

The Actuarial Profession

making financial sense of the future



Society of Actuaries of Ireland
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Resource and Environmental Limits to Economic Growth

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Resource and Environmental Limits to Economic Growth

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- Chair of the IAA Environment Working Group (EWG)



Resource and Environmental Limits to Economic Growth

1. **Introduction: we live in an exponential world**
2. Resource and environmental limits?
3. A systems view: economic growth in perspective
4. Can technology solve our problems?
5. Questioning GDP growth
6. Implications for the financial system?
7. Actuaries and sustainability

1. We live in an exponential world

Exponential growth

Well known rule of thumb for doubling time

- Approx. doubling time = $70 / (\text{Growth Rate in \%})$
Reason: $70 \approx 100 * \ln(2)$
- E.g. 3% p.a. growth means doubling time of $70/3 = 23$ years

“The greatest shortcoming of the human race is our inability to understand the exponential function”

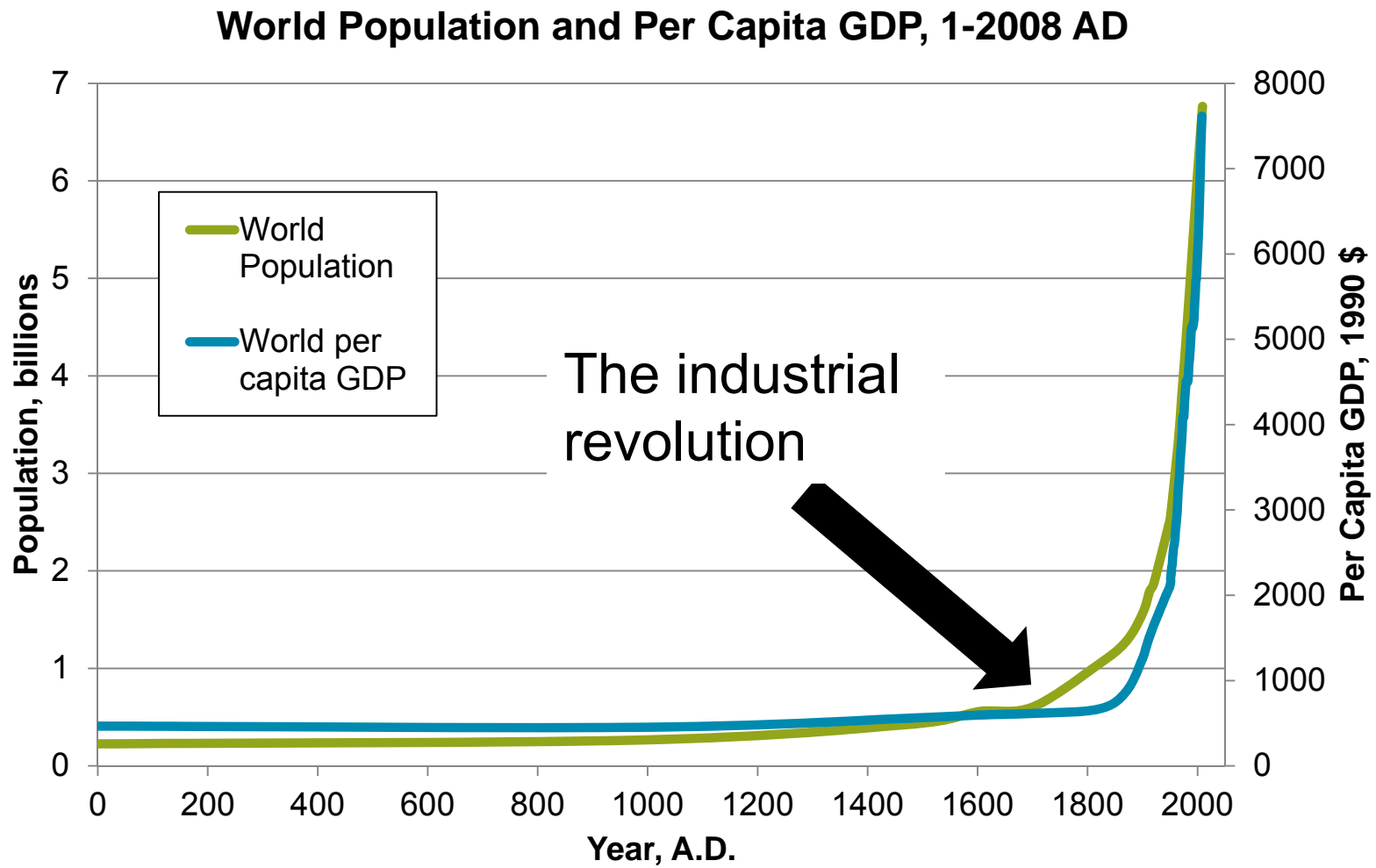
– Professor Albert Bartlett, Colorado University

Source: <http://www.albartlett.org>

There is a great presentation about exponential growth at this web address.

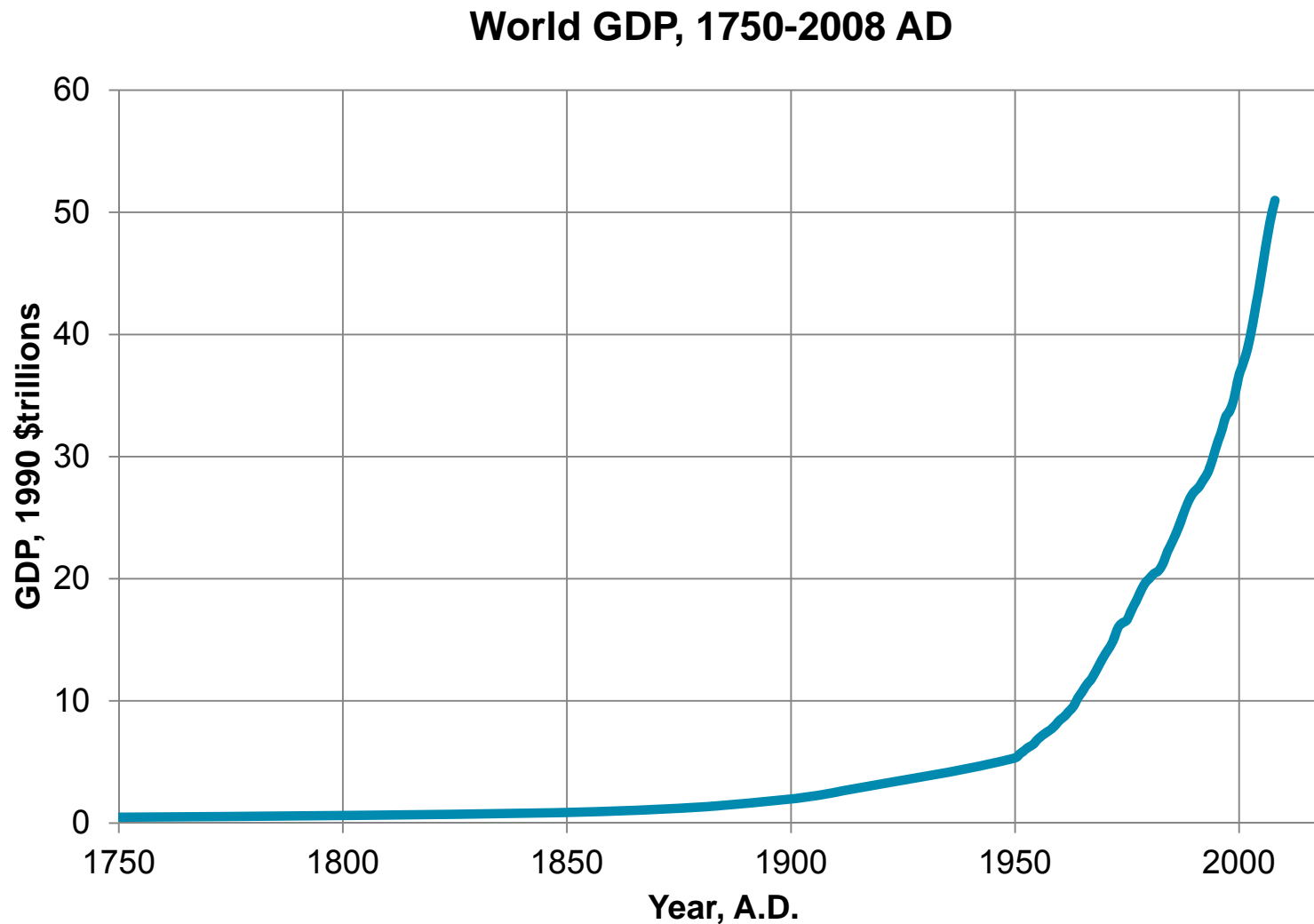
1. We live in an exponential world

A long term view of growth



1. We live in an exponential world

World GDP, 1750-2008 AD



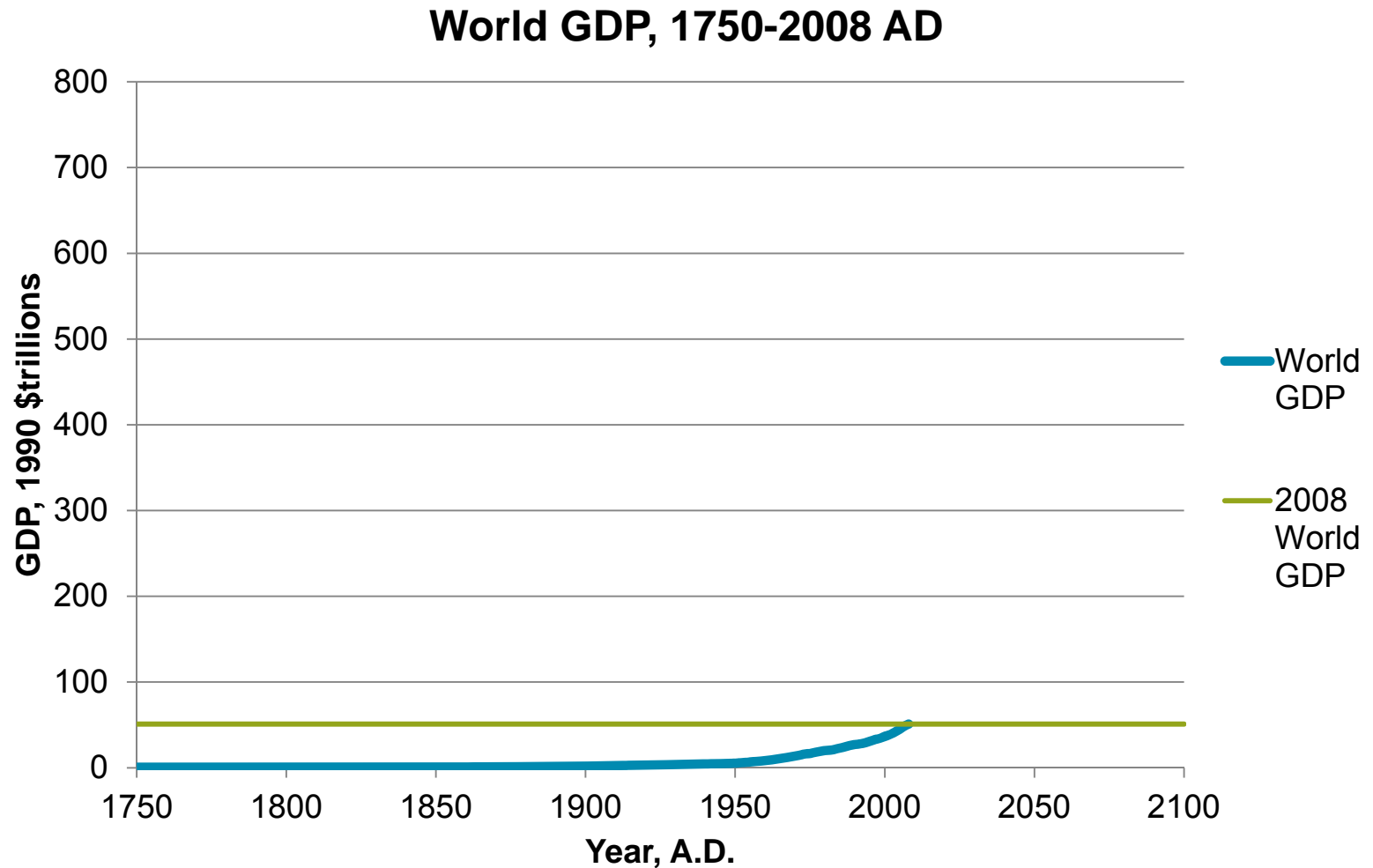
1. We live in an exponential world

Future world GDP growth: the conventional view

- In real terms world GDP has grown at average rate of c.3% per year in recent decades = doubling time 23 years.
- 2012 to 2100 is almost 4 doubling periods.
- If 3% growth continues, world economy would grow 14 times as large in 2100 as it is now.

