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Scenarios for Global CO_2 Emissions

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Abstract

According to the Intergovernmental Panel on Climate Change (IPCC), global greenhouse gas (GHG) emissions must be reduced by 50 to 80 percent by 2050 to avoid dramatic consequences of global warming. The development of global CO_2 emissions depends on policies and regulatory framework implemented to reduce global warming, and, therefore, scenarios for CO_2 emissions show large variations depending on what assumptions are used. According to a business-as-usual scenario established by the International Energy Agency (IEA), global CO_2 emissions will more than double from now until 2050. On the other hand, studies from IEA show that establishing incentives and regulatory framework favoring new technologies could reduce global CO_2 emissions in 2050 by 27 percent compared to emissions today.

All the scenarios from IEA indicate that 50 to 80 percent reduction in global CO_2 emissions will *not* be achieved. Therefore, sufficient reductions in global CO_2 emissions can only be achieved by introducing far more ambitious policies and incentives than addressed by the IEA.

1. Introduction

Emissions of greenhouse gasses (GHG) will increase the average global temperature by 1.1 to 6.4 ^oC by the end of the 21st century [1] according to the Intergovernmental Panel on Climate Change (IPCC). A global warming of more than 2 ^oC increase in global average temperature will lead to serious consequences, and IPCC have therefore stated that global GHG emissions should be reduced by 50 to 80 percent by 2050 [2].

The consequences of too high global warming will be melting of glaciers, leading to reduced water and food resources. The sea level will rise, and there will be more extreme weather, more draughts, and more floods. As a consequence more than 200 million humans can become climate refugees. Ecosystems will be disrupted, and 15 to 40 percent of all species can be extinct [3,4, 5].

The International Energy Agency (IEA) has published several reports with detailed analysis of future energy demand and resulting CO_2 emissions. The report "World Energy Outlook 2006" [6] is a comprehensive report with studies on global energy demand from today and until 2030, and the report "Energy Technology Perspectives 2006" [7] presents scenarios on how a wide and rapid introduction of new technology can reduce global CO_2 emissions by 2050. None of these reports indicate sufficient reductions in CO_2 emissions to avoid global warming above 2 ^oC.

The objective of this paper is to analyze how global energy demand and CO_2 emissions will develop based on the assumptions and scenarios established by the IEA. This paper will also present the suggested actions by IEA for reducing global CO_2 emissions. Furthermore, the scenarios from IEA will be compared to scenarios established by the IPCC.

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Scenarios for global energy demand and CO_2 emissions are presented in Section 2 and 3, respectively. A discussion of the scenarios is given in Section 4 before conclusions are presented in Section 5.

2. Scenarios for Energy Demand

2.1. The Reference Scenario (RS) and the Alternative Scenario (APS)

Anthropogenic CO_2 emissions are mainly a result of energy production based on fossil fuel. In order to predict future CO_2 emissions it is therefore necessary to perform a comprehensive analysis of future energy demand. The IEA has established two scenarios for future energy demand; a *Reference Scenario* (*RS*) and an *Alternative Policy Scenario* (*APS*) [6].

The *RS* is a business-as-usual scenario where today's trends in the energy market are expected to continue unchanged until 2030. This scenario predicts a large increase in CO_2 emissions and an energy demand not in balance with energy resources. Therefore, the IEA has characterized the *Reference Scenario* as not sustainable. The *Alternative Policy Scenario* is therefore established to identify how "*actions considered today, but not implemented yet*" can contribute to a more sustainable development in energy demand by 2030. These actions include:

- A large increase in bio fuel production.
- More biomass for heating in the western world.
- The establishment of fiscal incentives favoring increased renewable energy production.
- More nuclear energy.
- The establishment of directives for enhanced energy efficiency in buildings.
- The establishment of programs for improving technologies for cleaner energy production from coal (often referred to as *Clean Coal*).

