Setting a Post-Kyoto Target for CO_2 Emissions:
A Mechanism and Process for International Consensus Building

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Climate change is now recognized to be a significant international problem. The short-term approach reflected in the Kyoto Protocol will have insufficient impact and a solid and permanent international scheme to address this problem has yet to be determined. The achievement of an effective treaty and protocol regime will be very difficult politically. This paper proposes a way to overcome these difficulties by setting long-term CO_2 emissions targets.

The rigorous scientific analysis and discussions that contributed to the third assessment report of the Intergovernmental Panel on Climate Change (IPCC) in 2001 shows clearly that climate change is a real problem for human beings. The root of this problem is energy usage based on fossil-fuel combustion. However, economic activities both in developed and developing countries require energy use.

Once greenhouse gas is emitted anywhere, its global influence will continue for many years. To overcome this problem, long-term international cooperation is essential. However, nations tend to focus on short-term targets and haphazard planning, and neglect long-term targets. National planning is strongly influenced by the short-term time frames of politics. A strategy is needed to encourage all countries to move together toward a long-term target.

Such a strategy must have a mechanism to keep countries consistently focused on the goal of CO_2 reduction until it is achieved. This paper will first clarify the long-term goal. Then, meaningful short-term steps leading to this objective will be identified. This analysis will show that even if some scientific uncertainties pertinent to the setting of long-term targets remain, the strategy will work if the flexibility to revise the target periodically using the newest scientific techniques is built into the mechanism. This method could be applied not only to the mitigation of climate, but for the abatement of many other environmental problems also.

The argument of the first section is that long-term target setting has important advantages over short-term target setting, such as Kyoto. The next section is a discussion of how a long-term target-setting strategy can be accomplished. The section includes a proposal for a bold new international treaty setting long-term goals and defining clear and predictable formulas and concrete mechanisms.

The third section will clarify requirements for hypothetical high-, middle-, and low-income countries. It will illustrate basic directions and standard time lines for each category. The fourth section includes a prediction of how countries will react to the new treaty proposal and an assessment of how the proposal dovetails with recently established environmental principles. The final section describes the political and negotiation aspects of building such a long-range climate protection treaty.

Why Work toward a Long-Term Target?
Long-term targets work very well in many cases. For example, students prepare more effectively for a final exam when the scope and task of each class, due dates of assignments, and the date of the final exam are stated in the syllabus at the beginning of the semester. Unless they know the length and due date for a required term paper, many students will not finish their papers before the end of the semester. Moreover, even if due dates and assignments are given, without incentives to start early busy people with many other things to do might also get a late start. Setting due dates for drafts every few weeks during the semester is a better method for success. The combination of final or long-term targets coupled with shorter-term incentives encourages people to reach important final objectives.

The Kyoto Protocol is an example of a short-term strategy for climate change mitigation. It was assumed that if the first international agreement took a small step (approximately eight percent CO_2 reduction over 15 years) then subsequent agreements could be more ambitious. This approach has not proven particularly successful. It might be time to experiment with an alternative approach, setting long-term targets over 50 to 100 years. This section explores the implications for mitigation and negotiation strategies.

Applying Long-Term Goal Setting to Climate Change Mitigation
This paper offers a proposal to achieve climate change mitigation over the long term through sustainable energy usage. The recently ratified Kyoto Protocol is just the beginning of climate change mitigation through the stabilization of CO_2 emissions. The IPCC states that even after 100 years of CO_2 emissions reduction, the global temperature will continue to rise for a few hundred years; sea level will continue to rise for over 1,000 years (IPCC 2001).

Factual and scientific evidence shows recent unusual changes in climate. For example, 1998 was the warmest year in the instrumental record and probably the warmest in 1,000 years; 2002 was the second warmest. Examination of ice cores suggests that the last half century may have been the warmest in 6,000 years. Observations over recent decades also show that glaciers are retreating, sea ice is shrinking, and sea level is rising.

The causes of these climate change symptoms appear to be human-related. They include:
1. Measured and observed global climate change;
2. Patterns of climate change due to greenhouse-gas increases that correspond to the predictions of climate science and computer modeling; and
3. Lack of any alternative explanation that would cause such a pattern.

According to scientific consensus, the consequences of a continued "business as usual" approach include these "best estimates":
1. The earth will become warmer than at any time in the last 160,000 years.
2. This warming will create major changes in climatic patterns: storm tracks, distribution of precipitation and soil moisture, and extremes of heat and cold.
3. Because these changes in climatic patterns will be so rapid, their effects on human well-being are likely to be more negative than positive.

Finally, some very unpleasant surprises are possible, for example
1. Large increases in the frequency and intensity of highly destructive storms;

2. Drastic shifts in ocean current systems that control regional climates (e.g. the influence of the Gulf Stream on Western Europe);
3. Multimeter sea-level rise from the disintegration of the West-Antarctic ice sheet; and
4. Runaway greenhouse effects from the decomposition of methane clathrates, amplifying prospects for all of the above.

Although the IPCC reports are recognized as the most authoritative and trustworthy at this moment, and its predictions are significant enough to affect all countries' immediate movements and actions, politicians seem to move very slowly against expectations. It is clear that further emissions reduction plans have to be applied globally. A long-term target for CO_2 emissions caused by world energy use should not be influenced by individual countries' unique conditions and stopgap policies. It is apparent that the conventional energy use trend in industrialized countries, which accompanies huge amounts of natural resource consumption along with CO_2 emissions, can no longer be easily sustained. This problem also includes developing countries which are demonstrating rapid increases of population and economic development.

Why are politicians unable to take measures immediately in response to the IPCC's threatening predictions? Uncertainties about the cost of actions, future technology benefits, and impacts have retarded provisions to mitigate climate change even among politicians who have recognized the problem's significance. This stagnation shows the limitation of climate change mitigation strategies through the conventional treaty regime which can only establish short-term targets. Faced with IPCC reports based the most reliable scientific analysis by top scientists, decision makers may recognize that a certain amount of emissions reductions will be needed at some point in the future. However, short-term political agendas lead to short-term target setting.

Unfair economic development based on energy use also requires long-term correction. The IPCC's first assessment report "made no attempt to address issues of equity." However, the second assessment report "broadened the IPCC policy by introducing the issues of equity" (IPCC 2001). The issue has been kept as a focus in the third assessment report.

In this paper, global consensus building towards setting a target for long-term energy consumption is examined as a climate change mitigation strategy through the new international treaty system. According to Adil Najam (2003) "The Kyoto process has been focused on the short-term need to launch the implementations phase, to get ratifications from the industrialized countries listed in Annex 1, and thereby to bring the Protocol into force. However, the focus on the longer-term objectives of the UNFCCC cannot be postponed for too long."

Of course, all greenhouse gases should be counted in the effort to mitigate climate change. However, only CO_2 emissions will be discussed here because these emissions symbolize the conventional energy consumption system which relies mainly on fossil fuel combustion.

Justifying a New Approach

A long-term target can be appropriate for two reasons. First, while countries have already considered the suggestions of the IPCC, it is very difficult for politicians to impose rapid

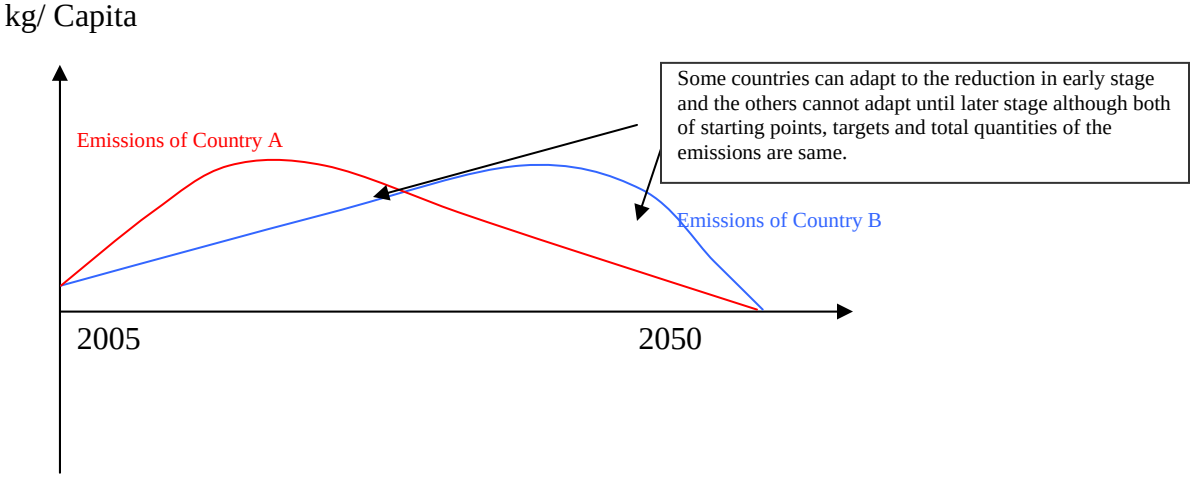
CO_2 reduction measures requiring mandatory changes in voters' lives. Spreading the burden of political liability over the long-term may become a favorable option for them.

Second, each country has different the economic, climatic, geological, and social situations including energy and resource management planning. Moreover, an energy portfolio cannot be turned around within a short period (e.g. five years) because power plants are planned to operate for several decades. For these reasons, commitment to short-term targets does not give countries sufficient time to consider their options. Rigid commitment to a long-term target enables each country to build flexible plans reflecting its unique situation and condition.

For example, ordinary power plants have roughly a 30-year lifespan in Japan.[1] In the short run, it is difficult to replace facilities. Japan cannot commit to short-term CO_2 emissions reduction by replacing old plants with new plants. However, in the context of a long-term action plan, the country can replace these plants with new plants at the appropriate time for the country. The later the replacement, the better its energy efficiency will be because of technological improvements; the replacement will enable Japan to achieve rapid emission reduction from that point forward.

As seen in Figure 1 country A can adapt to the reduction at an early stage. Country B cannot adapt until a later stage. However, both countries' total quantities of emissions are the same because country B would be able to adopt more advanced technology than country A. Moreover with short-term targets only, it is difficult to evaluate the CO_2 emissions during the those terms as a total which includes future emissions. Because of scientific uncertainties, what is needed in total is very vague. What is now possible is also vague, as is what we will be able to do in the future, and how much these efforts can contribute to long-term mitigation.

Figure 1. Difference in Adaptation to the Target between Countries



The uncertainties involved in long-term predictions make it difficult to agree on a long-term action plan. By agreeing to long-term CO_2 reduction, politicians may not only lose votes, but

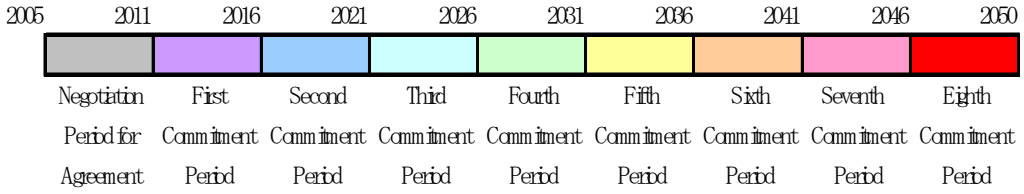
also leave themselves open to blame for future negative impacts the agreement may have on the nation's economy. By providing for mid-term revisions, flexible target setting can address these difficulties.

Major Treat Mechanisms for Setting Long-term Targets

Agreeing on a schedule will require extensive international discussion. However, the decades between the present and 2050 would be a reasonable period for long-term targeting because important factors such as the population estimates may be available and reasonably reliable. Moreover, as the first commitment period of the Kyoto Protocol lies between 2008 and 2012, a long-term emissions amendment period proposed to begin in 2011 and run to 2050 will cover 40 years.[2]

Such a period might be divided into eight commitment periods as shown in Figure 2. The appropriate length of periods will be negotiable. For example, five-year periods may be onerous for some nations, which would be more comfortable with ten-year targets; however, when it is necessary to avoid procrastination, three-year periods may be necessary. Dividing every few years into periods is very important because it is almost impossible to set exact targets from the beginning; periodic revising of targets based on the latest scientific evidence will make long-term planning feasible. Parties can plan and submit their plans to meet the targets of the newly revised overall plan for each commitment period at periodic conferences of the treaty.

Figure 2. An Example of Setting Commitment Periods



There is no clear reason *a priori* why the Kyoto Protocol produced targets of seven percent below the base year emissions for the United Kingdom, six percent for Japan, and zero for New Zealand. According to Najam and Page (2003), "The lack of a clear and predictable formula or basis for emissions reductions not only sets a bad precedent for the future, but leaves developing countries without any clue about the basis on which they will be required to enter the regime at some future, unspecified date." The major feature of this new treaty should be a formula based on a set of agreed-upon criteria. This is in sharp contrast to the political process used at Kyoto. Najam and Page (2003) comment that "Developing countries would have preferred an arrangement based on maximum allowable emissions according to some negotiated formula." They also mention that one potentially useful approach is to move towards a per capita emissions target.