1. We live in an exponential world

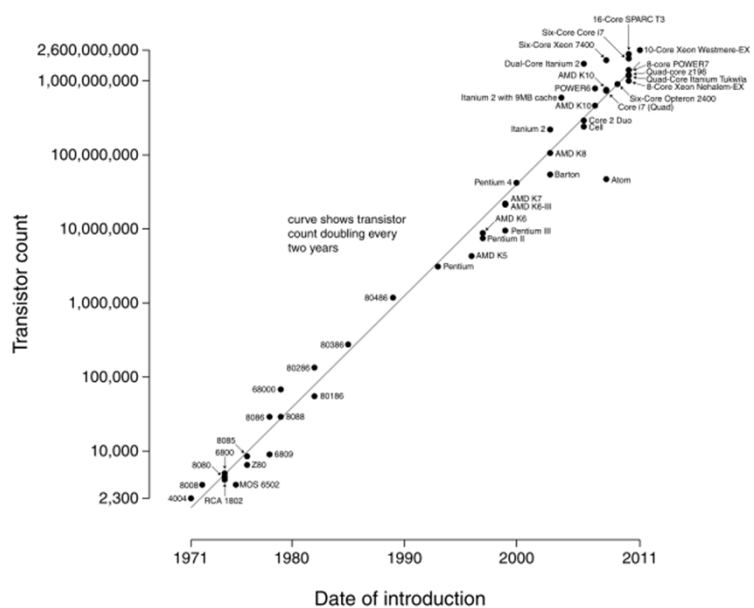
Hypothetical projected World GDP 1750-2100 AD



1. We live in an exponential world

Growth of "goods" e.g. Technology and knowledge

Microprocessor Transistor Counts 1971-2011 & Moore's Law

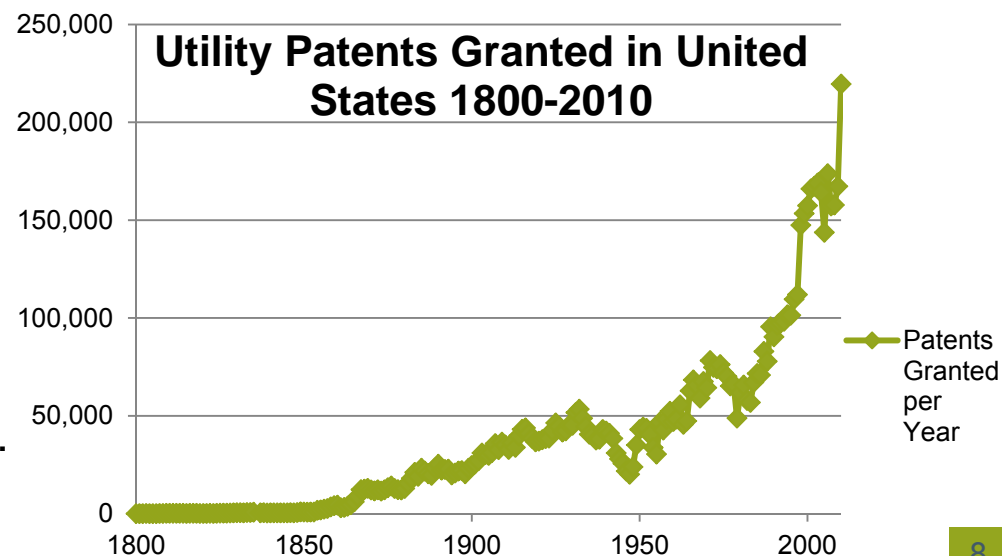


Moore's Law

The number of transistors that can be placed inexpensively on an integrated circuit doubles approximately every two years.

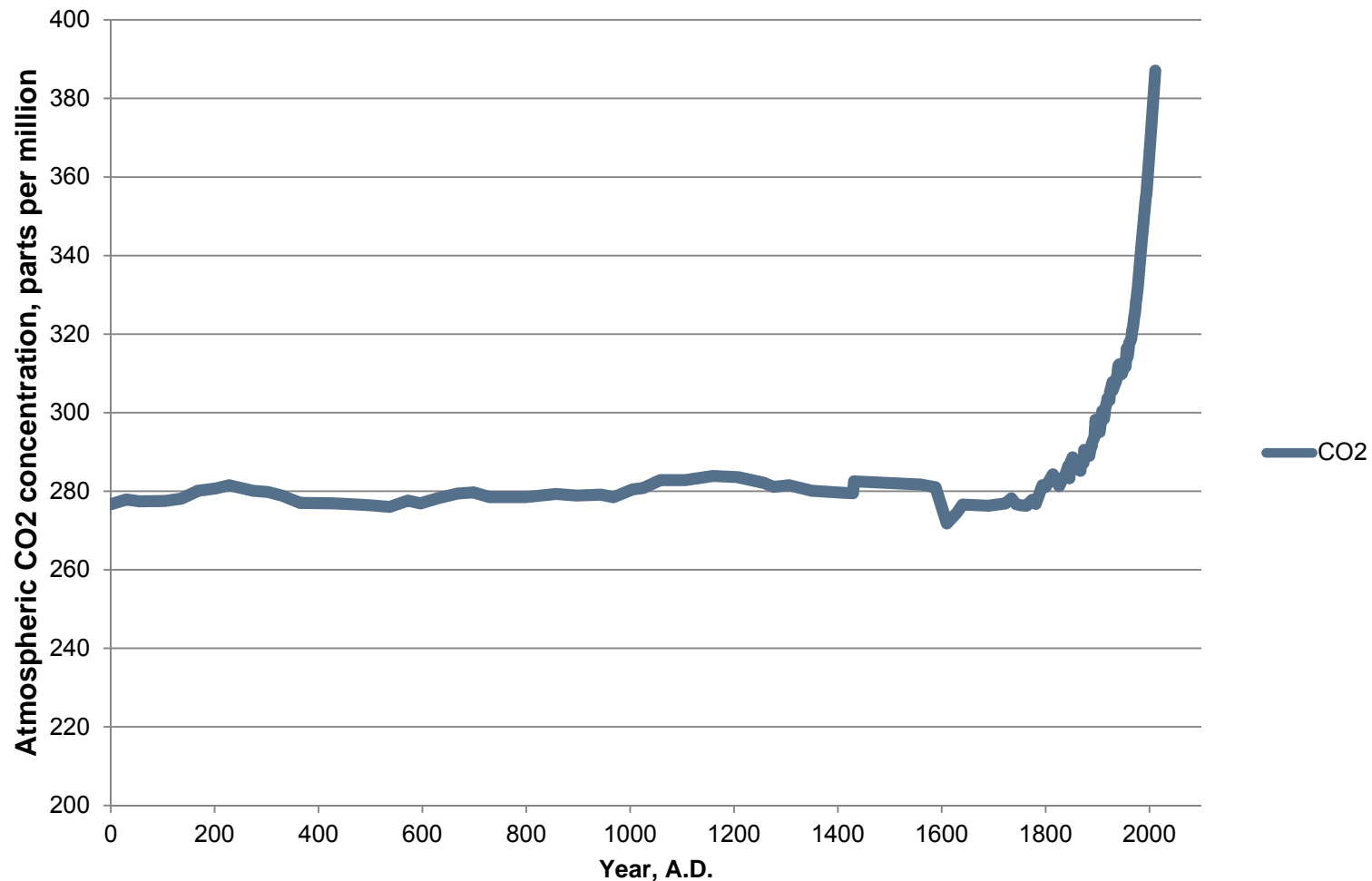
Intellectual Property

No. of patents granted illustrates the explosive growth in human knowledge.



1. We live in an exponential world

Growth of “bads” e.g. Atmospheric carbon dioxide



Source: Scripps Institution of Oceanography (SIO) CO2 Program <http://scrippsco2.ucsd.edu> R. F. Keeling, S. C. Piper, A. F. Bollenbacher and S. J. Walker

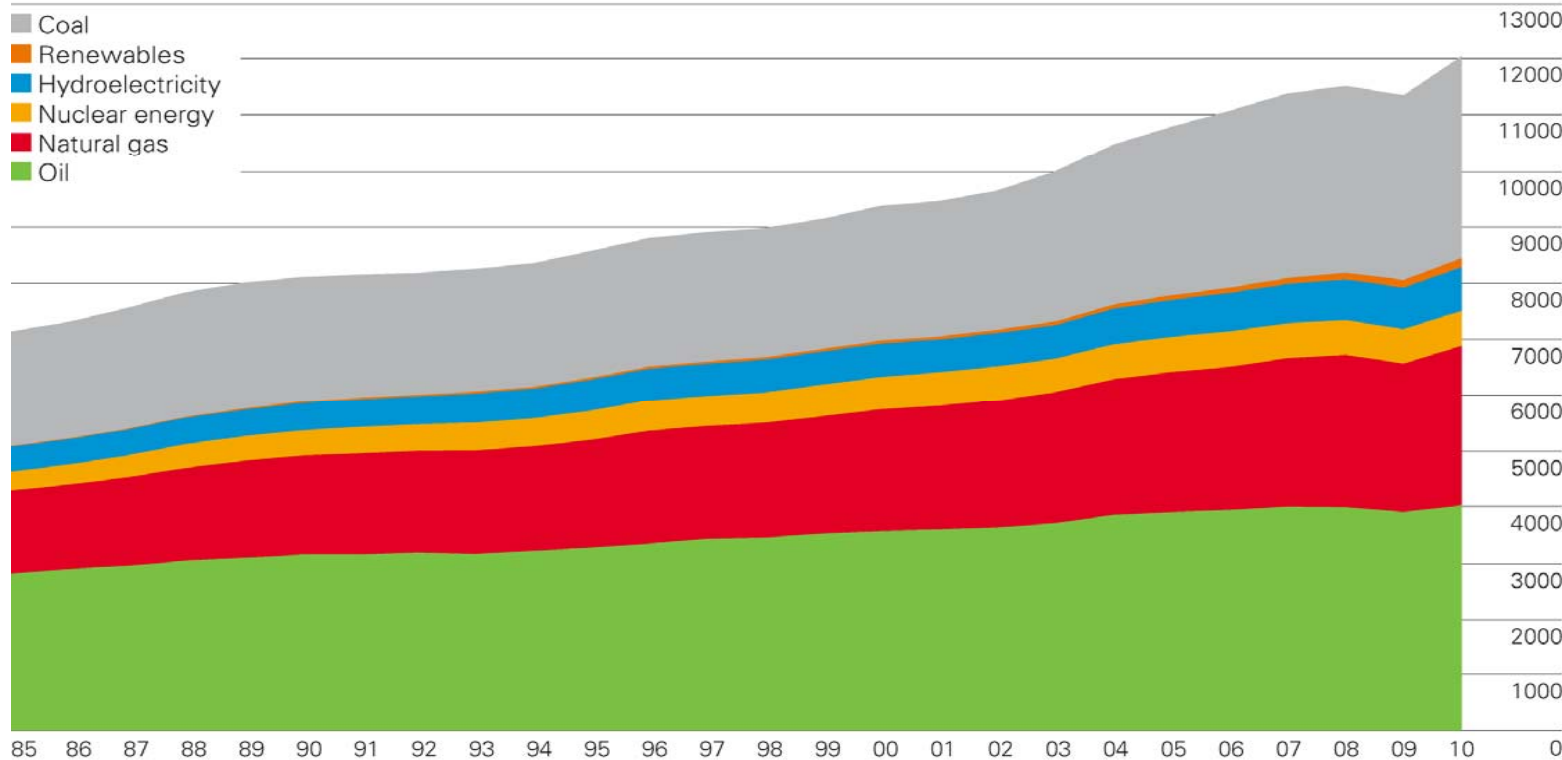
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2. Limits to growth? Energy

