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4 WHAT SHOULD BE DONE?

THE GLOBAL WATER CRISIS WILL REACH IN COMING YEARS UNFORESEEN DIMENSIONS. TODAY MORE THAN 1.2 BILLION PEOPLE HAVE NO ACCESS TO CLEAN DRINKING WATER, AND ABOUT 2.4 BILLION NO ACCESS TO FUNCTIONING SANITATION DEVICES. THE GOALS OF THE UNITED NATIONS IS THE 50%-REDUCTION OF THESE NUMBERS UNTIL 2015. TO REACH THESE GOALS OR A PART OF THEM THERE ARE LARGE NUMBERS OF RECOMMENDATION FROM THE EXPERTS. WE HAVE TO PROTECT CLIMATE IN ORDER TO LOWER THE PROBABILITY FOR EXTREME HYDROLOGICAL EVENTS LIKE DROUGHTS AND FLOODS. OTHER IMPORTANT STEPS ARE THE STOP OF THE CONTAMINATION OF SURFACE WATERS AND GROUNDWATERS, EFFICIENT UND SUSTAINABLE MANAGEMENT OF SCARCE WATER RESOURCES IN ARID AND SEMI-ARID REGIONS.

ON THE OTHER HAND WE HAVE TO INTRODUCE NEW WATER SAVING MEASURES, CONCEPTS AND TECHNOLOGIES IN THE URBAN (E.G INNOVATIVE SANITATION SYSTEMS) AND INDUSTRIAL SECTOR (E.G. INTRODUCTION OF OWN WASTEWATER TREATMENT PLANT). IN AGRICULTURE THE KEY IS THE PRODUCTION OF MORE FOOD WITH LESS WATER. NEW PLANTS WITH BETTER HEAT TOLERANCE, IMPROVED DROUGHT AND SALT RESISTANCE SHOULD BE INTRODUCED. IT IS IMPORTANT FOR COASTAL COUNTRIES TO PROMOTE RESEARCH AND DEVELOPMENT IN WATER DESALINATION TECHNOLOGY.

INTERNATIONAL CONFLICT IN USING WATER IN ARID AND SEMI-ARID REGIONS HAVE TO BE SOLVED IN CO-OPERATION. CENTRAL QUESTIONS ARE THE HUMAN RIGHT OF ENOUGH WATER FOR ALL AND HOW PRIVATISATION OF THE WATER SUPPLY CAN CONTRIBUTE TO SOLVE THE GLOBAL WATER CRISIS.

4.1 Measures for climate protection

HARTMUT GRASSL

SUMMARY: *Climate protection, i.e. the dampening of the anthropogenic global climate change rate, needs global action. A large part of the projected warming in the 21st century is due to positive feedbacks of water cycle components. Staying within the climate window of maximum tolerable mean global warming (+2 °C until 2100) translates into an equivalent carbon dioxide (CO_2) concentration in the atmosphere of about 450 ppmv. It can only be reached by a rapid energy system transformation away from the fossil fuels oil and coal towards renewable energies, whose prerequisite is internalisation of external costs, hence a strong political will.*

The expression »climate protection« seems arrogant for some as humans have no influence on the Earth's orbit around the sun and as the quasi-periodic changes of this orbit stimulate ice age-interglacial cycles and thus large ecosystem shifts or even extinctions. I would like to see climate protection only as the growing dampening of the anthropogenic climate change rate in the 21st century, in order that a sustainable development remains possible.

The water cycle as a central element of the climate system

The substance water covers not only the oceans with 71 percent of the globe in form of ocean water or sea ice, but also large parts of the continents are covered by snow and ice. In addition, large rivers and lakes are not at all negligible parts consisting of fresh or saline water. It is therefore no exaggeration, if we call our Earth a water planet as more than 78 percent of the planet's surface are covered by water (see Chapter 1.1).

Why is it then necessary to talk about a water crisis? Where, in addition global warming intensifies with high probability the global water cycle? A natural law, called Clausius-Clapeyron equation in physics, stipulates a 6 to 20 percent increase in water vapour mixing ratio per degree Celsius warming (6% at +20 °C and 20% at -80 °C) and thus will lead to much more water vapour in the atmosphere, if relative humidity stays nearly constant. The answer is simple: Firstly, there will be more humans – the United Nations' best guess number is 9 billions in 2050 – and secondly, we pollute more and more freshwater in industry, villages and cities as well as in agriculture. Thirdly, the tendency exists for a further drying of semi-arid regions by both locally caused desertification (wrong agricultural practices) and reduced precipitation at higher evaporation, the latter a consequence of mean global warming.

The measures to reduce water crises in many countries are therefore obvious: population policies, sewage treatment, efficiency increase in water use (especially in agriculture), keeping natural water cleaning mechanisms intact and global climate policies.

Only the last measure, global climate policies, is the topic of this contribution.

