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LEARNING FROM A LAUREATE: SCIENCE, SECURITY AND SUSTAINABILITY

HEARING

BEFORE THE

SELECT COMMITTEE ON
ENERGY INDEPENDENCE
AND GLOBAL WARMING
HOUSE OF REPRESENTATIVES

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LEARNING FROM A LAUREATE: SCIENCE, SECURITY AND SUSTAINABILITY

WEDNESDAY, JANUARY 30, 2008

HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON ENERGY INDEPENDENCE
AND GLOBAL WARMING,
Washington, DC.

The committee met, pursuant to call, at 9:07 a.m., in Room 1324, Longworth House Office Building, Hon. Edward J. Markey (chairman of the committee) presiding.

Present: Representatives Markey, Inslee, Herseth Sandlin, Cleaver, and Hall.

The CHAIRMAN. This hearing of the Select Committee on Energy Independence and Global Warming is called to order.

Last February, the Intergovernmental Panel on Climate Change released the first report of their fourth assessment, which provided a scientific smoking gun that human activities were unequivocally responsible for global warming. Three more reports followed throughout 2007. Taken together, the fourth assessment reports represent the seminal review of the science of global warming, its impacts and strategies to address it.

For their work in educating the world about both the dangers of global warming and the policies needed to prevent it, Dr. Rajendra Pachauri, Chairman of the IPCC, and his colleagues were jointly awarded the 2007 Nobel Peace Prize with former Vice President Al Gore. With the award of the Peace Prize, the Nobel Committee acknowledged that stopping global warming is not just a matter of economics or environmental stewardship, it is a matter of war and peace.

As the fourth assessment shows, the dangerous buildup of heat-trapping gases in the atmosphere due to human activities is already threatening the peace and security of communities around the world. Sea levels are rising, rainfall patterns are changing, public health is suffering, conflicts are spawned and fed, and the disproportionate amount of injury is occurring in the developing world to the people least responsible for global warming. And so a scientific report highlights our moral obligation to reduce global warming pollution and prepare for those impacts that have become unavoidable.

We can't mortgage the children of the planet's future by continuing to emit global warming pollution in the atmosphere unabated. We need to achieve real reductions now.

The energy bill that became law in December was a significant down payment on the necessary emission reductions, but it was no-

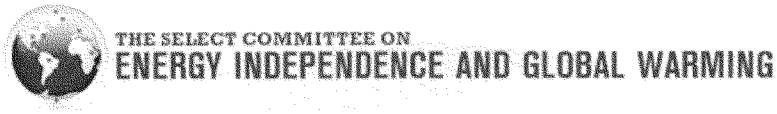
where near sufficient to meet the enormous challenge which we face. In order to further reduce global warming pollution the House will consider legislation this year that puts the United States on a path for an 80 percent reduction in our emissions by the year 2050.

The obligation of the United States to adopt such policies is clear and compelling. When the Chinese and Indians look up in the sky, they see red, white and blue CO_2. The United States alone is responsible for over a quarter of the carbon dioxide increase in the atmosphere over the last 150 years. While China's total annual emissions may now equal those of the United States, U.S. emissions are still four times greater than China's on a per capita basis. It is time for the Congress to reestablish America's position in the fight against global warming as a leader and not a laggard.

In his acceptance speech, Dr. Pachauri quoted fellow Nobel Peace Prize winner Willy Brandt's observation that "next to reasonable politics, learning is the true credible alternative to force." I believe history will look back upon the work of the IPCC, and especially the fourth assessment as the very credible force that helped the world avoid catastrophic global warming conflicts and secure an equitable energy peace. So we are very proud of our witness today, and I think it is going to be a historic hearing.

So let me turn and now recognize the gentleman from Washington State, Mr. Inslee, for an opening statement.

[The prepared statement of Mr. Markey follows:]



Opening Statement for Chairman Edward J. Markey
Select Committee on Energy Independence and Global Warming
"Learning from a Laureate: Science, Security and Sustainability"
January 30, 2008

Last February, the Intergovernmental Panel on Climate Change (IPCC) released the first report of their Fourth Assessment, which provided a scientific smoking gun that human activities were unequivocally responsible for global warming. Three more reports followed throughout 2007. Taken together, the Fourth Assessment reports represent the seminal review of the science of global warming, its impacts and strategies to address it.

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With the award of the Peace Prize, the Nobel Committee acknowledged that stopping global warming is not just a matter of economics or environmental stewardship – it is a matter of war and peace.

As the Fourth Assessment shows, the dangerous buildup of heat-trapping gases in the atmosphere due to human activities is already threatening the peace and security of communities around the world. Sea levels are rising. Rainfall patterns are changing. Public health is suffering. Conflicts are spawned and fed. And the disproportionate amount of injury is occurring in the developing world, to the people least responsible for global warming.

And so a scientific report highlights our moral obligation to reduce global warming pollution and prepare for those impacts that have become unavoidable.

We can't mortgage our children's and the planet's future by continuing to emit global warming pollution in the atmosphere unabated. We need to achieve real reductions now. The energy bill that became law in December was a significant down payment on the necessary emission reductions, but it was nowhere near sufficient to meet the enormous challenge we face. In order to further reduce global warming pollution, the House will consider legislation this year that puts the United States on a path for 80 percent reductions in our emissions by 2050.

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States alone is responsible for over a quarter of the carbon dioxide increase in the atmosphere over the last 150 years. While China's total annual emissions may now equal those of the United States, U.S. emissions are still four times greater than China's on a per capita basis. It is time for the Congress to re-establish America's position in the fight against global warming as a leader, not a laggard.

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I believe history will look back upon the work of the IPCC -- and especially the Fourth Assessment -- as the very credible force that helped the world avoid catastrophic global warming conflicts and secure an equitable energy peace.

Mr. INSLEE. Thank you.

This is a tremendous honor for us in the House today to have Dr. Pachauri here, because I really believe that you couldn't have any of several billion folks on the planet to be in a more important position than Dr. Pachauri; and it is a great honor that he has joined us today. There really is no one else walking on the face of the Earth that has played a bigger role in preventing the Arctic eventually from disappearing, in preventing the desertification of substantial parts of the middle latitudes, in preventing us from losing a good portion of our Midwest agricultural base, in preventing millions from losing drinking water from the glaciers in the Himalayas and in preventing the conflicts that my friend, Ed Markey, has talked about.

And so it is really a great honor that you have joined us because spreading this news is allowing us to move.

And Dr. Pachauri and I had a chance to talk briefly before this hearing. And I just want to share one thing with the good doctor who, I know, may have had some frustration—with the rest of the world—with the United States' inability to move on global warming. And given the certainty of the science, that has been frustrating.

But the cavalry is on the way. Things are changing here. The ice is melting in the Arctic, but the ice of resistance to science is melting here in the United States Congress as well, and we are going to get this job done.

I will be particularly attentive to Dr. Pachauri's discussion of what our targets need to be to prevent these devastating losses. Looking at the report suggests that to have a 50 percent chance of stabilizing temperature increases below 2.5 degrees Celsius above preindustrial levels would require that global emissions—global emissions—peak by the year 2015, and industrialized countries, including the United States, will have to decrease to 25 to 40 percent below 1990 levels by 2020.

That is an incredibly important target. I look forward to his discussion of why that is important, because the United States Congress will be setting targets, we hope this year. We need to be more aggressive on those targets.

To date, Doctor, I regret to say no legislation has been introduced to achieve those targets. That is going to change shortly. And I hope that you will address the importance of those near-term targets to really tame this beast.

Thank you very much.

The CHAIRMAN. The gentleman's time has expired.

The chair recognizes the gentlelady from South Dakota, Ms. Herseth Sandlin.

Ms. HERSETH SANDLIN. Thank you, Mr. Chairman, and thank you for hosting this hearing.

And I want to echo the sentiments of my colleague, Mr. Inslee, Doctor, for your being here and for the work that you have done to address the serious issue of global climate change.

I represent the State of South Dakota in the Great Plains, and so I am very interested today in hearing more from your testimony and perhaps posing some questions as it relates to the risk of climate change globally in agricultural sectors, but also the opportu-

nities that that provides for rural parts of the world, particularly the economic advantages of renewable energies in all forms, as well as the issue that we are going to be grappling with that actually got some attention here just a couple of days ago as relates to the offsets that were purchased by the House of Representatives, and one of the projects being in the agricultural sector—actually, perhaps two of them—and how we go about measuring it and having standardized measurements for the carbon that can be stored in the soil based on farming types, grazing practices, farming practices and the importance of making sure we get that right. Because there are already farmers and ranchers that are trading on the Chicago Climate Exchange, and I have significant worries about how that is currently structured, what the value of those offsets will be in the future and the monitoring that is required.

So thank you very much for being here today. I look forward to your testimony.

The CHAIRMAN. The gentlelady's time has expired.

Over 2,000 of the world's top scientists from more than 130 countries contributed to the IPCC's fourth assessment. It takes an exceptionally talented individual to lead such a diverse group and produce such an outstanding analysis. I am honored to have such a person before the Select Committee this morning, Dr. Rajendra Pachauri, Chairman of the IPCC.

On December 10, 2007, the immense contribution of the IPCC was honored with the Nobel Peace Prize, which Dr. Pachauri accepted on behalf of the IPCC. I will enter his Nobel acceptance speech into the Congressional Record.

The CHAIRMAN. In addition, his contributions to improving the global environment have been recognized by the Indian and the French Governments. He was also named the science journal Nature's first-ever Newsmaker of the Year.

Dr. Pachauri is also the Director-General for The Energy and Resources Institute, TERI, in India where he has served as the Chief Executive since 1981. Understandably, the Indian Government has asked him to serve in a variety of advisory roles, including his current membership in Prime Minister Singh's Council on Climate Change.

He has a Ph.D. in industrial engineering and a Ph.D. in economics, both from the North Carolina State University in Raleigh. He has taught at a variety of academic institutions in the United States and India and served on a number of nongovernmental organizations and business boards throughout the world.

I am told he is also passionate about cricket and is a handy swing bowler, having taken 348 wickets for the TERI team. But I think it is more likely that Dr. Pachauri will get Members of Congress to understand these climate change science policies than cricket.

It is not often that Members get to learn from a Nobel laureate. And so I would ask unanimous consent that he is allowed to speak 10 minutes in his opening remarks before we turn to questions from the subcommittee members.

Dr. Pachauri, it is our honor to have you before us today. Whenever you are comfortable, please begin.

STATEMENT OF RAJENDRA K. PACHAURI, Ph.D., DIRECTOR-GENERAL, THE ENERGY AND RESOURCES INSTITUTE, AND CHAIRMAN, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Mr. PACHAURI. Mr. Chairman and honorable members, may I express my sense of privilege at being given this opportunity.

Indeed, I have regarded the U.S. as a home because I have lived and worked over here and, therefore, I have a special respect and a great deal of reverence for this remarkable institution which I think the whole world looks up to. So thank you very much for giving me this opportunity.

And, Mr. Chairman, you have already laid out, and so have the honorable members who have spoken, some of the major challenges and some of the major opportunities that we have globally. And you have also brought out the importance of timing and timeliness in taking action, because we really don't have a moment to lose.

I would seek your privilege in presenting a very brief PowerPoint presentation which essentially summarizes the testimony that I have submitted for this occasion. So I will turn to the first slide, if I may.

One important fact that we brought out in the fourth assessment report is that if we continue with GHG emissions, greenhouse gas emissions, at current levels or above that, then further warming would induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century.

When we use the term "very likely," it advisedly represents a probability of over 90 percent; and therefore we know, based on projections that we have made, that if we don't do anything to reduce emissions of greenhouse gases and stabilize the Earth's atmosphere, we would have warming and consequent other impacts that would be far more severe than what we have witnessed in the past.

Next, please.

What is of particular importance, given the fact that the U.S. is a major leader, is the leader of the Free World, and clearly its actions and its positions have a major impact on peace and stability over the world, as the chairman has mentioned, the Norwegian Nobel Committee, by awarding the Nobel Peace Prize for 2007, has acknowledged the importance of stabilizing the Earth's climate in the absence of which we will clearly run into problems of disruption of peace and stability in different parts of the world.

Now, if you look at the impacts on the poor regions, next, then we know, based on our projections, that people would be exposed to increased water stress by 2020 to the extent of 120 million to 1.2 billion in Asia, 75 to 250 million in Africa, 12 to 81 million in Latin America. And therefore we must keep this in mind, particularly since several parts of the world already suffer from water stress; and climate change would only add to these stresses and exacerbate them to a point where they could be critical in determining the stability, the well-being of these societies.

We also know that there would be decline in agriculture in several parts of the world. Roughly 50 percent by 2020 in some Afri-

can countries, 30 percent by 2050 in Central and South Asia and 30 percent by 2080 in Latin America.

I might mention, Mr. Chairman, that there is evidence from my own country, India, where agricultural scientists are now finding that several crops are actually experiencing declines in yields—wheat, in particular. And wheat is very, very sensitive to temperature increases at a particular point of its growth cycle. If those temperatures increase anywhere between 1.5 to 2 degrees Celsius, they have a major impact on the decline of productivity of the wheat crop; and we have growing evidence of that in India. I am mentioning this because this clearly has major implications for food security worldwide.

