How Consistent are Alternative Short-Term Climate Policies with Long-Term Goals?

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NOTA DI LAVORO 157.2004

DECEMBER 2004

CCMP – Climate Change Modelling and Policy

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Summary

Choosing long-term goals is a key issue in the climate policy agenda. Targets should be easily measurable and feasible, but also effective in damage control. Once goals are set globally, given the uncertainty affecting long-term strategies and region-specific preferences for different policy instruments, policies will be better represented by a diversified portfolio to be revised over time, rather than "once and forever" decisions. It therefore becomes crucial to understand to what extent different strategies (or policy portfolios) are consistent with long-term targets, that is, when they imply emission paths which do not irreversibly diverge from globally set goals. The present paper aims to investigate emission paths implied by plausible policy scenarios against those derived by imposing alternative long-term targets, comparing, for example, differences in peak periods. Plausible policy scenarios are for instance Kyoto-type targets with or without participation by the U.S. and/or by developing countries. Different long-term targets considered focus on stabilisation of CO_2 concentrations, radiative forcing and the increase in atmospheric temperature relative to pre-industrial levels. In order to account for the uncertainty surrounding the climate cycle, for each long-term goal multiple paths of emission - the most probable, the optimistic and the pessimistic ones - are considered in the comparison exercise. Comparative analysis is performed using a newly developed version of the FEEM-RICE model, a regional economy-climate model of optimal economic growth which is based on Nordhaus and Boyer's RICE model crucially extended in order to account for induced technical change. In particular, both carbon and energy intensity are affected by a new endogenous variable – Technical Progress – which captures both the role of Learning by Researching and of Learning by Doing. These are in turn determined by the optimal levels of Research and Development and of Emission Abatement.

Keywords: Climate policy, Long-term climate targets, Climate sensitivity uncertainty, Capping radiative forcing

JEL Classification: H0, H2, H3

This paper is part of the research work being carried out by the Climate Change Modelling and Policy Research Programme at Fondazione Eni Enrico Mattei. We acknowledge the financial support of the European Commission, DG Research, Environment and Sustainable Development Programme, within the project NEMESIS-ETC - New Econometric Model for Environment and Strategies Implementation for Sustainable development / Endogenous Technical Change.

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1. Introduction

Goals are for the long run, policies for the short run. Goals relate to what we should do, policies more often than not relate to what we can do. In their implementation process policies often are subject to various constraints imposed by policy making, goals are more easily set. In the case of climate change this general statement is especially relevant and acute. Evidence has been accumulating on the need to take action against the effects of climate change. The policies envisaged by the Kyoto Protocol during the first commitment period 2008-2012 are a major example. At the same time, because of the long time horizon over which climate change displays its effects, goals are set in the distant future. Indeed, no reference to goals in terms of, say, temperature, radiative forcing, concentrations, is made in the Kyoto protocol itself.

Alternative goals can be stated and proposed just like alternative policy portfolios may be conceived and suggested. Most, if not all, of these have been subject to study. However, a clearly relevant issue is how congruent policy packages and goals are with each other. And this is an issue much less studied. One of the few exceptions is represented by the present paper. In it we try to get some insights on how short term policies, which are strongly connected with the actual socio-political scenario and economic constraints binding abatement expenditures, are related with long-term goals, which are generally proposed by the scientific community being more concerned with the importance of immediate unconditional GHGs abatement.

The analysis conducted here is based on the FEEM-RICE model, a multi-region optimal growth model incorporating a climate module: with it we investigate the magnitude of anthropogenic emissions over time when different climate policies, such as those of the

Kyoto Protocol, are adopted. Those emission paths are then compared with emissions deriving from scenarios where global targets, such as a constraint on global temperature, radiative forcing or on atmospheric carbon concentrations, have been imposed. The main reason for this exercise is that uncertainty surrounding the climate change cycle makes it very hard for the scientific community to agree upon an “acceptable” level of greenhouse gas concentrations: see, for example, Schneider (2001). This implies that the main policy objective should be to keep human activities on a reversible path of emissions which leaves open future options to stabilize concentration to some “secure” level. “*It is obvious that no ‘once forever’ solution exists (...) the most promising approach to climate policy is sequential decision making (...) Short term strategies are then crafted so that both GHG emissions and the underlying socio-economic processes (resource use, technologies) evolve in a direction which makes future course corrections in any direction the least expensive.*” (Toth and Mwandosya, 2001)

Because uncertainty is central to the problem of reconciling policies and goals, in the paper we also explicitly tackle the issue of how uncertainty affects the most critical model parameters through sensitivity analysis. In particular, long-term goal scenarios are simulated for different values of a few key FEEM-RICE parameters which define the climate sensitivity to a doubling of carbon atmospheric concentration and the carbon rate of retention in the atmosphere.

In general the simulation results appear to suggest that some policy action should take place not too late for the short term policy scenarios we have identified to be compatible with our chosen long term targets. In particular, it is to be noted that the Kyoto regime soon to start appears to be on a compatible emission path, at least up to the second commitment period. Zooming in on the first half of the simulation period, we find that the most stringent targets for concentrations and temperature reduction are clearly out of reach of any policy that could be decided for the first commitment period. In addition, the Kyoto scenario during the first commitment period turns out to actually be below the 550 ppmV stabilization target. This is however not so if we adopt a 2.5^{o}C temperature reduction as our final target. Looking at the uncertainty affecting the climate parameters of the model, it clearly emerges that if they take on a pessimistic value, then we are gravely underestimating our mitigation efforts. This is not so however in the most probable situation and even more so in the optimistic case. In particular the Kyoto scenario, with which we are especially concerned, is compatible, or actually below, both the most probable and optimistic 550 ppmV concentrations targets. Instead, when we look at temperature the Kyoto policy is in 2035 below the optimistic case but above the most probable situation.

The rest of the paper is organized as follows. Section 2 summarizes and compares advantages and disadvantages of alternative targets. Section 3 sketches the FEEM-RICE model and describes the treatment of induced technical change, a fundamental ingredient of climate-economy models for long term analysis. Section 4 presents the results.

2. Comparison of Alternative Targets

The climate change cycle represented in Figure 1 consists of earlier stages, namely human and natural activities producing greenhouse gasses emissions, and final stages, namely the damage feedback effect, both on human activity and on the ecosystems. It is possible to consider constraints and targets on each of these different phases of the cycle. Different targets present advantages and shortcomings as thoroughly discussed by, for instance, Pershing and Tudela (2003).

In general, focusing on earlier stages (such as production or emissions) means having more precise information on what the required effort should be, but it may not produce effectively the desired effects, mainly because of the loose relationship between actions and climate impacts. The reverse is true for targets imposed on later stages.

The IPCC conventionally has concentrated its attention on the earlier phases of the cycle, namely by imposing constraints on atmospheric emissions of tons of greenhouse gasses or on emission intensity (emissions per unit of output), (see IPCC, 2001). Targets on emissions are relatively easy to identify, to implement and to measure. However, given a certain level of emissions through time, resulting concentrations of gasses in different layers of the atmosphere are extremely uncertain and, consequently, it is hard to forecast how severe the final impacts on the climate system and on human activities are going to be. Indeed, each subsequent phase of the chain is highly characterized by uncertainty, thereby making accurate forecasts difficult and scarcely reliable. Nevertheless, targets on actual and future emissions allows to better understand who should undertake abatement efforts and when, thus providing clearer grounds for the international equity debate and climate negotiations among the parties.

Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) states that the goal is the “stabilization of greenhouse gases (GHGs) concentrations in the atmosphere”, thus moving the policy focus one step forward in the climate cycle. While Sarofim, Forest, Reiner and Reilly (2004) discuss whether separate concentration targets should be established for each GHG, Wigley, Richels and Edmonds (1996) discuss the issue of stabilizing carbon concentration in the atmosphere and what are the implications in terms of timing the necessary effort. Setting the control on concentrations implies a less immediate link between the desired goal and the necessary action, a fact that is also true in the cases of targets on radiative forcing or on the rate and magnitude of the change of atmospheric temperature. Many recent scientific studies have emphasized the need to go beyond GHGs atmospheric concentration targets and move forward in the climate cycle. Richels, Manne and Wigley (2004) discuss the issue of imposing a cap on temperature increase and the potential beneficial effect on treating relevant uncertainty, while Sarofim, Forest, Reiner and Reilly (2004) discuss the issue of stabilizing radiative forcing. The motivation for this is both scientific - a greater control on the climate phenomena effects might be attained - and policy oriented - these targets incorporate a greater deal of information and consideration which are critical for policy makers. Given the global nature of any climate policy and, therefore, of these targets, it becomes necessary to think of ways of accordingly distributing the effort (for example in terms of emission rights) among different countries, following some equity or efficiency criterion (e.g., on the basis of GDP per capita). For a detailed discussion on various participation incentives the reader is referred to Bosello, Buchner and Carraro (2003) and Buchner and Carraro (2003a; 2003b). Both in the case of atmospheric concentrations and of temperature complications in the measurement phase are absent. However, complications arise when actually trying to measure efforts relative to the defined targets.

