The Oil Drum: Europe

DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

IEA WEO 2008 - Fossil Fuel Ultimates and CO2 Emissions Scenarios

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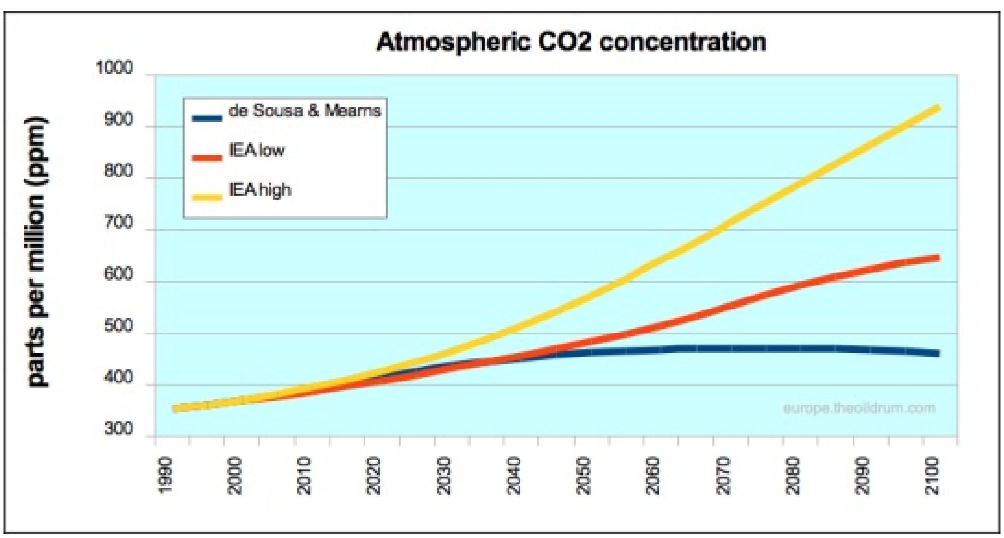
Part 3 of IEA WEO 2008 analyzes the expected impact of fossil fuel combustion upon climate change.

> Page 382: As emissions of greenhouse gases build up in the atmosphere faster than natural processes can remove them, their concentrations rise. The Reference Scenario puts us on a path to doubling the aggregate concentration in CO2 equivalent terms by the end of this century, entailing an eventual global average temperature increase up to 6 ºC.

Rather surprisingly, IEA WEO 2008 does not provide any data on fossil fuel reserves and production forecasts to 2100 to back up this claim. Instead, it chooses to rely upon fossil fuel reserve figures underlying the Intergovernmental Panel on Climate Change (IPCC) models. Furthermore, using MAGICC (climate temperature model), and the default climate sensitivity constants, we are unable to reproduce the outcome of as much as a 6 ºC increase.



Using a CO2 emissions scenario based on our 2008 Olduvai Assessment combined with MAGICC, we estimate that global average temperatures may peak at around 1.6ºC above 1990 values toward the end of this century. Other climate models may produce temperature outcomes higher or lower than this.

CO2 emissions from Energy in the overall emissions panorama

Part 3 of the IEA WEO 2008 report starts by characterizing the expected increase in CO2 emissions from energy usage from now until 2030. This is apparently done based on demand forecasts, without any adjustment for fossil fuel reserves and/or production constraints. CO2 emissions from energy usage are thus projected to grow from 28 Gt in 2006 to 41 Gt in 2030-–an increase of 45%. The outlook for the complete greenhouse emissions scenario is given as follows (page 381):

> World greenhouse-gas emissions, including non-energy CO2 and all other gases, are projected to grow from 44 Gt CO2-equivalent in 2005 to 60 Gt CO2-eq in 2030, an increase of 35% over 2005. The share of energy related CO2 emissions in total greenhouse-gas emissions increases from 61% in 2005 to 68% in 2030.

The growth in energy related emissions is projected to come mainly from outside the OECD, with coal accounting for the bulk of the growth. CO2 emissions from energy usage in the OECD are projected to remain flat until 2030. Worldwide CO2 emissions per capita are forecast to grow, with the non-OECD countries increasing toward OECD levels.

Non-energy related emissions are expected to increase more slowly than those related to energy usage. Industry and land-use represent the lion's share of these emissions, with gas flaring and cement production the next in importance. In the period to 2030, non-energy related emissions are forecast to grow mainly because of methane from wastewater, ruminants, coal mines and leaking pipelines.

