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# Implications of "Peak Oil" for Atmospheric CO2 and Climate

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The title is that of a paper recently (20th April 2007) submitted by James Hansen and Pushker Kharecha. The complete paper can be downloaded here:

Implications of "Peak Oil" for Atmospheric $CO_2$ and Climate

James Hansen is a physicist, adjunct professor: Earth and Environmental Sciences, Columbia University and director: NASA's Goddard Institute for Space Science. Outside the scientific community Hansen is probably best known for accusing the Bush administration of trying to silence him after he gave a lecture in December 2005 calling for prompt reductions in emissions of greenhouse gases linked to global warming.

In this paper Hansen and Kharecha consider "realistic" (they use EIA data) reserves for oil and gas and conclude that due to approaching peaks it is feasible to keep atmospheric $CO_2$ from exceeding approximately 450ppm as long as coal and unconventional fossil fuels are used responsibly.

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## Introduction

The twin problems of peak oil and climate change are rarely considered with respect to one another, in fact some leading climate change campaigners advocate not talking about peak oil at all (see George Monbiot's recent speech here and my response here). The problems are closely related and the best course of action must fully consider the best thinking on both subjects. For this reason I applaud Hansen as one of the very few climate scientists who does fully integrate an understanding of peak oil (and gas) into his work on climate change.

In this paper Hansen briefly introduces Hubbert's notion of peaking oil production rates when about half of the economically recoverable resource has been exploited, going on to mention subsequent work highlighting geological and geographical constraints that similarly lead to the pattern of growth, a production peak followed by declining production of minerals, natural gas and coal.

This seemingly obvious fact of life does not feature largely in today's studies of climate change:

> Despite the obvious relevance of "peak oil" to future climate change, it has received little attention in projections of future climate change. For instance, in the $CO_2$ emissions scenarios outlined in the Special Report on Emissions Scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC, 2000), socioeconomic and technological changes are employed as determinants of future energy use, without

explicitly addressing the consequences of peak production of fossil fuels.

The focus of the paper is the relevance that the *magnitudes and production rates* of remaining fossil fuels have to avoiding "dangerous anthropogenic interference" which is taken as likely at $CO_2$ concentrations of 450ppm and possibly lower.

## Reserves

This chart illustrates the fossil fuel reserves Hansen is working with. They are expressed in terms of their carbon content rather than energy content.

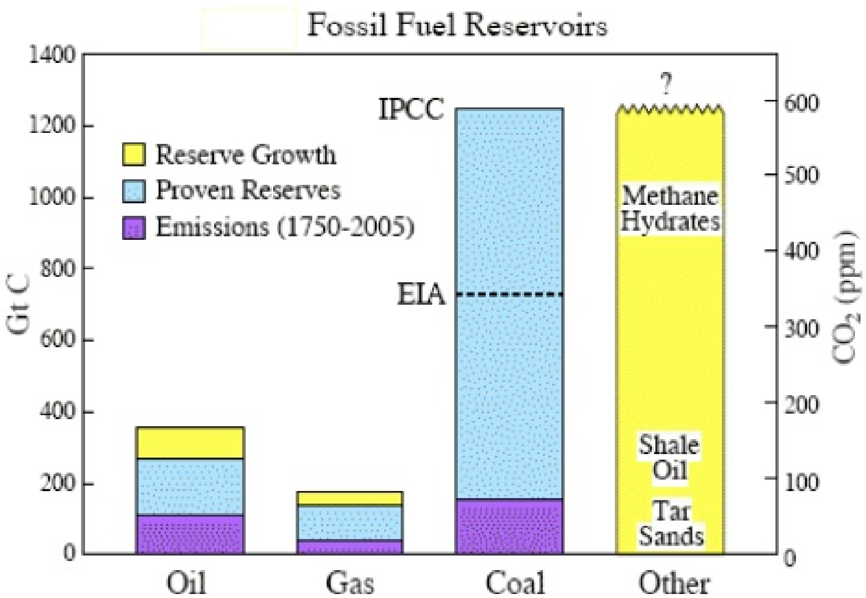


Fig 1. *Historical fossil fuel emissions (Marland et al., 2006; BP, 2006), current proven conventional reserve estimates for oil and gas (EIA, 2006) and coal (IPCC, 2001a), reserve growth estimates for oil and gas (EIA, 2006), and possible amounts of unconventional resources (IPCC, 2001a).*