Next.

We also see the possibility of abrupt or irreversible impacts.

Next.

For instance, partial loss of the ice sheets on polar land, which includes essentially Greenland and the west Antarctic ice sheet, could imply several meters of sea level rise. And I know that you have visited Greenland, Mr. Chairman, and you have seen visibly the kinds of changes that are taking place over there. This clearly would be a disaster if it was to occur.

Next.

We also know that 20 to 30 percent of the species that the IPCC has assessed are likely to be at risk of extinction if increases in warming exceed 1.5 to 2.5 degrees Celsius. And these are abrupt and irreversible changes because, once this kind of damage takes place, we really have no way of turning back.

Next.

We also know the impacts on North America would be quite considerable. Warming in the western mountains is projected to cause decreased snowpack and reduced summer flows, and this will exacerbate competition for overallocated water resources in these regions.

Next.

Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilized water resources, so there would be unfavorable impacts on agriculture as a result. We also know that increased number intensity and duration of heat waves will have potential for adverse health impacts.

I don't want to draw attention to what happened in Europe, for instance, in the year 2003. But I think it does provide an important example of the kind of infrastructure that would be required to deal with heat waves. And you would recall that in 2003 in the city of Paris and its surrounding areas there were about 30,000 lives that were lost as a result of a heat wave.

And I might mention this kind of thing happens periodically and regularly in different parts of the developing world, because you just don't have the health care and early warning infrastructure whereby people's lives could be saved. We also know that coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.

So there are going to be a diverse set of impacts of climate change on North America which makes it necessary for North

America to be a part of the solution for global, as well as local regions.

Next.

Now, I would like to highlight the fact that there is a certain inertia in the climate system. If we were to freeze the concentration of greenhouse gases, even at current levels, further warming would continue for the next two decades at a rate of about 0.1 degrees Celsius per decade. So there is certain inertia in the system, as a result of which, even with very stringent, immediate measures, we would see climate change continuing for some period of time.

And we know that the energy system inertia is also particularly relevant, because if you look at buildings, if you look at other infrastructure which uses energy, you really can't bring about major changes simply because there is a lot of locked-in capital in technology which can't be changed overnight. So we need to be concerned about the fact that even if we were to take very ambitious steps today, we would find it very difficult to stop climate change for several decades.

All of which means that we have to bring about mitigation measures as early as possible because, otherwise, the impacts of climate change will become more serious over a period of time; and therefore, choices about the scale and timing of mitigation measures would involve balancing costs of emission reductions against the risks of delay. And the risks of delay essentially translate into impacts of climate change which could become very serious and severe.

Next.

Now, this is an important table which I would like to draw your kind attention to, and I want to focus on the first row of numbers that I have shown over here. The IPCC has examined several stabilization scenarios. And the one that is shown at the top indicates stabilization at roughly current levels of concentration that we have today in CO_2-equivalent terms.

Now, this would limit temperature increase to 2 to 2.4 degrees Celsius, and as the chairman pointed out earlier, if we were to achieve this particular scenario, it is essential that we ensure that the emissions of greenhouse gases don't increase beyond the year 2015 and, therefore, they must decline beyond that date. This gives us a very short window of opportunity.

And I might say that the IPCC, of course, does not recommend any particular level of stabilization because we are an assessment body. But we look at various scenarios and we present the facts related to each of these, and then it is really up to the negotiators and decision makers on the basis of value judgments to decide what it is that would be the right level for stabilization.

Now, here I might say that this is not really such a favorable scenario, because if you look at global sea level rise as a result of even this fairly ambitious scenario, we would have sea level rise due to thermal expansion alone; and this does not take into account, I repeat, the melting of the ice bodies across the globe. This would give you thermal expansion leading to sea level rise of 0.4 to 1.4 meters.

Now, if you talk to somebody in the Maldive Islands or in some of the South Pacific islands, they will tell you that this level of sea level increase is going to be disastrous for them. And therefore I

think what we require is a value judgment in deciding where the world wants to stabilize its concentration of greenhouse gases. Is this good enough or should we really do better progressively over a period of time?

Next.

I would like to highlight some of the co-benefits of mitigation. And since I have the privilege of addressing the Energy Independence and Global Warming Select Committee, reducing emissions of greenhouse gases will lead to health co-benefits from reduced air pollution. There would certainly be increased energy security. There would be greater rural employment. And as the honorable member has just reminded us about the opportunities in the agricultural sector, if we were to use renewable energy technologies on a decentralized basis, there would be a generation of jobs and employment opportunities in several rural areas. And may I emphasize, this is of particular relevance to the developing countries where you still have a very large percentage of the population living in rural areas.

And there would be benefits of increased agricultural production and reduced pressure on natural ecosystems because there would be decreased tropospheric ozone concentrations. There would also be co-benefits of mitigation action which would offset mitigation costs and provide the opportunity of no-regrets policy. So, in other words, the cost of mitigation should be reduced to the extent that you have these co-benefits as a result.

Next.

Now, I would like to emphasize the fact that the cost of mitigation, even at a very stringent and ambitious level, will not be high at all. If you look at the last row in this particular table, you will find that stabilization at a level equivalent to what I had pointed to earlier, 445 parts per million of CO_2 equivalent and thereabouts, would result in a reduction of GDP of less than 3 percent in the year 2030; and this amounts to a reduction of 0.12 percent annually.

Now, what does this mean in very simple terms? I will turn to the next slide. This really—next.

This means that if there was GDP without mitigation, this is the kind of line you would get.

Next.

And with mitigation—next—you would get a slight shift of this line, which really means that the level of prosperity that the world would reach in 2030 would at best be postponed by a few months or at the most a year or so. That is clearly not a very high price to pay; and particularly if you were to account for the co-benefits from mitigation actions, this cost could be even lower.

Next.

Now, I would like to highlight the fact that—next—all stabilizations that we have assessed can be achieved by deployment of a portfolio of technologies that are currently available or expected to be commercialized in coming decades. So we really don't have to wait for anything dramatic or anything miraculous; we have all the technologies that are required to carry out the mitigation measures that we have assessed.

Next.

But, of course, this assumes that investment flows, technology transfer and incentives are in place for technology development; and this only highlights the fact that technology by itself is not going to do enough. You really need policies and a framework of policies that would lead to development of the right technologies and would also lead to their dissemination on a large scale.

And I come more or less to the end of my presentation.

Next.

Why should we adhere to deep cuts in greenhouse gas emissions? Well, firstly, the world is going to move towards a low-carbon future. And if that is the case, U.S. companies must look at the opportunities that they have in business if they are going to focus on the future. And those companies that don't obviously are going to lose in terms of profits as well as reputation.

And may I submit that nations would also fall within a certain similar categorization. Those nations that are seen to take action will certainly command a lot more political and moral power than those that do not. And therefore I think it is essential, may I submit, for the U.S. to take action.

And I go to the next slide.

The role of the U.S. is critical because it would enable the achievement of global stabilization targets, would ensure U.S. competitiveness in the world market dominated by low-carbon products and undoubtedly reestablish confidence in U.S. leadership on critical global issues.

Finally, may I submit before you an important philosophical perspective. I think overall we must remember that we as human beings are a part of nature. Nature is not subordinate to us. And I think it is to the benefit of human society to be able to find a pattern of development that ensures the sustainability and the conservation of natural resources.

Thank you very much, Mr. Chairman.

[The statement of Mr. Pachauri follows:]

Summary of testimony provided to the House Select Committee on Energy Independence and Global Warming, US Congress, Washington DC

by R.K. Pachauri, Chairman, Intergovernmental Panel on Climate Change and Director General, The Energy and Resources Institute

The Intergovernmental Panel on Climate Change (IPCC)

The role of the Intergovernmental Panel on Climate Change (IPCC) is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding climate change, its potential impacts and options for adaptation and mitigation. The IPCC produces key scientific material that is of the highest relevance to policy-making, and is agreed word by word by all governments, from the most sceptical to the moat confident.

Over recent years the IPCC has effectively become the voice of the mainstream scientific community. It has been repeatedly vetted and endorsed by the National Academy of Science in the United States, its counterparts in other countries, and by the leading professional organizations like the American Meteorological Society, the American Geophysical Union, the American Association for the Advancement of Science.

Observed impacts of climate change

One major finding of the IPCC Fourth Assessment Report, which was completed in 2007, is that:

> "Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century".

Among the most significant impacts observed throughout the 20th century, the frequency of heavy precipitation events has increased over most land areas. Increased precipitation has been observed in eastern parts of North and South America, northern Europe and northern and central Asia. Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.

More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics.

Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent.

There is also evidence for an increase in intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures.

For a range of emissions scenarios that do not assume additional climate policies above current ones, best estimates for global average temperature increase range between 1.8° and 4.0°C by 2100 relative to 1980-1999 depending on emissions scenario. This range may be compared to the warming of about 0.74°C that the world has experienced over the past 100 years.

Impacts on poor regions

I would like to use this opportunity today to highlight the impacts of climate change in poor regions of the world. The poor and marginalised have historically been most at risk, and are most vulnerable to the impacts of climate change. Recent analyses in Africa, Asia and Latin America, for example, show that marginalised, primary resource-dependent livelihood groups are particularly vulnerable to climate change impacts if their natural

resource base is severely stressed and degraded by overuse or if their governance systems are in or near a state of failure and hence not capable of responding effectively.

Water availability will significantly be affected for human consumption, agriculture and energy generation due to changes in precipitation patterns, increasing salinity of groundwater due to increases in sea level and over-exploitation, glaciers melting decreasing river flows.

The number of people exposed to increased water stress by 2020 is projected to include:

120 millions to 1.2 billion in Asia

75 to 250 millions in Africa

12 to 81 millions in Latin America

If coupled with increased demand, this will adversely affect livelihoods and exacerbate water-related problems.

Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes. It is projected that there could be a possible reduction in yields in agriculture of:

50% by 2020 in some African countries

30% by 2050 in Central and South Asia

30% by 2080 in Latin America

In Africa, crop net revenues could fall by as much as 90% by 2100, with small-scale farmers being the most affected.

This would further adversely affect food security and exacerbate malnutrition.

These consequences, associated with increased number of extreme events and sea level rise, could translate in large number of displaced people, as migration is a common response to calamities such as famines and floods. The impacts of climate change on the

most vulnerable communities could prove extremely unsettling and threaten world security.

Abrupt or irreversible impacts

There is also the possibility of abrupt or irreversible impacts as a result of climate change, which could occur on account of partial loss of ice sheets on polar land implying several metres of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands. Such changes are projected to occur over millennial time scales, but more rapid sea level rise on century time scales cannot be excluded.

Also possible is the risk of extinction for 20-30% of the species assessed by the IPCC if increase in warming exceeds 1.5 to 2.5°C. As global average temperature increase exceeds about 3.5°C, model projections suggest significant extinctions (40-70% of species assessed) around the globe.

Impacts in North America

Impacts of climate change on North America could include:

- Warming in western mountains, which is projected to cause decreased snowpack and reduced summer flows, exacerbating competition for over-allocated water resources.
- Major challenges for crops that are near the warm end of their suitable range or which depend on highly utilized water resources.
- Increased number, intensity and duration of heat waves, which have potential for adverse health impacts.
- Coastal communities and habitats becoming increasingly stressed by climate change impacts interacting with development and pollution.

Defining mitigation targets

Mitigation of climate change has to deal with the inertia of the climate system because even if concentrations of greenhouse gases were held constant, a further warming trend would occur in the next two decades at a rate of about 0.1° C per decade. A delay in reduction of emissions would lead to investments that lock in more emission intensive infrastructure and development pathways.

Choices about the scale and timing of greenhouse gas mitigation would involve balancing costs of emissions reductions against risks of delay. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts. All in all, the costs of unmitigated climate change could be far larger than the cost of mitigation.

Some of the stabilization scenarios assessed by the IPCC

With one particular scenario, assessed by the IPCC, which would stabilize concentration of greenhouse gases between 445-490 ppm of CO_2 equivalent, the requirement would be for CO_2 emissions to peak no later than 2015. This scenario implies a global mean temperature increase of 2.0-2.4° C at equilibrium above pre-industrial levels.

However, even with this mitigation scenario global sea level rise above pre-industrial levels from thermal expansion alone would be 0.4-1.4 metres at equilibrium. The long time scales of thermal expansion and ice sheet response to warming imply that stabilisation of greenhouse gases concentrations at or above present levels would not stabilise sea level for many centuries. The eventual contributions from Greenland ice sheet loss could be several metres, and larger than from thermal expansion, should warming in excess of 1.9-4.6°C above preindustrial be sustained over many centuries.

There are also major co-benefits from mitigation, which include increased energy security, higher health benefits from reduced air pollution and greater rural employment. There would also be benefits in the nature of increased agricultural production and reduced pressure on natural ecosystems. Such co-benefits of mitigation action offset mitigation costs and provide the opportunity for no-regrets policies.