Long-term CO2 emission scenarios

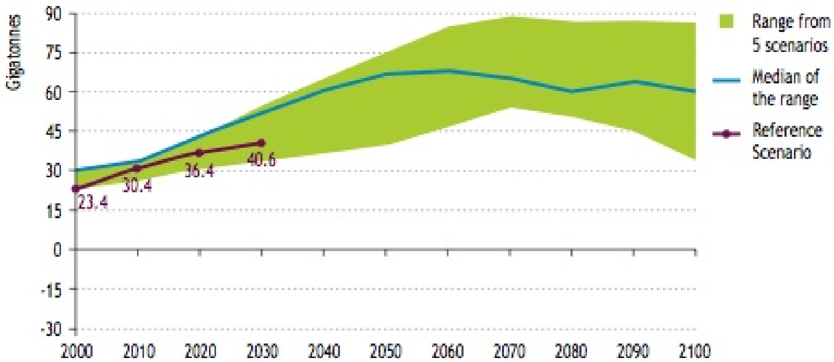
After a characterization of CO2 emissions by sector, the report goes on to forecast long term overall emissions of greenhouse gases and their impact on climate, something included for the first time in the report. To forecast long term overall emissions, the IEA used the latest version of MAGICC to model the carbon cycle until 2100. The atmospheric concentration of greenhouse gases is expressed in two ways: CO2 in parts per million (ppm) and total gases in ppm of CO2-equivalent. Today's concentrations are given as 385 ppm for CO2 and 445 ppm CO2-eq.

The report describes the emissions Reference Scenario on page 401:

> Our projected increase in energy-related CO2 emissions to 2030 lies in the middle of the range of CO2-equivalent emissions scenarios that have been modelled, assuming an absence of new climate policies (IPCC, 2007), with respect to both emissions and concentrations (Figure 16.16). Most of these scenarios project emissions to continue to rise during this century. The projected CO2 emissions are also consistent with model outputs of concentrations from MAGICC (Version 5.3). Atmospheric CO2 concentrations by around the end of next century are in line with the 660 to 790 ppm CO2 (855 to 1 130 ppm CO2-eq) ranges assessed from the five scenarios considered (IPCC, 2007). This leads to a temperature rise above pre-industrial levels of about 6ºC.

The fossil fuel consumption underlying the emissions reference scenario is not provided either graphically or numerically; the only projections presented are those shown in Figure 16.16. This shows the IEA reference case scenario to 2030 and the IPCC (2007) scenarios range. One might expect that the International Energy Agency would have provided the IPCC an energy scenario to work with. Instead, very surprisingly, the reverse has happened. The IPCC, a body that has little expertise in energy matters, has selected energy scenarios to use in its models, and the IEA has accepted without question the scenarios used by the IPCC.

Figure 16.16 • Energy-related CO_2 emissions in the Reference Scenario to 2030 compared with other published scenarios to 2100



Note: Shaded area gives the ranges taken from five scenarios published since 2001. Some of these included emissions of non-energy CO_2 and other greenhouse gases.

Sources: IPCC (2007); Nakicenovic (2007) and IEA analysis.

The IEA Ultimate Recoverable Reserves

The emissions range presented (Figure 16.16) has been converted into annual fossil fuel consumption figures and is compared in Figure 1 with the data gathered for the Olduvai Assessment presented on The Oil Drum in February 2008.