Finally, as for targets at the final stages of the climate cycle, the major benefit would be that of having direct control on the amount of damage, which is exactly what a policy eventually would aim to control. The target could take the form of a limit on sea level rise, loss of ecosystems or of economic activities or some other identifiable indicators. Hence, a direct cost-benefit analysis of climate policy would be available. Two problems limit the applicability of this last approach. First, the current limited ability of quantifying damages. Second, the distance between the object under control (final impact) and the control itself grows even larger, thus making this approach, quite unlikely in terms of implementability.

For the just mentioned reasons, in this paper we concentrate our attention on investigating and comparing the first four categories of targets, namely different targets on emissions (which we will refer to also as short-term policy scenarios in order to emphasize their scarce connection with long-term objectives), on one side, and constraints on GHGs atmospheric concentrations, radiative forcing and increase in temperature (which we refer as long-term stabilization scenarios), on the other side.

3. The FEEM-RICE Model

The analysis of the issues discussed in the previous section is conducted by means of a numerical climate-economy model called FEEM-RICE. The FEEM-RICE model, which we briefly describe here, is an extended version of Nordhaus and Boyer (2000)'s RICE model. This is a Ramsey-Koopmans single sector optimal growth model suitably extended to incorporate the interactions between economic activities and climate. There is one such model for each of the eight macro regions into which the world is divided: USA, Other High Income countries (OHI), OECD Europe (Europe), Russia and Eastern European countries (REE), Middle Income countries (MI), Lower Middle Income countries (LMI), China (CHN), and Low Income countries (LI).[1]

Within each region a central planner chooses the optimal paths of two controls, fixed investment and carbon energy input, so as to maximize welfare, defined as the present value of per capita consumption. The value added, absorbed from production (net of climate change) according to a constant returns technology, is used for investment and consumption, after subtraction of energy spending. The technology is Cobb-Douglas and combines the

[1] The countries belonging to each one of the macro-regions above indicated are listed in Nordhaus and Boyer (2000). The aggregation in macro-regions does not account for the enlargement process which took place on 1st of May 2004.

inputs from capital, labor and carbon energy together with the level of technology. Population (taken to be equal to full employment) and technology levels grow over time in an exogenous fashion, whereas capital accumulation is governed by the optimal rate of investment.

The carbon-energy input is modeled as being the source of GHGs emissions in the production process, and cumulated emissions (i.e. concentrations) cause an increase in the worldwide temperature. To close the circle, global temperature (relative to pre-industrial levels) is responsible for the wedge between gross output and output net of climate change effects.

In FEEM-RICE each country plays a non-cooperative Nash game in a dynamic setting leading to an Open Loop Nash equilibrium. This is a situation where in each region the planner maximizes its utility subject to the individual resource and capital constraints and the climate module for a given emission production of all the other players.

The major innovation of the FEEM-RICE model is the endogenization of the process of technical change (TC hereafter). In many top-down climate-economy models technical progress has been often depicted as an exogenous process. This feature is also shared by the original RICE model in which the following production function (*n* indexes regions, *t* time periods) is specified:

$$(1)\qquad Q(n,t) = A(n,t)[K_F(n,t)^{1-\gamma-\alpha_n} CE(n,t)^{\alpha_n} L(n,t)^{\gamma}] - p_n^E CE(n,t)$$

where Q is output (gross of climate change effects), A the *exogenously given* level of technology, K_F, CE and L are the inputs from physical capital, carbon energy and labor, respectively, and p^E is the fossil fuel price. In addition, carbon emissions are proportional to carbon energy, that is:

(2) $E(n,t) = \varsigma(n,t)CE(n,t)$

where E is industrial CO_2 emissions, while ς is an idiosyncratic carbon intensity ratio which also *exogenously* declines over time.[2] In this way, Nordhaus and Boyer (2000) make the assumption of a gradual, costless improvement of the green technology gained by the agents as time passes.

We consider this treatment of TC as non satisfactory for a model designed to study issues related to climate change. In particular, the induced nature of the bulk of technical innovation should be recognized and consequently modeled. [3]

In FEEM-RICE we focus on two distinct sources of potential TC: the energy intensity of production and the carbon intensity of energy use. These two aspects allow us to address energy-saving as well as energy-switching issues. The main novelty of our new formulation hinges on a new variable, which we call (with poor inventive activity) Technical Progress, which accounts both Learning-by-Researching and Learning-by-Doing *at the same time*. We assume that innovation is brought about by R&D spending which contributes to the accumulation of the stock of existing knowledge. In addition to this Learning-by-Researching effect, the model accounts also for the effect of Learning-by-Doing, now modeled in terms of cumulated abatement efforts. Thus, Technical Progress *TP* is defined as follows:

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[2] Throughout the paper we will indifferently refer to 'environmental' technology or 'green' technology when mentioning the time-varying coefficient ς.

[3] The RICE model has been used by Nordhaus (2002) himself and by Popp (2003) to lay out a model of induced innovation brought about by R&D efforts. Both use the non-regional version of the model, called DICE.

(4) $TP(n,t) = f[ABAT(n,t), K_R(n,t)]$

The variable *TP* is conceived to affect both energy intensity (i.e., the quantity of carbon energy required to produce one unit of output) and carbon intensity (i.e., the level of carbonization of primarily used fuels). More specifically *TP* is formulated as a convex combination of the stocks of knowledge and abatement:

(5) $TP(n,t) = ABAT_S(n,t)^c K_R(n,t)^d$

where $K_R(n,t)$ is the stock of knowledge and $ABAT_S$ represents the stock of cumulated abatement, in turn defined as:

(6) $ABAT_S(n,t+1) = ABAT_F(n,t) + (1-\delta_A) ABAT_S(n,t)$

δ_A being the depreciation rate of cumulated experience and $ABAT_F$ the abatement flow. The stock of knowledge $K_R(n,t)$ instead accumulates in the usual fashion:

(7) $K_R(n,t+1) = R\&D(n,t) + (1-\delta_R) K_R(n,t)$

δ_R being the depreciation rate of knowledge.

How does the Technical progress affect the rest of the economy? As seen in equation (1), the factors of production are labour, physical capital and effective energy. Let us first consider the effect of technical progress on factor productivity (the energy intensity effect). In this case the production function is modified so that (1) is replaced by the following specification:

(1') $$Q(n,t) = A(n,t)[K_F(n,t)^{1-\alpha_n(TP)-\gamma} CE(n,t)^{\alpha_n(TP)} L(n,t)^{\gamma}] - p_e(n,t)CE(n,t)$$

where:

(8) $$\alpha_n = \alpha_n[TP(n,t)] = \frac{\beta_{1n}}{2 - \exp(-\beta_{0n}TP(n,t))}$$

and β_{0n} and β_{1n} are region specific parameters. Thus, an increase in the endogenously determined Technical Progress variable reduces – *ceteris paribus* – the output elasticity of the energy input. It is worth noting that the output technology in (1') also accounts for TC evolving exogenously.

Let us now turn to the effect of technical progress on the carbon intensity of energy consumption. As shown in (2) effective energy results from for both fossil fuels input use and (exogenous) TC in the energy sector. We postulate in this case that *TP* serves the purpose of reducing, *ceteris paribus,* the level of carbon emissions. More precisely:

(2') $$E(n,t) = h[CE(n,t), TP(n,t)] = \varsigma(n,t)\left[\frac{1}{2 - \exp(-\psi_n TP(n,t))}\right]CE(n,t),$$

Here an increase in *TP* reduces progressively the amount of emissions generated by a unit of fossil fuel consumed.

