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Conference Paper

Energy versus climate change

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Environment: Dealing with Climate Change

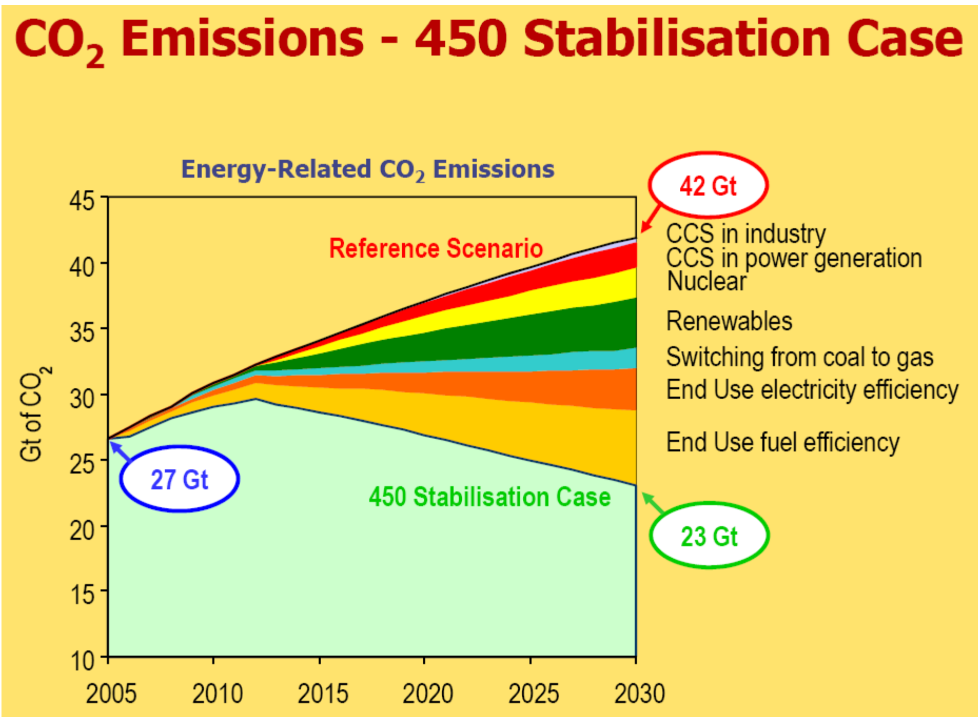
Energy versus Climate Change

Summary

Both economic growth and climate change are powered by an increasing demand for energy, mainly fossil fuels. The puzzle is how to manage energy generation and demand so as to enable economic growth and deal with climate change.

The aim of the session is to explore the potential contributions of various solutions to the energy puzzle: decarbonizing energy supplies, switching to clean renewables, substituting low-carbon energy suppliers like gas for high-carbon energy sources like coal, increasing the share of nuclear energy or capturing and storing carbon. What is the optimal mix of such options? What is the politically feasible mix?

What policy instruments are required to implement this mix? What is the appropriate time frame for these policies in order to avert serious consequences of climate change?



Proposed Solutions

Expert Opinion

The problem of global warming requires immediate reductions of carbon emissions. Limiting temperature increase below 2°C requires the reduction of worldwide average per capita emissions to 0.3t carbon annually which is equal to India's level today. Such a great cut of the world's emissions requires cumulative investments in energy supply infrastructure of $22 trillion by 2030. Consequently, energy R&D relative to GDP has to increase from over 0.02% today to about 0.08% in 2080. Policy should support all feasible energy sources so that technological innovations and market forces can reveal the most efficient options.

The future energy portfolio will contain fossil fuels, nuclear power, and renewables, whereby the shares of the two former sources will decrease over time and the share of the latter one will increase. The evolvement of the fossil fuels share strongly depends on the implementation of carbon capture and storage (CCS) technologies allowing fossil fuels to constitute an important intermediate solution for the energy puzzle. Nuclear power will constitute as well an important temporary option due to its provision of emission free power. However, at least 20 1GW new nuclear power plants would have to be built each year to achieve the drastic emission reductions for the 2°C target. Since there are unsolved major caveats of nuclear power, such an expansion of the nuclear power share is not the complete answer to the energy puzzle. The share of renewables has to constantly increase whereby energy storage technologies have to be included in the energy portfolio to compensate the fluctuations of renewable energy supply. In the long-run renewables will constitute the largest share in the energy portfolio or even a 100 percent share if nuclear fusion does not become feasible. However, neither wind, nor biomass nor geothermal energy have the potential to completely cover the world's growing energy demand in the long run. For instance, about 60,000 large open-sea wind turbines would be needed to meet the emission target until 2050. Solar energy is the only energy technology that satisfies almost unlimited as well as carbon free energy supply. However, the large scale use of solar energy still requires huge R&D investments, and the achievement of a 100 percent solar energy supply will last for centuries. Covering 15% of Europe's energy demand by solar thermal power plants located in North Africa until 2050 would require investments amounting to ca. 400 billion €.