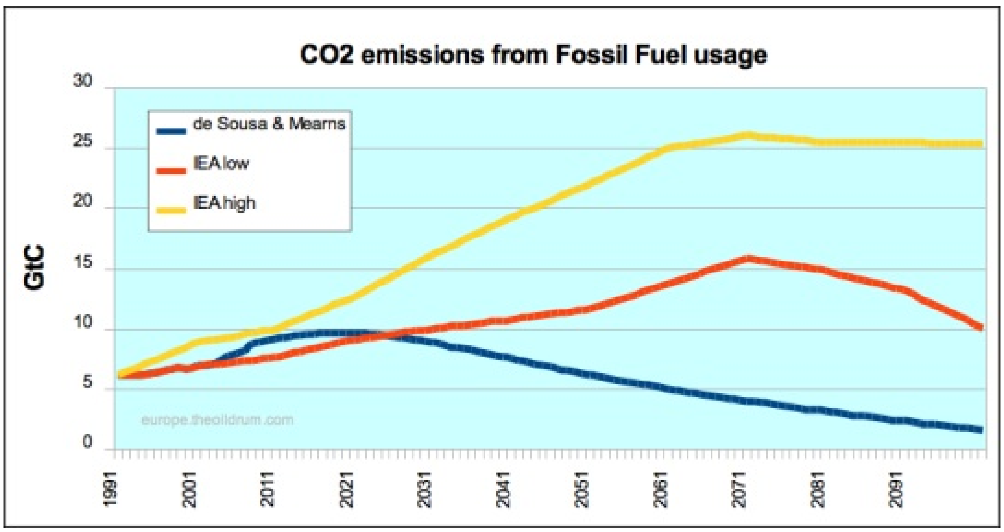


Figure 1 – Carbon emissions from energy consumption (expressed as giga tonnes carbon). The blue line in all charts is de Sousa and Mearns' 2008 Olduvai Assessment.

The energy scenarios range used by the IPCC and copied by the IEA are represented here as a low case and a high case, corresponding to the boundaries of the range. While the Olduvai scenario remains within the range up to 2025, it afterwards evolves below the IPCC / IEA's forecasts. The low case scenario peaks by 2070. At that time, the cumulative fossil fuel production is 1200 Gtoe; it surpasses 1600 Gtoe by 2100. The high case scenario enters a plateau that implies yearly fossil fuels production of 30 Gtoe (triple of today) with cumulative production exceeding 2600 Gtoe by 2100.

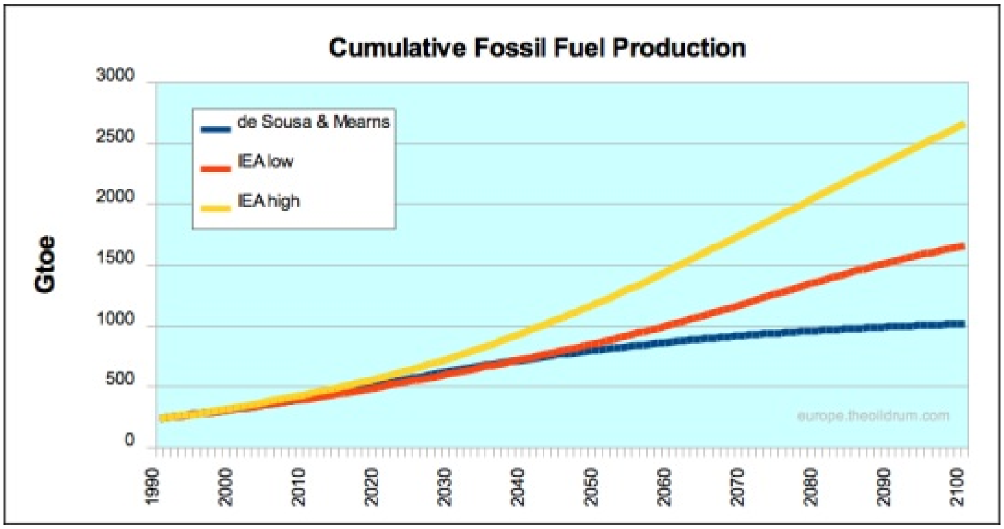


Figure 2 – Cumulative fossil fuel production associated with various CO2 estimates.

The ultimate recoverable reserves (URR) used for these scenarios can be calculated to be around 2400 Gtoe for the low case (considering a mid-point of depletion at the peak in 2070) and at least 4400 Gtoe for the high case (considering immediate decline after 2100). These numbers are higher than fossil fuel reserve assessments based on geological data, dwarfing for instance those presented in the Olduvai assessment (1050 Gtoe) or those published by BP in its annual [Statistical Review of World Energy](#).

