Emissions Pathways to Avoid Dangerous Climate Change — A Trans-Atlantic View

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I Overview

Greenhouse-gas emissions have increased steadily on a global basis since at least the beginning of the industrial revolution. Other things being equal, growth in emissions would have been expected to continue for hundreds of years. But Earth's climate is now being changed in ways that are scientifically distinguishable from natural variations and in some cases even discernible by the average person. This realization has led to attempts by the global community over the past 20 years to change the expected course of future emissions in order to avert dangerous levels of climate change.

The objective of this paper is to examine the feasibility of emissions pathways that would eventually stabilize atmospheric concentrations so as to avoid dangerous interference with the climate system. This stabilization goal is defined by the UN framework convention on climate change (UNFCCC), a piece of international law that has been ratified by most nations, including the US and the nations making up the EU. We discuss the specific options open to the US and the EU in working towards global emissions pathways to avoid dangerous climate change. On the basis of global assumptions about long term global concentration and temperature goals, therefore, we take a bilateral perspective: What are reasonable objectives for the US and the EU in view of this global problem? What factors enhance or limit the ability of each to reduce emissions? How may critical obstacles be surmounted? We do not discuss other global players—Japan, China, Brazil, etc.—because we want to focus on our own regions of origin. Hopefully, this will stimulate similar reflection in other parts of the world.

We assume as a guideline that a long term global goal of limiting warming to about 2°C (see Edmonds and Smith 2005, Hare et al. 2004, O'Neill and Oppenheimer 2002) will eventually be viewed as a plausible guideline for coordinating national policies, either informally or formally (e.g., through implementation of Article 2 of the UNFCCC). Note that various studies use two degrees above 1990, current or pre-industrial levels as a proposed long term target, objectives which differ by as much as 0.6°C. The implications for long-term emissions, however, are basically the same:

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in the long run, emissions must not exceed the centuries-scale capacity of the oceans to absorb greenhouse gases from the atmosphere, i.e. about 2 gigatonnes (Gt) of carbon per year. This is less than one third of today's emissions of about 7 Gt. Roughly speaking, the challenge then is to reduce emissions from today's levels by about 5/7, i.e. about 70%. The challenge is compounded by the fact that emissions are rising with a long-term trend of more than 1% per year. The question is: how many years will it take to achieve a turnaround of this trend and how will emissions evolve after the turnaround?

To address this question, we draw on several background papers synthesizing the relevant literature as well as on a variety of research findings concerning specific issues to be discussed. We first discuss the global perspective, next European alternatives, then American opportunities, and end by drawing conclusions for the next steps.

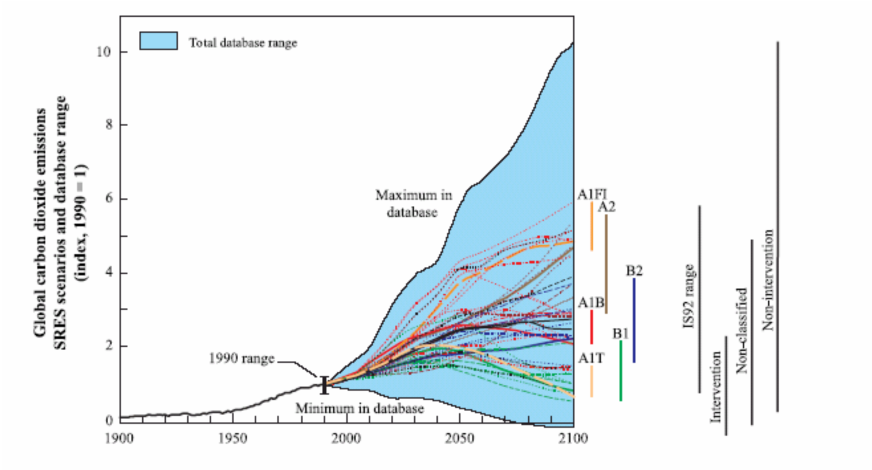
II The Global Perspective

The debate about climate change has reached a point where it is not easy to get an overview in the face of all the technicalities under discussion. A useful starting point is given by figure 1, providing a synopsis of emissions scenarios for the 21st century as discussed in the literature. The fastest growth of emissions represented in the table corresponds to a growth rate of about 2%. At the lower end, decreasing emissions are discussed as well, up to the point where emissions turn negative. This is the case if human greenhouse gas production is counteracted by intentional increases in absorption capacity of the Earth system.