The approach proposed should mitigate climate change by achieving sustainable energy usage in the long-term. To achieve this, fair use of energy and natural resources are essential. Some quantitative comparison of each country's contribution to climate change will be needed. The World Development Indicators provided by the World Bank gives us some useful measurements such as CO_2 emissions (kg per1995); Purchasing Power Parity (PPP) $ of Gross Domestic Product (GDP); CO_2 emissions (kg per 1995 US$ of GDP); total CO_2

emissions (kt); CO_2 emissions (metric tons per capita); energy production (kt of oil equivalent); energy use (kg of oil equivalent per capita); and energy use (kt of oil equivalent) (The World Bank Group 2004).

CO_2 emissions (kg per 1995 PPP $ of GDP) and CO_2 emissions (kg per 1995 US$ of GDP) are useful in comparing the efficiency of CO_2 emissions by countries,[3] but are not appropriate for the comparison of each country's total contribution to climate change. This is because total national CO_2 emissions (kt) reflect each country's population; it is not directly linked to the fair distribution of energy. It is also inappropriate to compare national energy production because many countries import or export energy such as electricity. Nor are energy use measurements such as "kg of oil equivalent per capita" or "kt of oil equivalent" appropriate because some energy sources such as hydropower and geothermal do not contribute to climate change.

For these reasons, only CO_2 emissions (metric tons per capita) can be regarded as an available and appropriate measurement of contribution to climate change. Recent trends in CO_2 emissions per capita show a huge imbalance between the high-income country group and the other income groups. The high-income country group emits about 12 tons per capita of CO_2 while the low income country group emits less than one ton per capita; the world average is around four tons per capita according to the World Bank Group. Ultimately, there must be a cap on total CO_2 emissions as well for each national population.

Another important factor is the overall reduction rate of emissions per capita. Recent efforts to increase energy efficiency are different in each country; some have been making more effective efforts than others.[4] Some countries might easily identify energy-saving measures because they have not made any previous effort. It is not appropriate to neglect differences in the degree of effort different countries have made up to now. The procedures to decide different countries' reduction quotas under the Kyoto Protocol were vague and there was no reasonable engagement on how to decide these reduction rate values.[5] The countries that can show evidence proving they have already been making efforts to reduce can be indemnified for doing so.

The third factor is the efficient use of energy. The obligation to exceed some values is necessary to force effective resource usage. Other units of measurement provided by the World Development Indicators can be used for supplementary functions. CO_2 emissions per PPP is an appropriate measure for this function. Otherwise countries that can still afford to emit excessive CO_2 per capita might not try as hard as they could to use CO_2-emitting fuels efficiently. The high-income group which includes industrialized countries does not necessarily demonstrate the most efficient resource utilization. According to the World Bank Group (2004), they emit about 0.5 kg CO_2 emissions per PPP compared to 0.4 kg in the low-income country group; the world average is around 0.6 kg.

However, many of the 30 richest countries use energy efficiently enough to achieve around 0.2 – 0.3 kg per PPP. Their technologies and experience can help others use resources more efficiently; the rich countries have a responsibility to transfer energy-efficient technologies and experiences to countries that need them.

These agreements should also include fairness for developing countries that have contributed little to recent CO_2 emissions. According to principle 7 of the Rio Declaration citing "common but differentiated responsibilities" (The United Nations Conference on Environment and Development 1992) industrialized countries and developing countries have different obligations. Moreover, the availability of natural resources that do not emit CO_2 is different in each country for geological and political reasons. For example, the Philippines is actively using its rich geothermal resources. However, many of Japan's most appropriate sites for the exploitation of its extensive geothermal resources are located inside national parks where development is prohibited or limited, making it difficult to promote use of this energy source.

When establishing the treaty, equitable access to energy should also be considered and improved. For this purpose, total available energy (kg of oil equivalent per capita) should be considered. Application of this metric should provide a reasonable advantage to developing countries because many of them still face difficulty in accessing energy sources. Politics also plays a part. For an example, France is known for active usage of nuclear power. Even though nuclear power use does not emit CO_2, it requires careful handling. In fact, in the Kyoto Protocol's Clean Development Mechanism (CDM), Joint Implementation (JI), and emission trading plans, CO_2 reduction by new nuclear power usage is not considered.

The new treaty would focus on CO_2 emissions per capita. A country's CO_2 emissions include those from all sources of energy, including nuclear power.[6] In practice, nuclear power usage is strongly related to security and safety issues. However, these factors should be avoided in the treaty discussion because they are part of countries' internal affairs. Energy use involved in nuclear plant activities from construction to radioactive waste management and storage should be counted, and the price of accident insurance converted into the value of energy use.

The same measurements should be applied to renewable energy resources and fossil fuel energy resources, though alternative energy sources such as wind and photovoltaic power will consume comparatively small amounts of energy during construction and production and insurance costs will be low. Biomass resource incineration will not increase CO_2 in the atmosphere if the full life cycle of biomass is considered. The greatest impacts will come mainly from fossil-fueled energy sources during the operation period, with low insurance costs compared to nuclear power sources.

The total life-time-assessed evaluation of each energy source converted into CO_2 emissions should also be provided by the IPCC and its successor or equivalent organization. Because each country's energy portfolio is different, the total impact of each country's CO_2 emissions will be also evaluated. The function that provides a numerical target will be:

Function 1.
Target Setting Function = Main Function + Supplementary Functions

Main Function = [CO_2 emissions per Capita]
Supplementary Functions = [Reduction Efforts in the Past], [Effective Usage of the Resources], [Energy Use per Capita], [Total Contribution by energy sources portfolio's life-time-assessed evaluation transferred into CO_2 emissions]

The ratio between the main function and the total of the supplementary functions, and the significance of each supplementary function will be suggested by the IPCC or an equivalent organization. Some countries can gain credits from the supplementary functions, allowing them to emit more than the value determined by the main function; other countries may lose credits. However, managers of the process should not attempt to increase some countries' allowed emissions to directly offset decreased emissions elsewhere; such a strategy would cause conflict and complicate the negotiations.

CO_2 emissions per capita are directly derived from the targeted total emission amount. Therefore, the influence of supplementary functions should not exceed around five percent lest world total for allowed emissions exceed the targeted amount. For example, each of the four supplementary functions can be allowed to deviate ±1.25 percent from the base line of CO_2 per capita.

Applying the Treaty: A Hypothetical Example

Let us assume that the appropriate CO_2 emissions per capita for countries in the world suggested by the IPCC is 2.8 tons per capita, a figure that will be used in hypothetical country scenarios in this paper.[7] Here is an example using the data of Japan and Sweden:

Emissions per capita in Sweden were reduced from 11.46 tons per capita in 1970 to 5.29 tons per capita in 2000. Meanwhile, emissions per capita in Japan increased from 7.08 tons per capita in 1970 to 9.34 tons per capita in 2000. This means that during this period, Sweden reduced emissions per capita by 46 percent while Japan increased emissions per capita by 132 percent. Comparison of these figures suggests that countries that have already taken measures to reduce emissions should be given appropriate credit, and reveals which countries have not and should be working harder. For these countries, it is comparatively easy to find means to reduce emissions.

During the period from 1970 to 2000, the country that improved emissions per capita most is Liberia, which achieved per capita emissions of 12.4 percent. The country that increased emissions per capita most is Bhutan--5487 percent. Fifty-one countries, many of them in the developing world, reduced their emissions per capita while 100 countries increased them. (Data from 45 countries are unavailable.)[8] A treaty might exempt the top five of the 51countries that reduced their emissions a full 1.25 percent from future reduction responsibility. This would allow these countries 2.835 tons per capita, 1.25 percent more than the baseline responsibility of 2.8 tons. Similarly, the next top five countries (six through ten) of the 51 countries might receive a one percent exemption. Each subsequent group of five (up to 25) might be exempted by 0.75 percent, 0.5 percent and 0.25 percent, respectively, over the baseline responsibility.

For the 100 poorly performing countries, the treaty might require the first five to assume a full +1.25 percent more responsibility. This means an emission level of 2.765 tons, 1.25 percent lower than the baseline of 2.8 tons per capita. Similarly, the next top five countries (six through ten) might be given one percent more responsibility. Each subsequent group of five (up to 25) might be given 0.75 percent, 0.5 percent, and 0.25 percent, respectively, more responsibility. As the fifteenth country in this group, Sweden would have a right to strike 0.75 percent from its reduction responsibility, while Japan would have to meet the baseline responsibility.

In terms of resource usage, Sweden used 0.23 kg per 1995 PPP $ of GDP in 2000 compared to 0.39 kg per 1995 PPP $ of GDP in Japan. This factor is the one used to avoid inefficient use of the resources. The emissions per capita is calculated by a formula shown below:

Function 2.

Emissions per Capita (Tons) = PPP (constant 1995 international $) ∗ Emissions per PPP (tons per 1995 PPP $ of GDP)

In these terms, a developing country may appear to be using resources inefficiently, and to have been allocated too high an emissions target when it demonstrates an unexpectedly low PPP increase. Taking technology improvements and technology transfer situations into consideration, the IPCC or an equivalent organization could suggest a marginal limit of emissions per PPP in each commitment period. Countries that cannot achieve the marginal limit will be assigned 2.5 percent more responsibilities. Through this function, no country will be assigned an excessive burden as long as it is making a minimum effort to avoid inefficient uses of resources that emit CO_2. Only countries that neglect the least efficient use of the resource will be urged to reduce emissions by this function. In this way the mechanism will not create any disadvantages for developing countries.

In terms of energy use per capita, Sweden used 5,355 kg of oil equivalent per capita in 2000 compared to 4,132 kg in Japan. Most of the countries with very low energy use per capita are in the developing world. These countries will need more energy during the development process. This function allows the countries a margin for excessive emissions. For example, the treaty can allow low-income (as determined by World Development Indicators) countries to emit 1.25 percent more than 2.8 tons of CO_2 per capita, and middle income countries to emit 0.75 percent more. As high-income countries, neither Sweden nor Japan benefit from this function, while all developing countries will.

In terms of total contribution from all energy sources and the portfolio's lifetime-assessed evaluation converted into CO_2 emissions, 36.4 percent of Sweden's primary energy comes from nuclear energy. This means Sweden cannot take advantage of this supplementary function if lifetime CO_2 emissions by nuclear sources are converted and included in the total. When nuclear power is included in these terms, Sweden would be forced to assume an excessive burden of emissions reduction. In addition, 13.2 percent of Swedish primary energy comes from hydro which will help reduce the burden. Biomass and waste combustion accounts for 15.8 percent of the primary energy (International Energy Agency accessed 2004). Waste should be divided into biomass-derived waste and other waste. The part of biomass usage that satisfies the "carbon neutral concept"[9] will help to reduce the burden. These estimations will be entrusted to the IPCC or an equivalent organization.

This is just one example of a negotiated agreement. While the process appears complicated, it is at least an attempt to reasonably allocate rate values; in the Kyoto Protocol's first commitment period no such process was applied. According to Najam and Page (2004) "In terms of developing country interests, a more robust regime architecture would be one that defines its targets not in terms of symbolic short-term measures, but long-term atmospheric

stabilization; which gives all countries a clear signal on what is likely to be expected of them in the future."

Based on this process, emissions allocations per country will range from a minimum of 2.66 tons per capita (2.8ton * 95%) to a maximum of 2.94 tons (2.8 tons * 105%). Care should be taken to avoid consuming many years on negotiations about biased emission setting.