The costs and technologies for mitigation

Even if co-benefits were not included the cost of mitigation measures assessed generally in keeping with the scenario described above would amount to less than 0.12% of GDP annually. By 2030 this would amount to 3% decrease of GDP in that year.

A wide range of mitigation options are currently available or projected to be available by 2030 in all sectors, with the economic mitigation potential at costs that range from net negative up to 100 US$/$tCO_2$-equivalent, sufficient to offset the projected growth of global emissions or to reduce emissions to below current levels in 2030.

All stabilization levels assessed can be achieved by deployment of a portfolio of technologies that are currently available or expected to be commercialised in coming decades.

This will only happen if the right policy framework is in place. Investment flows, technology transfer and incentives are essential to ensure the development, acquisition, deployment and diffusion of these technologies and to address related barriers.

It is important to note that the assessment of the costs and economic potential of mitigation assumes the implementation of climate policies to address barriers and provide incentives to those who can take action on mitigation. The market potential of currently known technologies is smaller than the economic potential; if we want to make

full use of the economic potential for mitigation, adequate policies have to be put in place. A wide range of policies is available, with advantages and disadvantages depending on specific circumstances; generally a portfolio approach is likely to be most effective. An effective price on carbon is generally believed to be an essential component of such a portfolio to create incentives for producers and consumers to significantly invest in low-emissions products, technologies and processes.

The long-term perspective

If one was to take a forward looking perspective, companies and businesses that move in the direction of deep cuts in greenhouse gases emissions would be both responsible and successful. Those that lag behind would suffer from losses in the market place and loss of reputation. The same prospect would apply to nations. There would be a dramatic loss of political power and influence for nations that stand unmoved by the growing global consensus for urgent "deep cuts" in emissions of greenhouse gases.

An active role by the US in mitigation measures would enable the achievement of global stabilization targets, as the US currently account for 22% of global greenhouse gases emissions. US leadership would also prompt other large emitters to take action. It would ensure the competitiveness of US companies in world markets dominated by low carbon products. It would finally re-establish confidence in US leadership on critical global issues.

Within a larger global context it would be useful to be reminded of the words of Chief Seattle, which are "Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself". Urgent action to mitigate greenhouse gases emissions is not only a moral issue to preserve Creation, it is also the inevitable path if we want to avoid the serious, disruptive impacts that unabated climate change could impose on human society.

WMO UNEP

Mitigating Climate Change

R. K. Pachauri
Chairman, IPCC
Director-General, TERI

House Select Committee

Washington DC,
January 30, 2008

IPCC

Continued GHG emissions at or above current rates would cause further warming and induce **many changes** in the global climate system during the 21st century that would very likely be **larger than those observed during the 20th century**

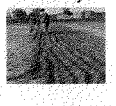
IPCC

Impacts on poor regions

People exposed to increased water stress by 2020:

- 120 millions to 1.2 billion in Asia
- 75 to 250 millions in Africa
- 12 to 81 millions in Latin America

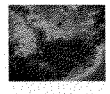
Possible yield reduction in agriculture:



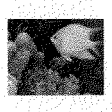
- 50% by 2020 in some African countries
- 30% by 2050 in Central and South Asia
- 30% by 2080 in Latin America

IPCC

Abrupt or irreversible impacts



Partial loss of ice sheets on polar land could imply several metres of sea level rise



20-30% of species are likely to be at risk of extinction if increases in warming exceed 1.5-2.5°C

IPCC

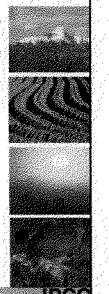
Impacts on North America

Warming in western **mountains** is projected to cause decreased snowpack and reduced summer flows, exacerbating competition for over-allocated water resources

Major challenges are projected for **crops** that are near the warm end of their suitable range or which depend on highly utilized water resources

Increased number, intensity and duration of **heatwaves** will have potential for adverse health impacts

Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution



IPCC

Defining mitigation targets

Climate system inertia: even if GHG concentrations were held constant, further warming trend would occur in the next two decades at a rate of about 0.1°C per decade

Energy system inertia: delayed emission reductions lead to investments that lock in more emission intensive infrastructure and development pathways

Choices about the scale and timing of GHG mitigation involve balancing costs of emission reductions against risks of delay

IPCC

Stabilisation scenarios

Stabilization level (ppm CO_2-eq)	Global mean temp. increase (°C)	Year CO_2 needs to peak	Global sea level rise above pre-industrial from thermal expansion (m)
445 – 490	2.0 – 2.4	2000 – 2015	0.4 – 1.4
490 – 535	2.4 – 2.8	2000 – 2020	0.5 – 1.7
535 – 590	2.8 – 3.2	2010 – 2030	0.6 – 1.9
590 – 710	3.2 – 4.0	2020 – 2060	0.6 – 2.4

Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels

IPCC

Co-benefits of mitigation

Health co-benefits from reduced air pollution

Increased **energy security**

More rural **employment**

Increased **agricultural production** and reduced pressure on **natural ecosystems**, due to decreased tropospheric ozone concentrations

Co-benefits of mitigation action offset mitigation costs and provide the opportunity for no-regrets policies

IPCC

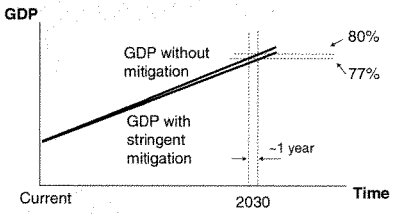
Costs of mitigation in 2030

Stabilisation levels (ppm CO2-eq)	Range of GDP reduction (%)	Reduction of average annual GDP growth rates (percentage pts)
590 - 710	-0.6 – 1.2	< 0.06
535 - 590	0.2 – 2.5	< 0.1
445 - 535	< 3	< 0.12

Mitigation measures would induce 0.6% gain to 3% decrease of GDP in 2030

IPCC

Impacts of mitigation on GDP growth



Stringent mitigation would postpone GDP growth of one year at most over the medium term

IPCC

Potential and cost of mitigation

All stabilisation levels assessed can be achieved by deployment of a portfolio of **technologies that are currently available or expected to be commercialised** in coming decades

This assumes that **investment flows, technology transfer and incentives** are in place for technology development

IPCC

Why adhere to deep cuts in GHG emissions?

Companies that take the lead would meet with success in both business and societal contexts

- ✘ Those that lag behind would suffer from losses in the marketplace and loss of reputation

Nations that show commitment to the growing global consensus would gain prestige

- ✘ Those that stand unmoved would lose political power and influence

IPCC

The role of the US

US action on mitigation will:

- enable the achievement of global stabilisation targets
- ensure US competitiveness in a world market dominated by low-carbon products
- re-establish confidence in US leadership on critical global issues

IPCC

Man did not weave the web of life,
he is merely a strand in it.

Whatever he does to the web,
he does to himself.

Chief Seattle, 1854

The CHAIRMAN. Thank you, Dr. Pachauri, very much.

And I will turn and recognize the gentleman from Washington State, Mr. Inslee, for 10 minutes.

Mr. INSLEE. Doctor, thank you for closing with a quote from Chief Seattle about us being part of the web of life. We appreciate that. I can tell you the Chief's spirit is still alive in Seattle, and that is where we are fighting to keep our snow and our salmon and our orcas, all of which are endangered by this problem. So I really appreciate your honoring us with Chief Seattle. I hope you spread it around the globe. I think it works everywhere around the planet.

I want to focus on what should be our relatively short-term targets, and I have to tell you that I have been very active on this front now with many members of this panel, but I have been stunned by your science that your team has developed on a level of how fast we have to move.

Several years ago I was thinking, well, we have to get ready for 2050. Your science has been a real dash of cold water, telling us, no, we have got to get ready by 2015 and 2020. And I want to ask you for your advice in that regard.

First off, I want to talk about the level that might get us into problems. And I was looking at your report, and it suggested that at a 2.5 Celsius level, if we are successful in holding the increase to 2.5 degrees Celsius, that still will result in a significant risk of extinction of 20 to 30 percent of all the species on the planet. So somewhere approaching a fifth to a third of all the species on the planet could be gone forever if we hold it at 2.5 degrees Celsius.

Now, to me, that would be an absolute minimalist's goal, because we are still going to have significant loss to the planet at that level.

I then go down to the next several pages of your report, and you are telling us that to hold the world at that level we have got to peak CO_2 emissions by 2015 and the industrialized world, including America, has to go down by 25 to 40 percent below 1990 levels by 2020, 20 to 40 percent reductions below our 1990 levels by 2020.

Now, the reason I want you to address this target is that that level, which to me is absolutely minimal, we ought to be more aggressive than that as our target, because losing more than a third of our species to me is incomprehensible. And yet I must tell you that no bill, to date, has been introduced in the U.S. Congress to come anywhere close to those target levels, including ones that I have introduced. And that is going to change; we are going to be introducing legislation to get to closer to those targets.

But I think your visit here today could be a real eye-opener to my colleagues about why that is short-term—and we are all talking about 2050—why that short-term target is so important and why it has to be more aggressive than, frankly, anything we are talking about.

We have got a bill to have a level of 1990 levels by 2020 that has moved through the Senate committee, and frankly, from your scientific testimony, that appears wholly inadequate to the task at hand.

So I guess, if you could, just elaborate on those levels and the 2020 targets we should be thinking of as industrialized countries.

Mr. PACHAURI. Thank you for that comment and question, sir.

May I submit that the issue of deciding where the world should stabilize the increase of temperatures and, therefore, of concentration levels really involves a value judgment; and I think an issue that is often ignored is the whole equity dimension of this problem.

If one talks to somebody, let us say, in the Maldive Islands—and the President of the Maldives, in fact, is coming over to a major event next week in New Delhi that I am organizing—he will tell you that they are already in peril; because most of the islands in that nation are at a height of 1 meter or a maximum of 2 meters above sea level, and they don't even have to wait to be inundated.

I remember that in 1997 the IPCC held its plenary session in the Maldive Islands. And President Gayoom stood before us and he said, "Ladies and gentlemen, 10 years ago the place where you are holding this meeting was under about 2 feet of water." Because they have strong surges, they have natural events which, with the high level of the sea, only inundates large areas of land.

So the point I would like to make, sir, is the fact that when we are thinking of a global target, we really need to look at some of the equity implications offsetting that target.

If you look at the country of Bangladesh, they have a large coastline, highly vulnerable to all kinds of natural disasters, which become so much worse with sea level rise. But how are we going to protect them? It is a densely populated country, highly dependent on agriculture, and every time they have a massive coastal flood, they find it very difficult to save lives and property.

Now, you really can't create infrastructure for them like the dikes in the Netherlands. Perhaps that might be feasible, but the kinds of resources that would be required would be very, very high.

If you look at the Himalayan range where the glaciers are melting very rapidly, and the entire reverse systems going into the northern part of the subcontinent and parts of China originate in these glaciers. And with the reduced flow that we project, there would be about 500 million people in South Asia that would face fairly serious reduction of water availability and about 250 million in China.

The reason why I am mentioning these facts, sir, is because when we set a target at the global level—and I hope the U.S. would be a leader in establishing these targets—we need to look at what is going to happen around the world.

And I would agree with you as a human being, not necessarily as Chairman of the IPCC, that we need to question this figure of 2.5 degrees Celsius increase in temperature. Is that good enough or should we be looking at something less? And I think that is an issue that negotiators and political leaders need to decide.

And as you rightly mention, species loss of 20 to 30 percent is clearly a huge loss that we have to do everything to prevent. It could make such a difference to ecosystems across the planet, it could make an enormous difference to economic activities that human beings are responsible for, that we really need to look at this issue.

And it involves a value judgment, it involves looking at what is going to happen to the rest of the world. And I think it is for a leader in the global comity of nations like the U.S. to start articulating some of the measures that are required.

So I would say that the IPCC's assessment of industrialized countries reducing emissions by 25 to 40 percent by 2020 is based on this particular stabilization level. But maybe this is something that needs to be revisited 5 or 10 years in the future. For the time being, perhaps, if we want to stabilize at that level of 2 to 2.4 degrees Celsius, then clearly this is something that is inevitable; and peaking by 2015 is an essential part of such a strategy.

May I just say in conclusion, I suppose it is for this reason that the conference of the parties in Bali spent so much time and attention talking about this 25- to 40-percent reduction figure. Of course, this was not accepted in the final statement, but I am happy to see that at least the wording in the final statement called for deep cuts in emissions; and I hope nobody waters down those deep cuts, because we do need deep cuts in emissions.

Mr. INSLEE. So I take it, your scientific assessment is, if all industrialized nations followed the most aggressive bill that is in the U.S. Congress right now, it is the bill that has gone to the Senate, it would simply call for the United States—and for the purposes of this question, we will assume all industrialized nations met this level—it simply called for reaching 1990 levels by 2020, not that 25- to 40-percent reduction you have suggested. If, in fact, that is the goal and if, in fact, that goal was met, it would still result in a more than 50/50 proposition of losing 20 to 30 percent of our species, substantial loss of shorelines, substantial loss of agricultural productivity and substantial loss of water, and we would still have these.

Mr. PACHAURI. We still would have these. We will still have more heat waves, we will still have extreme precipitation events and we will still have this commitment to sea level rise which, due to thermal expansion alone, would be quite significant.