For the purposes of climate policy, it is useful to focus on a second magnitude, represented in figure 2: the additional carbon accumulated in the atmosphere since the beginning of industrialization. Before industrialization, the atmosphere of planet Earth contained about 550 Gt of carbon. These caused the natural greenhouse effect that helped maintain the Earth's climate in a range basically hospitable to human beings. Since the beginning of industrialization, increasing use of commercial energy—mainly based on fossil fuels—has led to a situation where the atmosphere contains about 200 Gt of additional carbon. To a lesser extent, other anthropogenic greenhouse gases as well as aerosols are modifying the climate system, too. As a result, the natural greenhouse effect is amplified by human actions in ways that engender risks of dangerous climate change.

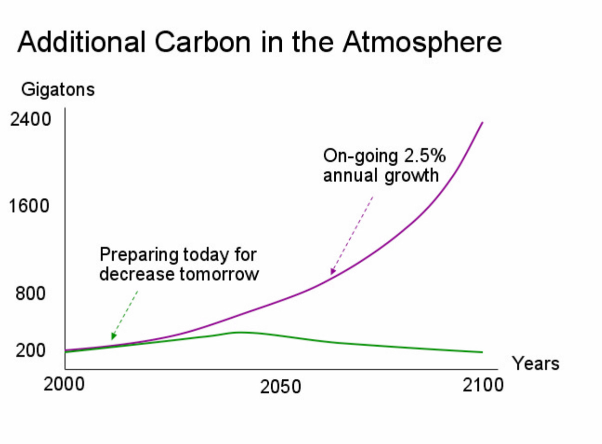
Even if emissions were stabilized at their current levels, the amount of additional carbon would keep growing for centuries—all the more so if emissions keep growing, too. Over the past decades, the additional carbon has increased at a rate of about 2%. There is enough economically recoverable carbon in the Earth's crust for even higher growth, say of 2.5%, to continue way beyond the end of this century. In many regions, this would lead to global warming of more than 10°C, and global mean temperature might keep rising for centuries until coming close to 10°C as well (Hasselmann et al., 2003). Nobody is advocating such a development, but then nobody was advocating World Wars in the past century either.

Figure 1



Source: Nakicenovic and Swart, 2000.

Figure 2
Upper and lower bounds for future amounts of additional carbon in the atmosphere



Source: own computations.

The lower end of plausible scenarios is given by a switch from the current increase to an actual decrease. Although some scenarios foresee such a decrease for reasons other than avoiding warming, intentional policy to reduce emissions will likely be necessary to about bring such a future while allowing for sustainable development.

A decrease of the additional carbon in the atmosphere can be achieved by combining reductions in emissions with enhancement of natural carbon absorption. The former involve consumption patterns with low content of commercial energy, highly efficient technologies for using such energy, and zero-emission technologies for generating it; the latter involve processes that take greenhouse gases out of the atmosphere. The most important such process is natural absorption by the oceans. Removal of carbon dioxide can be enhanced beyond this level and coupled to energy production in several ways, e.g. by producing commercial energy from biomass while capturing the resulting carbon dioxide, storing it in geological formations, and letting new biomass absorb additional carbon from the atmosphere. Moreover, there may be technological possibilities to capture atmospheric carbon by chemical processes. If a turnaround of global emissions is achieved in the coming decades, additional carbon may thereafter be reduced at a rate of up to 4 Gt per year. While the upper end of possible emission scenarios would lead to warming in excess of the 2° target within this century, the lower end would stabilize atmospheric concentrations at levels compatible with this target by the end of the century.