## $CO_2$ Pulse Response

In addition to the magnitude of stated reserves this analysis also depends on how carbon emissions relate to atmospheric $CO_2$ concentrations. For this Hansen uses the following parameterisation of the Bern carbon cycle model:

$$CO_2 (t) = 18 + 14 \exp(-t/420) + 18 \exp(-t/70) + 24 \exp(-t/21) + 26 \exp(-t/3.4)$$

This pulse response function for anthropogenic $CO_2$ emissions illustrates the proportion of $CO_2$ that remains airborne t years after emissions and looks like this:

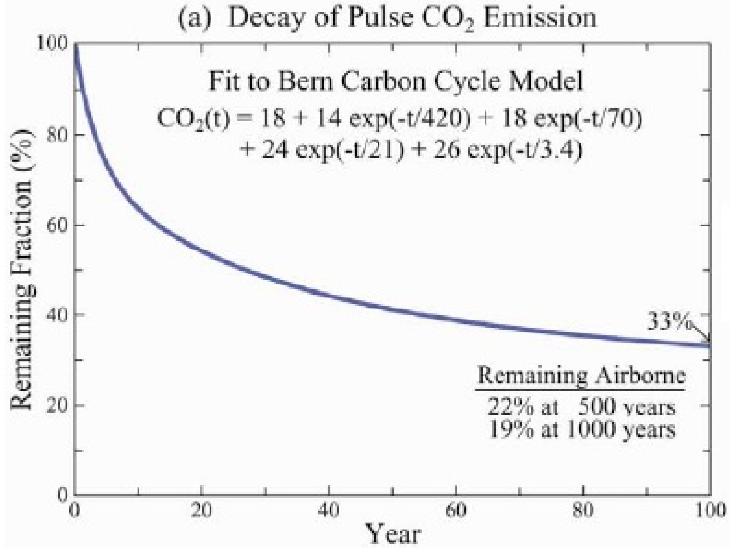


Fig 2. *Decay pulse*

> [the expression] implies that one-third of anthropogenic $CO_2$ emissions remain in the atmosphere after 100 years and one-fifth after 1000 years.

Hansen also points out that this should be considered as a “lower bound” as the uptake capacity of the oceans decreases as the dissolved carbon increases and there exists the potential for feedbacks to make additional $CO_2$ emissions. On feedbacks he makes this observation:

> However, the nonlinearities and climate feedbacks do not appear to have played a large role in the increase of atmospheric $CO_2$ from 280 to 382 ppm, so their effects may remain moderate if further $CO_2$ increase is limited.

We hear a lot about feedbacks these days with many mechanisms proposed however there seems to be little direct evidence that such nonlinear responses start **now** apposed to say 30ppm earlier or perhaps 30ppm later. This is a critical point, if feedbacks are not yet playing a critical role as Hansen hopes then perhaps we have a little linear “breathing room” to mitigate dangerous climate change through controlling our emissions. However if feedbacks are now critical climate drivers then there seems little scope for mitigation through anthropogenic emission control – in a feedback dominated system anthropogenic emissions are simply no longer the dominate variable, rendering much of this analysis academic.

Testing this pulse response with known anthropogenic emissions from 1750 to 2005 against measured $CO_2$ concentration increases shows an underestimation of approximately 15ppm – this Hansen ascribes to deforestation and soil disturbance.

## Scenarios

Four scenarios are modelled based on realistic reserves, the $CO_2$ pulse response and varying exploitation responses.

> In the **BAU scenario** peak oil emission occurs in 2016, peak gas in 2026, and peak coal in 2077. **Coal Phase-out** moves peak coal up to 2022. **Fast Oil Use** causes peak oil to be delayed until 2037, but oil use then crashes rapidly. **Reduced Oil Reserves** results in peak oil moving from 2016 to 2010, under the assumption that usage approximates

the near symmetrical shape of the classical Hubbert curve.