We finally recognize that R&D spending absorbs some resources, that is:

(9) $$Y(n,t) = C(n,t) + I(n,t) + R\&D(n,t) + p^{p}(t)NIP(n,t)$$

where *Y* is output net of climate change effects, *C* is consumption, *I* gross fixed capital formation, *R&D* research and development expenditures, p^{P} is the equilibrium price on the emissions rights, and *NIP* is the net quantity of permits demanded on the relative markets (when positive; otherwise, it just indicates the supplied quantity on the same market). In summary, our formulation introduces R&D as a further strategic variable of the model that contributes to output productivity. Knowledge is a substitute for experience, but both quantities are typically positive and therefore affect carbon and energy intensities.[4]

4. Simulations and Results

The FEEM-RICE has been used to simulate both policy and long-term stabilization scenarios, at the same time accounting for uncertainty on a few key parameters. In particular, four policy scenarios have been simulated, which are defined by alternative assumptions on the involvement of different areas of the world and different time frames. These are reported in Table 1.

[INSERT TABLE 1 ABOUT HERE]

Specifically, Scenario 1 is the business-as-usual projection, which is used as a benchmark for the evaluation of any other scenario. Scenario 2 represents the usual

[4] For an extensive description of the FEEM-RICE model the reader is referred to Bosetti, Carraro and Galeotti (2004). The issue of induced technical change is discussed at length in the same paper and in Carraro and Galeotti (2003). The appendix reports all model equations.

assumptions regarding the nearest future, while in Scenario 3 and 4 some kind of engagement for subsequent commitment periods is considered. After the U.S. announced its defection from the Kyoto Protocol in March 2001, the remaining Kyoto countries, EU and Japan, and - from October 2004 - Russia, participate in the Kyoto protocol. This is depicted in the "Kyoto Forever without U.S." (Scenario 2), where Annex B countries, except the U.S., have to comply with the Kyoto target in the first and in subsequent commitment periods. They are also allowed to trade emission permits in an international market, while the U.S. undertakes abatement efforts according to an energy intensity target. Specifically, this target specifies that the country must reduce its intensity ratio by 18% by 2010 relative to the 2000 level. The rest of the world has no constraints on emissions. As far as non-U.S. Annex B countries are concerned, "2020 Global Target" (Scenario 3) is close to Scenario 2. The U.S. observe the same reduction in terms of intensity target in 2010 and minus 10% with respect to Scenario 1 in the second and subsequent commitment periods. Developing countries adopt the same unconstrained Scenario 1 behavior in 2010 and 2020, while 10% reduction vis-à-vis the business-as-usual scenario is imposed from 2020 onwards. Finally, Scenario 4 differs from Scenario 1 only for the third commitment period, in which 2000 emission levels have to be achieved by all countries.

The long-term stabilization target scenarios we consider are summarized in Table 2.

[INSERT TABLE 2 ABOUT HERE]

The first set of constraints is on the level of aggregate atmospheric concentrations of CO_2, which range from 500 to 650 ppmV. The second set relates to the increase in atmospheric temperature above pre-industrial levels: here the range of maximum increases allowed goes from 2.3 to 3 degrees C. The reason why we consider multiple concentration and temperature targets derives from the open debate concerning what should be a "realistic" stabilization scenario. Nonetheless, for in depth analysis we have concentrated on stabilization levels of 550 ppmV for CO_2 concentrations and 2.5 degree C for temperature, which are considered as "appropriate target" by the IPCC (2001). In addition to these two scenarios, we have also simulated a radiative forcing stabilization scenario with a target of 4.5 watts per square meter.

The climate module included in the FEEM-RICE model is a very simplified three box cycle. Nevertheless, it roughly reproduces dynamic phenomena which are much more exhaustively detailed and precisely represented in physical-biogeochemical models (see for example the papers by Joos, Muller-Furstenberger, and Stephan, 1999, and Joos, Prentice, Sitch, Meyer, Hooss, Plattner, Gerber, and Hasselmann, 2001). What is generally recognised within this strand of climate literature is that the climate sensitivity parameter is extremely uncertain, it is known perhaps only to a factor of three or less; at the same time it plays a key role in determining final temperature changes (a detailed discussion on the role of the climate sensitivity parameter can be found in Caldeira, Jain, and Hoffert, 2003). Climate sensitivity is defined as the global mean climatological temperature change resulting from a doubling of atmospheric CO_2 content. In several papers the effect of changes in the value of the climate sensitivity parameter is investigated, as for example in Nordhaus and Popp (1997) or Gerlagh and van der Zwaan (2004). In the former paper the authors, investigating the effect of parameters uncertainty on model results, underline the importance of taking into account also other sources of uncertainty, such as uncertainty concerning the GHG atmospheric retention rate. The simplified climate model we use and which is linked to the economic module represents only the basic dynamics. In particular the climate system is represented as a multi-strata system, composed by an atmosphere stratum, an upper ocean and a lower-ocean stratum.[5] A parameter matrix represents the transition from one stratum to the other and the retention rate to each stratum. The GHG atmospheric retention rate represents the rate at which emissions are retained in the atmosphere stratum. Following these considerations, each of the long-term stabilization scenarios considered here have been simulated for a set of different values of these two parameters: the GHG–temperature sensitivity coefficient and the GHG-atmospheric retention rate. In particular, the scenarios considering a cap on temperature increases have been simulated letting the sensitivity parameter take on values 1.5, 2.5 and 4.5 degree C per CO_2 doubling, as these are commonly considered the most optimistic, probable and pessimistic potential realizations of the parameter. As far as the retention parameter is concerned, scenarios considering a cap on atmospheric concentrations have been simulated for a central value of 60.897, an upper value of 63 and lower value of 61.5.

We begin our presentation of the results with Figure 2 which displays global emissions when no constraints on emissions are imposed (Scenario 1) vis-à-vis the case of maximum emission levels compatible with a global cap on concentration of 550 ppmV. The figure also provides the reader with the regional detail as well the temporal evolution of emissions. The 550 ppmV target is the "standard" most usually considered in the literature. In this respect note that under this stabilization scenario abatement effort has been allocated among the different regions purely on the basis of economic efficiency, with no account for equity considerations. Comparing BaU and stabilization scenarios we see that appreciable differences in emissions start to be perceived only after 2075. Indeed, as reported in Table 3, that year is the turning point for emissions under the cap, while in the BaU they increase without limit. From the point of view of the regional disaggregation, most of the abatement effort is undertaken by the U.S. (and to a lesser extent by Low-Middle Income countries) after

[5] See equations (A9)-(A13) in the Appendix. The reader is referred to the description of the climate module in Nordhaus and Boyer (2000).

the turning point, whereas emissions of the remaining regions do not significantly decrease and those of China even increase.

[INSERT TABLE 3 ABOUT HERE]

The evidence presented in Figure 3 is central to this paper, in that it shows the emission paths corresponding to the various short term scenarios and to the long term goals. The picture appears to suggest that some policy action should take place not too late for the short term policy scenarios we have identified to be compatible with our chosen long term targets. Note that in the latter case we simply impose a cap at some future date without asking how economies would actually meet those targets. It is to be noted that the Kyoto regime soon to start appears to be on a compatible emission path, at least up to the second commitment period. At the last simulation period we find, as expected, that emissions must be lowest under a global temperature limit, relative to a radiative forcing ceiling and even more to a stabilization cap. Indeed, Table 3 shows that the turning point for emissions occurs much earlier in the case of a temperature ceiling, relative to the bound to radiative forcing and even more so relative to a cap to concentrations. Looking at short run policies, in 2105 emissions produced by a Kyoto (plus US intensity target) regime (Scenario 2) would be inferior only to the unconstrained ones. Interestingly emissions under Scenario 4 – a 2020 global cap – would be roughly similar to those produced under a 550 ppmV stabilization scenario.

Figure 4 and 5 zoom in on the first half of the simulation period, up until 2045, and focus on concentration and temperature long term targets, respectively. Can we in this case get a clue as to when policy action should be undertaken? And how coherent are such policies with concentration and temperature goals respectively? What emerges is a different story for the two targets. Firstly, the most stringent targets – 500 ppmV concentrations and 2.3^{o}C temperature reduction – are clearly out of reach of any policy that could be decided for the first commitment period. The second interesting finding is that the Kyoto scenario (Scenario 2) during the first commitment period is actually below the 550 ppmV stabilization target (and well below the 650 ppmV cap). This is however not so if we adopt a 2.5^{o}C temperature reduction as our final target. Emissions in this case start to progressively deviate after 2015 from all other paths. Scenario 2 remains compatible with a 3.0 degree reduction until 2010, while it deviates thereafter. A final remark is the notable fact that emissions under the Kyoto scenario 2 are coherent with a 650 ppmV stabilization target for the whole second simulation period that is from 2025 until 2105.