Establishing a Global Target

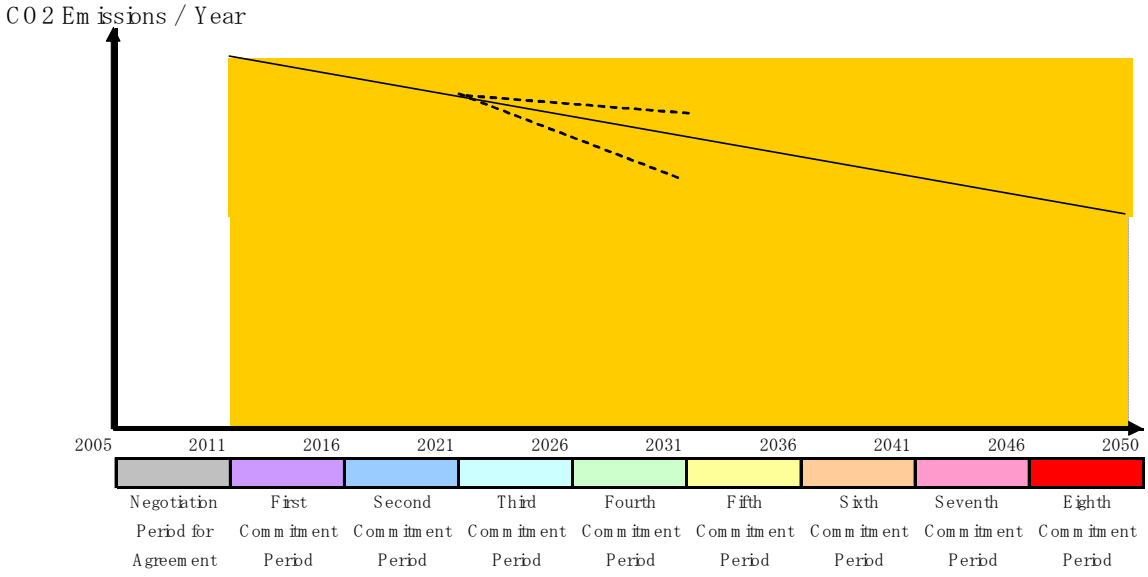
The organization that sets the global target should have a high degree of credibility, relevance to the problem, and legitimacy.[10] From these perspectives, the IPCC or its successor is appropriate. The newest scientific assessments should provide an estimate of the level of world CO_2 emissions that must be achieved by 2051 to avoid "dangerous anthropogenic interference with the climate system" (United Nations 1992). It will need to have improved estimates from the ones that were shown in the UN report, *Climate Change 2001*. This report concluded that even the lowest emissions scenario can cause some risks and an increase in impacts. Because of uncertainties, if the IPCC or an equivalent organization is not allowed to decide the value, it can at least propose "applicable" temperature change until stabilization.[11] From the temperature change, corresponding total emissions and thus corresponding CO_2 emissions per capita can be derived. Politicians will then have to approve the value as the long-term target (Moomaw 2004; United Nations 1992).

The estimated limits of CO_2 required to avoid "dangerous" consequence can be revised every five years, a concept illustrated in Figure 3. The point is that CO_2 emissions for each year should not be set by the treaty organization because it will reduce the flexibility of national planning. The organization should focus on total emissions for 40 years. Based on scientific estimates for the total amount required, CO_2 emissions per capita will be established by:

Function 3.

CO_2 emissions / Capita = Estimated Total Amount of CO_2 Emissions from 2011 to 2050 / Aggregate Population of Each Year from 2011 to 2050

Figure 3. Concept of Estimated Total Amount of CO_2 Emissions Until 2050

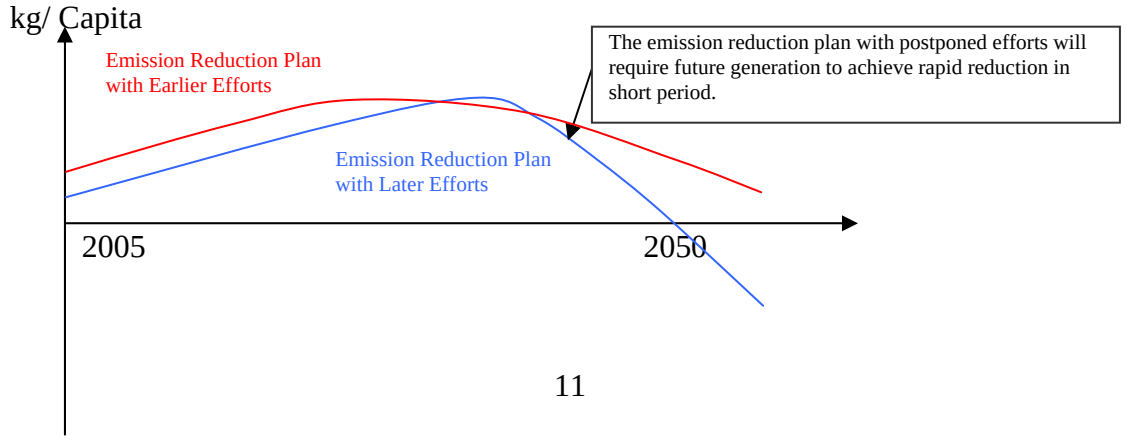


Mechanisms for Success

All the parties involved in the treaty will be expected to submit a national plan that includes both an overall plan for the entire 40 years and plans for each commitment period, to satisfy the target assigned by Function 1 to each party. As mentioned, the target will be revised every five years by the organization. Each sovereign country will be entrusted with its own planning, based on its own national conditions. In this scheme, each party can make scheduled reductions within the context of a long-term perspective and final target.

One problem is that a country may choose to plan reductions in the distant future, rather than right away. (See Figure 4.) Such postponed efforts will burden future generations if, for example, they are required around 2040 to make sharp, difficult reductions in a short period. Furthermore, a hastily contrived, highly demanding plan is more likely to fail. For this reason, there should be special incentives in the mechanism to reward early efforts. If the results of the supplementary function used to account for prior reduction efforts (explained above) is recalculated at each conference of the parties, when the 40-year target is revised, countries that have made a strong beginning will receive a higher quota for the next five-year commitment period.

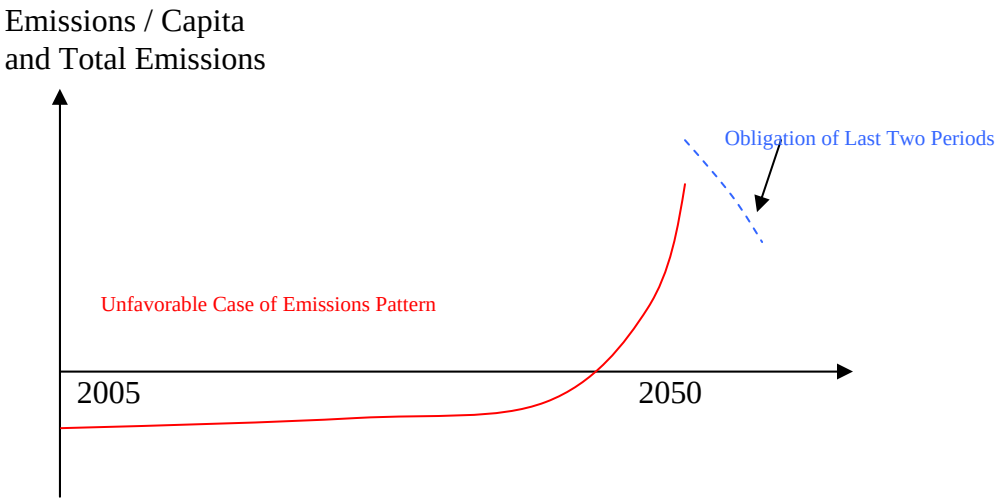
Figure 4. Comparison of Earlier and Later Reduction Plans



For example, at the beginning of the third commitment period in 2022, the target of the base line emissions per capita and the supplementary function's effect for 40 years from the fifth commitment period starting from 2031 will be revised. Each country's efforts until that point will be reflected in its new target. Under the Kyoto Protocol, nations must make additional reductions after 2012 if goals are not met.[12] However, giving benefits can be better incentive toward reduction for countries than imposing a penalty.

Another concern is that some countries may increase emissions continuously while still operating within their assigned levels. This may happen in developing countries having continual difficulty in accessing energy. Even though these countries may be meeting their emission targets, such a situation cannot be considered a success because high-emission patterns and processes will burden future generations assuming that post-2050 a much higher level of development will lead to rapid emission increases. In these circumstances, the countries are likely to have made no improvements to energy accessibility prior to 2050. (See Figure 5.) To avoid this pattern, at each conference of the parties each country should be obligated to show reducing or stabilized emission tendencies during the previous two periods (commitment periods 7 and 8) as shown in Figure 5. Even though assuming this obligation might make a country reluctant to ratify the treaty, stabilization of its emissions tendency is the ultimate goal for the treaty organization when one considers global emission after 2050.

Figure 5. An Unfavorable Case and the Country's Obligation during the Last Two Periods



It is also important to establish a backup plan for countries that cannot satisfy their assigned targets until 2050. Imposing penalties will only cause countries to leave the treaty, thus defeating its purpose. Here again, national sovereignty should be respected. At the year 2045 when the last commitment period begins, countries destined to fail should be expected to make a revised plan for the far future. Tentative emissions targets from 2051 to 2100 should also be suggested, subject to periodic revision.[13] (As emissions targets for the distant future are recalculated every five years, it may be assumed that they will become more accurate.) The countries in question should be expected to make a revised plan to offset earlier shortfalls within 20 years or so. For example, a country may need 25 years from 2045 until 2070 to renovate its social structure including the power industry. [14]

The emission- trading mechanism in the Kyoto Protocol should be continuously encouraged because it can promote the achievement of the target. However, at the same time, a mechanism should be devised to promote economic development in the developing world that is more effective than the CDM. Such a mechanism could, for example, address the imbalance of emissions through a system in which industrialized countries can buy emission credits from developing countries.

Projects that use the mechanism should be much more economically attractive. For example, the GEF (Global Environment Facility) or its successor can pay the extra costs incurred when an industrialized country invests in an emissions-reducing project in a developing country where uncertainties pose higher risks compared to projects in developed countries. The mechanism will also help stabilize the price of CO_2 by providing long-term management of energy development projects, thus making emissions trading more predictable. Uncertain price fluctuation during a project period dampens enthusiasm for emission-trading projects. This issue will be mentioned in greater detail below.

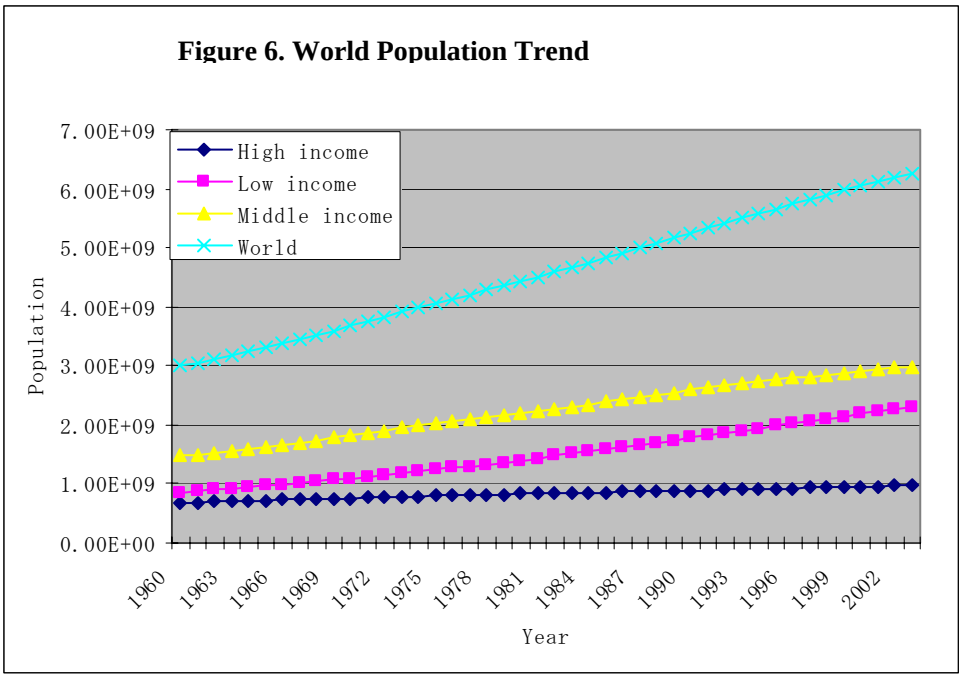
Application to Hypothetical Countries

This section will use the World Development Indicators provided by the World Bank and the *State of the World Population Report 2004* provided by United Nations Population Fund to illustrate what the method might produce for hypothetical high-, middle-, and low-income countries. A few assumptions will be applied to simplify these models.

Figure 6 shows the world population trend including data for high-, middle-, and low-income groups. Simplified population increase estimates based on the *World Population Report 2004* for each group are shown in Figure 7. The population assumption at 2050 is in the band used in the IPCC report (IPCC 2001). At the same time, let us assume that the IPCC or equivalent organization suggests that total CO_2 emissions until 2050 should equal the CO_2 emissions at the 1990 level which is $2.13 * 10^7$ kilo tons per year (Figure 8). The actual total amount of CO_2 in 1990 was $2.13 * 10^7$ kilo tons per year. As suggested by Function 4, total CO2 emissions until 2050 from 2003 will be assumed here to be $2.13 * 10^7$ kilo tons per year * 48 years = $1.0224 * 10^9$ kilo tons.

