NTVA – rapport: 1 - 2007

Ethics of Climate Change

Exploring the principle of equal emission rights

by

Inge Johansen

with the support of a reference group:

Knut H. Alfsen
Olav Bolland
Einar Hope
Jørgen Randers
Svein Sundsbø

Norwegian Academy of Technological Sciences
NTVA

Information on NTVA: http://www.ntva.no

Preface

Norwegian Academy of Technological Sciences, NTVA, has chosen “The Ethics of Climate Change” as heading for the seminar arranged as part of its “Technology Forum 2007”. Our ambition is every year to select a topic related to technology and technological development which is important to Norway and to the world. After our theme was chosen IPCC has published its three last reports. They have, together with the Stern Report, expressed a strong opinion that a global climate change with dramatic consequences is under way. Obviously this situation calls for ethical reflections on how to handle this situation.

NTVA has a responsibility to stimulate discussion on such issues. We will create a forum for exchange of experience and reflections. Our basis for that is science and research. We need to challenge published results and political opinions and we need to view problems from different angles.

The chosen topic is a controversial one, with strong opinions expressed both to the extent that we can observe a significant climate change, what the causes are and how the situation can be handled. We are concerned in this report with the ethical issues connected to this.

NTVA has asked a working group to reflect on the ethical relevant basis when confronting this issue. As technologists we are aware of the importance of technology, but technology alone is no answer to the challenge. It is a combined economic, technological, political and ethical issue.

On behalf of NTVA and myself, I wish to express our sincere appreciation to the group headed by Professor Inge Johansen. He is the author of the report, the others were functioning as a reference group. The group, consisting of people with broad professional background on climate change issues, energy industry, technology and economy, was willing to combine their experience and come up with their reflections on what the guiding principles shall be. We appreciate especially that they have applied the principles on actual development work going on in Norway and demonstrate that it need not be a large distance between ethical principles to the selection of concrete development work.

We believe this report will be studied with interest and feel it as a privilege to present it on this seminar on “Technology Forum 2007”.

Asbjørn Rolstadås

President
NTVA

Preface by the Working Group

We have approached the challenge from NTVA with humility. It is a major task to reflect on ethical dilemmas created by man-made climate change, particularly since none of us have professional experience from work on ethical issues. But we used our combined professional background, and looked at the ethics of climate challenge with an open mind.

The climate problem is already acute: Major change can already be observed in the global climate and more will come, according to the best science in the field. There is intense need for climate action, and we believe such action would be greatly helped if it were guided by "ethical principle". This report presents the principle we chose and its ramifications.

The global atmosphere is a unique example of a common good. All humans benefit from it and all share the cost when it is damaged. With the limited ability of the atmosphere to absorb human greenhouse gas emissions, and the obvious need to reduce humanity's collective emissions to below the sustainable level, it became natural for us to study how this limited emission should be distributed among the people of the world. This report explores the most obvious principle: an equal right for each human being to emit the same amount of greenhouse gases each year. In short "The Principle of Equal Emissions Rights".

If the Principle of equal emissions rights shall be sustainable, the per capita emission right must be limited to the globally sustainable emission divided by the world's population at the time. The result is indeed a low amount, around 1 ton of CO_2-e per person per year, roughly one tenth of current emissions in rich countries like Norway. Thus the Principle of equal emission rights leads to the need for very deep cuts in human greenhouse gas emissions.

Furthermore, we chose to explore equal emission rights in the "footprint" sense of the word. That is, we focus on the emissions associated with consumption, not production. At the individual level these are all emissions associated with a person's consumption of goods and services - at home and abroad. At the national level this amounts to emissions from domestic production corrected for export and import. One important consequence of the Principle of equal climate footprint, is that it does not place constraints on where production takes place. Importantly, this footprint perspective differs from that of the Kyoto agreement, which focuses on the emissions arising within some chosen territory – eg within Norway.

The author of the report is Inge Johansen. The rest of us have provided input and advice in meetings and in the form of comments on earlier drafts. Johansen is, however, solely responsible for the viewpoints presented. But the deep concern for choosing the right ethical approach when combating climate change is shared by us all.

The Working Group is hoping that the report will stimulate continuing reflection on the ethical issues confronting us and also on practical approaches on how the climate change challenge shall be tackled.

Trondheim, 25 of July 2007

Inge Johansen	Knut H Alfsen	Olav Bolland
Einar Hope	Jørgen Randers	Svein Sundsbø

Executive Summary

The worldwide rise in energy consumption in all countries has been an ever increasing concern in the last 25 years. The Intergovernmental panel on Climate Change (IPCC) has in a number of reports during the last 20 years directed the attention to the relation between the greenhouse gas emissions, mostly due to fossil fuel, and the climate. Three reports published by IPCC this year point out the strong scientific evidence between the increased level of greenhouse gases in the atmosphere and the rising global average temperature observed over the last twenty years and its effect on the climate, nature with its habitat. The reports also highlight what is required to reduce the emission to an acceptable level.

Unaffected by such concerns world economy requires more energy than ever before, with fossil fuel as the dominant energy source. Affluent developed countries have not, in spite of well established energy systems, managed to put a ceiling on their energy consumption and the developing countries see increasing use of energy and greater power supply as essential on the road to a better life. If development follows the same path as in the preceding fifty years, nature and people a few generations after us will be left with a climate that according to most predictions will not be able to sustain life as we know it today.

This report deals with the ethical dilemmas this situation imposes on us. Up to twenty years ago the atmosphere was regarded as having infinite capacity for absorbing greenhouse gases. We now recognise that the capacity is finite and represents a common that must be shared by all people on the globe. Some have to reduce their emissions and take the cost and we all, including future generations, will benefit. There are a large number of stakeholders that will be affected. They have all to solve a common global problem of immense importance together.

The Kyoto-protocol was the world's first step in sharing burdens in an attempt to limit the emission of greenhouse gases on the globe. Some of the developed countries made a pledged to a reduction of five per cent within 2012 based on the emissions level in 1990. Since then the global emissions of the greenhouse gas CO_2 alone has increased between 30 and 40 %. This demonstrates the necessity of a global agreement on principles on an approach to emission reduction.

In this report we test the feasibility of an equal emission right of greenhouse gases to all individuals where persons in the industrialised countries are on par with persons in developing nations and of persons living some generation after us. We define the emission right according to the "ecological footprint" principle where all emissions originating from a person's consumption of products and services are included.

According to democratic rules we let the people be the judge on how the principle should be applied.

If this principle of equal emissions rights shall be sustainable, the per capita emission right must be limited to the globally sustainable emission divided by the world's population at the time. The result is indeed a low amount, around one ton of CO_2-e per person per year, roughly one tenth of current emissions in rich countries like Norway. Thus the Principle of equal emission rights leads to the need for very deep cuts in human greenhouse gas emissions.

This principle of equal right to emission of greenhouse gases is compared with other ethical principles and other forms of rights. We claim that this type of right should be regarded as a universal right to a global common and may be compared to the right to water, more fundamental than property rights and related to human rights. In our view the principle does not exclude cost-benefit analysis approaches as a tool in finding cost-effective solutions as long as it does not infringe the principle. The principle relates also the precautionary principle and to the principle of sustainable development, but is more specific in taking care of the interests of all stakeholders.

The principle of equal emission right based on ecological footprints focuses to our mind the attention directly where it should be, on the emissions associated with a given consumption of product and services. It is the consumption pattern and the climate consequences of that which must be changed to reduce the climate footprint of each human being.

The consequences of the principle of equal emission right are applied on situations that the threats of climate change have brought us into. International agreement between countries has to be negotiated, succeeding the Kyoto-protocol. In order to make the principle of equal rights to everybody feasible, the emission right of each person has to be transferred to his country. The sum of the "footprints" of the concerned country is its total production with import added and export subtracted. The emission right of each country will then simply be the sustainable emission level times the population at the time. Only some of the least developed countries have emissions at a sustainable level. The emission level on the globe has to be reduced to a small fraction of the current emission. That is the dramatic challenge ahead of us.

It is acknowledged that the principle of equal rights can not be fully implemented at once. It takes years to get the necessary international agreements and appropriate technology in place and a plan must be implemented in steps, with a stepwise reduction in the global emission levels. That will hurt future generations more than those living today. In order to make the system efficient a cap on the emission for each country and trade of emission rights between the countries are assumed. That may distort the equal right principle between people in different countries. The rules of democracy inside a country may also distort the equal emission right between individuals inside the country.

The principle will, however, give directions and guidance and in sharing the emissions rights between the countries the principle should not be compromised.

The dilemmas that the present and coming climate change has brought the world and its various stakeholders are illustrated in two "ethical dialogues" inspired by the German philosopher Jürgen Habermas. In the first dialogue *the industrialised countries, the developing countries, future generations, aboriginal people and the petroleum exporting countries* meet and have an open and frank discussion on how burdens and benefits in the actions that they conclude as necessary should be shared. The other ethical dialogue is between the stakeholders within a country, more specifically Norway. The participants in the dialogue are *industry, employee, consumers, environmental activists and the authorities.* They all agree that the situation calls for action. At the end of the dialogue *the authorities* invite the stakeholders to review a number of possible measures to reduce greenhouse gas emissions with the following results:

- *The CO_2 capture and storage project* receives a positive assessment as a means for reducing the emissions in Norway and as a contribution to developing a technology

that is not yet commercial, but is expected to be important worldwide in combating climate change.

- *Wind power* development should be intensified, especially offshore. Offshore development may be the fastest way to supply offshore installations with emission free electric power. Offshore wind power may also be important in supplying Europe with renewable power.
- *Increased energy efficiency and saving* is recommended to be enforced and encouraged by three approaches which address different groups of consumers. In order to make this effective we recommend that the government should:

    - Support the development of higher and more stable prices through greater transport capacity of electric power to the grid on the Continent will give. This will stimulate investment in energy efficient equipment.
    - Speed up work on a system that requires labelling of energy need in equipment, buildings and constructions and the greenhouse gas emission associated with their production.
    - Supply generous support to innovators and entrepreneurs that introduce equipment and services to the market where emission reduction can be quantified.
    - Quantify and assess carefully the effect of subsidies to projects with the aim of reducing emission of climate gases compared to other measures

- *Hydropower* competence and Norwegian financial resources should be utilised to harness electric power *in developing countries*, through cooperation in planning and construction and joint operation and ownership in order to support increased use of emission free energy sources.
- *Nuclear power* provides emission free power supply in countries where it is or can come to be accepted by the public. The governmental support to the international cooperation on R&D activities on the Halden reactor is regarded as a suitable Norwegian support to the development of nuclear power.
- *Solar power* will not have a significant effect on the reduction of greenhouse emissions in Norway, but will often be the first electric power supply in many of the poor regions of the world. This renewable energy source is also applied in industrialised countries as Germany and United States. *Research leading to photo-voltaic cells* has had governmental funding and such support should continue. Through entrepreneurship, our traditions in power intensive industries and R&D competence in the field of silicon metal, successful solar cell production has been established in Norway.
- Introduction of *bio-ethanol and bio-diesel* as energy sources in the transport sector should be done with care. The energy need in the transport sector is very large and bio-liquids may compete with the food industry for raw materials and thus disturb the market. The vulnerability of the market is enhanced by the large variation in agricultural subsidies and protectionism between different countries. Industrial maturity of production facilities based on cellulose may make a wider use of bio-liquids more environmentally benign.

Chapter 1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) has since 1990 issued a number of reports about the effect on the climate of the growing content of CO_2 and other greenhouse gases in the atmosphere. The fourth and so far the last reports from the three working groups under IPCC all agree that a man-made climate change already has taken place and that more changes will come, regardless of what type of measures are taken. This statement is made with a high degree of scientific certainty. If the development follows a path of "business as usual" in the coming two decades there is a fear that an unstable climate situation may develop, with temperature increases that nobody can predict. That is a threat to nature and humanity that have not been witnessed since the time of the ice age.

It seems as if these grim facts have been accepted by most people. The Kyoto-protocol was the response to the first IPCC report. The Annex I countries according to the Kyoto-protocol agreed to a careful reduction on their emission of greenhouse gases, a reduction that has to be implemented during the period from 2008 to 2012. The measures are, however, too weak to have a substantial impact, especially since USA and Australia did not ratify the Protocol. An intense discussion on how to deal with the situation has started. The measures will require governmental plans and actions, international actions based on agreement among both rich and poor countries and will have an impact on everyday life around the world.

The world is confronted with a situation not previously experienced. It requires actions on national, international and individual level, it requires development of new technology and introduction of new regimes for trading with energy. What are the basic ethical principles for guiding each country and the world toward a climate that is tolerable and at the same time fair for everybody involved? That can not be answered fully by traditional policy and basic ethical issues have to be considered. Philosophical and religious based ethics follow two main paths. The right conduct or action is the one where you fulfil your duties. The alternative is the utilitarian approach. The action that gives most happiness or utility is the good action. In all ethical approaches there is a mix of the two ethical approaches.

In political decision-making cost-benefit analyses is a most useful tool. That is closely related to utilitarian ethics. The alternative that gives most utility or "welfare" for a given input is the preferred alternative. The utilitarian approach was introduced by the philosopher John Stuart Mill (1806-73) and since refined by a number of others. The cost-benefit approach with its standard discount rates on future events may readily be seen as unacceptable as the main approach in combating climate change. That would put the value of people a few generations from now close to nil, an ethical judgement that very few will share.

An ethics based on duty was developed by Immanuel Kant. It may be somewhat disrespectful to catch the ethical philosophy of Kant in one phrase, but the sentence: "I will never treat other people otherwise, than wishing that this action of mine might be accepted as a general law (maxim)" may concentrate an important part of it. Kant tells us to act according to a set of such maxims. That is our duty and "the categorical imperative" we should follow regardless of utility and consequences.

All ethical approaches have included certain components of Mill's utilitarianism and Kant's categorical imperative. That is the cases for religious based ethics as well as for ethics based on some chosen ethical value. One such value may be certain basic rights that are supposed to belong to each person regardless of ethnicity, sex, age, etc, like the right to express oneself, to

choose religion, not to be discriminated, etc. UN has developed a long series of human rights that are supposed to be respected, but that are violated daily all over the world. Yet they represent principles that democratic societies all over the world struggle to implement in own countries as well as in other parts of the world.

