Climate Change and Energy

Introduction

With the Kyoto Protocol expiring in 2012, will the global community manage to negotiate a new, binding climate treaty? The meager results of the last few climate summits offer slim hope. Part of the problem is that binding limits on greenhouse gas emissions must be global, and not just applied to industrial nations. Politicians and scientists agree that's the only way to get the problem of global warming under control. It will take other measures too, of course. That's as certain as the fact that nothing will happen without an entirely new approach.

Nevertheless, a subliminal reluctance to trust authority in general has manifested itself in an unwillingness to listen to researchers' urgent warnings. "This kind of irrationalism, in whatever form, can be very dangerous in our society," says Hans Joachim Schellnhuber, founding director of the Potsdam Institute for Climate Impact Research who acted as the scientific advisor for the first session on Climate Change and Energy.

At the OCF conference, participants joined together to come up with ideas on how to overcome the problems of the world's changing climate. On the one hand, experts discussed ways to halt or even roll back the damage already done. Known as mitigation, this approach involves strategies ranging from capturing carbon from power plants and natural gas wells deep underground, to developing technologies for mobility and manufacturing that use less fossil fuels and have a smaller carbon footprint.

On the other hand, international academics and representatives of relevant institutions joined to discuss different options of adaptation. Adaptation involves the clear-eyed realization that climate change is coming, whether we curb emissions or not, and the sooner we learn to deal with it the better. "Mitigation and adaptation are two aspects of one problem," says Reinhard Huettl, scientific director of the German Research Centre for Geosciences in Potsdam, who was the scientific advisor for the second session on Climate Change. "Just reducing emissions can't stabilize the climate now and for ever – we need to also adapt to changes that occur, now and in the future."

No matter what their area of study, how to communicate better with the world's politicians – and the public they represent – was high on the list of priorities for the experts at the climate sessions. Participants noted that as multilateral negotiations flame out and fail, one common theme in the discourse has been the lines drawn between developing nations, who have an interest in raising the standard of living for their citizens to levels long enjoyed in the global North, and developed countries, hoping to preserve what they have without sacrifice. With speakers and attendees from both sides of the divide, the OCF conference was a hopeful sign that science and rationalism can endure in the face of denial and narrow-mindedness – and, in the end, overcome them.

½ of the world's wetlands have been lost since 1900.

442 nuclear power plants around the world produce 375 gigawatts of energy.

845

plant species in the EU may lose their habitat due to global warming, 1/20th of the continent's total.

12,000,000,000,000

tons of carbon, mostly in the form of coal, is left on Earth.

900 liters of water are needed to produce 1 liter of wine.

Keys to Curbing Climate Change

"We have to leave the majority of the reserves of coal, oil, and gas underground."

Ottmar Edenhofer is deputy director and chief economist of the Potsdam Institute for Climate Impact Research and co-chair of the mitigation working group of the Intergovernmental Panel on Climate Change.

Everyone knows something must be done about climate change. The question is, what – and how? As the nations of the world debate what the future will bring, issues of justice inevitably arise. Does the developed world have a responsibility to sacrifice some of its prosperity to help the poor of the world achieve higher standards of living without further damage to the environment? Renowned climate expert Ottmar Edenhofer says cooperation and technology are both key to navigating the perilous future we face together.

The world's leading climate researchers agree that the Earth's system has certain tipping elements sensitive to global warming. Once specific temperatures are exceeded, events might be set into motion that we cannot reverse – receding ice caps leading to rising sea levels, melting permafrost in Siberia emitting substantial quantities of methane into the atmosphere or significant changes in ocean currents, for example. The dimension of these impacts on the planetary machinery has a profound impact on how economists think about climate policy and the whole climate change issue.

These events are hard to determine precisely. Even if their probability would be low, the impacts are very high. This is what some economists call a "fat-tail" distributed event. This has a very important implication: cost-benefit analysis cannot be applied if you are confronted and challenged by these kinds of events.

To deal with the potentially high impact of those tipping elements, we need a kind of precautionary principle. One such principle is that in order to avoid dangerous climate change, the increase of global mean temperature must be limited to two degrees Celsius, compared to preindustrial levels. This would hopefully result in avoiding large-scale risks to the planet. We have already increased the global mean temperature by 0.8 degrees over the last centuries, so we can afford an additional 1.2-degree rise over the next century. But even if the actual concentration of greenhouse gases in the atmosphere could be stabilized right now, global mean temperature would still rise by 0.6 degrees. This adds up to already 1.4 degrees – just a little lower than the limit of two degrees the United Nations agreed upon.

We have already seen the implications for emission reduction profiles. In an ideal world, the only thing we as scientists would have to do is to communicate these insights to the policy makers. They then have to choose reasonable climate and energy policies in order to reduce emissions.

However, there's another risk, a very important one, emphasized in particular by the developing countries. And this is what I would like to call the risk of dangerous emission reduction.

If you look at the world's distribution of capital stock per person over the last five decades, the results aren't much of a surprise: The United States is very rich, Latin America is poor, Africa is very poor, and Europe is also relatively rich.

This distribution becomes a little bit more interesting if you compare it to how much CO_2 different countries have deposited in the atmosphere over the last five decades. The countries which have been successful in promoting economic growth and overcoming poverty are the same countries which have used the atmosphere to a large extent. And this is a one-to-one relationship. Historically, increasing capital stock per capita by one percent, also increased emissions by one percent.

Tragic Trade-off

We have never successfully decoupled economic growth from emissions. We are confronted with a tragic trade-off. A world where we have climate protection means emission reductions and sacrificing economic growth. Or we have economic growth without climate protection, and risk dangerous climate change. It seems that it has been burnt in the memory of humankind that well-being, welfare, and economic growth are associated with burning coal, oil, and gas. This historical experience is the reason why so many developing countries are reluctant to accept binding commitments.

The crucial question is: Are we able to decouple economic growth from emissions growth in the next century? "Business as usual" leads to an increase of global mean temperature of around four to five degrees. So we risk really dangerous climate change. To achieve the two degree Celsius target, on the other hand, requires that we peak our emissions around 2020, then reduce emissions substantially by the end of the century. In the long run we have to achieve negative emissions.

There is a gap between what will happen and what should happen. Do we have the technologies, and can we transform our energy system to achieve the two degree Celsius target?

Our energy system is a fossil-fuel based energy system dominated by oil, coal, and gas. There's a little bit of nuclear power, a lot of traditional biomass (largely firewood), and a very tiny part of the mix is renewables. From now on, we have to transform our energy system substantially.

Renewables will be an important part of any future energy system. Another important element will be negative emissions. This means some kind of carbon extraction technologies like the almost CO_2-neutral use of biomass combined with carbon capture and storage, and nuclear power. The costs of implementing these solutions are between one and two percent of world GDP – in other words, postponement of economic growth for a few months between now and 2030.

"The crucial question is: Are we able to decouple economic growth from emissions growth in the next century?"