The two most obvious measures for reducing global CO_2 emissions are enhanced energy efficiency and increased production of renewable energy. The *APS* assumes stronger incentives for energy efficiency and renewable energy than the *RS*. As a result, the *APS* indicates lower energy demand and higher renewable energy production than the *RS*, as shown in Figure 1.

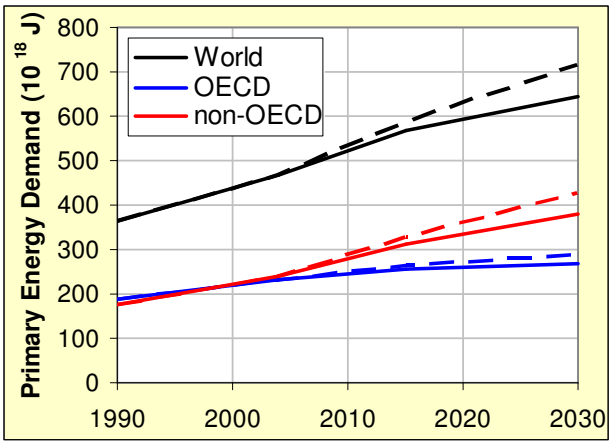

Figure 1 – Global primary energy demand. Full lines represent the IEA Alternative Scenario and dotted lines represent the IEA Reference Scenario.

Today's increase in the global energy demand is mainly due to large global population growth and large economic growth in developing countries such as China and India. The global energy demand is expected to increase by 50 percent by 2030 according to the *RS*, while the *APS* indicates a somewhat lower growth. Figure 1 shows that most of the growth in global energy demand will take place in the developing countries, represented by non-OECD countries in the figure.

2.2. Energy Sources

Fossil fuels are the most important energy sources today. Even though a large increase in renewable energy is expected, fossil fuels will still be the most important energy sources in 2030. Figure 2 shows sources for global energy production, and although the energy demand will grow, the different sources are expected to have similar marked shares in 2030 as today. According to the *APS*, fossil fuels will account for 77 percent of global

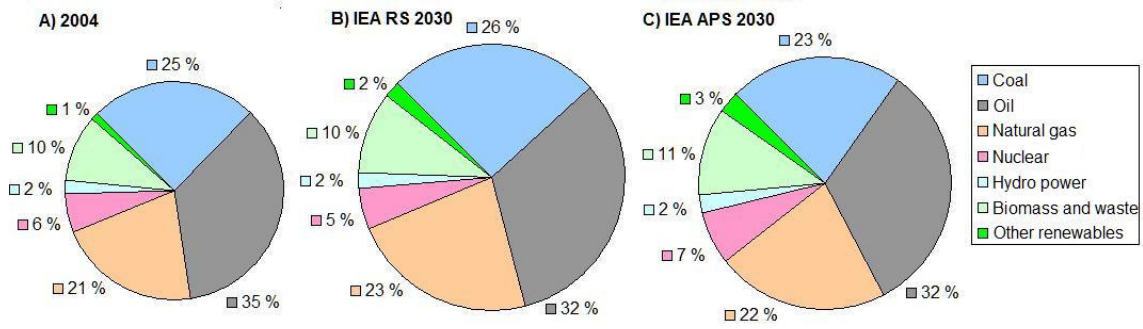

Figure 2 - Primary global energy demand split on energy sources. Left: 2004. Middle: The IEA Reference Scenario in 2030. Right: The IEA Alternative Policy Scenario in 2030. The area of the circles reflects the total global energy demand.

energy consumption in 2030. This is only a small reduction of the marked share today which is 81 percent.

Renewable energy sources like solar, wind, wave, tidal, and geothermal are represented as ”other renewables” in Figure 2. The market share of such renewable sources is expected to be three times higher in 2030 than today. This is a considerable increase in renewable energy production, but the market share increases only from 1 to 3 percent according to the *APS*. The share of all renewable sources, *i.e.* hydropower, biomass and those other renewable sources mentioned above, will, according to *APS* be 16 percent in 2030. This is only a slight increase from today's market share of 13 percent of the total energy production. Due to the large increase in global energy demand, and the low marked share of renewable energy there will still be a large gap between energy demand and renewable energy production in 2030. This gap has to be filled by fossil fuels, and the world will therefore continue to be dependent on fossil fuels for several decades.

