

Kypreos, Socrates

**Working Paper**

## A MERGE Model with Endogenous Technological Change and the Cost of Carbon Stabilization

Nota di Lavoro, No. 123.2005

**Provided in Cooperation with:**

Fondazione Eni Enrico Mattei (FEEM)

*Suggested Citation:* Kypreos, Socrates (2005) : A MERGE Model with Endogenous Technological Change and the Cost of Carbon Stabilization, Nota di Lavoro, No. 123.2005, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:

<https://hdl.handle.net/10419/74169>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

**A MERGE Model with  
Endogenous Technological Change  
and the Cost of Carbon  
Stabilization**  
Socrates Kypreos

NOTA DI LAVORO 123.2005

**OCTOBER 2005**

CCMP – Climate Change Modelling and Policy

Socrates Kypreos, *Paul Scherrer Institute, Energy-Economics Group, Switzerland*

This paper can be downloaded without charge at:

The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:  
<http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm>

Social Science Research Network Electronic Paper Collection:  
<http://ssrn.com/abstract=840565>

The opinions expressed in this paper do not necessarily reflect the position of  
Fondazione Eni Enrico Mattei  
Corso Magenta, 63, 20123 Milano (I), web site: [www.feem.it](http://www.feem.it), e-mail: [working.papers@feem.it](mailto:working.papers@feem.it)

This paper is one of a series published by FEEM on the theme of innovation modeling in the context of the challenge of stabilising atmospheric concentrations of greenhouse gases, as part of the Innovation Modeling Comparison Project. This is an international project launched and overseen by the Steering Committee of the informal International Programme on the Economics of Atmospheric Stabilisation. The broad aim of the collaboration is to advance understanding of the economic issues surrounding atmospheric stabilisation, and the specific aims of the IMCP are to provide insights into the "state of the art" and implications of endogenous modeling of technical change in global energy-environment models when applied to various levels of atmospheric stabilisation.

Members of the Steering Committee provided review comments on earlier drafts and the paper has been forwarded to external review, the final results will be published as a Special Issue of the Energy Journal. The papers have all been encouraged to draw on a common baseline (the "Common Poles-Image baseline") and to report results in comparable formats, so as to facilitate intercomparison of the different modeling results. All the results and judgements expressed here remain the responsibility of the authors.

The research presented in this paper has been conducted within the Swiss NCCR-Climat (grant from the Swiss National Science Foundation). FEEM fund the working papers series, and seed money for the coordination work of the Innovation Modeling Comparison Project was provided by UK Department of Environment, Food and Rural Affairs and the German Ministry of Environment.

# **A MERGE Model with Endogenous Technological Change and the Cost of Carbon Stabilization**

## **Summary**

Two stylized backstop systems with endogenous technological learning formulations (ETL) are introduced in MERGE: one for the electric and the other for the non-electric markets. Then the model is applied to analyze the impacts of ETL on carbon-mitigation policy, contrasting the resulting impacts with the situation without learning. As the model considers endogenous technological change in the energy sector only some exogenous key parameters defining the production function are varied together with the assumed learning rates to check the robustness of our results. Based on model estimations and the sensitivity analyses we conclude that increased commitments for the development of new technologies to advance along their learning curves has a potential for substantial reductions in the cost of climate mitigation helping to reach safe concentrations of carbon in the atmosphere.

**Keywords:** Climate change stabilization policies, Non-linear optimization, Induced technological change, Energy and macroeconomy

**JEL Classification:** C61, O30, Q42, Q43

*Address for correspondence:*

Socrates Kypreos  
Paul Scherrer Institute  
Energy-Economics Group  
5232 Villigen  
Switzerland  
Phone: +4156 310 2675  
E--mail:socrates.kypreos@psi.ch

## 1. Introduction

The Innovation Modelling Comparison Project (IMCP) is an effort to present the state of the art in modelling technological change. The project brings together a variety of different approaches to the inclusion of technological change in global macroeconomic, Integrated Assessment and energy system models. In particular, the project aims to compare and contrast the cost and investment time-paths that could lead to stabilization at 450, 500, 550 ppmv carbon dioxide by 2100, and to explore sensitivities to different modelling approaches and technical assumptions. The PSI group has developed for the Swiss NCCR-Climate Program on “Climate Variability and Risk” Integrated Assessment Models (IAMs) to simulate policies to aid in climate-change mitigation. We report herein model changes and results from a version of MERGE, Manne et al. (1995), Kypreos (2000), Manne and Richels (2002), Kypreos (2005) that supports endogenous and induced technological learning in the energy sector.

The study reported herein is an effort to evaluate the economic advantages of endogenous learning *via* RD&D spending in support of carbon-free energy technologies. The method presented investigates R&D support and learning investments in carbon-free systems to aid these technologies to follow their learning curves. This dedicated RD&D spending could influence developments during the demonstration and deployment phases and reduces the cost of new technologies. We assume that R&D spending together with learning investments creates path dependent knowledge that is diffused on the global level *via* market uptake of these fundamentally different technological systems. We also expect that the increased sales of these advanced systems introduced under a global carbon constraint will induce technological change and significantly reduce the cost of carbon mitigation.

As this special issue gives an overview concerning the state of the art on modeling technological change we focus herein on the problems realized when RD&D spending is introduced as decision variable in hybrid optimization models with perfect foresight. Some first studies applying optimization models introduced by Barreto and Kypreos (2004), Bahn and Kypreos (2002) produced a restricted level of R&D investments reported as needed to support new and advanced technologies. On the contrary, simulation models with adaptive expectations, Criqui et al. (2000) and Kouvaritakis et al. (2000) do not indicate such behaviour. This article presents this version of MERGE that overtakes the difficulty.

Section 2 discusses the new version of MERGE that defines RD&D as decision variable and the assumptions on which costs, emissions, and learning characteristics of technologies that compete in the energy markets are based; this section also explains the formulation of the two factor learning curve (TFLC) model, together with the introduction of subsidies in MERGE. We consider scenarios related to a stabilization of CO<sub>2</sub> concentrations in the atmosphere when including (or excluding) technological learning. Section 3 then reports on this numerical application, and describes impacts of modelling endogenous technological progress in the MERGE environment. Section 4 performs a sensitivity analyses on the most critical input parameters to test the robustness of results. Finally, section 5 concludes with an elaboration of the importance of policies that foster endogenous technological learning while the Appendix describes in some details the calibration and the sensitivity analyses with MERGE.

## 2. Modelling framework

### 2.1 MERGE

The model for evaluating regional and global effects (MERGE) is an integrated assessment model (IAM) that provides a framework for assessing climate-change management proposals. We apply the MERGE5 version described by Manne and Richels (2002), which already includes some generic technologies capable of learning-by-doing (LBD), but we model both learning-by-searching (LBS) and learning subsidies. The world modelled in MERGE is divided into nine geopolitical regions: Canada, Australia and New Zealand (CANZ); China; eastern Europe and the former Soviet Union (EEFSU); India; Japan; Mexico, and OPEC (MOPEC); western Europe (WEUR); the United States of America (USA); and the rest of the world (ROW).

An ETA-MACRO model describes each of these nine regions. The ETA component is a ‘bottom-up’ engineering model; it describes the energy-supply sector of a given region, including the production of non-electric energy (fossil fuels, synthetic fuels, and renewables) as well as the generation of electricity. The ETA model captures price-dependent substitutions of energy forms (*e.g.*, switching to low-carbon fossil fuels) and energy technologies (*e.g.*, the use of renewable-energy power plants instead of fossil-fuel systems) to achieve specified CO<sub>2</sub> reduction targets.

MACRO is a ‘top-down’ macro-economic growth model that balances the non-energy part of the economy of a given region using a nested constant-elasticity-of-substitution (CES) production function. The MACRO model also captures autonomous (*e.g.*, price-independent) effects and macro-economic feedbacks between the energy sector and the rest of the economy, such as the impacts of higher energy prices (*e.g.*, resulting from CO<sub>2</sub> control) on economic activities. The mathematical formulation of regional ETA-MACRO sub-models translates into a non-convex, non-linear, optimization problem, where the economic equilibrium is determined by a single optimization. Finally, inclusion of a simple climate and damage model makes MERGE an Integrated Assessment Model. MERGE considers market (through production losses), and non-market damages (through losses in global welfare).

The model maximizes a welfare function defined as the net present value of the logarithm of regional consumption adjusted for the non-market damages. Included in the wealth of each MERGE region are initial endowments in fossil fuels, renewables, and CO<sub>2</sub> emission permits.

MERGE links the regional ETA-MACRO sub-models, and aggregates the regional welfare functions, adjusted for the non-market damages, into a global welfare function using appropriate Negishi weights (Negishi, 1972). Global trade constraints applied in each period ensure that international trade of commodities is balanced. Regional technological learning with global spillovers, climate-change impacts and the associated market and non-market damages further enhance the regional links and interactions.

### 2.2 Technology Description

Table 1. Technologies used in MERGE5 and naming conventions

<b>Electric</b>	<b>technologies</b>	Introduction date	Gen. Cost mills/kWh	Carbon Emissions kg C/kWh
HYDRO	Hydroelectric, and other renewables	Existing	40.	0.0
NUC	Remaining initial nuclear	Existing	50.	0.0
GAS-R	Remaining initial gas fired	Existing	35.7	0.1443
OIL-R	Remaining initial oil fired	Existing	37.8	0.2094
COAL-R	Remaining initial coal fired	Existing	20.3	0.2533
GAS-N	Advanced combined cycle (AGC)	2000	30.3	0.0935
GAS-A	Gas-Fuel Cell with removal	2020	47.7	0.0
COAL-N	Pulverized Coal	2000	40.6	0.1955
COAL-A	Coal-FC with CO2 recovery	2020	55.9	0.0068
IGCC	IGCC with CO2 removal	2020	62	0.024
ADV-HC	Carbon-free technologies, high cost	Existing	95	0.0
LBDE*	Generic back-stop with LBD	2010	95	0.0
<b>Non-Electric</b>	<b>technologies</b>		US\$/GJ	tons C/GJ
CLDU	Coal direct use	Existing	2.5	0.0241
OIL1-OIL10	Oil categories	Existing	3-5.25	0.0199
GAS1-GAS10	Gas categories	Existing	2-4.25	0.0137
SYNF	Synthetic fuels	Existing	8.33	0.04
RNEW	Renewables	Existing	6.	0.0
NEB -HC	Renewables Back-stop, high cost.	Existing	14.	0.0
LBDN*	Generic back-stop with LBD	2010	14.	0.0

\*) The two technologies with LBD become available in 2010 once sufficient RD&D investments will be made, otherwise are not available at all. Also, their penetration rates increases and their production cost is assumed to reduced due to RD&D spending.

Technological learning describes how the specific cost of a given technology is reduced through the accumulation of knowledge. This learning process evolves either from manufacturing and operation of the technology (LBD) or research-and-development (LBS) expenditures allocated to that technology. A learning curve relates the specific cost incurred by a given technology to one or more factors describing the accumulation of knowledge in that technology.

Specific components of the energy technologies are treated as generic; for instance, high-cost (ADV-HC) and low-cost (ADV-LC) carbon-free power plants, or plants producing low-cost, non-electric energy from renewables (RNEW) are identified. Table 1 lists the technologies modelled in MERGE, with, the first generic learning technology corresponding to power generation and the second technology referring to a non-electric energy system.

We assume for LBD that a 20% cost reduction is incurred for each doubling in production, and a 15% cost reduction for each doubling in the knowledge stock. Also, a barrier is introduced to represent a maximum possible reduction of generating cost of (*e.g.*, 40 mills per kWh for electric backstop systems and 6 US\$/GJ for the non-electric backstops). Electric-generation backstop technologies consist of renewable sources, like wind, solar PV and biomass, new nuclear concepts and carbon capture and sequestration<sup>1</sup>. Non-electric energy-generation/carrier backstops are identified with the

<sup>1</sup> CCS systems are explicitly introduced in the technological options listed in Table 1 but as learning is not adopted for technologies other than the back-stop systems, CCS systems are not explicitly introduced in the solution.

use of methanol or hydrogen fuels, while the primary-energy sources for these non-electric energy carriers are either biomass or renewable electricity or nuclear (*i.e.*, a carbon-free non-exhaustible energy form). All technologies and the non-learning costs associated with these backstop systems are assumed to be encompassed in an autonomous cost reduction at a rate of 0.2% per annum.