Additionally, the urgency of the energy and climate change problem requires a substantial reduction of energy demand, both in the business and private sector, especially in the sectors of energy intensive production and transportation. From a global perspective, national and international policy needs to identify which technologies of energy generation and reducing energy consumption fit to which countries and which infrastructure needs to be built up. While carbon capture and storage is a major option for coal abundant China, solar energy is a promising opportunity for countries in North Africa and the Middle East.

Strategy Perspectives

DESERTEC: Clean Power from Deserts for a Sustainable World with 10 Billion People

Gerhard Knies

Coordinator, Trans-Mediterranean Renewable Energy Cooperation (TREC); Director for The Club of Rome for the DESERTEC Concept

- Affordable and sufficient energy as well as a stable climate are indispensible preconditions for civilized life of expected 10 billion people on planet Earth, and for a stabilization of world population by wealth.
- Fossil and nuclear fuels can neither supply affordable and sufficient energy nor can they – with present technologies for their use – avoid a global climate catastrophe.
- If organized properly, energy and climate security can be achieved simultaneously by a rapid transition, i.e., within about 3 decades, to almost 100 (“90+”) % renewable energy resources. In other words: energy and climate security can be achieved in due time with available technologies from known renewable energy sources.
- These surprising statements can be inferred from 3 studies conducted by DLR (German Aerospace Center) and TREC (Trans-Mediterranean Renewable Energy Cooperation) for the German Government, during 2004 to 2007, which investigated the potential of solar energy from deserts in the MENA region for energy and water security in Europe, the Middle East and North Africa. These studies allow for an assessment of how the global energy and climate crises can be tackled.
- Here are the basic facts:
  - With the technology of concentrating solar thermal power (CSTP) 1 TWh electricity can be generated per year from a desert area of 5 km².
  - The sunny desert belts north and south of the tropics cover about 40 Million km², and receive within 6 hours more energy from the sun than humankind uses in a year.
  - World electricity consumption now is 18,000TWh/y, requiring 90,000 km² for collector space: this is 0.2% of available desert space.
  - Via HVDC (High Voltage Direct Current) long-distance low-loss transmission lines more than 90% of world population can be served by clean power from deserts – in combination with clean power from other renewable sources like wind, PV, hydro, geothermal, tidal, wave, etc.
  - From additional stored solar heat (from day to night) “solar” steam for the CSTP plants can also be produced at night, and at day time, allowing for power generation by demand at any time.
  - With present collector technologies solar steam is competitive with steam from oil at oil prices of app. 80$/barrel.
  - In 2040, with close to 10 billion people and an average power consumption of 5 MWh/y, a global collector capacity for 10,000 Gigawatts is required for supply of a 50% share of clean power from deserts. This capacity can be produced and installed by industry until 2040, if a targeted effort for mass production is launched now (**DESERTEC-Apollo Program**).
  - The world is driving into a global ecological and economic emergency. Emergency measures instead of smooth transitions are required for their avoidance. With 0.1% of present military expenses (from app. 1,000 billion €/y) for “security” as kick-off money, for a commercialization phase of less than 10 years, such

DESERTEC-Apollo Program can be launched and global energy and climate security can be reached and ensured “for ever”.

- **Where is the energy and climate problem?** The answer is: not in the growing world population, not in the level of consumption per capita, but in the unnecessary and dangerous hesitance to replace fossil by clean energy sources.