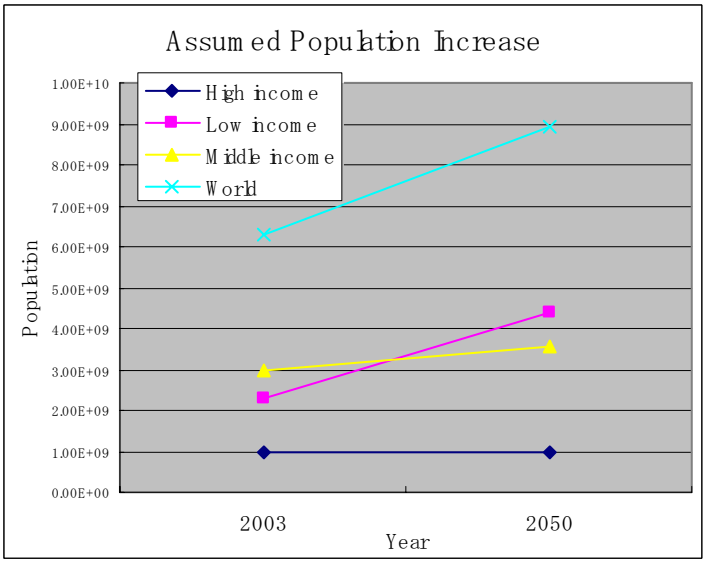
Although recent IPCC reports do not predict exactly the same scenario, the total amount of CO_2 emissions assumed here is relatively similar to the IPCC's scenario B1, the most ambitious emission stabilization case, even though CO_2 concentration has been predicted to go beyond 500ppm in the scenario. According to scenario B1, global temperature will rise by 2 ℃ during the period 2000 to 2100 (IPCC 2001).

Figure 6. World Population Trend



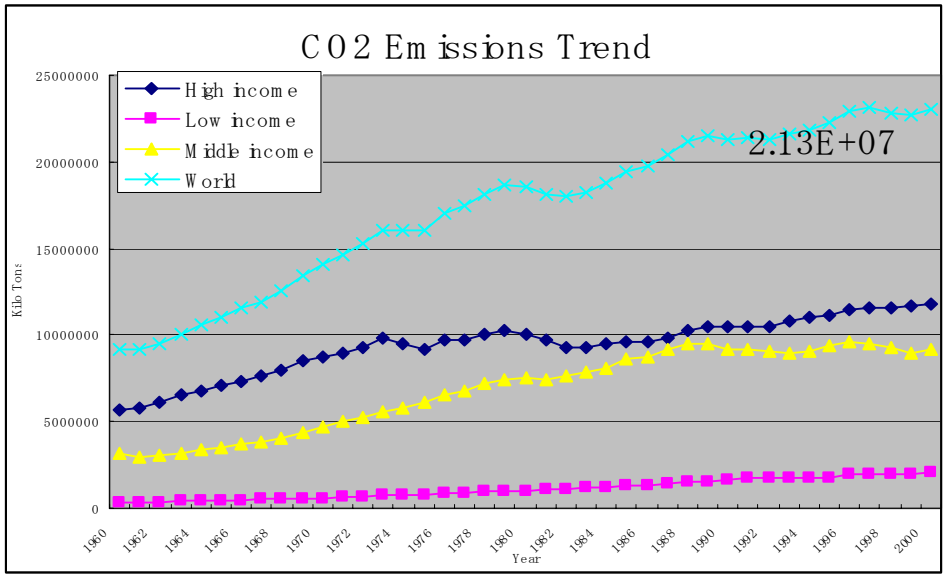
Source: The World Bank Group, *WDI Online,* (accessed November 13, 2004) available from http://80-devdata.worldbank.org.ezproxy.library.tufts.edu/dataonline/

Figure 7. Assumed Population Increase



	2003	2050
High income	9.71E+08	9.71E+08
Low income	2.31E+09	4.39E+09
Middle income	2.99E+09	3.56E+09
World	6.27E+09	8.92E+09

Figure 8. Emissions Trends



Source: The World Bank Group, *WDI Online,* (accessed November 13, 2004) available from http://80-devdata.worldbank.org.ezproxy.library.tufts.edu/dataonline/

Given these assumptions, for the period 2003 to 2050, the total amount of CO_2 emissions will be:

Function 4.

2.13 ∗ 10^7 kilo tons per year ∗ 48 years = 1.0224 ∗ 10^9 kilo tons

The cumulative world population in this period will be:

Function 5.[15]

(6.27^9 + 8.92^9) 48 years / 2 = 364.56 10^9

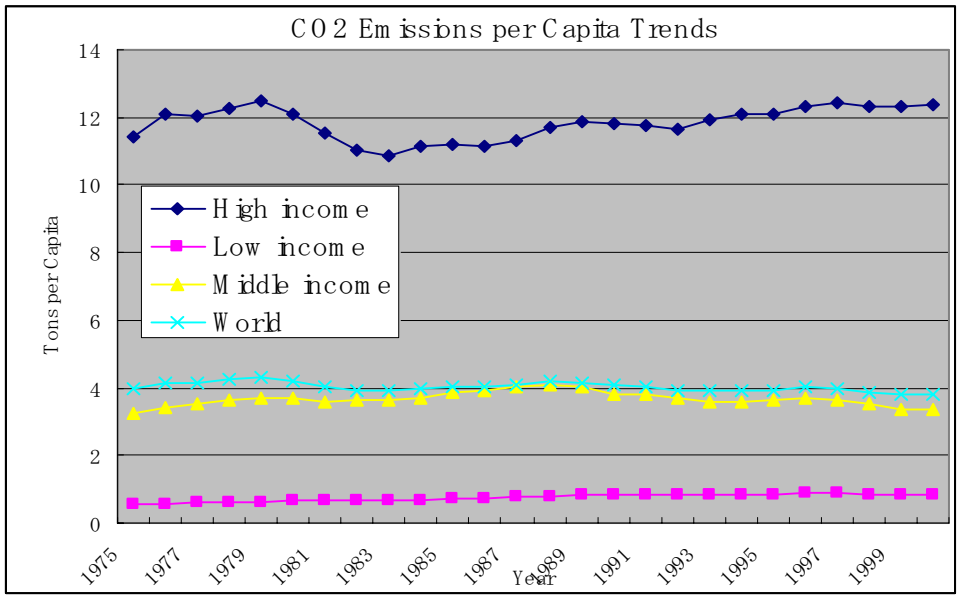
Thus, the basic value of world CO_2 emissions per capita in the period will be:

Function 6.

1.0224 ∗ 10^12 tons / 364.56 ∗ 10^9 ≒ 2.8 tons per capita

Each country needs to establish a plan allowing an average of 2.8 tons of emissions per capita from 2011 to 2050.[16] This mechanism gives countries considerable flexibility in planning emissions strategies to maintain this average value over 40 years. Figure 9 shows per capita CO_2 emissions for each income group of countries.

Figure 9. CO_2 Emissions per Capita Trends



International discussions of this new treaty agreement will hinge on who might and might not support it. Countries the treaty would allow to promote economic development and population increases on a large scale would be unlikely to object. Countries that would carry greater burdens are less likely to support the treaty. Different optional reduction plans will have different implications for high-, middle-, and low-income nations.

Given the per capita target of 2.8 tons, emissions per PPP can also be calculated:

Function 7.

PPP of each year (constant 1995 international $) ∗ Emissions per PPP of each year (Tons per 1995 PPP $ of GDP) = Emissions per Capita of each year (Tons / Capita)

Function 8.

Total Emissions of each year (Tons) = Emissions per capita of each year (Tons / Capita) ∗ Population of each year

Function 9.

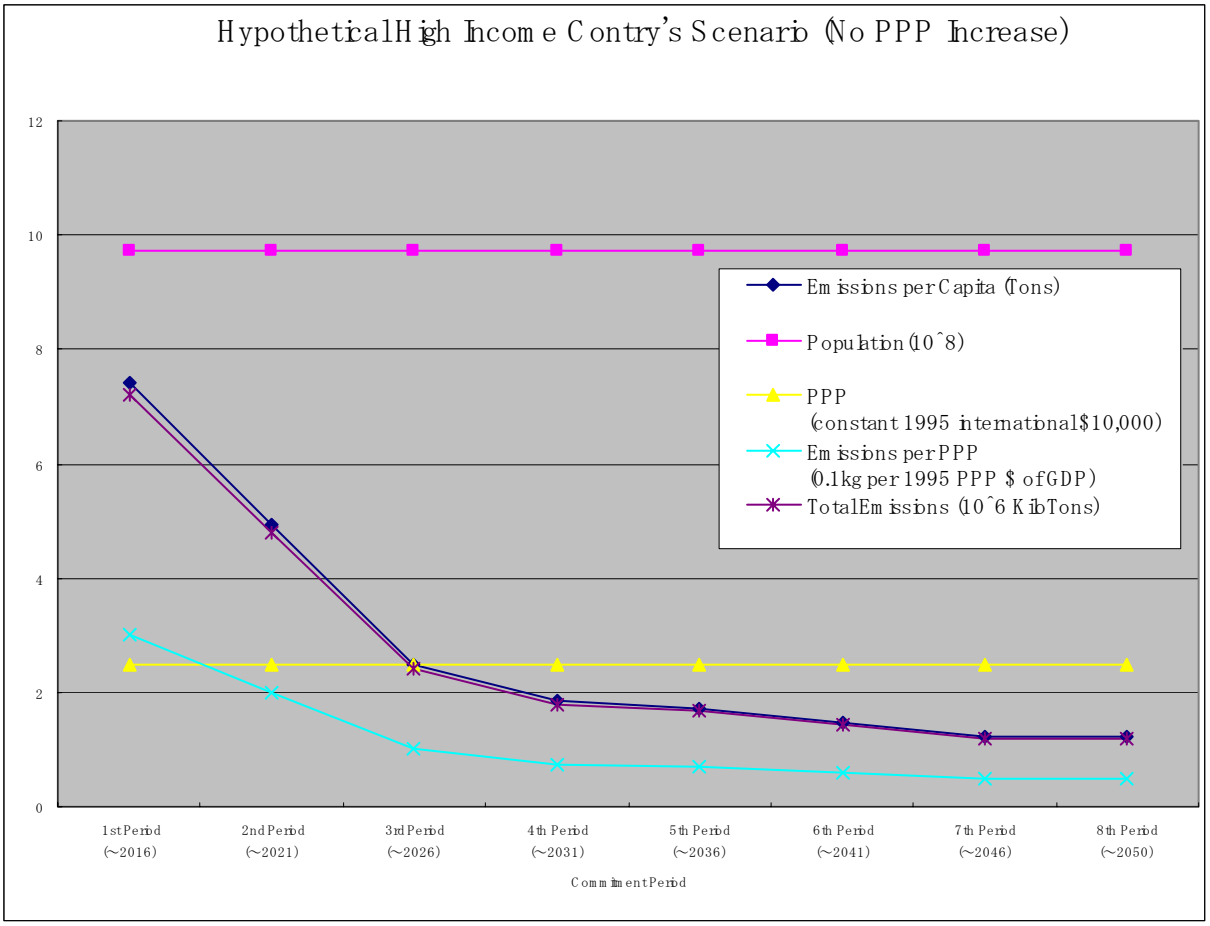
Average emissions per capita from 2011 to 2050 (Tons / Capita) = Sum of each year's Total Emissions (Tons) / Cumulative Population

Population trends can be assumed to be comparable to those shown in Figure 7. PPP trends have been set in two cases for each of the countries, and the rates of increase in PPP are expected to become smooth. Each plan will be divided into eight commitment periods of five years. Emissions per capita for each year may be derived by inserting the PPP for each year (constant 1995 international $) and the emissions per PPP of each year (tons per 1995 PPP $ of GDP) into Function 7. Total annual emissions can be derived from the assumed population and emissions per capita for each year using Function 8. The sum of each year's total emissions in Function 9 can be derived from the total emissions for each year calculated in Function 8. Finally the average emissions per capita from 2011 to 2050 (tons/capita) can be derived by dividing each year's total emissions by the presumed cumulative population.

Figure 10 shows the hypothetical high-income country's typical emissions plan from 2011 to 2050 (Scenario H-1). This basic plan doesn't include economic development leaving the PPP stable at the 2000 level. As the population and the PPP for the country are derived, emissions per capita for each of the commitment periods have been calculated to achieve 2.8 tons of average emissions per capita during the period from 2011 to 2050. The value of emissions per capita in 2000 was 12.36 tons with an emissions value per PPP of 0.490, a level which must be reduced to achieve average emissions of 2.80 tons per capita. According to this simulation, the country needs to reduce emissions from 0.49 kg to 0.1 kg per PPP by 2026, the end of the third commitment period, and to further reduce the value down to 0.05 kg per PPP within the eighth commitment period ending 2050.