Oil is our most important energy source

World consumption
Million tonnes oil equivalent



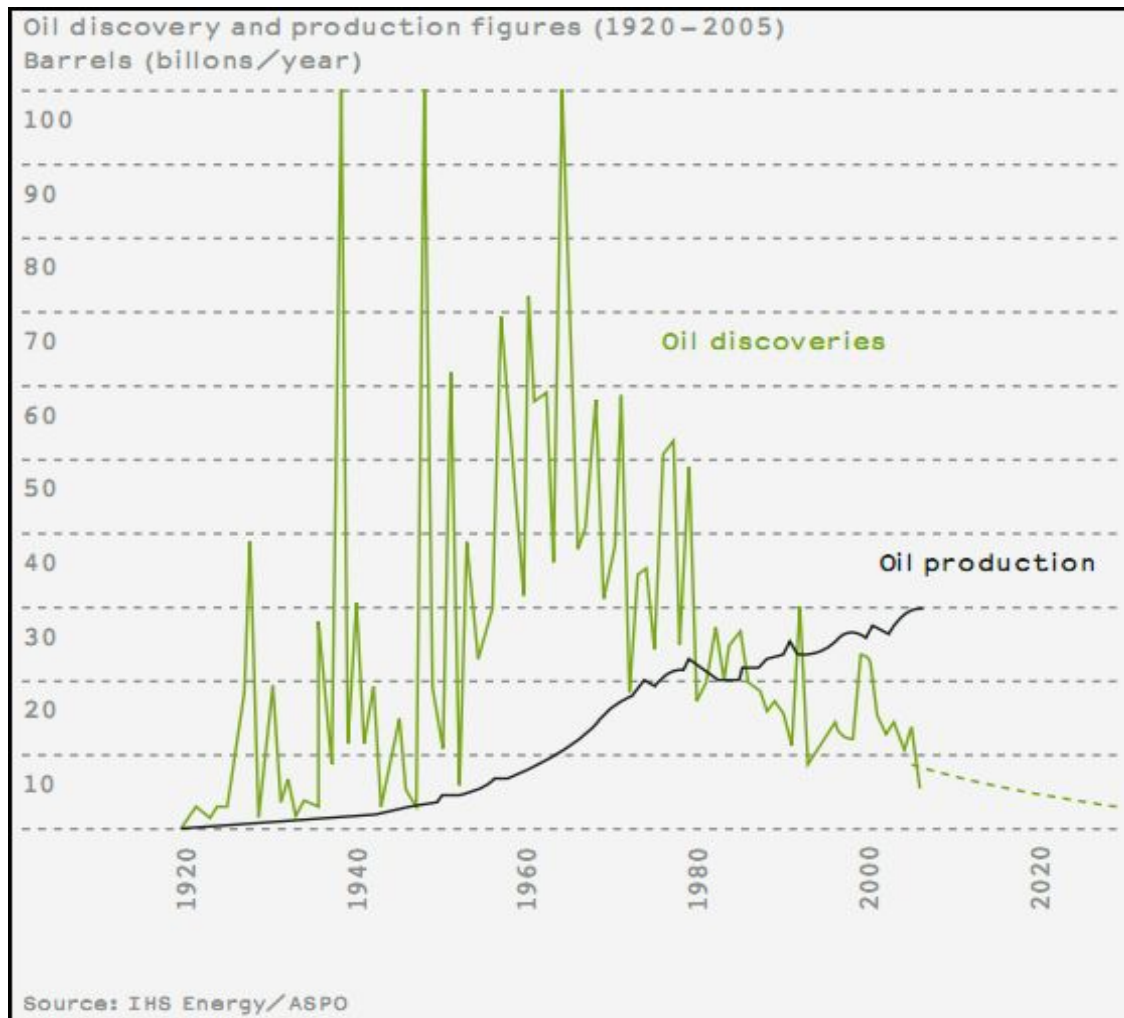
World primary energy consumption grew by 5.6% in 2010, the strongest growth since 1973. Growth was above average for oil, natural gas, coal, nuclear, hydroelectricity, as well as for renewables in power generation. Oil remains the dominant fuel (33.6% of the global total) but has lost share for 11 consecutive years. The share of coal in total energy consumption continues to rise, and the share of natural gas was the highest on record.

- Our industrial civilization uses about 13 Tera Watts for machinery.
- Estimated net primary productivity of Earth's ecosystems $\approx 70\text{TW}$ on land.

Source: BP Statistical Review of World Energy 2011

2. Limits to growth? Energy

Oil discoveries versus oil production



“Discoveries of new deposits peaked as far back as the 1960s and 1970s. Now a number of countries in addition to the UK and the USA, for instance, have reached their production limits. The quantity of oil being pumped out of the earth exceeds new discoveries.”

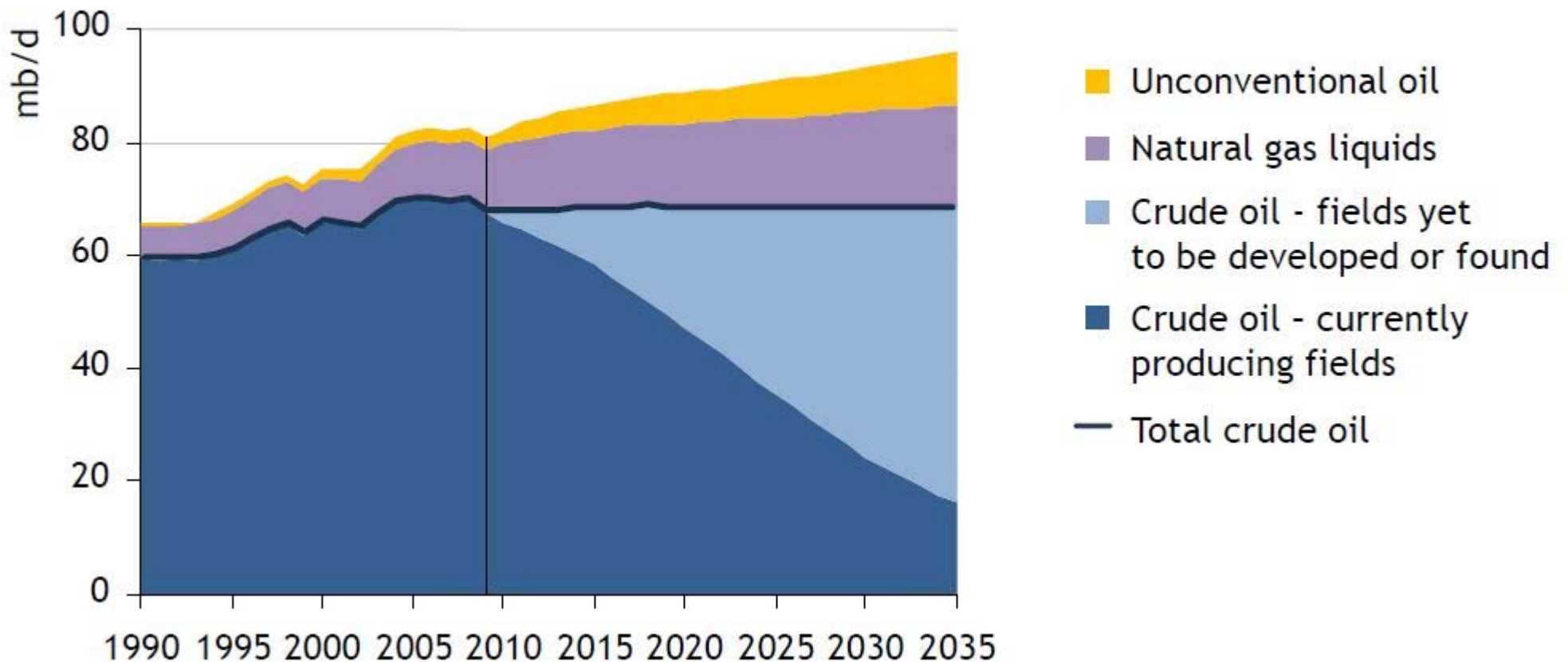
Source: Munich Re Foundation 2009 Report page 28

http://www.munichre-foundation.org/StiftungsWebsite/Publications/2009report_Publication_summary.htm

2. Limits to growth? Energy

International Energy Agency World Energy Outlook

World oil production by type in the New Policies Scenario

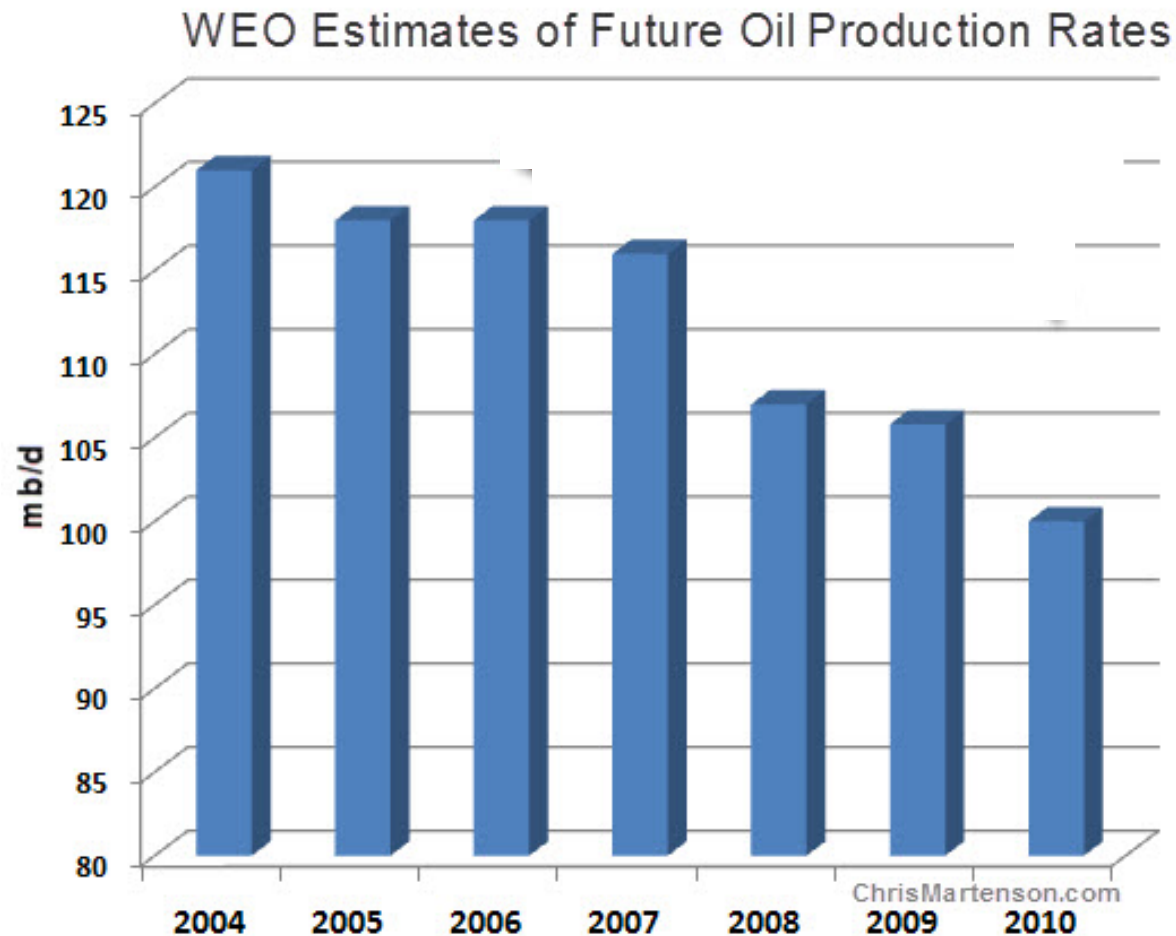


Source: Lecture Fatih Birol, Chief Economist of the International Energy Agency, at Imperial College, 18 January 2011

http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/naturalsciences/climatechange/newssummary/news_20-1-2011-13-4-51

2. Limits to growth? Energy

IEA: WEO forecasts in years 2004-2010



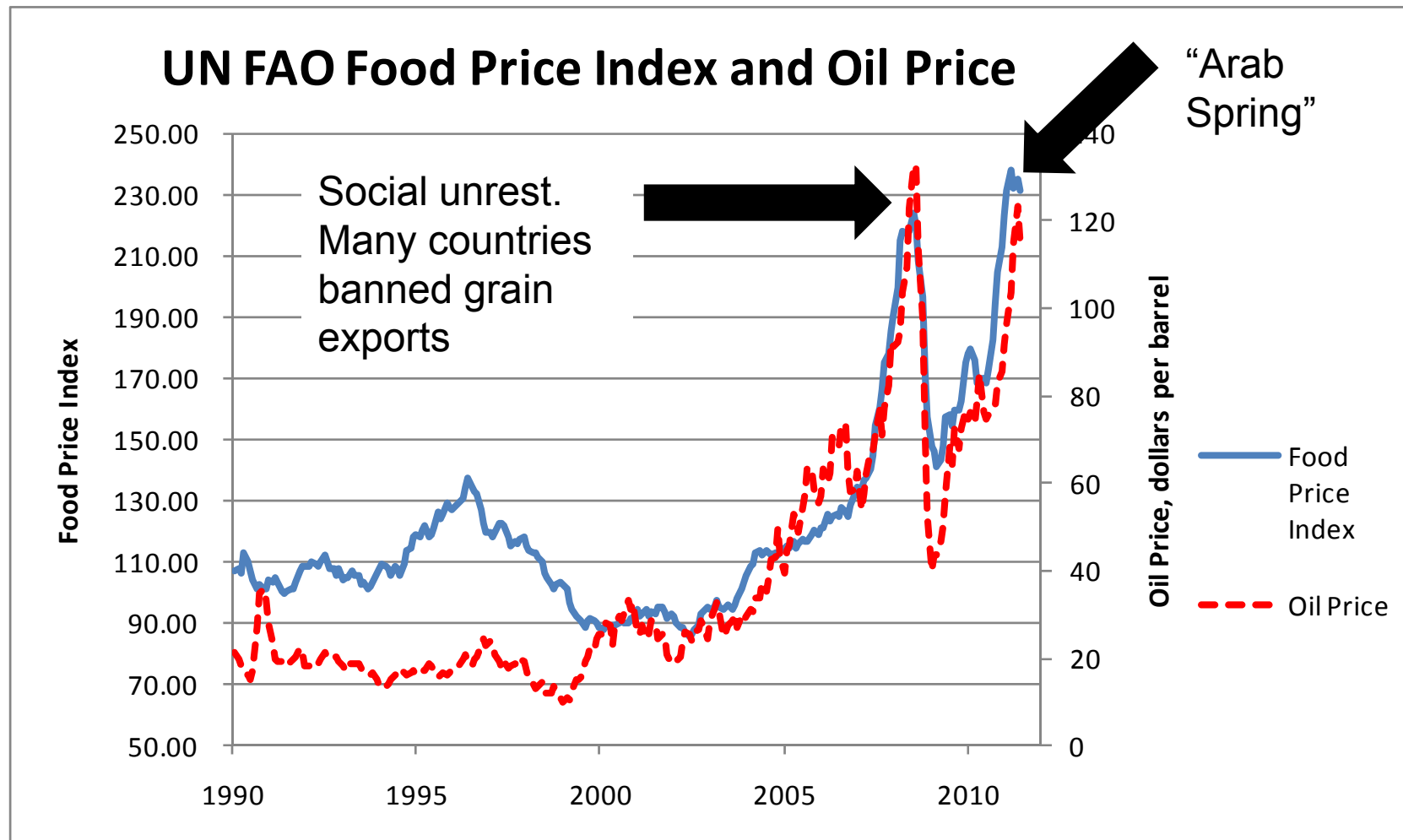
In the 2004 WEO forecast of oil price until 2030:

- Baseline forecast was \$25 a barrel.
- “High” scenario was \$35 a barrel.