Mr. INSLEE. And this is a nonscientific statement.

But as a human being, stepping out of your hat as IPCC Chairman for the moment, would you agree that every culture and community in the world would believe that this is unacceptable and, therefore, believe that we ought to have a more aggressive target than that 1990 level for industrialized nations?

Mr. PACHAURI. As a human being, sir, this prospect causes me deep anguish, because I would really question whether human progress that is going to result in these kinds of outcomes can really be labeled as human progress.

Mr. INSLEE. I appreciate that.

I don't want to leave under that note of gloom. I want to suggest we are fully capable of solving this problem. I gave you a book I have written about this. We are advancing this issue in Congress. We are going to join you in this effort. Thank you very much.

The CHAIRMAN. The gentleman's time has expired. The Chair recognizes for 10 minutes the gentleman from Missouri, Mr. Cleaver.

Mr. CLEAVER. Thank you, Mr. Chairman. I won't take the 10 minutes, and I am probably not going to be able to stay and listen to a gentleman that I have a great deal of admiration and respect for.

In fact, I would like to apologize to you and the other scientists who have done so much work to bring us to this point. My level

of embarrassment was rising with the sea level when Harlan Watson, who represented the United States in Bali, said that we are "not ready to commit." And those four words are probably the words that have been used in every generation to slow progress: We are "not ready to commit." So I appreciate all of the work that you have done.

I have got to go and catch a bus outside.

The question that I would love to have time to listen to you respond to is, if all of the CO_2 emissions were stopped today at a quarter to 10:00, what would happen and what could be reversed? I am going to submit a statement, Mr. Chairman, and hope that if you have time to respond to that question, that I can get your answer through the committee.

Thank you very kindly.

The CHAIRMAN. I know the gentleman has to leave, but I think, with the acquiescence of the other members of the committee, we would like to have you answer that question right now, if you could. And we understand the gentleman from Missouri has urgent business that he has to attend to, but we thank him for coming.

But please respond to the question, sir.

Mr. PACHAURI. I would like to respond to the honorable member that I would be very happy to send you a detailed response to this question, sir.

But in summary form, let me say that if we were to stop all emissions today, climate change would still continue for several decades, and that is precisely why we cannot allow this state of affairs to continue. Because if we don't do anything, then clearly the impacts will become far more severe and far more difficult to handle.

But this also highlights the importance of adaptation measures because if climate change is to continue, as we know it will, irrespective of what we do today, we need stringent mitigation measures to minimize, postpone, delay or avoid future impacts. But at the same time we would also need to take several adaptation measures to be able to handle the impacts of climate change that are going to take place in the future.

But I would be very happy to send you a detailed response, sir.

Mr. CLEAVER. Yes. I would appreciate it.

The CHAIRMAN. The gentleman's time has expired.

The Chair recognizes the gentlelady from South Dakota, Ms. Herseth Sandlin, for 10 minutes.

Ms. HERSETH SANDLIN. Thank you, Mr. Chairman.

Again, Doctor, thank you for your testimony. And if we could spend a few minutes on agriculture, if you could, respond to this proposition: I have a constituent in the western part of South Dakota who believes quite strongly that the agricultural sector, not just in the United States, but across the world—but in the United States in particular—is essential to transitioning from where we are now in deploying new technologies, particularly in the coal-fired plant facilities for electricity generation, because he feels that there is potential within the agricultural sector to work as a carbon sink so that the greenhouse gas emissions don't get any worse from now until we get these new technologies on line.

Would you respond to that proposition? Do you agree? Disagree? And if you agree, how imperative is it that agriculture be participating in a cap-and-trade system if indeed that is the direction that we choose to go in the United States, but also perhaps integrating agriculture into the European cap-and-trade system.

Mr. PACHAURI. Conceptually, ma'am, I think, yes, agriculture should be a part of any such scheme that involves mitigation of greenhouse gas emissions. And I would combine with this forestry options as well, because anything that grows by way of biomass has the potential to fix carbon dioxide, and I think it should be part of an accounting system.

But having said so, there are problems in terms of measurement, verification and monitoring, all of which need to be sorted out.

I think it is also essential for us to look at the net emissions from agriculture. And in several parts of the world these are quite serious; they do result in greenhouse gas emissions. So we will need to modify agricultural practices. In some cases, we might even have to design new crops. And this may be essential simply because there is likely to be a decline in the yields and productivity of some crops. And, therefore, I think there is a huge research region and development agenda, which I think countries like the U.S. can really take a leadership role in and provide answers for the rest of the world.

I mean, this is a country that really brought about the green revolution in the rest of the world. What we need now is a new kind of revolution, which hopefully will also help to reduce the net emissions of greenhouse gases in the atmosphere. So this could become a major objective in terms of research and development.

Ms. HERSETH SANDLIN. Thank you so much for your response, because you have touched on a couple of other issues I would like to explore.

Given the realities that you have illuminated through the scientific analysis that Mr. Inslee was exploring with you, as well, the recognition that given the projections and the pressure and the demand by many for industries to adapt, I also think it is very important that nongovernmental organizations, that environmental organizations in particular, also take a step back and reassess the positions that they have advocated in the past in light of the imperative of acting to reduce greenhouse gas emissions.

So when we passed the energy bill last December, unfortunately, at the last minute, a change was made to the definition of biomass as it related to the participation and the renewable fuel standard to prohibit the use of biomass off Federal lands for qualifying toward meeting the targets in the renewable fuel standard—biomass in a national forest that, if it is left to rot its methane into the atmosphere, biomass that, if burned, emits carbon into the atmosphere.

And I understand that we have to make sure that we are not turning our national forests into fuel farms. No one wants that. But within the existing forest planning process I think we can address these issues. And so when you mentioned forestry practices, I think that not only in the discussion of deforestation and the problems associated with that and finding the right balance between the need for increased yields in crop production so that we

have food security and also its role in energy security, I do appreciate your reference to biomass.

And I would just bring to my colleagues' attention on the committee that I am introducing a bill to fix the definition. I think it needs a fix in biomass to allow the use of biomass off Federal lands in the United States to participate in the renewable fuel standard.

It was an egregious change at the last minute, we had a consensus on that definition; and I would like your ideas on whether or not you think, from your experience, biomass whether it is off Federal lands in the U.S.—or maybe you could elaborate when you referenced "biomass"—being an important part of evaluating the forestry options as it relates to agriculture.

And then also the design of new crops: We have a lot of organizations across the world that are opposed to genetically modified organisms. Now, as it relates to food scares in other parts of the world, I have been eating GMOs for over 10 years; a lot of us have here in the United States.

But when we are talking about biofuels production and we are talking about drought–resistant crops to be grown in different parts of the developing world, as well, I think that that is another area where people have to take a step back and say, what is the reality of today and do we need to reassess as it relates to the priorities of what we are dealing with environmentally, as well as the energy security issues and food security issues.

So if you could maybe elaborate just a little bit more on the reference to biomass and forestry practices and the issue of genetically modified organisms as it relates to the crop varieties, that even if there continues to be resistance on the food front, that we have to address the issue of crop varieties—whether GMOs, drought–resistant, what have you—to address the issue of water resources and increasing crop yields in light of the climate change challenges we face.

Mr. PACHAURI. I would agree with you on this approach, ma'am, because I really think we need to look at new scenarios of how biomass can be part of the solution not only in terms of reducing emissions of greenhouse gases, but providing food as well as fuel.

Now, it is obvious that if we can come up with a technology that converts cellulosic material into liquid fuels, for instance, it just opens up a huge opportunity. There are parts of the world with large quantities of agriculture residue, which is really a nuisance, and it is just burnt on the fields. Now, if you had a technology by which this residue could be converted to useful energy, then I think it just opens up an enormous opportunity.

And this is where I would submit that research and development in this country can make an enormous difference. It creates opportunities for the world as a whole. And I think if we can develop such a technology, there are large areas of wasteland in different parts of the world where you could grow inferior crops, inferior forms of biomass which may not have any other purpose, but can be converted as cellulosic material into useful fuels.

So I think this is where imagination has to be exercised.

On the issue of GMOs, I mean, I fully appreciate that we have to build in safeguards. We have got to carry out trials, we have got

to make sure that there are no ill effects from any kind of genetically modified crop.

But you don't make the best the enemy of the good. You just don't throw the baby out with the bathwater. And I think it is absolutely essential for us to look at the potential of GMO. I mean, this is science which can work to the benefit of the human race, so why should we not work with opportunities by which, who knows, in the future perhaps you don't need dwarf varieties of crops, you might need those that have large quantities of biomass and much taller variety, so that, quite apart from giving you food, these will also give you large quantities of fuel.

So I really think that in the agricultural sector we need to look at a whole range of scenarios and exercise our imagination by which we can then lay down research and development priorities and come up with some of these solutions. I think the agriculture sector can really make an enormous difference in this entire field. There is a huge area of land in different parts of the world that could be used fruitfully for producing some of these products and energy.

Ms. HERSETH SANDLIN. Thank you very much for your testimony.

And you may know this already, but I think I have mentioned it to the chairman, as well, and to Mr. Hall, there is a technology that exists currently in Upton, Wyoming, right across the border from South Dakota where they have been using slash piles off the national forests in the Black Hills, and off private lands, as well, to convert woody biomass into cellulosic ethanol; and they are looking to expand not only at that plant, but elsewhere throughout the region.

And I am sure you can imagine their response when the biomass definition in the energy bill would not allow them to qualify toward the RFS when they couldn't use the slash piles off the national forest. And here they are ready to move us forward within the next year or two toward commercial development of cellulosic ethanol; and yet they now face some barriers to their potential growth and sharing that technology, obviously moving that technology to benefit the economic situation here in the marketplace overall.

So thank you very much for your testimony and your insights.

The CHAIRMAN. The gentlelady's time has expired.

The Chair recognizes the gentleman from New York State, Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman. And I apologize for being late and I apologize to the witness as well.

Congresswoman, I would be happy to support your bill. We have in my district and in the Hudson Valley several cellulosic ethanol producers who are currently operating, one of them being a wood sustainable tree farm, which is making high-end furniture for sale in New York business rooms, big, large conference tables that are varnished within an inch of their lives so that you can see your reflection off the wood. And they take all the sawdust and all the leaves and twigs and the little wood cuttings from the ends of the boards and grind them and put them into the enzyme vat and the biodiesel generator, and they run all their farm vehicles and all of their road vehicles off of their own biodiesel. And they plant as many trees as they cut.

They are not in a position, because it is not that they didn't attempt to do this, but they are not in a position to sell at this point, but they are certainly self-sufficient; and it is a break-even—better than a break-even process.

And then there is another, at least one more commercial biodiesel—actually, a very interesting project in my district which involves converting municipal solid waste after humans and machines remove such things as batteries and pesticides and other household hazardous waste that you don't want to get into the environment, and recyclables.

And then they end up with paper waste, wood waste, plant waste, farm waste, et cetera, et cetera. All goes into a gasification process which then spins a turbine and generates tens of megawatts of power and ethanol at the same time. And 48 percent of the gas that they generate is hydrogen, so they can actually charge hydrogen fuel cells—if we ever get to the point where you have cars to do that—from the gas that they are currently producing.

So it is not even so much a matter of research and development, although that is certainly needed; but there are technologies where it is just a matter of investing in them and yet just building them.

And in terms of the biomass that is removed from national parks or from private land, I think that the equation has to do with how much fossil fuel of what kind has to be burned to provide the energy to get that out to the facility where it is converted to cellulosic ethanol, and making sure that is a net gainer. And the solution to that is to have those vehicles and those machines be driven by renewables to begin with.

Mr. HALL. But anyway, to my questions. We just had in the last 3 years, in my district in New York, three 50-year floods, floods that are only expected in that intensity once every 50 years. Is that consistent with the computer models that you have been looking at?

Mr. PACHAURI. Sir, if I might respond, around the world, essentially some of these floods are going to become more frequent and certainly more severe. So I think when we talk about adaptation measures, then clearly we would have to take into account the responses that society should build in to something that, let's say, happened once in 50 years now occurring every once in 5 years or so.

Mr. HALL. Right. I mean, part of my job as a Representative, I think, is to be a two-way conduit of information from my constituents as I represent them here in the United States Congress, but also to try to bring back information such as you are providing for us today and to educate them and pass on the information to them.

And, you know, with that in mind, I would also ask—I know that there can be anomalies and that the overall trend has ups and downs and a cycle, a natural cycle of warmer and colder, but that the overall trend is warmer. The fact that we have had two winters now in the Northeast, where, in northeast Dutchess County, which usually is pretty cold up on the ridge that I live on, and snowy, we have had, the last 2 years, daytime highs between 50 and 60 degrees Fahrenheit right through the winter holidays, the Hanukkah, Christmas, New Year's holidays and into January, and then rel-

atively light snow events followed by quick thaws and, at this point, have a snow pack that is to be measured in a few inches as opposed to what used to be feet, would that be consistent with the models that you are seeing?

Mr. PACHAURI. Yes. In fact, here again may I say globally, sir, 11 of the 12 warmest years in history, since we have had instrumental record of temperatures, have occurred in the last 12 years.