2.2. Energy Demand by Sectors

Energy demand can be divided into four sectors: Power Generation, Industry, Transport, and Other Sources (*i.e.* buildings, agriculture, etc). The energy demand is largest in the power generation sector as seen in Figure 3. This is also the sector where the largest increase in energy demand is expected, and, according to the *APS,* 40 percent of the total energy demand will be required for power generation in 2030. The large increase in power generation is due to large economic growth in several developing countries, resulting in higher power demand. As an example, China is commissioning a new coal fired power plant every week [8].

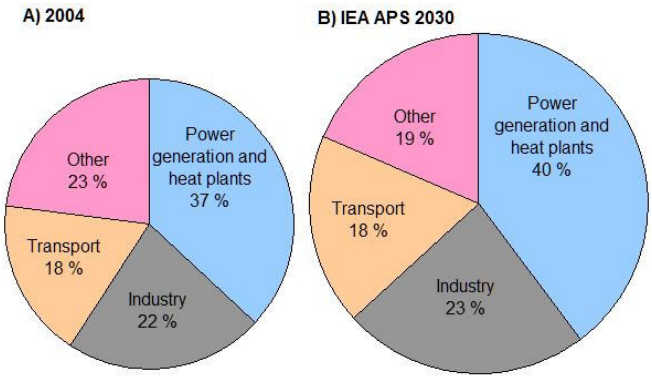

Figure 3 - Primary global energy demand from different sectors. Left: 2004. Right: The IEA Alternative Policy Scenario (APS) in 2030. The IEA Reference Scenario shows similar market shares as APS in 2030. The area of the circles reflects the total global energy demand.

2.3. Comparison of IEA and IPCC Scenarios

The analysis from the IEA is based on a comprehensive database with detailed energy data from countries and sectors worldwide. As such, the IEA studies are some of most cited scenarios on energy demand and CO_2-emissions. However, the

IEA has been criticized for being too conservative regarding the potential for energy efficiency and renewable energy. Therefore, a comparison of scenarios from the IEA and the IPCC has been performed.

The IPCC has established 40 scenarios for global energy demand and CO_2 emissions based on different models for economical, technological, and demographical development [9]. The IPCC has summarized its results in four main scenarios. The scenarios with highest and lowest predicted energy demand of the four main IPCC scenarios are compared to the IEA scenarios in Figure 4. IEA and IPCC predicts similar trends in global energy demand and renewable energy production. This is an indication that IEA and IPCC have concurrent points of view on development of energy demand and CO_2 emissions.

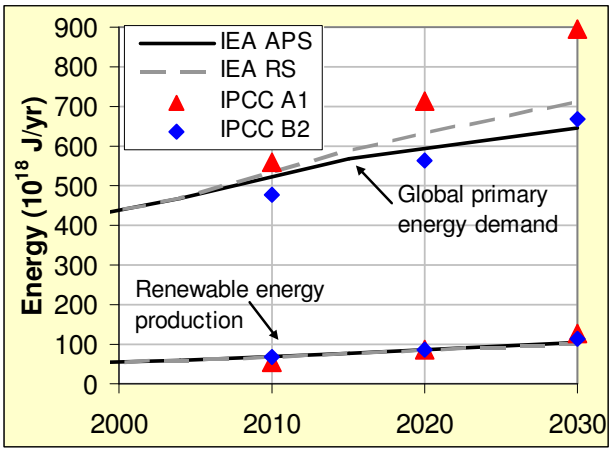

Figure 4 – Global energy demand and renewable energy production from the IPCC and IEA scenarios. Only the A2 and B2 of the four main IPCC scenarios are shown.