Source: Chris Martenson summary of IEA WEOs <http://www.chrismartenson.com/>

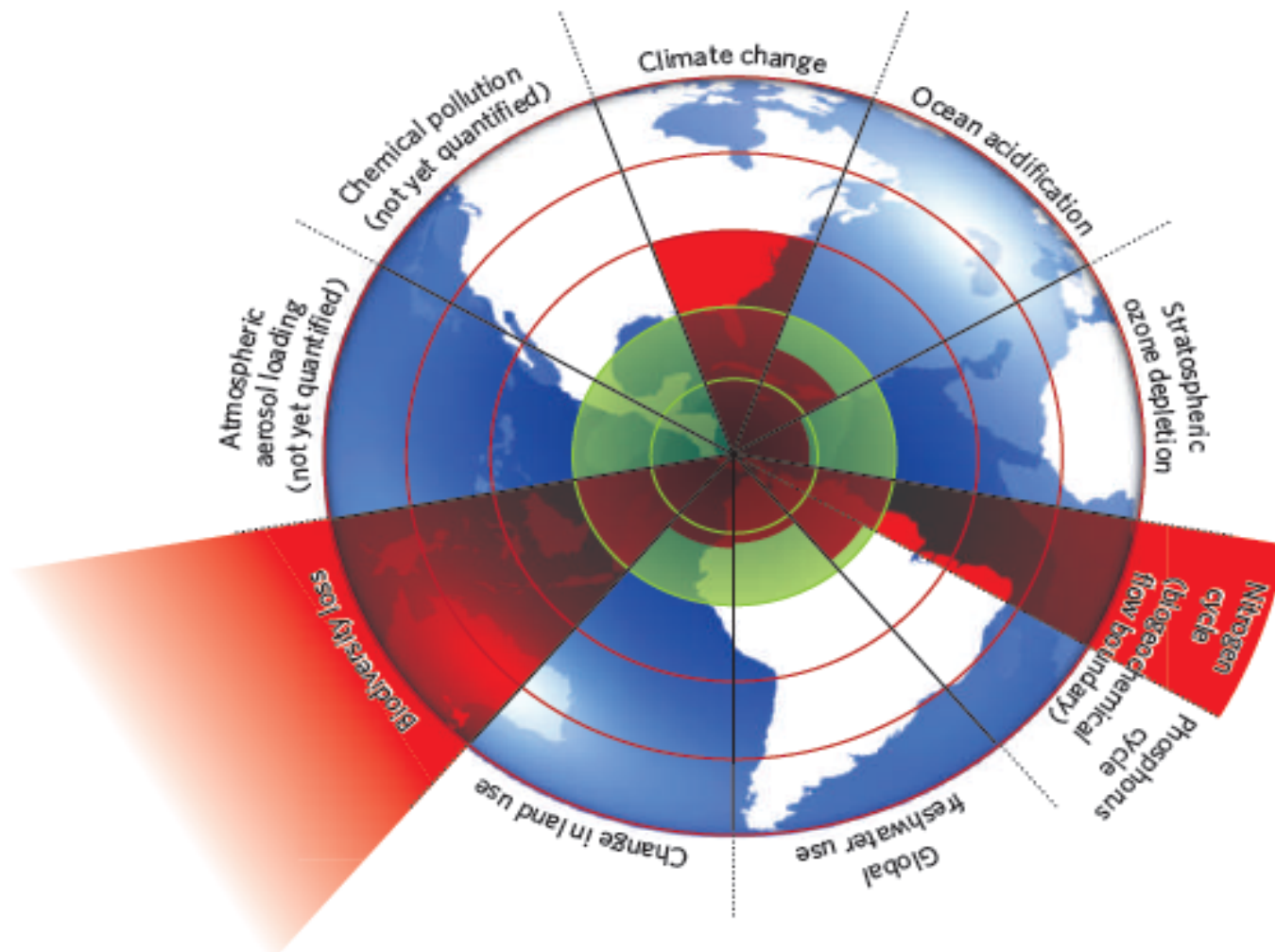
2. Limits to growth?

Limits interact e.g. oil, food prices and civil unrest



Sources: <http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/>
<http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=rbrte&f=m>

2. Limits to growth? Environmental Hard-wired environmental limits?



From Rockstrom et al "A safe operating space for humanity", Nature 2009

<http://www.nature.com/nature/journal/v461/n7263/full/461472a.html>

2. Limits to growth? Climate change

United States' National Academy of Sciences 2011

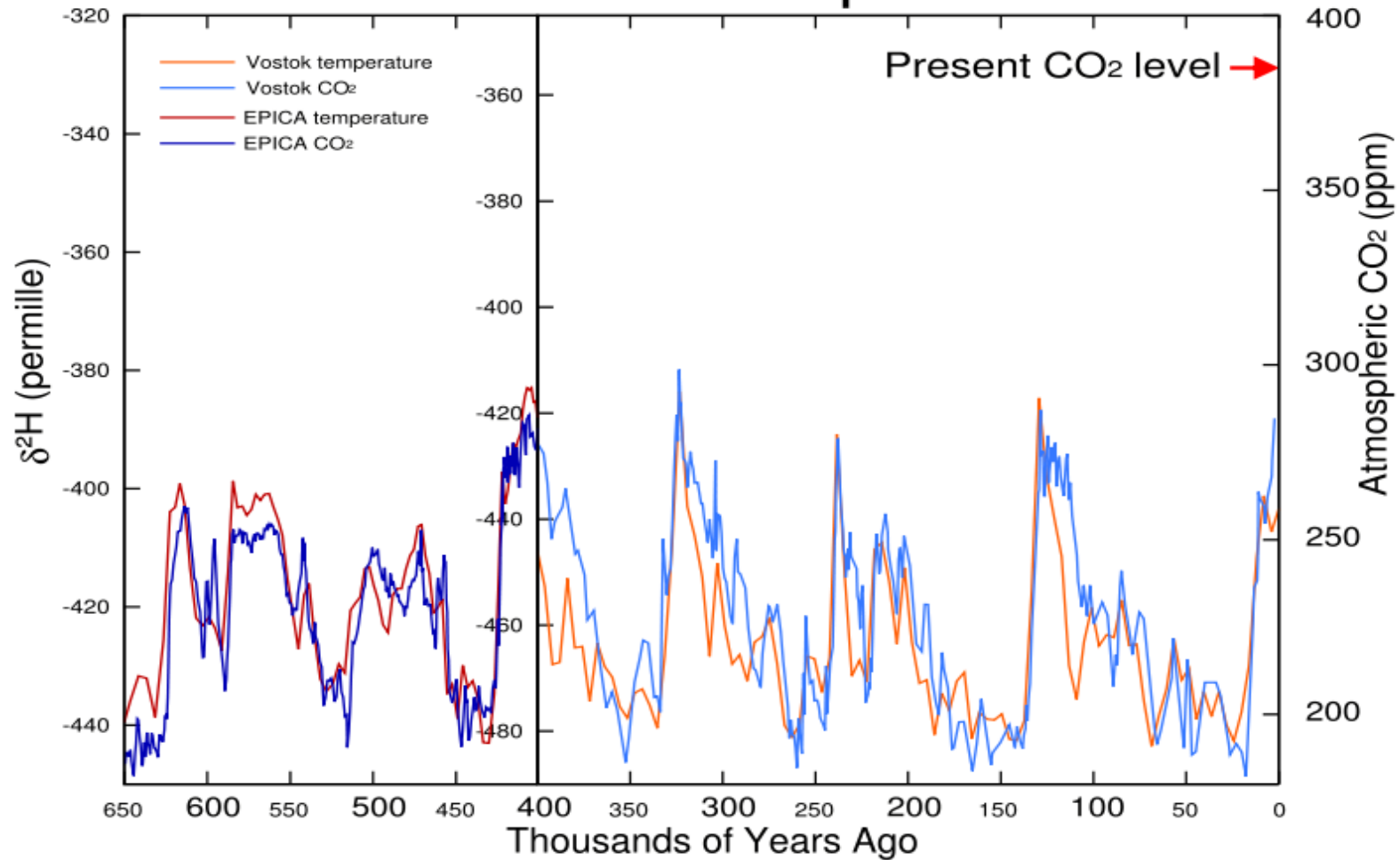
- Fossil fuel CO₂ emissions have created new epoch.
- Human activities will largely determine the evolution of Earth's climate.
- Man-made CO₂ stays in the atmosphere a long time.
- Future generations may be locked into a range of impacts, some of which could become very severe.
- E.g. For 4°C temperature increase, c.9 out of 10 summers warmer than warmest ever experienced in late 20th century.

Source: “**Climate Stabilization Targets: Emissions, Concentrations, and Impacts Over Decades to Millennia**” <http://dels.nas.edu/Report/Climate-Stabilization-Targets-Emissions-Concentrations/12877>