Fundamental Questions on Energy and Climate Change

Kurt Lauk

Member, European Parliament

- What is the certainty that global warming is man-made and thus can be limited by man?
- What do Geologists say about periods of global warming in the past, what happened then and what would be different today?
- The intent to limit CO2-emission leads to a restructuring of our societies:
- It is a large scale in industrial reengineering.
- It is a massive redistribution of wealth between societies and within societies.
- Can this lead to increase social inequality and social unrest?
- Increased inequality and social unrest lead to limits of global warming one cannot comply with. And thus the limit of 2 degree Celsius would be made obsolete in order to avoid increase inequality and social unrest.
- The future energy portfolio needs to be carried by CO2-free energy technologies. Their increasing share would put down the price of oil. Are the production costs of oil permanently lower than CO2-free energy productions? If this is so, than CO2-free energy productions must be permanently subsided. Is this economically sound? Is this a good way of spending taxpayers money?
- Given the fact that at the moment roughly 450 power plants are producing energy, what creates the perception that they are inherent unsafe?
- The perceptions of opposing danger need to be changed if at least 20 1-gigawatt-new power plants could/ should be built each year
- Renewables have to play a significant role, in addition to environmental also for security reasons: it would make the world less independent on an instable Middle East region with respect to oil and on Russia with respect to gas.
- What is the future of solar energy? Have we reached the limits of efficiency? Can future R&D push the limits further? How far?
- How efficient is it to have 60 thousand open-sea-wind turbines in 2050 as long as the transportation losses are 60% over longer distances?
- Increase in standard of living is associated with increased levels of CO2 per capita: Is the fight against poverty contradicting the fight against global warming?
- Doomsday scenarios, which might happen tomorrow, prompt policy makers today into significant measures to change industrial infrastructure and social coherence. Is a relevant but small database sufficient to make such far-reaching political decisions in OECD-countries, even if theses measures could proof almost irrelevant, if there is no straight cooperation from the other non-OECD-countries?

- Wouldn't a 100-year-time horizon be much better used with a more prudent long-term-policy using energy home construction, renewable energies and CO2-free production or electricity or electric cars from the very beginning than short-term activism?

The Changing World: Energy Perspectives and Climate Change

Nebojsa Nakicenovic

Professor of Energy Economics, Vienna University of Technology; Acting Deputy Director, International Institute for Applied Systems Analysis (IIASA)

Main Messages

- Humanity is on a brink of a grand transition to be compared with the emergence of agriculture some 20 thousand years ago and the Industrial Revolution two centuries ago.
- The transition will no doubt transform the very fabric of societies and establish new techno-economic paradigms, however, the exact dynamics and direction of change is elusive.
- Scenarios as a kind of “future histories” are one of major methods for assessing the deep uncertainties associated with the wide range of plausible future developments, their consequences and possible tipping points.
- Integrated assessment combines the qualitative methods of storyline writing with quantitative modeling of future developments, ranging from human capacity and well being to economic activities, technological change and environmental implications from air pollution to climate change.
- The most recent stabilization scenarios, assessed by the IPCC that were developed by a number of modeling groups including IIASA, outline greenhouse gas mitigation strategies, technology needs, structural changes and possible policy levers.
- Stabilization scenarios that avert the more “dangerous” climate change by limiting future temperature increases to two degrees Celsius imply the fundamental transition and paradigm change that is likely to fundamentally transform ways we live and work.
- Beyond describing these future changes and challenges, the main message will be the required investment requirements for achieving more sustainable futures.

Introduction

The humanity left the Stone Age, as Sheikh Yamani, Saudi Arabia’s former Minster of Oil, is attributed with saying, not because we ran out of stones, but because we discovered something better – the agriculture and early civilization. In part this was possible because the climate has been very kind to humanity over the last 20 thousand years even when measured on geological time scales. Ever since, one transition followed the other through an ever-changing evolutionary process. The last and most vigorous transition emerged with the industrial revolution. It has catapulted humanity into a planetary development phase. Figure 1 illustrates three development phases and transitions by showing the increase in global population and thus also in the Earth’s carrying capacity.

Nobel Laurite in Atmospheric Chemistry, Paul Crutzen has suggested that we should not call the present era the Holocene but rather the Anthropocene so as to denote the unprecedented interference of humanity with planetary processes and equally unprecedented increase in human well being and prosperity.

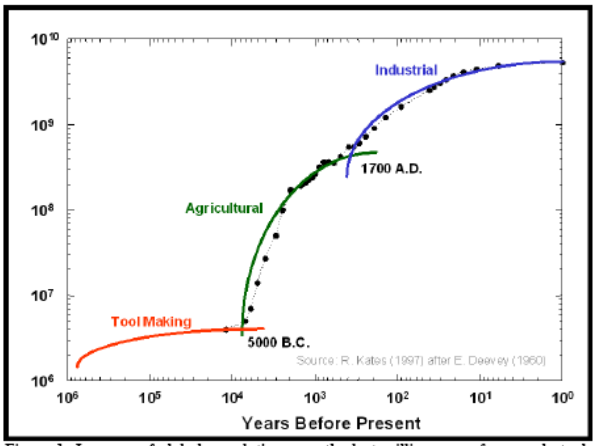


Figure 1: Increase of global population over the last million years from early tool-making phase, to agricultural development phase and early civilizations to the most rapid expansion phase since the beginning of the industrial revolution. Source: Kates (1997) after Deevey (1960).