In this report we will test if equal per capita emission rights of greenhouse gases for all, including future generations, can be a valid basis for a fair distribution of benefits and burdens among all relevant present and future stakeholders represented in the drama of the world's climate. In our per capita right we include emission embedded in consumed products and services, according to the "ecological footprint" principle. That will focus the attention on the *consumption* of the end-user and its effect on greenhouse gas emissions. The sum of all such consumptions is the prime reason for the ever increasing emission levels.

It is a basis for this report that the important decisions as far as possible are made according to democratic principles and through agreements between nations.

The Climate Change

The cause and the dynamics of climate change is now reasonably well established and well known. A summary of the most important aspects of the development is a useful starting point for our discussion on the ethical dilemmas

Until the start of modern industrialisation in the last part of the eighteenth century, the concentration of CO_2, the dominating greenhouse gas, in the atmosphere was around 280 ppm. By now this has reached 380 ppm, and at the present level of emission the content of CO_2 in the atmosphere increases with two to three ppm annually. These figures apply for CO_2 alone. If we add the other greenhouse gases that the Kyoto-protocol has counted (CH_4, N_2O, HFCs, PFCs, SF_6), and transform them to units with the same efficiency as greenhouse gas as CO_2, the atmospheric content was equivalent to a concentration of 290 ppm CO_2 in 1850 (290 ppm CO_2e) and about 440 ppm today.

The dynamic between the generating and absorbing capacity of CO_2 in nature has been disturbed by the CO_2 originating from fossil fuel. It is the accumulation of these greenhouse gases in the atmosphere during the development of the industrialisation in the OECD countries that is causing most of the climate change. Inexpensive energy sources, coal, oil and gas, have on one hand been the basis for the living standard and lifestyle in the highly productive industrial societies and on the other hand brought a large new source of greenhouse gas into the atmosphere and caused climate change.

The main contributors to CO_2 emissions are electricity production, industrial use (production of steel and metals, chemicals, etc) and transport. The emission sources demonstrate their close link with the development of modern industrial societies, with their dependency on a reliable electricity supply, efficient industry and efficient and flexible transport systems. The other large contributor is deforestation. The need for new farmland and the global need for timber are the driving forces in the deforestation. Brazil and Indonesia are currently the two largest contributors. In the past North America and Europe contributed significantly.

The annual emission rates per capita of greenhouse gases in the various parts of the world are worked out by IPCC and shown on fig 1.1. It demonstrates the large difference between the

emission rates per capita in the Annex I countries (mostly OECD countries) and the non-Annex I countries (developing countries) and that the industrialised OECD countries are the largest emitters. One point three billon people from the industrialised countries emit about 21 gigatons CO_2-e, about as much as five billion people from the developing countries. The responsibility will rest even more on the rich OECD countries when CO_2 emissions accumulated in the atmosphere in previous centuries is accounted for.

Fig. 1.1 gives the direct emissions from the various regions of the world and does not account for imports and exports of emissions through trade with product and services, as required when the sum of ecological footprints in a region shall be recorded. The difference between "direct emissions" and "ecological footprints" varies from region to region. In a country like China with a large export of products that require energy input, the direct emissions referred to here is larger than the ecological footprints. In most industrialised countries, the opposite is the case. The ecological footprints of Norway are less than the direct emissions, mainly because of the large export of metals.

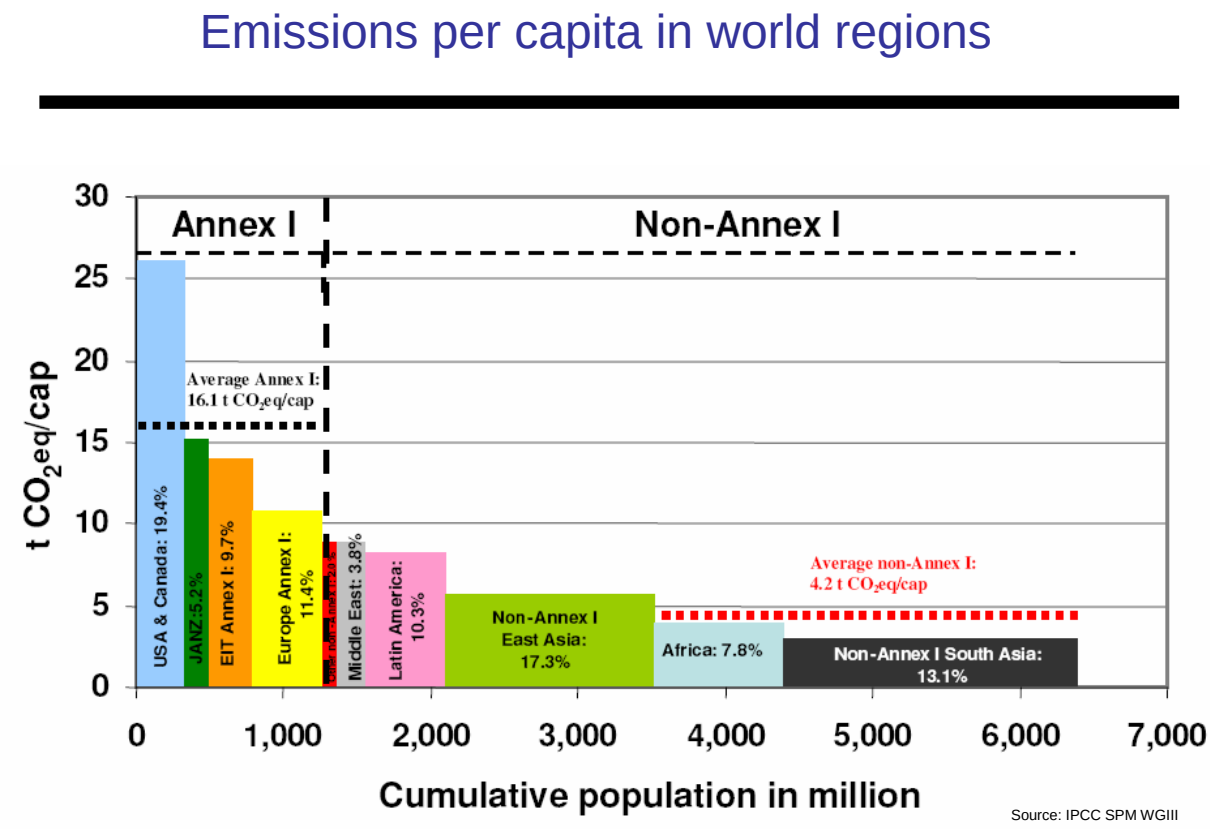

Figure 1.1: The vertical axis shows the annual CO_2-e emission per capita in tons in various regions of the world. The population in the regions is marked along the horizontal axis. The size of the areas is a measure of the CO_2-e emission from that region

Fig. 1.1 gives a static picture of the CO_2-e emissions. Whereas the emissions per capita by far are largest in the OECD countries, the annual relative growth is largest in the developing countries. The rapid economic growth that is witnessed in large countries as China and India is followed by about the same growth in the need for power. In 2007 China overtook USA as the largest emitter of greenhouse gases.

The physical cause of climate change is the increased amount of energy trapped in the atmosphere of the earth. The culprit is the increased content of greenhouse gases that retain more of the energy from the sun on the surface of the earth. Its prime effect is an average temperature increase across the globe. As demonstrated in fig. 1.2 this effect can already be observed and because the growth in the accumulation of greenhouse gases is faster than nature's absorbing capacity it will continue to rise even if the emission is frozen at its present level. Fig. 1.2 gives the prognoses for the increase in average temperature on the globe under various assumptions. The red curve assumes a development according to the present economic and demographic trends and with no special political initiatives to reduce the greenhouse emissions. The pink curve visualises the development if the concentration level were frozen at the level of year 2000. That would require immediate and substantial emission reductions. All alternatives which are deemed realistic predict a temperature rise of about one centigrade from year 1980 to 2030, regardless of the initiatives taken.

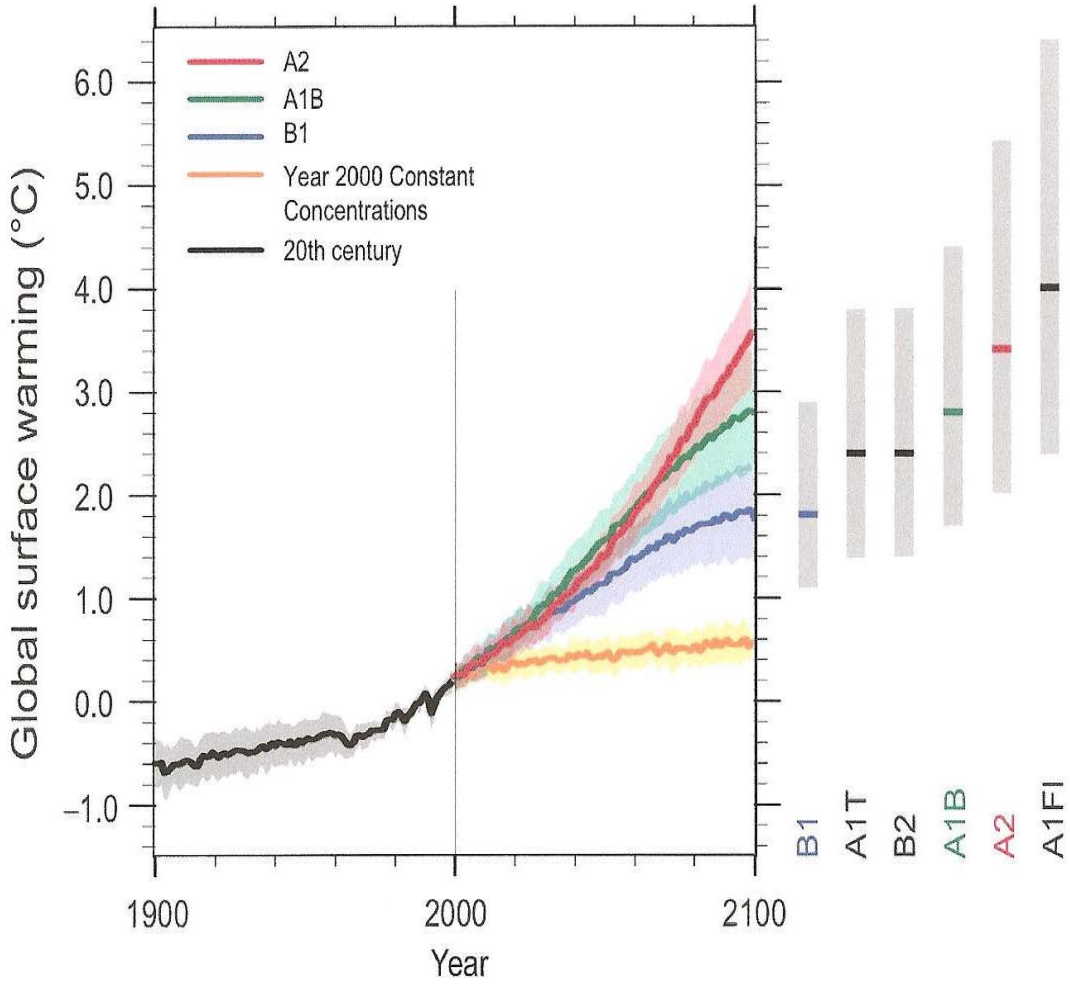

Figure 1.2: Expected temperature increase owing to increased level of greenhouse gases in the atmosphere for different scenarios:

B1: The emphasis on global solutions to economic, social and environmental sustainability and a rapid change toward a service and information society. The population of the world is expected to peak in the middle of the century.

A1T: Rapid economic growth, international cooperation and emphasis on a non-fossil fuel energy supply. The population is assumed to peak at the middle of the century.

B2: Emphasis on local solutions to economic, social and environmental sustainability and more diverse technological change than in scenarios A1 and B 1.

A1B: This scenario foresees a converging world with more emphasis on reduction on material intensity and the introduction of clean and resource efficient technologies.

A1F1: This scenario represents close to a business as usual approach. The population growth will peak in the middle of the century. Economic growth is expected to be high and fossil fuel with CO_2 emission will be continued. Source: IPCC, WG 1, 2007

We have so far been concerned with the temperature increase. The three working groups under IPCC have issued reports on the consequences and on the measures that should be taken if a benign climate for nature and coming generations should be secured. Substantial reductions in the global emission of greenhouse gases are recommended.

How should this challenge be met? Energy, a lifeline in the industrialised societies and a tool for rise from poverty in developing countries, has at the same time become a threat to us all and even more so to the generations ahead of us. We have a number of stakeholders and each of them will have to carry some burdens in order to avoid the most damaging effects of climate change. What type of ethical approach is acceptable when these stakeholders are confronting each other? The necessity of global concerted action is obvious and to find concerted actions that are acceptable to all will be hard. When emission from coal power has to be reduced, how should the immediate burden of emission reduction be shared between countries in exchange for a long-term benefit for all? The cost of emission reduction is felt immediately and may hit people and countries differently, whereas the benefit is long-term and evenly distributed.

An Ethical Approach to the Climate Change Issue

In the next chapters we will test the feasibility of an ethical approach built on equal individual rights to emission of greenhouse gases to the atmosphere. This principle regards the atmosphere as a common, in the way Hardin uses the phrase in his article “The Tragedy of the Commons” in Science in 1968. The yardstick for this right is the individual direct emission in addition to emission hidden in the individual consumption of products and services, the *greenhouse gas footprint* of the individual.

How fundamental this right will be compared with other type of rights, like human rights, right to water, property rights etc. This principle of right is also compared with the principles applied in the Stern Review, the “precautionary principle” and the principle of “sustainable development”. The principle is also tested on its applicability. We divide the stakeholders in three levels, the international level, the national level and the level of enterprises and individuals. As described above concerted international measures, politically controlled measures within each country and measures by each enterprise and each citizen are necessary.

The problem ahead of us is a political, social, economic and physical problem of global nature. An adequate energy supply system is a prerequisite for a well functioning, modern society. All historic data show that economic development in a country relies on an energy supply of high quality, and the dominant supply has been fossil fuel to electricity supply, transport and industrial use. The developing countries have also fully recognised an adequate energy supply as a necessity in the struggle for improved social and economic conditions. It is an immense and global challenge to transform this reliable source of energy to a supply with a drastically reduced emission level. That is, however, exactly what is necessary in order to save the climate for future generations.