The last two pictures, Figure 6 and 7, relate to the uncertainty issue. They plot the emission paths produced by the four policy scenarios, together with those predicted by simulating just one long-term scenario. Also in this case we zoom in on the first, and more relevant, simulation period (up until 2035). This is a global target on atmospheric concentrations of CO_2 (550 ppmV) in Figure 6 and on temperature increase (2.5^{o}C) in Figure 7. In the two figures, however, we respectively consider different values of the previously mentioned key uncertain parameters. In this way we obtain a "most probable", an "optimistic" and a "pessimistic" concentrations or temperature stabilization scenarios. In both cases it clearly emerges that if the two parameters take on the corresponding pessimistic value, then we are gravely underestimating our mitigation efforts. This is not so however in the most probable situation and even more so in the optimistic case. Here we have some difference across the two parameters/targets. In particular the Kyoto scenario 2, with which we are especially concerned, is compatible, or actually below, both the most probable and optimistic 550 ppmV concentrations targets (see Figure 6). Instead, when we look at temperature and at the climate sensitivity parameter, the Kyoto policy is in 2035 below the optimistic case but above the most probable situation. This adverse effect takes place only after the last ten years, as Kyoto emissions were lower until 2025.

5. Concluding Remarks

Choosing long-term goals is a key issue in the climate policy agenda. Targets should be easily measurable and feasible, but also effective in damage control. Once goals are set globally, given the uncertainty affecting long-term strategies and region-specific preferences for different policy instruments, policies will be better represented by a diversified portfolio to be revised over time, rather than "once and forever" decisions. It therefore becomes crucial to understand to what extent different policy portfolios are consistent with long-term targets, that is, when they imply emission paths which do not irreversibly diverge from globally set goals.

In this paper we have investigated emission paths implied by plausible policy scenarios, such as Kyoto-type targets with or without participation by the U.S. and/or by developing countries, vis-à-vis different long-term targets on CO_2 concentrations, radiative forcing and the increase in atmospheric temperature relative to pre-industrial levels. Moreover, we have accounted for the uncertainty surrounding the climate cycle, by considering in the comparison exercise the most probable, optimistic and pessimistic value of a couple of key climate model parameters.

The analysis has been performed using a newly developed version of the FEEM-RICE model, a regional economy-climate model of optimal economic growth which is based on Nordhaus and Boyer (2000)'s RICE model, crucially extended in order to account for induced technical change. In particular, both carbon and energy intensity are affected by a new endogenous variable – Technical Progress – which captures both the role of Learning by

Researching and of Learning by Doing. These are in turn determined by the optimal levels of Research and Development and of Emission Abatement.

In general the simulation results appear to suggest that some policy action should take place not too late for the short term policy scenarios we have identified to be compatible with our chosen long term targets. In particular, it is to be noted that the Kyoto regime soon to start appears to be on a compatible emission path, at least up to the second commitment period. At the last simulation period we find, as expected, that emissions must be lowest under a global temperature limit, relative to a radiative forcing ceiling and even more to a stabilization cap. Zooming in on the first half of the simulation period, up until 2045, and focusing on concentration and temperature long term targets, respectively, we find that the most stringent targets – 500 ppmV concentrations and 2.3^{o}C temperature reduction – are clearly out of reach of any policy that could be decided for the first commitment period. In addition, the Kyoto scenario during the first commitment period turns out to actually be below the 550 ppmV stabilization target (and well below the 650 ppmV cap). This is however not so if we adopt a 2.5^{o}C temperature reduction as our final target. A notable fact is that emissions under the Kyoto scenario are coherent with a 650 ppmV stabilization target for the whole second simulation period that is from 2025 until 2105. Looking at the uncertainty affecting the climate parameters of the model, it clearly emerges that if they take on a pessimistic value, then we are gravely underestimating our mitigation efforts. This is not so however in the most probable situation and even more so in the optimistic case. In particular the Kyoto scenario, with which we are especially concerned, is compatible, or actually below, both the most probable and optimistic 550 ppmV concentrations targets. Instead, when we look at temperature the Kyoto policy is in 2035 below the optimistic case but above the most probable situation.

References

Bosetti, V., Carraro, C., and Galeotti, M. (2004) The Dynamics of Carbon and of Energy Intensity in a Model of Endogenous Technical Change. Fondazione Eni Enrico Mattei, **May**.

Bosello, F., Buchner, B. and Carraro, C. (2003) Can Equity Enhance Efficiency? Some Lessons from Climate Negotiations. *Journal of European Economic Association* **1**, 601-611.

Buchner, B. and Carraro, C. (2003a) China and the Evolution of the Present Climate Regime. *FEEM Working Paper* **103.03**, Milan.

Buchner, B. and Carraro, C. (2003b) Emissions Trading Regimes and Incentives to Participation in International Present Climate Agreements. *FEEM Working Paper* **104.03**, Milan.

Caldeira, K. Jain, A. T., Hoffert, M.I. (2003) Climate Sensitivity Uncertainty and the Need for Energy Without CO_2 Emission. *Science*, March **299**.

Carraro, C. and Galeotti, M. (2003) Does Endogenous Technical Change Make a Difference in Climate Change Policy Analysis? A Robustness Exercise with the FEEM-RICE Model. *Fondazione Eni Enrico Mattei*, October.

Gerlagh R., and van der Zwaan, B.C.C. (2004) A sensitivity analysis on timing and costs of greenhouse gas abatement, calculations with DEMETER. *Climatic Change* **65**, 39-71.

Gritsevskyi, A., Nakicenovic, N. (2000) Modelling uncertainty of induced technological change. *Energy Policy* **28**, 907-921.

Joos, F. Muller-Furstenberger, G. and Stephan G. (1999) Correcting the carbon cycle representation: how important is it for the economics of climate change?. *Environmental Modeling and Assessment* **4**, 133-140.

Joos, F. Prentice, I.C., Sitch, S., Meyer, R., Hooss, G., Plattner, G.-K. Gerber, S. and Hasselmann, K. (2001) Global warming feedbacks on terrestrial carbon up take under the Intergovernmental Panel on Climate change (IPCC) emission scenarios. *Global Biogeochemical Cycles* **15-4**, 891-907.

IPCC, Climate Change (2001) The Scientific Basis, Cubasch et al., Contribution of Working Group I the Third Assessment Report of the Intergovernmental Panel on Climate Change. Houghton et al. (eds.), Cambridge University Press, Cambridge, UK.

Nordhaus, W. D. and Popp, D. (1997) What is the value of Scientific Knowledge? An application to global warming using the PRICE Model. *The Energy Journal* **18-1**, 1-44.

Nordhaus, W. D. and Boyer, J. (2000) Warming the World: Economic Models of Global Warming, The MIT Press.

Nordhaus, W.D. (2002) Modeling Induced Innovation in Climate-Change Policy, in A. Grübler, N. Nakicenovic, and W.D. Nordhaus (eds.), *Technological Change and the Environment*, Washington D.C.; Resources for the Future Press, 182-209.

Popp, D. (2003) ENTICE: Endogenous Technological Change in the DICE Model of Global Warming, *Journal of Environmental Economics and Management* **48**, 742-768.

Pershing, J. and Tudela, F. (2003) A long-term target: framing the climate effort. *Working Draft Pew Center* **07**.

Richels, R.G., Manne, A. S. and Wigley, T. M. L. (2004) Moving beyond concentrations: the challenge of limiting temperature change. *AEI-Brookings Joint Center Working Paper* **04-11**.

Sarofim, M. C., Forest, C. E., Reiner, D. M., Reilly, J. M. (2004) Stabilization and global climate policy. *Working Paper MIT*. http://hdl.handle.net/1721.1/5423

Schneider, S. H. (2001) What is 'Dangerous' Climate Change?. *Nature*. **411**, 17-23.

Toth, F. and M. Mwandosya. (2001) Decision-Making Frameworks. In Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, B. Metz et al., eds. Cambridge: Cambridge University Press.

Wigley, T.M.L., Richels, R. and Edmonds, J.A. (1996) Economic and environmental choices in the stabilization of atmospheric CO2 concentrations. *Nature* **379**, 240-243.

Appendix: Model Equations

In this appendix we reproduce the equations that make up the original RICE model, including those that have been subsequently modified.