Figures 2, 3 and 4 illustrate phenomenologically this enormous progress of humanity since the beginning of the industrial revolution: urbanization, higher-level education and democracy. All have increased in unison and curiously have reached the 50 percent mark during this decade. Given the underlying dynamics, the processes could last another 100 to 150 years fundamentally altering the very fabric of our societies and lifestyles.

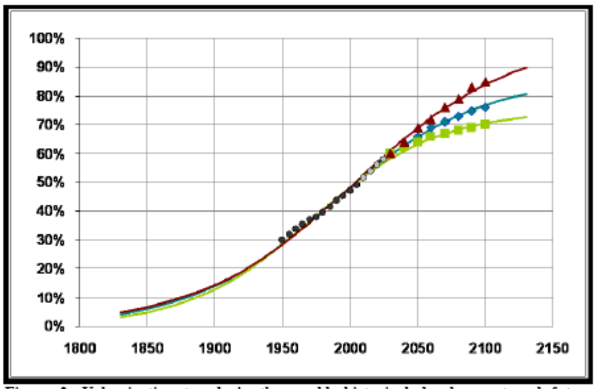


Figure 2: Urbanization trends in the world, historical development and future scenarios, showing share of people living in urban areas. Source: Gruebler *et al.*, 2007.

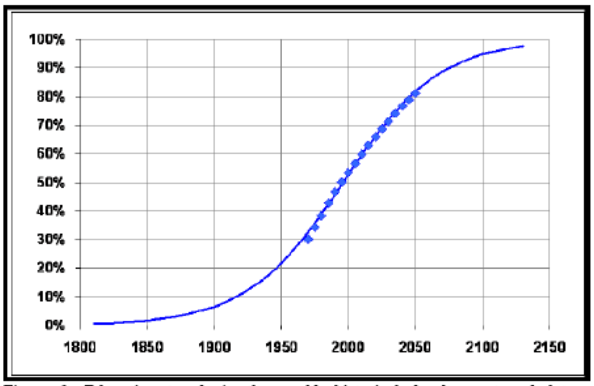


Figure 3: Education trends in the world, historical development and future scenarios, showing share of people with secondary and tertiary education levels. Source: Lutz *et al.*, 2007.

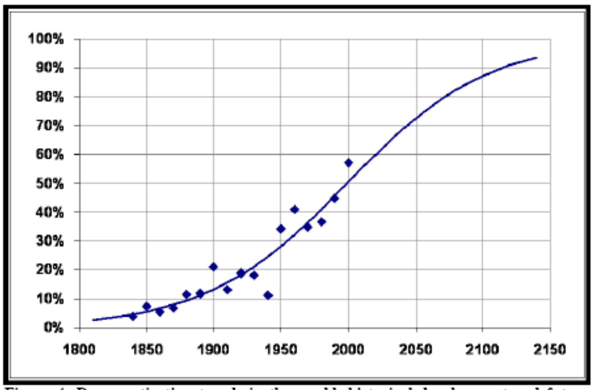


Figure 4: Democratization trends in the world, historical development and future scenarios, showing share of people living in pluralistic and parliamentary governance systems. Source: Modelski, 2002.

Energy Transitions

These developments were accompanied by the ever-growing needs for resources including energy and ecosystem services to sustain human well being and development. In some ways, this is also the root of a paradox that is central to the human development – fossil energy has replaced human and animal labor and has thereby powered unprecedented increase in both material well being as well as adverse environmental consequences across all scales, from local to global including major interference with ecosystems and planetary processes. Figure 4 illustrates this increase in global energy needs and the transition from traditional energy sources such as biomass to coal with the advent of the steam, steel and railways development phase of the 19th century to be replaced by exponential expansion of the oil era along with motor vehicles, electricity and many other energy-related developments associated with affluence and modern life. Energy services are essential for the eradication of poverty in the world and for improving human well being. A formidable challenge for the 21st century is to assure the provision of clean and affordable energy services. New energy technologies are needed for providing the essential services to the two billion without access to modern energy forms as well as for improving the efficiency and reducing adverse impacts of energy in the more affluent parts of the world.