Some measures have, however, already been taken. The Annex I countries, except USA and Australia, have ratified the Kyoto-protocol and have agreed to limit their emissions to a certain maximum level. From an ethical point of view there are several weaknesses in the Kyoto-protocol. We will deal with two of them. First, the allocation of emission rights to each country is based on its present emission level, and those emitting most may continue to do so. That may be hard to give an ethical justification. Next, USA and Australia did not ratify the protocol and have refused to share the burden of the specified concerted measures. Even with these critical comments, the Kyoto-protocol should be regarded as an important first step in an international effort to combat climate change

How trade with emission rights may be practised in view of our principle and its consequences for the priority between adaptations and mitigations is also discussed.

In a separate chapter we let stakeholders confront each other in two separate ethical dialogues inspired by the German philosopher Jürgen Habermas. In the first dialogue *the industrialised countries, the developing countries, future generations, aboriginal people and the organisation of petroleum exporting countries (OPEC)* meet and have an open and frank discussion on how they should share the burdens and benefits in the measures that all see as necessary. The other ethical dialogue is between the stakeholders within a country, more specifically Norway. The participants in the dialogue are *industry, employee, consumers, environmental activists and the authorities.* They all agree that the situation calls for action. At the end of the dialogue *the authorities* invite the stakeholders to review a number of actual projects in light of the principle of equal rights.

This evaluation is the content of the last chapter. Projects concerned energy efficiency and saving, capture and storage of CO_2, hydropower development in developing countries, wind power, nuclear energy, solar panels and bio-fuels are assessed.

Chapter 2: An Ethical Approach

The atmosphere may be characterised as our most critical common natural heritage. It is free for all to use and our lives depend on it. The preceding chapter describes how people on earth are about to make serious damage to this most critical natural environment. What type of ethical principle should then be applied, principles that are fair to everybody; people in the industrialised nations, in the developing countries and to those living some generations from now and that can be a guiding principle in prioritising necessary measures.

The main aim of this report as defined in Chapter 1 is to explore if *equal rights to emission of greenhouse gases to the atmosphere for all individuals* can be made an overriding ethical principle in international, national and individual efforts to fight climate change. Our chosen yardstick for this right is the *greenhouse gas footprint* of the individual. That is the total greenhouse gas emission associated with all products and services consumed by each individual. The term "ecological *footprint*" was first coined by the Canadian ecologist and professor at University of Colombia, William Rees, in 1992 and is understood as a measure of man's total utilisation of natural resources. The term greenhouse gas footprint has a more narrow definition, but constitutes a very important part of the broader definition of the term.

We are tying our concept to the total *consumption* of product and services. Another principle would be to assign equal right to per capita direct emission from the country of concern. That would fit better into a system in which direct greenhouse gas emissions are recorded for each country, as in the Kyoto-protocol. The footprint principle is chosen because it relates the emission associated with each person directly to his total consumption and its emission. That is a quantity he can identify, and feel or be made responsible for. Equal right to direct emission would mean that a person's right partly would be determined by the total production of his country and partly by the direct emission caused by himself. That gives a figure that a person may have difficulties in identifying himself with. The footprint principle will no doubt make the personal responsibility regarding climate change more explicit.

Democratic decision making is the other principle that will not be compromised. Democracies are in our mind the best watchman of ethical principles relevant to the present situation and the best monitor of the principle of equal rights. Even though undemocratic societies exist and will have to join in concerted reduction measures the rules of democracy is our basis.

The principle of equal rights of emission to the atmosphere is meaningful only if the atmosphere is a limited resource. Chapter 1 demonstrates clearly that this is the case. This resource has up to now been free to use for all and thus a common to all persons, enterprises and countries. Who are then competing for these resources? As seen from figure 1.1 the industrialised countries have up to now taken their large share of this limited resource. In arguing about how much of this resource should go to people in the developing countries in competition with the industrialised countries Kant's principle can be used: "Act so that you can will that the maxim of your action be made the principle of a universal law". If we follow Kant it will be hard to find arguments against equal emission rights for all people living today. The reciprocity between people living today in the statement of Kant put people all over the world on equal footing. There is, however, nothing in the statement that concerns future generations.

The German theologian and philosopher Hans Jonas has been extensively occupied with that. His concern is the ever more far-reaching impact of technology on nature, in a geographical

as well as in a time context. What we are doing today will have effects long into the future. What is our responsibility? Jonas realises that we can not have the same type of care for people living several generations after us as we have for our own children. He sees it, however, as an existential moral responsibility to facilitate future generations with conditions that enable them to realise their own ambitions and goals. Minimum requirement is a nature and a climate that is liveable. According to Jonas this is metaphysical or god-given responsibility that can not be derived in the same way as Kant derives his maxims.

In our context the mission will be to determine emission levels today that also will ensure sustainability for people living some generations from now. *The principle of equal rights to the atmosphere to all individuals means that we shall limit the personal emission to a level that is assumed to be sustainable.*

Hardin has in his classical paper, "The Tragedy of the Commons" in Science from 1968 dealt with the general problem of utilising resources that are public and common property. We may place our issue in this category. If no plan for the utilisation of such resources is accepted by all involved, the common will according to Hardin not be optimally utilised and will give lower return than investment in own property. The reason is that the common is not treated with the same care as private property. Investment in own property will give full return for oneself. That would also be the case with investment in the common if everybody involved contributed on equal terms. However, some will suspect other owners for failing to do their part, be "free-riders", and may therefore end up as "free-riders" themselves.

Hardin conclude that some type of regulations by authorities or some type of binding agreements between the owners must be in place if the common should be utilised optimally.

Hardin then expands the definition of the commons in the following way:

> "In a reverse way, the tragedy of the commons reappears in problems of pollution. Here it is not a question of taking something out of the commons, but of putting something in -- sewage, or chemical, radioactive, and heat wastes into water; noxious and dangerous fumes into the air; and distracting and unpleasant advertising signs into the line of sight. The calculations of utility are much the same as before. The rational man finds that his share of the cost of the wastes he discharges into the commons is less than the cost of purifying his wastes before releasing them. Since this is true for everyone, we are locked into a system of "fouling our own nest," so long as we behave only as independent, rational, free enterprisers."

The atmosphere should be regarded as a common, to which we have some rights. Because the atmosphere has been regarded as having an infinite capacity for absorbing greenhouse gases, the problem of getting restrictions or cost associated with the emission has not come up until recently. It then became clear that the atmosphere indeed had limited capacity to absorb greenhouse gases if serious damage to the climate should be avoided.

We may notice the time difference between 1968 and now. The problem of greenhouse gases is not even mentioned in Hardin's paper and many of the problems in 1968, polluted water and noxious fumes into the air, are at least partly taken care of in many industrialised countries. The potential danger of the greenhouse gases seemed not to be known by Hardin. Although the ecological danger of the increased content of carbon oxide in the atmosphere

was mentioned in the Club of Rome study: “The Limit to Growth” from 1972 it was first in the eighties that the matter got much attention.

The problem confronting us now has larger dimensions compared to the pollution problems that Hardin was addressing. The problems of pollution to air and water can be tackled within one country by enacting laws and regulations when that is necessary. In some cases bilateral or multilateral agreements have to be made. Examples of that may be seen within the European Union. The public got during the sixties and seventies so annoyed with air and water pollution that the matter became a political issue. The will of the public was reflected in political actions and thirty to forty years later the environment and the public have profited greatly by the actions taken.

Hardins paper is not addressing the issue on how a limited resource should be shared, although there is an underlying assumption that everybody has the same or some defined rights to the common resource. In our case we will test the principle of equal rights to greenhouse gas emissions to the atmosphere from several angles. The idea is to see if this axiomatic declared principle stands the scrutiny of other accepted ethical principles and what type of other ethical and moral principles may follow. We will also assess how the principle can be a guide in policies and strategies in the struggle for a benign climate:

- How does the principle compare to other type of ethical principles?
  - The ethics behind the Stern Review
  - The Contraction & Conversion scheme
  - The precautionary principle
  - Sustainable development
  - Conflicts with other type of rights?
- The application of the principle
  - on international policy and agreements
  - on national policy
  - as a guide for individual ethics on matters of climate
  - on the priority between adaptation and emission reduction measures

The Principle of equal Emission Rights Compared with other Ethical Principles

A number of ethical platforms have been applied when environmental issues are discussed and below we will briefly discuss those mostly applied. In many cases the ethical platform is not explicitly outlined, but more or less taken as self evident.

The most widely used principle is the utilitarian approach as we meet it in cost-benefit analyses or modified as in the Stern Review. We will deal with the underlying ethical basis of the Stern Review. Some of the same ethical approach can also be found in the “Contraction & Conversion” scheme developed already in the 1990-ties. The precautionary principle is often applied when confronted with environmental issues. When some new species are appraised for placement in nature with any chance of unforeseen and unwanted effects, the precautionary principle may be required used. The principle of sustainability, a third ethical platform, may contain elements of many ethical platforms.

The Stern Review

The Stern Review applies basically an utilitarian approach, however combined with restrictions based on other ethical approaches and adapted to the matter of climate change. We will briefly describe its methods and conclusions. This is useful because it illustrates how different ethical approaches may complement each other.

The Stern Review is undoubtedly the most complete assessments made of the effect of climate change and the cost of combating it, outside the basic and comprehensive work being done by IPCC in the last 20 years. The problems that the Stern Review addresses are (1) if any measures at all concerning climatic change should be undertaken, and (2) if measures should be initiated and implemented, what type of measures should it be and at what time should they be implemented? The Stern Review takes a global approach to the cost of global warming and the benefits from curbing it.

The Stern Review concludes that measures indeed should be taken and that they should start now. If future generations should maintain the welfare and goods we enjoy today, it is more economical to start with measures to reduce the emissions now, rather than wait. It is certainly an ethical standpoint behind this care for future generations that goes beyond an ordinary utilitarian approach. Future generations are valued on line with this generation. The same ethical attitude is, without any extensive elaboration, the basis for the report "NOU 2006:18, Et klimavennlig Norge" (A Climate Friendly Norway). The level of greenhouse gases in the atmosphere should also for future generations be compatible with a friendly climate. It values future generations on line with this generation with essentially no discount.

Large mitigation efforts today will decrease future risks for more frequent and intense storms, sea level rise and the risks for floods, droughts and extreme rainfalls. The problem for the Stern Review was then to find out at what time and to what extent should measures be taken. According to economic theory that is when the marginal investment cost equals the marginal benefit. The conclusion of the Review is that mitigation measures should already have been started, and that any postponement will be more expensive and risky than to start now.

The Stern Review takes into account the science of climate change as far as it is known today. The uncertainties are given due considerations by following various scenarios so that the effects of a numbers of parameters can be assessed, such as the economic growth pattern, population growth, industrial and technological development, etc. In the models used it is also accounted for the lasting effect that mitigation measures of today will have and how that will reduce investment requirements in the future. An installed windmill today will permanently supply carbon free electric power. It will thus reduce the need for mitigation measures later and it will also reduce the social cost of the effect of a more adverse climate. That enhances the value of an early start in the reduction of greenhouse gas emissions.

This approach looks deep into the future in the sense that it maps a path into a climate future which is assumed to be sustainable. On the way to that goal, the Stern Review visualises developments that stabilise the content of CO_2-e in the atmosphere at 450 ppm and 550 ppm respectively in line with similar scenarios from IPCC. A stable content of 450 ppm requires that emissions peak within the next ten years and then an annual reduction of more than five per cent, resulting in no more than 70 % of the present emission level by 2050. The Stern Review believes this to be unachievable with current and foreseeable technologies. Stabilisation at below 550 ppm CO_2-e will require that greenhouse gas emissions peak in the

next 10 to 20 years and then fall at one to three per cent annually. By 2050 the emissions will then be reduced to 25 % of the present level.

The Stern Review, as well as IPCC has given up the goal of securing the same climate to coming generations as the world is enjoying today. The burden that is imposed on them can not be predicted exactly, but will be in the form of a warmer and more violent climate.

The Review discusses also how burdens and benefits could be shared between individuals and countries during the development to a stable climate and takes a pragmatic approach to that. It discusses how game theory could contribute to solve the problem of sharing costs, and points also to the ethical responsibilities of the industrialised countries. Its recommendation that the OECD countries reduce their emissions by 60 % within 2050, even with no commitments from other parts of the world, is a reflection of that. It advocates, however, no principle of equal rights to the atmosphere for all people in the world and has neither any statements to the contrary

In a plan that seems to have broad political support, Britain could become the first country to set legally binding carbon reduction targets at that level. That may be a concrete result of the Stern Review.

Contraction & Convergence

This scheme for guiding the world to a sustainable emission level was developed by the Global Commons Institute in the nineteen-nineties. The Contraction & Convergence scheme (C&C) provides a framework for a smooth transition to a low greenhouse gas emission level. It is meant either to follow or replace the Kyoto protocol. The first step in this scheme is to agree on a sustainable emission level, a level that the countries of the world are assumed to share in an equitable way. This principle of convergence to an equitable and sustainable emission level for all is close to the principle presented in this report.. The “contraction” of the emission level is supposed to take place linearly from its present state in the country of concern and “converge” to the same equitable level for all countries.

The C & C scheme provides thus no principle of equality on the right to emission in the period until a sustainable emission level is reached. The countries with the higher per capita emissions will, however, lose their privileges gradually during the time of convergence. The equal emission right principle will seem more radical and give the developing countries possibilities to keep up their struggle for economic progress and force the industrialised countries to step up their efforts to reduce emissions. Rules for caps and trade will make the equal right principle achievable

The Precautionary Principle and the Principle of Sustainable Development

The C & C scheme and the Stern Review are strictly addressing climate change issues. We will also look into some principles applied on more broad environmental issues.

The *precautionary principle* may best be defined by citing Principle 15 in the Rio Declaration:

> “In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or

> irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation"

This is a principle of caution when confronting a potential present or coming threat to the environment and when measures should be assessed. The content of this statement may seem vague in terms of its applicability to specific cases. Two conditions should be fulfilled when the principle is applied. It should be restricted to matters of some importance. In addition, the risk for a serious damage should have *some solid* scientific basis.

In the case of climate change, the precautionary principle should have been applied and led to drastic measures already in 1990. The first assessment report from IPCC presented so much scientific evidence of climate change that it certainly qualified for action. The importance of the problem is large and there should be all reasons to avoid negative risks. The Kyoto-protocol may be seen as a way of adhering to the precautionary principles, although in a rather feeble way.