Figure 10. Hypothetical High Income Country's Presumed Plan with no PPP increase (Scenario H-1)

	Year 2000	1st Period (~2016)	2nd Period (~2021)	3rd Period (~2026)	4th Period (~2031)	5th Period (~2036)	6th Period (~2041)	7th Period (~2046)	8th Period (~2050)		Average emissions per capita from 2011 to 2050 (Tons)	Total Emissions from 2011 to 2050 (10^7 KiloTons)
Emissions per Capita (Tons)	12.36	7.42	4.95	2.47	1.85	1.73	1.48	1.24	1.24		2.80	
Population(10^8)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71			
PPP (constant 1995 international $)	24730.92	24730.92	24730.92	24730.92	24730.92	24730.92	24730.92	24730.92	24730.92			
Emissions per PPP (kg per 1995 PPP $ of GDP)	0.490	0.300	0.200	0.100	0.075	0.070	0.060	0.050	0.050			
Total Emissions (10^7 KiloTons)	1.20	0.72	0.48	0.24	0.18	0.17	0.14	0.12	0.12			10.75

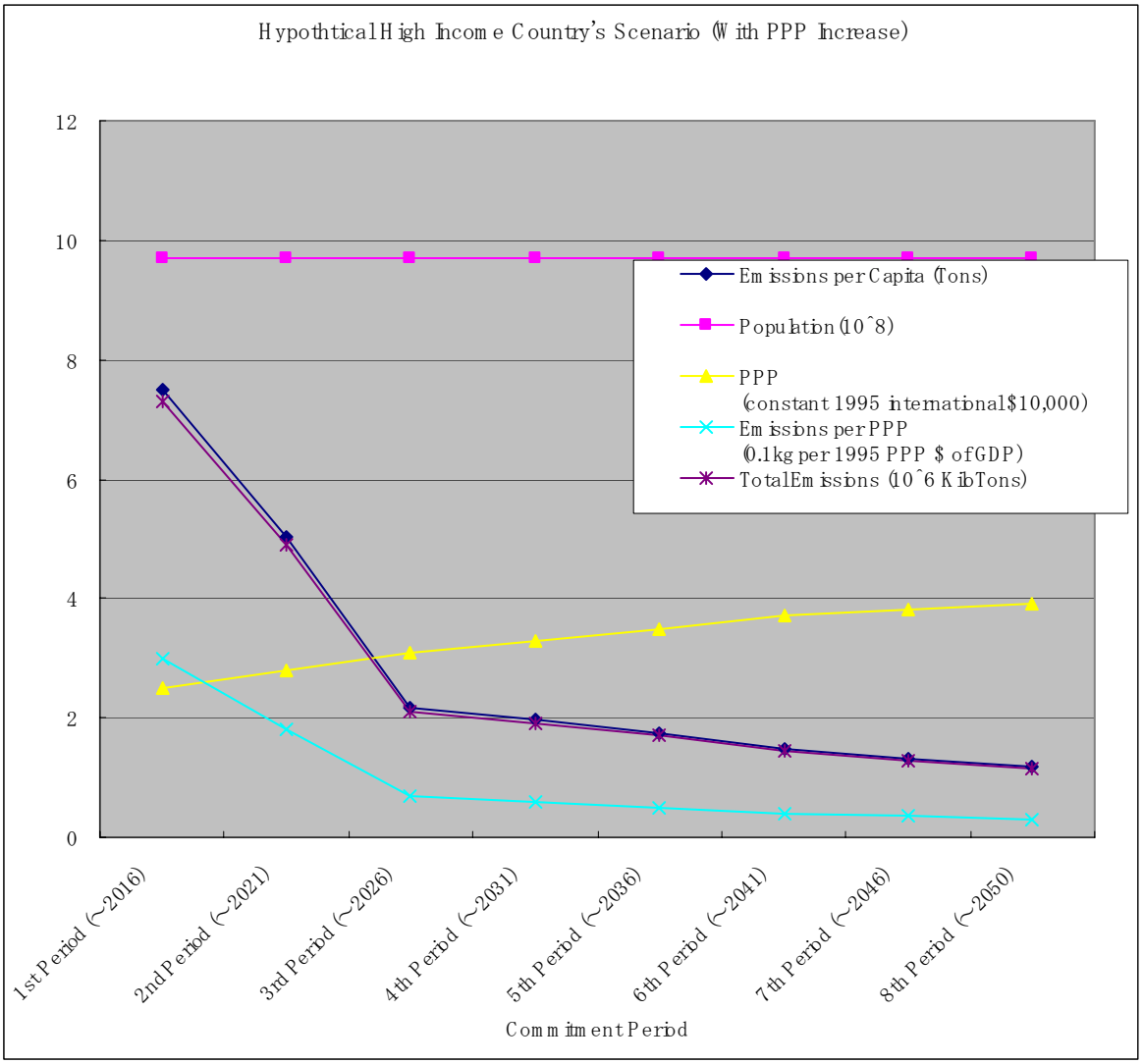


Rapid decrease in emissions per PPP enables reduction of the emissions per capita. The decrease in the period up to 2026 will need to be particularly drastic; a major transition in energy use will be required to reduce emissions by one fifth. During the fourth through eighth commitment periods, improvements in the new energy system will be relatively minor.

This proposal includes the assumption that no PPP increase will be impossible for the countries, particularly those of low and middle income, to accept. Thus PPP increases up to 1.5 times until 2050 have been considered in Figure 11 (Scenario H-2). Actual high income countries' PPP increase in the past from 1975 until 2000 was about $10,283 (from $14,448 to $24,731) according to World Bank data. Thus the assumption allowing about $15,000 of PPP increase is a reasonable target for a high-income country.

Figure 11. Hypothetical High Income Country's Presumed Plan with High PPP Increase (Scenario H-2)

	Year 2000	1st Period (~ 2016)	2nd Period (~ 2021)	3rd Period (~ 2026)	4th Period (~ 2031)	5th Period (~ 2036)	6th Period (~ 2041)	7th Period (~ 2046)	8th Period (~ 2050)		Average emissions per capita from 2011 to 2050 (Tons)	Total Emissions from 2011 to 2050 (10^7 KiloTons)
Emissions per Capita (Tons)	9.71	7.50	5.04	2.17	1.98	1.75	1.48	1.33	1.17		2.80	
Population(10^8)	12.36	9.71	9.71	9.71	9.71	9.71	9.71	9.71	9.71			
PPP (constant 1995 international $)	24730.92	25000.00	28000.00	31000.00	33000.00	35000.00	37000.00	38000.00	39000.00			
Emissions per PPP (kg per 1995 PPP $ of GDP)	0.490	0.300	0.180	0.070	0.060	0.050	0.040	0.035	0.030			
Total Emissions (10^7 KiloTons)	1.20	0.73	0.49	0.21	0.19	0.17	0.14	0.13	0.11			10.77



It is assumed that the rate of increase in PPP will gradually decline as 2050 approaches. In this case required improvement in emissions per PPP will be needed lower than in scenario H-1. In these examples, emission per PPP in scenario H-2 is 0.18 kg instead of 0.2 kg during the second commitment period. It should be reduced to 0.07, 0.06, 0.05, 0.04, 0.035, and 0.03 kg per PPP in each commitment period from the third to eighth periods as opposed to the reductions of 0.1, 0.075, 0.07, 0.06, 0.05, and 0.05 kg per PPP in scenario H-1. This means that the reductions per PPP in scenario H-2 will happen roughly ten years earlier than in scenario H-1. The difference between these two examples suggests that if a high-income country expects economic improvement, earlier and more significant reduction in emissions per PPP will be needed.

Figure 12 is the scenario for a hypothetical middle-income country with high PPP increases (scenario M-2). To obtain an agreement for the new treaty from middle-income countries, it should be assumed that their PPP will catch up with that demonstrated in the high income country scenario H-2. In this case, similar to the other scenarios, the population assumption is derived from Exhibit 7 and it is assumed that the increase rate of PPP will gradually become more gradual over time until 2050. PPP will finally catch up with the PPP of H-2--about $39,000 in year 2050.

With these assumptions, average emissions per capita from 2011 to 2050 can be brought below 2.8 tons (2.73 tons in this case) emissions per PPP for each commitment, as shown Figure12. Notice that the emissions per PPP from the third period until the eighth period are exactly the same as the emissions per PPP from the first period until the sixth period in scenario H-2, which are: 0.3, 0.18, 0.07, 0.06, 0.05, and 0.04 kg per PPP. This scenario includes a ten-year delay in improvements in emissions per PPP during which technology and energy-efficient social systems are transferred from the high-income country to the middle-income country.

Figure 13 is a scenario for a hypothetical low-income country; the assumptions are similar to those for the middle-income country scenario. This scenario is based on a high PPP increase (scenario L-2). In this case, it is assumed that the increased rate of PPP will gradually slow as the year 2050 approaches. Finally, it will almost catch up with the PPP of H-2--about $39,000 at 2050. With these assumptions, to bring the average emissions per capita below than 2.8 tons (2.55 tons in this case) during the period 2011 to 2050, emissions per PPP for each commitment period are as shown. Notice that the emissions per PPP from the third period until the eighth period are exactly the same as those from the first period until the sixth period in scenario H-2, which are 0.3, 0.18, 0.07, 0.06, 0.05, and 0.04 kg per PPP. Again, a ten-year delay to improvements in emissions per PPP is allowed for technological and capacity transfer. However, no delay is allowed for technology transfer from middle- to low-income countries.

Figure 12. Hypothetical Middle Income Country's Presumed Plan with High PPP Increase (Scenario M-2)

	Year 2000	1st Period (~2016)	2nd Period (~2021)	3rd Period (~2026)	4th Period (~2031)	5th Period (~2036)	6th Period (~2041)	7th Period (~2046)	8th Period (~2050)		Average emissions per capita from 2011 to 2050 (Tons)	Total Emissions from 2011 to 2050 (10^7 KibTons)
Emissions per Capita (Tons)	3.386033	3.51	4.51	4.01	3.37	1.70	1.77	1.77	1.55		2.73	
Population (10^8)	29.90	30.61	31.33	32.04	32.75	33.46	34.18	34.89	35.60			
PPP (constant 1995 international$)	4753.46	7626.56	10499.66	13372.76	18721.86	24338.42	29449.49	35339.39	38873.33			
Emissions per PPP (kg per 1995 PPP $ of GDP)	0.6944761	0.460	0.430	0.300	0.180	0.070	0.060	0.050	0.040			
Total Emissions (10^7 KibTons)	1.01	1.07	1.41	1.29	1.10	0.57	0.60	0.62	0.55			35.55