Water vapour as an amplifier of the greenhouse effect

Water vapour is – with a large margin – the most important greenhouse gas, its contribution reaches roughly two thirds

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of the greenhouse effect of the atmosphere of about 33,6 °C. Its concentration is strongly temperature dependent. At typical ambient temperatures maximum water vapour concentration doubles every 10 °C increase. Hence, at a warming stimulated for example by a carbon dioxide (CO_2) increase, a positive feedback by water vapour will amplify the warming. Such a concentration increase has been observed in the planetary boundary layer and the lower troposphere, but is still not certain for the upper troposphere because of lack of precision of time series at these heights. In the lower stratosphere a considerable increase of water vapour concentration of up to 0.5 percent per year has been derived for the recent decades from patchy long-term records (Kley et al. 2000). The water vapour amplification of the growing greenhouse effect, known already since about half a century, is reliably calculated in all climate models. While a doubling of CO_2 content in the atmosphere leads to 1.2 °C mean warming only, it roughly doubles if water vapour reacts to the stimulus.

A further certainly positive feedback of the water cycle is the so-called snow/ice-albedo/temperature feedback. If air warms or radiation increases snow and ice melt faster, the snow- and ice-free, hence darker surfaces absorb more solar energy increasing temperature further and thus also melting faster remaining snow and ice in the region. Following Hansen (2003) this positive feedback has led to a radiative forcing of 5.6 W/m^2 for the transition from the intense glaciation (~ 20,000 years ago) into the Holocene. This value is more than double the forcing by the increased greenhouse effect due to increases of CO_2, methane (CH_4) and nitrous oxide (N_2O) for the same transition. Its 2.5 W/m^2 are identical to the accumulating greenhouse gas effect since industrialisation began (IPCC 2001). Radiative forcing is defined here as the instantaneous radiation flux density change at the tropopause calculated for an atmosphere with otherwise fixed composition and temperature structure. In reality such a forcing leads to climate change, reducing the forcing, in order to establish a long-term energy balance between absorbed solar and emitted heat radiation. However, because of the inertia of ocean and ice the radiative forcing needs at least decades to be reduced to 1/e, i.e. 37%.

For the anthropogenic greenhouse effect addition the delay is at present dominated by the thermal inertia of the ocean as very large ice sheets no longer exist on the Northern Hemisphere. In other words: At future stable greenhouse gas concentrations (for CO_2 this would mean at least halving the global emissions) temperature change would still continue over decades reaching roughly double the values of already observed temperature change. Sea level would rise over centuries and even millennia should the Greenland ice sheet melt substantially.

Clouds as the key uncertainty

A hitherto unanswered question is: How will clouds react to an increased greenhouse effect? We know that clouds cool the Earth's surface at present on average (radiative forcing with and without clouds differs by -15 W/m^2), however, we do not know whether this cooling by clouds increases or decreases at mean global warming. The reaction depends on such subtle changes as size of ice crystals in high clouds, changed three dimensional structure of convective clouds, cloud condensation nuclei number, soot content of aerosol particles, ice nuclei concentration, etc. These open questions are the main reason for the large range of so-called climate sensitivity. There was no change of this sensitivity between the second and third full assessment of the Intergovernmental Panel on Climate Change (IPCC) from 1995 to 2001. Still valid is: A doubling of the pre-industrial CO_2 mixing ratio of the atmosphere from 280 to 560 parts per million by volume (ppmv) would lead to a global mean near surface air temperature increase at full reaction of the climate system between 1.5 and 4.5 °C. All general circulation models taking part in an international comparison lay in between 1,7 and 4.2 °C (IPCC 2001).

Goals of climate politics

In 1992 at the Earth Summit in Rio de Janeiro the United Nations got the signature under their Framework Convention on Climate Change (UNFCCC) by 154 countries. In the meantime more than 180 countries have ratified UNFCCC and thus accepted its main goal as international law: The final goal of this convention is the stabilisation of greenhouse gas concentrations in the atmosphere at a level which prevents a dangerous anthropogenic interference with the climate system.

The operationalization of this noble and difficult goal leaves a lot to do. Research on climate change impacts is in its infancy and emission reductions are so deeply interfering with the industrialised societies that all hesitatants and potential loosers warn of the »huge« costs and exaggerate the uncertainties of scientific statements.