Is this realistic? Can we expect such a transformation, based on what we have seen regarding the evolution of our international institutions, the Copenhagen Accord and the ongoing evolution of our energy system? I would argue that we cannot expect such a transformation unless we have international binding agreements.

Over the last five years, the carbon intensity around the world actually increased. After the recovery of the world economy we will have an even higher growth rate, and an increase in carbon intensity. This will lead to an increase in emissions.

But we need carbon intensity and emissions to go down, not up. It is quite clear that the scarce resources in the 21st century are not coal and gas, and oil; the limited resource is the capacity of the atmosphere. This is, from my point of view, the most important insight of the economics of climate change: We have to leave the majority of the reserves of coal, oil, and gas underground.

> "We have to ... manage the atmosphere, one of the most important assets we have."

This will reduce the profits for some companies and nations. And this is the reason why they will oppose any global binding agreement: Because such a treaty would reduce their resource rents. What we have to do, in one way or another, is transform their profits. We have to transform their resource rents into a kind of a climate rent, which is then the property right to the atmosphere for humankind as a whole.

Therefore it seems to me that we need global institutions that allow us to manage this transformation. These institutions consist of an international cap and trade system: A kind of atmospheric trust; promotion of climate-friendly technologies; funds to avoid deforestation; an international adaptation fund and a new kind of development policy, as outlined below.

Managing the Atmosphere

First of all, we have to recognize that the atmosphere is a global common. We have around 12,000 gigatons of carbon as exhaustible resources underground. And we can deposit just 230 gigatons of that in the atmosphere if we want to achieve the two degree Celsius target. That's why the atmosphere is the limited resource, not carbon. We have to establish a kind of an earth atmospheric trust to manage the atmosphere, one of the most important assets we have, on behalf of humankind.

Innovative Technologies

Then the crucial question becomes how should we distribute, in a fair way, these emission rights over the course of the next century? To highlight these issues of fairness and justice, let me tell you a little fairy tale.

Think about ten people in a desert. These ten people have a limited amount of water. Two people drink a lot of water, and they have already used half of the water. At some point, the whole group realizes water is a scarce resource.

So the two who have already drunk the most come up with a splendid idea. They argue, "let's distribute the rest of the water in a fair way so everybody gets the same amount of water." Two people in the group are quite happy with that plan. The other eight people are not happy. They point out that the first two have already used half of the water.

In the end, it doesn't matter: If the ten people in the desert start fighting about the proper way to distribute the rest of the water, in the end they will all die of thirst.

This is what economists call a serious zero-sum game. And zero-sum games cannot be solved. A philosopher could probably solve the problem, but there are no philosophers in the desert: They're all sitting at home writing marvelous essays about why it is not a good idea to walk through a desert with a limited amount of water. So philosophy cannot help us.

Instead, we need a bunch of people who undertake a trip to the next oasis together. The next oasis, in this case, is a carbon-free economy with a reasonable portfolio of mitigation options and new technologies. Without climate-friendly technologies, without innovation, I believe we cannot solve the climate problem. We have to distribute the water in a way which allows the whole trip to the next oasis. It might be plausible that the whole trip will reach the next oasis if the water is distributed equally among the group. However, without new technologies, this climate problem becomes a purely distributional zero-sum game. And humankind doesn't have the capability to solve zero-sum games.

Analyzing the climate problem with the eyes of an observer who would like to see much more innovation, it is quite worrisome that research and development investment in renewable energy technologies is not as high as it should be. And R&D investments do not have the right composition to bring the appropriate technologies forward in the long run. In particular, we need new storage technologies for renewables and also investments in carbon capture and storage.

Stop Deforestation

Thirty percent of carbon emissions come from land use and land use change emissions, in particular deforestation. The southern hemisphere, in particular, is responsible for these kinds of emissions. Here we are challenged by another global common: The forests. To protect the forests, we have to think about how to compensate people who do not use them. But, again, such a compensation scheme is quite tricky.

> "To protect the forests, we have to think about how to compensate people who do not use them."

This entire process is especially difficult given the interconnected nature of the global economy and its links to forests around the world. Even efforts to produce greener fuels seem to be backfiring. Increasing oil prices, for example, have led to an increasing rise in maize prices. Why was this the case? Due to the increasing oil price, it becomes incredibly competitive for the farmers all over the world to produce biofuels – in particular bioethanol and biodiesel. This means that the opportunity costs to protect the forests increased, because now the demand for food and the demand for biofuels have increased the land rents. That is an additional incentive for farmers not to protect the forests, but to chop them down.

> "The energy markets … are the most important force behind what happens in the agricultural market."

This aspect is quite worrisome. Now the energy markets, in particular the oil market, are the most important force behind what happens in the agricultural market. The increasing demand for biofuels has led to an increase in deforestation. This is simply first-semester microeconomics.

However – and this is quite important – people who are designing the compensation mechanism to protect the forests have not taken into account the fact that oil prices determine what happens in the agricultural markets.

Adapting to Climate Change

Adaptation is quite an important issue. Even if we are able to limit the increase of global mean temperature to just one degree Celsius, there will be some climate change. In particular, poor countries have to adapt to climate change. And therefore an international adaptation fund has to help these countries redesign their infrastructure.

But if we take only into account infrastructure investments, we're not sufficiently understanding adaptation. We need also a new agricultural policy. An increase of global mean temperature beyond two degrees will have a severe impact on agricultural productivity, particularly in poorer countries, and in particular in Africa. Here, again, we need a redesign, in particular of the European agricultural policy. To deal with a decline of food production we need an integrated agricultural market where poor countries have access. Otherwise, I do not think we can prevent food crises in the future.

Finally, we need to redesign development policy. When we distribute our emission rights according to equal shares per capita – let's say by 2020 each person on earth has the same right to emit CO_2 – across the globe, it is quite obvious that the poorest countries, particularly in Africa, will substantially benefit from this scheme. We should use the international cap and trade system as an important tool to redesign and to enhance development policy. An international cap and trade system is an important device to mobilize money, which then can be invested in the poor countries.

This is, from my point of view, the global deal we need. Even if you are not so interested in climate policy, these kinds of global institutions are necessary to manage our global commons. The atmosphere and the forests are some of the most important examples of a global common resource.

We need these institutions in order to manage other global crises, like the food crisis and the migration problem. While it seems to me these kinds of global institutions are absolutely necessary, I have to say I do not know if it is likely global institutions like this will be implemented in the next five years. In the end, it is up to us to make it likely.

This is a condensed version of a speech given at the session on Climate Change and Energy. More can be found at www.ourcommonfuture.de/edenhofer

Water in a Global Perspective

"Sustainably solving the world's water problems will come at a high price."

Wolfgang Kinzelbach is a professor of hydromechanics at ETH Zurich. His research focuses on sustainable water resources management in arid and semiarid regions, mainly in Africa and China.