3. CO_2 Emission Scenarios

3.1. Global CO_2 Emissions Until 2030

In a business-as-usual scenario (*i.e. RS*) the global CO_2 emissions is expected to increase with as much as 48 percent by 2030. The IEA Alternative Scenario also predicts increased CO_2 emission by 2030, and according to *APS*, global CO_2 emissions will be 26 percent higher in 2030 than today. Figure 5 shows that most of the increased emissions will take place in non-OECD countries. This is a consequence of the large increase in energy demand in developing countries.

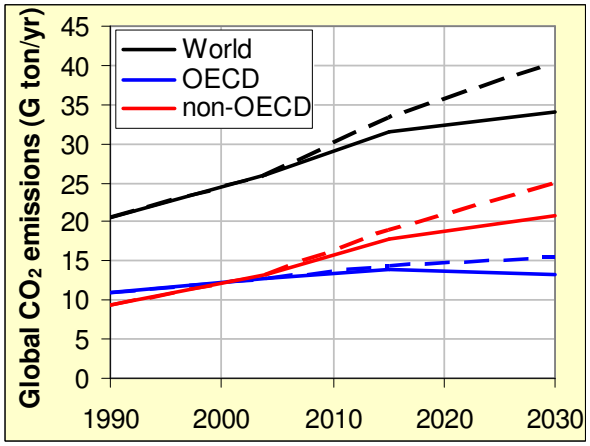

Figure 5 - Global CO_2 emissions. Full lines represent the IEA Alternative Scenario and dotted lines are the IEA Reference Scenario.

Today, the US is the country with the largest CO_2 emissions. However, China is expected to pass the US as the world's largest CO_2 emitter by 2010 due to its large economic growth and its frequent commissioning of new coal fired power plants. The CO_2 emissions will continue to grow in China and the US, while the emissions in the EU are expected to decline after 2015 as indicated in Figure 6.

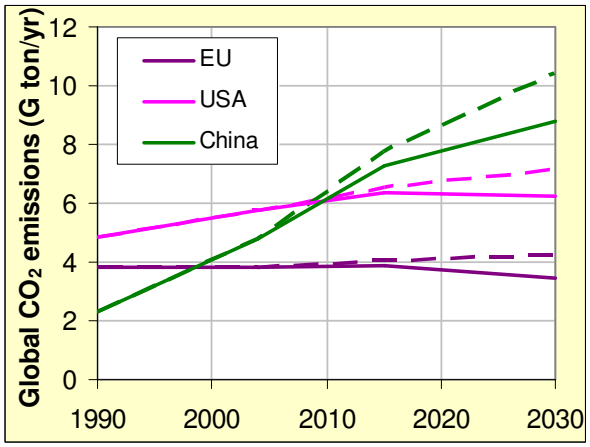

Figure 6 - CO_2 emissions in the EU, the US and China. Full lines represent the IEA Alternative Scenario and dotted lines are the IEA Reference Scenario.

3.2. Emission Reduction by Introducing New Technology

The IEA report "Energy Technology Perspective" [7] is a study on how deployment of new environmentally friendly technology can lead to reduced CO_2 emissions. The main scenario in this report is the *ACT Map Scenario* (*ACcelerated Technology Map*). In addition to the assumptions behind the *APS*, this scenario also addresses an ambitious, but realistic introduction of new technology including the following options:

- Realize the potential for energy efficiency. This option is the source of half of the CO_2 emission reduction from the *APS* to the *ACT Map*.
- Introduce carbon capture and storage (CCS).
- Substitute coal with natural gas in power production.
- More nuclear energy than addressed by *APS*.
- More power production from renewable sources as hydropower, offshore and onshore wind, biomass, geothermal energy, and solar cells.
- Establish political and economic framework to stimulate RD&D and commercialization of promising technologies.
- Introduce hydrogen and fuel cells in the transport sector.
- More bio fuel than addressed by the *APS*.