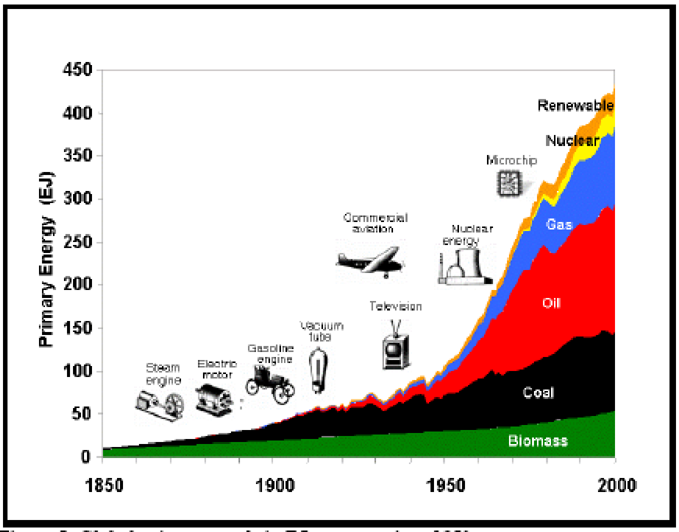


Figure 5: Global primary needs in EJ per year since 1850.

Table 1 summarizes the dynamics of the last two centuries since the beginning of the industrial revolution: population has increased six-fold from 1 to 6 billion people, economic output about 70-fold, resulting on average in more than a 10-fold increase of per capita output. This required enormous amounts of energy resulting in a 35-increase (with a square of population) and 20-fold increase of carbon dioxide emissions.

Table 1: Increase of global population, economic output, primary energy and carbon dixide emissions from 1800 to 2000.

	1800	2000	Factor
Population (billion)	1	6	x6
GDP PPP (trillion 1990 $)	0.5	36	~x70
Primary Energy (EJ)	12	440	~x35
CO_2 Emissions (GtC)	0.3	6.4	~x20

Global Warming

After two centuries of ever-increasing primary energy consumption in the world, at on average more than two present per year, today 80 percent of global energy comes from fossil sources. The resulting 20-fold increase in carbon dioxide emissions translated to about 1.7 percent per year despite continuous decarbonization of global energy.

Reduction of average carbon content of energy, or decarbonization, resulted from a shift in primary energy mix from coal to oil, gas and now to growing shares of renewables and nuclear energy. Figure 6 shows that due to the anthropogenic sources of carbon dioxide and other greenhouse gas emissions, the average global temperature change of some 0.75 degrees Celsius compared with pre-industrial times with the same order of committed temperature increase still to occur.

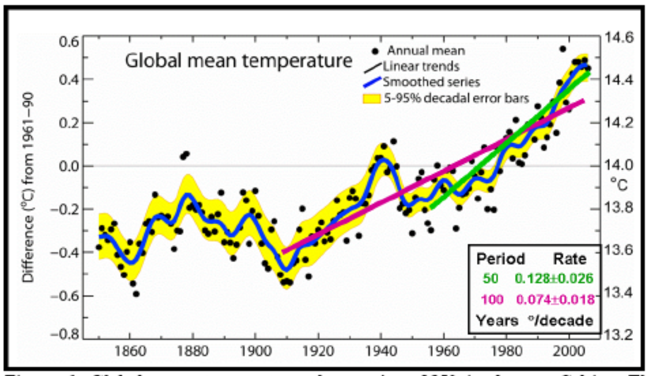


Figure 6: Global mean temperature change since 1850 in degrees Celsius. The warmest years on the record occurred during the last 12 years. Source: IPCC AR4, WGI, 2007.

Climate change is a central aspect of adverse impacts of human activities on the environment. Thus, the challenge is to improve human well being while simultaneously mitigating anthropogenic climate change. The role of technology in achieving this double challenge is unique. Technology is one of the main driving forces of increasing greenhouse gas (GHG) emissions. It is also an important part of the possible solution both in mitigating global warming through reductions of GHG emissions and in helping adapt to its impacts. Technology was very important in catalyzing the historical drive of doing more with less – from increasing efficiency of factor inputs to reducing some of the adverse impacts of human

activities – and it at the same time important driving force of ever-higher (per capita) consumption levels. In a way, this is the paradox of technology of being both a part of the problem and a part of the solution.