With all the discussion about the world's dwindling supply of fossil fuels, another critical substance is often overlooked. Life on Earth depends on water, and yet the world is well on its way to a water crisis. All across the globe, farmers need more water to supply food for a growing world population. Water expert Wolfgang Kinzelbach of ETH Zurich says a combination of political will and creative technology is needed to get us safely through the decades to come.

In South Africa, there's a popular slogan: "Save water, drink wine." Sadly, the slogan is completely wrong. To produce one liter of wine, you need about 900 liters of water. That's water for the vine to grow and the leaves to develop, water for the grapes to ripen, and water to wash the bottles before you fill them.

This false slogan illustrates a problem in the public debate over water resources. When we talk about water, most people just think about drinking water. Drinking water is a minor, even negligible, problem as far as water quantity is concerned: What we really need water for is to grow plants and, more specifically, food.

Banking Water

In truth, we have two types of water. One is the surface water you see in lakes and rivers. The other is ground water hidden under the surface. They're very different, in two ways: Surface water has a relatively small volume but a large renewal rate, while groundwater has huge volume but a very small renewal rate. Surface water takes, on average, two to three years to exchange once, while groundwater takes thousands of years to exchange once.

Think of it in terms of a bank account. When setting a budget, the important thing is our monthly paycheck, not the money in our savings account. Savings are for when we get into trouble and need to fix the car – just like groundwater is important when we have a drought and have to pull up water to save the harvest. But we should base what we really do on the rapidly renewing surface water. Groundwater is not something which goes well with large-scale irrigation.

Another difference is between blue and green water. Green water is the rainwater which is stored in the root zone of the plants and released into the atmosphere again through the plants' evapotranspiration. Blue water is runoff left on the land. It collects on the surface or comes out of springs, flows into channels and rivers, and then on to the ocean.

When we look at rain-fed agriculture, we talk about green water use. It's the rain which is stored in the soil and then evaporated by the plants. Irrigated agriculture is blue water use. Only blue water is easily managed and distributed. Green water can be managed only indirectly by land-use change.

Finally, we distinguish between nonconsumptive water use and consumptive water use. If I wash my hands, the water is, for example, coming from the Rhine River. It will go down the sewage canal. It will go to the sewage treatment plant. And it will return to the Rhine. It has just made a detour. I didn't use the water: I used its cleanliness, maybe its low temperature, but not the water itself.

This is different in agriculture, where water is evaporated. It's not lost, but it probably doesn't come down as rain in the same catchment area it was taken from. So, as far as the catchment is concerned, it may be lost, or consumed. This consumptive use will have a consequence. If the people upstream use a lot of water for agriculture, they evaporate it and the people downstream will lack that water.

Water into Wine

Finally, there's virtual water. This is a term coined by John Anthony Allan, a British geographer and economist. We call it virtual water because there is water which has been used in the production of a good which is afterwards not contained in the good, like the 900 liters it takes to make one liter of wine.

To put this in perspective, most people drink two to five liters of water a day. Yet one kilogram of grain takes in its production 500 to 2,000 liters of water, making grain essentially concentrated water. If you use that grain to feed animals, then the water is doubly concentrated, or more. And one kilogram of animal products – meat or milk – consumes 5,000 to 15,000 liters of water.

Should we become vegetarian? I think if we look at this question a bit more scientifically, then we should differentiate carefully – if we told countries like Mongolia, Botswana or Argentina not to eat meat but to grow food on their prairies, they would ruin their countries, just as in the Dust Bowl in the United States almost a hundred years ago. Usually, the only reasonable way of turning a prairie into edible calories is to put cows or sheep on it.

> "In 2025, there will be three billion people living in areas with scarce water resources."

Competition for Resources

But in most of the world, the intense water use that comes along with agriculture contributes to a growing, and urgent, problem: Water scarcity. According to the UN, serious water scarcity starts when there are less than 1,000 cubic meters per year, per person in a region. That's not just water for drinking, it's water for everything from agriculture to industry. According to that definition, we had about 400 million people who fell into this category in the year 2000. In 2025, there will be three billion people living in areas with scarce water resources – more than a sixfold increase.

Scarcity is growing for four reasons. Reason number one is population growth to about 9 billion by 2050, when hopefully it will stop and decline again. Our task is not really to fight against the exponential curve, it's to make it to 2050 – if we manage that, then afterwards things will become better again. Second is an increase in living standards. The fact is that the last doubling of population caused a tripling in water use. We eat better, we drink better, we do more for our hygiene – we each use more water. Third is the water required for agrofuels. Fourth, and finally, there's climate change. Climate change does not change the amount of water we have on Earth, but it changes the distribution of rain on the surface of the Earth.

Due to all of these factors, global demand could double in the future. That makes water security a global problem. How do we make global water consumption sustainable and avert a water crisis? First we must look at the ways in which our water use today is deficient. There are many practices today for which there is no simple alternative, but which at the same time cannot go on indefinitely without running into a crisis.

One example is the depletion of a finite resource which cannot be replaced. If a country lives on groundwater alone because there is no other perennial water source, and this groundwater is pumped out faster than it can be replaced, you have an unsustainable situation. The same goes for soil: If we erode it faster than it is formed, we will have none left in the end. And the same goes for biodiversity. You cannot recreate species which are extinct.

Another example is the accumulation of substances in the soil or groundwater. Salt accumulation may be a very slow trend. But if you go on accumulating, you reach a limit where plants cannot do their osmotic work and the soil becomes sterile. Salts and heavy metals are "ingredients" which could accumulate and carry us over game-changing thresholds. Unfair allocation of a resource is also a situation which might not be sustainable. If users upstream are taking all the water, people downstream might have a problem – maybe even to the point of an armed struggle. The breakdown of institutions due to bad governance is also unsustainable. And runaway costs for water would be as well.

> "How do we make global water consumption sustainable and avert a water crisis?"

So what are the largest problems of unsustainable water use on Earth? The first is of course the depletion of aquifers. One-quarter of all withdrawals are nonrenewable. It's fossil water, which is not renewed. And 40 percent of irrigated agriculture in the world is affected by declining groundwater levels.

The two worst places are in India's Ganges valley and in the North China Plain. In the North China Plain, the pressure on underground water resources is so heavy that the price of water has gone up, because more electricity is needed to get the water up from the lowered groundwater table. As a result, it is no longer economically feasible to grow irrigated wheat in the North China Plain. The irrigated wheat farming is migrating to the country's northeast, where it can be grown with rainwater. That is one way of adapting to the situation.

The situation in India is more critical. In India, unsustainable water use is encouraged by the fact that electricity is free for the farmers. Whenever something is free, there's no incentive to conserve or value it. And that is what is happening with water: Indian farmers pump it from the ground excessively because the electricity is free. No exit strategy is on the horizon. Politicians are reluctant to impose unpopular tariffs on electricity in the countryside.