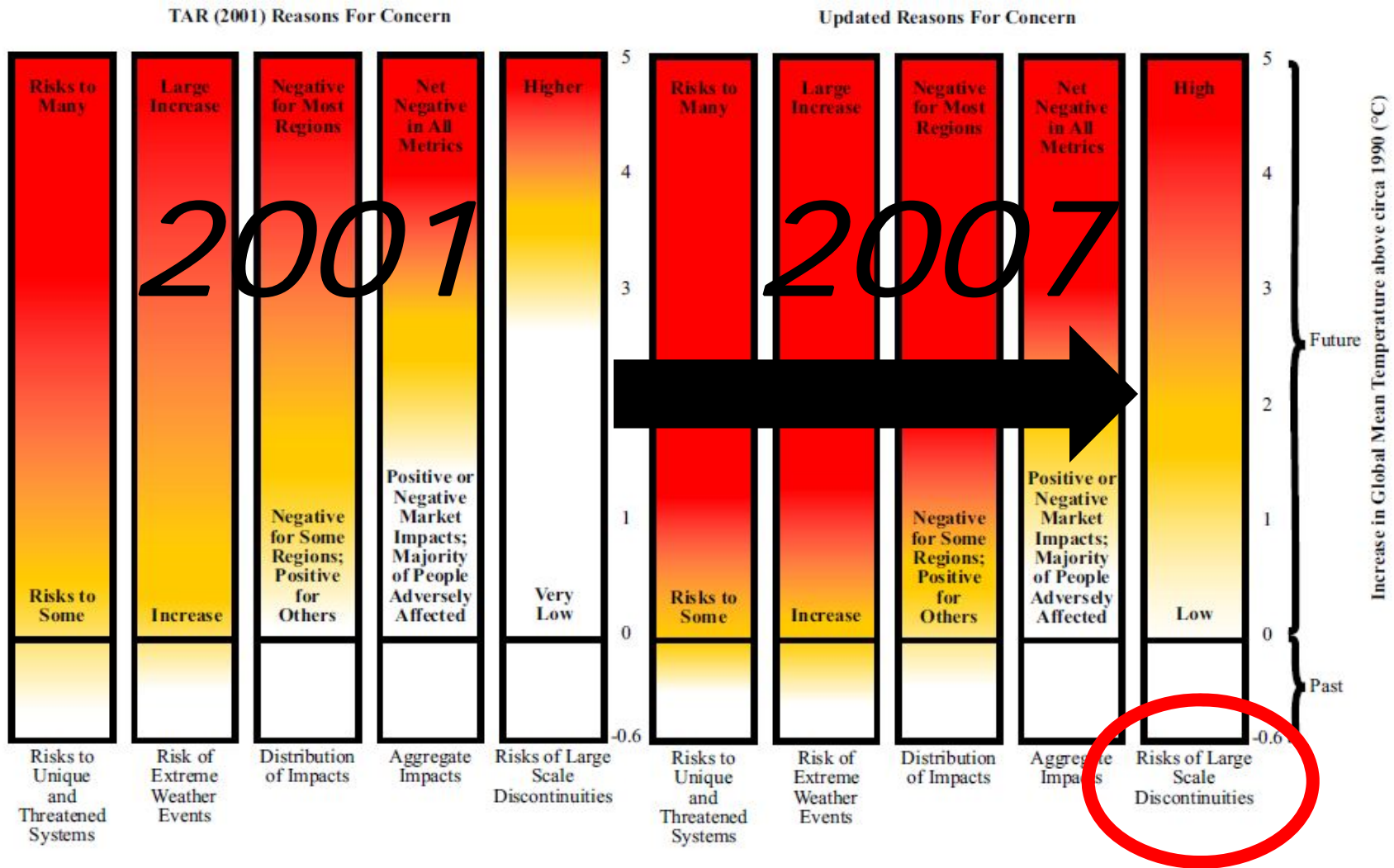
2. Limits to growth? Climate change

Temperature versus CO₂ concentration

Carbon Dioxide and Temperature Records



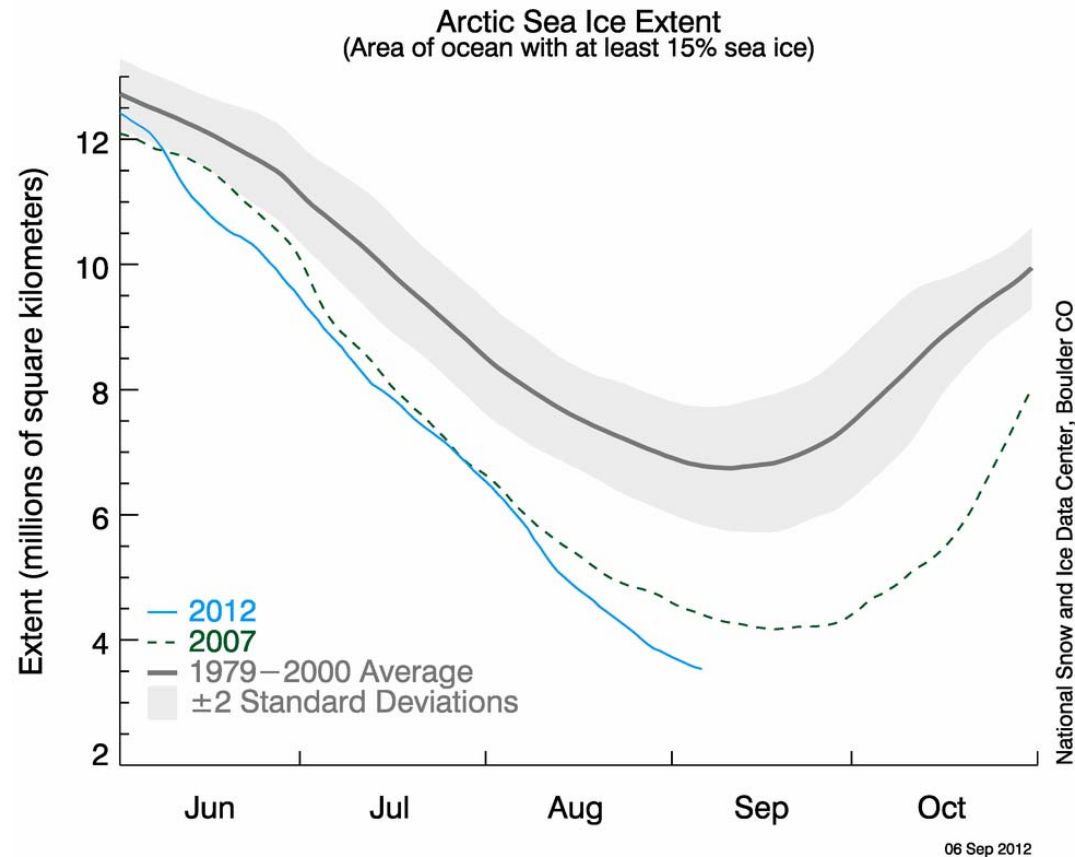
2. Environmental limits to growth: Climate change Updated “Reasons for Concern”



From: J.B.Smith et al PNAS 2009

2. Limits to growth? Climate change

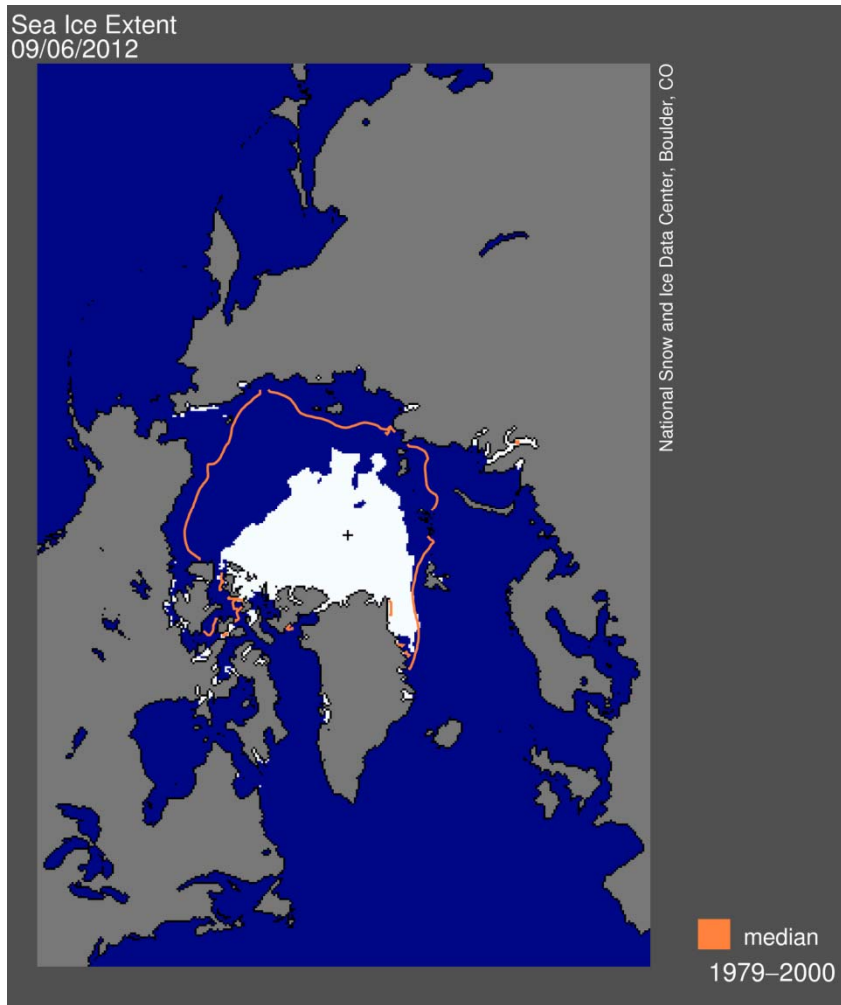
Arctic summer sea ice area breaks 2007 record low



Source: National Snow and Ice Data Center <http://nsidc.org/>

2. Environmental limits to growth: eg Climate change

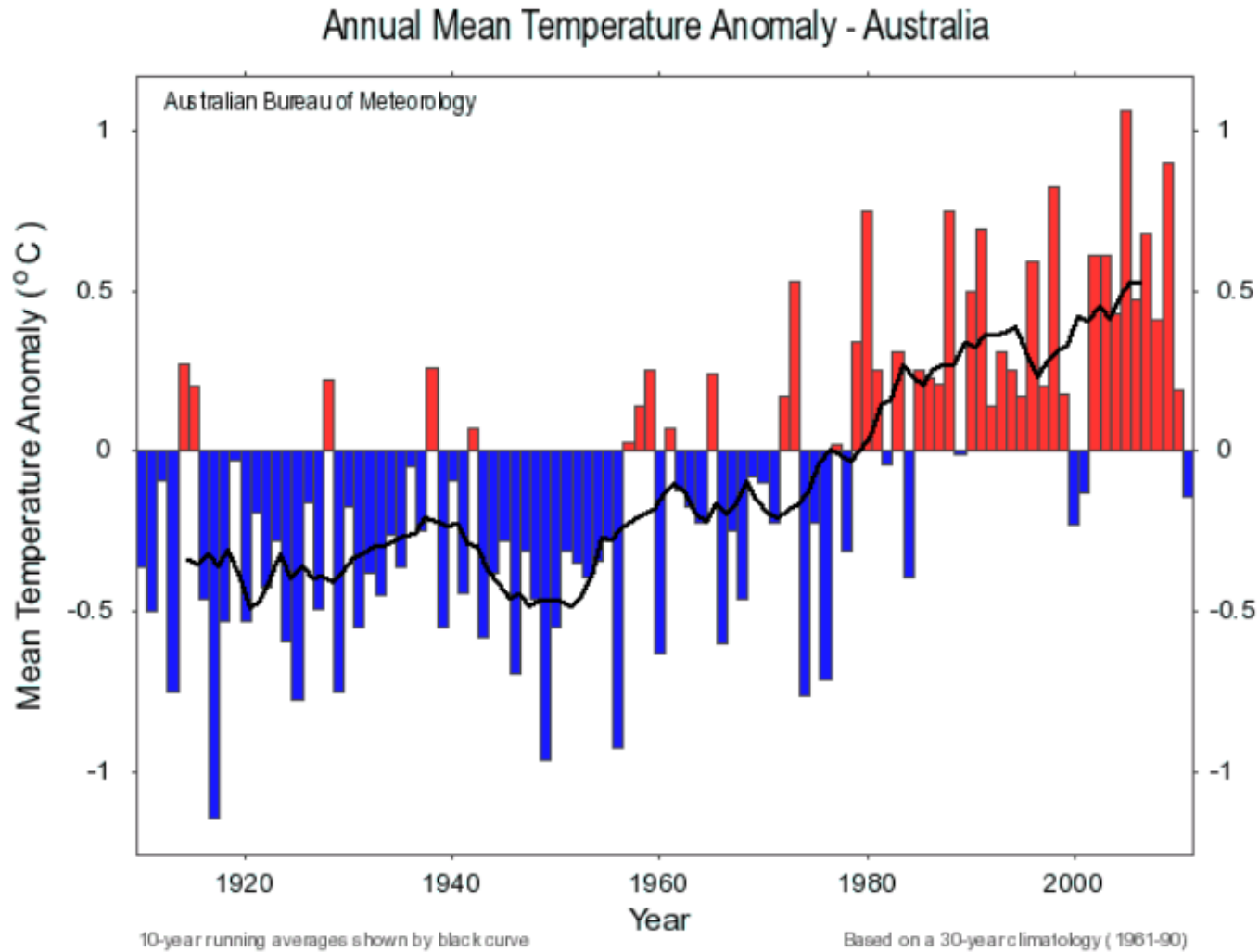
Arctic summer sea ice area breaks 2007 record low



- Arctic sea ice is melting much faster than projected in the 2007 IPCC report
- As ice melts, open water absorbs more heat from the sun

Source: National Snow and Ice Data Center <http://nsidc.org/>

2. Environmental limits to growth: eg Climate change Example: Australian climate



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3. A systems view: economic growth in perspective

Link between problems

- Climate change
- Other environmental problems e.g. loss of biodiversity
- Oil depletion
- Other resource depletion e.g. phosphorus

All driven by increasing consumption by humans – caused by exponential growth of population and the global economy.

Growth drives our problems!

Corollary: more growth = more risk

3. A systems view: economic growth in perspective

Is growth always good?