And I can tell you from my own experience, I was born in the mountains in India, and I remember looking at the snow capped peaks, the highest peaks in the world. I went to one of these places where I could get a beautiful view of these mountain peaks during Christmas this last year in December, and I couldn't believe the thin covering of ice that I saw on these peaks.

It is happening the world over. I have been to the Arctic region, and you just have to see to believe what is happening over there.

Mr. HALL. Thank you, Doctor.

I was in Los Angeles on Sunday and just out there for a day, but the lady who picked me up at the airport in a driving rain storm—I think it was the third day they had had of record rainfall and mudslides and so on. And she told me there had been a tornado that touched down, I think it was in Hollywood or somewhere close to there, on Sunday, and it was the first one anyone could remember in the Los Angeles area. I am sure that it must have happened sometime. But that sort of extreme weather event would also be consistent?

So, whereas any one of them by themselves does not prove anything, at some point one might look at these extreme weather events around the world, whether we have been fortunate in the last few years to dodge another Hurricane Katrina, but the Yucatan Peninsula got hit and that area of Central America and Mexico was hit this past summer during hurricane season very hard, and there was a supercyclone in Bangladesh and other places. So I am just trying to make sure that we, as Americans, and my constituents understand the connection between them and the changes that we see in the Arctic and the Greenland ice sheet and other projected changes that you described in your testimony.

As you know, this year we passed—or last year, in December, the Congress passed energy legislation with an historic increase for our country in vehicle fuel economy and energy-efficiency measures. Can you briefly discuss what impact these actions have had, if any, on the views in the IPCC or internationally about U.S. efforts?

What else can Congress do to send a message to the rest of the world that we are serious about fighting with other countries against climate change?

Mr. PACHAURI. If you grant me the privilege to let me just respond to what you said about these extreme events.

We have found, for instance, that extreme precipitation events—that means heavy quantities of precipitation in short periods of time—are on the increase and will continue to increase. So what you described in Los Angeles, of course, could be an isolated event, but if one was to look at the trend, that is the kind of picture that one can foresee.

On the issue of the energy bill that came into existence in December, I think this clearly sends a very favorable message around

the world. Because, if I could be candid, the perception around the world is that the U.S. has not been really active in this area. The U.S. did not ratify the Kyoto Protocol. Australia didn't do it, but now with the new government one of the first things they did was to ratify the Kyoto Protocol. And I think this legislation has certainly made a difference. It has certainly created, I think genuinely, an impression that the U.S. is now serious about business.

On the question that you asked, though, on what else needs to be done, may I submit that I think the starting point would be to say that the U.S., like other developed countries, is going to stabilize the concentration of greenhouse gases at a particular level that could be decided on, and then work backwards to see how you might be able to implement measures to achieve those levels.

Now, one of the things that we have brought out very clearly in the IPCC reports is, firstly, you need policy measures to bring about technological change. You certainly need a price on carbon, because if you want to use the market to bring about changes in the future, unless you price carbon appropriately, I don't think you would get the research and development efforts, the technology development efforts to give you the kinds of outcomes that you are looking for.

So I think there are some measures that would have to be put in place to bring about a pricing of carbon at an appropriate level. This may involve taxation, this may involve cap and trade systems, but I think that is absolutely critical.

Mr. HALL. Thank you very much.

My time has expired, but if I may, I just wanted to ask one more question, which is, since the Hudson River, which splits my district—I have three counties to the east of the Hudson and two to the west. And the Hudson River is tidal all the way from New York City up to Troy, just north of Albany, New York.

And I would like my constituents to have some idea what they can expect, since the freight rail line on the west bank of the Hudson and the passenger rail line on the east bank of the Hudson are only a few feet above the current river level, and many communities have spent a lot of money and people have invested time and energy and are very excited about rebuilding their waterfronts with restaurants and shops and promenades and so on, how high might we, in a sort of medium-case and then a worst-case scenario—I assume you don't think that we are likely to achieve a best-case scenario. But if we achieve a medium—and then a worst-case scenario, how high would you expect a tidal estuary like the Hudson to rise in the next 50 years, say?

Mr. PACHAURI. To be quite honest, one would have to carry out very specific modeling of that region to see what is going to happen. But our projections for sea-level rise by the end of this century lie between 18 to 59 centimeters. So, let's say if average sea-level rise—which doesn't mean this will be uniform across the globe—was to be anywhere close to the upper end of our projections, then you are talking about half-a-meter increase in sea levels. And with storm surges, with all kinds of natural events——

Mr. HALL. Tides.

Mr. PACHAURI [continuing]. That clearly poses a very serious problem.

Mr. HALL. Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. I thank the gentleman very much.

And the Chair will now recognize himself for a round of questions. And I think we will have an opportunity to come back to the members if they have other questions which they would like to ask.

You have already spoken, Dr. Pachauri, about the fact that the level of global warming pollution could keep the temperature rise to upwards of 4 degrees Fahrenheit. The IPCC has reviewed over a hundred greenhouse gas stabilization scenarios. And recently Jim Connaughton in the White House, on President Bush's staff, described all of those scenarios as "a range of responsible paths."

Do you agree with that statement?

Mr. PACHAURI. Well, the IPCC has looked at a whole range of outcomes, and we, of course, are in no position to predict how the economy is going to grow, how technology is going to grow. What we have is a range of plausible scenarios, and we have a high level of confidence that these scenarios essentially represent the kinds of outcomes that we are likely to see in the future.

And as part of that, we have examined the stabilization scenarios, one of which I directed your attention to, Mr. Chairman. It is obvious to me that if we want to limit temperature increase to a level like, say, 2 to 2.4 degrees Celsius, then we necessarily have to stabilize the concentration of greenhouse gases at 445 parts per million of CO_2 equivalent and above, slightly above, which is more or less where we are today. And that is precisely why we came up with this deadline, if I could use the term, of 2015 by which we would have to ensure that we start reducing emissions globally.

So I would say that the scenarios that we have looked at are plausible; we stand by them. And if we have to limit temperature increase to anything that the world decides on, then those are kinds of trajectories that we will have to achieve.

The CHAIRMAN. So under the scenarios which you looked at, could you talk about some of them at higher temperatures, at higher degrees of Fahrenheit increase, another 2 degrees Fahrenheit, another 4 degrees Fahrenheit, in terms of the impact that it would have upon the world? As you examined those patterns, what was the conclusion the IPCC came to, in terms of how the world would be affected?

Mr. PACHAURI. For the first time, we have come up with a table which clearly shows temperature increase and a range of impacts that are going to occur in areas like water, ecosystems, food security, human health. And this particular table, which I would be very happy to draw your attention to, Mr. Chairman, clearly indicates that anything that goes above 2 degrees Celsius is really going to cause some very serious problems.

The CHAIRMAN. And 2 degrees Celsius translates into what Fahrenheit, about 4 degrees Fahrenheit?

Mr. PACHAURI. Roughly, roughly, 4 degrees Fahrenheit.

So I think that if one was to link that temperature increase with the kind of impacts that we will face—again, one is looking at different regions of the world. Some of them, of course, will be much worse hit than other regions. I mean, I gave some numbers about Africa, for instance. We would find 75 million to 250 million people

in Africa suffering from water stress by 2020. And that is a pretty serious situation, because there already is a very serious problem of water availability in several parts of Africa.

Food security is another area. And may I mention that climate change is going to add to existing stresses. Now, the entire agricultural subsidy problem really impacts unfavorably on a number of poor countries, where farmers really are not able to compete with subsidized food produced, let's say, in Europe or possibly in North America. And on top of that, if they have decline in yields as a result of climate change, it really wipes them out. They really don't know how to survive.

The CHAIRMAN. Now, could you talk to us a little bit about some of the other benefits that the world would derive in the public health sector from the efforts to reduce CO_2, in terms of how that would also have the same benefits or similar benefits in reduction of sulfur and the reduction of other pollutants that contribute to smog, that contribute to other public health problems? How does all of that interrelate, in terms of the public health impact on the planet?

Mr. PACHAURI. Yes, sir. I think there is a range of health benefits that would accrue from stabilizing the world's climate.

Firstly, heat waves. We know, as temperatures increase, as climate change progresses, heat waves will become more frequent, more intense. And these, obviously, are a great health hazard. They can affect morbidity and mortality of large populations, as we have seen, for instance, in the case of the heat wave that took place in Europe in 2003.

We know that vector-borne diseases, including diseases like malaria, would be on the increase. Just to give you an example, recently there has been an increase in diseases in countries like Italy, where temperatures have been going up. And a lot of the pests, a lot of the vector-borne diseases would become more prevalent with higher temperatures and changes that are taking place.

The increase in floods and droughts have major implications for health. Every time there is a flood anywhere in the world, the biggest challenge for policymakers and health officials is to see that you minimize and control the outbreak of disease as a result of flooding.

So there is a whole range of these benefits, health benefits, that would arise if we were able to stabilize the concentration of greenhouse gases and temperatures.

And the converse of that is, if we don't do anything, then I think the health problems all over the world will also have major economic impacts. If one looks at factories and businesses and if we find people are going to suffer from disease to a much greater extent, this would obviously have a major harmful impact on productivity of various goods and services.

The CHAIRMAN. Could you tell us what the most recent developments that have been identified in global warming are of greatest concern to you, that scientists never anticipated 3 to 5 years ago?

Mr. PACHAURI. I think one issue that is causing a lot of concern among scientists, Mr. Chairman, is the possibility of collapse of the Greenland and West Antarctic ice sheets. And if that were to hap-

pen, then essentially we would be changing the geography of this planet, because you would have sea-level rise of several meters.

Now, I am not saying that there is any great certainty attached to that happening, but recent writings seem to raise that concern to a much greater extent than was the case, say, 5 years ago, because we find that there is much greater evidence of changes taking place in these large bodies of ice that are sitting on large areas of land. And if they were to collapse, then we would really have a very serious crisis, as far as sea-level rise is concerned.

The CHAIRMAN. Now, we just failed in the United States Congress by a small number of votes to put on the statutes of the United States a requirement for the production of renewable electricity as a national standard.

Is it important for the United States to set a national standard, to set an example for the rest of the world? And if that did happen, what would the benefits be to the planet if we had a revolution in renewable electrical generation?

Mr. PACHAURI. I could draw an analogy with the CAFE standards for the automobile industry. They clearly had a major impact in terms of producing global benefits through energy security, because automobiles across the world improved their efficiency levels. And I would say that, in the case of renewable energy, any such measure will spur a substantial amount of research and development, bring about reduction in costs of some of these technologies. And this would have global benefits.

And this would also provide commercial opportunities to American companies. I mean, if one looks at what has happened to the renewable energy industry, say, in Germany, there has been a renaissance of this particular industry. And a number of companies that were in the conventional energy business are now thriving because they are producing renewable energy goods, because there has been a very proactive policy, for instance, in that country, in Germany, which has promoted renewable energy in a big way.

So I think there would be just substantial benefits. And the benefits in terms of energy security worldwide, and certainly for this country, which is so dependent on oil imports, I would say are incalculable, incalculable. They would be huge. So I think a measure of this nature would really make an enormous difference in stabilizing the concentration of greenhouse gases.

The CHAIRMAN. Thank you.

The time of the Chairman has expired. Let me recognize the gentlelady from South Dakota for a second round for 5 minutes.

Ms. HERSETH SANDLIN. Thank you, Mr. Chairman.

And the renewable electricity standards certainly would be important not only here but across the world in developing wind and solar technologies. Just as you were saying, in terms of waste land or other less fertile land where you could grow maybe inferior crops for food, you could grow certain crops for fuel, renewable fuels production, similarly we have great swaths of land in the Great Plains with wind resources, and the American Southwest, and then of course the biomass in the Southeast.

And so I am pleased that the Chairman probed, sort of, that topic and the importance, too, of the infrastructure necessary with the electricity grid. Because we know what we did in the energy

bill helped us on the transportation fuel side and its contribution to greenhouse gases, but we also know on the electricity side that that contribution is even greater, and hope that those new energy sources would be deployed to developing countries or those that are beginning to match the United States in terms of energy consumption.

You had mentioned previously, in response to Mr. Hall's questions, the importance of the market signals of a price on carbon. And I know I am sort of probing here with you some policy versus the scientific analysis that you have done. But in all of your discussions with those around the world and how we best send the market signal without doing damage to GDP in the short term or the long term, looking at, again, the opportunity for economic growth in light of your example of Germany and how we have lost market share here in the U.S. in renewable technologies to Japan and Germany and other countries, is there a consensus that is emerging as it relates to cap and trade and how you allocate the allowances versus a carbon tax?

At least at this stage of the discussion here in the United States, my preference would probably be cap and trade, and that, based on an auction of the allowances, you could generate a revenue stream to help soften the economic blow to lower-income Americans, put that money toward R&D, as well, and infrastructure development.

And I also think that, given the complexities of the measures, whether it be in agriculture or other sectors, it seems to me you can, over time, perhaps more easily develop a global market and allow the market to help us, versus a carbon tax that may be different in different countries and the political challenges that we face. And I don't know if a carbon tax as it relates to imports, exports, and how that frustrates international trade.