The important thing to remember is that you can do things which are not sustainable, but only for a while. You can do them to gain time, and as a temporary fix. But you need an exit strategy. China's exit strategy is twofold: Number one is the water transfer from Southern China to Northern China. And number two is a land grab in Africa, where food for Chinese cities will be grown in African fields instead of on Chinese land. This is a way of adapting to the situation, but whether it's a good way is another question.

Damning Diversity

Another growing issue is the decreasing flow of rivers in low-flow season. Many rivers which used to be perennial – the Nile, the Yellow River – have become seasonal rivers. On the Yellow River, for example, reservoirs have been built to an extent that their combined storage volume now equals the average annual flow of the river. That means that in an average or below-average year you can retain every drop of the river's water within the watershed, and not leave anything to the sea.

> "The world's wetlands have shrunk by 50 percent over the last century ... due to competition."

Damming the river's upper stream, of course, has a lot of repercussions on the lower reaches of the river. The most tragic example for upstream use leading to downstream misery is the Aral Sea, where water is now evaporated in agriculture upstream instead of in the lake. As a result, what was once a vast inland sea has almost vanished, except for a small basin which is saved by a dam.

The world's wetlands have shrunk by 50 percent over the last century. In the first part of the century, wetlands disappeared in North America and Europe. In the second part of the century, it's Asia and Africa that are losing their wetland biospheres at a rapid rate due to competition from agriculture both for land and water. With the loss of the wetlands we lose biodiversity, which may be very important for our survival in the future. An example of a wetland, which can still be saved, is the Okavango Delta in Botswana, where I've been doing research for the last 12 years or so. If the international community can help the upstream countries save water, the decrease of the swamp area could still be stopped.

Hope for the Future

All this is not to say the situation is hopeless. If we want to solve these water problems, we must start with the biggest user: Agriculture. There is no other way. We could make dramatic strides in water conservation – on the order of 1,000 cubic kilometers per year – by implementing improved technology. Nowadays, if a Pakistani farmer takes one cubic meter of water out of a reservoir and brings it to his or her field, half is lost on the way. Half of that is lost in the field itself to non-productive evaporation from the bare soil or seepage. And when you bring the grain to your granaries, about 40 percent of it is lost to fungi, rats, and other avoidable pests, making a final efficiency of water use of around 10 percent. It could be easily doubled, which means producing the same amount of food with half the water. Food losses occur also in rich countries like Germany or Austria, where food worth 300 euros is thrown in the garbage per person, per year. About 10 percent of the food sold in supermarkets is thrown away before the package is ever opened. These are all places where we can really save a lot with smarter management.

Another important technological application is increasing the yield of rain-fed agriculture. A big chunk of our food comes from rain-fed fields, and making this area more efficient through the use of biotechnology – for example by breeding drought-resistant and high-yielding strains, perhaps using genetically modified organisms – will be an important tool.

Division of Labor

And then, of course, there is the increasing efficiency of the international division of labor. We should grow wheat where there is a marginal advantage of growing wheat, rather than growing wheat in the desert where we ruin the water resources as a result. In water terms, that means that for some countries increasing imports of "virtual water" in the form of grain will play a big role.

There are less sweeping, more local options, like rainwater harvesting, new dams and the desalination of seawater. Wastewater recycling can increase the water we have at our disposal. And resettlement of people and birth control are ways to reduce demand for water and the products made from water. But of course these all carry costs, whether in terms of energy or political capital.

Water Saving

How much more water do we really need? Taking into account population growth, unsustainable practices, and mitigation of climate change, plus agrofuels, we will need 4,000 to 6,000 cubic kilometers more per year. If we cut out agrofuels, which at present are disastrous for the world's poor, we still need 3,000 to 4,000 cubic kilometers more per year, either in increased resources or water saved. The task is enormous, if we consider that the present blue-water use of about 4,500 cubic kilometers per year cannot be increased substantially. The potential of all water-saving and resource-enhancing options is on the order of 3,000 cubic kilometers. Any remaining discrepancy will most probably be covered by taking green water from natural ecosystems.

> "There's no doubt … the water resources remaining for natural ecosystems will further decrease."

There are already serious regional water problems. We don't have to wait for the future to see water scarcity. But these problems are increasing in intensity for the reasons I have described. Part of our present water supply is not sustainable. And climate change will increase the pressure on water sources.

The only way to avoid a global water and food crisis, in my opinion, is to do without agrofuels and to use our water much better than we do today. This involves not only the solution of technical problems but also of socioeconomic problems which, as a rule, are more difficult to solve and time-consuming. Sadly, there's no doubt in my mind that the water resources remaining for natural ecosystems will further decrease in favor of agriculture.

Generally, I think humankind will have to allocate a larger portion of its income to food and water in the future. Food has become less and less expensive over the last century. This is not a natural law – the food price fluctuations we have seen in the last few years are an indicator that this time is over. If we allocate enough of our resources to the problem, we can do anything; but sustainably solving the world's water problems will come at a high price, and that means more money spent on food.

As an engineer, I'm optimistic about our ability to overcome the water problems, given the political will to do it. But I'm less certain that we can allocate the resources on the Earth in an equitable way to all of its inhabitants. That's the really big problem, and unfortunately I have no answer for that.

This is a condensed version of a speech given at the OCF conference's sessions on Climate Change and Energy. More can be found at www.ourcommonfuture.de/kinzelbach

The Third Revolution

"We stand today on the verge of another grand transformation."

Nebojsa Nakicenovic is deputy director of the International Institute for Applied Systems Analysis (IIASA) and professor of energy economics at the Vienna University of Technology.

Nebojsa Nakicenovic argues that we need nothing short of an energy revolution comparable with the Neolithic and the industrial revolutions to achieve further development in the world and goals of a sustainable, equitable future. Addressing the Our Common Future conference session on Climate Change in Hannover, Nakicenovic – an expert in long-term patterns of technological and climate change – said the next revolution will take investment in research and deployment, sound policy, ingenuity and above all commitment.

Before discussing possible future developments it is instructive to first look at our past. Humanity has evolved in the more recent history through major revolutions. Going back a few million years, human beings lived as hunters and gatherers. This way only a few million people could be sustained on the planet. The Neolithic revolution, some five to ten thousand years ago, led to the domestication of plants and animals. This innovation resulted eventually in the development of agriculture and city-states, both of which enormously expanded the niche of humans on this planet. This transformative change can be also seen as the first energy revolution: Enhanced productivity in agriculture enabled to harness human and animal muscle power and thereby provide the essential mechanical energy for basic human needs, from building settlements, infrastructures required for essential activities from water pumping to mobility and food processing.

By the year 1700, there were about 900 million people on the Earth exceeding one billion shortly after the 1800s. About this period came the Industrial Revolution, the second major energy transformation in the Earth's history. The inanimate sources of energy with the development of the steam engine and other innovations were able to replace human and animal work and thereby further expand global population to seven billion people today. The "age" of coal and steam was followed by the "age" of oil and gas, internal combustion engine, electricity and numerous other technologies, institutional and social changes. The explosive development initiated with the industrial revolution is still under way.