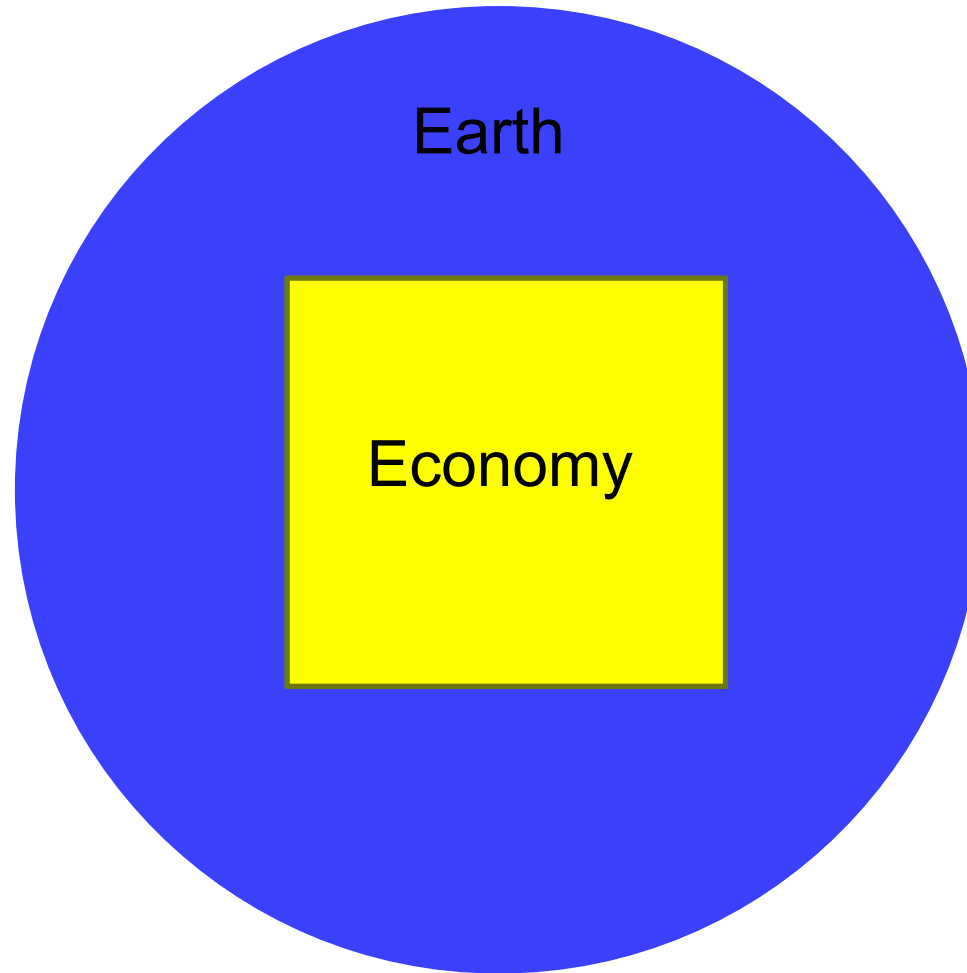
- Many things have an optimal size – further growth is bad
 - E.g. People!



Question: Is economic growth always good?

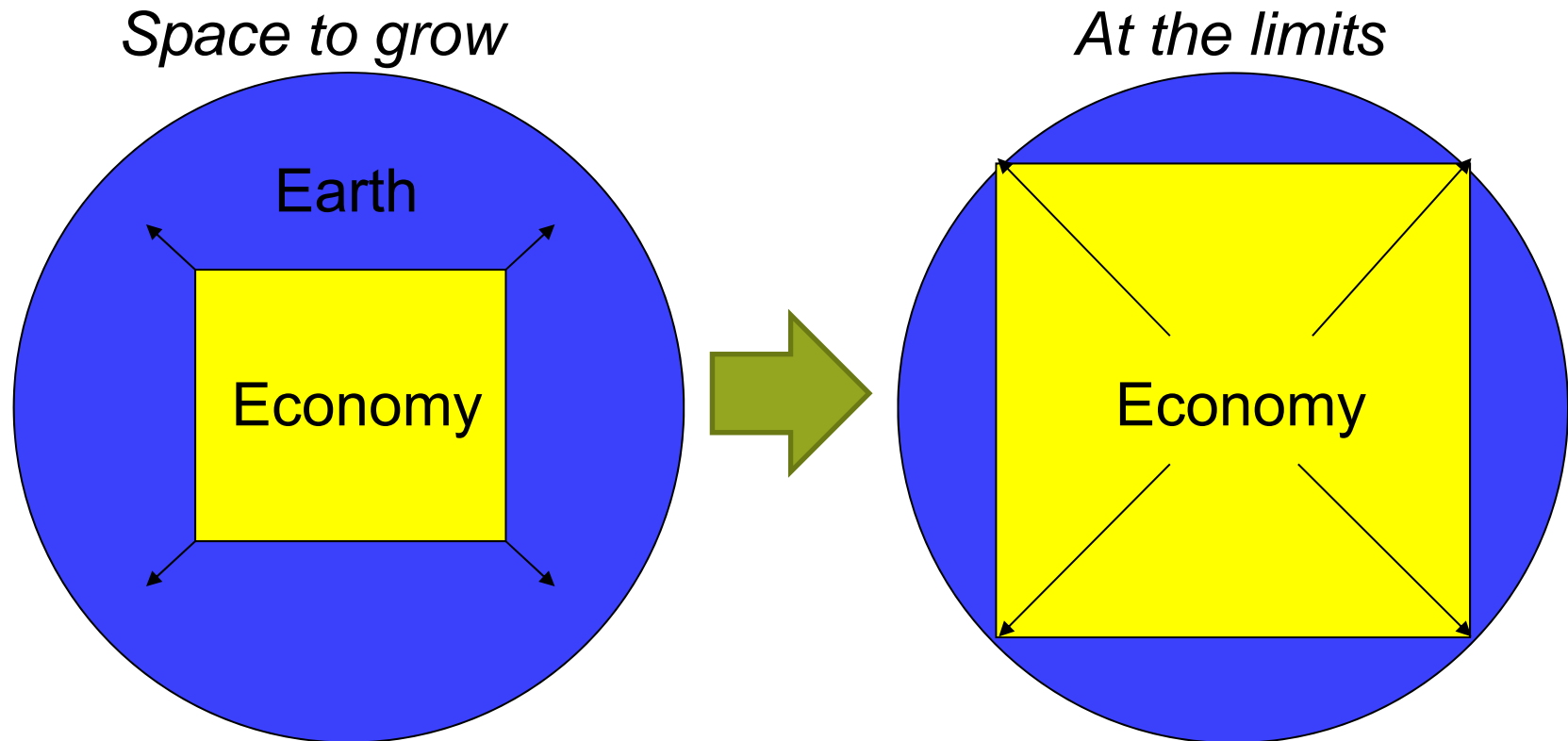
3. A systems view: economic growth in perspective

The human economy is a subset of the Earth



3. A systems view: economic growth in perspective

The human economy is a subset of the Earth



(adapted from Clapp and Dauvergne 2005: p.101)

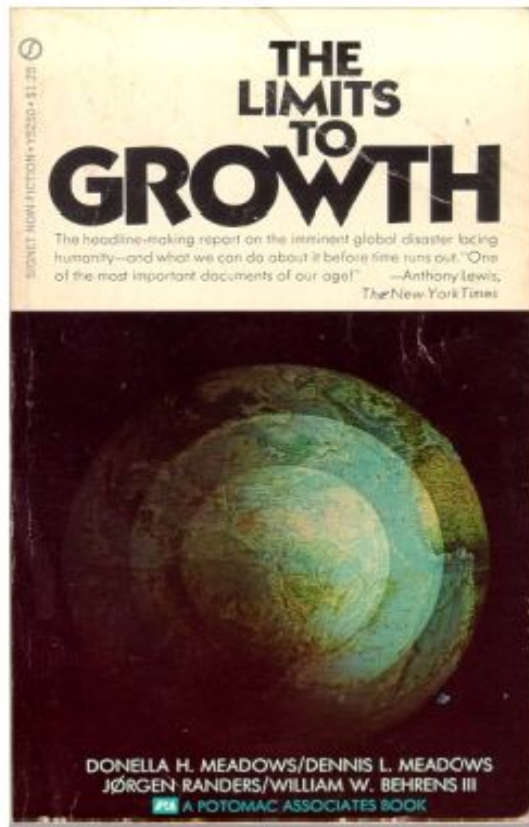
3. A systems view: economic growth in perspective

Why didn't anyone see this coming?

- Exponential growth has a simple mathematical formula.
- Why didn't anyone predict these problems decades ago?
- Answer: Someone did, but the message was forgotten.

3. A systems view: economic growth in perspective

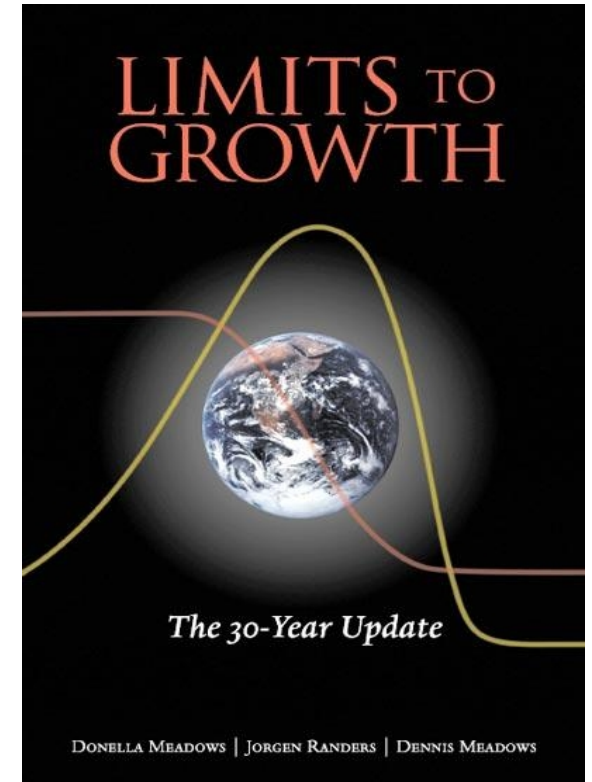
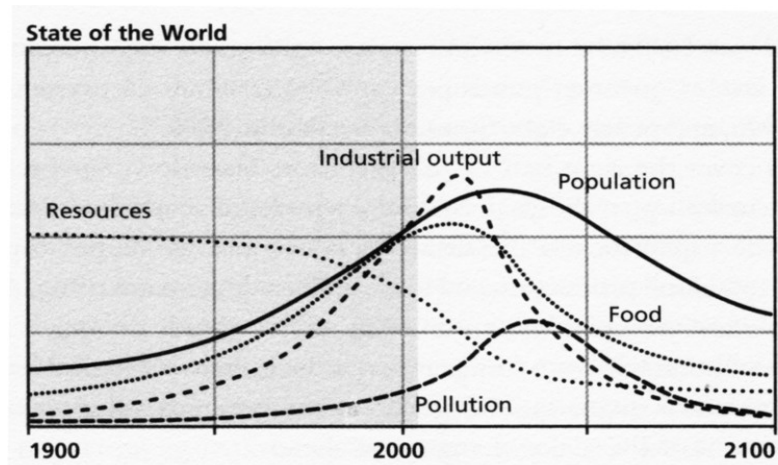
The “Limits to Growth” study



The original 1972 study was updated in 2004



Example below of one of the indicative modelled scenarios (not a prediction)

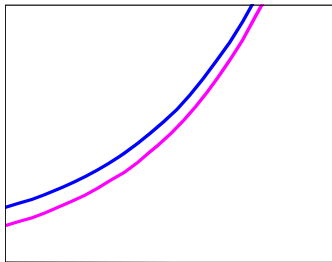


3. A systems view: economic growth in perspective

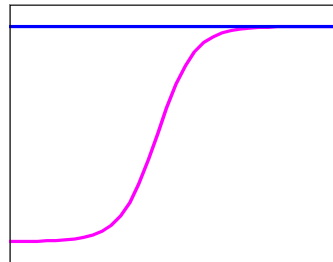
The “Limits to Growth” argument

- Endless physical growth in a finite world is not possible.
- If growth in consumption is not contained, humanity will exceed the carrying capacity of the Earth.
- Exceeding the carrying capacity of the Earth carries risk.

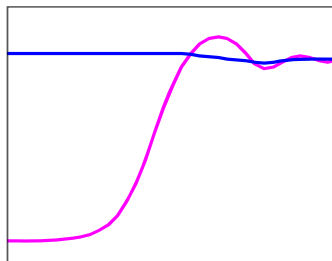
Continuous growth



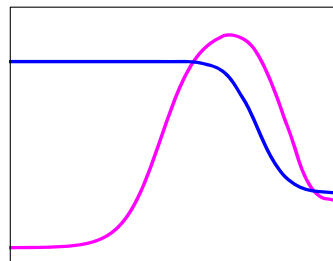
Sinusoidal Growth



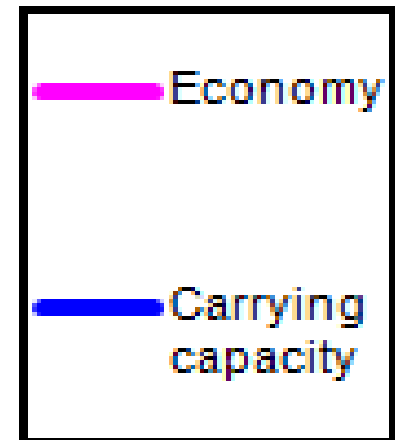
Oscillation



Collapse



The 4 possibilities for exponential growth.



3. A systems view: economic growth in perspective

Scale of human impact? The Anthropocene Age

From The Economist magazine, May 2011

- Humans are reshaping the planet on a geological scale
- e.g. Athabasca tar sands, 30 bn tonnes of earth moved per year = 2x sediment flowing down all rivers in the world
- Moment of realisation, like Copernicus grasping that the Earth revolves around the sun.
- “It would be odd not to be worried.”



You maniacs! You blew it up!

Source: The Economist – 26 May 2011 <http://www.economist.com/node/18744401>

3. A systems view: economic growth in perspective

The “End of the World Syndrome”

- Joseph Tainter “The Collapse of Complex Societies”*
- Every age has its doomsayers. They’ve all been wrong.
- Need a scientific approach not value judgments.
- Is there data which shows that our age is objectively different?
Yes!
 - Wealth
 - Fossil fuel use
 - Atmospheric CO₂ concentration c.390ppm
 - Population c.7 billion
- ‘Goods’ and ‘bads’ are growing together. Is it really that bad?
- Ask the experts.