Do you have any thoughts, based upon your conversations with policymakers in other parts of the world, as to whether or not any consensus is emerging in terms of a preferred approach?

Mr. PACHAURI. Ma'am, I think we would really need a combination of approaches. One would be essentially through cap-and-trade types of measures. You would also need some regulation. I mean, whether one looks at appliances or automobiles, setting certain standards and benchmarks, even in the case of buildings, would make an enormous difference, because in the building sector we do consume a lot of energy. And much of that can be reduced through the right kinds of technologies and know-how built into the design of buildings.

And may I also say that perhaps taxation measures can make a difference. Take the case of automobiles. Perhaps there ought to be a higher tax on inefficient vehicles rather than efficient vehicles. And I think there could be incentives being provided to efficient devices.

So it seems to me one needs a combination of regulatory measures, one needs taxation and fiscal measures, and perhaps the creation of a market through maybe a cap-and-trade type of system.

And I think all of this will place a price on carbon. Once we see carbon being priced in the market, there would be research and development efforts being made to come up with low-carbon solutions. And even the consumer would react to these signals in the market

and perhaps go in for goods and services that represent much lower carbon intensity.

So I think we need a package and a mix of measures. And the debate should really look at how the public is willing to accept a mix of these and how one might be able to bring about a transition without too much of hardship to any section of society.

Ms. HERSETH SANDLIN. Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. Great.

The gentlelady's time has expired. The Chair recognizes the gentleman from New York, Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman, and thank you for indulging a second round of questions.

I was just looking at your recommendations, the panel's recommendations for mitigation. As I understand it, one of the problems with global warming is the warming of the oceans, and not just saltwater but also large freshwater bodies or rivers. I see you nodding.

In your discussions or studies about nuclear power, which is the one thing in your energy supply recommendations and the panel's recommendations that I have a problem with, several problems with, did you discuss the millions of gallons a day that go through the reactor? For instance, in my district, taken out of the Hudson River, circulated and returned to the river in a stream of water so hot that it kills the fish in the river if they happen to be too close.

Given that we have in this country 103 operating nuclear plants at this point, and that some plans would call for that to be multiplied worldwide, is there a point at which the direct warming of these bodies of water by using them to cool a nuclear core essentially has the same effect of warming the ocean?

Mr. PACHAURI. We have assessed some of these implications of expanded nuclear power generation, but, to be quite honest, we really would have to do that on a very specific location basis to be able to come up with what the local implications of any such measures should be.

I do recall when I was doing my doctoral work in North Carolina, there was major plant that was being proposed in North Carolina, a nuclear power plant, and that would have raised the temperature of a body of water by something like 2 to 2.5 degrees Fahrenheit. And through the public hearings that took place, they just gave up that plant, because they found that some forms of life that existed over there would have vanished with that kind of temperature increase.

So I think we have to be very sensitive to some of these impacts.

Mr. HALL. Right. Not to mention the fossil fuels that are burned in the mining and milling of uranium, the transportation of the uranium, the other fuel supplies that are used for enrichment, transportation to the plant of the enriched fuel, the transportation if we ever find a repository for spent fuel to a high-level waste storage site, the cooling water that is constantly circulated in the cooling ponds in the meanwhile while we are storing it on-site. All of those things use energy. So I just wanted to throw that out.

There is an article in a recent paper about some nuclear plants in the southeast United States that had to be—or were facing a

possibility of being shut down because the drought in the Southeast, in Georgia and Florida and the Carolinas, has gotten so bad that the river level had dropped to the point where they couldn't take the cooling water out and cool the plant without a danger of either drawing river level down further or just because of the reduced flow in the stream that the additional heat they are dumping into the river would be too much for any of the life in the river.

So that is—you don't have to answer that; that is just more of the same thought.

An article in this past Sunday's New York Times which you may have seen—I am sure you are well aware of this. One of the major issues that some people bring up is the global demand for meat and the defoliation of larger areas of rain forest to grow grain to feed cattle. And, in fact, according to this story, significant greenhouse gases are released by the growing of cattle for meat. And just this past week, the President of Brazil announced emergency measures to halt the burning and cutting of the country's rain forests for crop and grazing land. In the last 5 months alone, the Government of Brazil says 1,250 square miles were lost.

And then, on the inside, there is a little graph that shows that the average 1,100-pound beef cow can produce manure at a clip of 14.6 tons annually, which of course means methane being released by the manure. And the average Iowa hog will produce 16.7 tons of manure for each of the 2,900 residents of the State. That, combined with the release of methane from landfilling—there are several sources of methane, decomposing plant waste, which Congressman Herseth Sandlin mentioned in the forests, but also in any wild environment, and also decomposing municipal solid waste in landfills release methane which are vented out those upside-down, J-shaped vents that we drive past as we are on the highway. And I also know, from having a lot of farms in my district and talking to the farmers, be they horse or cattle farmers, that they all have a severe manure management problem.

This might seem a little off-the-wall to some in this country, I think, but it strikes me that there is a possibility, since methane is 20 times worse than carbon dioxide if it is released into the upper atmosphere, it is worse than carbon dioxide for global warming, that perhaps we should be examining ways of capturing the methane, be it from manure or from decomposing matter in landfills or in the forests, as was pointed out before. And if you burn the methane for power, well, at least you are reducing by a factor of, you know, 20 the impact on climate change.

Would you comment on that?

Mr. PACHAURI. Well, in countries like China and even in India, a lot of the animal refuse is used for generating bio-gas, and that is burned as a fuel. So, in a sense, you are capturing what would have been emitted into the atmosphere.

And I think a program of that nature—I remember way back in the early 1970s, Senator Gaylord Nelson introduced a bill based on the work that he had seen being done in China and India on providing subsidies for bio-gas plants in some of the farm States. I really don't know what happened subsequently. But I think this is an area that requires a comprehensive national policy.

But internationally, let me mention a concern that I have, sir, with the shift toward greater consumption of animal protein. We are going to find more and more food grains being provided just to produce animal protein. And this article clearly showed the equation between, let's say, X kilograms of food grains or X pounds of food grains producing one pound of meat protein. I think, with higher incomes, this is happening everywhere in the world.

And I have been saying this, of course with muted breath, that I think the world has to consume much less meat, because this would certainly make human beings healthier, and it would make this only planet that we have a bit healthier, too. Because we are really releasing a lot of emissions of greenhouse gases through the entire cycle. I just wanted to mention that.

Mr. HALL. Thank you very much, Mr. Chairman.

The CHAIRMAN. The gentleman's time has expired. And I think we might be able to come back to each of you one more time.

You know, there was a lot of good news generated right at the end of 2007. And here in the United States, an astounding new number: Of all of the new electrical generating capacity installed in the United States in 2007, 30 percent of all of the new installed capacity was wind, 56 percent of the new installed capacity was natural gas, 10 percent was coal, 1 percent was oil, and 3 percent was other renewables. Now, that is an incredible revolution in the United States without a national renewable electricity standard.

So wind is moving very, very rapidly. And globally, last year there was 16,000 new megawatts of wind installed globally and only 3,000 new megawatts of nuclear installed globally. And in the United States, there was no nuclear last year. There will be no nuclear this year or next year or the year after or the year after or the year after. In fact, there is an expectation that, by the end of 2010, that we will see 80,000 new megawatts of wind installed globally, just by the end of 2010. There is only 80,000 megawatts of installed capacity of nuclear in the country of France.

So there is obviously something happening here that is working. It is working in the marketplace. And it is something that we, I think as a Nation, should put in place as a policy that can give the leadership to the rest of the world. Because in many, many instances in Third World countries and developing countries wind is a better option than a huge nuclear power plant, than a huge coal-fired plant in some remote village. It will bring them electricity more quickly, more efficiently and with much fewer environmental impacts right in that local community as well.

Can you talk a little bit about this technological revolution and how already the regulations that maybe 20 States in the United States have put in place and certain countries around the world have put in place have already generated this tremendous revolution that we are beginning to identify in a significant way occurring here and around the world?

Mr. PACHAURI. Thank you, sir. Yes, I would like to say—let me first refer to wind energy. I mean, this is a remarkable record of technological development that has made such a difference in the last 25 to 30 years. Wind energy technology has progressed so substantially, and the costs of power generation from wind and under regimes of wind speeds has changed so drastically, that the whole

thing has become completely viable. And I expect that this will continue.

The kinds of sizes of machines that are now being produced in Europe and in this country are so much bigger, so much lower in terms of costs per unit, that it would make a sea change to the economics of this particular option.

There are a lot of areas, and one area that I would like to mention for the reference of the honorable members is the fact that there are 1.6 billion people in this world who have no access to modern forms of energy and certainly no electricity. And essentially, these are people who really don't have any means for lighting their homes. They live in small homes. They are poor people, large numbers of people crowded together in a small, one-room dwelling and no form of lighting.

Now, I have decided, as a mission personally and through my institute, to launch something that I call "Lighting a Billion Lights." We have developed a set of solar lanterns that cost the equivalent of about $70 and a set of solar flashlights or torches, and these cost the equivalent of about $8. And I think if one can get these financed, either through corporate philanthropy, through development assistance—not free of cost but we price them in a manner that is affordable for the poor people of the world—it can make such a difference. And more than anything else, this obviates the possibility of setting up large, centralized coal-based power stations just to supply electricity to rural areas through transmission and distribution systems that are often terribly wasteful. So I think one has to jump-start this kind of process.

And I think biomass gasification has enormous potential. There is a lot of agriculture residue, as I mentioned, in several parts of the world which can be gasified for power generation for local and decentralized distribution.

So I think we are on the verge of a revolution of this nature. And it would help enormously if the U.S. could get into some partnership activities with the developing countries, because you can then develop technological solutions that would have relevance certainly to this country but to several other parts of the world. And you are then, therefore, forestalling the possibility of conventional energy development, which obviously would have greenhouse gas emissions over a period of time.

So I think, as you said, Mr. Chairman, I think we are on the verge of a revolution. But if we could assist this through policy measures, through legislation, we would be able to achieve results that much faster.

The CHAIRMAN. Well, Dr. Pachauri, that is the goal of the select committee this year. We are going to be visiting Brazil in February, and it will give us an opportunity to begin to think through what we should do to find ways to partner with countries that are emerging economically but with sometimes too high of a price paid in terms of the environmental impact inside of that country, which we now realize has an effect upon the rest of the world, because there is only one sky and we are all going to be affected by it.

So it is in our interest in the United States, in Europe, to find ways of partnering with these countries with new technologies, with ways of compensating these countries not to engage in the

same kind of destructive behavior that we did in our first generation of industrialization. So we are going to explore that in a very, very aggressive way this year to try to develop policy recommendations to achieve that goal.

The time of the Chair has expired. Let me turn once again and recognize the gentlelady from South Dakota, if she has any other questions.

Ms. HERSETH SANDLIN. No questions, Mr. Chairman.

The CHAIRMAN. The gentleman from New York, Mr. Hall.

Mr. HALL. I have one question, Mr. Chairman.

If you would, sir, Doctor, would you—I will turn my mike on—I am glad to see that one of the key topics in discussion in Bali was the technology transfer to help developing countries leapfrog over fossil fuel development. And I thought that the President, our President's call for an international clean energy fund to meet this goal was one of the few bright spots of the State of the Union address this week.

America has the technological know-how and the resources to develop many of the technologies that could be used to help bring developing countries into a clean energy future without having to go through the fossil-dependent phase that we have spent so much time in.

What steps should our Government be taking to aid this process, which would also make America an energy exporter and not just a fuel importer?

Mr. PACHAURI. Sir, I personally think that there are several areas in which there could be cooperative activity between the U.S. and some of these countries.

One would be in terms of technology development. I do realize scientific and technical know-how is at a very high level in this country. But often, to ensure that these technologies would be directly useful in the developing countries, you need to customize some of these technologies for application in the developing country. And that would involve partnerships, it would involve working with local organizations and local institutions to come up with the right mix of technological solutions.

I think there is a lot that could be done in the policy arena. I mean, in this country there has been major achievement in terms of improvement of appliance efficiency for household appliances. And this took place about 10 to 15 years ago. And the measures by which this was brought about would be of great relevance to a number of countries in the world. If one looks at what has happened in the State of California in bringing about energy efficiency improvements, I think that is very, very heartening. And I think this required a lot of policy and regulatory measures, all of which would be of great relevance to developing countries.

So what I would submit is that, quite apart from scientific and technical cooperation, which would help flow of technology on a commercial or, let's say, facilitated basis through facilitation by the Government, I think there is a lot of benefit in transferring some of the good practices, the policy experiences in this country that have created, say, a market for improved appliance efficiency and so on, because that is where I find in a number of developing countries there is a weakness. And if we don't address that weakness,

then the transfer of technology will not take place to the extent that would be optimal.

So I think there is need to define some of these comprehensive areas where one could ensure cooperation.

Mr. HALL. Thank you very much, Doctor.

Thank you, Mr. Chairman. I yield back.

The CHAIRMAN. I thank you.

And let me just conclude with a couple of questions.