### 2.3 The Two Factor Learning Curve

In the two-factor learning curve, the cumulative production (output) is used as a proxy for the accumulation of experience that affects the specific investment cost of a given technology. Similarly, the knowledge stock, defined as the accumulation of a depreciated *R&D* spending, is used to determine cost reductions attendant LBS processes. The learning curve for the generation cost  $GC_{k,t}$  (in US\$ per MWh for electric or US\$ per GJ for non-electric) of a technology  $k$  is then defined as:

$$GC_{k,t} = a \cdot CP_{k,t}^{-b} \cdot KS_{k,t}^{-c} \quad (1)$$

with the knowledge stock  $KS_{k,t}$  estimated as the depreciated sum of annual *AR&D*

$$KS_{k,t} = KS_{k,t-1} \cdot (1-s) + AR \& D_{k,t} \cdot ypp_t \quad (2)$$

where  $s$  is the depreciation factor (e.g., 3 percent per year) and  $ypp$  the number of years per period.

The parameter  $a$  can be calibrated by applying equation (1) for the initial point ( $GC_{k,0}, KS_{k,0}, CP_{k,0}$ ) of the learning curve, and the parameters  $b$  and  $c$  are the learning indices. The latter define the speed of learning and are derived from the learning ratio. The learning ratio  $lr$  is the rate at which the generating cost declines (e.g., 20%) each time the cumulative capacity doubles, while  $lrs$  is the rate at which the cost declines each time the knowledge stock doubles. The relation between  $b$ ,  $c$ ,  $lr$  and  $lrs$  can be expressed as follows:

$$1 - lr = 2^{-b} \quad \text{and} \quad 1 - lrs = 2^{-c} \quad (3)$$

The model assumes that both "learning" and "knowledge" diffuse to the entire world and eventually create positive externalities. For the changes in the model, a few new variables and equations are defined. The new variables refer to the annual research and development (*AR&D*) spending, the knowledge stock ( $KS$ ) and the amount of subsidized production ( $SPE$ ). The cumulative production of electricity ( $CP$ ) is based on the annual generation of unsubsidized  $PE$ , and subsidized electricity,  $SPE$ .

$$CP_{k,t} = CP_{k,t-1} + (PE_{k,t} + SPE_{k,t}) \cdot ypp_t \quad (4)$$

The learning curve is coded directly as a non-linear and non-convex formulation according to equation (5), e.g., as function of the cumulative production and the knowledge stock relative to the starting year<sup>1</sup>. The CONOPT3 optimizer defines directly

---

<sup>1</sup> The initial annual energy R&D is 360 million US\$ equally divided for electric and non-electric backstop technologies. The assumed initial knowledge stock is 8 times the annual spending with a maximum annual growth rate in R&D of 5 percent. The depreciation rate of knowledge is 3% per year.



the global optimal solution in the case that terminal conditions are defined such that local optima are excluded, as explained by Manne and Barreto, (2004).

$$\frac{GC_{k,t}}{GC_{k,0}} = \left( \frac{CP_{k,t}}{CP_{k,0}} \right)^{-b} \cdot \left( \frac{KS_{k,t}}{KS_{k,0}} \right)^{-c} \quad (5)$$

The budget equation of MERGE is re-formulated to take into account R&D spending and the subsidies in learning investments. We assume that knowledge creates positive externalities due to spillovers across different production firms and regions. We also assume public support via subsidies (e.g., learning investments) in the early stage of technology implementation. If the subsidized backstop systems become competitive in the markets their cost decreases with time based on LBD and LBS. Equation (6) describes the budget constraint;  $C_{rt}$  is for consumption;  $I_{rt}$  for investments;  $EC_{rt}$  for the energy cost;  $DC_{rt}$  for damages and  $NTX_{rt}$  for the net trade balance of a region.

$$Y_{rt} = C_{rt} + I_{rt} + EC_{rt} + DC_{rt} + NTX_{rt} + AR \& D_{rt} \quad (6)$$

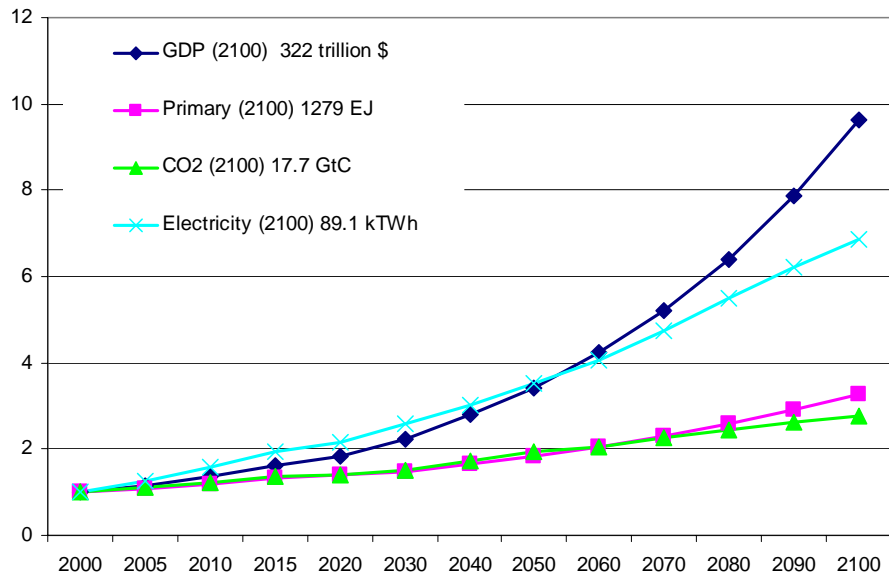
We also assume that the two learning technologies could be made available in 2010 if competitive, while their penetration rates are increased (e.g., to 13.5 % *per annum*; *i.e.*, above the standard value of 11.5% applied in MERGE). Annualized R&D spending is included in the budget Eq. (6) but they are introduced only when enough benefits are generated to compensate for the cost of research and development. In other words, the induced benefits of the cost reduction for energy production should be greater than the discounted and cumulative cost of R&D. The subsidies option was not active in this study.

### 3 Case studies

#### 3.1 The BaU cases

Several scenarios related to CO<sub>2</sub> emission control are presented as illustrations of the results generated by this version of MERGE. Apart from the business-as-usual (BaU) cases, where CO<sub>2</sub> emissions are not limited, we have considered the implications of stabilizing atmospheric carbon concentrations to 550-450 ppmv. All scenarios are assessed with and without ETL options. The baseline case is designated by BaUS, where technological change is endogenous. The database for the baseline cases reflects the original technology data of MERGE5, while the growth data are downwards adjusted to reflect the assumptions of the Innovation Modelling Comparison Project (IMCP). Constraints are introduced only on the CO<sub>2</sub> concentration although MERGE considers all other greenhouse gases (GHGs), carbon sinks and aerosols.

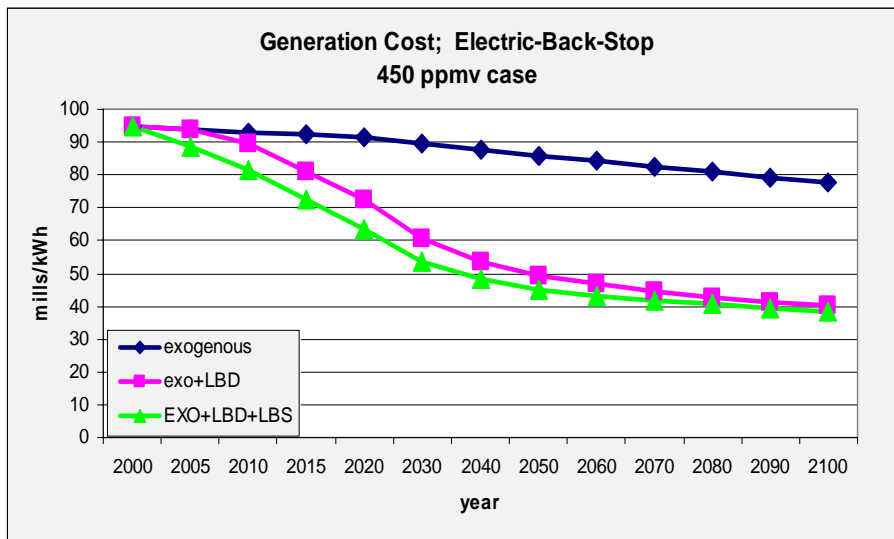
All stabilization scenarios without ETL assume that the penetration of backstop technologies is on the same levels as in the baseline case with ETL. This is equivalent with the assumption that in these scenarios the same level of RD&D spending or investments into niche markets will take place.



**Fig. 1:** Basic indicators for the BaUS case of MERGE with LBD relative to the starting year.

In the BaUS case, the world GDP grows more than 9 times (*i.e.*, to US\$312.5 trillion in 2100); but primary-energy supply and carbon emissions are strongly decoupled from economic growth and increase to 1246 EJ of primary energy per annum (at 45% efficiency for the backstop electricity) and 17.91 GtC/yr carbon emissions in 2100. In the BaUS case, global CO<sub>2</sub> concentrations increase to 693 ppmv, while the average temperature rise between the year 2000 and the year 2100 is 2.36° Celsius. Most of the economic growth occurs in economies (currently) in transition and in developing countries. Regional differences in income, primary-energy intensity, and carbon intensity of GDP are decreasing over time. The currently less-developed countries assume a high economic growth such that they will produce most of the global GDP in the year 2100 while OECD countries will contribute by 38% to the total output. It should be noted that the potential socio-economic growth underlying this scenario is exogenous as well as the autonomous efficiency improvement.

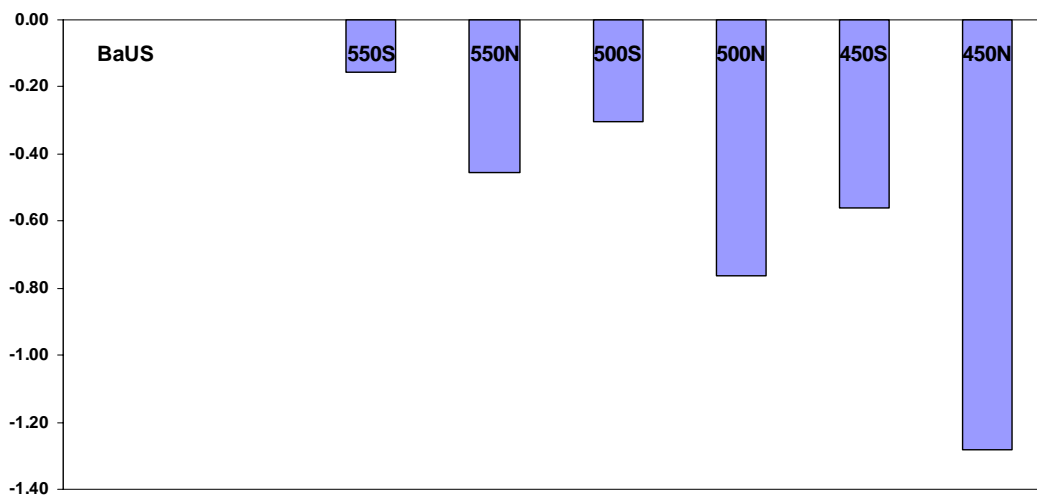
Energy efficiency and decarbonisation continue to contribute to improved energy, economic, and environmental indices. Policies that support technological learning result in a strong contribution of renewables in meeting non-electric-sector demands. This shift enhances the use of non-electric backstop technologies. For the BaUS case, therefore, renewable-energy sources and nuclear contribute 38%, coal 46%, oil 7% and gas 9% of the energy mix. Figure 2 illustrates the impact of learning on the generating cost of electricity for the 450-ppmv cases. We assume a moderate exogenous rate of generation cost reduction that of 0.2% per year. The most significant mechanism in cost reduction is the contribution of the LBD while LBS is important during the first, introductory periods of the new technologies.



**Fig. 2:** A significant cost reduction over time is shown when LBD applies. RD&D policies are important in the early stage of introducing a new technology.

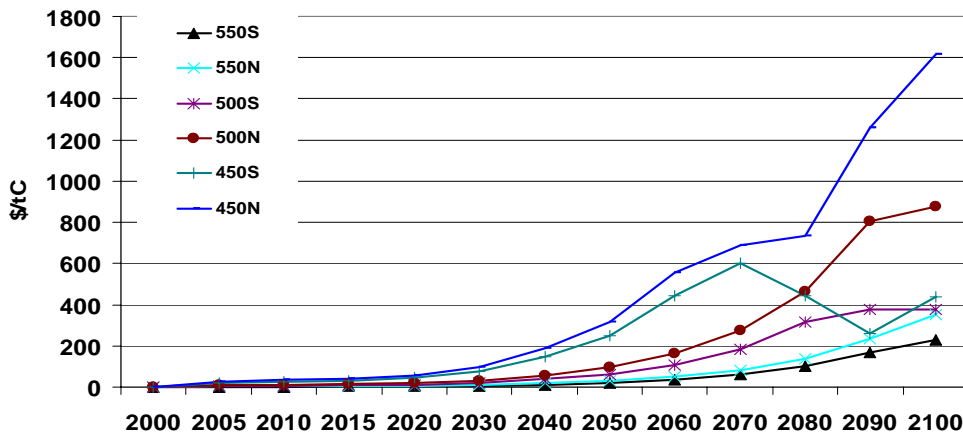
### 3.3 Stabilizing carbon concentrations

Economic considerations govern the transition to a low-carbon economy. Two of these considerations represent key options for the second half of this century: the exhaustion of oil and gas resources, and the significant cost reduction in carbon-free energy technologies. When R&D policies are appropriately applied, we attain a significant reduction of energy generation cost and carbon control costs, as shown in Figures 2 to 4. Obviously, the stronger the carbon constraint is, the faster the penetration of carbon-free technologies into the market mixes, and the stronger the relative cost reduction.