The precautionary principle is mostly applied in cases where new technology with potentially adverse environmental effects should be considered stopped, as when the use of gene-modified plants in agriculture is assessed. In the case of the threat of climate change, the problem would be to assess if traditional energy supplies with potentially negative effects should be stopped and substituted with energy supplies with no greenhouse gas emissions. With the knowledge of today, use of fossil fuels would have been forbidden, if it had appeared as a new energy source today. Now the world depends on it.

The precautionary principle seeks to safeguard the future generations in the same way as the principle of equal emission rights does. The precautionary principle has, however, not directly expressed a position about equality between individuals of all generations, but is on the other hand a more broad principle that may be applied to all types of impact on the environment, greenhouse gas emissions included.

Today there are no more uncertainties about the conclusion that a climate change will occur and that a man-made component is involved in this development. The certainty in the predictions is such that IPCC, the Stern Review and others can make economic assessments of the result of reduction measures. The precautionary principle is still useful. The details of the future development of the climate are full of uncertainties. In protecting certain areas for avalanches owing to extreme rain, in securing buildings and landscape against storms and flooding, in being prepared for sea level rise etc, it may be good policy to supplement traditional actuarial calculations with the application of the precautionary principle.

The definition of *"Sustainable development"* most widely referred to is that given in the Brundtland report:

> "Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs."

This anthropocentric definition focuses on the well-being of people today and coming generations. The principle of *sustainable development* and the *precautionary principle* may have the same aim in mind. They represent, however, different approaches to how actions with consequence for the future should be met. The precautionary principles tell us to be

careful if not sure of the consequence. The principle of sustainable development may invite us to be less cautious and more ambitious in projects that are believed to benefit nature and present and coming generations.

Neither the precautionary principle, nor the principle of sustainable development, gives any direct guidance on how to make priorities as cost-benefit analyses may provide. The precautionary principle may be looked upon as a stop order for some courses of actions that may lead to a dangerous development and cost-benefit methods may well be used for those alternatives that are considered acceptable. In relation to the principle of sustainable development, the cost-benefit approach may also be useful. When the Stern Report has valued benefits for future generations on par with the current generation it may be looked upon as a way of introducing the principle of sustainable development into a cost- benefit approach.

A requirement of sustainable development will safeguard the rights of future generations in relation to the present generation and is in that respect on line with a principle of equal emission rights. It does not, however, state so clearly that people in poor and rich countries should share these rights equally.

The principle of equal individual emission rights does not violate other ethical platforms that are used when environmental issued are raised, nor is it preventing that the most economical measures to combat climate change are used as long as its basic principles are respected. The principle safeguards, without violating other basic ethical principles, a just share of the right to utilise the atmosphere for all, for rich and poor and for those living today and in the time to come.

To what extent can a principle of equal rights to the atmosphere be made a basic right with precedence over other types of rights?

The phrase “rights” may have several flavours. Some type of rights are regarded as rather fundamental in some countries, however given a low value in others. Private property rights are highly protected in US, are respected in most industrialised countries and do not exist in some communist countries. On the other side United Nations have been defining some universal human rights in all together 30 articles, where rights to security, political freedom, equality, welfare, education etc are defined. We will assess the principle of right used in this report with other types of rights.

A universal right to equality regarding the use of the atmosphere is regarded as closely related to the type of rights that UN has defined. Before the nineteen-eighties the right to emit greenhouse gases was not an issue because the atmosphere was considered infinite in its capacity to absorb CO_2. The acknowledgement of its limited capacity raised the issue on how this common resource should be shared.

We may make a comparison to another natural resource, water. It is regarded as essential that all human beings have access to water. It may be of uneven supply and a scarcity at some places. But if a dramatic drought sets in, the international community regards it as a moral duty to supply the minimum which is required even if this moral responsibility is not always followed up. Overloading the atmosphere with greenhouse gases gives no immediate effect. During some decades, however, it affects everybody in an uneven, but adverse way.

We may ask if anybody according to common law could have some historic rights to the emission of greenhouse gases like indigenous people are considered to have rights to the land of their forefathers. Before the industrial revolution the emission must have been largely evenly distributed among people and even if some were large emitters it would hurt nobody. The use of coal was minute and emission and the absorption of greenhouse gases in nature were largely in balance. The atmosphere was free for all to use and the issue of rights to the atmosphere would have seemed strange if anybody raised that question.

Since the industrial revolution, in a period of more than 200 years, the industrialised countries have made use of the atmosphere as a storage space for CO_2. It is hard to see how common law should give some exclusive rights for the future, any more than previous air pollution by a factory in a region should give right to continue its air pollution, or colonisation in one historic period should give right to continued colonisation. Common law should give no privileges to previous practices when this practice is violating vital interests of other people.

The countries and regions on earth have large variations in their natural conditions and needs for energy. A number of factors may be considered. Each country has its special characteristic with regard to climate, availability of emission free energy sources, industrial structure, industrial and financial competence, etc. Let as take Norway as an example. We may need more energy due to the cold climate. On the other hand the Norwegian hydropower system is supplying the country with electricity that would emit about 100 million tons of CO_2 if produced by coal power, a large privilege when it comes to securing energy sources free from greenhouse gas emissions. The privileges and obstacles in a country will also vary with time. The hot climate in India may seem like a privilege today compared to a cold Siberia. When India one day may wake up as a rich country, the demand for air condition systems may be a burden and the present advantage could turn into a disadvantage.

We believe it would be an impossible task to portion out emission rights according to natural conditions and that equal rights to the atmosphere should be regarded as a basic human right and the main principle when greenhouse gas emission quotas are shared among the countries of the world.

We have now discussed if anybody might have special rights to the atmosphere. A follow-up question is if *anybody should be blamed* for the climate change that has and will occur and thus have more responsibility for correcting the situation than others. As is seen in fig.1.1 the overloading of emission to the atmosphere is mostly caused by the industrialised countries and they have thus a common responsibility for the situation. Taking the historical emissions during the last century into account will enhance that conclusion. According to the principle of “the polluter pay principle” the industrialised countries are responsible for repairing the damage. Up to 1980 the emissions were due to negligence as very few were aware of the negative consequences. After 1980 the developed countries knew that greenhouse gas emissions might have adverse effects and emitting greenhouse gases after that time may be regarded as a wilful act. In a juridical sense that enhances the guilt and the liability for repairing the damage that has been caused.

Conclusion

The consequence of the principle of equal emission right is simple in theoretical terms. The principle makes it necessary to achieve agreement on the long-term goals for emission reduction to a sustainable level.

This reduction has to be taken in steps without losing sight of the principle. A gradual reduction in emission is planned in all approaches to combat climate change. A reduction of greenhouse gases by 50 % before 2050 is among the most ambitious goals that have been expressed. According to the principles presented in this report the Annex I counties will then have to reduce their emissions by 85 % and the non- Annex I countries by 20 %, to an average of slightly more than two tons to each individual. That takes the population increase into account. Norway will have to reduce its emission by about 80 % and US by about 90 % of their present emissions according to this scenario.

In this calculation we have not used the footprint approach because of lack of data.
That would probably require more cuts in emissions from most industrialised countries and less for most developing countries. .

The Application of the Principle on Policy and Strategy

We have to realise that our principles can not be fully implemented. We have already acknowledged that a climate change seems unavoidable and future generations will not enjoy a climate as today. In applying the principle the goal should, however, be achieved as far as possible.

The experience will also most likely be that democracies are not willing to adhere fully to declared principles, whatever they might be, and we have to discuss how the principle best can be implemented within each country.

Individual equal emission rights have been defined above in relation to the *footprint* caused by the burden of greenhouse gas emission on nature. There is, however, no clear cut definition of the burden on the atmosphere of a specific type of consumption of products and services. It seems obvious that direct emissions and emissions put into the products during the production process, like the CO_2 emitted during the production of steel and metals, should count. But should the transport of the employees back and forth to the work place and the space heating in the assembly hall be counted as part of the manufacturing process? On implementing the system practical considerations come in and standardised routines must be developed. A system based on equal direct emission right based on the average direct emission from a country may be a first step in implementing the system. In international agreements, which are required to implement the system, precise definitions of procedures as well as quantities are required, and it may take several steps in a development to fully implement a system as proposed here.

The implication of the principles in the international community, in each country and for individuals

Even though uncoordinated greenhouse gas reduction measures taken in some countries may be an important and even necessary start in combating climate change, concerted actions among the largest emitting countries are in the long run required.

There are several approaches to that. The Stern Review has outlined two of them. One is by international agreement on a carbon tax on all emissions. The Stern Review concludes that the tax regimes and tax traditions are differing widely from country to country. It is unrealistic to hope for systems with the degree of uniformity that coordinated effects can be obtained. The

Review concludes that a cap on the emissions in each country is the most efficient and safe system even though strict control regimes and heavy bureaucratic systems are necessary. That is also a system which is most compatible with the principle of equal rights to the atmosphere for all. That is also the basis for Kyoto-protocol, although only a limited number of the nations has joined that agreement as equal partners.

It seems obvious that a system in which each person is responsible to a world wide institution is not manageable. We conclude without discussion that the management of the individual emission rights has to be taken care of by the country in charge and utilised in transport, industries and households according to the economic, industrial and social policy of the country concerned. We have then a system with three levels, the international level, the level of sovereign nations and the individual level. We start with the relation between the international community and the nations.

The principle of equal rights is readily applicable to *the relation between countries and the international community*. An agreement of the size of emission rights to each country has to be negotiated and reached by agreement. Such negotiations are not straight forward. Cuts in greenhouse gas emissions will affect the economy of a country, its industrial life and daily life of people. At the negotiating table the countries should have the future of the planet as a common concern. But they are also responsible for the interests of people and enterprises in their own country.

The principle of equal rights to the atmosphere for all people should make it simple to make an agreement if the principle of equal emission rights is accepted. The problem will be to decide how much the globe can tolerate of total emissions. It would also be unachievable to obtain this reduction in one step and the challenge will be to decide which emission level is tolerable in the long run and agree on the steps in emission reductions and a timetable for those. In each step the equal right to emission among all living today must be respected, whereas it is compromised in the relation to future generation.

Development of new technology with support from the industrialised countries in finance and competence, international agreements on caps and trade will make the principle feasible. Goals for emission reductions in 2020 and 2050 have already been established in some countries regarding their own emission reductions and some go for reductions of 30 and 50 % respectively. Such reductions have, however, to be established for the global emissions. The principle of equal emission rights will mean a higher reduction than the global average in the industrialised countries and some developing countries may not utilised their emission rights.

There are three technologies with worldwide applicability that has to come into play if the global emission level shall be reduced. That is CO_2 "Capture and Storage" technology, wind power and nuclear power. Other sources may also give some contributions. The most widely applicable is the first one because fossil fuel stands for more than half of the electricity production in both industrial and developing countries and will continue as the dominant energy source in the coming decades. The cost of adding CO_2 "Capture and Storage" technology to fossil fuel power plants will thus represent the upper cost limit when conventional coal power shall be substituted by emission free power sources. The added cost is by experts estimated to USD 0,025 to 0,04 per kWh (Se chapter 4). The other two energy sources will have to match that cost figure.

The introduction of these power sources into the system is hampered by long planning times and pubic concern (nuclear power), by lack of commercial maturity and by the lack of a new trade regime with caps on emissions and long-term rules for international trade with emission rights. The Kyoto-protocol expires already in 2012. With a system for caps and trade in place, the caps and the emission level can be reduced gradually in line with the development of more inexpensive emission free technology.

The outline here is simply a rough sketch. There will a large job to design a system that make the system as described above practical and efficient.

One problem is how to handle the variation in the population when each country gets its emission right assigned. The world population is expected to be about nine billion by 2050. In the developing countries there is generally a large increase. During one decade the increase has been as much as 20 %. In some countries there is a decline, especially in some European countries. Should countries with large population increases be honoured by getting their emission rights per capita raised? China may argue that its rather strict control of the population growth should be honoured with increased emission levels, whereas other countries will strongly argue that a country's policy on population growth should have no consequences on the individual rights of its citizens. There will be hard to find other acceptable principles than letting each individual and thus the actual size of the population count.

The development leading to climate change has been caused by the industrialised nations. The large emissions of the past have also been a source for wealth and in fact also of competence building. Without further arguments we conclude that they should take a larger burden in leading the development of reducing the emission levels. The following initiatives are seen as a responsibility of the industrialised nations based on their past utilisation of the atmosphere a common good:

- Immediate unilateral cuts by large industrialised nations without assurance about an international agreement. The climate may not sustain waiting for the result of tedious international negotiations.
- Offering competence and financial resources in the development and construction of energy systems, industrial processes and transport systems with no or low greenhouse gas emissions.
- Support in developing sustainable market mechanisms for emission rights.

These "requirements" on the industrialised nations are added to the principle of equal emission rights to all.

In the Kyoto-protocol there are mechanisms whereby Annex I countries may trade emission rights with each other. If one of the Annex I countries can reduce its emission level below its cap, it may sell its surplus to another Annex I country that is exceeding its emission cap. That is one important aspect of the Kyoto-agreement. Another scheme is the "Clean Development Mechanism" (CDM) whereby an Annex I country may introduce a greenhouse gas reduction commitment by investing in projects that reduce emissions in a developing country as an alternative to more expensive emission reductions in own country.

How will such measures fit into the system with emission rights? As described we see trade with emission rights as a tool for better resource utilisation as long as the trade is within

international agreements and in line with the responsibilities of the industrial nations outlined above. Trade may also be a method of technology transfer from industrial to developing nations that not yet have reached the emission ceiling. Both parties must be expected to utilise the available emission right as efficient as possible and use the best available technology to that end, the developing country because it supposedly needs expansion of energy systems itself and the industrial country because it is against its interest to deplete the market for emission rights faster than necessary. That will raise the price level.

Tying emission rights to the footprint concept as introduced in this report raises two aspects regarding trade with emission rights. First, the concept may in itself mean a disincentive to trade as when the implementation of new emission free energy systems may mean export to the country of the trading partner. That may add emission rights to the exporting country and subtract emission rights to the importing country and further raise the cost of keeping the buying country below a given cap.

Second, trade with emission rights may distort the sum of ecological footprints in a country compared to other countries. That may be unavoidable. The rich country can buy goods from poor countries in the form of more extensive emission rights. Emission free or emission reduction projects has probably to be required in such trade in order to prevent too large distortion. A developing country will have to assess the value of an expansion in own facilities with greenhouse emission versus the economic and environmental value that the trade will give.