In each region, *n*, there is a social planner who maximizes the following utility function (*n* indexes the world's regions, *t* are 10-years time spans):

(A1) $$W_n = \sum_t U[C_n(t), L_n(t)]R(t) = \sum_t L_n(t)\{\log[c_n(t)]\}R(t)$$

where the pure time preference discount factor is given by:

(A2) $$R(t) = \prod_{v=0}^{t}[1+\rho(v)]^{-10}$$

and the pure rate of time preference $\rho(v)$ is assumed to decline over time.
The maximization problem is subject to:

(A3) $$Q_n(t) = \Omega_n(t)\{A_n(t)K_{nF}(t)^{1-\gamma-\alpha}L_n(t)^{\gamma}CE_n(t)^{\alpha} - p_n^E(t)CE_n(t)\}$$

(A4) $$c_n(t) = \frac{C_n(t)}{L_n(t)}$$

(A5) $$K_{nF}(t+1) = (1-\delta_K)K_{nF}(t) + I_n(t+1)$$

(A6) $$Q_n(t) = C_n(t) + I_n(t)$$

(A7) $$E_n(t) = \varsigma_n(t)CE_n(t)$$

(A8) $$p_n^E(t) = q(t) + markup_n^E$$

(A9) $$M_{AT}(t+1) = \sum_n [E_n(t) + LU_j(t)] + \phi_{11}M_{AT}(t) + \phi_{21}M_{UP}(t)$$

(A10) $$M_{UP}(t+1) = \phi_{22}M_{UP}(t) + \phi_{12}M_{AT}(t) + \phi_{32}M_{LO}(t)$$

(A11) $$M_{LO}(t+1) = \phi_{33}M_{LO}(t) + \phi_{23}M_{UP}(t)$$

(A12) $$F(t) = \eta\{\log[M_{AT}(t)/M_{AT}^{PI}] - \log(2)\} + O(t)$$

(A13) $$T(t+1) = T(t) + \sigma_1\{F(t+1) - \lambda T(t) - \sigma_2[T(t) - T_{LO}(t)]\}$$

(A14) $$\Omega_n(t) = \frac{1}{1+\left(\theta_{1,n}T(t) + \theta_{2,n}T(t)^2\right)}$$

List of variables:
W = welfare
U = instantaneous utility
C = consumption
c = per-capita consumption
L = population
R = discount factor
Q = production
Ω = damage
A = productivity or technology index
K_F = capital stock
CE = carbon energy
p^E = cost of carbon energy
I = fixed investment
E = carbon emissions

M_{AT} = atmospheric CO_2 concentrations
LU = land-use carbon emissions
M_{UP} = upper oceans/biosphere CO_2 concentrations
M_{LO} = lower oceans CO_2 concentrations
F = radiative forcing
T = temperature level
q = costs of extraction of industrial emissions

List of parameters:
α, γ = parameters of production function
δ_K = rate of depreciation of capital stock
ζ = exogenous technical change effect of energy on CO_2 emissions (carbon intensity)
$\phi_{11}, \phi_{12}, \phi_{21}, \phi_{22}, \phi_{23}, \phi_{32}, \phi_{33}$ = parameters of the carbon transition matrix
η = increase in radiative forcing due to doubling of CO_2 concentrations from pre-industrial levels
σ_1, σ_2 = temperature dynamics parameters
λ = climate sensitivity parameter
$markup^E_.$ = regional energy services markup
θ_1, θ_2 = parameters of the damage function
M_{AT}^{PI} = pre-industrial atmospheric CO_2 concentrations
O = increase in radiative forcing over pre-industrial levels due to exogenous anthropogenic causes
ρ = discount rate
T_{LO} = lower ocean temperature

Table 1: Summary of the Four Short Term Policy Scenarios

	2010	2020	from 2020 onwards
Scenario 1: "Business-as-usual"			
Annex B_{-US}	business-as-usual	business-as-usual	business-as-usual
U.S.	business-as-usual	business-as-usual	business-as-usual
Developing countries	business-as-usual	business-as-usual	business-as-usual
Scenario 2: "Kyoto Forever without US"			
Annex B_{-US}	Kyoto target: -5.2%	2010 level	2010 level
U.S.	-18% intensity target	business-as-usual	business-as-usual
Developing countries	business-as-usual	business-as-usual	business-as-usual
Scenario 3: "2020 Global Target"			
Annex B_{-US}	Kyoto target: -5.2%	2010 level	2010 level
U.S.	-18% intensity target	-10%	2020 level
Developing countries	business-as-usual	business-as-usual	-10%
Scenario 4: "2020 Global Cap on Emissions"			
Annex B_{-US}	business-as-usual	business-as-usual	2000 emissions
U.S.	business-as-usual	business-as-usual	
Developing countries	business-as-usual	business-as-usual	

Table 2: Summary of the Long Term Target Scenarios

Constraint	*Level*
Aggregate Atmospheric Concentrations of CO_2 (ppmv)	500
	550
	650
Atmospheric Temperature (degrees C above pre-industrial)	2,3°
	2,5°
	3°
Radiative Forcing (watts per square meter)	4.5

Table 3: Summary of the Turning Points for Emissions under Alternative Scenarios

Turning point	World
Scenario 1	Above 2105
Scenario 2	Above 2105
Scenario 3	2105
Scenario 4	2025
550 ppmv	2075
4.5 watt/m2	2055
2.5 deg C	2015

Figure 1: The Climate Change Cycle.