**Fig. 3:** Cumulative and undiscounted GWP losses for the Carbon stabilization cases, relative to BaUS. Global losses are significantly reduced in the case of LBD and LBS. For the 450-ppmv cases, the cumulative loss is reduced to 0.56 %.

The scenarios where atmospheric CO<sub>2</sub> concentration is held to 450-ppmv assume that efficient strategies will be adopted worldwide and a full-scope transfer of “know-how” will take place. Under these circumstances, the following conclusions can be made: First, the induced cumulative GWP losses of the carbon-stabilization are low (e.g., in relation to the cumulative baseline-GWP): for example, below 1.26% in the case without learning, while with ETL policies the GWP losses are less than 0.55% (Figure 3). Secondly, the marginal costs related to carbon stabilization are also reduced to a fraction of the marginal cost without learning (Figure 5), but remain always significant for the case of the 450 ppmv atmospheric carbon limit (e.g., below 600 \$/tC in the 450 ppmv case with ETL).



**Fig. 4:** The marginal costs of carbon control are reduced by almost 50% by the end of the century in the case of ETL and in relation with cases without learning. To avoid terminal conditions effects on the shadow prices by the end of time horizon the cases have been analyzed up to 2120 while results are reported up to 2100.

#### 4. Calibration and Sensitivity Analyses

The mathematical formulation of the production function in MERGE is given by the set of equations (7):

$$Y = \left[ a(K^\alpha \cdot L^{(1-\alpha)})^\rho + b(E^\beta \cdot NE^{(1-\beta)})^\rho \right]^{1/\rho} \quad (7)$$

with  $\rho = (\sigma - 1) / \sigma$   $\sigma \neq 0, 1, \infty$

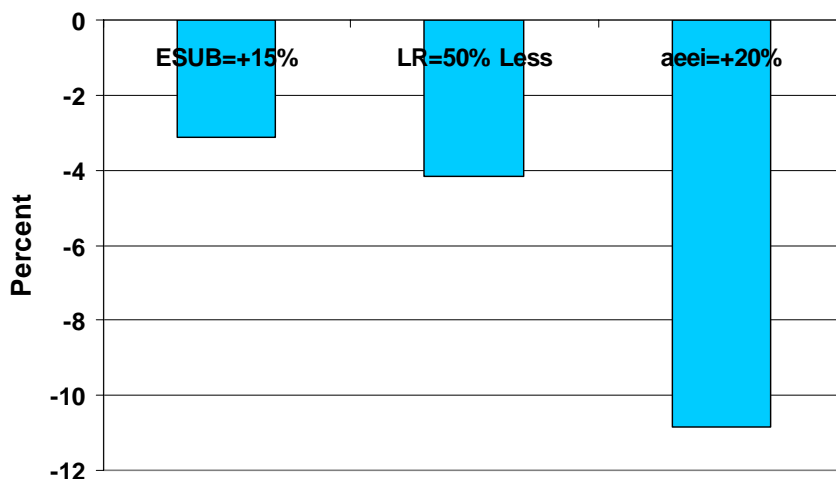
The aggregate economic output Y is described by a nested constant elasticity of substitution function between the value added pairs of capital (K) and Labour (L) and the energy related pairs of electric (E) and non-electric (NE) energy<sup>1</sup>. Details of the calibration procedure are explained in the Appendix together with the key input used for the specification of the reference development.

<sup>1</sup> MERGE is neither an endogenous growth model nor considers explicitly R&D for the non-energy sector. A new model formulation that includes R&D in energy conservation and non-energy related R&D was beyond the scope of the IMCP study due to time and resource limitations.

The standard MERGE model is calibrated such that the primary energy use, the regional GDP, the installed capacities and electricity production by region are consistent with the statistics of the starting year. Also, emissions and energy flows for the first decades are consistent with EIA projections given in the IEO (2004) report. There is no effort to provide empirical estimates of the production function of the model. Instead, the authors describe in “Buying Greenhouse Gas Insurance” (Manne and Richels, 1992) the model’s ability to reproduce past statistics. This model verification work is not repeated here. Instead, we perform a sensitivity analysis with alternative assumptions on key model input parameters like the elasticity of substitution (ESUB), the autonomous efficiency improvement (AEEI) and the learning rates (LBD & LBS) to check the robustness of our conclusions reported herein and to explain the model behaviour. Details of the sensitivity analyses are explained in the Appendix.

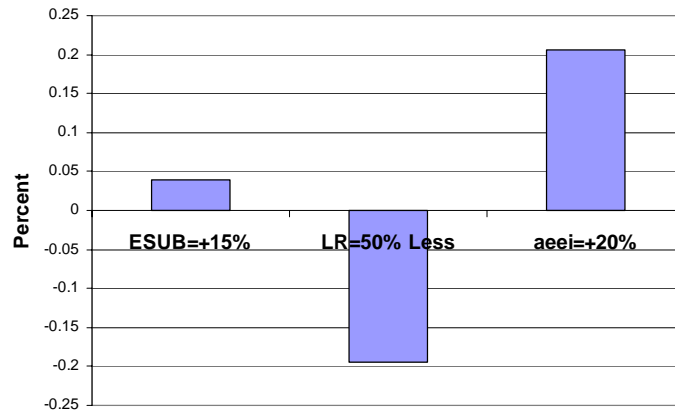
As the model introduces R&D spending as a decision variable, it was not possible to perform any sensitivity analyses on R&D other than assuming different elasticity values for learning by searching. Thus, learning elasticity rates describing LBD and the LBS performance are reduced to 50% of their reference levels.

The AEEI factor is a modelling invention to describe the autonomous (i.e., price independent) decoupling between economic growth and primary energy use. MERGE assumes that the AEEI is a given fraction (e.g., 40% to 50%) of the regional economic growth rate. In most of the cases structural economic changes and not the efficiency improvement, explain the value of the factor, in spite of the name used. On the other hand, the elasticity of substitution (ESUB) describes the price-induced substitution for energy using capital and labour when the energy price changes. The higher the value of ESUB the easier it is to substitute capital and labour for energy when prices increase. Interesting is to emphasize that at low energy system costs ESUB is almost the same as the absolute value of the price elasticity of demand. In the sensitivity analyses ESUB is increased by 10% for Annex I and by 20% for non-Annex I regions. Key results are reported in Figures 5 and 6; e.g., the primary energy use change and the cumulative GWP in relation with the 450 ppmv case under endogenous technological change.



**Fig. 5:** Cumulative Primary Energy (2000-2120) change relative to 450 ppmv Reference case in percent. The level of primary energy use per case is very sensitive to the AEEI factor.

Results on primary energy use are very sensitive to the AEEI factor but less sensitive to ESUB. Assuming a reduction by 50% to the LBD and the LBS elasticity increases the economic cost of carbon control and the marginal cost of energy production and reduces primary energy demand as energy becomes more expensive.



**Fig. 6:** Cumulative GWP change (2000-2120) relative to the 450 ppmv reference case in percent

## 5. Conclusions

Technological progress has and will continue to play a fundamental role in the evolution of energy systems; as such progress favours the transition toward more-efficient, economic, and cleaner energy technologies, rather than being driven by resource depletion *per se*. It is important, therefore, to incorporate the dynamics of technological change into energy system models. The work reported herein quantifies the impacts of RD&D spending on the development and promotion of carbon-free energy technologies that mitigate global warming. To quantify these impacts, the TFLC formulation has been introduced together with learning investments in favour of the two clusters of backstop technologies in MERGE5. Impacts have been quantified with the help of top-level economy indicators and a sensitivity analyses on key input factors is performed. We also considered several scenarios related to CO<sub>2</sub> emissions and technological learning.

Although our model shows that technological learning favours new advanced back-stop systems, this model formulation does not significantly change the conclusions derived from the original MERGE model for the first half of this century; as fossil fuels (mainly coal and natural gas) will continue to retain a significant share of the global electricity and energy-supply markets in the next 50 years, while energy-related carbon emissions will continue to grow substantially. But, RD&D spending is significantly increased in the first half of the century paving the way to reach carbon mitigation targets.

In the case where atmospheric carbon is stabilized at 450-ppmv, a significant development and market penetration of low-carbon generation options is required. Technological learning in these circumstances favours new advanced systems, represented collectively in the model as electric and non-electric backstop systems. Finally, the importance of technological progress for carbon control has been shown, as such progress allows low-cost carbon-reduction options to enter the generation mix and, hence, reduces GWP losses and minimizes the marginal cost of carbon control.

With the help of the main results and the sensitivity analyses shown herein, we conclude that RD&D increased commitments (either private or public) towards the development of new technologies, is a key strategy against global warming as otherwise conventional technologies will be locked-in the system.

## 5. References

- Bahn O, Kypreos S (2002). "MERGE-ETL: An Optimisation Equilibrium Model with Two Different Endogenous Technological Learning Formulations. PSI Report No 02-16, Paul Scherrer Institute, Villigen, Switzerland
- Barreto L, Kypreos S, (2004). Endogenizing R&D and market experience in the "bottom-up" energy-systems ERIS model. *Technovation* 24(8), 615-629
- Criqui P, Klaassen G, Schratzenholzer L, (2000). *The Efficiency of Energy R&D Expenditures*. Proceedings of the Workshop on Economic Modelling of Environmental Policy and Endogenous Technological Change. November 16-17, 2000. Amsterdam.
- IEO (2004) **International Energy Outlook**, April 2004; Energy Information Administration, Office of Integrated Analysis and Forecasting; U.S. Department of Energy Washington, DC 20585

Kouvaritakis N, Soria A, Isoard S (2000). Modelling Energy Technology Dynamics: Methodology for Adaptive Expectations Models with Learning by Doing and Learning by Searching. *Int J of Global Energy Issues* **14** 1/2/3/4 (2000), pp. 104–115.

Kypreos S (2000). *The MERGE Model with Endogenous Technological Change*. Proceedings of the Economic Modelling of Environmental Policy and Endogenous Technological Change Workshop. November 16-17, 2000. Amsterdam. Kypreos S (2005). Modeling experience curves in MERGE (model for evaluating regional and global effects), *Energy* **30** (2005) 2721-37

Manne A, Mendelsohn R, Richels RG (1995). “MERGE: A model for evaluating regional and global effects of GHG reduction policies. *Energy Policy* **23**: 17-34

Manne A, Richels R (2002). *The Impact of Learning-by-Doing on the Timing and Costs of CO<sub>2</sub> Abatement*. Presented at the International Energy Workshop, 18-20 June 2002, Stanford, USA

Manne A, Barreto L (2004) Learn-by-doing and Carbon Dioxide Abatement. *Energy Economics*, 26(4):621-633, 2004.

Manne A, and Richels R (1992), **Buying Greenhouse Gas Insurance: The Economic Costs of CO<sub>2</sub> Emission Limits**. Cambridge, MA: MIT Press.