Reducing the CO_2 emissions represents more political than technical challenges [10]. The main challenge in order to achieve the development outlined by the *ACT MAP Scenario* is to ensure that politicians and decision makers establish the required regulatory framework. Such a framework must be transparent and long-term and address political and economic incentives favoring all the technological options listed above.

The IEA has also published a scenario called *TECH Plus* [7]. This scenario is based on the same assumptions as *ACT Map*, but it has a more optimistic point of view on how fast new technologies can be developed and commercialized. As such, the TECH Plus scenario addresses low barriers for deployment of technologies for renewable energy, hydrogen, fuel cells, and nuclear power. The *TECH Plus* scenario is the scenario from IEA that indicates the lowest global CO_2 emissions in 2050. However, the IEA characterize this scenario as speculative because it addresses much lower barriers for deployment of new technology than all other scenarios from IEA.

3.3. CO_2 Emissions by Sectors

Global CO_2 emissions can be divided into the same four sectors as energy demand, *c.f.* Figure 7. Power generation is the sector with largest CO_2 emissions, and today 48 percent of global CO_2 emission is a result of power generation. According to the *TECH Plus* scenario the power generation sector is also the sector with the largest potential for emission reduction.

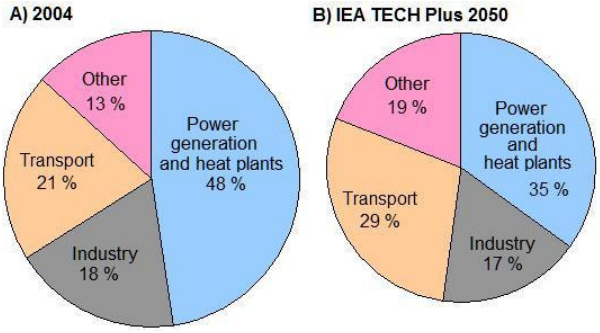

Figure 7. Global CO_2 emissions from different sectors. Left: 2004. Right: The IEA TECH Plus scenario for 2050. The area of the circles reflects the total global energy demand.

3.4. Global CO_2 Emissions Until 2050

Global CO_2 emissions are expected to increase until 2030. The *IEA Reference Scenario* also indicates a large increase in CO_2 emissions from 2030 to 2050. However, other IEA scenarios