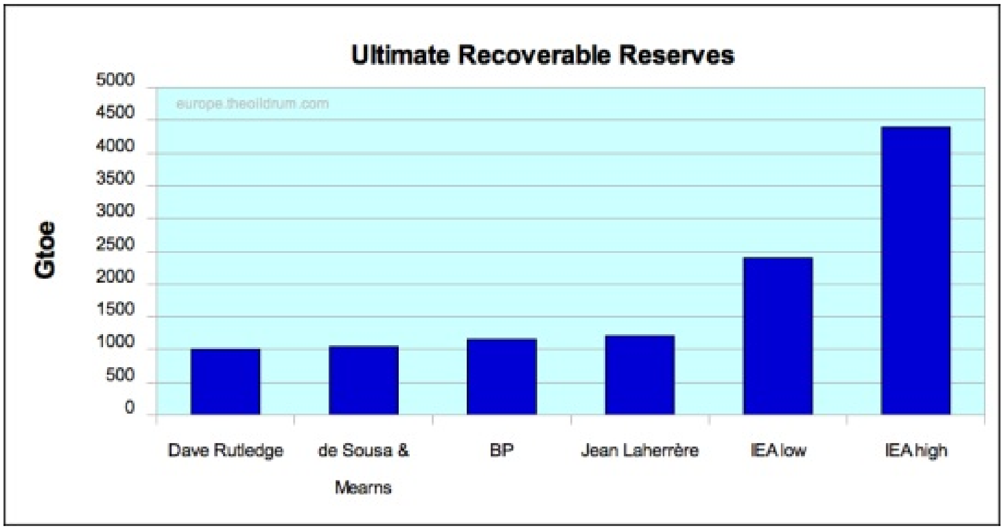


Figure 3 – Ultimate Recoverable Reserves from the IEA's scenarios compared with other

estimates. Note that the IEA estimates are based upon the CO2 emissions scenarios of the IPCC.

In 2001, Jean Laherrère delivered a report at a conference of International Institute for Applied Systems Analysis calling for a serious review of oil reserves by climate modellers working for the IPCC. So far, that call has been left unanswered. Last year Professor Kjell Aleklett wrote an article, once more stressing that the fossil fuel reserve estimates used by the IPCC are not realistic, even when compared with the industry's numbers.

Impacts on climate

MAGICC was used to assess the expected temperature increase arising from the production of fossil fuels at the rates identified in the Olduvai Assessment. The program was run with the default climate sensitivity parameters. Non-energy related emissions were based on Tom Wigley's latest WRE profiles (kindly provided by Professor David Rutledge). Two other runs were performed, one for each of the energy emissions' boundary scenarios presented by the IPCC /IEA. The results are presented in Table 1.

Table 1 – Atmospheric CO2 concentrations and temperature increases by 2100 for each scenario according to MAGICC.

	CO2 (ppm)	Temp. (ºC)
de Sousa & Mearns	(*) 460	1.6
IEA low	645	2.5
IEA high	940	3.5

(*) after peaking at 470 ppm by 2075.

Using geology-based fossil fuel resource data, the atmospheric concentration of CO2 peaks before the end of the century, while both of the IPCC/IEA scenarios show concentrations still increasing until 2100. The range resulting from the IPCC/ IEA's boundaries is relativity large and matches the 700 ppm figure pointed out at the opening of Chapter 16.

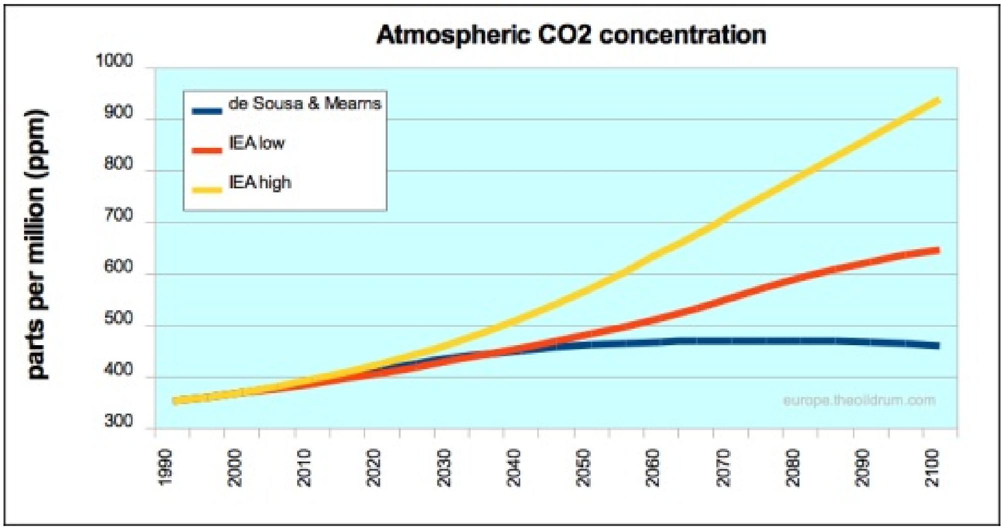


Figure 4 – Atmospheric CO2 concentrations throughout the 21st century for the emissions scenarios in Figure 1, as calculated by MAGICC 5.3.

As for temperatures, the picture is not as clear. The output of MAGICC 5.3 indicates an increase of 2.5 ºC to 3.5 ºC over 1990 levels by 2100, quite far from the 6 ºC indicated in the WEO 2008 report. Using the data from the Olduvai assessment, temperatures stabilize at 1.6 ºC above 1990 levels after 2085.