Negishi T (1972) **General Equilibrium Theory and International Trade**. North-Holland Publishing Company, Amsterdam



## Appendix: MERGE calibration

### The production function

The aggregate economic output  $Y$  is described by a nested constant elasticity of substitution function between the value added pairs of capital (K) and Labour (L) and the energy related pairs of electric (E) and non-electric (NE) energy.  $a$  and  $b$  are scaling factors which are defined based on first-order optimality conditions taking into account the price of oil at the refinery at gate. The autonomous energy efficiency improvement factor (AEEI) is summarized by the growth of the scaling factor  $b$ .  $\alpha$  denotes the optimal value share of capital in the value added pair and  $\beta$  the optimal value share of electricity in the energy pair.

$$Y = \left[ a \left( K^\alpha \cdot L^{(1-\alpha)} \right)^\rho + b \left( E^\beta \cdot NE^{(1-\beta)} \right)^\rho \right]^{1/\rho}$$

$$\text{with } \rho = (\sigma - 1) / \sigma \quad \sigma \neq 0, 1, \infty$$

$$\text{if } f \equiv a \left( K^\alpha \cdot L^{(1-\alpha)} \right)^\rho + b \left( E^\beta \cdot NE^{(1-\beta)} \right)^\rho \text{ then, } Y = f^{1/\rho}$$

### Calibration

We apply the first-order optimality condition for the starting period:

$$\partial Y / \partial NE = PN = \partial Y / \partial f \cdot \partial f / \partial NE$$

$$PN = 1 / \rho \cdot f^{1/\rho-1} \cdot \rho \cdot b \cdot (1 - \beta) \cdot E^{\beta \cdot \rho} \cdot NE^{(1-\beta)\rho-1} \Rightarrow$$

$$b = PN \cdot Y^{\rho-1} / ((1 - \beta) \cdot E^{\beta \cdot \rho} \cdot NE^{(1-\beta)\rho-1})$$

with known  $b$  we can define  $a$  as:

$$a = Y^\rho - b \left( E^\beta \cdot NE^{(1-\beta)} \right)^\rho / \left( K^\alpha \cdot L^{(1-\alpha)} \right)^\rho$$

### The autonomous energy efficiency improvement factors (aeei):

We assume that energy use per unit of output follows an autonomous (i.e., price independent) annual rate of efficiency improvement  $aeei$ . The factor is defined such that it varies around 0.5% of the GDP growth rate. The factors and the Labour productivity define the reference energy use time path assuming that energy prices remain constant.

$$Eref_t = L_t \cdot E_0 \cdot \prod_{\tau=1,t} (1 - aeei_\tau)^{nypp}$$

$$Nref_t = L_t \cdot N_0 \cdot \prod_{\tau=1,t} (1 - aeei_\tau)^{nypp}$$

$$Yref_t = L_t \cdot Y_0$$

$$Kref_t = L_t \cdot K_0$$

Applying the first-order optimality conditions again we can define the reference development such that the scaling factors depend on time and to avoid the rebound effect i.e., artificial demand increase.

$$b_t = PN_0 \cdot Yref_t^{\rho-1} / ((1 - \beta) \cdot Eref_t^{\beta \cdot \rho} \cdot Nref_t^{(1-\beta)\rho-1})$$

$$a_t = Yref_t^{\rho} - b_t \cdot (Eref_t^{\beta} \cdot Nref_t^{(1-\beta)})^{\rho} / (Kref_t^{\alpha} \cdot L_t^{(1-\alpha)})^{\rho}$$

**Data used in the model and values applied in the sensitivity analyses:**

**Table 1: Regional population in billions**

	Usa	Weur	Japan	Canz	Eefsu	china	India	Mopec	Row
2000	0.276	0.389	0.127	0.054	0.412	1.275	1.009	0.608	1.899
2005	0.29	0.39	0.13	0.06	0.41	1.32	1.09	0.67	2.09
2010	0.30	0.39	0.13	0.06	0.40	1.37	1.16	0.73	2.28
2015	0.31	0.39	0.13	0.06	0.40	1.41	1.23	0.79	2.48
2020	0.33	0.39	0.13	0.06	0.39	1.45	1.29	0.86	2.68
2030	0.33	0.39	0.13	0.06	0.39	1.47	1.36	0.95	2.97
2040	0.33	0.39	0.13	0.06	0.39	1.49	1.41	1.03	3.21
2050	0.325	0.387	0.126	0.063	0.394	1.494	1.442	1.093	3.403
2060	0.325	0.387	0.126	0.063	0.394	1.497	1.462	1.146	3.564
2070	0.325	0.387	0.126	0.063	0.394	1.498	1.475	1.19	3.696
2080	0.325	0.387	0.126	0.063	0.394	1.499	1.484	1.226	3.804
2090	0.325	0.387	0.126	0.063	0.394	1.5	1.489	1.256	3.894
2100	0.325	0.387	0.126	0.063	0.394	1.5	1.493	1.281	3.967
2110	0.325	0.387	0.126	0.063	0.394	1.5	1.496	1.302	4.027
2120	0.33	0.39	0.13	0.06	0.39	1.50	1.50	1.32	4.08

**Table 2: Reference development expressed as GDP in trillion USA \$2000 per year that defines the labour productivity growth (L)**

	Usa	Weur	Japan	Canz	Eefsu	china	India	Mopec	Row
2000	9.83	9.76	4.60	1.32	1.05	1.17	0.52	1.25	3.91
2005	11.08	10.88	4.88	1.54	1.29	1.68	0.67	1.46	4.55
2010	13.10	12.26	5.42	1.79	1.59	2.30	0.87	1.83	5.72
2015	15.273	13.762	5.937	2.057	1.93	3.092	1.129	2.266	7.08
2020	17.584	15.439	6.461	2.353	2.32	4.126	1.457	2.75	8.596
2030	19.735	17.869	7.185	2.752	2.994	5.967	2.227	3.861	12.055
2040	22.026	20.556	7.956	3.198	3.853	8.524	3.33	5.279	16.461
2050	24.439	23.486	8.769	3.689	4.942	12.077	4.909	7.08	22.047
2060	26.951	26.639	9.619	4.221	6.313	16.987	7.164	9.354	29.093
2070	29.534	29.979	10.498	4.789	8.023	23.704	10.37	12.211	37.933
2080	32.154	33.463	11.4	5.384	10.132	32.754	14.891	15.777	48.954
2090	34.779	37.034	12.313	5.997	12.696	44.69	21.199	20.196	62.595
2100	37.375	40.635	13.23	6.615	15.76	59.993	29.863	25.622	79.337
2110	39.908	44.202	14.14	7.227	19.347	78.912	41.51	32.221	99.679
2120	42.35	47.677	15.034	7.822	23.446	101.277	56.72	40.148	124.101

**Table 3: Macroeconomic parameters used for the calibration of the production function**

	Usa	Weur	Japan	Canz	Eefsu	china	India	Mopec	Row
Capital to GDP	2.4	2.8	2.8	2.8	3	3	3	3	3
ESUB	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Capital Value-share	0.24	0.28	0.28	0.28	0.3	0.3	0.3	0.3	0.3
Electricity Value-share	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Price of oil \$/GJ	4	4	4	4	3.7	4	4	3.7	4
Non-Elect \$/GJ	2.75	5	6	4	2.5	2.5	2.5	2.5	2.5

**Sensitivity study on the elasticity of substitution (ESUB) by region**

	Usa	Weur	Japan	Canz	Eefsu	china	India	Mopec	Row
ESUB-Sensitivity	0.55	0.55	0.55	0.55	0.5	0.5	0.5	0.5	0.5
ESUB-Reference	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4

**Sensitivity study on AEEI:**

The model defines AEEI by multiplying the annual GDP growth rate (minus of the annual population growth) by a factor of 0.5. This factor was increased by 20%, i.e. from 0.5 to 0.6.

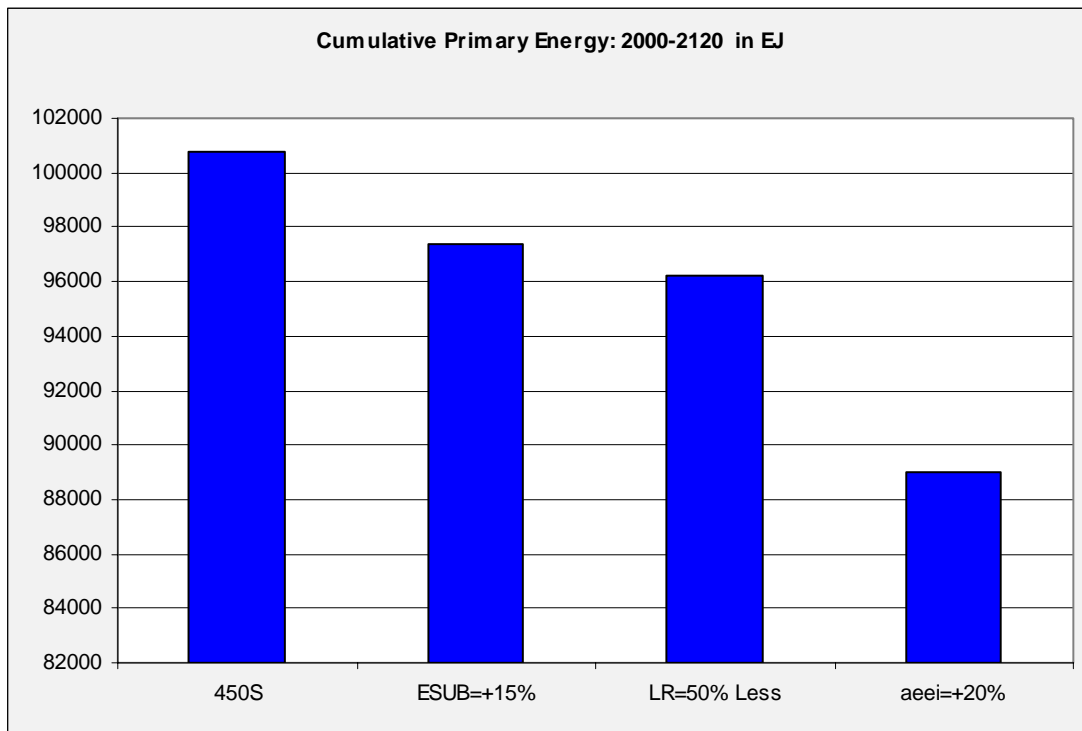
**Sensitivity study on learning by doing (LBD) and learning by searching (LBS):**

The LBD elasticity was reduced from 20% to 10% per doubling of experience while the LBS factor was reduced from 15% to 7.5% per doubling of knowledge stock.

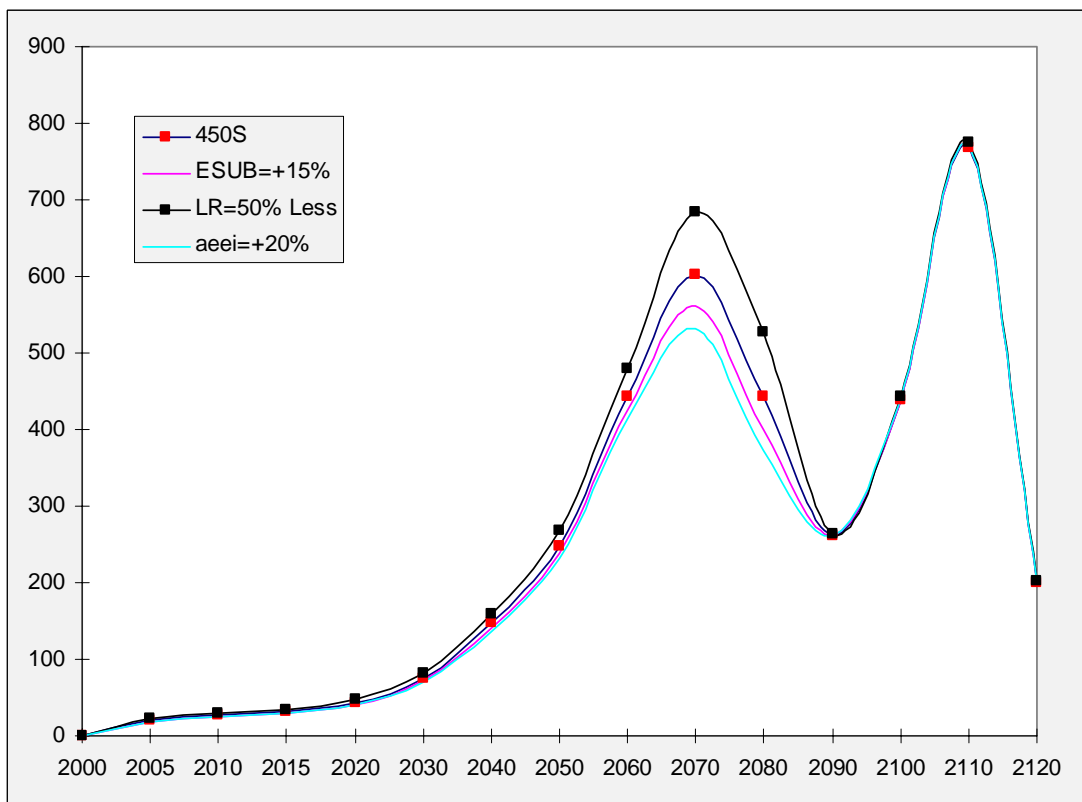
**Results obtained for the sensitivity analyses not shown in the main report:**

Two extra figures are given herein; the first refers to cumulative primary energy use and the second to the marginal cost estimates. The primary energy use is quite sensitive to the AEEI factor as it varies almost proportional to the factor modifying the AEEI coefficients. The fact that the relative reduction of the primary energy is not exactly proportional to the change is due to the model specification for the first decades that is kept constant to the results to the International Energy Outlook.