Uncertainty in climate sensitivity and in the importance of forcing by other trace constituents such as aerosol, has a very large effect on the chances of attaining the 2° target. Climate sensitivity—the increase in global mean temperature to be expected from a doubling of carbon dioxide in the atmosphere—may be as high as 4.5°C. In this case, it is virtually certain that global mean temperature will overshoot the 2° target for some time. It would then still be possible to reach the long-term target by limiting this overshooting to a period of several decades, although significant environmental consequences may result.

How can a turnaround in global emissions be achieved? To address this question, it is important to notice that commercial energy is used mainly for consumption purposes—like driving cars and regulating the temperature of dwellings. Of course, the given infrastructure along with prevailing lifestyles rather heavily constrain the options for individual choice, but at the same time they open up important options for public policy. Production of economic goods uses just about one third of total commercial energy, and this proportion is likely to decrease with the spread of the service economy. Moreover, international differences in energy use also deserve attention: While in the US commercial energy is used at a rate of about 12 KW per capita, the EU has a rate of about 6 KW, and the global average is just 2KW. Just as the rate of horses or typewriters per capita have ceased to be significant measures of welfare, rates of commercial energy use may cease to be such measures in the current century.

In the long run, changes in infrastructure—like better insulation of houses, distribution networks for alternative car fuels, amenities in the midst of densely populated megacities—along with changes in lifestyles—like new status symbols and an emerging emphasis on place-based social networks connected in cyberspace—have the potential to shift a large fraction of demand for commercial energy towards other goods and services. The remaining amount of commercial energy can then by produced by a mixture of renewable sources and fossil fuels so as to respect the 2° target.

The difficulty, however, lies in the short run, i.e. the next several decades. Over this period, global population is likely to increase to 9 billion people or more, and income per capita is likely to increase by 100% or more. All IPCC scenarios indicate that greenhouse gas emissions will grow at least for the next 50 years absent specific policies aimed at reining them in. Developing countries are under tremendous pressure to satisfy expectations of increasing welfare, and they need to do so with technologies available now at competitive costs with a sound record of reliability. Under these circumstances, a turnaround in global emissions can only be achieved if highly industrialized countries assume leadership. The European Union has claimed such leadership by its active role in getting the Kyoto protocol ratified and in implementing a regional emissions trading system. Therefore, we next look at options for Europe.

III European Alternatives

In this section, we give a first look at alternatives for Europe over the next 10-20 years in view of triggering a turnaround in global emissions pathways. In principle, the EU can drastically reduce carbon emissions by gradually restricting the amount of emissions sold under the EU emissions trading scheme (EU-ETS) while enlarging the domain of validity of the EU-ETS to those sectors not yet under its rule (mainly use of commercial energy for private consumption).

Den Elzen and Meinshausen (2005) show how the 2° target can be reached if the EU reduces its emissions by at least 15% by 2020 and then by at least 75% by 2050; similar numbers are indicated by Azar 2005. They also show—again in line with Azar (2005)—that this is feasible without prohibitive costs if North America, Japan, Oceania, and the countries of the former Soviet Union join the effort. According to these assessements, the costs would be no larger than a delay of less than a year in economic growth—the level of production that might otherwise be reached in February would be reached in August, but without the risks and damages resulting from failure to reach the 2° target.

However such a joint effort can only start after a complex process of diplomacy, opinion formation, research & development, etc. Such a process will take several years, to say the least. Can Europe support it by committing itself to the mentioned emissions reductions unilaterally? This is unlikely to happen because it would imply Europe paying the transition costs to new technological solutions and the rest of the world free-riding on the benefits. Even if at a global scale the benefits should vastly outweigh the benefits—which they may well do—this is not an acceptable alternative for Europe.