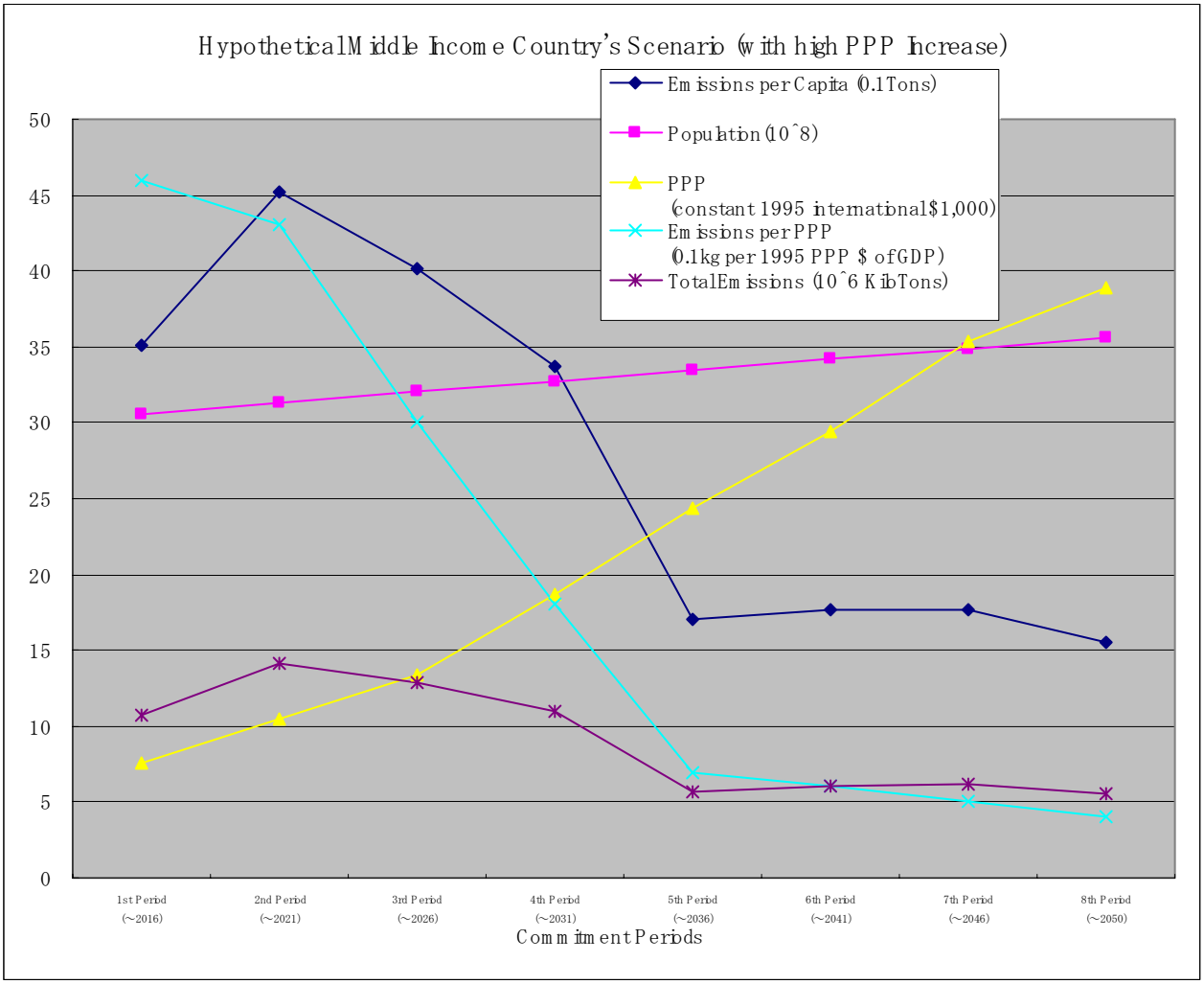
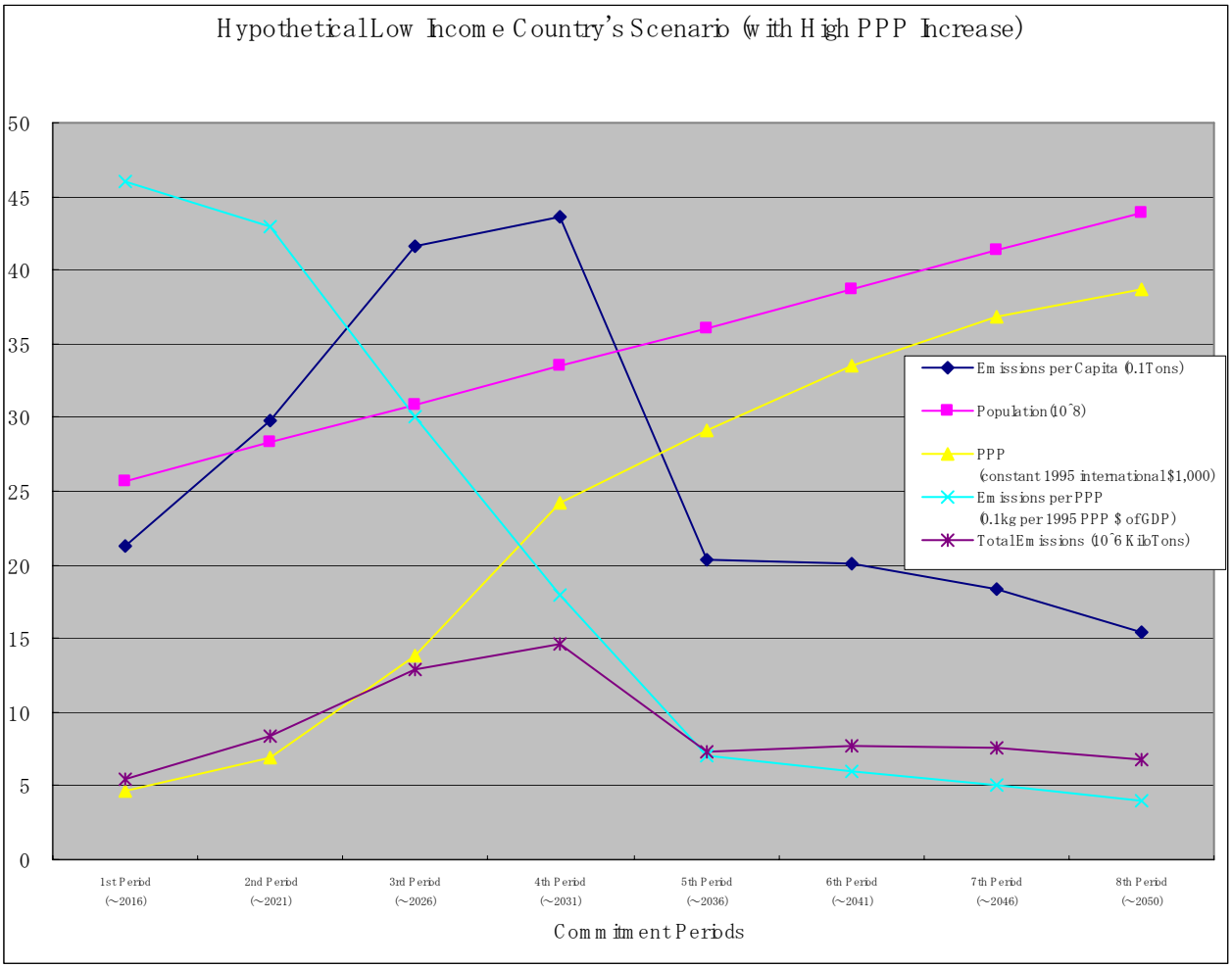


Figure 13. Hypothetical Low Income Country's Presumed Plan with High PPP Increase (Scenario L-2)

	Year 2000	1st Period (~2016)	2nd Period (~2021)	3rd Period (~2026)	4th Period (~2031)	5th Period (~2036)	6th Period (~2041)	7th Period (~2046)	8th Period (~2050)		Average emissions per capita from 2011 to 2050 (Tons)	Total Emissions from 2011 to 2050 (10^7 KiloTons)
Emissions per Capita (Tons)	0.8615444	2.12	2.98	4.16	4.36	2.04	2.01	1.84	1.55		2.55	
Population (10^8)	23.10	25.70	28.30	30.90	33.50	36.10	38.70	41.30	43.90			
PPP (constant 1995 international $)	1745.421	4618.52	6927.78	13855.56	24247.24	29096.68	33461.18	36807.30	38647.67			
Emissions per PPP (kg per 1995 PPP $ of GDP)	0.457769	0.460	0.430	0.300	0.180	0.070	0.060	0.050	0.040			
Total Emissions (10^7 KiloTons)	0.20	0.55	0.84	1.28	1.46	0.74	0.78	0.76	0.68			34.75



By 2050, rich countries may be assumed to have achieved 1.17 tons per capita and middle- and low-income countries 1.55 tons. Though the populations of low- and middle-income countries are expected to increase, total world emissions between 2011 and 2050 are expected to be much lower. This suggests that tentative targets for the second half of the century might be achieved by sustaining the emissions levels of 2050 throughout the period. This means that the most important period is that leading up to 2050. If emission-reduction targets are met, the burden of reductions will be much less in later years.

Findings from the Scenarios

These scenarios show, more or less, outlines for proposals for countries at each economic level, if the assumptions are correct. The scenarios assume an ideal situation in which total emissions, emissions per PPP, and emissions per capita are continuously reduced as we approach 2050. Also, PPPs of the countries were assumed reach a similar value, becoming stable around 2050. Considering past trends, actual population figures are likely to be very similar to those assumed in the scenarios. However, for low- and middle-income countries, assumptions about future PPP may be close to science fiction, when past performance is considered.

In general, the accuracy of a plan will depend on the difference between expectations and reality. Countries expecting to triple their recent PPP won't be satisfied with doubling it. However, these scenarios allow middle- and low-income countries to plan to double their economic growth in ten years as development accelerates. In 2004, Russia surprised the world by setting a very ambitious economic growth target of doubling their GDP by 2010 (NHK News 2004). In defense of the scenarios' figures for PPP, they truly mirror the ambitions of developing countries for their economic development.

One finding is remarkable: Despite the assumptions, scenario M-2 shows us that these countries can increase their total emissions until 2021; the level of total emissions can exceed those of 2000 until 2031. They can also increase emissions per capita until 2021, and exceed 2000 levels until 2031. In the scenario L-2, they can increase their total emissions until 2031, and the level of the total emissions can exceed 2000 levels until 2050. They can also increase their emissions per capita until 2031, and the 2000 level of the emissions per capita until 2050. As low- and middle-income countries now consider themselves committed to reducing emissions in the Kyoto Protocol's second commitment period, these tendencies show that a new treaty aimed specifically at long-term emissions may be more palatable to them than the Kyoto Protocol.

When population and affluence (PPP) are fixed in the scenarios, the keys to achievement are technological improvements that make the emissions per PPP reduction possible. Function 10 reflects a relationship suggested by Ehrlich and Holdren (1971):

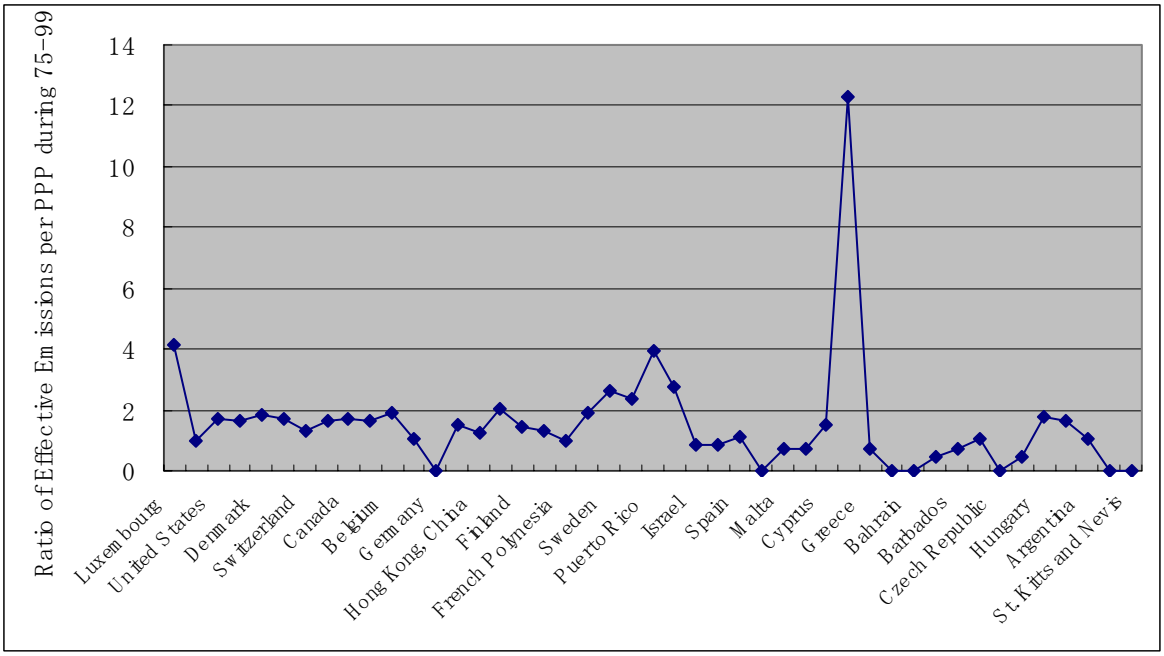
I = PAT
where
I = impact (tones of carbon)
P = population (number of persons)
A = affluence ($ GDP / person)
T = technology (tones of carbon/ $GDP) '
(Function 10)

Because technology-transfer is so important, the most significant and urgent issue is the establishment of highly improved energy efficiency in the industrialized countries. According to scenario H-2, a high-income country will need to improve its CO_2 per PPP by a factor of ten by 2050. During the 25 years from 1975 to 1999, only one of the rich countries, the Commonwealth of the Bahamas, improved its emissions efficiency to this degree. Only two rich countries, Puerto Rico and Luxembourg, were able to improve by a factor of four

during the period. Almost all the other countries were unable to achieve less than double the improved efficiency during this period.

For this reason, the targets of a plan relying this heavily on technological improvement will be very difficult to achieve. Applying the supplementary function of "Reduction Efforts in the Past" suggested by Function 11 will enable countries that begin efforts early to benefit from competition. Technology development will be most effective if it occurs during the first 20 years of the treaty. The next step will be the transfer of the technologies and the appropriate social support systems to the developing countries as quickly as possible.