The shadow prices for the 450 ppmv cases indicate the existence of two peaks, one in the year 2070 and a second in the year 2110 with a valley around 2090. It also shows that shadow prices after 2090 are independent of the parameters varied in the sensitivity analyses. The first peak appears only in the 450 ppmv case that forces early and strong penetration of low carbon emitting technologies. The second peak is due to terminal conditions in MERGE.



**Fig. 7:** Cumulative Primary Energy (2000-2120) for the 450 ppmv reference and sensitivity cases. The primary energy use is very sensitive to the AEEI factor..



**Fig. 8:** Shadow prices for the 450 ppmv reference and sensitivity cases. Model results are sensitive to the reduction of LBD and LBS factors (which are changed by 50%) only around 2070 but back-stop systems do not dictate the shadow prices after 2080.

## NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

### Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:

<http://www.feem.it/Feem/Pub/Publications/WPapers/default.html>

<http://www.ssrn.com/link/feem.html>

<http://www.repec.org>

### NOTE DI LAVORO PUBLISHED IN 2004

IEM	1.2004	<i>Anil MARKANDYA, Suzette PEDROSO and Alexander GOLUB: <u>Empirical Analysis of National Income and So2 Emissions in Selected European Countries</u></i>
ETA	2.2004	<i>Masahisa FUJITA and Shlomo WEBER: <u>Strategic Immigration Policies and Welfare in Heterogeneous Countries</u></i>
PRA	3.2004	<i>Adolfo DI CARLUCCIO, Giovanni FERRI, Cecilia FRALE and Ottavio RICCHI: <u>Do Privatizations Boost Household Shareholding? Evidence from Italy</u></i>
ETA	4.2004	<i>Victor GINSBURGH and Shlomo WEBER: <u>Languages Disenfranchisement in the European Union</u></i>
ETA	5.2004	<i>Romano PIRAS: <u>Growth, Congestion of Public Goods, and Second-Best Optimal Policy</u></i>
CCMP	6.2004	<i>Herman R.J. VOLLEBERGH: <u>Lessons from the Polder: Is Dutch CO2-Taxation Optimal</u></i>
PRA	7.2004	<i>Sandro BRUSCO, Giuseppe LOPOMO and S. VISWANATHAN (lxv): <u>Merger Mechanisms</u></i>
PRA	8.2004	<i>Wolfgang AUSENNEGG, Pegaret PICHLER and Alex STOMPER (lxv): <u>IPO Pricing with Bookbuilding, and a When-Issued Market</u></i>
PRA	9.2004	<i>Pegaret PICHLER and Alex STOMPER (lxv): <u>Primary Market Design: Direct Mechanisms and Markets</u></i>
PRA	10.2004	<i>Florian ENGLMAIER, Pablo GUILLEN, Loreto LLORENTE, Sander ONDERSTAL and Rupert SAUSGRUBER (lxv): <u>The Chopstick Auction: A Study of the Exposure Problem in Multi-Unit Auctions</u></i>
PRA	11.2004	<i>Bjarne BRENDSTRUP and Harry J. PAARSCH (lxv): <u>Nonparametric Identification and Estimation of Multi-Unit, Sequential, Oral, Ascending-Price Auctions With Asymmetric Bidders</u></i>
PRA	12.2004	<i>Ohad KADAN (lxv): <u>Equilibrium in the Two Player, k-Double Auction with Affiliated Private Values</u></i>
PRA	13.2004	<i>Maarten C.W. JANSSEN (lxv): <u>Auctions as Coordination Devices</u></i>
PRA	14.2004	<i>Gadi FIBICH, Arieh GAVIOUS and Aner SELA (lxv): <u>All-Pay Auctions with Weakly Risk-Averse Buyers</u></i>
PRA	15.2004	<i>Orly SADE, Charles SCHNITZLEIN and Jaime F. ZENDER (lxv): <u>Competition and Cooperation in Divisible Good Auctions: An Experimental Examination</u></i>
PRA	16.2004	<i>Marta STRYSZOWSKA (lxv): <u>Late and Multiple Bidding in Competing Second Price Internet Auctions</u></i>
CCMP	17.2004	<i>Slim Ben YOUSSEF: <u>R&amp;D in Cleaner Technology and International Trade</u></i>
NRM	18.2004	<i>Angelo ANTOCI, Simone BORGHESI and Paolo RUSSU (lxvi): <u>Biodiversity and Economic Growth: Stabilization Versus Preservation of the Ecological Dynamics</u></i>
SIEV	19.2004	<i>Anna ALBERINI, Paolo ROSATO, Alberto LONGO and Valentina ZANATTA: <u>Information and Willingness to Pay in a Contingent Valuation Study: The Value of S. Erasmo in the Lagoon of Venice</u></i>
NRM	20.2004	<i>Guido CANDELA and Roberto CELLINI (lxvii): <u>Investment in Tourism Market: A Dynamic Model of Differentiated Oligopoly</u></i>
NRM	21.2004	<i>Jacqueline M. HAMILTON (lxvii): <u>Climate and the Destination Choice of German Tourists</u></i>
NRM	22.2004	<i>Javier Rey-MAQUIEIRA PALMER, Javier LOZANO IBÁÑEZ and Carlos Mario GÓMEZ GÓMEZ (lxvii): <u>Land, Environmental Externalities and Tourism Development</u></i>
NRM	23.2004	<i>Pius ODUNGA and Henk FOLMER (lxvii): <u>Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya</u></i>
NRM	24.2004	<i>Jean-Jacques NOWAK, Mondher SAHLI and Pasquale M. SGRO (lxvii): <u>Tourism, Trade and Domestic Welfare</u></i>
NRM	25.2004	<i>Riaz SHAREEF (lxvii): <u>Country Risk Ratings of Small Island Tourism Economies</u></i>
NRM	26.2004	<i>Juan Luis EUGENIO-MARTÍN, Noelia MARTÍN MORALES and Riccardo SCARPA (lxvii): <u>Tourism and Economic Growth in Latin American Countries: A Panel Data Approach</u></i>
NRM	27.2004	<i>Raúl Hernández MARTÍN (lxvii): <u>Impact of Tourism Consumption on GDP. The Role of Imports</u></i>
CSRM	28.2004	<i>Nicoletta FERRO: <u>Cross-Country Ethical Dilemmas in Business: A Descriptive Framework</u></i>
NRM	29.2004	<i>Marian WEBER (lxvi): <u>Assessing the Effectiveness of Tradable Landuse Rights for Biodiversity Conservation: an Application to Canada's Boreal Mixedwood Forest</u></i>
NRM	30.2004	<i>Trond BJORN DAL, Phoebe KOUNDOURI and Sean PASCOE (lxvi): <u>Output Substitution in Multi-Species Trawl Fisheries: Implications for Quota Setting</u></i>
CCMP	31.2004	<i>Marzio GALEOTTI, Alessandra GORIA, Paolo MOMBRINI and Evi SPANTIDAKI: <u>Weather Impacts on Natural, Social and Economic Systems (WISE) Part I: Sectoral Analysis of Climate Impacts in Italy</u></i>
CCMP	32.2004	<i>Marzio GALEOTTI, Alessandra GORIA, Paolo MOMBRINI and Evi SPANTIDAKI: <u>Weather Impacts on Natural, Social and Economic Systems (WISE) Part II: Individual Perception of Climate Extremes in Italy</u></i>
CTN	33.2004	<i>Wilson PEREZ: <u>Divide and Conquer: Noisy Communication in Networks, Power, and Wealth Distribution</u></i>
KTHC	34.2004	<i>Gianmarco I.P. OTTAVIANO and Giovanni PERI (lxviii): <u>The Economic Value of Cultural Diversity: Evidence from US Cities</u></i>
KTHC	35.2004	<i>Linda CHAIB (lxviii): <u>Immigration and Local Urban Participatory Democracy: A Boston-Paris Comparison</u></i>

KTHC	36.2004	<i>Franca ECKERT COEN and Claudio ROSSI</i> (I xviii): <u>Foreigners, Immigrants, Host Cities: The Policies of Multi-Ethnicity in Rome. Reading Governance in a Local Context</u>
KTHC	37.2004	<i>Kristine CRANE</i> (I xviii): <u>Governing Migration: Immigrant Groups' Strategies in Three Italian Cities – Rome, Naples and Bari</u>
KTHC	38.2004	<i>Kiflemariam HAMDE</i> (I xviii): <u>Mind in Africa, Body in Europe: The Struggle for Maintaining and Transforming Cultural Identity - A Note from the Experience of Eritrean Immigrants in Stockholm</u>
ETA	39.2004	<i>Alberto CAVALIERE</i> : <u>Price Competition with Information Disparities in a Vertically Differentiated Duopoly</u>
PRA	40.2004	<i>Andrea BIGANO and Stef PROOST</i> : <u>The Opening of the European Electricity Market and Environmental Policy: Does the Degree of Competition Matter?</u>
CCMP	41.2004	<i>Micheal FINUS</i> (I xix): <u>International Cooperation to Resolve International Pollution Problems</u>
KTHC	42.2004	<i>Francesco CRESPI</i> : <u>Notes on the Determinants of Innovation: A Multi-Perspective Analysis</u>
CTN	43.2004	<i>Sergio CURRARINI and Marco MARINI</i> : <u>Coalition Formation in Games without Synergies</u>
CTN	44.2004	<i>Marc ESCRHUELA-VILLAR</i> : <u>Cartel Sustainability and Cartel Stability</u>
NRM	45.2004	<i>Sebastian BERVOETS and Nicolas GRAVEL</i> (I xvi): <u>Appraising Diversity with an Ordinal Notion of Similarity: An Axiomatic Approach</u>
NRM	46.2004	<i>Signe ANTHON and Bo JELLES MARK THORSEN</i> (I xvi): <u>Optimal Afforestation Contracts with Asymmetric Information on Private Environmental Benefits</u>
NRM	47.2004	<i>John MBURU</i> (I xvi): <u>Wildlife Conservation and Management in Kenya: Towards a Co-management Approach</u>
NRM	48.2004	<i>Ekin BIROL, Ágnes GYOVAI and Melinda SMALE</i> (I xvi): <u>Using a Choice Experiment to Value Agricultural Biodiversity on Hungarian Small Farms: Agri-Environmental Policies in a Transition al Economy</u>
CCMP	49.2004	<i>Gernot KLEPPER and Sonja PETERSON</i> : <u>The EU Emissions Trading Scheme. Allowance Prices, Trade Flows, Competitiveness Effects</u>
GG	50.2004	<i>Scott BARRETT and Michael HOEL</i> : <u>Optimal Disease Eradication</u>
CTN	51.2004	<i>Dinko DIMITROV, Peter BORM, Ruud HENDRICKX and Shao CHIN SUNG</i> : <u>Simple Priorities and Core Stability in Hedonic Games</u>
SIEV	52.2004	<i>Francesco RICCI</i> : <u>Channels of Transmission of Environmental Policy to Economic Growth: A Survey of the Theory</u>
SIEV	53.2004	<i>Anna ALBERINI, Maureen CROPPER, Alan KRUPNICK and Nathalie B. SIMON</i> : <u>Willingness to Pay for Mortality Risk Reductions: Does Latency Matter?</u>
NRM	54.2004	<i>Ingo BRÄUER and Rainer MARGGRAF</i> (I xvi): <u>Valuation of Ecosystem Services Provided by Biodiversity Conservation: An Integrated Hydrological and Economic Model to Value the Enhanced Nitrogen Retention in Renaturated Streams</u>
NRM	55.2004	<i>Timo GOESCHL and Tun LIN</i> (I xvi): <u>Biodiversity Conservation on Private Lands: Information Problems and Regulatory Choices</u>
NRM	56.2004	<i>Tom DEDEURWAERDERE</i> (I xvi): <u>Bioprospection: From the Economics of Contracts to Reflexive Governance</u>
CCMP	57.2004	<i>Katrin REHDANZ and David MADDISON</i> : <u>The Amenity Value of Climate to German Households</u>
CCMP	58.2004	<i>Koen SMEKENS and Bob VAN DER ZWAAN</i> : <u>Environmental Externalities of Geological Carbon Sequestration Effects on Energy Scenarios</u>
NRM	59.2004	<i>Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA</i> (I xvii): <u>Using Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management</u>
NRM	60.2004	<i>Timo GOESCHL and Danilo CAMARGO IGLIORI</i> (I xvi): <u>Property Rights Conservation and Development: An Analysis of Extractive Reserves in the Brazilian Amazon</u>
CCMP	61.2004	<i>Barbara BUCHNER and Carlo CARRARO</i> : <u>Economic and Environmental Effectiveness of a Technology-based Climate Protocol</u>
NRM	62.2004	<i>Elissaios POPYRAKIS and Reyer GERLAGH</i> : <u>Resource-Abundance and Economic Growth in the U.S.</u>
NRM	63.2004	<i>Györgyi BELA, György PATAKI, Melinda SMALE and Mariann HAJDÚ</i> (I xvi): <u>Conserving Crop Genetic Resources on Smallholder Farms in Hungary: Institutional Analysis</u>
NRM	64.2004	<i>E.C.M. RUIJGROK and E.E.M. NILLESEN</i> (I xvi): <u>The Socio-Economic Value of Natural Riverbanks in the Netherlands</u>
NRM	65.2004	<i>E.C.M. RUIJGROK</i> (I xvi): <u>Reducing Acidification: The Benefits of Increased Nature Quality. Investigating the Possibilities of the Contingent Valuation Method</u>
ETA	66.2004	<i>Giannis VARDAS and Anastasios XEPAPADEAS</i> : <u>Uncertainty Aversion, Robust Control and Asset Holdings</u>
GG	67.2004	<i>Anastasios XEPAPADEAS and Constadina PASSA</i> : <u>Participation in and Compliance with Public Voluntary Environmental Programs: An Evolutionary Approach</u>
GG	68.2004	<i>Michael FINUS</i> : <u>Modesty Pays: Sometimes!</u>
NRM	69.2004	<i>Trond BJØRNDAL and Ana BRASÃO</i> : <u>The Northern Atlantic Bluefin Tuna Fisheries: Management and Policy Implications</u>
CTN	70.2004	<i>Alejandro CAPARRÓS, Abdelhakim HAMMOUDI and Tarik TAZDAÏT</i> : <u>On Coalition Formation with Heterogeneous Agents</u>
IEM	71.2004	<i>Massimo GIOVANNINI, Margherita GRASSO, Alessandro LANZA and Matteo MANERA</i> : <u>Conditional Correlations in the Returns on Oil Companies Stock Prices and Their Determinants</u>
IEM	72.2004	<i>Alessandro LANZA, Matteo MANERA and Michael MCALEER</i> : <u>Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns</u>
SIEV	73.2004	<i>Margarita GENIUS and Elisabetta STRAZZERA</i> : <u>The Copula Approach to Sample Selection Modelling: An Application to the Recreational Value of Forests</u>