*Tainter, Joseph A (2003. First published 1988), The Collapse of Complex Societies, Cambridge University Press, ISBN 0-521-38673-X,

3. A systems view: economic growth in perspective

The Planet Under Pressure conference

Planet Under Pressure 2012 was the largest scientific conference leading up to the United Nations Conference on Sustainable Development (Rio+20), with over 3000 delegates.



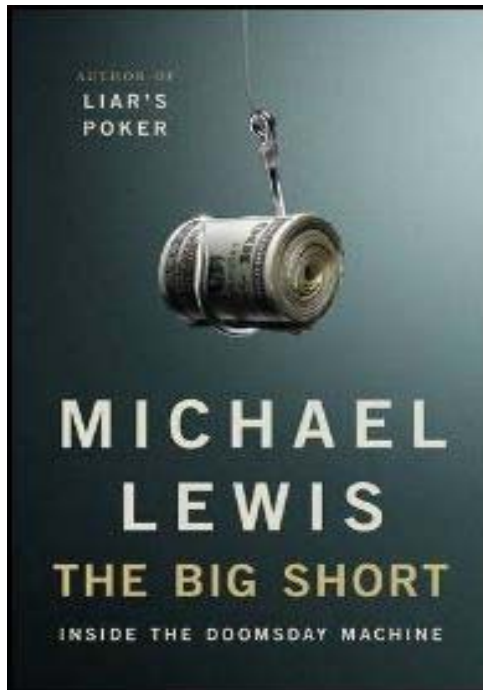
State of the Planet Declaration:

- “1. Research now demonstrates that the continued functioning of the Earth system as it has supported the well-being of human civilization in recent centuries is at risk...”

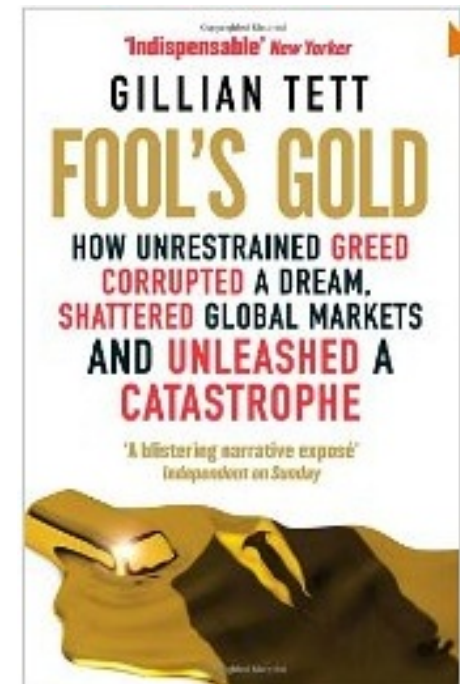
See: <http://www.planetunderpressure2012.net/>

3. A systems view: economic growth in perspective

Why isn't there more public concern?



Two excellent books telling stories about people that saw the financial crisis coming.



- Not many people predicted the severity of the credit crunch.
- But some people did predict it - it was predictable.
- Why did so few people predict the credit crunch?
- Are we heading for an energy/environmental crunch?

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4. Can technology solve our problems?

Human impact on the Earth – a simple approach

$$I = P \times A \times T$$

I = Impact

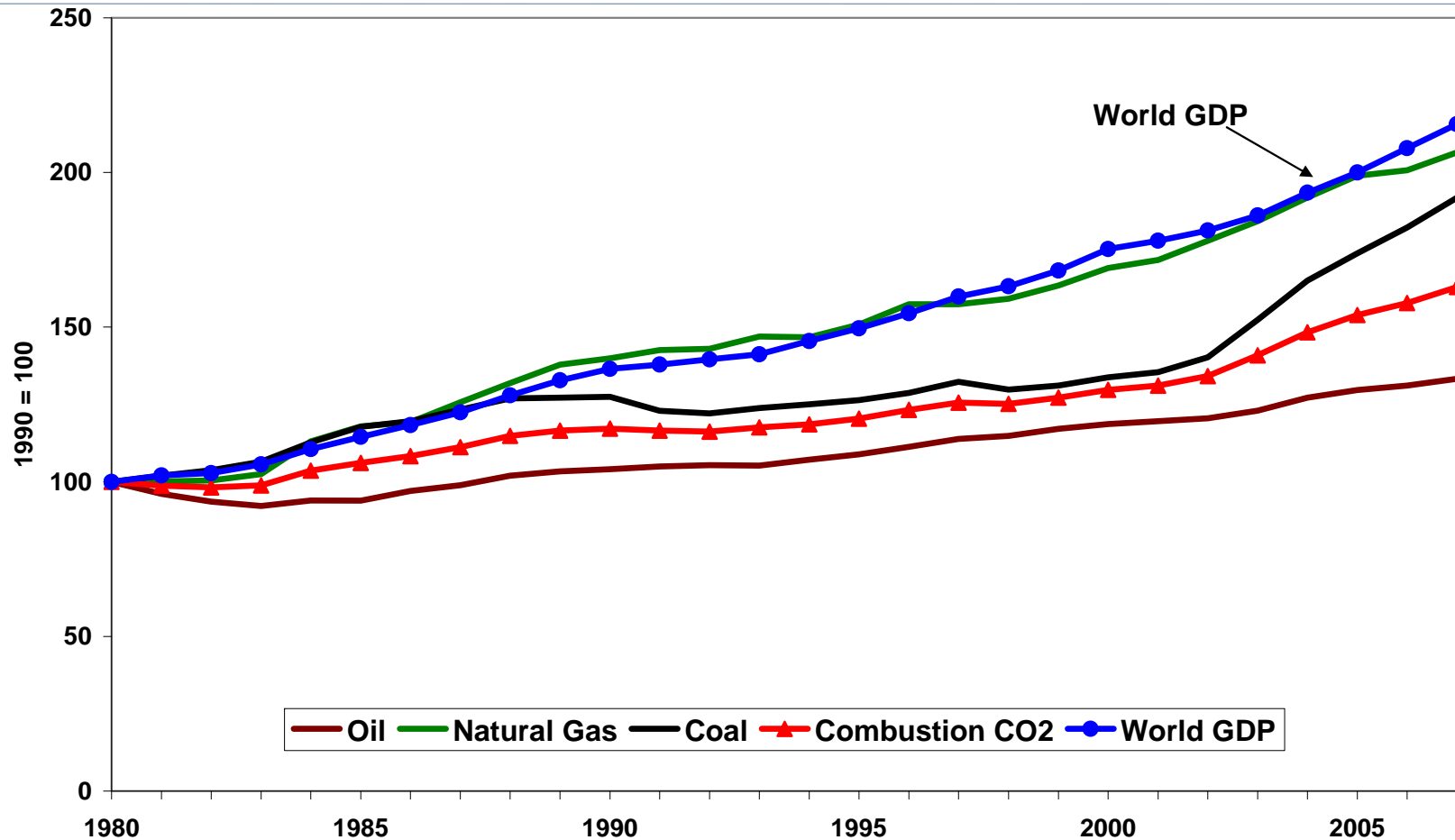
P = Population

A = Affluence (consumption per capita)

T = Technology (environmental impact per unit of consumption)

4. Can technology solve our problems?

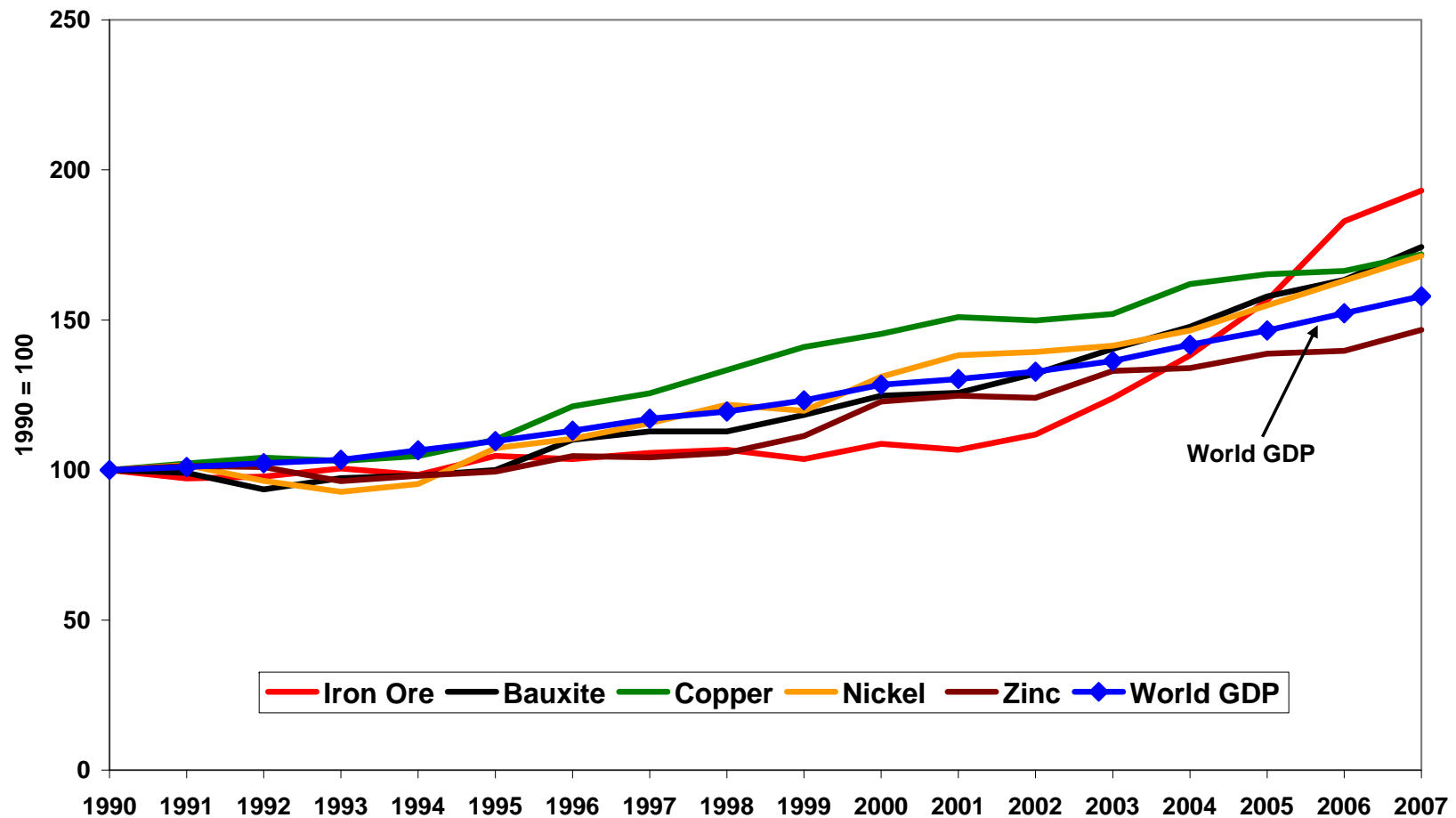
Can technology decouple growth from pollution?



Jackson, T. (2009) *Prosperity Without Growth? Economics for a Finite Planet*, Routledge, London, UK.

4. Can technology solve our problems?

Can technology decouple growth from resources?



Jackson, T. (2009) *Prosperity Without Growth? Economics for a Finite Planet*, Routledge, London, UK.

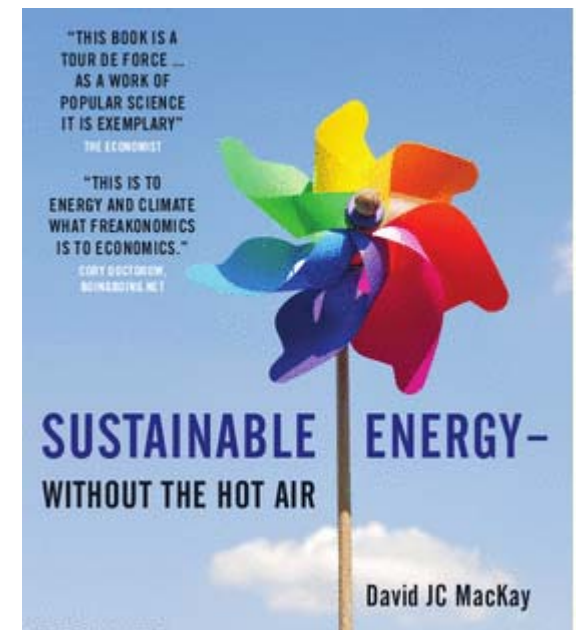
4. Can technology solve our problems?