The last two centuries of this unprecedented development in the world have improved the human condition enormously. The gross world product now stands at almost ten thousand dollars per capita, which is sufficient to provide for a good average quality of life. However, at the same time, inequities are increasing and the "bottom billion" has to live on barely a dollar a day. A predominant social issue that is increasingly becoming a major preoccupation for world leaders is addressing social inequality and poverty, especially in the developing world. These contrasting developmental patterns have not only resulted in increasing gaps between the poor and the rich but also in adverse environmental impacts on all scales, from indoor air pollution to climate change and biodiversity loss.

We stand today on the verge of another grand transformation or revolution. In terms of demographic change, we are at a crossroads: Most population projections indicate another 50 percent increase in the global population, to about nine billion people by mid-century, followed by a decline to about or below the current level of seven billion. All of that increase will essentially be in cities. Already, more than 50 percent of the global population lives in cities. Urban population will probably double to about six to seven billion people in the second half of the century.

The combination of rapid urbanization, end of population growth and approaching planetary boundaries mark the possible emergence of the third grand transformation to emissions-free development pathways. One of the major challenges is to provide sustainable access to energy and ecosystem services. These include food and water for the half of the humanity that's essentially excluded from global prosperity.

Universal Access

In many ways, the industrial revolution has propelled only half of the global population into affluence. About three billion people still have to cook with solid fuels, about half a billion with coal and two and a half with noncommercial biomass. Of these, about half a billion live in sub-Saharan Africa; the rest are mostly in Asia. Many of these people either have no or inadequate and unreliable access to electricity.

Universal access to energy services is a prerequisite for development and is thus an essential development goal in itself. There is another, little-known dark side to this lack of access. The World Health Organization estimates that on the order of one and half to two million children die prematurely each year from respiratory diseases related to indoor air pollution that is caused by cooking with an open fire in enclosed rooms. Providing access to energy will have a health co-benefit as well. The challenge is to provide both upfront investments and adequate subsidies for "priming the development pump" until access can enable productive activities that generate income and make energy services more affordable. Other co-benefits in addition to health would include time released from collecting solid fuels for other productive activities.

The problem is not one of lack of energy resources or renewable potentials. From coal and oil shale to frozen methane, there are ample occurrences of hydrocarbons, many of which could be economically tapped in the future provided that appropriate technologies are deployed and environmental compatibility resolved. The vast quantities of carbon in resources also indicate that the planetary boundaries associated with climate change would indeed present the ultimate limit to future extraction of hydrocarbons. This means that in the future there is an urgent need to use alternative, non-carbon sources of energy or decarbonize fossil energy sources. This can be done by carbon capture and storage technologies. Many of the components have been in use by the oil industry for enhanced oil extraction, however the quantities of separated carbon to be stored in the case of fossil energy decarbonization would be truly gigantic (in orders of gigatons of carbon dioxide). Storage possibilities can pose limitations as well as potential risks and the need to store carbon for millennia to come.

Uranium resources are also vast and with advanced fuel cycles practically infinite. In this respect the nuclear option could lead to a substantive reduction of carbon dioxide emissions by replacing fossil energy. The limitations however are due to risks of accidents as the Fukushima plants have experienced in the aftermath of the gigantic tsunami in 2011. Furthermore, there are inherent risks of proliferation of fissile materials and the need to store the waste products for millennia.

Fortunately, renewable energy potentials are also vast. The economic potential of renewables is in the range and may even exceed the current global energy requirements. The technical potential is truly huge and for obvious reasons solar energy potential is practically inexhaustible.

A robust conclusion is that we are not really limited in terms of energy potentials or resources. We may be limited by our ingenuity, by the capability of our economic system, and by the will of our political institutions to achieve the energy revolution under way toward a more sustainable future. But, in principle, energy resources and potentials are there.

Vigorous Decarbonization

The real limitations to future energy use are the environmental and planetary boundaries, particularly climate change. To keep the Earth's climate within two degrees of its preindustrial temperature, future global emissions need to reach a peak this decade, proceed to decline by about 80 percent by the middle of the century, falling to zero or even becoming "negative" in the second half of the century. The later the peak, the more "negative" the emissions need to become. By negative emissions we understand the situation where carbon is effectively removed from the atmosphere. A possible technology is sustainable biomass with carbon capture and storage. From the energy point of view, nothing short of a revolution is necessary to bring the changes required to achieve such radical emissions reductions. The key question is whether the vigorous decarbonization is possible over the next four to five decades and whether this transformational change would bring other benefits beyond the direct ones for the energy system and climate.

Transformational Change

Fundamental, game-changing energy transformations are needed for a shift toward more sustainable development paths. By significant investment in new technologies and decarbonization multiple co-benefits may be achieved – from provision of affordable access to energy services and creation of new business and economic opportunities to averting the threat of climate change. Decarbonization of the global economy is such a paradigm-changing transformation. In the energy area, this implies a shift from traditional energy sources, in the case of those who are excluded from access, to clean fossils and modern renewable energy. It also requires a shift from fossil energy sources to carbon-free and carbon-neutral energy services in the more developed parts of the world.

In all cases, the transformational change means a vigorous improvement of energy efficiencies, from supply to end use, expanding shares of renewables, more natural gas and less coal, vigorous deployment of carbon capture and storage, and in some cases (where it is socially acceptable and economically viable) also nuclear energy.

All of these energy technologies need to mesh with emerging innovations in energy networks and end use in the direction of smart integration. There is enormous potential for most renewables such as solar energy. High shares of intermittent renewable energy require development of smart grids to harmonize supply and demand that would also include storage and gas power plants as reserve capacity (or virtual storage). There are even projects in the works to tap the solar energy from remote deserts such as from the Sahara to supply power to Europe and sub-Saharan Africa or from the Gobi desert into metropolitan areas of coastal China. With advanced nuclear technologies, in principle we could do the same. This kind of revolutionary change would occur at a number of levels, from local and distributed to centralized generation. The very nature of energy end use would be undergoing fundamental transformation toward more self-organization and Internet-like structures and integration.

The emerging new energy systems require two complementary co-evolutions – one is technological and the other institutional. With new technologies and systems, new business models and institutional arrangements will emerge. All of these complementary and co-evolving transformations would imply and require market, regulatory and behavioral changes.

Sustained Investments

Using a holistic and integrated approach, researchers at IIASA (2011) have identified management and policy options that could bring about the transformational change of energy systems. The possible benefits of this transformation, or energy revolution, would include:

- Vigorous reduction of greenhouse gas emissions in order to avert dangerous climate change;
- Universal access to affordable energy services by 2030;
- Improved air quality and improved human health and life expectancy;
- Improved energy security (reducing reliance on energy imports and reliability of energy systems);
- Avoided costs associated with the adverse impacts of climate change; and
- Avoided energy subsidies.