Coal phase out modelled thus:

> Coal Phase-out, is meant to approximate a situation in which developed countries freeze their usage rate of coal by 2012 and within a decade developing countries similarly halt increase in coal use. Between 2025 and 2050 it is assumed that both developed and developing countries will linearly phase out emissions of CO2 from coal usage. Thus in Coal Phase-out we have global CO2 emissions from coal increasing 2% per year until 2012, 1%/year growth of emissions between 2013 and 2022, flat emissions from 2023-2025, and finally a linear decrease to zero CO2 emissions from coal in 2050.

The results of these scenarios are summarised in this table and detailed in the following charts:

| **Scenario** | **Peak emission** | **Year of peak** | **Peak $CO_2$ level** | **Year of peak** |
|---|---|---|---|---|
| BAU | 14 Gt C/yr | 2077 | 580 ppm | 2100 |
| Coal Phase-out | 10 Gt C/yr | 2017 | 440 ppm | 2050 |
| Fast Oil Use | 11 Gt C/yr | 2025 | 460 ppm | 2050 |
| Less Oil Reserves | 9 Gt C/yr | 2022 | 425 ppm | 2040 |

*Peak fossil fuel $CO_2$ emissions and atmospheric $CO_2$ levels.*

Projected $CO_2$ emissions:

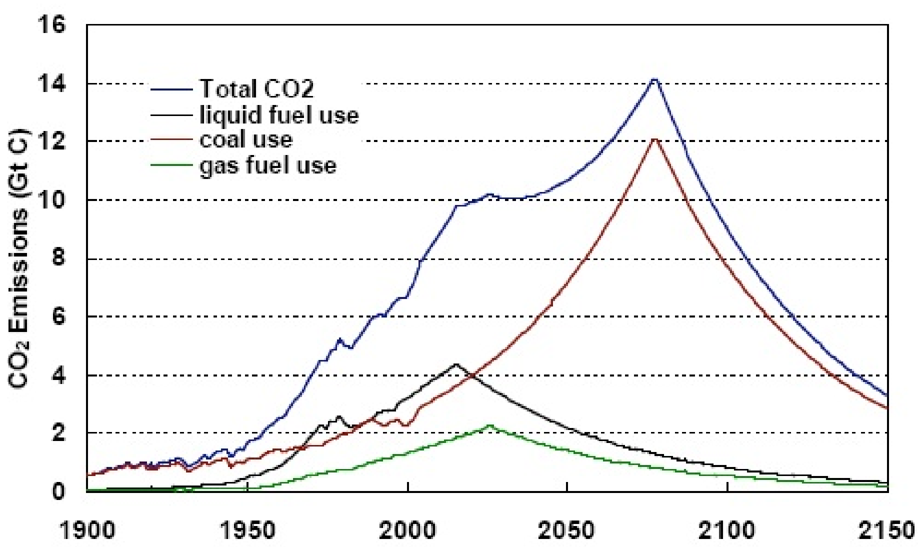


Fig 3. *$CO_2$ emissions: BAU*

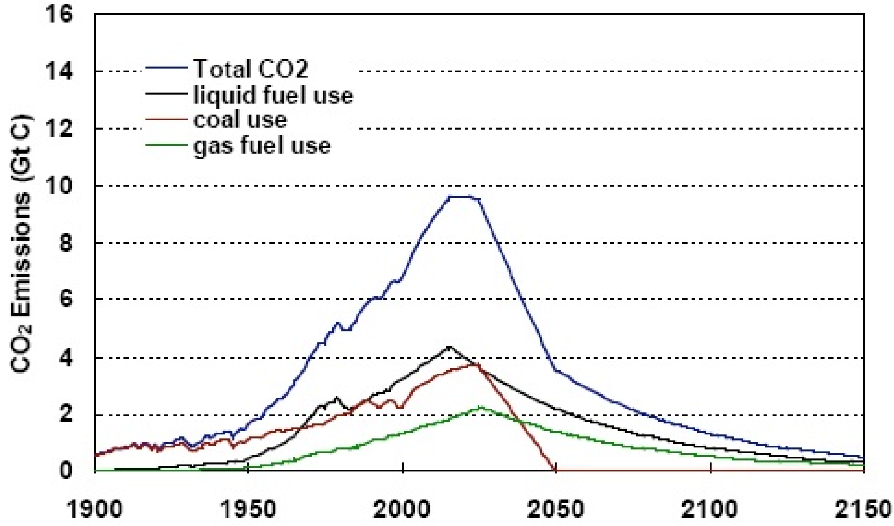


Fig 4. *$CO_2$ emissions: Coal Phase-out*

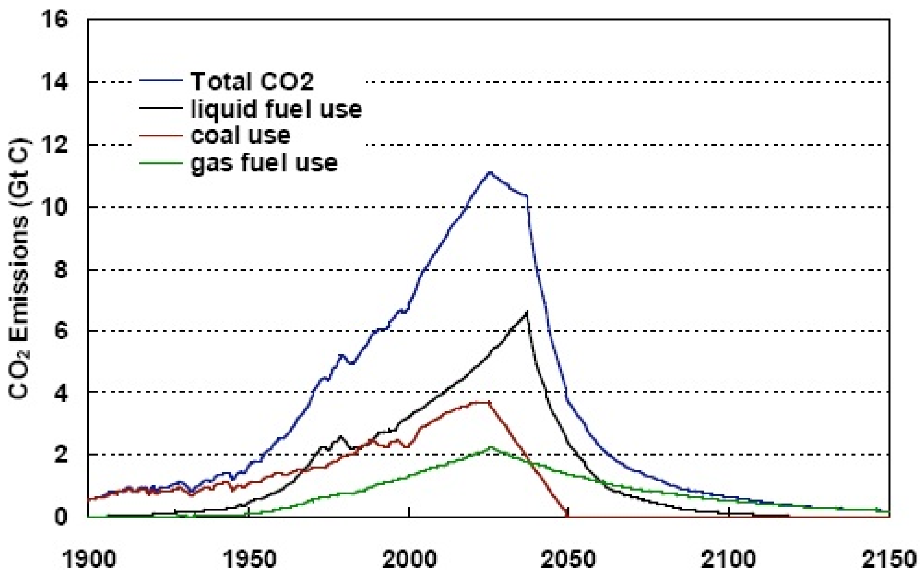


Fig 5. *$CO_2$ emissions: Fast Oil Use*

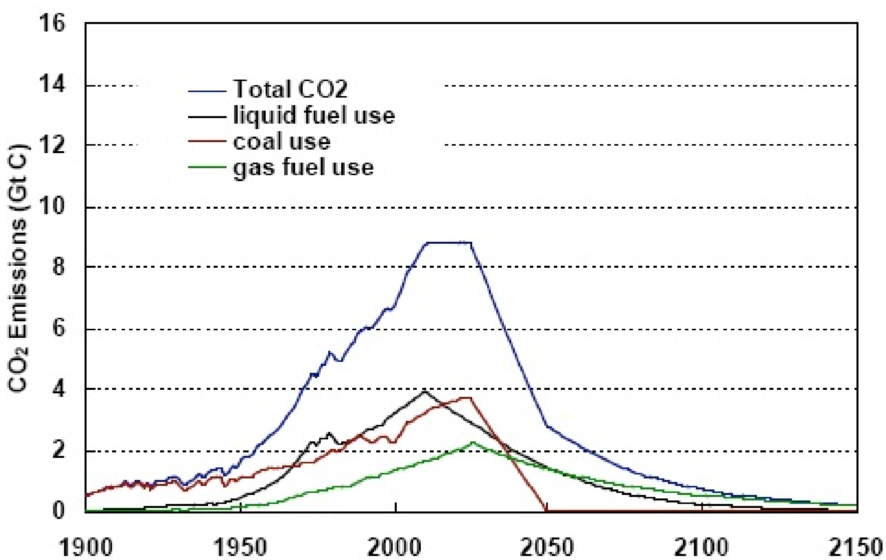


Fig 6. *$CO_2$ emissions: Less Oil Reserves*

Projected $CO_2$ concentrations:

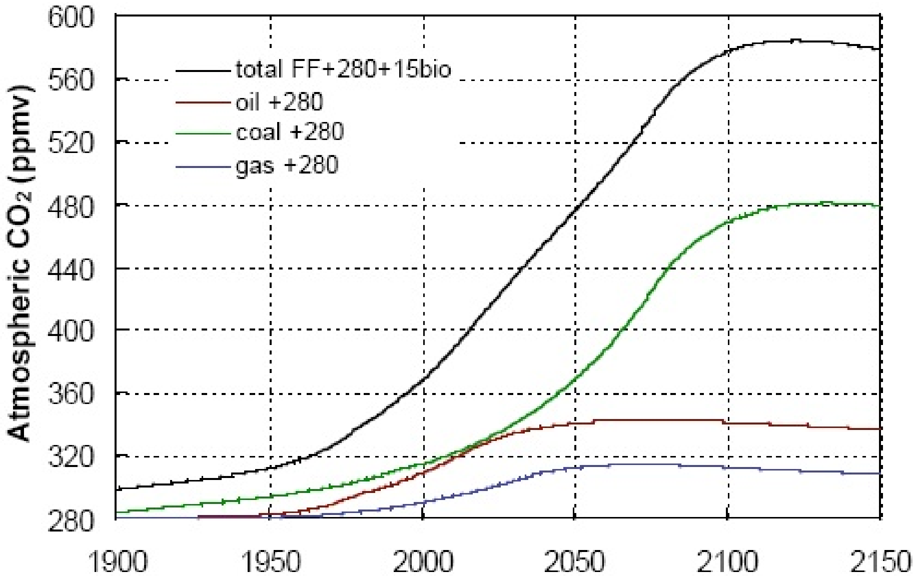


Fig 7. *Projected $CO_2$ concentrations: BAU*

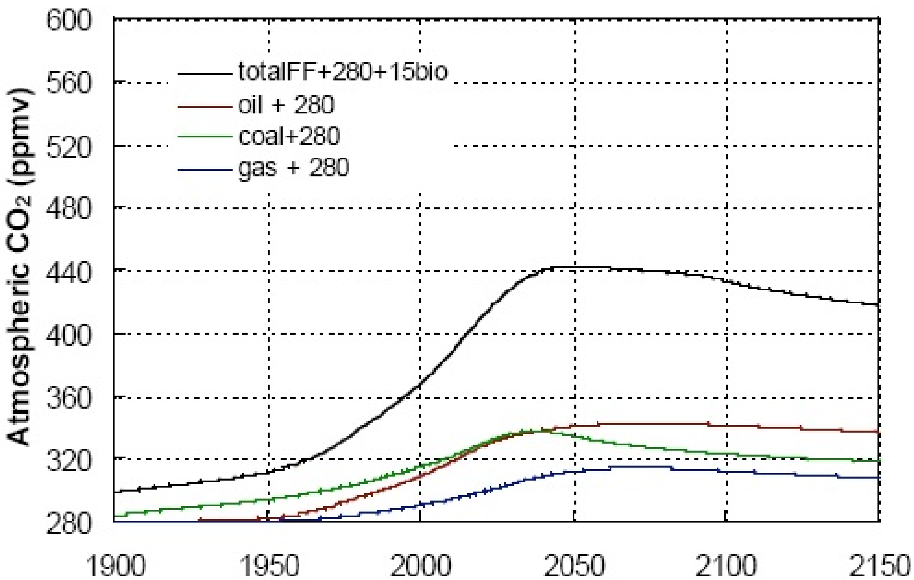


Fig 8. *Projected $CO_2$ concentrations: Coal Phase-out*

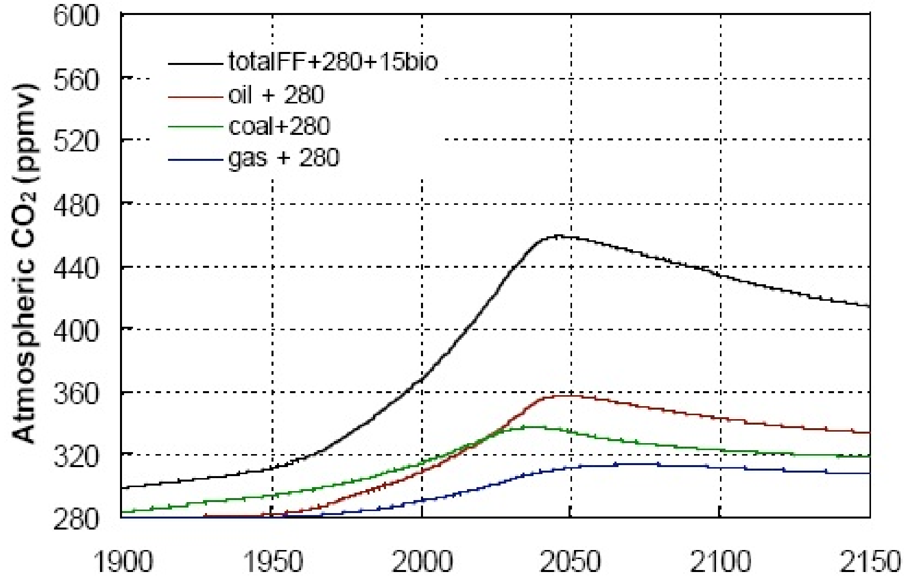


Fig 9. *Projected $CO_2$ concentrations: Fast Oil Use*

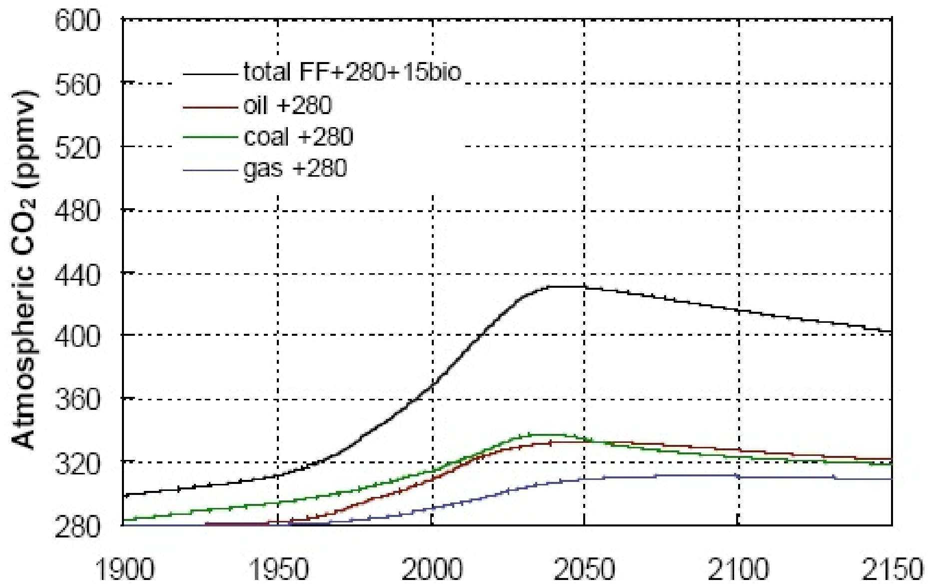


Fig 10. *Less Oil Reserves*

## Comparison with IPCC

The lower chart shows the atmospheric $CO_2$ concentration resulting from the $CO_2$ emissions scenarios outlined in the IPCC's Special Report on Emissions Scenarios (SRES). The Fourth Assessment Report (2007) has updated the temperature forecasts slightly from this chart however it's the $CO_2$ concentrations we are most concerned with here.