The idea of “green” economic growth

- Need to decouple economic growth from resource use & environmental impacts
 - Absolute not relative decoupling
 - Global not national (take account of trade)
- But is decoupling possible?
 - Rebound effects / Jevons paradox
 - Role of energy in generating economic growth

4. Can technology solve our problems? Is low-carbon renewable energy the solution?

- Huge renewable potential, but hard to realise it
 - Diffuse, intermittent sources
 - Capture, storage & transmission
- Massive investment needed
- Lock-in to existing infrastructure
- Long lead-time for new technologies



Source: Sustainable Energy Without the Hot Air, by David MacKay

4. Can technology solve our problems?

Conclusion

- We badly need new technology for sustainability e.g. for
 - Clean energy
 - Efficiency gains
 - Water recycling
- But, it's not prudent to rely on technology alone
- Data so far suggests that only deep structural changes will produce a sustainable economy.

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5. Questioning GDP growth

David Cameron, 2010

"We'll continue to measure GDP as we've always done, but it is high time we admitted that, taken on its own, GDP is an incomplete way of measuring a country's progress."



Cameron: 'Happiness cannot be captured on spreadsheet'

Quoting former US senator Robert Kennedy, who said GDP measured everything "except that which makes life worthwhile", he said the information gathered would help Britain re-evaluate its priorities in life.

Source: BBC News 25 November 2010 <http://www.bbc.co.uk/news/uk-11833241>

5. Questioning GDP growth

Bobby Kennedy, 1968

‘Too much and for too long, we seemed to have surrendered personal excellence and community values in the mere accumulation of material things. Our gross national product, now, is over \$800 billion dollars a year, but that gross national product – if we judge the United States of America by that – counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage. It counts special locks for our doors and the jails for the people who break them. It counts the destruction of the redwood and the loss of our natural wonder in chaotic sprawl. It counts napalm and counts nuclear warheads and armored cars for the police to fight the riots in our cities and the television programs which glorify violence in order to sell toys to our children.

Yet the gross national product does not allow for the health of our children, the quality of their education or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages, the intelligence of our public debate or the integrity of our public officials. It measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to our country, it measures everything in short, except that which makes life worthwhile. And it can tell us everything about America except why we are proud that we are Americans.’

Source: Institute of Chartered Accountants in England and Wales “Qualitative Growth”, Fritjof Capra and Hazel Henderson

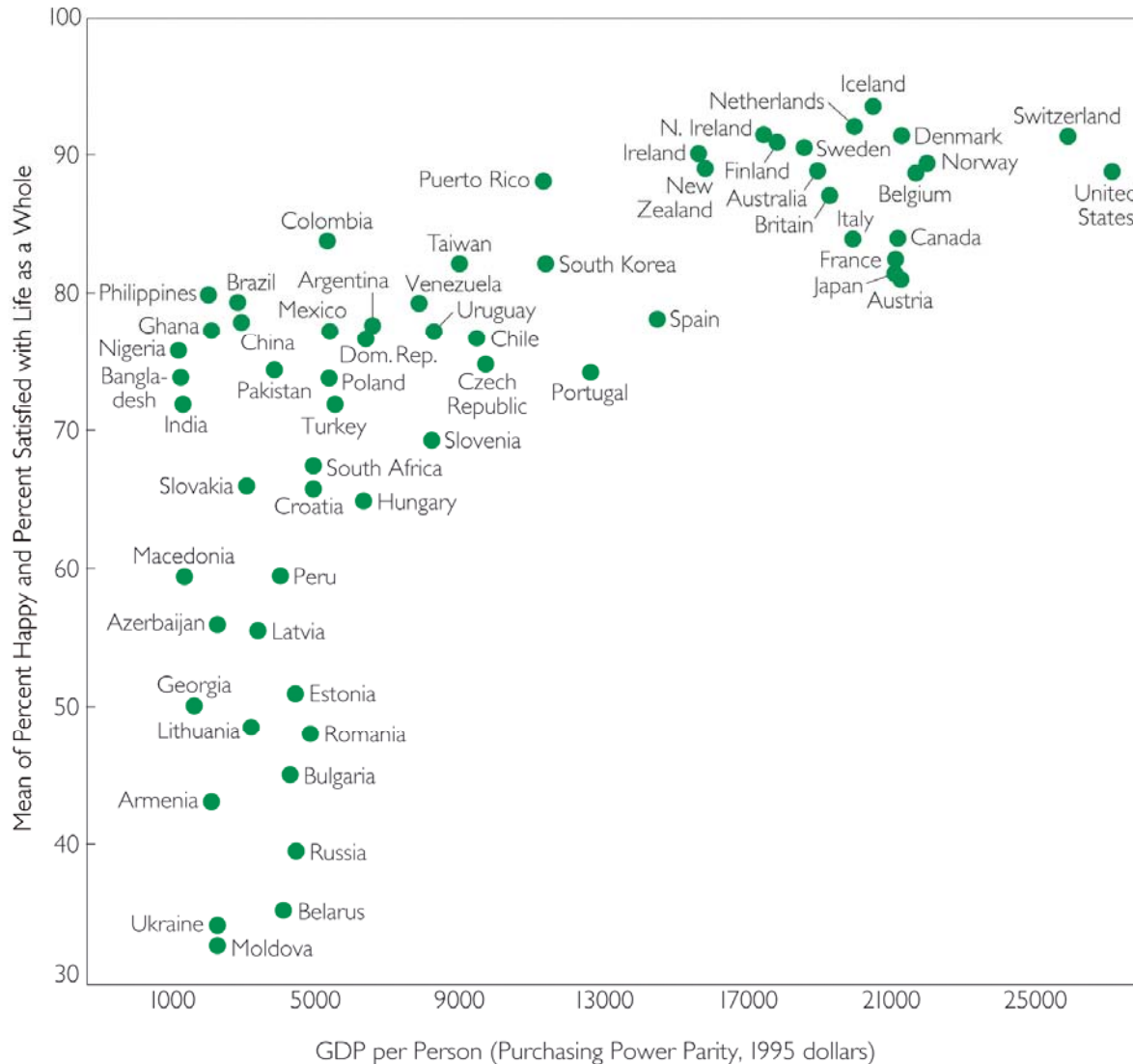
5. Questioning GDP growth

What is economic growth for?

- Rich countries have reaped enormous benefits from economic growth.
- Poor countries need to grow their economies for basic needs: housing, sanitation, healthcare, education.
- But, once material needs are met, increasing GDP has relatively small effect on life satisfaction.

5. Questioning GDP growth

% of people content vs GDP



% of people content versus GDP per person at PPP

Source: Jackson, T. (2009) Prosperity without growth? Economics for a finite planet,

5. Questioning GDP growth

The role of economic growth in society

- Economic growth remains the dominant concern of politics even in rich countries. Why is this?
- Society is structurally dependent on economic growth:
 - Technological progress increases productivity.
 - Fewer workers needed for same production,
 - Hence rising consumption needed or unemployment rises.
- A way out – aim for stability over growth? Trade wealth for leisure? Steady state economy.

5. Questioning GDP growth

JS Mill on the stationary state

John Stuart Mill, Principles of Political Economy, 1848

...the increase of wealth is not boundless. The end of growth leads to a stationary state. The stationary state of capital and wealth... would be a very considerable improvement on our present condition.

...a stationary condition of capital and population implies no stationary state of human improvement. There would be as much scope as ever for all kinds of mental culture, and moral and social progress; as much room for improving the art of living, and much more likelihood of it being improved, when minds ceased to be engrossed by the art of getting on."

5. Questioning GDP growth

John Maynard Keynes, 1945

On the unimportance of wealth once material needs are met

- “The day is not far off when the economic problem will take the back seat where it belongs, and the arena of the heart and the head will be occupied or reoccupied, by our real problems — the problems of life and of human relations, of creation and behaviour and religion.”

5. Questioning GDP growth

Economist and Nobel Laureate Robert Solow, 2008

“It is possible,” says Solow, “that the United States and Europe will find that, as the decades go by, either continued growth will be too destructive to the environment and they are too dependent on scarce natural resources, or that they would rather use increasing productivity in the form of leisure. . . . There is nothing intrinsic in the system that says it cannot exist happily in a stationary state.”

Source: Harper’s Magazine, March 2008

5. Questioning GDP growth

Adair Turner, 2012

On GDP growth as a policy target

- “GDP figures are almost useless as measures of long-term changes in human well-being.”
- “It is not clear that long-term economic growth should be the overriding objective of policy in rich developed countries, since it is not clear that it necessarily delivers increased human welfare, or happiness, or utility,”

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6. Implications for the financial system?

The money supply

- Our money supply is based on fractional reserve banking
- Hence money is loaned into existence by private banks (97% in the UK). Hence

Money = Debt

- This is pro-cyclical and inherently unstable
 - in a boom money supply expands rapidly, in a recession money supply shrinks
- Debt increases the growth imperative in the economy.
- Arguably, our money system is not suited for low growth world.

Refer: “Where does money come from”, by Josh Ryan-Collins, Tony Greenham, Richard Werner, Andrew Jackson

6. Implications for the financial system?

Further research is needed

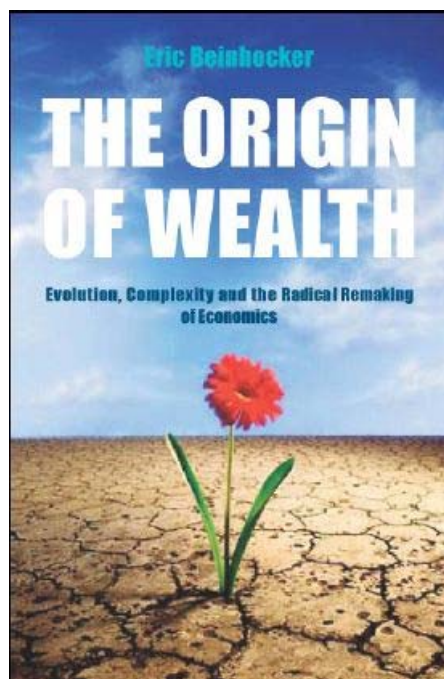
Need research on:

- **Financial system**
 - Is the money system suitable for a low or non growth economy?
 - What are the interactions between the financial system and real economy?
 - Is the financial system driving sustainability problems?
 - What financial system do we need and want for the 21st century?
- **Economics:**
 - **“practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist.”, J.M.Keynes**

7. Implications for the financial system?

Economics has problems e.g. thermodynamics

- Conventional (neo-classical) economics does not incorporate the 2nd law of thermodynamics
- How did this happen? For explanation, read “The Origin of Wealth” by Eric Beinhocker.



Albert Einstein on thermodynamics

“It is the only physical theory of universal content which I am convinced will never be overthrown, within the framework of applicability of its basic concepts.”

6. Implications for the financial system

Financial crisis raised deep questions on economics

Adair Turner, on the need to “reconstruct” economics

- “... do we really need, as Skidelsky argues, to ‘reconstruct economics’? My conclusion is that we do.”
- “... in the translation of ideas into ideology, and ideology into policy and business practice, one oversimplified strand [of economics] dominated in the pre-crisis years, and that domination, though partly a perversion and simplification of economics, was also based on some dangerous tendencies within the dominant strand of economics itself.”
- “... economics ... must not assume that additional income will ... increase utility or happiness;”

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7. Actuaries and sustainability

Why do actuaries have relevant skills?

Global problems worsened by:

- Lack of understanding of risk and uncertainty
- Lack of understanding of exponential growth
- Disregard for science
- Wilful blindness of the data
- Over-optimism

Actuaries' core skills/methods are in these areas:

- Risk and uncertainty
- Exponential growth
- Scientific methodology
- Base decisions on data
- Prudential view

7. Actuaries and sustainability

What are actuaries doing? Some examples

UK profession:

- Resource & Environment MIG (REG) has >500 members. 2 literature reviews published, 3rd due in Spring 2013.
- Resource & Environment Panel set up to guide profession.
- Research into the limits to growth commissioned.

Other actuarial organisations (examples, not a full list):

- IAA Environment Working Group
- CAS Climate Change Committee
- SOA have started a group looking into resource issues
- Australian actuaries active for many years on climate change

7. Actuaries and sustainability

UK Profession's research into Limits to Growth

By the Global Sustainability Institute at Anglia Ruskin University.
Launch date 17 January 2013. Will include:

- The economics of limits to growth
- Review of discourse on limits to growth
- Examination of the evidence for limits to and effects on:
 - Oil, coal and gas and uranium
 - Land and soil
 - Water
 - Commodities
 - Population
 - Capital
- Examination of impact on actuarial advice
- Scenario analysis of societal responses

7. Actuaries and sustainability

- Examples:
- Barry Maher
- Trevor Maynard
- Milliman systems science unit
- Links with ERM

7. Actuaries and sustainability

Join the International Actuarial Association Environment Working Group

- Next meeting is in November, Nassau

Further reading

Further reading:

- <http://www.planetunderpressure2012.net/> (science)
- <http://www.withouthotair.com/> (energy)
- <http://www.neweconomics.org/> (economics for sustainability)
- www.theoil drum.com (energy)
- <http://www.energybulletin.net/> (energy)
- <http://www.positivemoney.org.uk/> (financial reform)
- <http://steadystate.org/> (CASSE – steady state economics)

Questions or comments?

Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

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