Energy-Technology Innovation and the Climate-Change Challenge

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Why energy-technology innovation is important:

Whatever you think "the energy problem" is, advances in technology are an important part of the solution. They can…

- Reduce the costs of energy end-use forms to consumers
- Further reduce costs of energy services by increasing end-use efficiency
- Increase the productivity of manufacturing
- Reduce dependence on imported oil in the USA and elsewhere
- Increase the reliability & resilience of energy systems
- Strengthen & sustain the US position in global energy-technology markets
- Minimize the ecosystem-disruption and biodiversity impacts of energy-resource exploration, extraction, and transport
- Reduce the emissions of air pollutants harmful to health, property, and ecosystems
- Improve the safety and proliferation resistance of nuclear energy
- Enhance the prospects for environmentally sustainable & politically stabilizing economic development

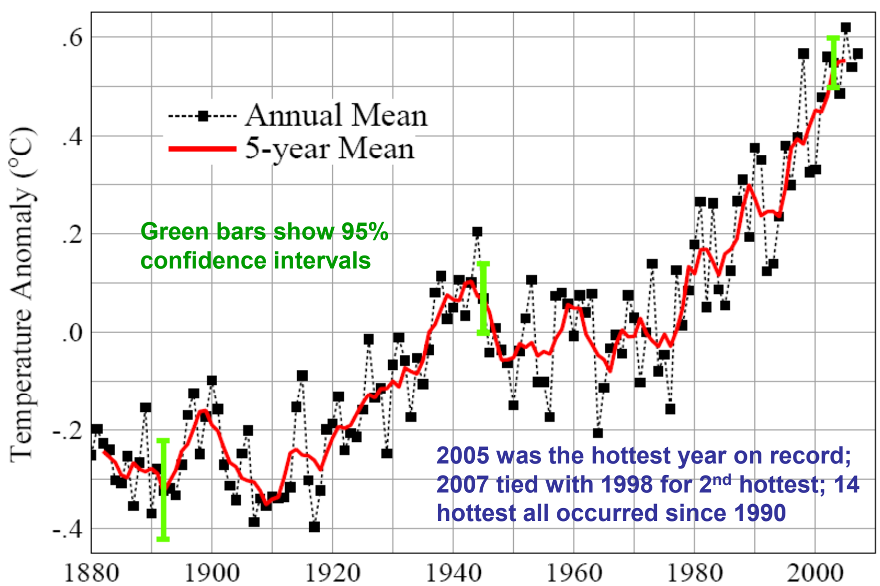
AND

- Reduce the energy sector's contributions to human disruption of global climate

Reducing energy's contributions to climate change is the most demanding driver of energy-technology innovation because of…

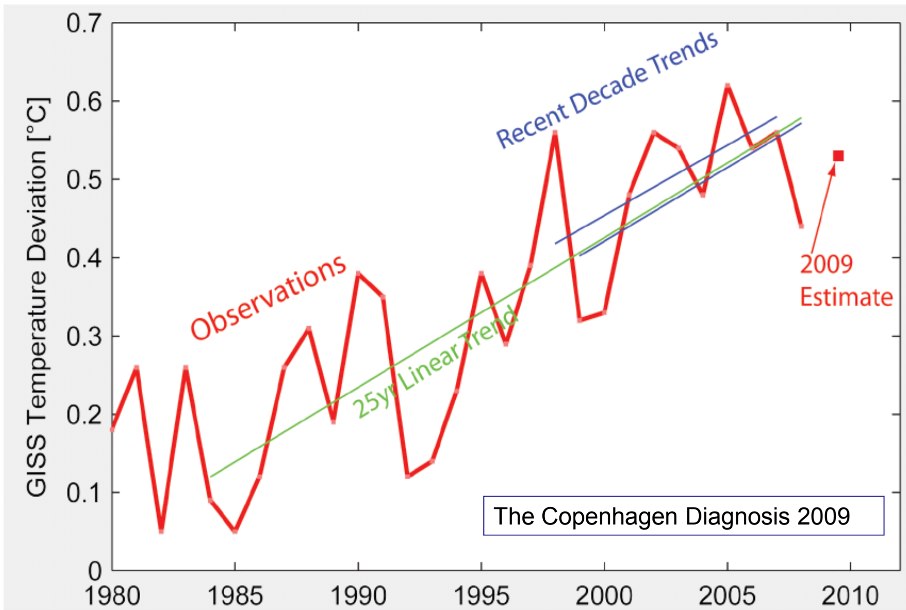
- The potentially unmanageable consequences of failing to adequately mitigate global climate change
- The dominant role of the energy sector in the causes of global climate change (most importantly via CO_2, CH_4, and black soot from both fossil & biomass fuels)
- The high proportion of US & global energy supply that comes from the offending fuels/technologies
- The barriers to new technologies' achieving significant penetration in the massive US and global energy systems and the long lead times needed to do so
- The mismatch between those lead times and the pace of energy-system change that adequate climate-change mitigation is likely to require