Notwithstanding, there are attempts to define a dangerous interference with the climate system. The preferred method is the fixation of a maximum, still tolerable mean global warming (WBGU 1995; 2003 a, b). The search for such a guard rail was driven by the following consideration: Climate states unknown to humanity have to be avoided. This led to the so-called Eem Interglacial, a warm period of about 10,000 years length some 125,000 years ago, in which the global mean near surface temperature lay about 1.5 °C above the one before industrialisation. The further assumption of a somewhat increased adaptation capability of modern societies finally

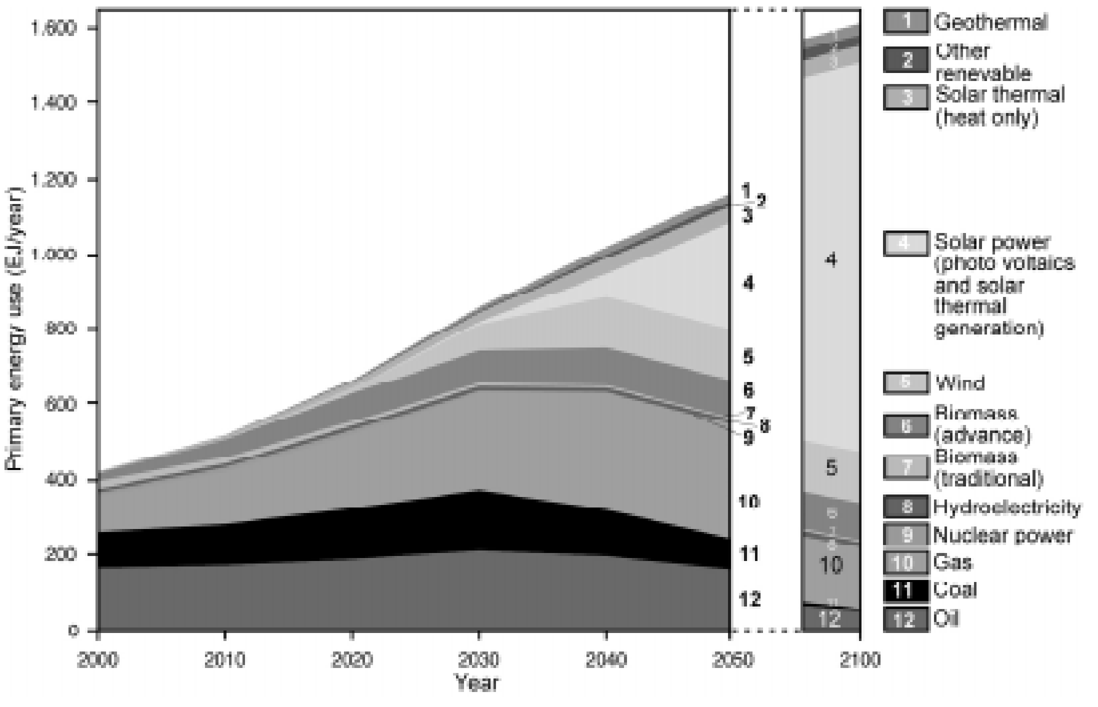

Fig 4.1-1: The exemplary energy path in the 21st century, for which the tolerable climate window is kept; a rapid transition towards renewable energies is needed and can be financed at climate protection costs below 1 percent GDP for all countries (WBGU 2003 a, b).

led to 2.0 °C as maximum tolerable mean global warming, which had to be kept in the 21st century.

Since the enhanced greenhouse effect will become dangerous mainly through its high increase rate (what is occurring in the undisturbed system in many millennia will be »squeezed« into two centuries), the Global Change Advisory Council of the German Federal Government introduced – in addition – a maximum tolerable warming rate of 0.2 °C per decade. This value is still not strongly confirmed because also here climate impact research does not offer much. If the »climate window« is accepted, the greenhouse gas concentration goal (given in equivalents for CO_2) must stay below 450 ppmv (WBGU, 2003 a, b). This is equivalent – in a slightly exaggerated form – to the rapid start to end the fossil fuel era. The exemplary path of such future energy system means a tremendous effort, can however be financed comparably easily, and its policies go well beyond all present treaties (WBGU, 2003 a, b). The European Union also defined the tolerable 2 °C climate window as its goal. Therefore, the EU-wide emissions trading scheme has started on 1 January 2005. 88 Countries, for which the transition towards a sustainable energy system is too slow, have defined in June 2004 at the Renewables 2004 Conference in Bonn their own goals in an action plan to be reviewed by the United Nations Commission on Sustainable Development (UN-CSD).

Fortunately, through ratification by the Russian Federation, the Kyoto Protocol, defining reduction goals for industrialised countries, has been enacted on 16 February 2005. Hence, for the first time a global, binding legal instrument for climate protection, though with milk-teeth, exists that will lead to first CO_2-emission reductions in industrialised countries after more than a century with often uninterrupted growth of emissions. As already laid out in the Kyoto Protocol in 1997, negotiations had to be and have started in 2005 for a further legally binding emission reduction instrument after the 2008 to 2012 Kyoto Protocol commitment period. The challenge will be the integration of emerging countries like China, India, Brazil and Indonesia into such a treaty not with emission reduction goals but with goals to partly decouple economic growth from energy input growth.

If external effects of present energy systems would be internalised, i.e. the correct costs would be paid for fossil fuel energy (about 300 billion US dollars are given as subsidies per year world-wide), renewable energies can become a major energy pillar in the coming decades (see *Fig. 4.1-1*). As long as this internalisation proceeds only slowly, supporting measures for renewable energies, like feed-in tariffs, are needed♦