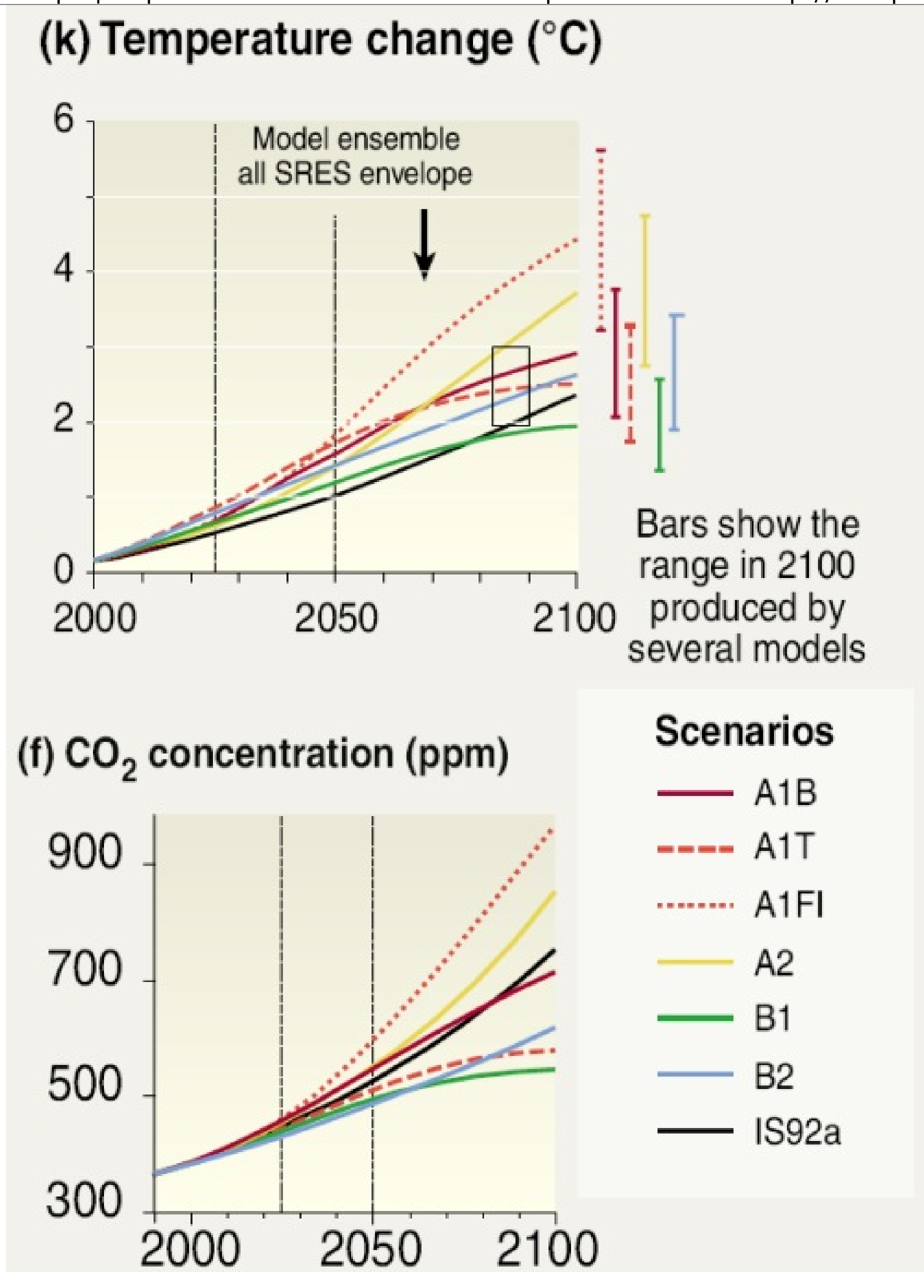


Fig 11. *IPCC Scenarios*
*Source: [IPCC 2001: Summary for Policymakers (.pdf)]*

For reference the A1F and A2 scenarios call for emissions in 2100 from fossil fuels of 30.3 GtC/yr and 28.9 GtC/yr respectively compared with 1990 emissions of 6.0 GtC/yr. The shear magnitude of fossil fuel reserves required to steadily increase emissions to approximately four times what they are now is incredible. Even the lowest A1T and B1 scenarios double 1990 emissions by 2050 before returning to a little below 1990 by the century's end. Source: [IPPC: Emissions Scenarios (.pfd)].

Compare these emissions with those in Hansen's table above. Note how most of the IPCC scenarios produce $CO_2$ concentrations far higher than even Hansen's BAU scenario when he considers realistic fossil fuel reserves.

By comparing the two BAU scenarios we can see how **Peak oil is clearly good news for climate change**. Hansen's Business as usual scenario tops out at 580ppm compared to the IPCC's over 900 and rising. In fact reading back from Hansen's $CO_2$ concentrations to the corresponding IPCC temperature change curve suggests less than 3°C.

## Hansen Interview

Kate Sheppard from the environmental news and commentary website Grist have an interview with James Hansen this week. The full text can be read here: Clarion Caller: An interview with renowned climate scientist James Hansen

When asked what needs to happen in the next few years he replies:

> A moratorium on coal-fired power plants and phasing those out over the next few decades. I think that's perhaps the most important thing.

On oil and gas Hansen adds:

> Then we also need to conserve the liquid and gas fuel so that we can develop the next phase of the industrial revolution because we're going to have to find energy sources that don't produce $CO_2$. In order to give us time to do that, we need to use oil and gas, which are precious fuels, as if they were precious.