A second alternative would be for Europe to simply retreat from its rhetoric and commitments regarding climate policy and to wait for the rest of the world to become more amenable to designing and implementing global agreements for effective emissions reduction. Given the robust level of environmental concern with the European public this is hardly politically feasible even under a rather Machiavellian approach. A third alternative is to keep the rhetoric but water down the commitments in practice. Experience shows that this may well be feasible, and it may be the outcome of the political process in the coming years.

None of these three alternatives offers a realistic prospect of achieving a turnaround in global emissions. What about nuclear energy? Europe has considerable know-how in the area and has invested huge resources in fusion research. For nuclear energy to play a significant role in a turnaround of global emissions, however, in a few decades the current number of a few hundred nuclear power plants would need to increase to about 7,000. For this to happen in, say, 50 years, one would need to build an average of more than 100 nuclear power plants per year. The likelihood of serious accidents would increase accordingly (particularly with no long term waste management stategy at hand) and the prospect of terrorist interference would also be significant. Inevitably, the media would amplify such episodes in the public sphere worldwide. As for Europe, in most countries the willingness of the public to accept, let alone support, such a course of action has been virtually non-existent for decades, and this is not likely to change in the years to come.

A realistic alternative then must accept the fact that Europe can only build on its current leadership role in climate policy by declaring modest, but significant goals and achieving them in a verifiable way. Important opportunities to move in this direction are given by public procurement policies. Public authorities are the single largest customers for a wide range of products, in particular when it comes to buildings and transport systems. A second kind of opportunities is provided by the competence pooled in European financial markets (Jaeger and Cameron, 2004). Insurance companies have started to recognize the importance of the new risks and opportunities associated with climate change and with the need to address it pro-actively. To the extent that institutional investors take these risks and opportunities into account in the management of their portfolios, financial markets will send important signals to the entrepreneurial community in Europe and abroad. Finally, the existence of persistent unemployment in Europe means that the European economy is not operating at its efficiency frontier. Under these conditions, a well-designed climate policy can actually be Pareto-improving—in this case: achieve environmental improvements and economic gains at once—by mobilizing underutilized resources.

If Europe develops its climate policy in a realistic and credible manner, the way may then open up for more ambitious goals. Such goals could include a global emissions trading scheme of the kind advocated by a Europe-centered coalition of global business leaders (World Economic Forum 2005). Wicke (2004) has indicated outlines of such a scheme as it might develop out of the current EU-ETS. Any such development, however, will require many years to unfold.

The key difficulty seems to be the Trans-Atlantic divide. If Europe would give in to the climate strategy of the current American administration, it would loose its leadership on the issue without any realistic prospect of achieving the needed turnaround in global emissions. On the other hand, given Americas role not only in emitting greenhouse gases, but also in defining technological trajectories in many energy related fields, any attempt by Europe to solve the problem without America would be doomed to failure. Therefore, we next look at American options.

IV American Possibilities

In this section we explore the realm of emissions pathways assuming that climate-driven policies will indeed be implemented, for the U.S. as well as other significant emitters. We emphasize not only what may be accomplished, but what is unique about the U.S. versus other countries.

Getting Started (The 20–50 year timeframe)

One way to examine the question of initial objectives is to focus on a near term goal of maintaining global emissions near today's levels over the next 50 years (Pacala and Socolow 2004). Although this emissions pathway is a caricature, it does simplify thinking about some of the basic elements of any approach designed to avoid a doubling of carbon dioxide (probably a necessary component of avoiding a 2°C warming). The key question is what such a global emissions pathway implies for the U.S.

A primary issue is the US' "fair share" of the global obligation. In a background paper, Greenblatt (200) examines this question from the perspective of per capita emissions, arguing that any long term program ought to envision a decrease in the large disparities in per capita emissions among countries, particularly industrial versus developing. In fact, it is unlikely that any global emissions-cap approach would succeed absent some concession by industrial countries in this regard. We do not argue that an explicit global deal on long term per capita emissions goals will be achieved; rather, adoption of emissions obligations involving developing country must result in some narrowing of this gap, or they will never be implemented.