CCMP	74.2004	<i>Rob DELLINK and Ekko van IERLAND</i> : <u>Pollution Abatement in the Netherlands: A Dynamic Applied General Equilibrium Assessment</u>
ETA	75.2004	<i>Rosella LEVAGGI and Michele MORETTO</i> : <u>Investment in Hospital Care Technology under Different Purchasing Rules: A Real Option Approach</u>
CTN	76.2004	<i>Salvador BARBERÀ and Matthew O. JACKSON</i> (lxx): <u>On the Weights of Nations: Assigning Voting Weights in a Heterogeneous Union</u>
CTN	77.2004	<i>Àlex ARENAS, Antonio CABRALES, Albert DÍAZ-GUILERA, Roger GUIMERA and Fernando VEGA-REDONDO</i> (lxx): <u>Optimal Information Transmission in Organizations: Search and Congestion</u>
CTN	78.2004	<i>Francis BLOCH and Armando GOMES</i> (lxx): <u>Contracting with Externalities and Outside Options</u>
CTN	79.2004	<i>Rabah AMIR, Effrosyni DIAMANTOUDI and Licun XUE</i> (lxx): <u>Merger Performance under Uncertain Efficiency Gains</u>
CTN	80.2004	<i>Francis BLOCH and Matthew O. JACKSON</i> (lxx): <u>The Formation of Networks with Transfers among Players</u>
CTN	81.2004	<i>Daniel DIERMEIER, Hülya ERASLAN and Antonio MERLO</i> (lxx): <u>Bicameralism and Government Formation</u>
CTN	82.2004	<i>Rod GARRATT, James E. PARCO, Cheng-ZHONG QIN and Amnon RAPOPORT</i> (lxx): <u>Potential Maximization and Coalition Government Formation</u>
CTN	83.2004	<i>Kfir ELIAZ, Debraj RAY and Ronny RAZIN</i> (lxx): <u>Group Decision-Making in the Shadow of Disagreement</u>
CTN	84.2004	<i>Sanjeev GOYAL, Marco van der LEIJ and José Luis MORAGA-GONZÁLEZ</i> (lxx): <u>Economics: An Emerging Small World?</u>
CTN	85.2004	<i>Edward CARTWRIGHT</i> (lxx): <u>Learning to Play Approximate Nash Equilibria in Games with Many Players</u>
IEM	86.2004	<i>Finn R. FØRSUND and Michael HOEL</i> : <u>Properties of a Non-Competitive Electricity Market Dominated by Hydroelectric Power</u>
KTHC	87.2004	<i>Elissaios PAPHAKIS and Reyer GERLAGH</i> : <u>Natural Resources, Investment and Long-Term Income</u>
CCMP	88.2004	<i>Marzio GALEOTTI and Claudia KEMFERT</i> : <u>Interactions between Climate and Trade Policies: A Survey</u>
IEM	89.2004	<i>A. MARKANDYA, S. PEDROSO and D. STREIMIKIENE</i> : <u>Energy Efficiency in Transition Economies: Is There Convergence Towards the EU Average?</u>
GG	90.2004	<i>Rolf GOLOMBEK and Michael HOEL</i> : <u>Climate Agreements and Technology Policy</u>
PRA	91.2004	<i>Sergei IZMALKOV</i> (lxv): <u>Multi-Unit Open Ascending Price Efficient Auction</u>
KTHC	92.2004	<i>Gianmarco I.P. OTTAVIANO and Giovanni PERI</i> : <u>Cities and Cultures</u>
KTHC	93.2004	<i>Massimo DEL GATTO</i> : <u>Agglomeration, Integration, and Territorial Authority Scale in a System of Trading Cities. Centralisation versus devolution</u>
CCMP	94.2004	<i>Pierre-André JOUVET, Philippe MICHEL and Gilles ROTILLON</i> : <u>Equilibrium with a Market of Permits</u>
CCMP	95.2004	<i>Bob van der ZWAAN and Reyer GERLAGH</i> : <u>Climate Uncertainty and the Necessity to Transform Global Energy Supply</u>
CCMP	96.2004	<i>Francesco BOSELLO, Marco LAZZARIN, Roberto ROSON and Richard S.J. TOL</i> : <u>Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise</u>
CTN	97.2004	<i>Gustavo BERGANTIÑOS and Juan J. VIDAL-PUGA</i> : <u>Defining Rules in Cost Spanning Tree Problems Through the Canonical Form</u>
CTN	98.2004	<i>Siddhartha BANDYOPADHYAY and Mandar OAK</i> : <u>Party Formation and Coalitional Bargaining in a Model of Proportional Representation</u>
GG	99.2004	<i>Hans-Peter WEIKARD, Michael FINUS and Juan-Carlos ALTAMIRANO-CABRERA</i> : <u>The Impact of Surplus Sharing on the Stability of International Climate Agreements</u>
SIEV	100.2004	<i>Chiara M. TRAVISI and Peter NIJKAMP</i> : <u>Willingness to Pay for Agricultural Environmental Safety: Evidence from a Survey of Milan, Italy, Residents</u>
SIEV	101.2004	<i>Chiara M. TRAVISI, Raymond J. G. M. FLORAX and Peter NIJKAMP</i> : <u>A Meta-Analysis of the Willingness to Pay for Reductions in Pesticide Risk Exposure</u>
NRM	102.2004	<i>Valentina BOSETTI and David TOMBERLIN</i> : <u>Real Options Analysis of Fishing Fleet Dynamics: A Test</u>
CCMP	103.2004	<i>Alessandra GORIA e Gretel GAMBARELLI</i> : <u>Economic Evaluation of Climate Change Impacts and Adaptability in Italy</u>
PRA	104.2004	<i>Massimo FLORIO and Mara GRASSENI</i> : <u>The Missing Shock: The Macroeconomic Impact of British Privatisation</u>
PRA	105.2004	<i>John BENNETT, Saul ESTRIN, James MAW and Giovanni URGA</i> : <u>Privatisation Methods and Economic Growth in Transition Economies</u>
PRA	106.2004	<i>Kira BÖRNER</i> : <u>The Political Economy of Privatization: Why Do Governments Want Reforms?</u>
PRA	107.2004	<i>Pehr-Johan NORBÄCK and Lars PERSSON</i> : <u>Privatization and Restructuring in Concentrated Markets</u>
SIEV	108.2004	<i>Angela GRANZOTTO, Fabio PRANOVI, Simone LIBRALATO, Patrizia TORRICELLI and Danilo MAINARDI</i> : <u>Comparison between Artisanal Fishery and Manila Clam Harvesting in the Venice Lagoon by Using Ecosystem Indicators: An Ecological Economics Perspective</u>
CTN	109.2004	<i>Somdeb LAHIRI</i> : <u>The Cooperative Theory of Two Sided Matching Problems: A Re-examination of Some Results</u>
NRM	110.2004	<i>Giuseppe DI VITA</i> : <u>Natural Resources Dynamics: Another Look</u>
SIEV	111.2004	<i>Anna ALBERINI, Alistair HUNT and Anil MARKANDYA</i> : <u>Willingness to Pay to Reduce Mortality Risks: Evidence from a Three-Country Contingent Valuation Study</u>
KTHC	112.2004	<i>Valeria PAPPONETTI and Dino PINELLI</i> : <u>Scientific Advice to Public Policy-Making</u>
SIEV	113.2004	<i>Paulo A.L.D. NUNES and Laura ONOFRI</i> : <u>The Economics of Warm Glow: A Note on Consumer's Behavior and Public Policy Implications</u>
IEM	114.2004	<i>Patrick CAYRADE</i> : <u>Investments in Gas Pipelines and Liquefied Natural Gas Infrastructure What is the Impact on the Security of Supply?</u>
IEM	115.2004	<i>Valeria COSTANTINI and Francesco GRACCEVA</i> : <u>Oil Security. Short- and Long-Term Policies</u>