In your opinion, what constitutes dangerous anthropogenic interference with the climate system, and how close are we to reaching dangerous interference with the climate system as a result of human activities? And are we there already?

Mr. PACHAURI. I think this is really the central objective of the Framework Convention on Climate Change, as is clearly stated in article 2 of the Convention.

But may I submit, sir, that the definition of what is dangerous is really something that involves value judgments. And when you get into the issue of value judgments, then you necessarily have to take into account some of the equity dimensions of the problem.

Now, I have been talking to a lot of leaders around the world. If you talk to some of them, they will tell you that we have already crossed that threshold of dangerous. Because these are some of the most vulnerable regions in the world, where the impacts of climate change are already causing hardship, if not a very tangible threat to life and property.

So I really think to come up with a global definition of what is dangerous, in my view, requires a Gandhian approach. Gandhi, in his exhortations to society, said that, "Anything you do, you must look at what the implications will be for the least privileged." And I think if we are going to add even a single unit of greenhouse gases to the Earth's atmosphere, we need to understand what it is going to do to the least privileged. And I think when, particularly in a society that is so focused on human rights and civil liberties and the right to live and the right to exist, I think we have to treat that as the touchstone of whatever policies we are evaluating.

And if one was to use that yardstick, and based on my own conversations with people in these countries, I would say that we have probably crossed that threshold, in their perspective. But it is for the global community to decide what it regards as acceptable, in terms of dangerous.

The CHAIRMAN. Thank you, Doctor. That was very eloquent.

I want to conclude just by thanking you and telling you that, a year ago, when Speaker Pelosi created this Select Committee on Global Warming and Energy Independence, that there was still a debate going on as to whether or not human beings were having an effect upon the climate and whether or not that change in climate was dangerous for the planet and for human beings and other living things.

Because of your work, because of your panel's work, that debate is now over. And one by one, as each one of your four reports were issued in 2007, it ended the debate over that issue. And now we are moving on to the question of what should we do about it.

But your constant warnings about what the impacts are, your international leadership is something that was justifiably recog-

nized with the Nobel Peace Prize. Because from Darfur to Somalia and increasingly other countries all across the planet, the impacts of climate change have profound effects upon the stability of nations. And you have now made it no longer a debatable issue. And, like Gandhi, you have now made an incredible change in the way in which the world views these issues, and we thank you for that.

What I would ask, if you could, is to give us your final summary, give us your final warning to us, in terms of what the world's expectations are of the United States in 2008, because you do believe that we are so close to that tipping point.

Mr. PACHAURI. Thank you very much, Mr. Chairman.

First, I must thank you for giving me this opportunity, and the honorable members of this select committee. It is indeed a great privilege for me to appear before you.

And as a final summary of what I feel on the subject, may I submit, as you rightly emphasized, Mr. Chairman, that the science is very clear: The impacts of climate change are serious, they are measurable, and we know that they are going to get worse over time and over space.

So, therefore, if we want to be responsible in terms of saving all forms of life and humanity across the globe, both in this generation and the coming generations, we need to act. We need to act by ensuring that we adapt to climate change, and that, as some societies that just don't have the ability or capacity to be able to adapt, I think as a humanitarian measure we must help those societies to adapt to climate change.

But also looking at how we might be able to prevent or delay impacts that would cause serious problems in the future, mitigation is absolutely essential. And I would like to say that, based on our reports, we find that the cost of mitigation, if anything, is going to be minimal. And in some cases, it might lead to so many benefits that the minor cost that we incur would be largely offset with the benefits that we reap from mitigation measures.

And I think we also have to ensure that the U.S. is in step with the rest of the world. And the rest of the world, if I may say, from all that I have been able to understand of what is happening, is moving in a direction where we will have a low-carbon economy. The U.S. has to be in a leadership position to bring about this transition to a low-carbon economy. It is not going to be costly. It is going to be of enormous importance and benefit to business to take early action in this area.

And I think, more than anything else, the rest of the world looks at the U.S. for leadership. It has been a leader in so many respects after the Second World War. What the U.S. brought about is really what we see as the benefits across the world of thriving democracies, of economies that are doing so well. We are at a similar juncture today. And I think if we can take leadership in this country to move in the right direction, there would be huge benefits and certainly an avoidance of huge costs that otherwise would accrue.

So I would like to salute this select committee, sir, for the initiative that you have taken. And I think if we move along rapidly along the lines that you have outlined, Mr. Chairman, I think the whole world will look up to you, will salute you, and I am sure this

society overall would benefit enormously, along with the rest of the world.

The CHAIRMAN. Thank you, Dr. Pachauri.

And as we close this hearing, I think you, as well, deserve the recognition for the work which you did and the difference that it has made in the way in which the world and the United States views these issues. And I think that you deserve the warm recognition, as we conclude this committee hearing. In addition to the Nobel Peace Prize which you received, I think that we should give you our own warm response, as well. Thank you so much, sir.

[Applause.]

The CHAIRMAN. This hearing is adjourned.

[Whereupon, at 10:56 a.m., the committee was adjourned.]

Response to additional questions provided by The Select Committee on Energy Independence and Global Warming

1. The estimate of 3% decrease in GDP should be seen in the context of co-benefits from the proposed mitigation measures, which have been highlighted in the Working Group III Report of the IPCC. These would include benefits involving higher energy security, lower levels of local pollution and related health benefits. If these and other such benefits are taken into account they would offset the cost estimate of 3% decrease in GDP in 2030. Elected officials can also highlight the benefits of increased employment for instance, on account of greater use of decentralized and renewable energy sources etc.

2. As of now there is very little evidence that the major economies process has provided any tangible benefit. However, the fact that the US is engaged in such a process clearly has benefits in terms of convincing the global community that the US is far more serious about solving the problem than it was say seven years ago.

3. I think the cap and trade system has some benefits, and while the European Trading Scheme has some administrative and procedural flaws, by and large it is providing actions and solutions that would help Europe as well as the world.

4. Coal power plants in my view will not be phased out in the near future, but they could be replaced in due course, with technologies that minimize emissions of greenhouse gases while using coal as a fuel. Nuclear energy is likely to grow in the future, but there are limitations on how soon they can replace coal power plants if it is so decided. Nuclear energy will certainly be an important source in the future but we also need to shift to greater use of renewable energy technologies and improving efficiency of energy use. Baseload power will come increasingly from nuclear plants but coal will retain a significant part of its share in the next 40 years.

5. Carbon sequestration still has problems but with the development of technology and know-how, concerns related to long term storage can be effectively dispelled.

6. To encourage a dialogue with developing countries, the US has to take a leadership position and establish its credibility as a problem solver at the global level. Dialogue will only follow from the establishment of a track record by the US in reducing greenhouse gases.

7. I have been very active with the scientific community and the governments of both China and India. In India I am a member of the Prime Minister's Advisory Council on Climate Change and in China I am a member of the China Council for International Cooperation on Environment and Development (CCICED), which is chaired by a senior Vice Premier and has membership from key government and other organizations in China.

8. I have not been involved in developing adaptation programmes and activities through the organizations mentioned.

9. There is undoubtedly no perfect certainty on the outcomes of actions taken today producing results several decades and hundreds of years in the future. However, an appropriate risk management strategy requires that we take these actions today. Any changes in priorities or refinements may be possible when new knowledge emerges. If, however, we do not take urgent action the impacts of climate change resulting from inaction can be negative and serious.

10. The figure of deforestation has increased slightly over the 1990 estimates of the IPCC.

11. Forestry management in several countries is robust and reliable, but there are several others where major weaknesses exist. Two nations that have arrested and reversed deforestation are China and India.

12. Forest fires can provide large scale emissions, but the effect on the concentration of carbon-dioxide and other greenhouse gases may not be significant. Hence, it cannot cause a global warming emergency. Forest fires are really the result of human failure or poor management techniques. There is little scope for technological innovation in this field.

13. Sustainable management of forests can provide biomass energy that could substitute fossil fuels and, therefore, this approach could be largely beneficial.

14. Since the IPCC carries out assessment of existing literature, it would be very difficult for us to estimate how many model runs were carried out by the researchers who are responsible for the various publications and outputs assessed in the Fourth Assessment Report.

15. For the most stringent stabilization category assessed (a stabilization level below 490 ppmv CO_2-equivalent), targetting a global mean temperature increase of 2.0°C to 2.4°C at equilibrium, emissions are required to decline before 2015 and to be reduced to less than 50% by 2050 compared to 2000 levels. For stabilization levels between 490 and 590 ppmv CO_2-equivalent, global emissions should peak around 2010–2030, followed by a return to 2000 levels, on average around 2040. For high stabilization levels (between 590 and 710 ppmv CO_2-equivalent), the median emissions peak around 2040 and increase in global emissions in 2050 should be limited to 60% compared to 2000 levels.

Acceptance Speech for the Nobel Peace Prize Awarded to the Intergovernmental Panel on Climate Change (IPCC)

Delivered by

R K Pachauri, Chairman, IPCC

Oslo

10 December 2007

Your Majesties, Your Royal Highnesses, Honourable Members of the Norwegian Nobel Committee, Excellencies, My Colleagues from the IPCC, Distinguished Ladies & Gentlemen.

As Chair of the Intergovernmental Panel on Climate Change (IPCC) I am deeply privileged to present this lecture on behalf of the Panel on the occasion of the Nobel Peace Prize being awarded to the IPCC jointly with Mr Al Gore. While doing so, I pay tribute to the thousands of experts and scientists who have contributed to the work of the Panel over almost two decades of exciting evolution and service to humanity. On this occasion I also salute the leadership provided by my predecessors Prof. Bert Bolin and Dr Robert Watson. One of the major strengths of the IPCC is the procedures and practices that it has established over the years, and the credit for these go primarily to Prof. Bolin for their introduction and to Dr Watson for building on the efforts of the former most admirably. I had requested Professor Bolin to receive this award on behalf of the IPCC, but ill health prevents him from being with us physically. I convey my best wishes to him. My gratitude also to UNEP and WMO for their support, represented here today by Dr. Mostapha Tolba, one of the founders of the IPCC and Dr. Michel Jarraud respectively. I express my deep thanks also to the Vice-Chairs of the IPCC, Professors Izrael, Odingo and Munasinghe for their contributions to the IPCC over the years.

The Fourth Assessment Report of the IPCC has had a major impact in creating public awareness on various aspects of climate change, and the three Working Group reports as part of this assessment represent a major advance in scientific knowledge, for which I must acknowledge the remarkable leadership of the Co-Chairs of the three Working Groups, Dr Susan Solomon, Dr Qin Dahe for Working Group I; Dr Martin Parry and Dr Osvaldo Canziani for Working Group II; and Dr Bert Metz and Dr Ogunlade Davidson for Working Group III respectively. The Synthesis Report, which distills and integrates the major findings from these three reports has also benefited enormously from their valuable inputs.

The IPCC produces key scientific material that is of the highest relevance to policymaking, and is agreed word-by-word by all governments, from the most skeptical to the most confident. This difficult process is made possible by the tremendous strength of the underlying scientific and technical material included in the IPCC reports.

The Panel was established in 1988 through a resolution of the UN General Assembly. One of its clauses was significant in having stated, "Noting with concern that the emerging evidence indicates that continued growth in atmospheric concentrations of "greenhouse" gases could produce global warming with an eventual rise in sea levels, the effects of which could be disastrous for mankind if timely steps are not taken at all levels". This means that almost two decades ago the UN was acutely conscious of the possibility of disaster consequent on climate change through increases in sea levels. Today we know much more, which provides greater substance to that concern.

This award being given to the IPCC, we believe goes fundamentally beyond a concern for the impacts of climate change on peace. Mr Berge Furre expressed eloquently during the Nobel Banquet on 10 December 2004 an important tenet when he said "We honour the earth; for bringing forth flowers and food – and

trees... The Norwegian Nobel Committee is committed to the protection of the earth. This commitment is our vision – deeply felt and connected to human rights and peace". Honouring the IPCC through the grant of the Nobel Peace Prize in 2007 in essence can be seen as a clarion call for the protection of the earth as it faces the widespread impacts of climate change. The choice of the Panel for this signal honour is, in our view, an acknowledgement of three important realities, which can be summed up as:

1) The power and promise of collective scientific endeavour, which, as demonstrated by the IPCC, can reach across national boundaries and political differences in the pursuit of objectives defining the larger good of human society.

2) The importance of the role of knowledge in shaping public policy and guiding global affairs for the sustainable development of human society.

3) An acknowledgement of the threats to stability and human security inherent in the impacts of a changing climate and, therefore, the need for developing an effective rationale for timely and adequate action to avoid such threats in the future.

These three realities encircle an important truth that must guide global action involving the entire human race in the future. Coming as I do from India, a land which gave birth to civilization in ancient times and where much of the earlier tradition and wisdom guides actions even in modern times, the philosophy of "Vasudhaiva Kutumbakam", which means the whole universe is one family, must dominate global efforts to protect the global commons. This principle is crucial to the maintenance of peace and order today as it would be increasingly in the years ahead, and as the well-known columnist and author Thomas Friedman has highlighted in his book *"The World is Flat"*.