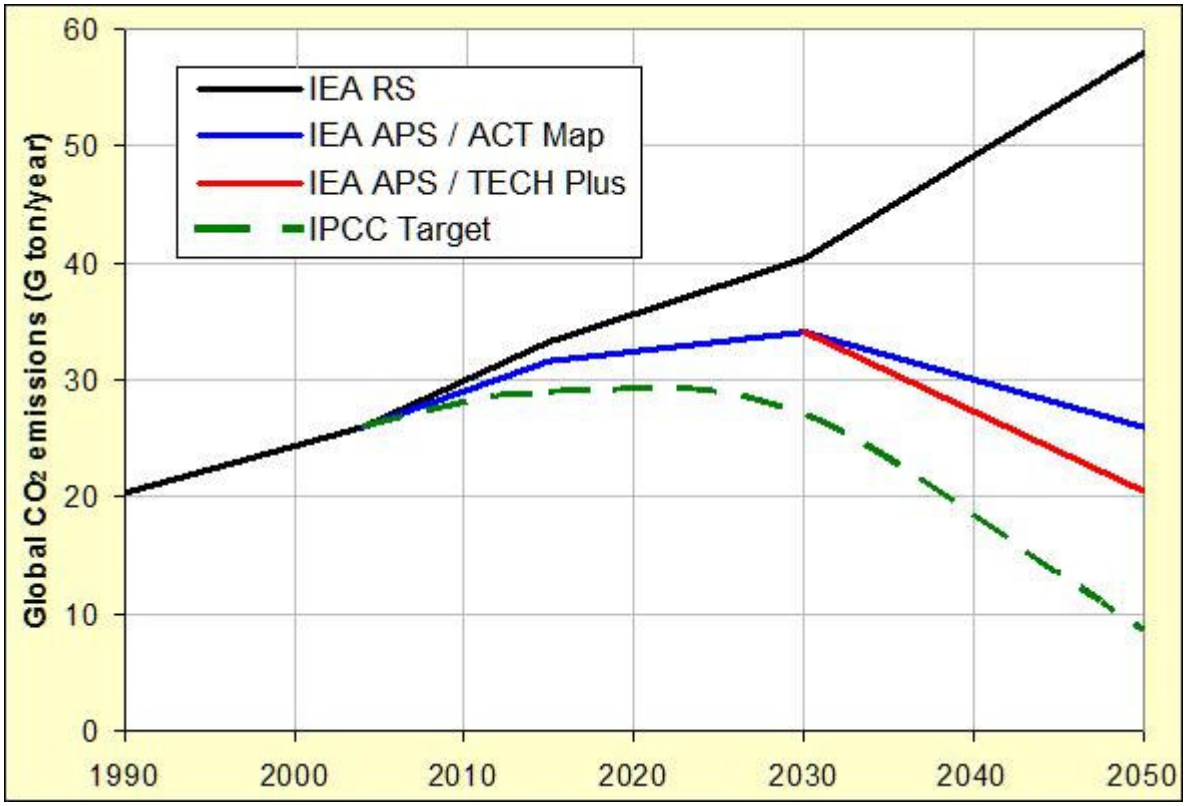

Figure 8. Global CO_2 emissions from the IEA scenarios. Blue line: The IEA Alternative Policy Scenario until 2030 and extrapolation to the ACT Map scenario for 2050. Red line: Extrapolation to the TECH Plus scenario for 2050. The IPCC recommends 50 to 80 percent reduction in global CO_2 emissions by 2050. This is represented by the green line which gives 70 percent reduction from 2007 to 2005.

indicate that global CO_2 emissions will decrease from 2030 to 2050, see Figure 8.

The *ACT MAP* scenario predicts global CO_2 emissions in 2050 at the same level as today. According to the *TECH Plus* scenario the global CO_2 emissions could be 27 percent lower in 2050 than today.

Only the IEA scenarios are presented in Figure 8. Global CO_2 emissions according to the IPCC scenarios [1,2] shows similar trends as IEA, *i.e.* large variations from 2030 to 2050 due to large uncertainty related to how strong political and economic incentives that will established to reduce the emissions.

4. Discussion

As can be seen in Figure 8, the most optimistic IEA scenario, *TECH Plus*, predicts global CO_2 emissions above the IPCC recommendation. In order to avoid catastrophic consequences from global warming, stronger incentives than addressed by the IEA must be introduced to achieve sufficient reductions in global CO_2 emissions.

It can be questioned if IEA is too conservative in its point of view of environmental friendly technologies. The last report from IPCC [11] concluded that CCS is one of the most important strategies to reduce the CO_2 emissions, and recent statements from IPCC indicates that the potential for CCS could be much larger than the IEA addresses in its scenarios. The Bellona Foundation has published a study that shows that wide deployment of CCS can reduce global CO_2 emissions by 37 percent by 2050 [12]. This is a larger CCS potential than the IEA addresses.

It can also be questioned if IEA is too conservative in their estimation of the potential for energy efficiency and renewable energy. Greenpeace has recently

published a report where it claims that enhanced energy efficiency and more renewable energy can reduce global CO_2 emissions with up to 50 percent by 2050 compared to emissions today [13]. This is a much larger potential for energy efficiency and renewable energy than addressed by the IEA. Greenpeace is very optimistic in its analysis, and it can be questioned if it is possible to realize as much renewable energy as Greenpeace claims. However, the study from Greenpeace is an indication that IEA *is* conservative in its point of view on energy efficiency and renewable energy.