Scenarios of Future Developments

The future is inherently unpredictable but the historical dynamics indicate that at current trends the risk of adverse impacts of changing climate needs precautionary response strategies. Scenarios in this context play a role of thought experiments that are conducted with rigor and captured in state-of-the-art models. This requires integration of different methodological approaches from demographic and economic developments, to energy and land-use changes and the consequences for climate and other global changes. At IIASA, such an integrated modeling approach has been developed across different research programs (Riahi and Nakicenovic, 2007). One of the scientific products is a set of holistic scenarios that assess both the future developments as well as possible response strategies. We will highlight only two of these scenarios here. Both are updated and revised versions of the original scenarios developed for the Intergovernmental Panel on Climate Change (IPCC, Nakicenovic *et al*., 2000**).**

One of the scenarios is called A2r that combines a relatively high global population with modest economic growth in what can be characterized as a more fragmented world, with a lot of regional interaction and cooperation, but with less emphasis on globalization. This is the reason for somewhat humble economic growth prospects and relatively slow pace of technological change. Figure 7 illustrates the evolution of the energy system in this scenario toward quite high growth and contiguous reliance on fossil energy sources.

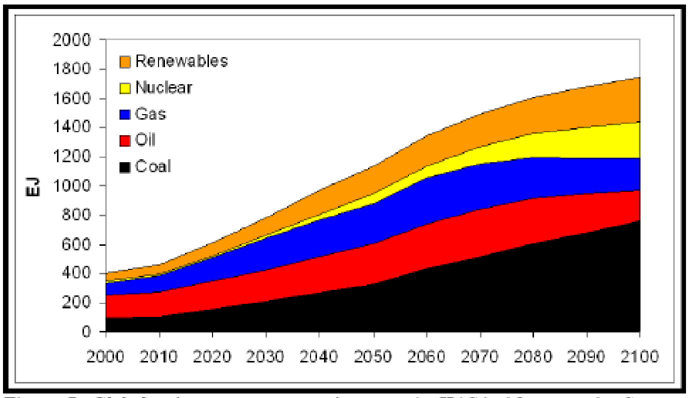


Figure 7: Global primary energy requirements in IIASA A2r scenario. Source: Riahi *et al.*, 2007.

In contrast, the other scenario, called B1, describes a transition toward much more sustainable development paths, with a global population that curves through a maximum of about 9 billion by mid-century declining thereafter. Economic growth is more vigorous but much less materials and energy-intensive. There is a strong globalization tendency but more directed at environmental awareness and protection than at material consumption. Figure 8 describes the evolution of the energy system in this scenario toward more efficient energy use and higher shares of zero-carbon options. In this scenario, less is more.

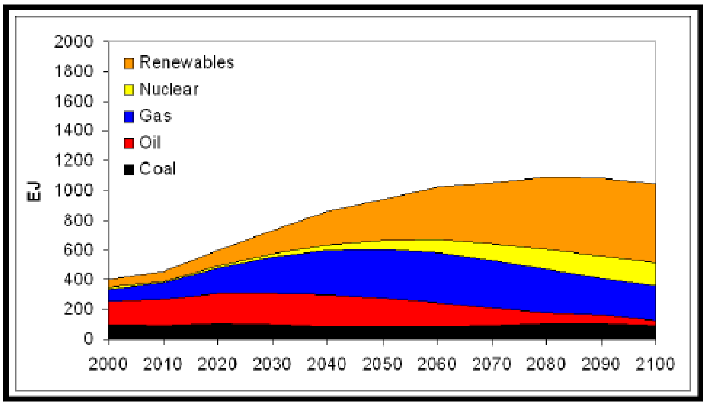


Figure 8: Global primary energy requirements in IIASA A2r scenario. Source: Riahi *et al.*, 2007.

Figures 9 and 10 show the climate consequences of these two scenarios. The first, A2r, would result in additional mean temperature increase of about 3.5 degrees Celsius by the end of the century and the second, B1, in almost a 2 degree increase. The historical temperature increase of 0.7 degrees Celsius needs to be added to obtain the increases of 4.2 and 2.7 degrees over the pre-industrial levels. Clearly, B1 scenarios is more benign, but is still in excess of the widely accepted upper bound of temperature increase of 2 degrees Celsius that in itself would lead to substantial adverse impacts. Limiting temperature increase to 2 degrees also constituted the declared European climate goal.