Neglect in protecting our heritage of natural resources could prove extremely harmful for the human race and for all species that share common space on planet earth. Indeed, there are many lessons in human history which provide adequate warning about the chaos and destruction that could take place if we remain guilty of myopic indifference to the progressive erosion and decline of nature's resources. Much has been written, for instance, about the Maya civilization, which flourished during 250–950 AD, but collapsed largely as a result of serious and prolonged drought. Even earlier, some 4000 years ago a number of well-known Bronze Age cultures also crumbled extending from the Mediterranean to the Indus Valley, including the civilizations, which had blossomed in Mesopotamia. More recent examples of societies that collapsed or faced chaos on account of depletion or degradation of natural resources include the Khmer Empire in South East Asia, Eastern Island, and several others. Changes in climate have historically determined periods of peace as well as conflict. The recent work of David Zhang has, in fact, highlighted the link between temperature fluctuations, reduced agricultural production, and the frequency of warfare in Eastern China over the last millennium. Further, in recent years several groups have studied the link between climate and security. These have raised the threat of dramatic population migration, conflict, and war over water and other resources as well as a realignment of power among nations. Some also highlight the possibility of rising tensions between rich and poor nations, health problems caused particularly by water shortages, and crop failures as well as concerns over nuclear proliferation.

One of the most significant aspects of the impacts of climate change, which has unfortunately not received adequate attention from scholars in the social sciences, relates to the equity implications of changes that are occurring and are likely to occur in the future. In general, the impacts of climate change on some of the poorest and the most vulnerable communities in the world could prove extremely unsettling. And, given the inadequacy of capacity, economic strength, and institutional capabilities characterizing some of these communities, they

would remain extremely vulnerable to the impacts of climate change and may, therefore, actually see a decline in their economic condition, with a loss of livelihoods and opportunities to maintain even subsistence levels of existence. Since the IPCC by its very nature is an organization that does not provide assessments, which are policy prescriptive, it has not provided any directions on how conflicts inherent in the social implications of the impacts of climate change could be avoided or contained. Nevertheless, the Fourth Assessment Report provides scientific findings that other scholars can study and arrive at some conclusions on in relation to peace and security. Several parts of our reports have much information and knowledge that would be of considerable value for individual researchers and think tanks dealing with security issues as well as governments that necessarily are concerned with some of these matters. It would be particularly relevant to conduct in-depth analysis of risks to security among the most vulnerable sectors and communities impacted by climate change across the globe.

Peace can be defined as security and the secure access to resources that are essential for living. A disruption in such access could prove disruptive of peace. In this regard, climate change will have several implications, as numerous adverse impacts are expected for some populations in terms of:

- access to clean water,
- access to sufficient food,
- stable health conditions,
- ecosystem resources,
- security of settlements.

Climate change is expected to exacerbate current stresses on water resources. On a regional scale, mountain snowpack, glaciers, and small ice caps play a crucial role in fresh water availability. Widespread mass losses from glaciers and

reductions in snow cover over recent decades are projected to accelerate throughout the 21st century, reducing water availability, hydropower potential, and the changing seasonality of flows in regions supplied by meltwater from major mountain ranges (e.g. Hindu-Kush, Himalaya, Andes), where more than one-sixth of the world's population currently lives. There is also high confidence that many semi-arid areas (e.g. the Mediterranean Basin, western United States, southern Africa, and northeastern Brazil) will suffer a decrease in water resources due to climate change. In Africa by 2020, between 75 and 250 million people are projected to be exposed to increased water stress due to climate change.

Climate change could further adversely affect food security and exacerbate malnutrition at low latitudes, especially in seasonally dry and tropical regions, where crop productivity is projected to decrease for even small local temperature increases (1–2 °C). By 2020, in some African countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised.

The health status of millions of people is projected to be affected through, for example, increases in malnutrition; increased deaths, diseases, and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas related to climate change; and the altered spatial distribution of some infectious diseases.

Climate change is likely to lead to some irreversible impacts on biodiversity. There is medium confidence that approximately 20%–30% of species assessed so far are likely to be at increased risk of extinction if increases in global average warming exceed 1.5–2.5 °C, relative to 1980–99. As global average temperature exceeds about 3.5 °C, model projections suggest significant extinctions (40%–

70% of species assessed) around the globe. These changes, if they were to occur would have serious effects on the sustainability of several ecosystems and the services they provide to human society.

As far as security of human settlements is concerned, vulnerabilities to climate change are generally greater in certain high-risk locations, particularly coastal and riverine areas, and areas whose economies are closely linked with climate-sensitive resources. Where extreme weather events become more intense or more frequent with climate change, the economic and social costs of those events will increase.

Some regions are likely to be especially affected by climate change.

- The Arctic, because of the impacts of high rates of projected warming on natural systems and human communities,
- Africa, because of low adaptive capacity and projected climate change impacts,
- Small islands, where there is high exposure of population and infrastructure to projected climate change impacts,
- Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges, and river flooding.

The IPCC Fourth Assessment Report concludes that non-climate stresses can increase vulnerability to climate change by reducing resilience and can also reduce adaptive capacity because of resource deployment towards competing needs. Vulnerable regions face multiple stresses that affect their exposure and sensitivity to various impacts as well as their capacity to adapt. These stresses arise from, for example, current climate hazards, poverty, and unequal access to

resources, food insecurity, trends in economic globalization, conflict, and incidence of diseases such as HIV/AIDS.

Within other areas, even those with high incomes, some people (such as the poor, young children, and the elderly) can be particularly at risk.

Migration and movement of people is a particularly critical source of potential conflict. Migration, usually temporary and often from rural to urban areas, is a common response to calamities such as floods and famines. But as in the case of vulnerability to the impacts of climate change, where multiple stresses could be at work on account of a diversity of causes and conditions, so also in the case of migration, individuals may have multiple motivations and they could be displaced by multiple factors.

Another issue of extreme concern is the finding that anthropogenic factors could lead to some impacts that are abrupt or irreversible, depending on the rate and magnitude of climate change. For instance, partial loss of ice sheets on polar land could imply metres of sea level rise, major changes in coastlines, and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands.

Global average warming above about 4.5 °C relative to 1980–99 (about 5 °C above pre-industrial) would imply:

- Projected decreases of precipitation by up to 20% in many dry tropical and subtropical areas.
- Expected mass loss of Greenland's ice if sustained over many centuries (based on all current global climate system models assessed) leading to sea level rise up to 4 metres and flooding of shorelines on every continent.

The implications of these changes, if they were to occur would be grave and disastrous. However, it is within the reach of human society to meet these threats. The impacts of climate change can be limited by suitable adaptation measures and stringent mitigation of greenhouse gas emissions.

Societies have a long record of adapting to the impacts of weather and climate. But climate change poses novel risks often outside the range of experience, such as impacts related to drought, heat waves, accelerated glacier retreat, and hurricane intensity. These impacts will require adaptive responses such as investments in storm protection and water supply infrastructure, as well as community health services. Adaptation measures essential to reduce such vulnerability, are seldom undertaken in response to climate change alone but can be integrated within, for example, water resource management, coastal defence, and risk-reduction strategies. The global community needs to coordinate a far more proactive effort towards implementing adaptation measures in the most vulnerable communities and systems in the world.

Adaptation is essential to address the impacts resulting from the warming which is already unavoidable due to past emissions. But, adaptation alone is not expected to cope with all the projected effects of climate change, and especially not in the long run as most impacts increase in magnitude.

There is substantial potential for the mitigation of global greenhouse gas emissions over the coming decades that could offset the projected growth of global emissions or reduce emissions below current levels. There are multiple drivers for actions that reduce emissions of greenhouse gases, and they can produce multiple benefits at the local level in terms of economic development and poverty alleviation, employment, energy security, and local environmental protection.

The Fourth Assessment Report has assessed the costs of mitigation in the coming decades for a number of scenarios of stabilisation of the concentration of these gases and associated average global temperature increases at equilibrium. A stabilisation level of 445–590 ppm of CO2 equivalent, which corresponds to a global average temperature increase above pre-industrial at equilibrium (using best estimate climate sensitivity) of around 2.0–2.4 °C would lead to a reduction in average annual GDP growth rate of less than 0.12% up to 2030 and beyond up to 2050. Essentially, the range of global GDP reduction with the least-cost trajectory assessed for this level of stabilisation would be less than 3% in 2030 and less than 5.5% in 2050. Some important characteristics of this stabilisation scenario need careful consideration:

- For a CO2-equivalent concentration at stabilization of 445–490 ppm, CO2 emissions would need to peak during the period 2000–15 and decline thereafter. We, therefore, have a short window of time to bring about a reduction in global emissions if we wish to limit temperature increase to around 2 °C at equilibrium.
- Even with this ambitious level of stabilisation the global average sea level rise above pre-industrial at equilibrium from thermal expansion only would lie between 0.4–1.4 metres. This would have serious implications for several regions and locations in the world.

A rational approach to management of risk would require that human society evaluates the impacts of climate change inherent in a business-as-usual scenario and the quantifiable costs as well as unquantifiable damages associated with it, against the cost of action. With such an approach the overwhelming result would be in favour of major efforts at mitigation. The impacts of climate change even with current levels of concentration of greenhouse gases would be serious enough to justify stringent mitigation efforts. If the concentration of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of

about 0.1 °C per decade would be expected. Subsequent temperature projections depend on specific emission scenarios. Those systems and communities, which are vulnerable, may suffer considerably with even small changes in the climate at the margin.

Science tells us not only that the climate system is changing, but also that further warming and sea level rise is in store even if greenhouse gases were to be stabilized today. That is a consequence of the basic physics of the system. Social factors also contribute to our future, including the 'lock-in' due, for example, to today's power plants, transportation systems, and buildings, and their likely continuing emissions even as cleaner future infrastructure comes on line. So the challenge before us is not only a large one, it is also one in which every year of delay implies a commitment to greater climate change in the future.

It would be relevant to recall the words of President Gayoom of the Maldives at the Forty Second Session of the UN General Assembly on the 19 October 1987:

"As for my own country, the Maldives, a mean sea level rise of 2 metres would suffice to virtually submerge the entire country of 1,190 small islands, most of which barely rise 2 metres above mean sea level. That would be the death of a nation. With a mere 1 metre rise also, a storm surge would be catastrophic, and possibly fatal to the nation."

On 22 September 1997, at the opening of the thirteenth session of the IPCC at Male, the capital of the Maldives, President Gayoom reminded us of the threat to his country when he said, "Ten years ago, in April 1987, this very spot where we are gathered now, was under two feet of water, as unusually high waves inundated one third of Male, as well as the Male International Airport and several other islands of our archipelago." Hazards from the impacts of climate change

are, therefore, a reality today in some parts of the world, and we cannot hide under global averages and the ability of affluent societies to deal with climate-related threats as opposed to the condition of vulnerable communities in poor regions of the globe.

The successive assessment reports published by the IPCC since 1990 demonstrate the progress of scientific knowledge about climate change and its consequences. This progress has been made possible by the combined strength of growing evidence of the observations of changes in climate, dedicated work from the scientific community, and improved efforts in communication of science. We have now more scientific evidence of the reality of climate change and its human contribution. As stated in the Fourth Assessment Report, "warming of the climate system is unequivocal", and "most of the global average warming over the past 50 years is very likely due to anthropogenic greenhouse gases increases".

Further progress in scientific assessment needs however to be achieved in order to support strong and adequate responses to the threats of climate change, including adaptation and mitigation policies.

There is also notable lack of geographic data and literature on observed changes, with marked scarcity in developing countries. Future changes in the Greenland and Antarctic ice sheet mass are another major source of uncertainty that could increase sea level rise projections. The need for further scientific input calls for continued trust and cooperation from policymakers and society at large to support the work needed for scientific progress.

How climate change will affect peace is for others to determine, but we have provided scientific assessment of what could become a basis for conflict. When Mr. Willy Brandt spoke at the acceptance of the Nobel Peace Prize in 1971, he

said, "...we shall have to know more about the origins of conflicts. ... As I see it, next to reasonable politics, learning is in our world the true credible alternative to force."

At a fundamental level the world now has to create knowledge and practice on a path of development which is not resource degrading and carbon intensive. Human ingenuity and strength are capable of meeting this challenge. Dr. Gro Harlem Brundtland told us 20 years ago of the importance of sustainable development as the path to peace and prosperity. We need to commit ourselves to that path today before it is too late.

The thirteenth Conference of the Parties to the UN Framework Convention on Climate Change is being held in Bali right now. The world's attention is riveted on that meeting and hopes are alive that unlike the sterile outcome of previous sessions in recent years, this one will provide some positive results. The work of the IPCC has helped the world to learn more on all aspects of climate change, and the Nobel Peace Prize Committee has acknowledged this fact. The question is whether the participants in Bali will support what Willy Brandt referred to as "reasonable politics". Will those responsible for decisions in the field of climate change at the global level listen to the voice of science and knowledge, which is now loud and clear? If they do so at Bali and beyond then all my colleagues in the IPCC and those thousands toiling for the cause of science would feel doubly honoured at the privilege I am receiving today on their behalf.

Thank you!