The Earth <u>is</u> getting hotter: the thermometer record



http://data.giss.nasa.gov/gistemp/graphs/

The rate of heating is not slowing down

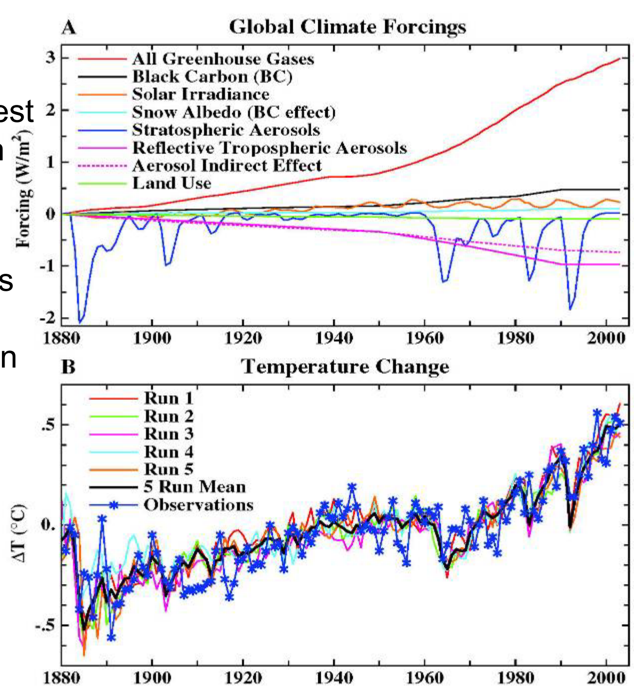


Human influence: the "fingerprint"

Top panel shows best estimates of human & natural forcings 1880-2005.

Bottom panel shows that state-of-the-art climate model, when fed these forcings, reproduces almost perfectly the last 125 years of observed temperatures.

Source: Hansen et al., *Science 308*, 1431, 2005.



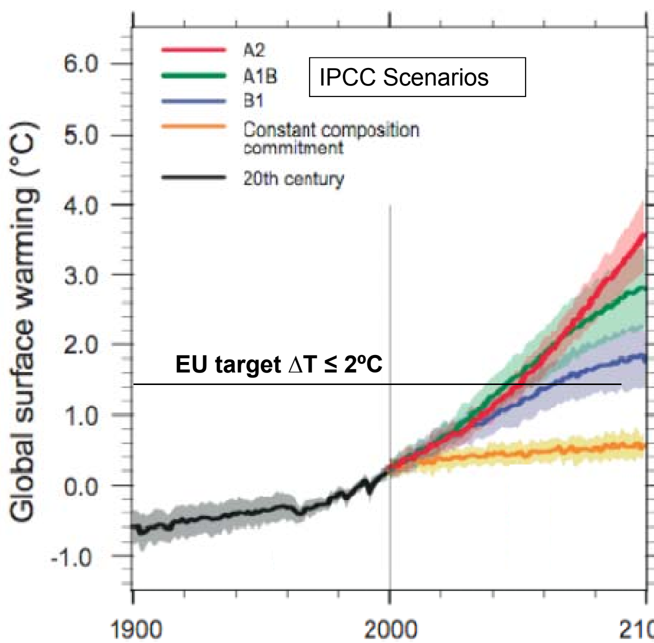
Harm is already occurring

Globally, we're seeing, variously, increases in

- floods
- wildfires
- droughts
- heat waves
- pest outbreaks
- coral bleaching events
- power of typhoons & hurricanes
- geographic range of tropical pathogens

all plausibly linked to climate change by theory, modeling

Climate change: Where are we headed?



Last time T was 2ºC above 1900 level was 130,000 yr BP, with sea level 4-6 m higher than today.

Last time T was 3ºC above 1900 level was ~30 million yr BP, with sea level 20-30 m higher than today.