Trade should only be allowed between countries joining the system.

At this point a visit to the political situation at home regarding climate policy has to be made. The Kyoto-protocol is valid until 2012. Binding statements on national ambitions with respect to reduction of greenhouse gases should be restricted to what can be done inside own borders after that time. National ambitions on what can be achieved outside the country could also be expressed, but can not with any certainty be made binding before agreements are in place. The policy of mixing national goals inside and outside own borders after 2012 (in 2020 and 2050) could be questioned.

The duty of a country will be to keep the total emissions due to its total consumption within the limit accepted in the negotiation rounds. The authorities have the necessary legal competence and may sell or give emission rights to industrial enterprises, impose taxes in order to reduce the consumption on items with high emission content, require minimum standards on products, constructions and buildings and forbid the use of products that may be deemed unacceptable. By using a range of tools the authorities can keep the emissions associated with all products and services below a given level.

In democratic countries policy ideally reflects the will of the people. We are introducing a principle of equality, whereas the practice in all countries, to various degrees, is one of inequality in the consumption of goods and services. We have some examples of goods that are equally shared, at least in some of the OECD countries, as for instance the access to nature and to public goods as education, health care, etc. The emission of greenhouse gases is, however, so intertwined with commercial goods, to which the access is limited by economy of individuals. This access is to some extent and to various degrees influenced by the tax regime in the different countries.

The only solution compatible with the general policy in countries with a market economy must be to make products that have emission of greenhouse gases associated with it expensive and with a social profile that is regarded as fair. The rules of democracy will outweigh the rules of equal individual emission rights inside a country. We may dislike the social and economic policy in some countries. The nation is, however, the only unit that has mandate to control and guarantee that obligations are kept and that can sign binding agreements with other countries on behalf of its citizens.

On the other hand, equal right to the atmosphere may stimulate to equality in the society by its ethical content and by stimulating a tax system that punish greenhouse gas emissions.

The focus up to now has been on the responsibilities and ethics at the political level in each country and in the international community of countries. We are now returning *to the individual to which we have given a certain emission right*. How can he cope with rights and responsibilities? We have already acknowledged that it is not practical policy that each individual makes claim on his personal emission right. The right is placed in the hands of the authorities of the country as a real "common". As members of a democratic society each one can make only his small contribution to develop a good system for the use of the common and then utilise it with conscious care.

As persons we are acting in different roles. We are all *citizens* of a country with rights and duties. We are all *consumers* and most of us have a role as an *employee* and some even as an *employer and owner of enterprises*. All those roles give a special relation to the generation of greenhouse gas emissions. What are the rights and ethical duties in these roles?

As *citizen* we elect the political leaders of the country. That is in fact one of the most important task we have as citizens regarding climate change. The political leaders are sitting on the key to action inside the country and in making agreements with other countries. Decisions by political leaders are often controversial. A benign climate of the future may require hardship on its citizens, on enterprises and their employees and it may require higher energy prices and new taxes. It is the duty of a citizen to contribute to an understanding among citizens and in politics that such unpopular hardships are unavoidable and necessary.

It should be acknowledged that the whole issue of climate change is complex and that it is of new date. The first priority is to acquire as much competence on the issue as possible. The first insight is to understand that efficient reduction measures involve a fine-tuned combination of international agreements, national policies, technological developments and market measures. There is a popular tendency to believe that an effort along one single axis may suffice. Up to now the US administration has advocated technological development alone as a solution to the problem. Technology has to be developed, but standing alone as the only effort it is doomed to fail, just as international agreements and national policies would be doomed if no new technology were developed.

The next duty as a citizen is to express the concern regarding the issue in his/her surroundings. Each has connection to one or several institutions, political parties, organisations of all types, churches etc. All such institutions and organisations are places where interactive and informal competence building ought to take place.

Our role as *consumers* is just as important. First, we have to observe our own utilisation of emissions and be prudent in our use of goods that includes emission. That is not always easy

because little information is given on that aspect in most products. That leads to the next role for the consumer, being a watchdog in all aspect of daily commercial life. If people generally asked for the CO_2 emission rates from a car and the emission connected with its production, that type of information would soon be included in all advertisements. The consumers have to create a climate where such information is good selling points. The list of goods where such information ought to be given is long. Washing machines, dryers, food, houses and apartments are all items that are causing emission during the production process and during their operational life cycle. The large individual variations in our consumption pattern do not prevent us from shifting consumption to products with low or no greenhouse gas emission. That this may require a change in lifestyle for people is part of the requirement that the climate change is imposing on us.

Reducing CO_2 emissions and being economical are often identical exercises. That may most clearly be seen when life cycle costs between various products are compared rather than investment costs alone. Such comparisons may be made for simple every day items as between incandescent light bulbs and fluorescent lamps. The economy by far favours the fluorescent lamp when the cost of electric power during its lifetime is accounted for. We may similarly make comparison between traditional electric heating and heat pumps. When the price of electric power is sufficiently high, the heat pump will win the price competition.

Most of us are *employed* in institutions or enterprises. Our responsibility depends on the type of enterprise and of rank and role in the organisation. We will limit this discussion to companies where energy expenses are a small part of total expenditures. In such cases the relation to energy consumption has many similarities with a family's relation to energy use. The energy bill seldom takes more than 10 % of the total budget. In such enterprises the benefits in cutting costs on energy may not be given high priority. Efforts in other activities, in marketing, in cost reduction in the production processes etc may give higher return on investments. Costs other than energy may dominate. This will draw the attention away from the company's use of energy.

Energy consultants experience that the introduction of new simple routines with no investments involved can save at least 10 % energy in almost every type of business. If account is taken to savings that may be achieved in energy use and emissions associated with business travels the figure would in many cases be much higher.

It ought to be the duty of employees on all levels to identify and take initiatives to an efficient use of energy resources on their work place.

Mitigation versus Adaptation

The consequences of climate change have already been seen and will continue. The effect of higher temperatures, more frequent and violent storms, more intense rainfalls and avalanches and more flooding and droughts, etc have already been observed and will according to all predictions increase. Dramatic events like this are in industrialised countries met by buying insurances. In the developing countries, communities hit by catastrophic events in nature may have to take the loss themselves. If the magnitude of the catastrophe gets international attention, national and international relief organisations may come in.

The strategy to meet unexpected events occurring in nature is on the one hand, to protect and fortify regions, cities and constructions so they can endure the largest stresses that with some

probability can occur. The owner may in addition insure his property to avoid loss if damage occurred despite all measures.

The climate change will require increased expenditures to reinforcements that will protect regions, cities, villages and constructions all over the world. These reinforcements will have no effect on the climate. It will only for a shorter or longer period enable its users to meet its consequences.

Cost connected to adaptation should on the large scale be regarded as operational expenses. They will increase with time and the increase will be more rapid if reduction measures are delayed. Mitigation may be regarded as investments with a permanent beneficial effect.

The developing countries will be hardest hit and will need more resources for adaptation to the new climate. The industrial countries have their insurance systems and adaptations can with some delay be part of operational costs. In the support from industrialised countries to developing countries it will be a competition between resources going to adaptation and mitigation. That is in fact a competition between people in the developing countries and future generations. According to the principle of equality between the present and future generations they should have the same priority.

In real life immediate needs tends to get priority in competition with needs that occur some time in the future even if the future need is large. Competition between adaptation and mitigation measures should for that reason be avoided. Emission reduction projects should not lose in priority to adaptation measures. One way of achieving that is to prioritise resources for the two types of measures within different financial frames.

Conclusions

The industrialised countries should add financial support and long-term commitment to technology development to the principle of equal rights to emission.

In order to make emission reduction projects efficient, caps and trade with emission rights must be a part of a system built on the equal right principle. That may to some extent distort the system of equality between the countries. Democratic systems and economic inequalities will have the same effect inside a country. Despite that, the equal right to emissions has still the promise of being a viable principle.

The industrialised countries should take a lead in developing low emission or emission free technology to be used in energy supply, transport and industrial processes.

Chapter 3. International and National Concerns for the Reduction of Greenhouse Gas Emissions

The need for concerted international action in reducing greenhouse gas emissions has already been emphasised. The Kyoto-protocol testifies that most industrialised countries have accepted that. The fact that USA and Australia in the end did not ratify the protocol is a reminder of the large difficulties involved in achieving concerted actions. The next round of negotiations announced before 2012 may be even more difficult. The reason is that the difference between the countries involved will be larger than in 1997 when the Kyoto-protocol was hammered out. In the next round it is necessary to have USA as part of the deal and the involvement of China, India and Brazil and other large developing countries. There will be little long-term effect on emissions without active cooperation from all sides.

The reason for the difficulties is that reduction of greenhouse gas emissions is causing problems inside each country. The various groups of industries, consumers and taxpayers may have difficulties in accepting new burdens on their shoulders that a deal with other countries will mean.

In order to visualise the problems as each stakeholder see them we will present a dialogue between the parties. The dialogue is following an ideal and theoretical approach to how an agreement between groups with widely different interests can be obtained when burdens and benefits shall be shared. The approach is inspired by the type of ethical discourse introduced by the German philosopher Jürgen Habermas. Habermas introduced his ethical discourse as a method of reconciling groups of people with widely different opinions on matters that were existential and dear to them. The aim of the dialogue was not necessarily to achieve agreement, but rather to find a way of living with each others disagreement in peace and find pragmatic ways of dealing with each other in practical matters even if disagreements still existed.

Greenhouse gas emission and its effect may not involve personal ethical stands. The matter is, however, of so large social and economic importance for people and groups with widely different interests that it is hard to reconcile all in a common plan that efficiently combats the emissions. That is, however, exactly what is necessary if the worst scenarios for climate change shall be avoided.

Let us first state the rules for our *ethical dialogue.* Habermas assumed that all the parties with vested interests in the matter took part in the dialogue. He did not see the dialogue as *negotiations* between the parties concerned. At the negotiation table every party keeps his cards close to his chest at the same time as he tries to reveal the secrets of the other parties, all in an attempt to obtain a good deal for himself. In the ethical dialogue, on the contrary, everybody is assumed to put all his cards on the table. The idea is not to modest on behalf of his own interests, but to examine his and others interests as objectively as possible together with the other parties. All matters of importance for the outcome of the issue on the table are supposed to be open for all.

In the dialogue the parties are supposed to meet as equal partners with no pressure in any form. In our case it is expected that there is an agreement of equal emission right for each person around the table. The aim of the dialogue will then be to see how this equal right can be achieved, taking into account the widely different interests of the participants. Below an

ethical dialogue between relevant groups of countries and a similar dialogue between relevant interest groups within one country are referred.

An Ethical Dialogue among Countries

In real negotiations each country protects its own interests, strongly supported by lobby groups in its country. Associations for industrial groups, labour unions, environmental activists, farmers unions, all are present to see that their national representatives, in charge of making a deal on behalf of the country, are not negotiating away their interests. When a deal is obtained in the "real world" it is the result of negotiating competence, use of economic pressure, hiding relevant information, and the deal may not be regarded as "fair" by all countries concerned.

Our ethical dialogue will be free from such pressure. We will also make simplifications, divide the world into groups of countries with the same basic interests and let they be represented by one person. That may be like forming groups of countries with common interests in international negotiations. In the division made below each group plays a vital role in the matter of emission reduction and they have also vital interests to defend.

Interest groups in an ethical dialogue about combating climate changes

Developing countries

About 80 % of the world's population belongs to this group. There are large variations in the GDP per capita, from the poorest countries (a few hundred USD per capita), to countries like China with a GDP of USD 7600 (PPP) per capita, one fourth of the average level of the OECD countries. The group has low greenhouse gas emissions per capita, all of the countries are below the present world average, 6,7 tons. Some have, however, exceeded a sustainable emission level. In spite of the low emission value the group is essential in getting emissions reduced because of the large population growth and the fast rise in energy consumption. The group contains large countries like China and India which together stand for 40 % of the population of the world.

The list of concerns and priorities for the developing countries is as follows:

- Insistence on continued strong increase in the GDP.
- Reduction in pollution levels in water and air, especially in large cities and in industrial areas.
- Fear of sea level rise.
- Fear of land erosion, especially in hilly areas, flooding and droughts and change in seasonal climate.

Industrialised countries

The OECD countries and countries with reformed economies (mostly countries belonging to the former Soviet Union) were the active countries in agreeing on the Kyoto-protocol. They are listed as Annex I countries in that protocol. The population is about 1,5 billion, exceeding 20 % of the population of the world. The GDP in the countries varies from USD 50 000, down to the level of the most advanced developing nations. The emission of greenhouse gases per capita is high and generally four to six times higher than among developing nations. In the

OECD countries the emission of greenhouse gases is about 16 tons per capita and in the countries in the sphere of former Soviet Union between 9 and 10 tons. The concerns and priorities in the developed countries are:

- Continued economic growth and low unemployment.
- Some concern about the climate change.
- The countries have started to introduce some measures to reduce their greenhouse gas emissions and introduced a carbon market as one measure. Great Britain's plan to enact a Law that will require 60 % cut before 2050 and Norway's pledge to be carbon-neutral by year 2050 by reductions at home and in other countries are examples.

Future generations

In an ethical dialogue future generations need a spokesman and the present generation is the only one that can take that role. The size of this group can not be given by any number, but it is by far the largest one. It is supposed to be a group with resources, and there is a risk that the inequalities between countries and individuals are as large as today. The future generations must be expected to have priorities as:

- A climate close to the present one.
- A world order that gives countries and individuals possibilities to develop according to wants and needs.

Aboriginal people

Indigenous people all over the world are today estimated to be about 300 million. They consist of a large number of smaller groups with a wide variety of cultures and traditions. The GDP per capita reckoned in the traditional way is low and the level of illiteracy is mostly high. Their interests have up through history and also today often been violated by the seizure of their land, often forest areas. Deforestation has violated their interests and has also raised emission levels. They are made a separate group because they are very vulnerable to climate change. They may be important in combating climate change and may have other requirements to the future than most other people in the developing and developed countries. Their concerns and priorities are:

- To keep their natural environment, often primeval forest areas, intact as inherited from their ancestors.
- To keep the ownership of the land areas where they have lived from pre-historic times.
- To keep the climate as it is now.