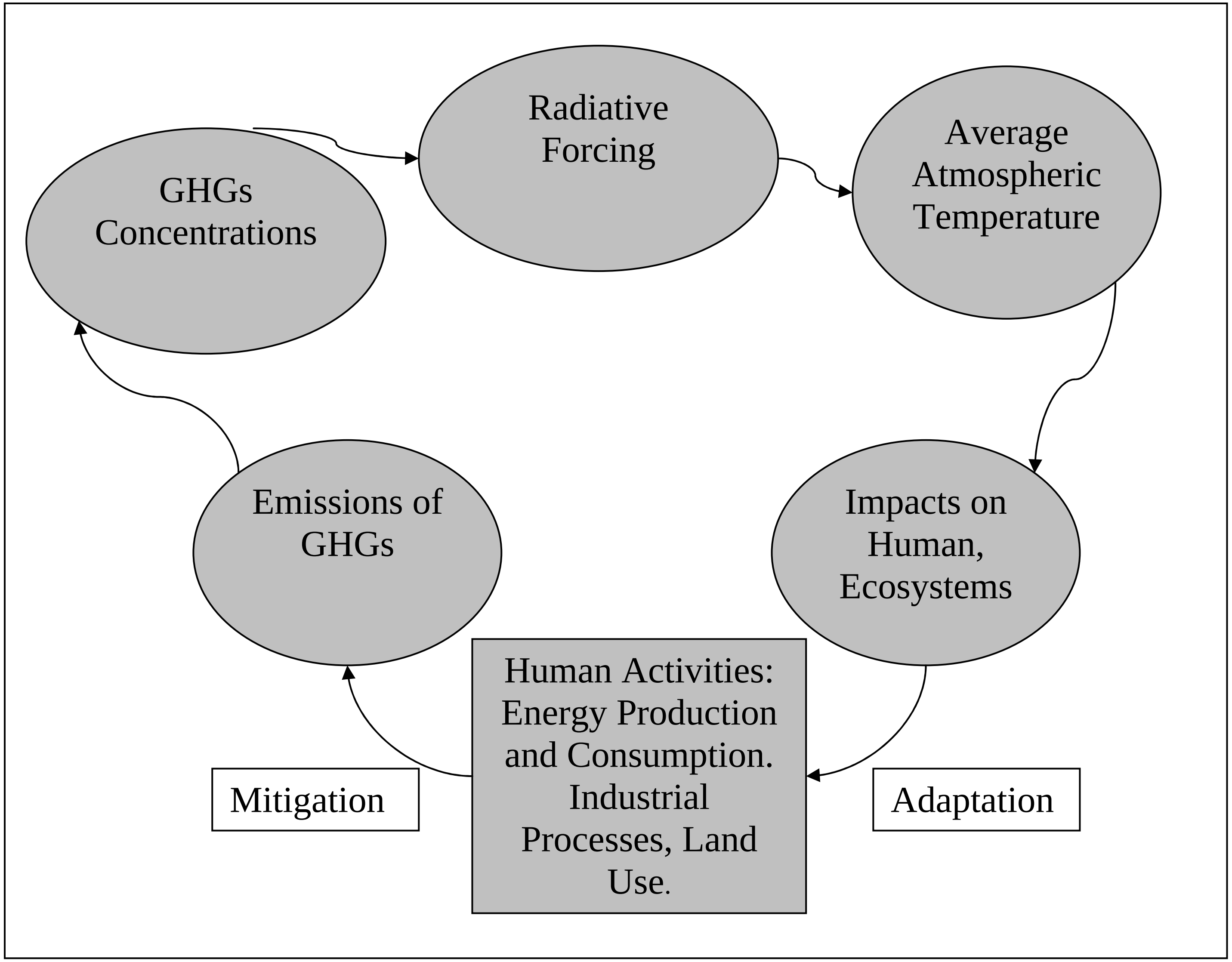


Figure 2: Carbon Emissions: BaU versus Stabilization at 550 ppmv Scenarios

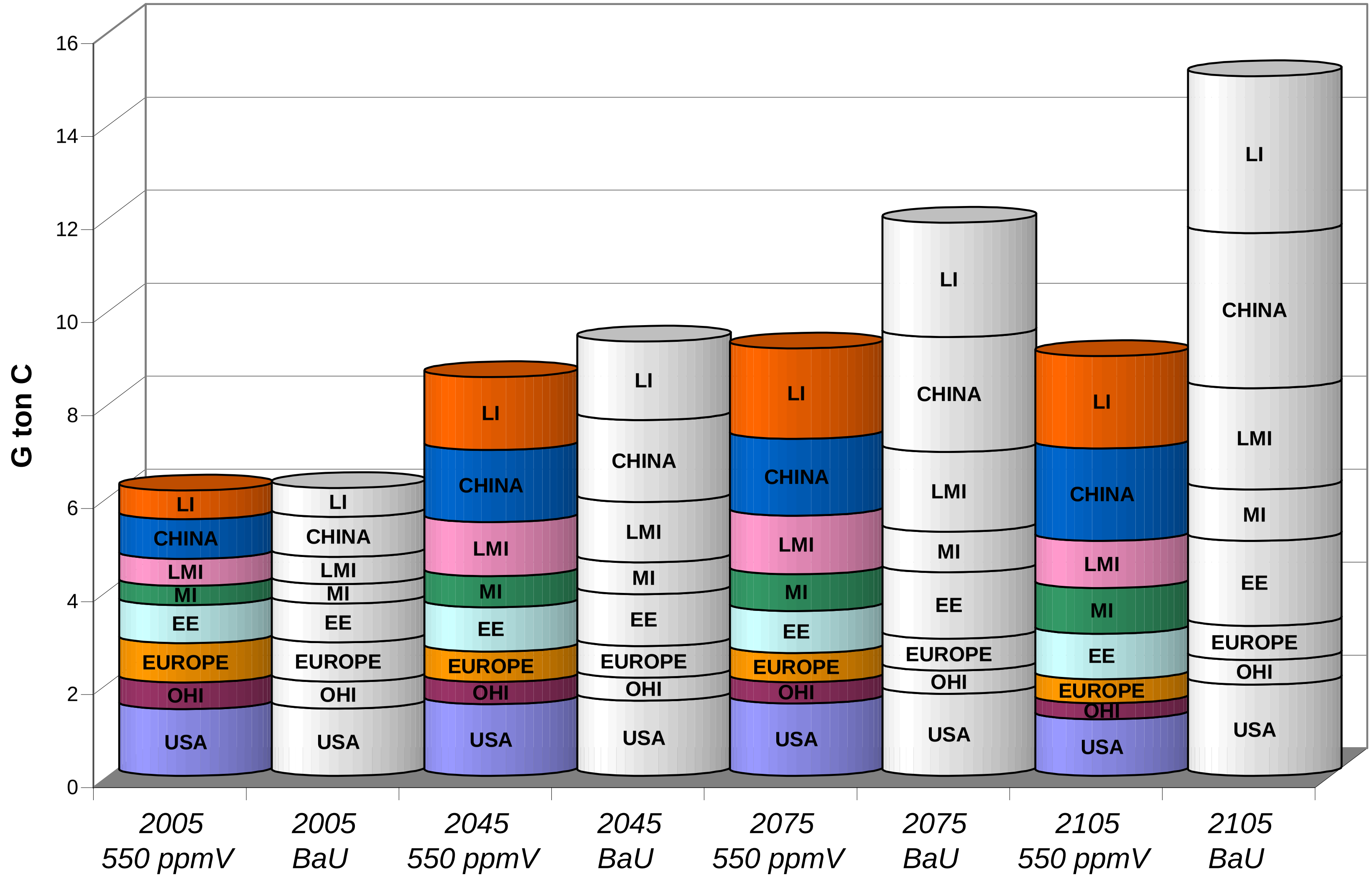


Figure 3: World Emission Paths for Short Term Policy Scenarios and Long Term Targets

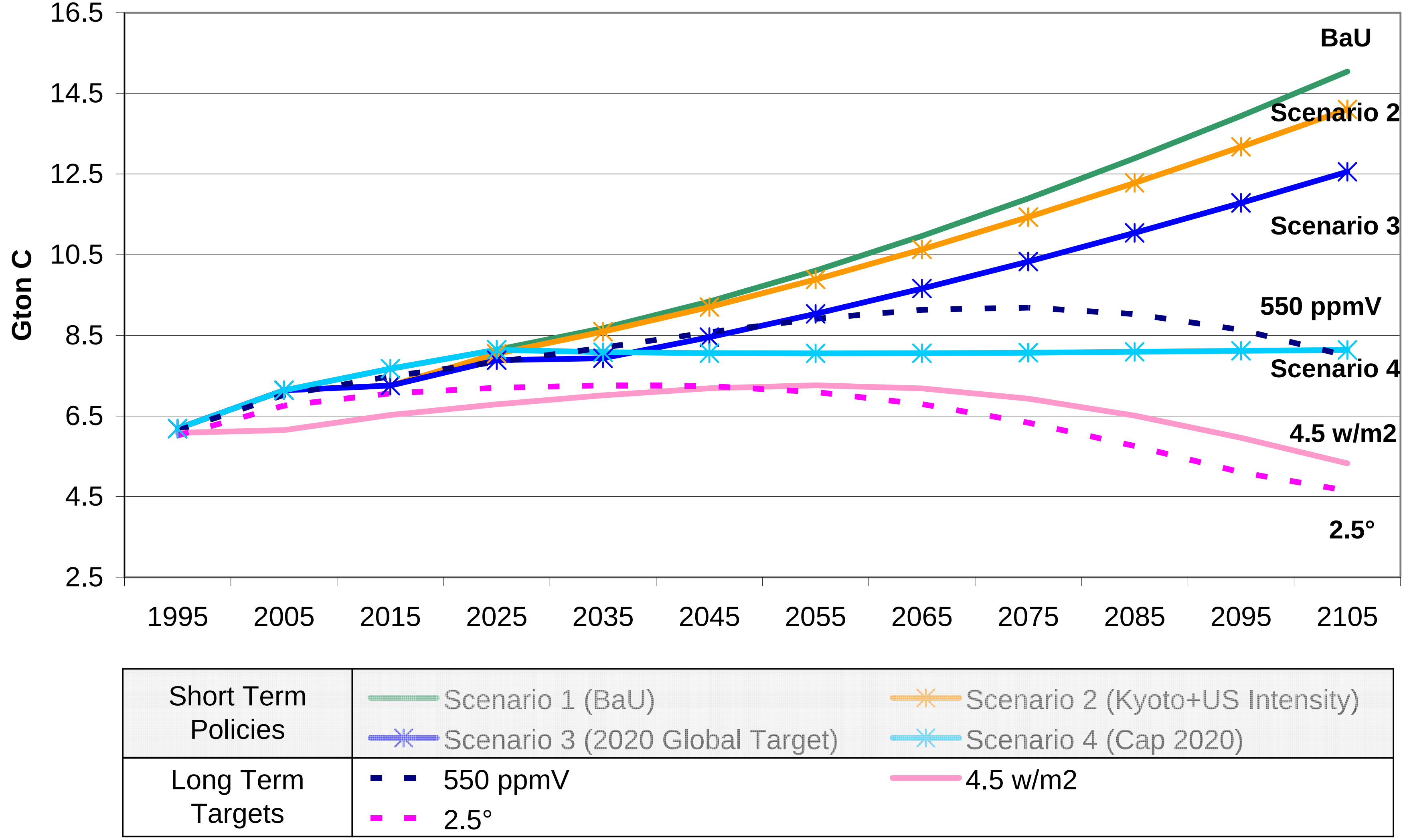


Figure 4: World Emission Paths for Short Term Policy and Stabilization of CO2 Concentration Scenarios