Note that in order to compare the fossil fuel emissions scenario of the Olduvai Assessment with those presented by the IEA, we have used the default sensitivity constants used in MAGICC. This does not mean that we agree with these constants.

It should also be noted that modeling global average temperature change based on variations in CO2 is imprecise and that a number of different climate models exist that produce different results. MAGICC has been used by the IPCC in its reports and tends to produce results towards the mid of this range.

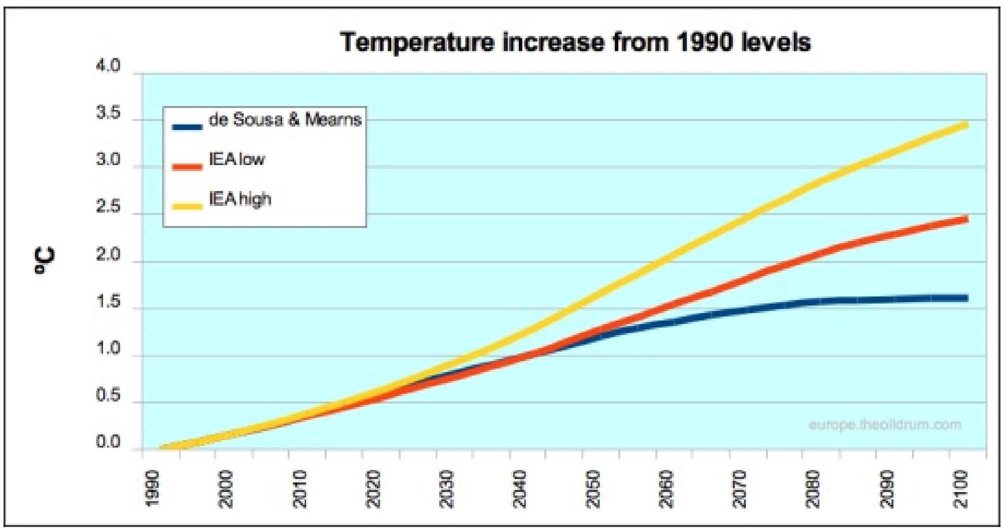


Figure 5 – Temperatures increases during the 21st century for the emissions scenarios in Figure 1, as calculated by MAGICC 5.3.

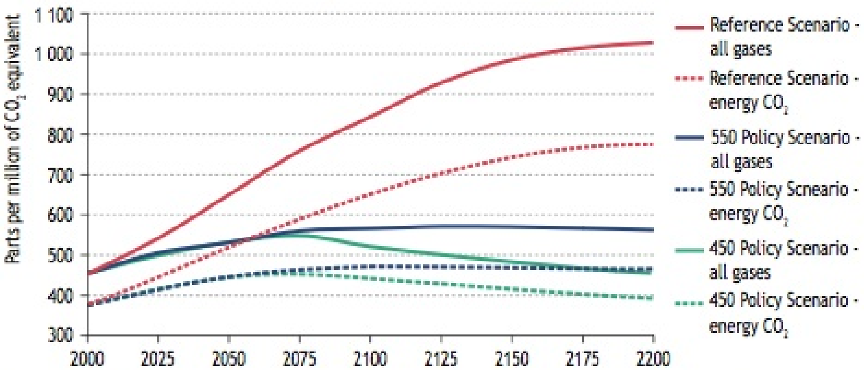
How does the discrepancy arise between the IEA projected temperature described in the report and the indications reported here using their data and the MAGICC simulation? Given that the CO_2 concentrations in the report and the simulation seem to match, we can propose two hypotheses:

- The 6 ºC refers to a later date, in a simulation where large amounts of fossil fuels continue to be available unconstrained throughout the 22nd century and maybe beyond;
- The climate sensitivity parameters used by the IEA were different from those used by default in MAGGIC.

MAGGIC incorporates a logarithmic temperature response function to CO_2 concentrations. With this function, each doubling of CO2 increases temperature by a fixed amount. This amount is by default 2.6 ºC, taken from the IPCC's Third Assessment Report. Because of this relationship, in order to increase temperatures 2.6 ºC above pre-industrial levels atmospheric CO2, concentrations have to reach circa 560 ppm; for an increase of 6 ºC, close to 1500 ppm are needed.