IEM	116.2004	<i>Valeria COSTANTINI and Francesco GRACCEVA: <u>Social Costs of Energy Disruptions</u></i>
IEM	117.2004	<i>Christian EGENHOFER, Kyriakos GIALOGLOU, Giacomo LUCIANI, Maroeska BOOTS, Martin SCHEEPERS, Valeria COSTANTINI, Francesco GRACCEVA, Anil MARKANDYA and Giorgio VICINI: <u>Market-Based Options for Security of Energy Supply</u></i>
IEM	118.2004	<i>David FISK: <u>Transport Energy Security. The Unseen Risk?</u></i>
IEM	119.2004	<i>Giacomo LUCIANI: <u>Security of Supply for Natural Gas Markets. What is it and What is it not?</u></i>
IEM	120.2004	<i>L.J. de VRIES and R.A. HAKVOORT: <u>The Question of Generation Adequacy in Liberalised Electricity Markets</u></i>
KTHC	121.2004	<i>Alberto PETRUCCI: <u>Asset Accumulation, Fertility Choice and Nondegenerate Dynamics in a Small Open Economy</u></i>
NRM	122.2004	<i>Carlo GIUPPONI, Jaroslaw MYSLAK and Anita FASSIO: <u>An Integrated Assessment Framework for Water Resources Management: A DSS Tool and a Pilot Study Application</u></i>
NRM	123.2004	<i>Margaretha BREIL, Anita FASSIO, Carlo GIUPPONI and Paolo ROSATO: <u>Evaluation of Urban Improvement on the Islands of the Venice Lagoon: A Spatially-Distributed Hedonic-Hierarchical Approach</u></i>
ETA	124.2004	<i>Paul MENSINK: <u>Instant Efficient Pollution Abatement Under Non-Linear Taxation and Asymmetric Information: The Differential Tax Revisited</u></i>
NRM	125.2004	<i>Mauro FABIANO, Gabriella CAMARSA, Rosanna DURSI, Roberta IVALDI, Valentina MARIN and Francesca PALMISANI: <u>Integrated Environmental Study for Beach Management: A Methodological Approach</u></i>
PRA	126.2004	<i>Irena GROSFELD and Iraj HASHI: <u>The Emergence of Large Shareholders in Mass Privatized Firms: Evidence from Poland and the Czech Republic</u></i>
CCMP	127.2004	<i>Maria BERRITTELLA, Andrea BIGANO, Roberto ROSON and Richard S.J. TOL: <u>A General Equilibrium Analysis of Climate Change Impacts on Tourism</u></i>
CCMP	128.2004	<i>Reyer GERLAGH: <u>A Climate-Change Policy Induced Shift from Innovations in Energy Production to Energy Savings</u></i>
NRM	129.2004	<i>Elissaios POPYRAKIS and Reyer GERLAGH: <u>Natural Resources, Innovation, and Growth</u></i>
PRA	130.2004	<i>Bernardo BORTOLOTTI and Mara FACCIO: <u>Reluctant Privatization</u></i>
SIEV	131.2004	<i>Riccardo SCARPA and Mara THIENE: <u>Destination Choice Models for Rock Climbing in the Northeast Alps: A Latent-Class Approach Based on Intensity of Participation</u></i>
SIEV	132.2004	<i>Riccardo SCARPA Kenneth G. WILLIS and Melinda ACUTT: <u>Comparing Individual-Specific Benefit Estimates for Public Goods: Finite Versus Continuous Mixing in Logit Models</u></i>
IEM	133.2004	<i>Santiago J. RUBIO: <u>On Capturing Oil Rents with a National Excise Tax Revisited</u></i>
ETA	134.2004	<i>Ascensión ANDINA DÍAZ: <u>Political Competition when Media Create Candidates' Charisma</u></i>
SIEV	135.2004	<i>Anna ALBERINI: <u>Robustness of VSL Values from Contingent Valuation Surveys</u></i>
CCMP	136.2004	<i>Gernot KLEPPER and Sonja PETERSON: <u>Marginal Abatement Cost Curves in General Equilibrium: The Influence of World Energy Prices</u></i>
ETA	137.2004	<i>Herbert DAWID, Christophe DEISSENBERG and Pavel ŠEVČIK: <u>Cheap Talk, Gullibility, and Welfare in an Environmental Taxation Game</u></i>
CCMP	138.2004	<i>ZhongXiang ZHANG: <u>The World Bank's Prototype Carbon Fund and China</u></i>
CCMP	139.2004	<i>Reyer GERLAGH and Marjan W. HOFKES: <u>Time Profile of Climate Change Stabilization Policy</u></i>
NRM	140.2004	<i>Chiara D'ALPAOS and Michele MORETTO: <u>The Value of Flexibility in the Italian Water Service Sector: A Real Option Analysis</u></i>
PRA	141.2004	<i>Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS (lxxi): <u>Bidding for Incomplete Contracts</u></i>
PRA	142.2004	<i>Susan ATHEY, Jonathan LEVIN and Enrique SEIRA (lxxi): <u>Comparing Open and Sealed Bid Auctions: Theory and Evidence from Timber Auctions</u></i>
PRA	143.2004	<i>David GOLDREICH (lxxi): <u>Behavioral Biases of Dealers in U.S. Treasury Auctions</u></i>
PRA	144.2004	<i>Roberto BURGNET (lxxi): <u>Optimal Procurement Auction for a Buyer with Downward Sloping Demand: More Simple Economics</u></i>
PRA	145.2004	<i>Ali HORTACSU and Samita SAREEN (lxxi): <u>Order Flow and the Formation of Dealer Bids: An Analysis of Information and Strategic Behavior in the Government of Canada Securities Auctions</u></i>
PRA	146.2004	<i>Victor GINSBURGH, Patrick LEGROS and Nicolas SAHUGUET (lxxi): <u>How to Win Twice at an Auction. On the Incidence of Commissions in Auction Markets</u></i>
PRA	147.2004	<i>Claudio MEZZETTI, Aleksandar PEKEČ and Ilia TSETLIN (lxxi): <u>Sequential vs. Single-Round Uniform-Price Auctions</u></i>
PRA	148.2004	<i>John ASKER and Estelle CANTILLON (lxxi): <u>Equilibrium of Scoring Auctions</u></i>
PRA	149.2004	<i>Philip A. HAILE, Han HONG and Matthew SHUM (lxxi): <u>Nonparametric Tests for Common Values in First-Price Sealed-Bid Auctions</u></i>
PRA	150.2004	<i>François DEGEORGE, François DERRIEN and Kent L. WOMACK (lxxi): <u>Quid Pro Quo in IPOs: Why Bookbuilding is Dominating Auctions</u></i>
CCMP	151.2004	<i>Barbara BUCHNER and Silvia DALL'OLIO: <u>Russia: The Long Road to Ratification. Internal Institution and Pressure Groups in the Kyoto Protocol's Adoption Process</u></i>
CCMP	152.2004	<i>Carlo CARRARO and Marzio GALEOTTI: <u>Does Endogenous Technical Change Make a Difference in Climate Policy Analysis? A Robustness Exercise with the FEEM-RICE Model</u></i>
PRA	153.2004	<i>Alejandro M. MANELLI and Daniel R. VINCENT (lxxi): <u>Multidimensional Mechanism Design: Revenue Maximization and the Multiple-Good Monopoly</u></i>
ETA	154.2004	<i>Nicola ACOCELLA, Giovanni Di BARTOLOMEO and Wilfried PAUWELS: <u>Is there any Scope for Corporatism in Stabilization Policies?</u></i>
CTN	155.2004	<i>Johan EYCKMANS and Michael FINUS: <u>An Almost Ideal Sharing Scheme for Coalition Games with Externalities</u></i>
CCMP	156.2004	<i>Cesare DOSI and Michele MORETTO: <u>Environmental Innovation, War of Attrition and Investment Grants</u></i>



CCMP	157.2004	<i>Valentina BOSETTI, Marzio GALEOTTI and Alessandro LANZA: <u>How Consistent are Alternative Short-Term Climate Policies with Long-Term Goals?</u></i>
ETA	158.2004	<i>Y. Hossein FARZIN and Ken-Ichi AKAO: <u>Non-pecuniary Value of Employment and Individual Labor Supply</u></i>
ETA	159.2004	<i>William BROCK and Anastasios XEPAPADEAS: <u>Spatial Analysis: Development of Descriptive and Normative Methods with Applications to Economic-Ecological Modelling</u></i>
KTHC	160.2004	<i>Alberto PETRUCCI: <u>On the Incidence of a Tax on Pure Rent with Infinite Horizons</u></i>
IEM	161.2004	<i>Xavier LABANDEIRA, José M. LABEAGA and Miguel RODRÍGUEZ: <u>Microsimulating the Effects of Household Energy Price Changes in Spain</u></i>

#### NOTE DI LAVORO PUBLISHED IN 2005

CCMP	1.2005	<i>Stéphane HALLEGATTE: <u>Accounting for Extreme Events in the Economic Assessment of Climate Change</u></i>
CCMP	2.2005	<i>Qiang WU and Paulo Augusto NUNES: <u>Application of Technological Control Measures on Vehicle Pollution: A Cost-Benefit Analysis in China</u></i>
CCMP	3.2005	<i>Andrea BIGANO, Jacqueline M. HAMILTON, Maren LAU, Richard S.J. TOL and Yuan ZHOU: <u>A Global Database of Domestic and International Tourist Numbers at National and Subnational Level</u></i>
CCMP	4.2005	<i>Andrea BIGANO, Jacqueline M. HAMILTON and Richard S.J. TOL: <u>The Impact of Climate on Holiday Destination Choice</u></i>
ETA	5.2005	<i>Hubert KEMPF: <u>Is Inequality Harmful for the Environment in a Growing Economy?</u></i>
CCMP	6.2005	<i>Valentina BOSETTI, Carlo CARRARO and Marzio GALEOTTI: <u>The Dynamics of Carbon and Energy Intensity in a Model of Endogenous Technical Change</u></i>
IEM	7.2005	<i>David CALEF and Robert GOBLE: <u>The Allure of Technology: How France and California Promoted Electric Vehicles to Reduce Urban Air Pollution</u></i>
ETA	8.2005	<i>Lorenzo PELLEGRINI and Reyer GERLAGH: <u>An Empirical Contribution to the Debate on Corruption Democracy and Environmental Policy</u></i>
CCMP	9.2005	<i>Angelo ANTOCI: <u>Environmental Resources Depletion and Interplay Between Negative and Positive Externalities in a Growth Model</u></i>
CTN	10.2005	<i>Frédéric DEROLAN: <u>Cost-Reducing Alliances and Local Spillovers</u></i>
NRM	11.2005	<i>Francesco SINDICO: <u>The GMO Dispute before the WTO: Legal Implications for the Trade and Environment Debate</u></i>
KTHC	12.2005	<i>Carla MASSIDDA: <u>Estimating the New Keynesian Phillips Curve for Italian Manufacturing Sectors</u></i>
KTHC	13.2005	<i>Michele MORETTO and Gianpaolo ROSSINI: <u>Start-up Entry Strategies: Employer vs. Nonemployer firms</u></i>
PRCG	14.2005	<i>Clara GRAZIANO and Annalisa LUPORINI: <u>Ownership Concentration, Monitoring and Optimal Board Structure</u></i>
CSRM	15.2005	<i>Parashar KULKARNI: <u>Use of Ecolabels in Promoting Exports from Developing Countries to Developed Countries: Lessons from the Indian LeatherFootwear Industry</u></i>
KTHC	16.2005	<i>Adriana DI LIBERTO, Roberto MURA and Francesco PIGLIARU: <u>How to Measure the Unobservable: A Panel Technique for the Analysis of TFP Convergence</u></i>
KTHC	17.2005	<i>Alireza NAGHAVI: <u>Asymmetric Labor Markets, Southern Wages, and the Location of Firms</u></i>
KTHC	18.2005	<i>Alireza NAGHAVI: <u>Strategic Intellectual Property Rights Policy and North-South Technology Transfer</u></i>
KTHC	19.2005	<i>Mombert HOPPE: <u>Technology Transfer Through Trade</u></i>
PRCG	20.2005	<i>Roberto ROSON: <u>Platform Competition with Endogenous Multihoming</u></i>
CCMP	21.2005	<i>Barbara BUCHNER and Carlo CARRARO: <u>Regional and Sub-Global Climate Blocs. A Game Theoretic Perspective on Bottom-up Climate Regimes</u></i>
IEM	22.2005	<i>Fausto CAVALLARO: <u>An Integrated Multi-Criteria System to Assess Sustainable Energy Options: An Application of the Promethee Method</u></i>
CTN	23.2005	<i>Michael FINUS, Pierre v. MOUCHE and Bianca RUNDSHAGEN: <u>Uniqueness of Coalitional Equilibria</u></i>
IEM	24.2005	<i>Wietze LISE: <u>Decomposition of CO2 Emissions over 1980–2003 in Turkey</u></i>
CTN	25.2005	<i>Somdeb LAHIRI: <u>The Core of Directed Network Problems with Quotas</u></i>
SIEV	26.2005	<i>Susanne MENZEL and Riccardo SCARPA: <u>Protection Motivation Theory and Contingent Valuation: Perceived Realism, Threat and WTP Estimates for Biodiversity Protection</u></i>
NRM	27.2005	<i>Massimiliano MAZZANTI and Anna MONTINI: <u>The Determinants of Residential Water Demand Empirical Evidence for a Panel of Italian Municipalities</u></i>
CCMP	28.2005	<i>Laurent GILOTTE and Michel de LARA: <u>Precautionary Effect and Variations of the Value of Information</u></i>
NRM	29.2005	<i>Paul SARFO-MENSAH: <u>Exportation of Timber in Ghana: The Menace of Illegal Logging Operations</u></i>
CCMP	30.2005	<i>Andrea BIGANO, Alessandra GORIA, Jacqueline HAMILTON and Richard S.J. TOL: <u>The Effect of Climate Change and Extreme Weather Events on Tourism</u></i>
NRM	31.2005	<i>Maria Angeles GARCIA-VALIÑAS: <u>Decentralization and Environment: An Application to Water Policies</u></i>
NRM	32.2005	<i>Chiara D'ALPAOS, Cesare DOSI and Michele MORETTO: <u>Concession Length and Investment Timing Flexibility</u></i>
CCMP	33.2005	<i>Joseph HUBER: <u>Key Environmental Innovations</u></i>
CTN	34.2005	<i>Antoni CALVÓ-ARMENGOL and Rahmi İLKILIÇ (Ixxii): <u>Pairwise-Stability and Nash Equilibria in Network Formation</u></i>
CTN	35.2005	<i>Francesco FERI (Ixxii): <u>Network Formation with Endogenous Decay</u></i>
CTN	36.2005	<i>Frank H. PAGE, Jr. and Myrna H. WOODERS (Ixxii): <u>Strategic Basins of Attraction, the Farsighted Core, and Network Formation Games</u></i>