The organisation of petroleum exporting countries (OPEC)

The population of this group is about 550 millions. The group sits on 78 % of the world's reserves of crude oil and 35 % of its production capacity. The group is very much dependent on oil export as its main income. Between 40 and 80 % of the GDP comes from oil export. OPEC was established in order to stabilise the price of crude oil by cooperating in controlling the production level. In this context these countries are made a separate group because the availability of crude oil and the price on this product is important for the consumption level of

fossil fuel. A successful reduction of greenhouse gas emissions will limit the need for oil, and may cause price and consumption fluctuations. It is therefore important to have the cooperation of this group if the emissions shall be reduced. Their concerns are:

- Export of crude oil is feared to slip. Export income should be kept at least at the same level as now.
- As many of its inhabitants live in hot desert areas there might be a fear for temperature increases due to climate change.
- An income source when oil runs out.

These five groups have vital interests tied to all matters related to climate change. Some have nothing to contribute of their own, like future generations. They are in the hands of spokesman and are there because they are considered as partners with "rights". The other groups have all contributions to make and will in different ways receive benefits from their contributions.

The dialogues will reveal the inherent ethical conflicts that arise when greenhouse gas emissions shall be reduced on a global scale and within each country. Some of the principles and concerns discussed in the preceding chapter will be recognised and get support during the dialogue. It demonstrates more directly the ethical dilemmas at hand when the climate change issue shall be tackled.

An ethical Dialogue

An ethical dialogue between the industrialised countries (IC), the developing countries (DC), future generations (FG), aboriginal people (AP) and petroleum exporting countries (PEC) could be like this:

FG: *We address this to all of you and especially to* ***IC****. We feel our existence to be threatened and we believe that you,* ***IC,*** *are most to blame for that. We think you are behaving irresponsibly. We have the same right to a life as you have had and be able to realise our dreams and hopes. You see the seriousness in the present threat to the climate and you are about to destroy our possibilities for life. We can see no excuse for not stopping your hazardous emission of greenhouse gases immediately. We are your children and we want to develop the world further with its basic conditions for life intact.*

IC: *We admit that we are the ones that are most to be blamed. However, to our excuse: We recognised the possibilities for a coming change in the climate only 20 years ago and even then we were not sure that the effect was real. Now we see that the effect is real and we have already agreed on some measures to reduce the emissions, although, to our dismay, some of us have refused to take part in this effort. But you must be aware of our problems. Curtailing the use of cheap energy from coal, gas and oil is hard. People are used to cheap energy and everybody protest when some measures are taken. You certainly remember all the difficulties we had in getting the Kyoto-protocol in place. Now some of us have even single-handed decided on further tough reduction on the emissions, up to 50 or 60 % before the middle of the twenty-first century. We hope that other countries will follow this example before we enter into formal negotiations about a new agreement that we hope will be much more comprehensive than the present one. We believe we are on the right track if we can get some stubborn partners among us and the rest of the world to come along.*

***DC: IC** are right that they are to be blamed. We understand that you, **FG,** are expecting contribution to an emission reduction from us too. We regard it, however, as unreasonable to require reductions from our side even before we have reached a level that the climate may tolerate. We take it for granted that every person on this globe has the same right to the atmosphere and we have just the same right to emit greenhouse gases as **IC** have. **IC**'s average annual emission per capita is about 16 tons whereas most of us are emitting only a quarter of that. The demand of emission reduction from us at present is just not fair. We need energy in order to attain the type of pleasant life **IC** are enjoying. Fossil fuel and especially coal is what is available to us at a price we can afford. We can't see how we can reduce our emissions, without seriously damaging the economic and social development we sorely need. We see the problem for **FG**, but **IC** have first to bring down their emission to our level before a contribution from our side can be expected.*

***IC:** Well, you are not quite innocent either. Deforestation in your area under your responsibility accounts for about one third of the emission of greenhouse gases. Just stopping that would make a large contribution to the reduction of global emissions. We certainly realise that we may be most to blame. But your increase in the emissions is so fast that you soon will be just as large violators as we are. We realise that the systems and installations that we have developed over the years have been bringing us large benefits. We did not, however, see the hidden dangers involved. The development the last 200 years has shaped our habits, traditions, technologies and investment patterns, which are hard and time-consuming to change. We can not move faster than the rules of democracy allow us. We need now a global plan on how to reduce the emissions and you must be part of that plan. It will take decades to implement the plan and if you are not part of it you very soon will end up as large violators like us.*

AP:** I finally got the floor. Even as a small group worldwide, our rights should be respected. More than tying our hopes and dreams to a high standard of living, we have a strong fear of losing our identity. That identity is tied to the nature where we live. In most cases that is undisturbed areas, for a large part forest areas and removal of our forest areas is in fact one of the greatest threats that we see to our existence. We are pleased to hear that the protection of forest areas will reduce emissions, and that will also be a benefit to future generations by saving an uncountable number of large and small species in our forest areas from extinction. We support **IC** in their eagerness to stop deforestation. But you are double communicating, **IC,** you are also buying quality wood from our forests and are in that way stimulating **DC** to cut down and claim property rights on our forests. That pressure is considerable and comes in addition to the pressure from the hungry **DC** who want more farmland. So, please, find a plan that saves our homeland and forests and other wilderness areas where we live. Many of them are severely threatened by climate change. Remember that we are the only ones living today with ambitions and hopes that also protect the interests of **FG.

***PEC**: Well, I may give my contribution to the reduction of greenhouse gas emissions too. I am representing a group of 550 million people and our group could be bigger if everybody with a sizable export of petroleum joined us. We realise that oil and gas, which for a large part of a century has been our main income, is the most important contributor to greenhouse gas emissions. But you certainly also realise that oil will remain important for decades, especially in the transport sector. We believe that we still will have a market because you, **IC,** will probably not be as efficient in reducing the emission as you plan and you, **DC,** are showing a large hunger for oil. We have, however, to play safe and secure income for coming generations. Efficient emission reductions may weaken the market for oil and gas and cause*

market fluctuations and instabilities in our income, a situation that will hurt us badly. It will also make stable predictions of petroleum consumption and greenhouse gas emission difficult. Before we discuss our willingness to take part in a plan to curb the emissions we need to know how you will secure the price on our products and our incomes. Remember, oil and gas is all we have to rely on.

***IC:** The problem is a tough one. We have come in an unpleasant position and we must realise that it is not possible to fulfil all wishes. Our way of living in the past has already resulted in climate change and whatever we do we will have a more hostile climate in the future. We have to put on the brakes to stop further increase in emissions and then ensure a reduction. We will propose to proceed according to the following guidelines which we see as fair and realistic:*

- *Global emissions of greenhouse gases are reduced to a level where they represent no danger to further climate degradation as fast as practicable within the constraint of democracy.*
- *Each individual on the globe is given the same emission right, set at a sustainable level. The size of the emission right is based on all emissions associated with the consumption of products and services of the individual, according to the footprint principle.*
- *Each country is allocated an emission right determined by its population times the sustainable emission per capita. If the emission reduction has to be made stepwise in time the equal per capita emission right principle should not be compromised when the emission rights are shared between countries.*
- ***IC** carry some responsibilities for the situation that has occurred and is willing to offer competence and financial resources to technological development and other projects that may help reducing greenhouse gas emission in **DC**.*
- *Market measures should be used as a mean of making the plan efficient, based on agreements between the parties.*

After some further deliberations did everybody agree to the principles in this proposal. There were, however two requirements from the other parties. **DC** required that **IC** without further negotiations about the detail of a proposal should unilaterally reduce their emissions by 50 % by 2050 inside its own borders and **AP** required that **IC** and **DC** met them in serious negotiation about their future. **FG** felt unsure about how its life situation would be and appealed again, as their children, to the other parties about the seriousness of the situation.

An Ethical Dialogue inside an Industrialised Country

Returning to their home bases, IC had to explain and convince their countrymen about the necessity of a reduction of the emission at home, even without any assurance that all countries would follow suit.

In Norway a number of interest groups were briefed on the situation. They had widely different opinions on the matters presented and met to discuss the situation. The groups taking part were the following:

Industry

As limitations on CO_2 emissions had most effect on the power intensive industries a spokesman from them was elected to present the view of the industry. The main concerns were:

- Fear of high energy prices
- Wish to compete with other countries on equal terms
- Opportunity to expand and to strengthen productivity

Employees

The employees followed the example of the industry and let a representative from the union in the power intensive industry serve as their spokesman. Their priorities were:

- Secure jobs and no need to move
- Stable and solid wage development
- Good work environment and an inspiring occupation

Consumers

The priorities of the consumers could simply be described as having access to a wide spectrum of goods and services at affordable prices in a nice environment.
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Environmental Activists

The priorities were stated as:

- Concern about the effect of the greenhouse gas emissions on the future climate
- Preservation of nature

Authorities

As a guardian of the interests to everybody in the country the Authorities stated their priorities carefully as not to hurt anybody:

- Stable economic development
- Low unemployment and stable, but competitive enterprises
- Fear of sudden increase in energy prices
- In a careful stated concern about a future climate change it was promised that adequate emission reduction measures should be taken with comfortably low costs.

An ethical Dialogue

An ethical dialogue between the groups, industry (I), employees (E), consumers (C), environmental activists (EA) and the authorities (A) developed as follows:

A: *We have just returned from a conference about the threat that is discussed everywhere nowadays, the climate change. We need your cooperation on implementing some of the obligations we had to accept. We could not loose face as a good and responsible country during the dialogue we had. You know we have a reputation for being among the best on*

environment. We assure you, however, that we will implement this as cautious as possible so that the burden of reducing the greenhouse emissions will be as low as possible. We are still hoping to get acceptance for a special price regime for electric power to industry and we have avoided a green certificate system for renewable power, because we were afraid it would be too expensive. We hope you follow our advice in driving more carefully and save electricity. We will also start some bilateral talks with some of the developing countries to see how some of the emission cuts, in spite our promises, could take place there.

E: *You scare us. In more than one hundred years now, cheap electric power has been the cornerstone in developing modern power intensive industries and now you tell us that cheap power is in jeopardy. We want assurances that an industrial power regime is introduced. Remember that the bulk of our hydroelectric power has a production cost of a half to one US cent per kWh. It would be meaningless to let the price of that power be decided by the market forces. Remember also that we have our work places on a number of isolated industrial sites in Norway, solely based on inexpensive hydropower. With market prices on power our employers will move their industries abroad or go bankrupt. In both cases we will lose our jobs as well as our homes. We recognise that climate change is occurring. The world needs, however, metals and nobody can produce that with less greenhouse gas emissions than we.*

I*: **E** is certainly right. We also recognise the climate change that is taking place. We have, however, to require similar conditions as competing companies around the world with respect to energy prices, environmental regulation and the availability to qualified manpower. To our dismay it is a real possibility that we may have to move activities and many companies out of the country, where we are subject to less strict requirements.*

*On the other hand, we see some opportunities in the present situation. We regard the present threat as real and that new carbon free power sources must be developed to meet this situation. This can not, however, be justified on commercial conditions as there is no market for such technology now. **A** has to finance development of new technology as a long-term investment. We offer our competence.*

EA: *All of you must remember what is at stake. We have 10 to 20 years on us to develop and start implementing binding agreements on how greenhouse gases shall be reduced if the civilisation and the global eco-system shall continue to exist in about the same way as today. We have immediately to start planning for a 50 % cut in 2050 inside our own borders. Don't you see the situation 40 years from now? It is just a dream to believe that you can find places outside own borders where it is cheaper to reduce emissions in the long run. With the present development China may approach the same level of greenhouse emission per capita and the same cost level as Norway. We have to reduce the emissions and the Chinese have to do the same. We must start now, expensive or not.*

C: *I am bewildered. What type of effect will this climate change have for me and can we really be sure that this climate change is for real. The prices on petrol are already high, **A** recommends us to a spread settlement in this country and that gives large expenses to commuting back and forth to work. The electricity prices are high already and I have to remind you of our old people living in old houses not well insulated. Remember also that we are said to be living in the richest country in the world. What are really the consequences of all this?*

A: *Well, we will take all your statements into account in our further planning. We think this will work out all right. We will continue our planning and with some small burdens to us all we will fulfil our obligations.*

EA: *We believe you are kidding us. We are afraid you do not take this situation seriously. This has to be a burden to us all, if not, it will have no effect on how we utilise energy and other sources of greenhouse gases. The petrol has to be expensive and the electricity price has to be high. If not, we will get no development of new technology that may solve our problems and we will continue to use energy in the same wasteful way as before, leading us to disaster.*

A: *We are taking this seriously. I suppose you know about the pilot plant project on capture and storage of CO_2 at Mongstad, the support we are giving to renewable power sources and to energy saving. And we will introduce measures to have some reduction of greenhouse gases in Norway*

Just take a close look at the projects that are under development and we give financial support to many of them.

A review and assessment of a number running and potential Norwegian projects are the content of the next chapter.

Chapter 4. Emission Reduction Projects in Norway

Basis for the Assessments

The basis for an assessment of the projects described below is the ethical platform outlined in chapters 2 and 3. How will Norwegian policy and actual activities that concern greenhouse gas emissions be valued based on these principles:

- The principle of equal emission rights to all based on the footprint principle
- A responsibility for the industrialised nations to develop technology that may be used worldwide and to give financial support to emission reduction projects. This responsibility has a special address to Norway as a wealthy nation with a large competence in energy technology.
- Industrialised countries should make emission reduction without any assurance of international agreements.

In meeting with the realities of a rigid economic and technological world the principles are adapted in the following way:

- The principle of equal right can first be implemented fully several decades from now. In order to be best in line with the principle, emission levels with corresponding per capita emission rights must be settled at fixed dates, for instance 2020 and 2050.
- In order to make the system efficient caps and trade of emission rights have to be introduced.

No country, including Norway, has adopted a principle of equal emission rights and it would therefore be meaningless to look for such principles in Norwegian policy. What we can do, however, is to assess concrete political decisions and the projects that the government is supporting in view of the principles we have presented. Let us first look at the political decisions:

- Norway has ratified the Kyoto-protocol. That was a positive choice of Norway. Norway has, however, had a lax attitude in following up the protocol, not in line with the spirit of the principles presented here.
- Norway has pledged an emission reduction of 30 % within 2020 and 100 % within 2050. These figures include emission reduction projects in other countries. This policy is not in line with our principles. In order to be in line with our principle Norway should declare its own ambitions inside its borders. It is in line with the principles to have ambitions outside the country, but as long as no agreement of trade or cooperation exist after “Kyoto” it is hard to see how such ambitions can be made binding.
- The Government has given support to a number of projects. We will evaluate some of them and also some projects or technologies with no government support. Before doing that we will in some more detail outline some additional requirements to government supported projects.