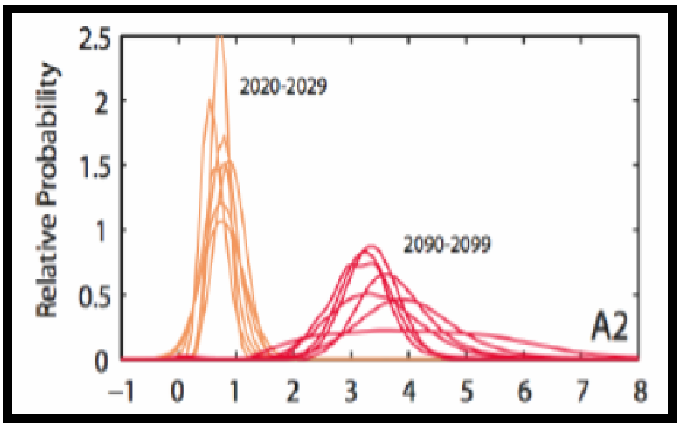


Figure 9: Global average surface temperature change for the A2 scenario. Source: IPCC AR4, WGI, 2007.

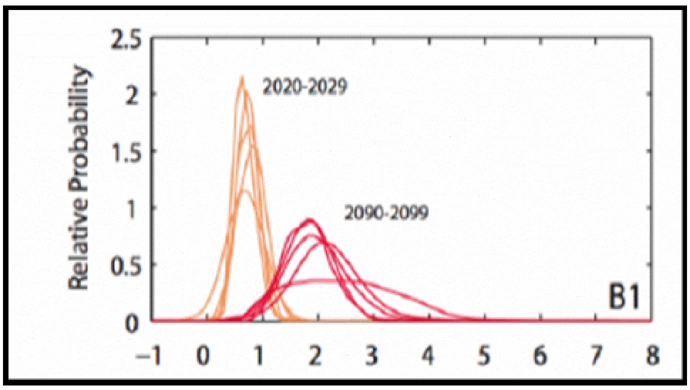
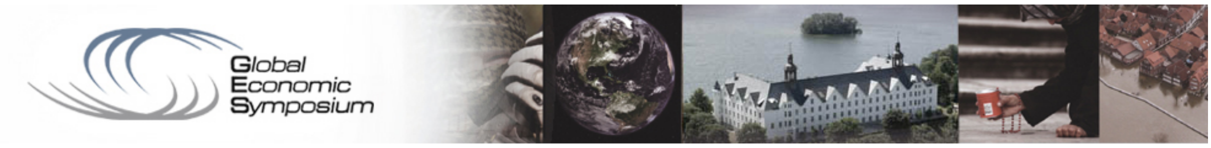


Figure 10: Global average surface temperature change for the A2 scenario. Source: IPCC AR4, WGI, 2007.



Energy Versus Climate Change

Reinier Zwitserloot

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Achieving a sustainable future balance between global economic growth, energy supply and climate protection is one of today's greatest challenges.

As stated by various sources like the International Energy Agency (IEA, OECD/IEA: World Energy Outlook 2007, Paris) or the Energy Information Administration (EIA: International Energy Outlook 2008, Highlights, June 2008) global energy demand will grow substantially and is predicted to be up to 50% higher in year 2030 compared to the year 2005 level. With a share of around 80%, non-OECD countries account for the bulk of this increase in energy demand driven by a strong economic growth in countries such as China, India and Brazil.

Considering how this surge in energy demand can be covered two features of the future energy mix are constant factors throughout many energy scenarios: First high growth rates for renewable energies and secondly the vast majority of global energy supply continues to relay on fossil fuels at least until 2030. Even with the alternative scenario of the IEA, which assumes a lesser increase in the global energy demand, the proportion of fossil energy sources would be around 75%. The situation is not any different for the EU-27 based on the reference scenario of the European Commission (European Commission, Directorate-General for Energy and Transport: European Energy and Transport, Trends to 2030 – Update 2007, Luxemburg 2008). Even if – as presumed in aforementioned alternative IEA scenario – the ambitious goal of a 20% share of renewable energies in overall energy consumption of the EU-27 were to be reached, the share of fossil fuels would still be about two thirds. Thus without disregard to the growth of renewable energy sources the energy mix of years to come has to incorporate fossil fuels as part of the solution and not as part of the problem.

Looking at fossil fuels, the long term global availability of coal is generally undisputed. However global oil and gas reserves will be also sufficient to cover global demand for hydrocarbons for decades. The expected lifetime of global oil and gas supply is a function of demand, price and technical progress. For example due to new technology the ratio of global oil reserves to global oil production has remained constant at 40 years throughout the last 20 years despite an increase of oil demand by 1.5% p.a.