Figure 17.3 on page 414 shows a CO2 concentration graph that extends to 2200. It shows stabilization of CO2 around 775 ppm for the reference scenario after 2175. In order for this scenario to produce an increase of 6 ºC, the climate sensitivity parameter used must have been around 4.1 ºC per doubling of CO2. Were that the case, the CO2 concentration increase of 70 ppm during the 20th century would have resulted in a temperature increase of 1.3 ºC, almost double that observed so far.

Figure 17.3 • Greenhouse-gas concentration trajectories by scenario



Note: We used MAGICC (Version 5.3)[7] to confirm that the projected emissions for all greenhouse gases to 2030 would result in concentration trajectories consistent with achieving stabilisation at around 700 ppm CO_2 (equivalent to around 1 000 ppm CO_2-eq) in the Reference Scenario, at 450 ppm CO_2 (550 CO_2-eq) in the 550 Policy Scenario and 380 ppm CO_2 (450 ppm CO_2-eq) in the 450 Policy Scenario.

The Policy Scenarios

In Chapter 17, the report lays down two policy scenarios intended to reduce the long term atmospheric CO2 concentrations resulting from the emissions projected by the Reference Scenario. The objectives of such scenarios are explained in page 410:

> There is no international consensus as yet on a long-term stabilization or emissions objective, or on the emissions trajectory to its attainment. Nonetheless, international discussions are increasingly centred on a stabilization level that ranges between 450 and 550 CO2-eq. According to the IPCC's *Fourth Assessment Report*, stabilization at 450 pp CO2-eq corresponds to a 50% chance of restriciting the increase in global average temperature to around 2 ºC, while stabilization at 550 ppm yields a rise of around 3 ºC (compared with 1 000 ppm and up to 6 ºC in the Reference Scenario). This *Outlook* analyses the implications for the energy sector of international and national policy action to achieve these stabilisation levels in a 450 Policy Scenario and a 550 Policy Scenario.

Again, these relations between projected temperature and CO2 allude to a climate sensitivity parameter much higher than what the IPCC used in its assessment reports and that used as default in MAGICC.

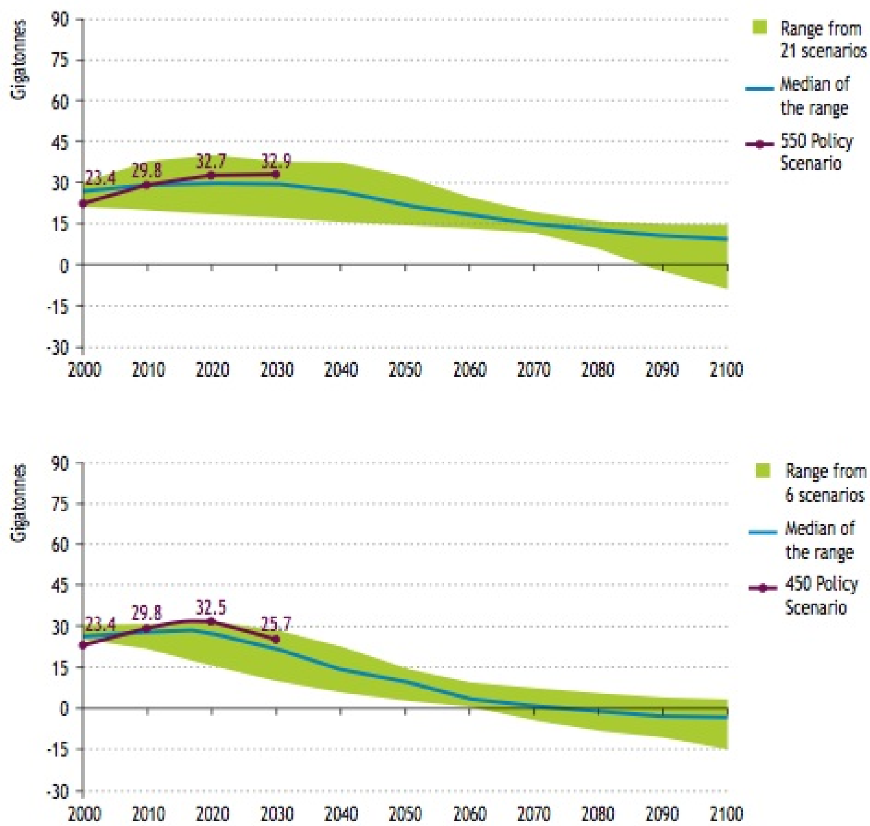
The report goes on to consider the “transformation” the energy sector should undergo to support such scenarios. More efficient energy sources usually take long periods of time to enter the market, because the sector has a slow rate of capital replacement. This is especially the case in the electricity sector, where fossil fuel power plants require large upfront investments. Policies to reduce CO2 emissions would result in costly early retirement of infrastructure.