There is an infinite number of ways to create national emissions obligations from such a 50-year objective. One extreme would keep emissions more or less constant5 for all countries, in many cases thereby increasing current disparities in per capita emissions. Another approach envisions equalizing per capita emissions. Neither is a plausible outcome of any foreseeable international negotiation. Greenblatt argues for a US obligation at the midpoint of these extremes. We adopt this case for illustrative purposes only.

Based on this allocation, US emissions would be restricted to about 1 GtC/yr in 2055, a 40% reduction from today's value. Thus, assuming a baseline scenario where CO_2 emissions rise to 3.5 GtC/yr by 2055, a reduction of 2.5 GtC/yr from the base case is needed. Again, the base case itself is subject to considerable uncertainty. The selected value is around the middle of plausible scenarios. In the following section, we discuss ways in which a no-policy base case might differ considerably from this, making emission reduction either much easier or much more difficult.

Greenblatt's down-scaling of the global analysis to the US suggests that in fact such a goal is achievable in a technical sense, and a background paper by Edmonds and Smith (2005) suggests that costs are manageable (for mid-range assumptions on uncertain factors like climate sesnitivity). The options with the highest potential for success are increased motor vehicle efficiency, conversion of coal-electric base-load generation to more efficient capacity, substitution of natural gas or synthetic gas (such as hydrogen) for coal combined with various capture-and storage options, increased wind –power capacity and biological sequestration. Additional options with perhaps lesser potential (due to cost, technical, or political obstacles) include enhanced nuclear capacity, photovoltaic generation, and expanded dependence on bio-fuels. It is highly unlikely that changes of this scale will occur without implementation of explicit policies aimed at reducing emissions.

Longer Timeframes (100–200 years) and Large Uncertainties

Attainment of such an objective is merely the first phase of achieving the US share of the long term goal of avoiding a 2°C warming. The subsequent 50 years must be characterized by a steady decrease in global emissions. Edmonds has viewed this problem from an alternative perspective: All scenarios incorporate an implicit technological improvement over the coming decades in the base case. How much additional technical change would be required to meet a stringent long term goal such as 2°C? The difference between base case emissions resulting from the implicit improvement in technology and emissions needed to meet a particular long term objective is called the technology gap.

Edmonds examines a similar set of technological changes necessary for stabilization of global mean temperature at 2°C (above pre-industrial levels) and makes two critical points. First, costs vary widely depending on assumptions made with regard to implicit improvements in technology embedded in the assumed base case, particularly during the second half of the century. An apparently small annual increment (~0.25%) in end use efficiency, for example, can reduce required emissions reductions by over 10GtC/yr by the end of the century by shrinking the technological gap that policy must close to meet the target. Second, uncertainty in climate sensitivity and in the importance of forcing by other trace constituents such as aerosol, has a very large effect on the cost of attaining such a climate goal. For example, if the climate sensitivity is 4.5°C, the possibility of reaching a 2°C target without overshooting may already be foreclosed. Given such large uncertainties in what may constitute "business-as-usual" technologies and in the climate system as well, policies that enhance rates of technological improvement have a high value.

However, considerable debate remains over the most effective approach. As Edmonds notes, "the history of technology development is nothing if not a lesson in forecaster humility. Technologies that were expected to develop have proved more difficult than expected, and technologies that were never envisioned have evolved to play a central role in the economy". This cautionary note certainly applies to US energy technology, which has a long history of large scale "bad bets" by government. On the other hand, certain programs have certainly been effective at spurring new technologies and lower barriers to implementing existing ones. These include tax incentives for wind generation, R&D subsidies aimed at improving appliance and building efficiency, and, particularly notable in the climate context and on the largest scale, an emissions cap-and-trade system for sulfur dioxide and nitrogen oxide emissions. A combination of incentives for research combined with a sequence of emissions caps declining toward zero net emissions over this century (and completing any remaining part of this objective during the next) may be the approach most suited to the US economy.