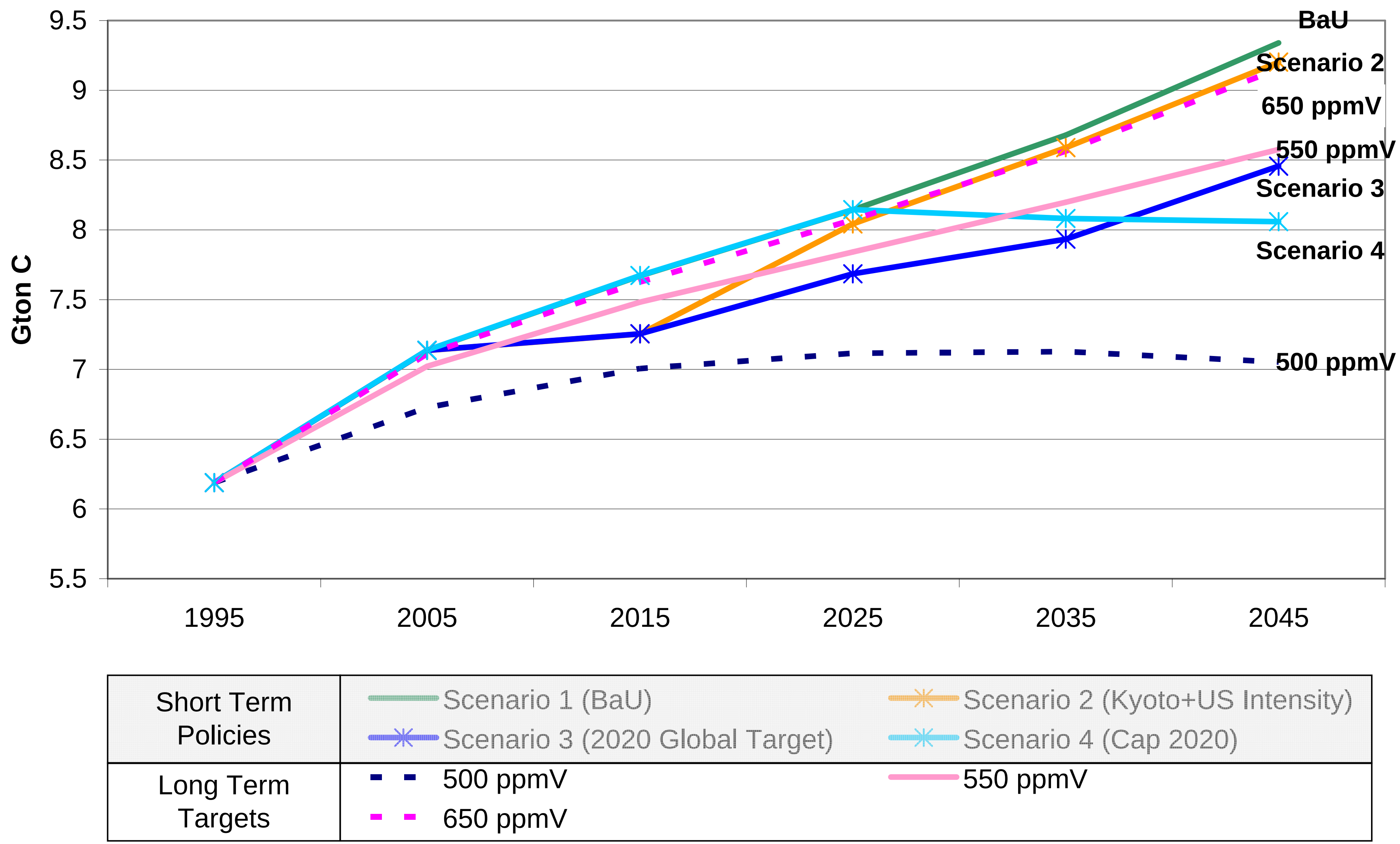


Figure 5: World Emission Paths for Short Term Policy and Stabilization of Temperature Scenarios