Uncertainty about market regulations imposed by governments hampers industry and business in developing new technology that may have a future potential in reducing emissions. This is

especially so when the investment in R&D is large and the lead time from R&D to the market is long. A market for plants and equipment with no greenhouse gas emission will not be there before large countries or international agreements ensure a new market. Companies are cautious of investing in new technology before they have assurance about what type of regulations will come. This situation will often delay the introduction of new appropriate technology. In combating climate change this delay can not be tolerated and the only ones that can close this gap are government supported projects. In reviewing projects their market in Norway as well as abroad is assessed.

In selecting development projects the competence and resources of Norway will be considered. The need for new technology to combat climate change is huge and the resources required to bringing even one new technology from the R&D and pilot phase to the commercial phase is large. This holds for financial as well as qualified manpower resources. Norway should therefore carefully consider where its development resources should be used.

The time scale of government supported projects should be considered. Development projects that are assumed to have market penetration in 2030 should in many cases start up as a pilot project in 2007. Projects in need for fundamental research have generally a longer time horizon. With the urgency for technology that is ready for use in the first 10 to 20 years, pilot projects should be prioritised. Fundamental research should by no means be stopped, but given priority according to the strategy and priorities given for fundamental research.

The time frame of most projects will be longer than one parliamentary period. It is important that shifting political majorities in Stortinget do not change strategy each time a new political constellation enters the government offices. That will weaken the stability of the market regulations and impair the will of industry to long-term development. For this reason a broad political agreement and broad public acceptance is needed on the strategy on how to combat climate change.

Developing projects aimed at reducing greenhouse gas emission will generally also support long-term development of Norwegian industry. This is a consequence of our belief that market mechanisms are an efficient tool in disseminating technology for reducing greenhouse gas emissions. It is important that government priority is given to projects according to the principles outlined here and not as an excuse to support Norwegian industrial projects with only scanty contributions to emission reductions.

With these priorities in mind some ongoing, planned or public debated projects are assessed. Some of the projects may, however, be seen as uncoordinated activities concentrated on a certain approach to the reduction of climate gases. On each project a presentation of the status of the technology will be given, followed by an assessment of the importance of the project in light of the ethical principles.

CO_2 Capture and Storage (CCS)

Status of the technology

“Carbon dioxide capture and storage” (CCS) or “carbon sequestration” is a family of methods for capturing and permanently isolating gases that otherwise would be emitted to the atmosphere and could contribute to global climate change.

Why capture CO_2? In the various processes where CO_2 is generated, it ends up diluted with a number of other gases. In the flue gas from power plants, the CO_2 concentration may be around 12-15% for coal, and 3-8% for natural gas. In industrial processes, cement production give a concentration of about 20% of CO_2, and refineries 3-8%. Most of the gas streams containing CO_2 are at or close to atmospheric pressure. It is commonly accepted that it requires too much energy to store in the ground the CO_2 with all other diluents. This means that CO_2 needs to be separated - or captured - from other gases and be brought up to a sufficient pressure for storage. The separation process involves mass transfer, which requires a certain volume and residence time, as well as consumption of energy.

It is important to keep in mind that CCS is a chain, consisting of capture, transport and storage. The chain may be long geographically, with possibly several hundreds of kilometres between capture and storage. The chain would normally have a very limited buffer capacity, meaning that the operation of the components in the chain is closely coupled. A larger number of sources (capture plants) and sinks (storage sites) can to some extent make the operation of the chain more flexible, both on short (hours) and long term (years).

Where should the CO_2 be captured? In general, large point sources with preferably high CO_2 concentration are the most economical. A lot of CO_2 is coming from power generation. It is expected that almost half of the global increase of anthropogenic CO_2 emissions from now and until 2030 will come from power generation. Power generation is important for CO_2 capture also because it is the sector which has by far the highest number of the very large CO_2 emission sources. Coal and heavy oil gasification processes are mostly well suited for CO_2 capture. It is possible to capture large amounts of CO_2 from each plant; 1-10 Mton CO_2/year.

Where should the CO_2 be stored? Different possibilities exist. CO_2 can be stored in the oceans, in the ground or be bound in solid materials. It is commonly agreed that the best way to store CO_2 is in the ground, in suitable formations which can hold the CO_2 for a very long period (>1000 yr). This is done in a number of places; in almost all occasions for enhancing oil production by injecting CO_2 into oil reservoirs. There are a few projects motivated by environmental reasons, like on the Sleipner gas field in the North Sea. Scientists believe that such storage can be done safely over a very long time, without much leakages or negative environmental impacts.

There is a controversy about the cost of CCS. One finds that the range in cost estimates is large. It is likely that CCS for new power plants will cost about 40-70 US$/ton CO_2, which translates into an increase in power cost of about 0,015 to 0,04 USD/kWh.

There are also some controversies about the availability and maturity of CCS technology. The technology for capture is in use, for industrial purposes, in a large number of plants with less than 100 kton CO_2/yr. Capturing CO_2 from power plants imply large-scale technology with one to ten megaton CO_2/yr, and one can say that the technology is not yet commercially available at this scale, but is though close. The confidence in storage technologies is high, and is mainly depending upon some solvable engineering and risk managing issues. *This means that there is no real barrier for starting to use CCS technology to reduce the greenhouse gas emissions, other than cost issues.*

Norway is a country with the required intellectual and financial resources to lead the way in CCS technology deployment. Norway has a very high standing in this field, very much because of the Sleipner CO_2 storage project. One or more new large-scale CO_2 capture and storage projects in Norway could really pave the way for a large-scale use of this technology in many countries.

Assessment

- Successful CCS technology enables Norway to utilise gas in electric power generation. A business as usual approach to electric power development will increase annual emissions by 20 Mt CO_2 by 2050. Use of CCS technology may reduce it between 16 and 18 Mton. The technology will also enable a reduction of emission from Norwegian industrial processes by several million tons.
- The CCS technology is regarded as one of the main instruments in reducing CO_2 emissions in a global context. Close to half of the greenhouse gas emission is coming from fossil fuel power plants (about 11 Gton), and fossil fuel will for the next decades be the dominant energy source for electricity generation. Norwegian development work will contribute to making this technology commercially mature.
- The cost of adding CCS to conventional coal power will determine the upper level of the carbon price. As coal is the most widely used energy source the cost of electricity from new conventional coal power supplied with CCS technology will determine the price level other emission free energy sources have to match
- The governmental financial contribution to the pilot installation of CCS technology at Kårstø is in line with the responsibilities for developing new technology that industrialised should take

Wind Power

Status of technology

From a technological point of view wind power is a mature technology. Denmark was one of the pioneering countries and established its first wind parks in the nineteen eighties. The development since that time has been an increase in the size of each wind turbine. In the first period 300 kW was the standard maximum size. Today 5 MW windmills may be ordered. The power output of a wind turbine is increasing with the diameter of the propeller, the size of which is limited by the stress and fatigue that available propeller materials can withstand. There are continuously R&D activities on materials and constructions that will bring the wind power costs down.

There is also state of the art technology available for the regulation of wind power, how wind power can be integrated in a larger power grid and on how electric power can be produced efficiently from the slowly rotating wind turbine.

Denmark was first in the field, both as a producer of wind turbines and in including them as power producers in the national grid. Today Germany, Spain and Denmark are the three leading countries in taking wind power in use. In Germany wind turbines with a capacity of 20 GW have been installed, producing 30 TWh annually. The market for wind turbines are growing rapidly with about 10 % annually worldwide and a total of 30 GW is installed, most

of it in Europe. It is planned a total installation in Europe of 75 GW by 2010 and 300 GW by 2020
The use of wind turbines in Norway has had a slow start. Up to now wind turbines producing between one half and one TWh have been installed and it is estimated that this will increase to three TWh within 2010.

The development has lately focused on wind turbines installed on deep sea. In continental Europe the reason for this development is simply lack of space on land. In Norway the reason is to get the wind turbines out of sight and to avoid conflict with bird life. The wind resources and wind velocities at open see are also larger. No new critical technology has to be developed in order to use wind power in open sea. Up to now one installation on about 50 meter sea depth has been installed with a foundation on the sea bottom. One installation with the turbine standing on an anchored floating structure is under planning in the North Sea. In a large scale systems anchored floating structures is planned

The development of offshore wind parks could start with instalments of smaller wind parks close to offshore installations with a capacity, say 20 MW. The wind turbines take as large a share of the load on the platform installations as the wind forces allow with the gas turbines on the platform as a back-up. That may cut the emissions from the offshore installations in half. Such a scheme can according to SINTEF Energy be ready by 2015. In a next step offshore wind parks in the 100 MW range can be built, connected to a network of offshore installations and to the grid onshore. It is technologically feasible to have such installations in place by 2020.

Inside a square of 10x 10 km wind power turbines with a capacity of 1000 MW may be installed. Power of that size may be connected to the grid onshore up to a distance of about 100 km with the use of state of the art technology. The energy sources in the North Sea are practically unlimited and large scale development should be regarded in a European context. Power transmission over longer distances is then required and high voltage DC cables have to be used. That is also a well established technology. European Union plans that 20 % of its power shall come from renewable energy sources in 2020. Then wind power from the North Sea will be one important source.

The cost of wind power is going down and is at present around 50 øre per kWh for onshore installations when the dimensioning wind velocity is 7 m/s (as in Germany) and around 25 øre when the wind velocity is 10m/s. Offshore installations will double the costs. The advantage of stronger winds offshore will, however, compensate, for most of that.

The rapid growth in wind power is due to subsidies in some countries. This is in a situation when conventional coal power and other conventional power sources are the competitors. Wind power and coal power plant with CCS technology will compete in price and performance in a market where carbon has a price.

Assessment

- Norway has been slow in starting up planning and construction of wind power parks in spite of Norway’s larger and more economical wind resources compared to other European countries.

- Technology for offshore wind parks is expected to be ready for use when some experience with the technology has been gained. There are almost unlimited energy sources in wind power offshore
- Development of offshore wind power technology should get larger governmental support than today in order to be competitive as a carbon free energy source when carbon gets a price. That will enable Norway to cut the emission from offshore installations with several megatons within a ten years period and supply the Norwegian grid with emission free electric power.
- Offshore wind parks may supply Continental Europe with a substantial part of its need for emission free electric power and support the European countries in achieving their planned emission reductions.

Energy Efficiency and Energy Saving

Status

Energy efficiency and saving imply a large number of political, economic and bureaucratic measures. Energy efficiency and saving might be enforced on energy consumers by public regulation and be stimulated by economic means, by new technology or by an ethical attitude towards the use of energy. Below a number of measures are listed that will affect energy saving, each of them having its effect and attraction depending on the person and his priorities.

- *Subsidies to certain types of equipment and technologies* that will contribute to greenhouse emission reduction.
- *High stable price on electricity* will promote energy saving. Stability of the price is just as important as the level. That enables people to calculate pay-back time with confidence when investments in energy saving equipment are made. Stability in prices is hard to attain in the energy island of Norway/Sweden with their weak links to strong electricity markets and their dependency of the unfaithful rain. More transmission capacity has been built in the later years. That will promote stable prices on a high level.
- *Power and energy requirement on equipment and constructions* are an efficient way of economising with energy. People, enterprises and institutions tend to prioritise low investment relative to operational and energy cost. Public requirements to energy efficiency will ensure that the life cycle cost and the total ecological footprint of the purchase and use of equipment are valued.
  Various technologies may be applied in reducing the energy requirements in equipments and constructions. In buildings better thermal insulation, automatic control of cooling, heating and ventilation systems, decentralised emission free heating and cooling system etc may be used. In equipment there is a large variety of technologies that may be used often connected to the basic function of the equipment.
- *A requirement to label each product with its "greenhouse gas footprint"* is a way for each citizen and each institution to keep track of his personal consumption of emission units.
- *Promotion of innovation and entrepreneurship on technologies* that may reduce greenhouse gas emissions. There are a large number of technologies that may give their small contribution to emission reduction. Use of mature technologies may

also offer opportunities to entrepreneurship as energy prices increase. The development of energy control systems, the use of heat pumps and more efficient light bulbs are testimonies of that.

Assessment

There have been a number of measures that will affect energy efficiency and saving, all of them with the objective of reducing the emission level of greenhouse gases. The measures and issues listed above address the consumers directly and affect their consumption pattern There have been no systematic attempts to quantify the emission reduction caused by the measures listed, although there are several studies of the price elasticity of power consumption We will comment each of the issues.

- Subsidies for certain types of equipment tend to be short-lived and are therefore not popular among equipment providers, however popular with politicians and customers. It is hard to find the right level of subsidy and its effect on emission reduction.
- The price of electricity is determined by the market. The price of electricity on the Continent will be more and more decisive on the Norwegian prices as higher transport capacity to the grid on the Continent is developed. The higher and more stable European electricity prices will, especially in the long-term, effectively stimulate energy saving and reduced emissions. The present development is satisfactory and should proceed along the same lines.
- The authorities should increase efforts in making up energy standards, either as requirements or recommendations, for equipments and buildings. The ecological footprint principle is expected to enhance the effect on emission reduction of the required standards.
- Support and stimulation to entrepreneurs in start-ups based on unique technologies or business ideas that will reduce emissions should be given. In the long run innovations and new business approaches will be critical important in getting the emission reduced sufficiently.

Hydropower

Status of the technology

Hydropower transforms the potential energy stored in water in high altitude to kinetic energy in a turbine and then to electric energy in a generator. Storage of water in reservoirs makes hydroelectric power a flexible and reliable power source not dependent on the seasonal variations in the rainfall.

Its ability to store energy in the system and its ability to an almost immediate adaptation to fast variation in the load makes hydropower a tool for more efficient utilisation of other energy sources in an electrical power system.

Hydropower for electricity generation is a mature technology and has been one of the applied energy sources since the start of the electrification more than one hundred years ago. The hydropower resources are limited by nature and climate and were the first to be utilised when the electrification started. With the low production cost (USD 0,005 to 0,01 per kWh) in most

Norwegian power plants and the high market price, hydropower is a very profitable business in Norway. Today the main natural resources are utilised in Norway and other industrialised countries. As the prices of electric power have increased, also smaller waterfalls, previously considered uneconomical, are being utilised. In the developing countries there are still large hydropower resources available for development. International Energy Agency (IEA) estimates that more than 2000TWh of hydropower is untapped around the world, of which 85 % is in developing countries.