Note: Shaded bands denote 1 standard deviation from mean in ensembles of model runs

IPCC 2007

Do recent disclosures about e-mails and IPCC missteps cast doubt on these conclusions?

- E-mails show climate scientists are human, too, and that increased efforts to ensure openness & transparency in conduct of climate science are warranted (consistent with Obama scientific-integrity principles enunciated a year ago)
- IPCC missteps show need for increased attention to following review procedures rigorously – and perhaps strengthening them further – but errors discovered so far are few in number and small in importance.
- IPCC is not the source of scientific understanding of climate change – it's just one of the messengers. The sources are the global community of climate scientists and the mountain of peer-reviewed research they've produced over decades.

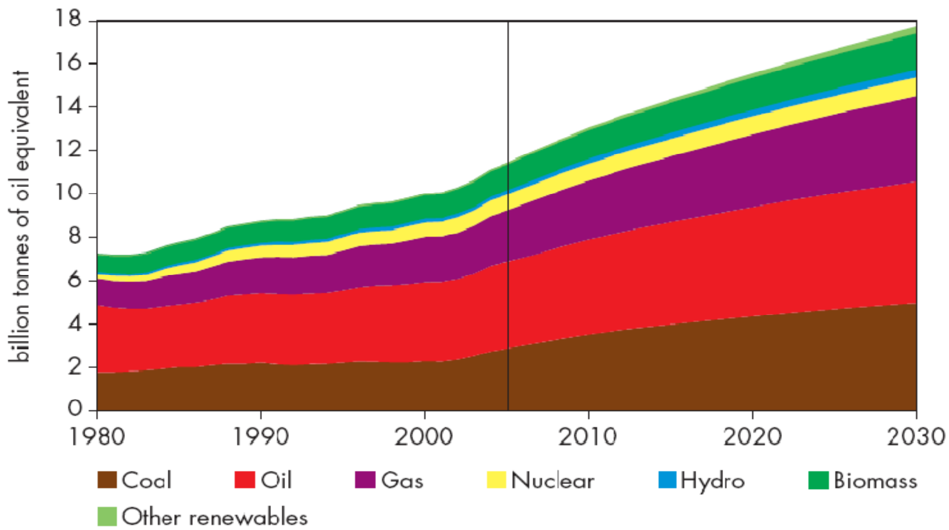
Recent disclosures (continued)

- Nothing that has come to light in e-mails or controversies about the IPCC rises to a level that would call into question the core understandings from climate science about what is going on:
  - Global climate is changing in ways that are unusual against the backdrop of natural variations.
  - Human activities, above all fossil-fuel and biomass burning and land-use change, are almost certainly responsible for a large part of the changes being observed.
  - These changes are already causing harm in many regions.
  - The harm is highly likely to get much larger if the offending emissions are not sharply reduced.

Key mitigation realities

- Human CO_2 emissions are the biggest piece of the problem (50% and growing)
  - About 80% comes from burning coal, oil, & natural gas (which provide >80% of world energy)
  - Most of the rest comes from deforestation & burning in the tropics
  - Industrialized & developing countries are now about equal in fossil CO_2 emissions.
- Methane (partly from energy system) and black soot (biomass fuels, 2-strokes, diesels) are the next most important contributors.

Fossil fuels & biomass dominate world energy supply and under BAU will continue to do so



WEO 2007

How much, how soon?

- Limiting ΔT_{avg} to ≤2ºC is now considered by many the most prudent target that's still attainable.
  - EU embraced this target in 2002, G-8 in 2009
- For 50% chance of ΔT_{avg}≤2ºC, sum of human influences (CO_2, other GHG, and atmospheric particulate matter) must be stabilized at a level equivalent to 450 ppm of CO_2 ("450 ppm CO_2-e").
  - In 2005 we were at 380 ppm CO_2 and 430 ppm CO_2-e from all GHG combined.
  - Effects of particles (warming from some, cooling from others) added up to a net negative 50 ppm CO_2-e, so total human influence in 2005 was 430 – 50 = 380 ppm CO_2-e.