Figure 14a. Improvement in CO_2 Emissions per PPP of Rich Countries from 1975 to 1999



Source: The World Bank Group. *WDI Online* accessed November 13, 2004. Available from http://80-devdata.worldbank.org.ezproxy.library.tufts.edu/dataonline/.

Negotiating the New Treaty

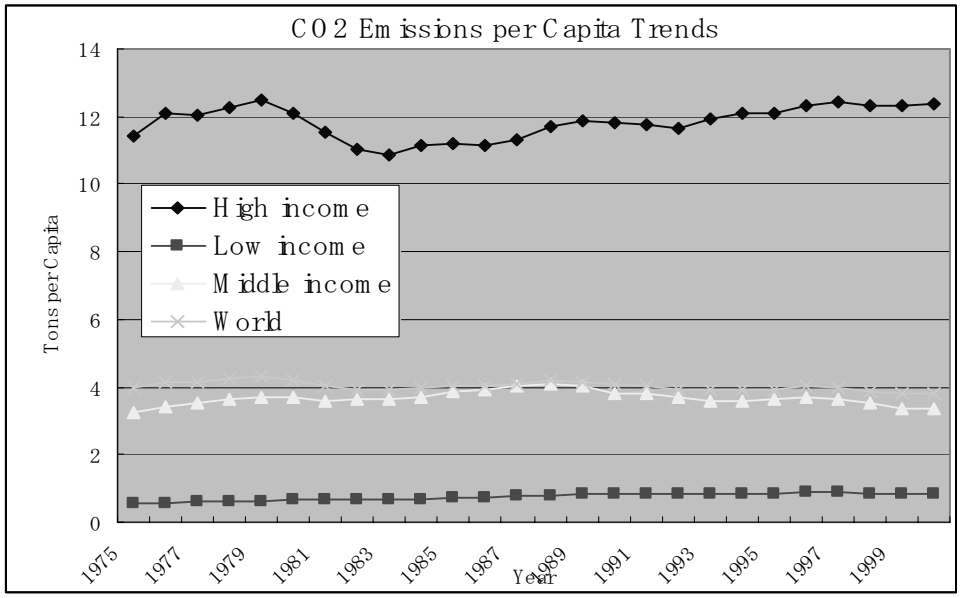
The first steps in establishing a new regime is to identify the important players and to determine which of them is likely to support or oppose the treaty.

Key Players

In this case, the important players fall into four categories that will be particularly affected:

- Countries that now emit the most CO_2,
- Countries that will emit the most CO_2 in 2050,
- Currently richest countries (High PPP countries), and
- Countries that now have high CO_2 emissions per capita.

Figure 14b. CO_2 Emissions per capita Trends



Note: The "World" line is barely visible on this graph in the printed volume; it runs roughly parallel to the "Middle income" line. See the on-line version of this volume for a full-color version of this graph.

Top CO_2-emitting countries will have strong interests in this treaty negotiation because it might have huge impacts on their emissions pattern and their social structures. Figure 15 shows these countries. The USA is by far the largest emitter, followed by China and Russia. Total emissions by the top 24 countries comprise more than 75 percent of the world's emissions.

Countries that will be the top emitters of CO_2 in 2050 should have about the same population, assuming that world PPP is equitable in 2050 and that the emissions per capita will be very similar. The most populous countries are shown in Figure 15; India is predicted to have the largest population in 2050 followed by China and the USA. The top 29 countries will have 75 percent of the world population in 2050, and thus a huge potential for CO_2 emissions by that time.

The current richest countries will also try to be deeply involved in the negotiation because the scenarios suggest that high-income countries will need to reduce CO_2 emissions per PPP drastically at first. The reduction needed will be so rapid that it will affect the very social structure itself. Countries with a PPP higher than $20,000 (constant 1995 international $) are shown in Figure 15. The top country is Luxembourg, followed by Norway and the USA.

Figure 15: Countries Involved in the Negotiation

Country	Recent CO2 Emissions (Top 24)	Population in 2050 (Top 29)	High PPP Countries (Top 21)	High CO2 per Capita (Top 26)	Region
Congo (Kinshasa)		10			Africa (Central)
Ethiopia		9			Africa (East)
Tanzania		24			Africa (East)
Uganda		17			Africa (East)
Libya				18	Africa (North)
Egypt		12			Africa (North)
Sudan		29			Africa (North)
Nigeria		6			Africa (West)
Mexico	12	11			America (Central)
USA	1	3	3	6	America (North)
Canada	8		9	12	America (North)
Brazil		8			America (South)
Chile	19				America (South)
Colombia		25			America (South)
Peru	24				America (South)
Japan	4	15	14	25	Asia (East)
Hong Kong, China	21		20		Asia (East)
South Korea	10			26	Asia (East)
China	2	2			Asia (East)
Taiwan	15				Asia (East)
Singapore	20			11	Asia (South East)
Indonesia	14	5			Asia (South East)
Malaysia	17				Asia (South East)
Myanmar		27			Asia (South East)
Philippines	18	13			Asia (South East)
Thailand	16	22			Asia (South East)
Vietnam	22	14			Asia (South East)
Afghanistan		23			Asia (South/Central)
Bangladesh		7			Asia (South/Central)
India	5	1			Asia (South/Central)
Iran		16			Asia (South/Central)
Pakistan		4			Asia (South/Central)
Qatar				1	Asia (West)
Bahrain				3	Asia (West)
Kuwait				4	Asia (West)
United Arab Emirates				8	Asia (West)
Saudi Arabia				9	Asia (West)
Israel				20	Asia (West)
Turkey		19			Asia (West)
Yemen		20			Asia (West)
Puerto Rico			21		Caribbean
Trinidad and Tobago				5	Caribbean
Czech Republic				15	Europe (East)
Norway			2	16	Europe (North)
Denmark			4		Europe (North)
Ireland			6	17	Europe (North)
Iceland			7		Europe (North)
UK	7	26	17	23	Europe (North)
Finland			18	19	Europe (North)
Sweden			19		Europe (North)
Estonia				14	Europe (North)
Italy	9		16		Europe (South)
Luxembourg			1	7	Europe (West)
Switzerland			5		Europe (West)
Austria			8		Europe (West)
Netherlands			10	2	Europe (West)
Belgium			12	21	Europe (West)
Germany	6	21	13	24	Europe (West)
France	11	28	15		Europe (West)
Russia	3	18		22	Former Soviet Union
Palau				13	Micronesia
Australia	13		11	10	Oceania
New Zealand	23				Oceania

Group 1

Group 2

Group 3

Group 4

Source: Recent CO_2 emissions- Exhibit 17, Population in 2050- Exhibit 18, High PPP Countries and High CO_2 per Capita- The World Bank Group. WDI Online. Accessed November 13, 2004. Available from http://80-devdata.worldbank.org.ezproxy.library.tufts.edu/dataonline/.

Countries that have high CO_2 emissions per capita now will also try to be involved in the negotiation because they will have to reduce them once the treaty is ratified. The top countries in this category produced more than nine metric tons per capita in 2000. (See Figure 15.) The country with highest CO_2 emissions per capita is Qatar, followed by the Netherlands and Kuwait.

Figure 15 shows that only four countries in the world appear in all four categories: the USA, Japan, the United Kingdom, and Germany. Only four other countries appear in three of four categories: Canada, France, Russia, and Australia. Moreover, other than these eight, no country appears in both the categories of high population in 2050 and high CO_2 per capita. This means that countries will bring two different interests to the negotiation. Some will be concerned with the inevitable increase of energy demand as their populations increase; almost all of these are developing countries. Almost all the richest countries, except those in West Asia, will be concerned with high CO_2 per capita.

Regional Groups

Four distinct regional groups are apparent in Exhibit 15. Group 1 is comprised of African nations. Seven out of the eight countries appear in the high population category in 2050; only Libya appears in any other category. These countries need to find the energy resources to meet rapid increases in demand due to rising populations and anticipated development. They can easily recognize that their emissions will also rise if they do not take effective measures in the near future.

Group 2 includes some Southeast and South/Central Asian countries. Twelve of these have been among the top emitters recently, and 12 countries are also in the population category for 2050. The group includes two top potential emitters, India and China, which will have large populations by that time. Six countries of the 12 are developing counties that appear in both the categories of recent top emitters and population in 2050. They will also be under great pressure to come up with effective CO_2 control measures as their huge populations will expect economic development.

Group 3 includes the petroleum-producing countries of West Asia. Because of their abundant oil resources, they all emit high CO_2 per capita and do not seem to use resources in an efficient way. They might welcome a reduction in domestic consumption of resources that might be saved for export. However, their greatest concerns will revolve around being forced to reduce high CO_2 per capita which will require major changes in their energy supply and demand systems.

Group 4 includes the 17 European countries. Of these, 15 are rich countries and ten are in the high CO_2 per capita category.

Support and Opposition

The important question is who would support and who would oppose this new treaty. In the following discussion, the US will be deliberately omitted from either sides of coalitions because its climate change policy can change dramatically at each national election—a single long-term direction is too difficult to assume. Moreover, as the impact of US climate change policy is so strong, a mistaken assumption can make this whole consideration meaningless.

To prevail, a pro-treaty coalition must be overwhelming even without US support or even with US opposition.

Public officials usually do not like to make long-range commitments, such as 50 years, because of the uncertainties involved; they do not want to impose unreasonable future burdens on their countries. However, this treaty may be revised every five years in response to new science. Also, measures and plans for target achievement are entrusted to each country; each will be able to choose appropriate measures for itself..

Countries that will benefit from the treaty, or that would be in trouble without it, will obviously support it. The main function of the treaty is to achieve sustainable CO_2 emissions per capita in the sense of avoiding climate change. In the long-term perspective, countries that will be required to reduce CO_2 emissions are those that will have huge populations in the future. These societies need to establish effective energy systems to ease the impact of population increase while supporting economic development.

The objectives of this treaty are not to restrain population increases or stimulate economic development. In fact, the scenarios suggest that the lowering of CO_2 per PPP society in rich countries in the earlier period is the first prerequisite condition for success. Once this is achieved, a transfer of the technology and the organization of sufficient capacity to support it in developing countries within 20 years or so is the second prerequisite for success. Insofar as technology and capacity transfer to developing countries is economically feasible and agreed upon, Group 1 and Group 2 countries can support the new treaty.

To emphasize their voices, the seven counties in Africa involved in Group 1 become the coalition concerned about energy increases attendant on population increase (AFEP). East and South East Asian countries could organize a coalition (ASEP) with India and China at the center that would also involve Japan in representing those who need to reduce CO_2 per capita and also become less reliant on oil, natural gas, and coal imports. AFEP and the ASEP can cooperate to promote technology and social systems transfer from rich countries.

Which countries would oppose the new treaty? It is apparent that the countries with high CO_2 emissions per capita need to make great efforts to adjust their emissions to a long-term target. For this reason, the six countries on the list that are petroleum-producing countries in West Asia will strongly oppose the treaty. Ten countries out of the 26 that have high CO_2 emissions per capita are located in Europe, and eight out of the ten are rich countries. However, the 17 countries in Group 4 are all members of the EU (except Norway and Iceland), and the EU is now trying to establish a unified energy market in which grids will be connected and managed by an organized future plan. Moreover, the EU is already greatly concerned about CO_2 emissions from the energy industry and about its heavy reliance on imported fossil fuels. It already has a renewable energy target of 12 percent by 2010 (Ministry of Foreign Affairs, Japan accessed 2004).

These countries will almost certainly move forward together in a positive stance toward the treaty. The EU has been a strong driving force for the Kyoto Protocol to be ratified. Russia has ratified the Kyoto Protocol but with the proviso that it would reconsider its participation in 2013, the beginning of the second commitment period. This means that Russia might abandon the protocol after selling its CO_2 credit within the first commitment period

(Mainichi Shinbun 2004). The protocol includes no linkage between the first and second commitment periods and no objectives regarding total long-term emissions. The EU could take the lead in amending this weakness of Kyoto.

The United Nations (UN) will, of course, be involved in the negotiations. The Working Group on Water, Energy, Health, Agriculture and Biodiversity (WEHAB) of the World Summit on Sustainable Development pointed out that energy is one of the five key issues to consider when discussing challenges and opportunities (World Summit on Sustainable Development 2002). The Working Group noted the wide disparities in the level of energy consumption per person among countries and also the need for advanced energy efficiency and renewable energy promotion. Moreover, in the United Nations document on Millennium Development Goals, Goal 7, the "Ensure environmental sustainability" indicator (#27), notes energy use per PPP which is relevant to CO_2 emissions per PPP (World Bank Group accessed 2004). Thus this new treaty is consonant with other UN goals.