Preliminary analyses indicate that these additional benefits outweigh most of the investments associated with achieving the revolutionary energy transformation. Furthermore, in many cases, the benefits are demonstrable in the short term and on national and local scales. Thus, there is a strong argument for an integrated development strategy, focusing on energy and climate as the key entry points with many co-benefits that achieve other environmental and social objectives.

The above-mentioned benefits can collectively be seen as the motivation for a "green growth" and decarbonization development pathway, one that is necessary to move both mature and emerging economies toward a more sustainable future.

"'Negawatts' are cheaper than ... kilowatts."

The most cost-effective greenhouse gas mitigation measures are increased energy efficiency and energy conservation. Energy efficiency improvements are among the most cost-effective options. "Negawatts" are cheaper than capacities for additional kilowatts. They lead to significant and long-term energy and emissions savings.

Increased use of renewable energy, expansion of nuclear capacity, and improvements in energy efficiency and conservation would reduce both greenhouse gas emissions and other airborne pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter. This would not only reduce the investment required for pollution control, but the resulting improved air quality would improve human health and lower health costs.

The estimated co-benefit value of reducing the emissions of air pollutants – including particulate matter, sulfur dioxide and nitrogen oxides – is in the range of US$400 to $500 billion per year and that up to 50 percent of air pollution emissions could be avoided by deep cuts in greenhouse emissions.

Many energy scenarios include additional costs for improving energy security through limiting energy imports and supporting larger domestic energy production, often despite higher costs. The co-benefits of an integrated energy and climate strategy would avoid energy security costs of some US$100 to 300 billion per annum. This does not include economic impacts that could result from ensuing political instability such as in North Africa and the Middle East or other disruptions to oil and gas supplies.

The development of technologies to reduce greenhouse gas emissions, such as carbon capture and storage or solar photovoltaics, serve as an example of how "green growth" can stimulate economic growth. Green development pathways also generate local employment, particularly in the case of sustainable energy options such as renewables and efficiency improvements. The co-benefits, including avoided costs, associated with the transformational change associated with the next energy revolution offset most of the investment costs.

These policies also advance the broader UN Millennium Development Goals. Energy is cited as the missing MDG, recognized by ministers and government representatives from 71 nations, including Africa, Latin America, and India in a declaration calling for 2012 to be designated by the United Nations as the "International Year of Energy Access" and the General Assembly Resolution to declare 2012 the "International Year of Sustainable Energy for All." These calls were reiterated at the Cancun climate talks in 2010, further reinforcing the relevance of energy to climate objectives. Energy would be an important entry point for addressing sustainable development at the Rio+20 Global Summit in 2012.

The policies and decisions on future energy sources, the efficiency of their conversion into energy carriers such as electricity, and the changing nature of energy end use in providing goods and services for human well-being, will profoundly enhance our ability to reduce poverty, improve health, minimize adverse environmental impacts, and avert dangerous climate change, whilst still empowering development. Progress, however requires a diverse and integrated portfolio of actions and policies applied at local, regional, and national scales and across sectors.

Conclusions

Greenhouse gas mitigation through an integrated energy and climate strategy is environmentally, socially, and economically viable if the many co-benefits and avoided costs are considered. Governments must look beyond short-term costs and consider both the short- and long-term benefits. This would bridge the "gap" that exists today between the needed investments for the energy transformation and the possible co-benefits that today cannot be fully appropriated by those who would provide the necessary finance.

The cumulative nature of technological and associated institutional changes, all compounded by deep uncertainties, require innovations to be adopted as early as possible in order to lead through experimentation and evolutionary changes to lower costs and wider diffusion in the following decades. The longer we wait to introduce these advanced technologies, the higher the required costs and emissions reduction will be as well as the "lock-in" into the old structures. The transformational change toward more sustainable futures requires enhanced research, development and deployment (public and private) efforts as well as early investments to achieve accelerated diffusion and adoption of advanced energy technologies and systems. The possible benefits of such revolutionary change would outweigh the needed investments. Achievement of universal access to energy services represents a humble and doable portion of the total investment needs.

The evident crisis of the "old" development patterns is an opportunity for the "new" ones to emerge and a possible beginning of the third energy revolution.

This is an updated version of a speech given at the OCF conference's sessions on Climate Change and Energy.

“As scientists, we want to be as neutral as possible.”

Liadi Mudashiru

“We should find positive metaphors to communicate.”

Clare Saunders

Research results and respective news about climate change have become so common that the topic threatens to fade into the background. At the OCF conference, we asked two young researchers from different fields – British political scientist Clare Saunders and chemist and energy researcher Liadi Mudashiru – to discuss ways researchers could boost public understanding and engagement in this important issue.

In the field of climate change, there's always new research coming out that trumps the old assumptions. Sorting through that can be overwhelming for the average person. How do you break through to people who are desensitized to this topic?

Mudashiru: It is part of our responsibility as researchers to be able to communicate what we do in the laboratory and behind the scenes to the public. Over the past five years, I've been a UK Science and Engineering ambassador. As part of the program, young people like me go to secondary schools. We use our energy, enthusiasm and passion for science to introduce a new young generation to the subject. We also have a national organization called the British Council for the Advancement of Science. We host an annual science festival in the Houses of Parliament. This has given us the opportunity and the platform to talk directly to the policy makers.

Saunders: I've gone to schools to do some outreach work. I try to give lively talks and relate things to people's individual lifestyles. Also, more of my work now is shifting towards understanding behavior change. General research on behavior change shows that we should find positive metaphors to communicate about environmental problems. So if we have headline articles saying, "Danger! Danger! We're all going to die!" people just switch off and bury their heads in the sand. So instead of saying "we need to avert dangerous climate change," we say "we need to look after this wonderful planet that we've got."

OCF Fellow Liadi Mudashiru, born in 1972, is a research associate at Newcastle University. His background is in chemistry and geosciences. For the past three years, he has focused on the clean use of fossil fuels.

OCF Fellow Clare Saunders, born in 1975, is a Research Council UK Fellow in energy and climate politics at the University of Southampton. She is a passionate advocate for the climate in her private life as well, organizing protests and training camps for environmental activists.

Dr. Saunders, you're a social scientist. Dr. Mudashiru, you deal primarily with energy research. What can you learn from each others' academic disciplines?

Saunders: I would really like to know more about carbon capture and storage on the basis of some of the things I've been studying. For example in 2008 in Kingsnorth in Kent, there was a big demonstration with around 2,000 protestors. They were there to protest against new coal-fired power stations being built. It was called partial carbon capture storage. I don't know if the activists knew exactly what partial carbon capture storage is. I'm curious whether the activist discourses make sense from a scientific perspective. Which science do they draw from to create their arguments? And how? And why?