Critically he's not taking about $CO_2$ from oil and gas here - he's talking about gaining maximum utility from oil and gas, making best use of the finite resource.

Later in the interview he explains how the $CO_2$ in oil and gas is all it takes to get to close to 450ppm adding *"It's pretty clear we're going to use those fuels…"*. This means we can't afford to burn much coal in a $CO_2$ free manner. He also says:

> A molecule of $CO_2$ from coal, in a certain sense, is different from one from oil or gas, because in the case of oil and gas, it doesn't matter too much when you burn it, because a good fraction of it's going to stay there 500 years anyway. If we wait to use the coal until after we have the sequestration technology, then we could prevent that contribution."

Sequestration of $CO_2$ from oil is likely never to be feasible but might work for coal. From a $CO_2$ point of view it doesn't really matter when the oil is burnt, any policy driven changes are only going to be on the order of years whereby $CO_2$ atmospheric life is many decades, even centuries. The timescales don't correlate.

## Activism and Conclusion

Whilst in this paper Hansen limits his recommendations to a moratorium on "free $CO_2$" (my shorthand term to represent non-sequestrated $CO_2$) exploitation of coal and unconventional fossil fuels and establishing a price on carbon emissions I have some further observations to make. Hansen's analysis suggests that oil and gas production is going to peak soon and as a result carbon in remaining reserves is relatively limited. Less than the IPCC scenarios assume and likely not enough to cross the "dangerous" threshold of 450ppm $CO_2$ atmospheric concentration. It follows then, that the climate change challenge we face is not so much to reduce oil and gas demand through policy and behavioural changes – to put it bluntly – we can leave natural depletion to reduce $CO_2$ emissions from these sources.

As we move into the post peak era, annual oil and gas combustion is determined by supply rather than demand, with increasing unsatisfied demand any achieved demand reductions will likely be absorbed elsewhere in the global economy leaving the global combustion and therefore emissions unchanged from what they would otherwise have been – the maximum that can be supplied. To suggest otherwise is to suggest that in the post peak era, policy decisions will further reduce oil supply from the geological potential.

Where mankind does have a degree of freedom to influence $CO_2$ emissions and the resulting concentration is in the exploitation of coal and unconventional fossil fuels, these being demand rather than supply limited for the time being. Primarily this means addressing electricity as that is where the vast majority of coal is used. This brings me back to environmentalists, not just the extreme who advocate against talking about peak oil but the majority who advocate addressing oil consumption as the number one response in the name of climate change. In light of Hansen's work I am unconvinced that **policies addressing oil demand** will influence the $CO_2$ contribution from oil, the bulk of which I expect to be burnt following the envelope of Hubbert's curve over the next few decades.

The mainstream view seems to be that aviation and driving, particularly SUVs are climate change enemies number one and two. This misconception arises from failure to consider the implication of peak oil. **Whilst advocating reduced aviation and driving is a thoroughly good thing for a wide range of reasons it is not an effective response to climate change, the most serious of threats.** We are not making the best use of available time, money and political capital that would be better spent on combating coal and unconventional fossil fuel exploitation.

Hansen shows us how an appreciation of realistic fossil fuel reserves is necessary to drive an effective response to climate change, this analysis is current lacking from the IPCC and from leading environmental NGOs in their lobbying of governments, leading to a less than optimal response to climate change being proposed.

## Professor Kjell Aleklett

Professor Kjell Aleklett, Uppsala University physicist and president of ASPO, The Association for the Study of Peak Oil & Gas, has recently written along similar lines considering oil, gas and coal peaks in comparison to the IPCC emission scenarios and finds the reserves wanting. Full text here: Global warming exaggerated, insufficient oil, natural gas and coal

> In the present climate debate, however, the amount of available fossil fuels does not appear to be an issue. The problem, as usually perceived, is that we will use excessive amounts in the years ahead. It is not even on the map that the amount of fossil fuels required in order to bring about the feared climate changes may in fact not be available.
>
> ...
>
> We do not have to discuss or doubt the established historic rise in temperature, but we have to discuss and doubt the future temperature increases that the IPCC scenarios project and the fossil resources that IPCC assumes in its prognoses.
>
> We need a new assessment of future temperature increases based on a realistic consumption of oil, natural gas and coal.

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