There is a large range of variation in the size of hydropower plants. The largest power installation in the world is "Three Gorges", the giant Chinese installation with an installation of 18000 MW. Such large developments have immense consequences for people and natural environment in large land areas, not all of them positive. Constructions where large water reservoirs are created may affect the natural habitat, landscape and people in an adverse way. Hydropower may, however, also be a choice on a small scale. A small village in a developing country could start their use of electricity with a turbine in the kW-range. Hydropower is an energy resource with essentially no greenhouse gas emissions.

The production of electricity to the Norwegian grid is dominated by hydropower with more than 99 %. Norway is considered as a leading nation in all aspects of hydropower technology. Norway has kept public ownership to most of its hydropower resources.

Hydropower on a small scale is considered in most countries as an environmental friendly and renewable energy source.

Assessment

- The contribution from small hydropower developments to emission free energy is positive. Even if it does not give a large contribution to a reduction of greenhouse gas emission inside Norwegian borders, it reduces the import of electric power, partly based on coal, to Norway and by that the emission associated with our consumption.
- Norway has competence and financial resources to support developing countries in developing their hydropower resources and should to a larger extent offer developing countries support in developing a framework for the utilisation of their hydropower resources. In these countries hydropower may according to EEA cover around 15 % of the forecasted need for electricity in 2030 and will also raise the efficiency and reduce greenhouse gas emissions in fossil fuel power plants connected to the grid.
- Norwegian hydropower companies should offer developing countries cooperation in developing specific hydropower sites in planning, construction, operation and ownership. Up to now there are few examples of such initiatives from Norwegian power companies. Each terawatt hour of annual production from a hydropower plant will reduce emission with one Mt CO_2 if it substitutes coal.
- With the dominating public ownership in Norwegian power companies the Government and municipal owners have to take the lead in such development.

Nuclear energy

Status of the technology

Nuclear power is the controlled use of nuclear reactions to release energy for work including propulsion, heat, and the generation of electricity. Nuclear energy is produced by a controlled nuclear chain reaction and creates heat — which is used to boil water, produce steam, and drive a steam turbine. The turbine can be used to produce mechanical work and also to generate electricity. Nuclear power provides 7% of the world's energy consumption and 15.7% of the world's electricity. All nuclear reactors in commercial or military use are based on the principle of fission, which is a process where a fissile material, usually uranium-235 or plutonium-239, is hit by a neutron and forms two or more smaller nuclei as fission products, releasing energy and neutrons.

The nuclear power industry experienced a serious setback after the 1979 Three Mile Island accident where a partial meltdown of the reactor core took place, and the Chernobyl accident where a core meltdown, followed by steam explosion and fire that spread radioactive material over a very large area and caused the death of about 10000 people over a period of time.

Today there is a renewed interest in nuclear power, and about 25-30 plants are currently being constructed. The greenhouse gas issue has been one of the factors contributing to the renewed interest. New types of reactors are being developed, both improvement of the current fission technology (thermal), but also *fast breeder reactors*. The latter is believed to extend the uranium resources 60-70 times, which will make the currently known uranium resources to last for several hundred years. Many countries remain active in developing nuclear power, including Japan, China and India, all actively developing both fast breeder and thermal technology, South Korea and the United States, developing thermal technology only, and South Africa and China, developing versions of the *Pebble Bed Modular Reactor*. Finland and France actively pursue nuclear programs; Finland has a new European Pressurized Reactor under construction by Areva. Japan has an active nuclear construction program with new units brought on-line in 2005. In the US three consortia were in 2004 given funding for reactor development, and subsidies were promised for up to six new reactors. Nuclear power is of particular interest to both China and India to serve their rapidly growing economies - both are developing fast breeder reactors.

A number of new designs for nuclear power generation, the Generation IV reactors, are being worked on. The goal of this work is to improve nuclear safety, improve proliferation resistance, minimize waste and natural resource utilisation, and to decrease the cost to build and operate such plants.

Nuclear power gives us the possibility to reduce greenhouse emissions by substituting use of coal, oil and natural gas. It is one important technology for supplying power with no greenhouse gas emissions.

On the political level in Norway the use of nuclear power has not been seriously assessed as a relevant option since the nineteen seventies. This spring (2007) the Ministry of oil and energy has initiated a study to establish a best possible data basis related to the risks and long-term possibilities for the use of thorium in energy production.

Assessment

- Nuclear power is eagerly embraced in some countries and rejected in others owing to the risks that have been associated with it. In countries where nuclear power is

accepted it can give a substantial and economically preferable contribution to the reduction of greenhouse gases.

- The official Norwegian position is given by a parliamentary decision made in 1979. It states that utilisation of nuclear power at time being is not part of energy policy in Norway. There is, however, no official negative Norwegian view on the use of nuclear power. The public support to the Halden Research Reactor, serving as a R&D institute for the international nuclear power industry and a large number of national regulating authorities, is a testimony of that.
- In view of other alternatives to reduce greenhouse gases the limited resources, available in a small country like Norway, it is not recommended that Norway enlarges its engagement in nuclear energy.

Solar Panels and Photo-voltaic Cells

Status of the technology

Solar panels utilises the energy directly, especially to water heating, whereas the photo-voltaic cell transform the energy in the sun light to electricity as it hits a doped single silicon crystal or polycrystalline structure in the form of a thin wafer.

Solar panels are in use in some parts of the world where the sun is above the horizon a substantial part of the day throughout the year and where sunshine is a predominant feature of daily weather as in hilly areas in Asia, southern Europe and parts of US and Canada. The technology is well established and should be competitive with fossil fuel even at low oil and gas prices. It is surprising that the market penetration for this technology has not been larger.

This rather simple technology will gain more importance in the future. The need for hot water will increase as health and social conditions hopefully will improve around the world. Water heating stood for 24 % of the energy use in households in Norway in 2004

In photo-voltaic cells crystalline wafers may obtain efficiency above 20 % when sunlight is transformed to electricity. When polycrystalline wafers are used the efficiency will be between 15 and 19 %. One meter square can produce power in the range from 140 to 200 watts when bright sun hits the square perpendicularly. When photo-voltaic cells first came on the market the efficiency was about 6 %. The theoretical upper limit is about 29 % when silicon wafers are used. The cost has decreased from $ 20 per watt in the seventies to $ 2.70 in 2004. There are intense research activities directed towards increasing the efficiency and to lower the cost further.

The market for photo-voltaic solar panels is found in developing countries in meeting their first need for electric power; in charging batteries for mobile phones and other electronic equipment, and for the first use of electric light and other electrical/electronic equipment with low power requirements. The sale may be on commercial conditions or made possible by subsidies provided by international organisations or NGOs. There is also a growing use in some countries in buildings and houses that in this way are made close to self-reliant on energy.

There are a number of international firms competing in producing and marketing solar cells. The three largest are the American Sharp, the German based Q-cells and the Chinese based

Suntech. The last company started as late as 2001 by a Chinese entrepreneur. The growth of the Norwegian company Renewable Energy is also remarkable.

This rapid growth in the use of photo-voltaic solar cells, exceeding 30 % annually for the last ten years, is astonishing. It is generous subsidies in some countries that explain this growth. At present about 2000 MW are installed every year worldwide. If this trend continue solar panels for more than 5000 MW will be installed annually in 2017. Compared with wind power solar power is still small, a capacity of 75 000 MW installed annually for wind power compared to 2 000 MW for photo-voltaic cells.

We may speculate about this difference in growth between the two renewable energy sources and why some countries so eagerly seem to subsidise solar power heavily. One reason may be the self-reliance in energy supply for smaller entities that solar power may provide. The connection to a grid will still be needed, but decentralised power may enable new, close to self-reliant building complexes to be connected to the existing grid with no expensive reinforcements.

Norwegians will mostly know solar cells as a low level energy supply to their cottages. As the sun is low a large part of the year solar panels are not well suited for Norway. On the other hand a viable industry has grown up, based on innovation, entrepreneurial spirit and industrial and R&D experience on silicon metal.

Assessments

- Solar cells do not have high priority as a way of reducing emissions in Norway, because of its small contribution compared to other technologies.
- Norwegian R&D and Norwegian industry have a unique competence in solar cell technology.
- Governmental support to long-term and fundamental research should be given, because of the importance of solar cells as a renewable and emission free energy source in developing countries as well as in some industrialised countries. This is part of the obligation Norway has in supporting other countries in combating climate change.

Bio-fuels

Status of the technology

Bio-fuel is most efficient if heat is needed directly, and covers a wide variety of use and technologies, from wood and waste material like cow dung, bagasse and straw in developing countries to the use of bio-ethanol and bio-diesel for transport purpose in some of the industrialised countries Bio-fuels cause emissions that belong to the chain of generation and absorption in nature

We take India as an example of the use of *bio-fuels in a developing country*. Wood and waste material from the agriculture are by IEA estimated to be about 1,5 kg wood and waste material per day and capita in 2001. These non-commercial energy resources are the largest energy source in the country. The use of wood is in many countries at an unsustainable level.

In many *industrialised countries with a cold climate wood and waste* are often used in addition to oil, gas and electricity for space heating in single homes or in distance heating systems and in some cases for electricity generation. The use of bio-fuels in solid form in stationary heat plants is a traditional and mature technology, although recent development greatly has improved efficiency and diminished pollution.

The interest in bio-fuels has lately focused on *bio-liquids, bio-ethanol and bio-diesel*, as means of reducing greenhouse gas emissions from the transport sector. Brazil and USA are the largest producers of bio-ethanol with 17 billions of litre annually in Brazil alone and a similar figure from US. Sugar cane, corn and wheat are the raw materials. Development of processes that utilise cellulose type raw material is underway. The first bio-ethanol processing plant based on cellulose is being erected in US. In Sweden a pilot plant is constructed in Örnsköldsvik and seven other plants are planned in Sweden. The use of cellulose will greatly enhance the pool of raw materials for bio-ethanol production.

Bio-diesel may be produced by fatty wastes from the food industry. That type of raw materials is limited and for larger industrial plants crops like soy, rapeseed and palms are used. Indonesia is the biggest producer using palm oil as the raw material. Expansion of farmland for palm oil production has accelerated deforestation in that area.

The transport sector is a large producer of greenhouse gases worldwide, second only to power generation. Petrol and diesel produced from crude oil has been the main energy source in the sector. It has low production costs and is a convenient fuel for all sorts of vehicles. There has been development along two paths in the search for ways to reduce greenhouse gas emissions. One is to improve the efficiency in the engines, also by using a hybrid technology and by designing lighter vehicles with improved aerodynamic shape. The other is by using bio-liquids, mostly blended with fuel from fossil fuel sources.

Assessment

- The use of cellulose as a raw material for bio-ethanol production will give a substantial new emission free energy source for the transport sector. This technology is on an early industrialisation or pilot plant phase and Norwegian authorities, industry and R&D should follow the development closely
- When the transport sector is competing with the food sector for raw materials, as is currently the case, there are three matters of concern.
    - Competition on raw materials may be expected on a free global market. The established markets for food may be distorted, as the size of the food market is about the same as transport market when measured in energy equivalents.
    - As agricultural production is heavily subsidised in most industrialised countries, it is very hard to predict the impact of the use of bio-fuel on the agricultural market. A sharp rise in the price of corn, a food for poor people, has been experienced in Mexico owing to subsidised production of bio-ethanol based on corn in US.
    - The search for farmland for growing crops as raw material may promote deforestation, which is an important source for greenhouse gas emissions. Netherlands has stopped its subsidies to bio-diesel from Indonesia, as tropical forests were slashed and burned in order to rid the way for palm oil production

- Owing to this situation there should be a careful approach to the use of bio-liquids. Efficient utilisation of the cellulose as a raw material may give bio-ethanol a future in the transport sector as a fuel without emission of greenhouse gases.

Conclusions

- The report explores if an equal right to greenhouse gas emission for all people, of this and of future generations, measured according to the "footprint" principle can be a valid ethical principle when measures for combating climate change shall be assessed. The obligations of the industrialised nations in leading the world in emission reduction measures are in addition regarded as their responsibility, based on their historic benefits of cheap energy and their previous large emissions. We conclude that the principles indeed are valid principles. This report should be regarded as a very first step in assessing their implications and practicality and we hope that the report can be an inspiration to further work
- The report compares this principle with the approach to climate change in the Stern Review, with the precautionary principle and a principle of "sustainable development" and concludes that the principle can be made a fair and viable principle when measures within one country shall be implemented and when concerted international measures shall be agreed upon. Even if the principles have to be adapted, the equal per capita emission right should not be compromised in sharing emission rights between countries.
- The principle are tested in an arranged "ethical dialogue" inspired by Jürgen Habermas' ethical discourse concept, in which one representative from each of the industrialised countries, the developing countries, aboriginal people, the organisation of the petroleum exporting countries and future generations take part. The "equal right principle" stands the scrutiny of the participants although with some hesitation and fear by the representative for future generations. It will impair future generations that lack of mature technology and international agreements and general inertia will require a stepwise approach to a sustainable emission level.
- A similar ethical dialogue is arranged between the most important stakeholders in Norway. They discuss what type of measures to fight climate change should be implemented. Without coming to an agreement on what should be done they agree on having a review of some ongoing and potential Norwegian projects.
- The report has the following assessment of the projects and Norwegian policy on climate change issues:
    - The development of CCS-technology, wind parks and wind power technology serves the dual purpose of enabling Norway to cut its emissions substantially in the future and also contribute to technology for emission reduction around the world. This is in line with Norway's responsibility for contributing to new appropriate technology.
    - Efforts to increase energy efficiency should be strengthened. That may be the most efficient mean for emission reduction inside Norway. High and stable prices on energy sources, such as electricity and fossil fuel products are regarded as a most important element in stimulating energy efficiency.
    - With its R&D competence and industrial production of solar cells, Norway is offering useful products and technologies for emission reduction abroad.
    - Some R&D projects supported by the government are in line with the responsibility that Norway according to our principles has. Norway has, however, had a lax attitude to limiting the emissions within own borders.
    - *Norway should set up specified national goals with timetables on how much emission reduction should be achieved within Norwegian borders in 2020 and 2050 and advocate principles that respect equal emissions rights for all.*

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