Page 414 notes that these two scenarios would require global participation, including both OECD and non-OECD countries. This is justified by the expected energy consumption growth outside the OECD, especially in Asia. Energy related emissions from non-OECD countries already surpass those from within the OECD, making any policy scenario without global participation pointless.

In the 550 Policy Scenario, emissions are required to level out around 2020 and start declining after 2030. The 450 Policy Scenario requires an immediate and sharp decline in emissions after 2020. In the later scenario, CO2 concentrations are actually allowed to temporarily surpass the 450 ppm target, stabilizing at that level only in the 22nd century. According to the IEA, any scenario preventing concentrations from reaching those levels is unlikely, because the infrastructure needed to comply with it couldn't be deployed in time.

As in the previous chapter, the energy related CO2 emissions underlying the Policy Scenarios are not made available beyond 2030, and once again the IEA report uses the energy scenario ranges from the IPCC instead (figure 17.4 from page 415). The following figures compare these scenarios with the data assessed for the Olduvai Assessment.

Figure 17.4 • Energy-related CO_2 emissions in the 550 Policy Scenario and 450 Policy Scenario



Sources: IPCC (2007); IEA analysis.

Note: The ranges are taken from published scenarios, some of which include industry CO_2 emissions whereas others only include energy-related CO_2 (Nakicenovic, 2007). The 550 Policy Scenario is compared to the IPCC's Class III of scenarios (440-485 ppm CO_2; 535-590 ppm CO_2-eq; ~3°C temperature rise); the 450 Policy Scenario is compared to the IPCC's Class I of scenarios (350-400 ppm CO_2; 445-490 ppm CO_2-eq; ~2°C temperature rise). The *WEO*'s CO_2 pathways are also consistent with the analysis of non-energy CO_2 and other greenhouse gases discussed in Chapter 18.

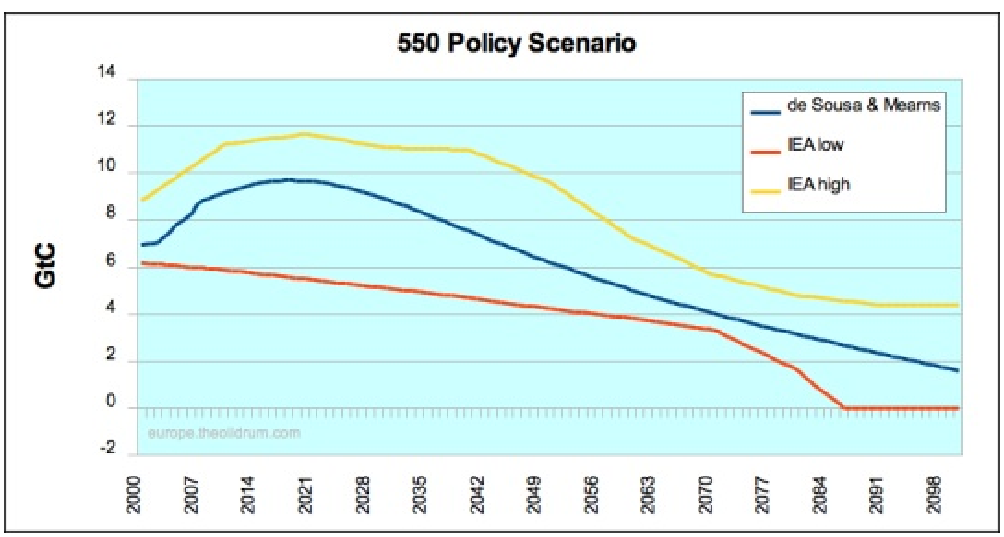


Figure 6 – The IEA's 550 Policy Scenario compared with the emissions based on the Olduvai

Assessment. Click for large version.