Mudashiru: I do agree with you, there is a lot of synergy. What we are trying to do is not downgrade the risk but better communicate the risk to the public. There have been various disasters but public engagement has been very successful. For instance, in France, the oil and gas company Total successfully built a carbon capture storage facility without any protests. It's because from day one the company embedded public engagement in the project management. It was very transparent. You could go on the Internet to see what they will do with the factory. So I think there is room for a lot of collaboration when it comes to communicating with the public.

Is there a danger of oversimplification when it comes to explaining climate science?

Saunders: Policy makers want to know: "What is the truth? Where do we stand?" But

science is always this continually evolving process. There is no such thing as smooth facts. When you communicate to schoolchildren, you can really simplify the message. When you communicate with the government, there is a real danger in saying, "This is what we know. This is the definitive fact on this." Also, it's important to take the human factor into account with anything that's technological. All technological solutions have to become politically acceptable and socially acceptable as well. Therefore, some social scientists suggest that what we need is a more discursive forum. That way, when a carbon capture and storage facility is proposed, for example, you can expand the conversation.

Mudashiru: I think that has always been the danger. People in the scientific community, we think we know it all. But the public doesn't like that. They want to be part of the process. They are very skeptical. They think we oversimplify risk – that we cover things up – especially when your research is being funded by big corporations like Shell. But as scientists, we want to be as neutral as possible.

Saunders: But it's so hard isn't it? Because you can say "the science shows this, but this is the confidence interval we have." And the minute you say that it loses the headline impact. And there's no way around it. It's the difference between making something snappy and being truthful and neutral at the same time.

Mudashiru: I think there are lessons to be learned. I think it will be in our own interests to be as transparent as possible. And people like Clare in her profession can help us do that. Because we scientists – we are not very good at communicating. But things are changing.

Cities, the Labs of the Future

Cities only occupy about two percent of the Earth's surface, but they consume the majority of the planet's resources. Balancing the demands for food, fuel, and water with a finite natural supply is a tough equation to solve. Yet cities are also fertile spaces for change and experimentation. Environmental governance expert James Evans, a participant in the OCF workshop on Climate Justice, says when we stop looking at cities as the problem, we may be able to unleash city dwellers' capacity to solve the issues of the future.

OCF Fellow James Evans, born in 1977, is a lecturer in the geography department at the University of Manchester and author of *Urban Regeneration in the UK: Theory and Practice.*

James Evans has a message for the world: The prevailing image of cities as giant masses of concrete has to change.

That perception doesn't fit reality in many cities, which actually demonstrate incredible environmental diversity. Birds build nests in the eaves of apartment buildings. Trees crack through concrete sidewalks. Flowers sprout on the embankments of busy roads. When given the opportunity, nature flourishes in cities.

The diverse city landscape can provide rich resources like cleaner air and water and access to healthy locally grown foods. For scientists, the city is potentially a ready-made laboratory for ideas that have the power to change the world for the better. The density and diversity of the cityscape lends itself to innovative solutions to challenges involving global warming and climate change, says Evans, an urban sustainability researcher at the University of Manchester.

Cities are suited to this kind of experimentation because researchers have access to diverse populations of people with a variety of needs and expectations. There is also usually more money and infrastructure to draw upon.

Take urban gardening: Brazil's largest southern city, Curitiba, pays residents to plant indigenous plants in their gardens in order to preserve biodiversity and prevent soil degradation that could lead to floods or droughts. The indigenous plants also provide natural filtration of water and air tainted by pollution.

A food program in Vancouver, Canada, connects residents willing to share their yards with amateur farmers who want to raise crops. Those crops are then sold cheaply at local markets. Innovative community-led approaches like this improve quality of life for residents.

"Residential gardens can be amongst the most biodiverse habitats on the planet," says Evans, who grew up on an English farm. "There's more biodiversity in many gardens than in parts of rural England that we have romanticized as being so natural." Transport is another area where cities have the capacity to lead the way for the rest of the world. "You could just use electric cars in the city, but only hire a petrol car when you want to drive long distances. Or you could simply improve high-speed rail lines between cities. Or you could have electric taxi vehicles in a city pool," Evans says. "It's about changing how people think. If you get them to buy into it, it'll happen."

Hamburg, Germany, for instance, is in the midst of an environmental experiment with its hydrogen-powered bus program. Hydrogen has the potential to reduce greenhouse gas, pollution, and improve energy security in Europe, so the city supported implementation of a hydrogen-powered bus fleet. The innovative program works because there's already a public transport network in place, the buses only need to make short trips, and locals are open to change. By initially experimenting with this technology in a city, scientists work out problems first, and can then spread the program to other places that don't have the same level of preexisting infrastructure.

But to turn urban spaces into effective laboratories, Evans says, individual cities need to create public and private partnerships to encourage such experimentation. "The lesson of my research would be that we need to make it possible and easy for people to try new things – I'm talking about residents living on a street, neighborhood associations, municipal governments, or a company that wants to deploy new technology," says Evans.

Supporting experimentation in the area of urban sustainability can include rewarding companies and individuals who cut down their energy use or better educating residents on ways to shrink their environmental footprints. "We need a social transformation in how people think and work," Evans says. "But this is feasible. The problem is helping people understand that another way is better."

Turning Google Earth Into a Global Warming Teaching Tool

Using a tool that's high tech, easy to use and – most importantly – free, members of the Global Young Faculty put together a way to reach out to the public over the Internet. The result is called "Facing Climate Change," and it could be coming soon to a computer screen near you.

When the members of the Global Young Faculty Climate Change team came together in 2009, one thing was immediately clear for their common project: An in-depth scientific project targeted to the academic community wouldn't make a lot of sense.

"We all came from very different disciplines," says team member Florian Leese, a researcher in the Department of Animal Ecology, Evolution, and Biodiversity at the Ruhr-Universität Bochum. "Many of us didn't necessarily have a lot of specific expertise in climate change. But we wanted to close the gap between scientific knowledge and public perception."

The team decided their project would have to reach out to the masses. And the obvious choice to do that? That free high-tech tool called Google Earth.

In 2010, the team created a Google Earth "layer" – a sort of overlay on the Google Earth map that gives users specialized information – focusing on the different local and global faces of climate change, its implications, and best-practice examples to confront it.

Called "Facing Climate Change," the layer aims to get basic scientific information across to the public in an accessible and eye-opening way.

Click on a spot in Brazil, for example, and a documentary on the country's role in climate change pops up. Click on another spot in the Arctic and there's a simulation of changes in sea ice coverage as global warming happens.

Other spots on the world map offer presentations by or interviews with prominent scientists, among other neat features.

The idea is to give laypeople the most current scientific information on climate change without forcing them to slog through complex academic papers, decipher tough equations, or attend a seminar far from home. Instead, they can just point and click to explore the changing world from the comfort of their home or office. By improving communication, unconventional and successful strategies to confront climate change in remote parts of the world may become best-practice examples for others.

