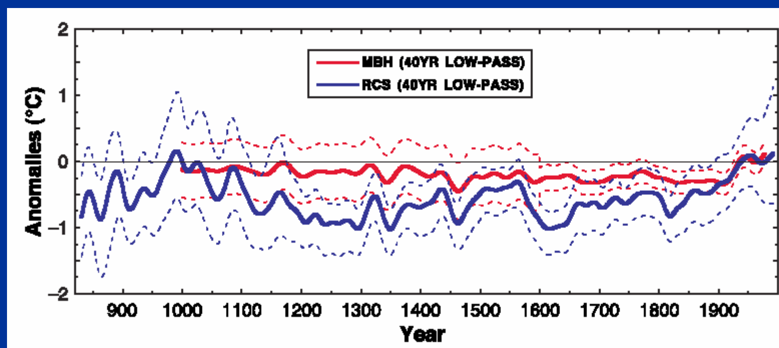


Figure 8. As Figure 7, using 20-year running mean to smooth.

Current temperatures not unprecedented when data and method corrected



Low-Frequency Signals in Long Tree-Ring Chronologies for Reconstructing Past Temperature Variability, Jan Esper, Edward R. Cook, Fritz H. Schweingruber, 22 MARCH 2002 VOL 295 SCIENCE

Revised data challenges

- Damage
  - Medieval warm period was a good time
- CO2 linkage
  - Can't explain last 1000 years
  - Can't explain the fact that the big rise from 1850 to 190 was before the big rise in CO2
- Current temperature data controversial
  - Land station rise not consistent with 1970+ satellite data

Nevertheless, the long – run problem is real – cumulated emissions

- From 1850 to 2000
  - CO_2 concentration – 280 ppm to 370 ppm
  - Atmospheric CO_2 – 560 Gt to 740 Gt (billion tons)
- Notional target – 550 ppm or 1100 Gt (we are 1/3 of the way)
  - Note most emissions from developed countries (about 1/6 of population)
  - Developing world's point – we have used up our share
- Current emissions 6 Gt of which the US is 25% (with 4% of population)
- Rate will double in 40 years
- Long-run problem about 3,000 billion tons of oil gas and coal in the service of the earth, 2/3 will be atmospheric
  - Will triple atmospheric concentration
  - Increase increment form 1850 by factor of 10

Kyoto targets / problems

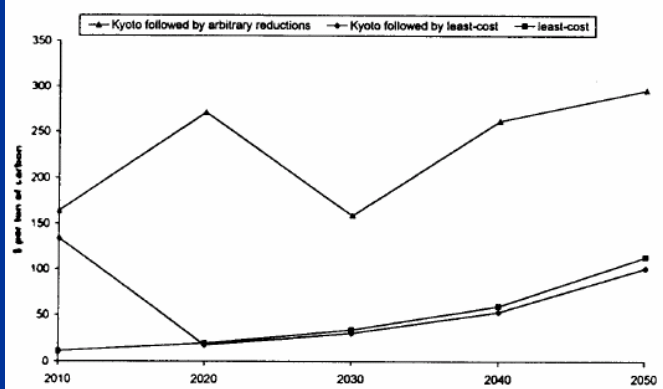
Kyoto Targets

(MtC)	1990	2000	Proj 2010	Kyoto Target 2010	Kyoto Target Decrease	Reduction from 1990
US	1348	1571	1810	1254	556	7%
Japan	272	314	367	256	111	6%
W. Europe	904	918	1071	832	239	8%
Canada	117	158	168	110	58	6%
Australia	62	97	87	67	20	-8%
FSU	996	709	781	996	-215	0%
E Europe	290	175	278	270	8	7%
Annex I	3989	3942	4562	3989	573	
Non-Annex I	1481	2501	2880			
Total	5470	6443	7442	6869	573	

- Participation = OECD + FSU+EEU
- FSU negative limit means tradable "hot air"
- Without US, and non-annex I, no scarcity

Kyoto targets are way too soon – problem is next generation of facilities

Figure 10. Incremental Value of Carbon Emission Rights Under Three Alternative Emission Pathways for Stabilizing Concentrations at 550 ppmv - Global Trading



From Manne-Richels MERGE model
Energy Journal, special issue on Kyoto

Kyoto problem

- Deep vs wide
- Needed to establish participation and measurement
- Too quick for turnover existing stock
- Cost of getting FSU in at 0% emissions suggests that no way to get non-Annex I countries in with effective emissions control
- “Got to start somewhere?”
- US pretty clearly won’t go near this until after at least 2008
- Alternative -- national programs and taxes?
- Carbon sequestration?