The most optimistic IEA scenario, *TECH Plus,* predicts higher CO_2 emissions from the transport sector in 2050 than today. This is very conservative as long as significant emission reductions are possible. *The EU Technology Platform on Hydrogen and Fuel Cells* concludes that hydrogen can become an important fuel with a market share of 50 % of the fuel consumption in 2050 [14]. If hydrogen can achieve such a marked share, and hydrogen production is combined with CCS, it is possible to reduce CO_2 emissions from the transport sector significantly.

There are large uncertainties in predictions of global CO_2 emissions onwards to 2050. However, all the scenarios indicate that stronger incentives than accounted for by the IEA are required to reach the IPCC target of 50 to 80 percent reduction in global CO_2 emissions by 2050.

5. Conclusion

The global CO_2 emissions will more than double by 2050 in a business-as-usual scenario. This is not a sustainable development, and actions are required to reduce CO_2 emissions.

Global CO_2 emissions can be reduced by establishing political and economical incentives to favor development and commercialization of new environmentally friendly technology. According to the most optimistic scenario from IEA, the *TECH Plus scenario,* global CO_2 emissions can be reduced by 27 percent by 2050. This reduction is not sufficient to reach the IPCC recommendation of 50 to 80 percent reduction in global CO_2 emissions by 2050.

Therefore, stronger incentives than accounted for by the IEA are required to achieve the IPCC target.

References

1 Intergovernmental Panel on Climate Change (IPCC), Climate Change 2007: The Physical Science Basis, Summary for Policymakers, February 2007, http://www.ipcc.ch/SPM2feb07.pdf.

2 Intergovernmental Panel on Climate Change (IPCC), Climate Change 2001: Synthesis report. Cambridge University Press, Cambridge, UK, 2001, http://www.grida.no/climate/ipcc_tar/.

3 Intergovernmental Panel on Climate Change (IPCC), Climate Change 2007: Impacts, Adaptation and Vulnerability, Summary for Policymakers, April 2007, http://www.ipcc.ch/SPM13apr07.pdf.

4 Climate Change Information Kit. M. Wiliams (ed.). Published by UNEP and UNFCCC, 2002.

5 N. Stern, Stern Review: The economics of Climate Change, Cambridge University Press, October 2006, http://www.hm-treasury.gov.uk/Independent_Reviews/stern_review_economics_climate_change/sternreview_index.cfm.

6 International Energy Agency (IEA), World Energy Outlook 2006, OECD and International Energy Agency report, Paris, France, 2006.

7 International Energy Agency (IEA), Energy Technology Perspectives 2006, International Energy Agency report, Paris, France, 2006.

8 The Norwegian Polytechnic Society, http://www.polyteknisk.no/referater/baerekraftige_tanker_om_fremtidens_energiomlegging?eZSESSIDpolytekn=41e49c91248718d5c308747093cd24ff.

9 International Energy Agency (IEA), Emission Scenarios. 2000. Special Report of the Intergovernmental Panel on Climate Change. Nebojsa Nakicenovic and Rob Swart (Eds.). Cambridge University Press, Cambridge, UK.

10 Stated by the Carbon Sequestration Leadership Forum (CSLF) meeting in London, November 2006, http://www.bellona.no/nyheter/Teknisk_mulig_men_politisk_vanskelig.

11 Intergovernmental Panel on Climate Change (IPCC), Climate Change 2007: Mitigation of Climate Change, Summary for Policymakers, May 2007, http://www.ipcc.ch/SPM040507.pdf.
12 A. Stangeland, A Model for the CO_2 Capture Potential, Bellona Paper, Oslo, Norway, 2006, http://www.bellona.no/filearchive/fil_Paper_Stangeland_-_CCS_potential.pdf.
13 Energy [r]evolution, Report from Greenpeace and European Renewable Energy Council (EREC), January 2007, http://www.greenpeace.org/international/press/reports/energy-r-evolutionsummary
14 The EU Hydrogen and Fuel Cell Technology Platform (HFP). Strategic Research Agenda. 2005. https://www.hfpeurope.org/uploads/677/686/HFP-SRA004_V9-2004_SRA-report-final_22JUL2005.pdf