While "Facing Climate Change" appears slick and easy to use, creating it wasn't so simple. Team members had to figure out how to program the layer, which is similar to Google Earth layers that automatically display all the restaurants or hotels in an area, for example.

It was also hard work coordinating with colleagues from around the world to create the necessary content. Much of it is original and created exclusively for the layer. "Facing Climate Change" isn't ready to be officially released yet due to some copyright issues, but it should be ready to go online soon. Once it goes live, users will be able to download the layer and install it into Google Earth themselves. A future goal is getting Google to include it in downloadable releases of Google Earth, something the team is currently negotiating.

And if the public finds it useful, there are all kinds of possibilities for future incarnations of "Facing Climate Change." More case studies from other regions and simulations of the consequences of global warming are potential add-ons.

For now, though, Leese and his colleagues are just happy that they created a successful project. Even among the hard-charging academics, there was always a niggling fear that they might not be able to pull the thing off. Indeed, much of the most important work on the layer happened in just the last few weeks and months before the Our Common Future conference.

Demonstrating the team's work at a mammoth touch-screen station in the lobby of the Essen Philharmonic during the Our Common Future conference, Leese sounded as proud as he was relieved. "I think we planted a seed for something pretty cool and important," he said. "This may really going to help educate the public on climate change realities."

More can be found at
www.facing-climate-change.org

Klaus Töpfer was German Federal Minister from 1987 to 1998, headed the United Nations Environment Program from 1998 to 2006, and is currently director of the Institute for Advanced Sustainability Studies in Potsdam, Germany.

"Take small steps, make incremental changes, and you'll see the world is changing much faster than you expected."

In a world where pessimism reigns, it takes real leaders to keep pressing for change. Former German environment minister Klaus Töpfer chaired the workshop on Climate Justice and Climate Governance at OCF. He challenged the leaders of the future to attack the issue on multiple fronts and talked about some of the obstacles to progress faced by politicians trying to negotiate a global climate agreement.

Has it become harder to push for climate justice in this economic climate?

Töpfer: Without any doubt, the financial and economic crisis concentrated a lot of political focus away from climate change. More and more people are saying, 'Maybe first we have to solve the economic crisis, and then we can come back to the climate.' We are fighting very hard against this position. We know that we can only solve both crises together. We must make a green economic solution possible. We must create a green industrial revolution. I believe more and more people are aware of these necessities, and understand this is not a prescription for destroying our way of life, but for changing it in a way that is less energy-intensive and consumes less than we did before. But there's still a lot to do.

> "We must make a green economic solution possible. We must create a green industrial revolution."

Was the failure of the Copenhagen negotiations a sign that there's a fundamental disconnect between the developed and developing world on climate change issues?

Töpfer: I'm not as pessimistic about the Copenhagen outcome as some. Whoever's aware of the real situation in the world couldn't have expected a legally binding agreement coming out of the conference. My very, very critical assessment is that this outcome is now misused by people who say 'first the politicians and the diplomats need to find a solution, and then we can act against climate change.' Developing countries are afraid that first the developed countries overused the environment, and now they want to misuse their sins as a blocking instrument against the development of developing countries. We have to change this mentality drastically.

> "It would be hard to convince politicians and the public in other countries to do something the United States is not doing."

Is it possible to achieve all this within the existing climate-negotiation system?

Töpfer: I'm always afraid that when you go to change the whole system, you go nowhere. Holistic approaches are destined to fail. I'm much more interested in having a clear direction and then going that way. Take small steps, make incremental changes, and you'll see the world is changing much faster than you expected. All those asking for the "Big Bang" change, they've been asking for years, and they forget to act.

Can serious progress be made without the United States?

Töpfer: No. Of course we need the United States. That's easy to understand – the United States leads the world in consumption and production, not only of CO_2 but of a lot of other things. It is the superpower in the world, and therefore it would be absolutely unconvincing to go forward without the United States. It would be very hard to convince politicians and the public in other countries to do something the United States is not doing. It's in the best interest of the United States to lead the fight against environmental destruction.

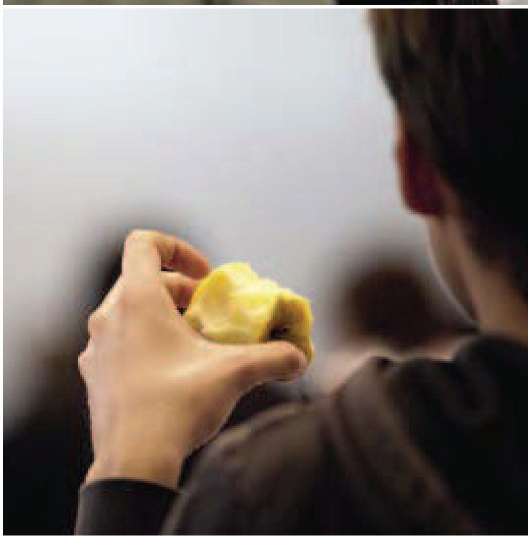
Are young scientists energized enough about this issue?

Töpfer: I think so. From what I've seen at the OCF conference, they are really enthusiastically linked with fairness, with justice, with the fact that you cannot have a peaceful world in the future without stabilizing the gaps between rich and poor. That injustice is a recipe for conflicts and wars. If we can overcome these differences while making sure the environment is not punished and misused we will have a good basis for the future as well.







Impressions from the conference.

“What fact makes you the most optimistic about our common future?”

Hüttl: We’re globally investing more in research and education, and the better we are educated the more research we can do. Whether the research will be applied is not in the hands of scientists, but in the hands of politicians and business leaders.

Schellnhuber: I’m optimistic about the potential humankind has to overcome crises. But I’m pessimistic that we will make use of it.

“What is the greatest challenge facing us in the next 25 years?”

Hüttl: Higher consumption in the future means more pressure on resources, which makes resource efficiency the real challenge.

Schellnhuber: We don’t have anything that might be called a global government, just a lot of nation-states playing poker. What we need is a bottom-up movement, supported by electronic media, to organize global citizens.

“What piece of advice would you give young researchers in your field today?”

Hüttl: Young researchers need soft skills – communication, management, leadership, teamwork – because the science of the future will mainly be done in teams.

Schellnhuber: Try to get training in a field which shows you how the scientific method works, but don’t lose sight of the big picture.

“What was the most surprising insight you had at this conference?”

Hüttl: It was clear that people really understand our common future lies in our hands, and we are responsible for it. We can influence it, and in a sustainable way.

Schellnhuber: I found it surprising we didn’t have a better turnout. To me, that shows people don’t care that much about our common future right now.

Hans Joachim Schellnhuber and Reinhard Hüttl served as scientific advisors for the OCF sessions on Climate Change. Schellnhuber is director of the Potsdam Institute for Climate Impact Research. Hüttl is scientific director of the German Research Centre for Geosciences (GFZ) in Potsdam.