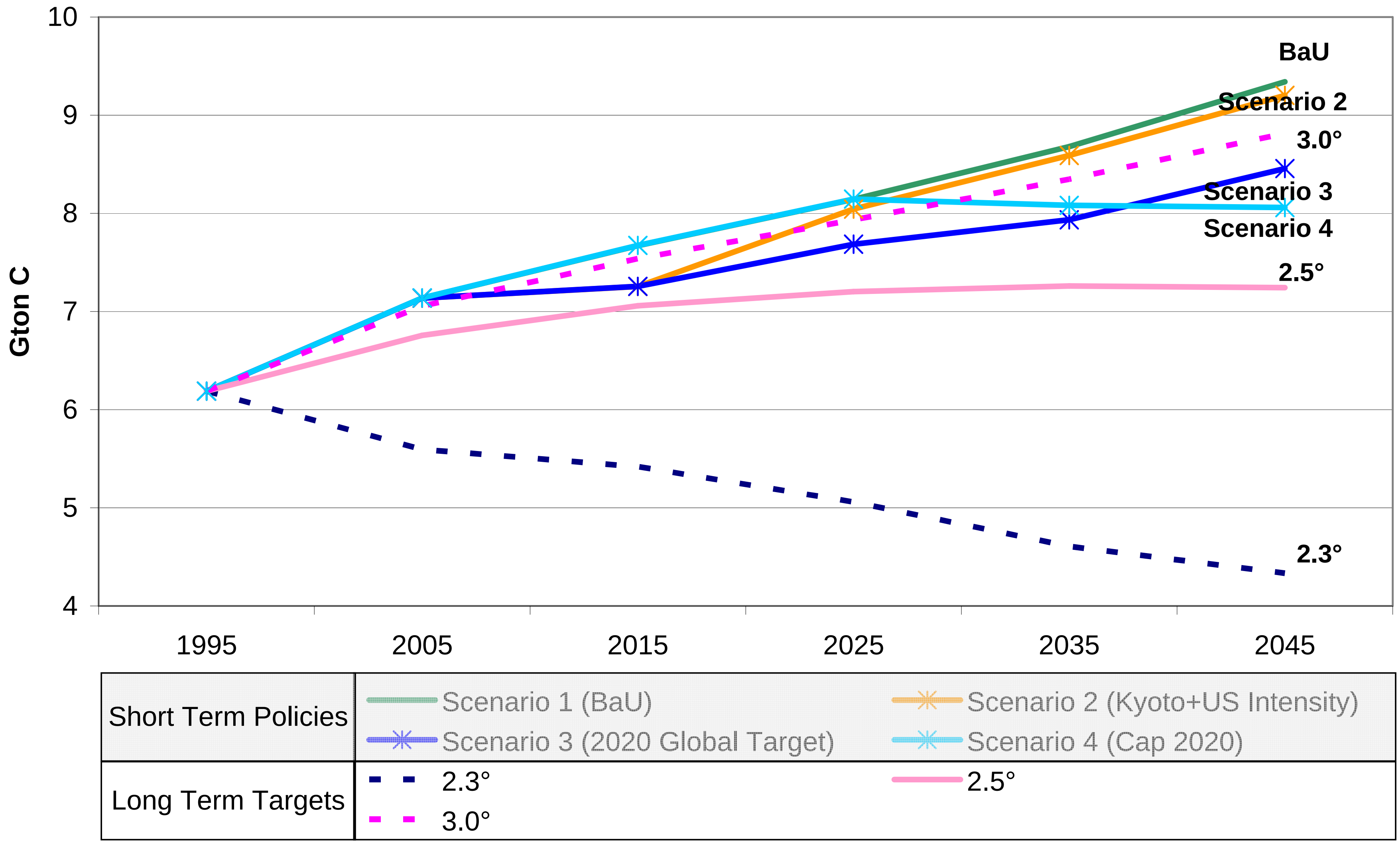


Figure 6: World Emission Paths - Uncertainty on Carbon Transition Parameter

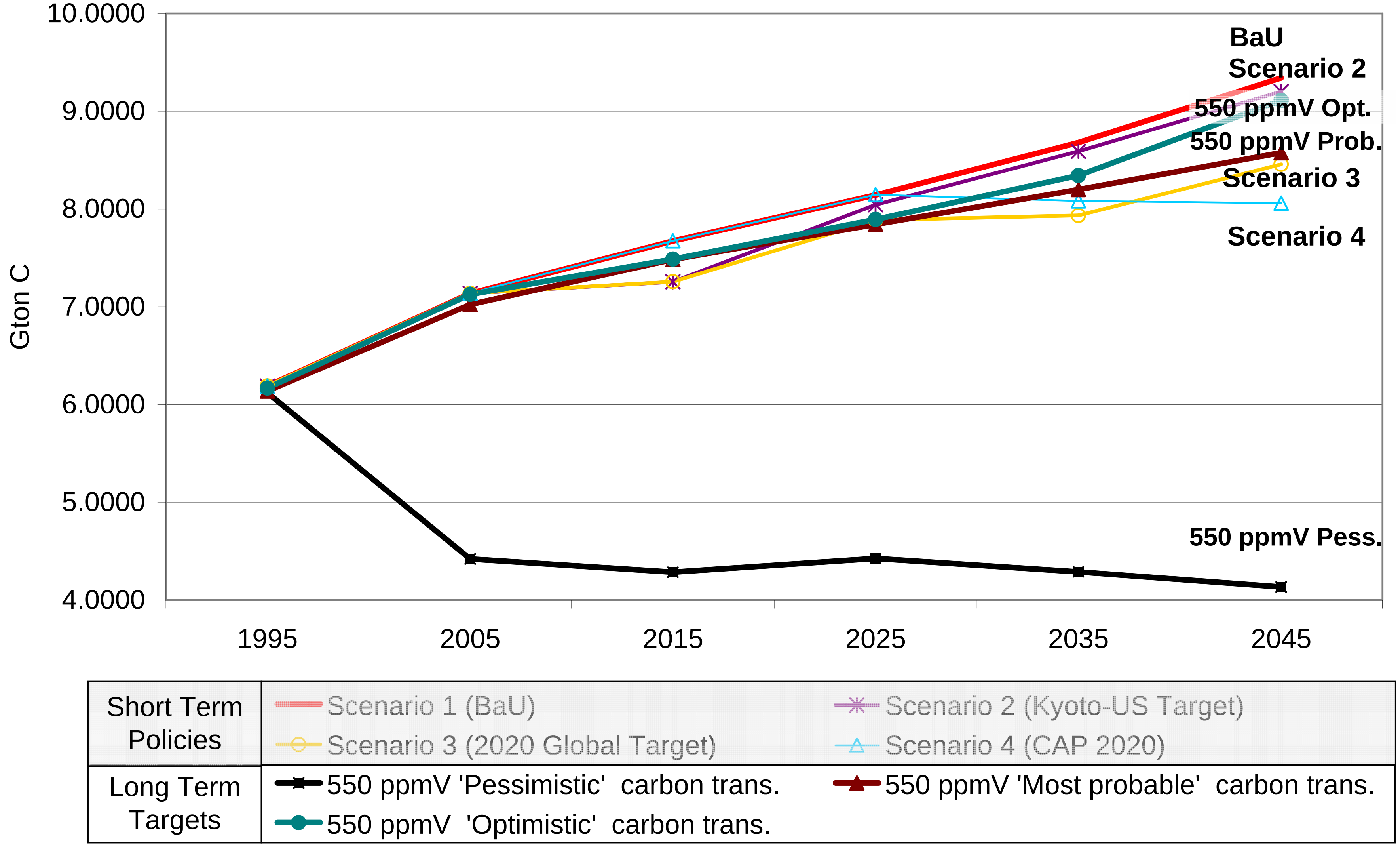
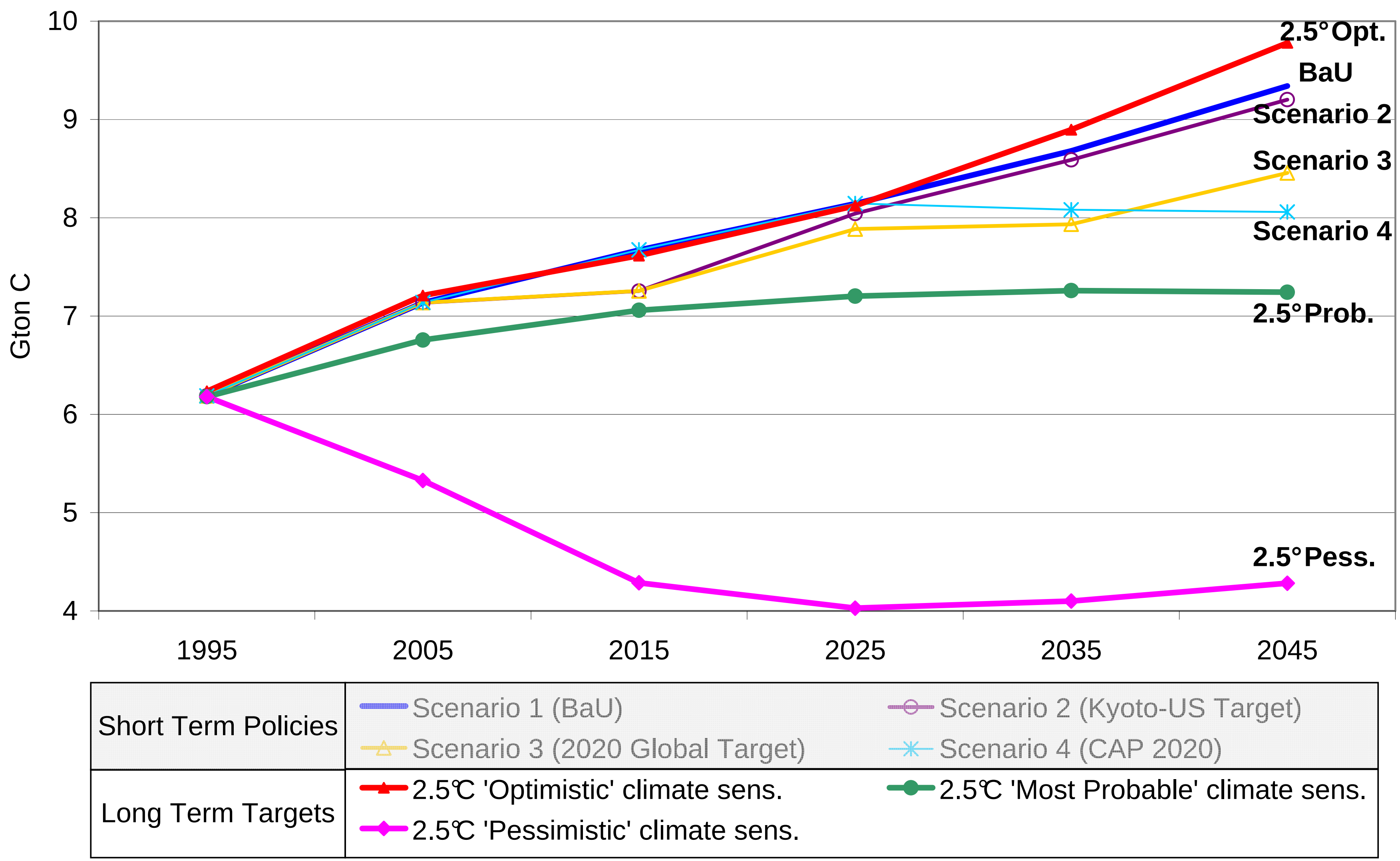


Figure 7: World Emission Paths - Uncertainty on Climate Sensitivity Parameter



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(lix) This paper was presented at the ENGIME Workshop on “Mapping Diversity”, Leuven, May 16-17, 2002
(lx) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002
(lxi) This paper was presented at the Eighth Meeting of the Coalition Theory Network organised by the GREQAM, Aix-en-Provence, France, January 24-25, 2003
(lxii) This paper was presented at the ENGIME Workshop on “Communication across Cultures in Multicultural Cities”, The Hague, November 7-8, 2002
(lxiii) This paper was presented at the ENGIME Workshop on “Social dynamics and conflicts in multicultural cities”, Milan, March 20-21, 2003
(lxiv) This paper was presented at the International Conference on “Theoretical Topics in Ecological Economics”, organised by the Abdus Salam International Centre for Theoretical Physics - ICTP, the Beijer International Institute of Ecological Economics, and Fondazione Eni Enrico Mattei – FEEM Trieste, February 10-21, 2003
(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003
(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL) , Venice, August 28-29, 2003
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(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003
(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003
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