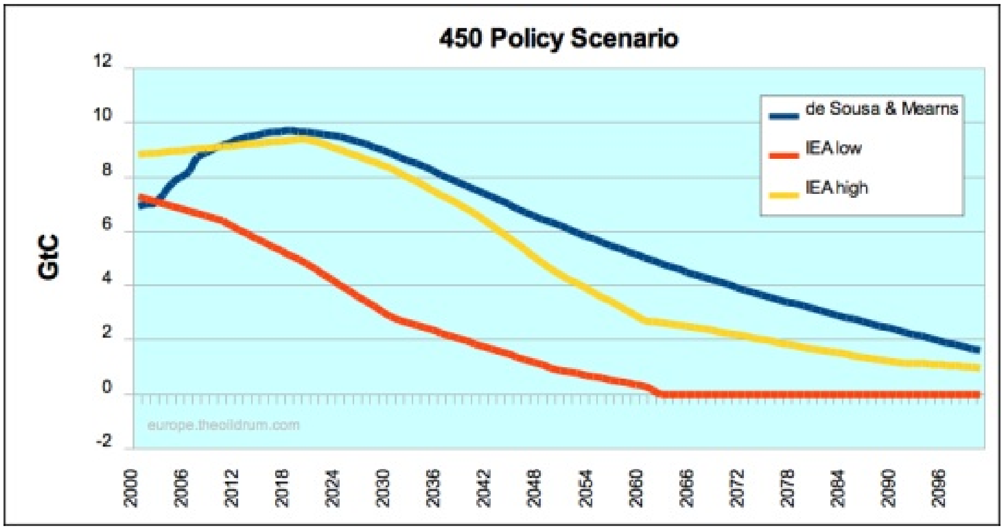


Figure 7 – The IEA's 450 Policy Scenario compared with the emissions based on the Olduvai Assessment. Click for large version.

It is interesting to note how the Olduvai scenario falls right in the middle of the 550 Policy Scenario range, with emissions going into decline visibly earlier than the high boundary curve. Comparing to the 450 Policy Scenario range, the Olduvai curve stays close to the high range up to 2030, diverging afterwards. But these graphs which extend only to 2100 do not show the complete picture. By end of the 22nd century, with the data used in the Olduvai assessment, CO2 concentrations (from all emitting sources) decline to 410 ppm, which is actually below what the report depicts in Figure 17.3 (page 414).

The main difference between the IEA 450 Policy Scenario and what should be expected from the unconstrained use of fossil fuels reserves in the Olduvai Assessment is the length of time CO2 concentrations stay above 450 ppm. Earlier work on The Oil Drum indicates that different patterns in coal reduction can be obtained by differing energy policies. (See end notes). Since coal is the fossil fuel farthest away from production decline, an approach of this type may help keep CO2 within desired parameters.

Conclusions

The IEA presents a scenario for future fossil fuel use, based on doubtful reserves and production estimates that are significantly higher than the figures both the energy industry and independent researchers have assessed. This cheerful view of Man's energy future is never set forth by the IEA in clear numbers or graphs. Instead, it is hidden behind scenarios provided by a third party (the IPCC) whose object of study is not energy.

Throughout these chapters, the IEA refers to potential climate impacts that imply a CO2 sensitivity parameter that is higher than that assessed by the IPCC and used by default in the temperature modelling software used. Such high sensitivity is incompatible with the empirical relationship between global temperatures and CO2 concentrations in recent decades.

These inconsistencies undermine much, if not all, the recommendations implicit in the 450 and 550 ppm policy scenarios. Our 2008 Olduvai Assessment suggests that CO2 emissions will fall this century with the exhaustion of fossil fuel reserves. This alone will provide the desired outcomes of the 450 and 550 ppm scenarios, without burdening the OECD and non-OECD countries with artificial constraints on their energy use.

The fossil fuel reserves and production estimates underlying our Olduvai Assessment are those produced in good faith by third parties (Samuel Foucher, Jean Laherrere, the Energy Watch Group and David Rutledge). We would be the first to agree that there are significant uncertainties in these data, and that these alone should not be used uncritically to plan the future energy supplies and CO2 emissions of mankind. The IEA should provide to us - their OECD clients - with *their* verifiable data on earth's oil, natural gas and coal reserves so that mankind's energy future and environmental impact can be properly modeled and forecast. WEO 2008 falls well short of this basic requirement, choosing instead to recycle dubious fossil fuel reserve estimates, and to draw similarly dubious conclusions about climate change from these, when their focus should be firmly fixed upon energy decline and growing energy poverty within the OECD.

Acknowledgement

The authors would like to thank Professor David Rutledge, California Institute of Technology, for data and advice provided during the preparation of this report.

Previous work at TheOilDrum

The Coal Question and Climate Change

Implications of "Peak Oil" for Atmospheric CO2 and Climate

Appendix

The files used to run the MAGICC simulations can be downloaded from the following links:

Olduvai

IEA low

IEA high

To be used by MAGICC the files' extension have to be changed to ".gas".