In the global competition for future energy supplies Europe is well positioned: For about 80% of the world's reserves of natural gas and crude oil are in a radius of about 4500 km of the EU. Particularly for the gas sector and its substantially growing import demand Russia plays a key role for the European supply security as it owns the world's largest gas reserves and is located 'within pipeline distance' to Europe. Through the combination of Russian gas reserves and attractive European consumer markets a strong energy partnership between Russia and Europe has developed. This energy partnership has proved its worth and reliability in the last few decades, even during Cold War political crises. The close partnership has been significantly strengthened in the last few years: joint investments in the development of gas reserves, the construction of transport and storage infrastructure and the signing of long-term gas supply contracts have shared the risks and created common interests.

Reducing atmospheric greenhouse gases, while increasing economic wealth, is only achievable with an intelligent mix of all available energy sources in order to bridge efficiently the period until the age after fossil energy supply. Principally it is of high importance, beside all efforts for further development of renewable energy sources, to focus also on the other energies, which will have a remaining share of about 80% of the total energy mix in year 2030.

The first main pillar of such bridge is a strong increased use of existing best technologies, which implies the following.

- Energy Efficiency:
  - Energy savings on the demand side, particularly in OECD countries, which are the most efficient method to reduce emissions on short-term.
  - Technology transfer from OECD countries to increase energy efficiency in non-OECD countries.
  - Improving the efficiency of fossil energy production; for example avoidance of flaring of associated gas.
- Extended Yields:
  - Extending the capacity and resource availability of reservoirs; for example usage of Enhanced Oil Recovery (EOR), which can increase the ultimate recovery of a reservoir.
- Low Carbon Energy:
  - Supporting the use of energy sources with relatively low impact on the climate; here natural gas stands out from other fossil fuels because of its high energy efficiency and its environmental properties. Natural gas releases much less carbon dioxide than other fossil fuels and therefore makes a vital contribution to climate protection. The increased substitution of natural gas for other fossil fuels has made the single biggest contribution to reducing CO2 emissions in Europe since 1990! Important growth areas for natural gas are in powering small and de-central Com-bined Heat and Power (CHP) plants and covering the growing medium load and peak load requirements in electricity generation. Here the positive impact of natural gas on climate protection is magnified if used in combination with renewable energies, for example, as a back up for wind energy.

The second pillar is the development of new technologies such as:

- Further development of renewable energies.
- Carbon capture and storage (CCS) for coal fired power generation.
- Technologies allowing efficient recovery of oil and gas resources in extreme con-ditions like deep water operations in the Gulf of Mexico.

The choice of the energy source and used technology shall consider the effects on other environmental impacts like water emissions, land use or soil erosion. Furthermore, social aspects need to be considered. There is an indication that an increased production of bio fuels out of regenerative sources drives prices for food which has a significant impact on the developing countries of the world.

Both, energy efficiency and new technologies, are key to achieve climate protection at manageable costs and hence to allow further economic growth. Mc Kinsey investigated in several national and international studies CO2 abatement potentials and its costs. In Germany for example (McKinsey & Company: Kosten und Potenziale der Vermeidung von Treibhausgasemissionen in Deutschland, September 2007, Berlin), a reduction by 25% of the CO2 emissions between 1990 and 2020 would be achievable through energy saving without any additional net costs. However based on **today’s technology** a reduction of 35% of CO2 would require already about 27 Billion Euro per year and the cost increase to reach the reduction target of 40% given by the German government would be outside of any reasonable scope. The required huge investments into a sustainable global energy mix underline, that energy will become an increasingly valuable and hence high priced good in the future. But high energy prices have also an important strengthening impact on the aforementioned two pillars of the bridge. First they are drivers for required investments into new technologies, both on the supply and on the demand side. Secondly they also stimulate a more careful way of global energy consumption. For example the recent drastic decline of SUV sales is a direct reaction of American consumers to the enormous price increase of gasoline. In essence future energy supply can only be brought in line with climate protection if managed in a global context. The asymmetry between OECD and non-OECD countries regarding per capita energy consumption and predicted economic growth puts a special responsibility on the OECD countries. However, also non-OECD countries should con-tribute to an efficient energy usage, for example through the introduction of advanced low emission technology in their respective countries. This global challenge requires an intelligent energy mix of all energy sources with a constant effort to develop new tech-nologies and improved energy efficiency in order to pave the way to an age with a significantly reduced share of fossil energy supply.