Quantitative realities of mitigation

- Stabilizing at 450 ppmv CO_2-e means 2050 global CO_2 emissions must be at least ~7-9 GtC/yr below BAU (i.e., a cut of 50% or more below BAU).
- Ways to avoid 1 GtC/yr in 2050 include…

- energy use in buildings cut 20-25% below BAU in 2050,
- fuel economy of 2 billion cars ~60 mpg instead of 30,
- carbon capture & storage for 800 1-GWe coal-burning power plants,
-700 1-GWe nuclear plants replacing coal plants,
-1 million 2-Mwe-peak wind turbines (or 2,000 1-Gwe-peak photovoltaic power plants) replacing coal power plants

Socolow & Pacala, 2004

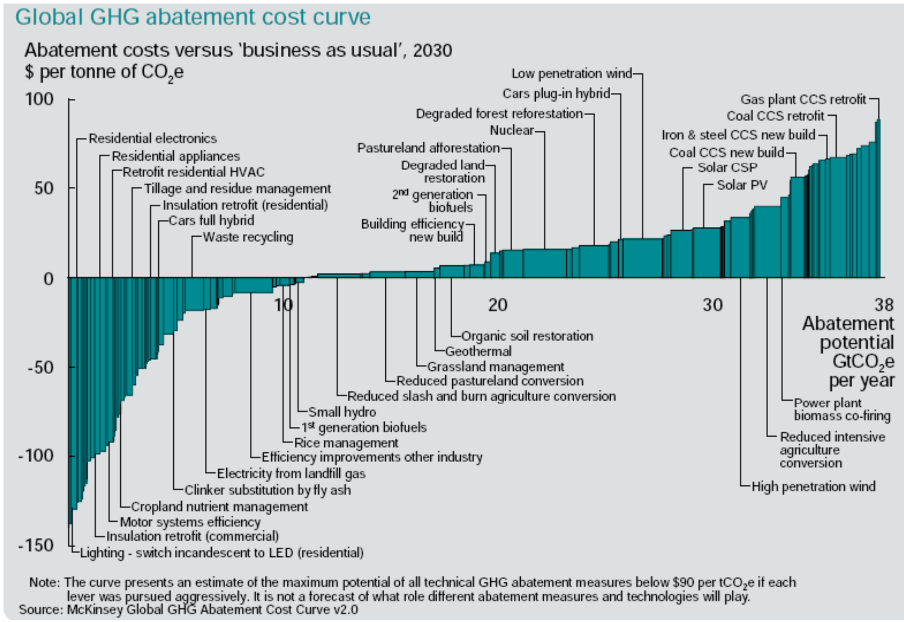
Qualitative realities of mitigation

- The cheapest, fastest, cleanest emissions reductions are those available from increasing the efficiency of energy use in buildings, industry, and transport and from reductions in deforestation and forest degradation.
- Efficiency increases are often "win-win": co-benefits in saved energy, increased domestic jobs, energy security, reduced pollution can offset costs of the measures.
- Supply-side mitigation is also sometimes "win-win", e.g., cogeneration, wind, some biofuels incl waste-to-energy.
- The "win-win" approaches will not be enough. Adequate mitigation will require putting a price on emissions of GHG to make the costlier reduction options profitable.

The fruit-tree metaphor

- Portraying the options for mitigation graphically as a "supply curve", from most profitable (negative cost) on the left to the most costly on the right – as on the next slide – brings to mind the fruit-tree metaphor, namely…
- There is quite a lot of low-hanging fruit – and some lying on the ground waiting to be picked up – but the many barriers that prevent this potential from being exploited are like a fence around the tree. One challenge for policy is to get that fence lowered or removed.
- A second policy challenge is to put a price on greenhouse-gas emissions, to incentivize reaching higher into the tree.
- And the third policy challenge is to ramp up energy-technology innovation, which has the effect of bringing more fruit into reach over time.

McKinsey GHG abatement *vs* cost for 2030



The Obama administration's approach

- Based on recognition that it isn't "climate change policy versus the economy" but "climate change policy for the economy".
  - costs of action, for the USA and the world, will be far smaller than costs of inaction
  - we can reduce costly and risky oil imports and dangerous air pollution with the same measures we employ to reduce climate-disrupting emissions
  - the surge of innovation we need in clean-energy technologies and energy efficiency will create new businesses & new jobs and help drive economic recovery & growth.

Obama administration approach (continued)

- Work with Congress to get comprehensive energy-climate legislation that will put the USA on the needed emissions trajectory with minimum economic & social cost and maximum co-benefits; ramp up public ERD&D, incentives for private sector to do same, public-private partnerships
- Work with other major emitting countries – industrialized & developing – and the UNFCCC process to build clean-energy technology cooperation + individual & joint climate policies consistent with a 2ºC target
- Develop adaptation strategies and capacities domestically and internationally to cope with climate change that mitigation doesn't avoid

Some key references

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