Setting Goals Consistent with Environmental Principles

Chapter 7 of *International Environmental Law* (Hunter, Salzman, and Zaelke 1998) outline the environmental principles that guide the formation of the hypothetical treaty. First, the basic concept of climate change mitigation may be derived from the *(1) Principle of Common Concern of Humankind* which "was first used in the environmental context in the 1992 Biodiversity and Climate Change Conventions." This principle is supported by the *(2) Obligation not to Cause Environmental Harm*, "a central principle in international environmental law." The principle of *(3) State Responsibility* will also support the treaty as it emphasizes the "responsibility to ensure that activities within [a country's] jurisdiction or control do not cause damage to the environment." The *(4) Principle of Intergenerational Equity* is based on a long-term view. The focus of this principle is "one of fairness, that present generations not leave future generations worse off by the choices we make today regarding development." In this sense, this principle encourages a mechanism in the new treaty that emphasizes efforts in the early stages of the treaty and also the responsibility of rich countries to establish highly energy-efficient societies. The mechanism to encourage and promise to transfer reliable technologies to developing countries and to help them build the social capacities to support the technologies corresponds to the principle of *(5) Common but Differentiated Responsibilities.* The *(6) Precautionary Principle* will also fit this new treaty because, while beginning with the currently best science, its targets will be revised in each commitment period based on evolving scientific evidence.

Relationships with other principles include: *(7) State Sovereignty* over natural resource exploitation in each state's territory. Long-term emissions targets do not conflict with this principle. The treaty allows each country to make its own plan and does not call for outside intervention in any country's reduction measures. Two main components of the principle of the *(8) Right to Develop* are that "sovereign states exercise control over their resources and the right to control their own economic, social and cultural development," and the right to enjoy "a certain minimum level of development." As shown in the scenarios, as far as the long-term target takes into account economic development and population increases in developing countries, the treaty will not interfere with this principle.

The new treaty does not seem to reinforce the principle that the *(9) Polluter and User Pay* for the use of natural resources. It is assumed that mechanisms of the treaty include economic

support for the establishment of highly energy-efficient societies in developed countries and also for the special treatment of petroleum-producing countries. As the GEF has "little confidence in the developing countries because its governance and agenda remains northern-dominated," controversy over this principle may arise.. The principle "states that the polluter should bear the expenses of preventing and controlling pollution to ensure that environment is in an acceptable state" (Najam and Page 2003).

In this case the polluter is a CO_2 emitter and the pollution is CO_2 emissions. CO_2 differs from other pollutants in that it is a by-product of the energy production and consumption which maintains a society. Thus, paying the expenses of preventing and controlling emissions requires a transition in the social system as well as in the energy supply system. When CO_2 emissions reduction is to be very significant, and some driving force is required to support the transition, there may be conflict over the polluter-pays principle.

Petroleum-producing countries can explore and use their own resources. The polluter-pays principle suggests these countries pay the cost to reduce their CO_2 emissions per capita by themselves. The involvement of these countries will be a symbol of a comprehensive alliance to fight for the reduction of CO_2 emissions per capita. For this special group, some compromise of the principle should be made. It will be necessary to provide some intergovernmental financial support for the transfer of new technology and social system development from the industrialized countries.

Bringing West Asia into the Coalition

Conflicts during the negotiation period are inevitable. As mentioned above, Group 3 countries will strongly oppose the new treaty. As their contributions to total world emissions will continue to be small, the coalition for the new treaty can try to ratify without their involvement. However, Qatar and Bahrain are the countries with the first and second highest CO_2 emissions per capita. As reduction in these figures is the main function of this new treaty, a coalition that does involve them will be an important example to others.

The pro-ratification coalition will need to propose some special treatment for these petroleum production countries in West Asia in order to establish a good relationship with them. Almost all of the main and supplementary functions of treaty mechanisms, such as CO_2 emissions per capita, reduction efforts in the past, effective usage of resources, and energy use per capita are disadvantageous for the countries in West Asia. There is no space for negotiation about these functions. The only supplementary function that might be compromised is that of total contribution of the lifetime-assessed evaluation of a country's energy-source portfolio converted into CO_2 emissions. For this function the coalition can add a proviso applicable only to countries that rely heavily on coal and oil exports. For example, these countries might be excused from emissions counts during the first two or three commitment periods.

Linkage is another way to involve these countries. The coalition can give them a proposal that compensates for economic damage done by losing profits from exporting oil. Even if the petroleum-producing countries do not want to be involved, the oil import reductions of the other countries can cause them great economic damage. It would be more advantageous for the West Asian countries to join the coalition and use the extension period to adjust to future reductions in oil export. Even after the treaty comes into force, the oil market will be

substantial because renewable sources will not supply all energy. Coalition involvement will help the West Asian countries maintain stable relationships with petroleum-importing countries. In addition, after the grace period ends, member states can expect technology and capacity transfer.

Building the Key Mechanisms

The first key to ratification is to establish a highly energy-efficient technology and social system in the rich countries in the first few decades. As suggested above, early efforts should be encouraged. The second key is the quick and reliable transfer of the technology and the capacity to implement it to middle- and low-income countries. Economic supports for CDM projects and stabilization of the price of CO_2 can support the transfer.

Early Incentives for the Rich Countries

To provide an even stronger support for ratification, appropriate UN agencies such as the joint institution of the United Nations Environmental Programme (UNEP)/United Nations Development Programme (UNDP)/GEF should be involved in the process from the beginning, although this will be very controversial. During the first decades of the regime, even rich countries will need some support. UN agencies should actively support these movements at first. The UN agencies must have control of all patents, concessions, and knowledge related the mechanism for capacity building in support of advanced technology. Countries cannot withhold or overcharge for these technologies and knowledge.

Competition between rich countries should be promoted. Some mechanism is needed to ensure that "first adopters" receive appropriate benefits, even if they are rich countries because the transition to energy efficiency will be extremely expensive. For example, the transition from coal and oil to natural gas will be a minimum requirement.[17] The cost of replacing all vehicles with hybrids will also be huge. If the UN agencies can help offset these initial costs during the first decade or so, the rich countries will soon be engaged in competition to become the front-running producers of the new technologies.

Developing Countries: Linkage with Development Aid

More than ever the most important issue for developing countries will be economic development and reduction of the economic gap between rich and poor countries. Linking this interest to the new treaty could be very effective (Susskind 1994). The coalition might be able to link economic development to CO_2 emissions reduction by setting a price for CO_2 to help developing countries that might be having difficulty increasing PPP as planned. In this case, while the price will not be decided by the market, it should be high enough to offset the remaining economic gap.

Let us go back to the scenarios and consider one example. Let us assume that $3 * 10^6$ kilo tons of trading would be needed by 2021 between a hypothetical high-income country and one middle- and one low-income country. Let us also assume that the PPPs in the hypothetical middle- and low-income countries would fall short by $3,000. Using estimated populations in the scenarios, the total economic shortfall in the middle-income country would be:

Function 10.

$3,000 per person ＊ 3,133 ＊10^6 (estimated population in 2021) = $ 9,399＊10^9

Similarly, the total shortfall in the low income country would be:

Function 11.

$3,000 per person ＊ 2,830 ＊10^6 (estimated population in 2021) = $ 8,490＊10^9

Thus the total shortfall for both countries combined would be $17,889＊$10^9$. When five percent of this shortfall is offset by CO_2 trading, the economics of the trade would be:

Function 12.

$17,889＊$10^9$ ＊ 0.05 = $894,450 ＊$10^6$

If the amount of traded CO_2 is assumed to be 3 ＊10^6 kilo tons, the unit price of CO_2 traded should be:

Function 13.

$894,450 ＊$10^6$ / 3 ＊10^9 tons = $ 298 per CO_2 ton

The right to emit the equivalent of one metric ton of carbon dioxide now sells for $3 to $8 (Progressive Policy Institute 2003). One report says that the permit price ($/tC) will be $54 (= $14.7 /t CO_2[18]) in the near future (Blanchard 2004). It is very difficult to evaluate the price of CO_2 for the year 2021 compared to the recent prices. While the market price is used for CO_2 trading, the price could fluctuate because of some event, such as the participation or secession of the US. If the coalition can establish a mechanism to stabilize the CO_2 trading price, developing countries should be more willing to be involved in the new treaty. They should be able to use their excess CO_2 emissions rights effectively to offset unfair economic development.

Conclusion

This paper shows that having a long-term emissions target can redeem flaws in a short-term emissions plan. Strategies that make long-term goal setting possible include having short-term commitment periods, encouragement of early efforts, and periodic revisions of targets using the newest scientific review provided by a reliable organizations. Mechanisms that will make such a scheme successful will allow countries the flexibility to address their own unique development conditions. Moreover, the commitments in the treaty can be revised as scientific uncertainties are resolved.

The hypothetical country scenarios suggested that highly energy-efficient social systems must be established in developed countries first. Developing countries should be allowed to increase their emissions for a few decades, but their ultimate success will depend on the smooth transfer of reliable systems from the developed countries. The time lag for the transfer will become shorter when faster economic development is desired: Sustainable economic development is tightly coupled to technological improvement.

The European Union (EU) can continue to support climate change mitigation by leading intergovernmental negotiation for the new treaty, while countries in Africa and Asia build supportive coalitions. This powerful combination can urge the establishment of new energy regimes in developed countries and appropriate transfer to developing countries. Linkage between involvement in the emissions-reduction coalition and eligibility for economic development support should be encouraged. Some additional special treatment for countries that rely on fossil-fuel production might be needed. These strategies and mechanisms for long-term climate change mitigation might also be applied to many other environmental and resource management problems.

Notes

1. The lifetime span is different from each country. For example, it will be 30-60 years in the United States.
2. Considering many international treaty require 10 or more years of negotiations to finalize, it does not seem realistic to plan to achieve international agreement by 2011. The example agreement discussed here could begin around 2015, depending on Kyoto's second commitment period negotiations which will begin in 2005.
3. In other words, this compares the ways in which countries efficiently consume fossil fuels that emit CO2.
4. The reduction rate should be considered to be the rate from earlier years such as 20-30 years ago. It will depend on data availability.
5. Tufts University, The Fletcher School, ILO L 223, *International Environmental Law*, lecture by Dr. Kilaparti Ramakrishna, November 1, 2004
6. The unit of the total energy use can be converted into a general unit such as kg of oil equivalent per capita.
7. The procedure to set this value will be explained in a later section of the paper.
8. Evaluation or estimation for countries for which data are unavailable should be done by the IPCC or equivalent organization.
9. The Ministry of Agriculture, Forestry and Fisheries of Japan, *Biomass Nippon Strategy,* December 27, 2002, (accessed August 4, 2004); available from http://www.maff.go.jp/biomass/eng/biomass_honbun.htm.

> *Since the CO2 gas released through burning biomass is the CO_2 which was actually once absorbed from the atmosphere for photosynthesis by organisms during the process of their growth, the biomass has this characteristic, namely, that it does not ultimately increase the amount of CO_2 in the atmosphere throughout the human life cycle; herein called "carbon neutral." Therefore, we can expect the replacement of energy and products derived from fossil fuels with biomass to greatly contribute to the reduction of CO_2.*

10. Massachusetts Institute of Technology, MIT – 11.364 and Tufts University, The Fletcher School, DHP P 251, *International Environmental Negotiation*, Guest Lecture by Dr. Henrik Selin, October 26, 2004.
11. It seems to be around 1-2 Cº increase until 2100 in the report of 2001.
12. Personal Interview with Professor William Moomaw, November 16, 2004.
13. Examples will be shown in the section on scenarios.
14. The period of 20-30 years is proposed here to allow enough time for capacity building and power plant replacement. However, this estimation is showing the period which can be assumed at this point. Thus, this period can be also revised by the IPCC or equivalent organization reflecting the rate of capacity-building in the future.

15. As all of the scenarios in the IPCC reports assume continuous increase in CO_2 emissions, total emissions will be larger than this amount of emissions in their scenarios. In this sense, this target is very ambitious.
16. In this paper, a common target of 2.8 ton per capita for all the hypothetical countries was set for simplification. However, in the actual negotiation stage, different targets might be considered depending on each country's economic development. In fact, the scenarios show that developed countries will have greater difficulty achieving their targets.
17. If the rich countries buy up available natural gas and thus raise its price, the developing countries will suffer. This potential situation should be carefully monitored during the transition process.
18. As weight ratio between C and CO_2 is 12: 44, \$54 * 12 / 44 = \$ 14.7

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