Population and Lifestyle: a Case for US Exceptionalism?

With or without climate policy, future emissions will depend on a variety of factors, including economic growth rates, population growth, technological development, and cultural and lifestyle factors. These are not independent variables. Rather, they are strongly linked, and many of these linkages are not even qualitatively understood. The above discussion is based on standard assumptions about population, lifestyle, and cultural factors. But the history of prognostication in these areas has been very poor, and with regard to down-scaling, there is a particular concern about arenas where trends are now anomalous. The US stands out in three ways as different from most other industrial countries, particularly Europe: Its population is growing fast with a relatively young age structure, relatively high fertility rates, and high immigration (see background paper by O'Neill, 2005). Second, fuel use in the transportation sector is projected to continue to grow faster than population, reflecting particular settlement patterns and lifestyle choices. Third, the country has not yet established a political consensus articulated by national leadership, to address the climate issue.

Population distribution according to age, geographic location (e.g., coastal/inland, urban/rural) in addition to lifestyle choices and total growth rates are believed to exert a strong influence over greenhouse gas emissions. It is plausible that the US will continue to grow while the current population leaders, India and China, stabilize; the US may even surpass them. Without a substantial change in either technology or lifestyles, emissions would grow accordingly and implementation of effective policy to restrain emissions would be extremely difficult. Equally plausible over the coming 100-200 years is a slow-down of emigration (due in part to policy choices) and fertility that would simplify the task of restraining emissions. Given these uncertainties, a focus on incentives and mandates for technological progress and implementation of new or available technologies for transportation fuel efficiency may prove particularly effective at restraining emissions in the US context.

V Next Steps

It is worth noting that rapid, decade-scale shifts in lifestyle and fertility choices are not unusual, for both the US and other countries. A fast transition to a framework that facilitates emissions reduction may occur for a variety of reasons, some potentially linked to the "environmental culture" itself. The same may be said of political transitions. Small cultural and political changes on a variety of fronts can eventually cause a concatenation of change at the largest scale. While in the US the great environmental reform of the 1970s appeared to come out of nowhere, it arose in part from state level and local level initiatives to clean the air and water. With the development of statewide initiatives to regulate greenhouse gas emissions in California and among several Northeast states, and with the development of a sense of inevitability of regulation in some quarters of the business community, it is not overly optimistic to imagine that seeds are now being planted that will scale up to a comprehensive federal approach within 5-10 years. Gradual change can sometimes instigate quantum leaps in outcomes.

In climate policy, the next years will be a gestation period preparing for a turnaround in global emissions. While no global breakthroughs should be expected, they should be prepared. This requires conscious measures at four levels.

At the global level, it is essential to keep the machinery of international environmental diplomacy going, to build up competence and trust through a pattern of patient and continuous interactions. The UNFCCC has shown to be an extremely useful legal and institutional framework, as has the Kyoto protocol. Neither of these two instruments can be expected to deliver the turnaround in global emissions that will be required a few decades from now, but both of them are essential to prepare that turnaround. Maintaining and gradually improving them is the main task at the global level.

At the regional level, a myriad of initiatives are possible and warranted. Public procurement policies can play a vital role in forstering the technological progress that will be needed for a global turnaround. This holds for single cities as for provinces and states.

At the level of the US and the EU, emission trading schemes and R&D measures seem especially promising. It is important to develop an array of experiences before trying to standardize such instruments worldwide. In this respect, the existence of the EU-ETS is an asset, not a drawback for global coordination.

Finally, interregional co-operation offers considerable opportunities in the coming years. The US and the EU have already started a joint effort on hydrogen technologies, similar efforts in other areas may be added in the years to come. There is also a need for co-operation between industrial and developing countries, say, between the US and latin American countries, or between the EU and North Africa. Bilateral co-operation may well prove to be one of the most fruitful areas of progress in climate policy in the coming years.

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