CTN	37.2005	<i>Alessandra CASELLA and Nobuyuki HANAOKI</i> (lxxii): <u>Information Channels in Labor Markets. On the Resilience of Referral Hiring</u>
CTN	38.2005	<i>Matthew O. JACKSON and Alison WATTS</i> (lxxii): <u>Social Games: Matching and the Play of Finitely Repeated Games</u>
CTN	39.2005	<i>Anna BOGOMOLNAIA, Michel LE BRETON, Alexei SAVVATEEV and Shlomo WEBER</i> (lxxii): <u>The Egalitarian Sharing Rule in Provision of Public Projects</u>
CTN	40.2005	<i>Francesco FERI</i> : <u>Stochastic Stability in Network with Decay</u>
CTN	41.2005	<i>Aart de ZEEUW</i> (lxxii): <u>Dynamic Effects on the Stability of International Environmental Agreements</u>
NRM	42.2005	<i>C. Martijn van der HEIDE, Jeroen C.J.M. van den BERGH, Ekko C. van IERLAND and Paulo A.L.D. NUNES</i> : <u>Measuring the Economic Value of Two Habitat Defragmentation Policy Scenarios for the Veluwe, The Netherlands</u>
PRCG	43.2005	<i>Carla VIEIRA and Ana Paula SERRA</i> : <u>Abnormal Returns in Privatization Public Offerings: The Case of Portuguese Firms</u>
SIEV	44.2005	<i>Anna ALBERINI, Valentina ZANATTA and Paolo ROSATO</i> : <u>Combining Actual and Contingent Behavior to Estimate the Value of Sports Fishing in the Lagoon of Venice</u>
CTN	45.2005	<i>Michael FINUS and Bianca RUNDSHAGEN</i> : <u>Participation in International Environmental Agreements: The Role of Timing and Regulation</u>
CCMP	46.2005	<i>Lorenzo PELLEGRINI and Reyer GERLAGH</i> : <u>Are EU Environmental Policies Too Demanding for New Members States?</u>
IEM	47.2005	<i>Matteo MANERA</i> : <u>Modeling Factor Demands with SEM and VAR: An Empirical Comparison</u>
CTN	48.2005	<i>Olivier TERCIEUX and Vincent VANNETELBOSCH</i> (lxx): <u>A Characterization of Stochastically Stable Networks</u>
CTN	49.2005	<i>Ana MAULEON, José SEMPERE-MONERRIS and Vincent J. VANNETELBOSCH</i> (lxxii): <u>R&amp;D Networks Among Unionized Firms</u>
CTN	50.2005	<i>Carlo CARRARO, Johan EYCKMANS and Michael FINUS</i> : <u>Optimal Transfers and Participation Decisions in International Environmental Agreements</u>
KTHC	51.2005	<i>Valeria GATTAI</i> : <u>From the Theory of the Firm to FDI and Internalisation: A Survey</u>
CCMP	52.2005	<i>Alireza NAGHAVI</i> : <u>Multilateral Environmental Agreements and Trade Obligations: A Theoretical Analysis of the Doha Proposal</u>
SIEV	53.2005	<i>Margaretha BREIL, Gretel GAMBARELLI and Paulo A.L.D. NUNES</i> : <u>Economic Valuation of On Site Material Damages of High Water on Economic Activities based in the City of Venice: Results from a Dose-Response-Expert-Based Valuation Approach</u>
ETA	54.2005	<i>Alessandra del BOCA, Marzio GALEOTTI, Charles P. HIMMELBERG and Paola ROTA</i> : <u>Investment and Time to Plan: A Comparison of Structures vs. Equipment in a Panel of Italian Firms</u>
CCMP	55.2005	<i>Gernot KLEPPER and Sonja PETERSON</i> : <u>Emissions Trading, CDM, JI, and More – The Climate Strategy of the EU</u>
ETA	56.2005	<i>Maia DAVID and Bernard SINCLAIR-DESGAGNÉ</i> : <u>Environmental Regulation and the Eco-Industry</u>
ETA	57.2005	<i>Alain-Désiré NIMUBONA and Bernard SINCLAIR-DESGAGNÉ</i> : <u>The Pigouvian Tax Rule in the Presence of an Eco-Industry</u>
NRM	58.2005	<i>Helmut KARL, Antje MÖLLER, Ximena MATUS, Edgar GRANDE and Robert KAISER</i> : <u>Environmental Innovations: Institutional Impacts on Co-operations for Sustainable Development</u>
SIEV	59.2005	<i>Dimitra VOUVAKI and Anastasios XEPAPADEAS</i> (lxxiii): <u>Criteria for Assessing Sustainable Development: Theoretical Issues and Empirical Evidence for the Case of Greece</u>
CCMP	60.2005	<i>Andreas LÖSCHEL and Dirk T.G. RÜBBELKE</i> : <u>Impure Public Goods and Technological Interdependencies</u>
PRCG	61.2005	<i>Christoph A. SCHALTEGGER and Benno TORGLER</i> : <u>Trust and Fiscal Performance: A Panel Analysis with Swiss Data</u>
ETA	62.2005	<i>Irene VALSECCHI</i> : <u>A Role for Instructions</u>
NRM	63.2005	<i>Valentina BOSETTI and Gianni LOCATELLI</i> : <u>A Data Envelopment Analysis Approach to the Assessment of Natural Parks' Economic Efficiency and Sustainability. The Case of Italian National Parks</u>
SIEV	64.2005	<i>Arianne T. de BLAEIJ, Paulo A.L.D. NUNES and Jeroen C.J.M. van den BERGH</i> : <u>Modeling 'No-choice' Responses in Attribute Based Valuation Surveys</u>
CTN	65.2005	<i>Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI</i> : <u>Applications of Negotiation Theory to Water Issues</u>
CTN	66.2005	<i>Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI</i> : <u>Advances in Negotiation Theory: Bargaining, Coalitions and Fairness</u>
KTHC	67.2005	<i>Sandra WALLMAN</i> (lxxiv): <u>Network Capital and Social Trust: Pre-Conditions for 'Good' Diversity?</u>
KTHC	68.2005	<i>Asimina CHRISTOFOROU</i> (lxxiv): <u>On the Determinants of Social Capital in Greece Compared to Countries of the European Union</u>
KTHC	69.2005	<i>Eric M. USLANER</i> (lxxiv): <u>Varieties of Trust</u>
KTHC	70.2005	<i>Thomas P. LYON</i> (lxxiv): <u>Making Capitalism Work: Social Capital and Economic Growth in Italy, 1970-1995</u>
KTHC	71.2005	<i>Graziella BERTOCCHI and Chiara STROZZI</i> (lxxv): <u>Citizenship Laws and International Migration in Historical Perspective</u>
KTHC	72.2005	<i>Elsbeth van HYLCKAMA Vlieg</i> (lxxv): <u>Accommodating Differences</u>
KTHC	73.2005	<i>Renato SANSA and Ercole SORI</i> (lxxv): <u>Governance of Diversity Between Social Dynamics and Conflicts in Multicultural Cities. A Selected Survey on Historical Bibliography</u>
IEM	74.2005	<i>Alberto LONGO and Anil MARKANDYA</i> : <u>Identification of Options and Policy Instruments for the Internalisation of External Costs of Electricity Generation. Dissemination of External Costs of Electricity Supply Making Electricity External Costs Known to Policy-Makers</u> <u>MAXIMA</u>

IEM	75.2005	<i>Margherita GRASSO and Matteo MANERA: <u>Asymmetric Error Correction Models for the Oil-Gasoline Price Relationship</u></i>
ETA	76.2005	<i>Umberto CHERUBINI and Matteo MANERA: <u>Hunting the Living Dead A “Peso Problem” in Corporate Liabilities Data</u></i>
CTN	77.2005	<i>Hans-Peter WEIKARD: <u>Cartel Stability under an Optimal Sharing Rule</u></i>
ETA	78.2005	<i>Joëlle NOAILLY, Jeroen C.J.M. van den BERGH and Cees A. WITHAGEN (lxxvi): <u>Local and Global Interactions in an Evolutionary Resource Game</u></i>
ETA	79.2005	<i>Joëlle NOAILLY, Cees A. WITHAGEN and Jeroen C.J.M. van den BERGH (lxxvi): <u>Spatial Evolution of Social Norms in a Common-Pool Resource Game</u></i>
CCMP	80.2005	<i>Massimiliano MAZZANTI and Roberto ZOBOLI: <u>Economic Instruments and Induced Innovation: The Case of End-of-Life Vehicles European Policies</u></i>
NRM	81.2005	<i>Anna LASUT: <u>Creative Thinking and Modelling for the Decision Support in Water Management</u></i>
CCMP	82.2005	<i>Valentina BOSETTI and Barbara BUCHNER: <u>Using Data Envelopment Analysis to Assess the Relative Efficiency of Different Climate Policy Portfolios</u></i>
ETA	83.2005	<i>Ignazio MUSU: <u>Intellectual Property Rights and Biotechnology: How to Improve the Present Patent System</u></i>
KTHC	84.2005	<i>Giulio CAINELLI, Susanna MANCINELLI and Massimiliano MAZZANTI: <u>Social Capital, R&amp;D and Industrial Districts</u></i>
ETA	85.2005	<i>Rosella LEVAGGI, Michele MORETTO and Vincenzo REBBA: <u>Quality and Investment Decisions in Hospital Care when Physicians are Devoted Workers</u></i>
CCMP	86.2005	<i>Valentina BOSETTI and Laurent GILOTTE: <u>Carbon Capture and Sequestration: How Much Does this Uncertain Option Affect Near-Term Policy Choices?</u></i>
CSRM	87.2005	<i>Nicoletta FERRO: <u>Value Through Diversity: Microfinance and Islamic Finance and Global Banking</u></i>
ETA	88.2005	<i>A. MARKANDYA and S. PEDROSO: <u>How Substitutable is Natural Capital?</u></i>
IEM	89.2005	<i>Anil MARKANDYA, Valeria COSTANTINI, Francesco GRACCEVA and Giorgio VICINI: <u>Security of Energy Supply: Comparing Scenarios From a European Perspective</u></i>
CCMP	90.2005	<i>Vincent M. OTTO, Andreas LÖSCHEL and Rob DELLINK: <u>Energy Biased Technical Change: A CGE Analysis</u></i>
PRCG	91.2005	<i>Carlo CAPUANO: <u>Abuse of Competitive Fringe</u></i>
PRCG	92.2005	<i>Ulrich BINDSEIL, Kjell G. NYBORG and Ilya A. STREBULAEV (lxv): <u>Bidding and Performance in Repo Auctions: Evidence from ECB Open Market Operations</u></i>
CCMP	93.2005	<i>Sabrina AUCI and Leonardo BECCHETTI: <u>The Stability of the Adjusted and Unadjusted Environmental Kuznets Curve</u></i>
CCMP	94.2005	<i>Francesco BOSELLO and Jian ZHANG: <u>Assessing Climate Change Impacts: Agriculture</u></i>
CTN	95.2005	<i>Alejandro CAPARRÓS, Jean-Christophe PEREAU and Tarik TAZDAÏT: <u>Bargaining with Non-Monolithic Players</u></i>
ETA	96.2005	<i>William BROCK and Anastasios XEPAPADEAS (lxxvi): <u>Optimal Control and Spatial Heterogeneity: Pattern Formation in Economic-Ecological Models</u></i>
CCMP	97.2005	<i>Francesco BOSELLO, Roberto ROSON and Richard S.J. TOL (lxxvii): <u>Economy-Wide Estimates of the Implications of Climate Change: Human Health</u></i>
CCMP	98.2005	<i>Rob DELLINK, Michael FINUS and Niels OLIEMAN: <u>Coalition Formation under Uncertainty: The Stability Likelihood of an International Climate Agreement</u></i>
CTN	99.2005	<i>Valeria COSTANTINI, Riccardo CRESCENZI, Fabrizio De FILIPPIS, and Luca SALVATICI: <u>Bargaining Coalitions in the Agricultural Negotiations of the Doha Round: Similarity of Interests or Strategic Choices? An Empirical Assessment</u></i>
IEM	100.2005	<i>Giliola FREY and Matteo MANERA: <u>Econometric Models of Asymmetric Price Transmission</u></i>
IEM	101.2005	<i>Alessandro COLOGNI and Matteo MANERA: <u>Oil Prices, Inflation and Interest Rates in a Structural Cointegrated VAR Model for the G-7 Countries</u></i>
KTHC	102.2005	<i>Chiara M. TRAVISI and Roberto CAMAGNI: <u>Sustainability of Urban Sprawl: Environmental-Economic Indicators for the Analysis of Mobility Impact in Italy</u></i>
ETA	103.2005	<i>Livingstone S. LUBOOBI and Joseph Y.T. MUGISHA: <u>HIV/AIDS Pandemic in Africa: Trends and Challenges</u></i>
SIEV	104.2005	<i>Anna ALBERINI, Erik LICHTENBERG, Dominic MANCINI, and Gregmar I. GALINATO: <u>Was It Something I Ate? Implementation of the FDA Seafood HACCP Program</u></i>
SIEV	105.2005	<i>Anna ALBERINI and Aline CHIABAI: <u>Urban Environmental Health and Sensitive Populations: How Much are the Italians Willing to Pay to Reduce Their Risks?</u></i>
SIEV	106.2005	<i>Anna ALBERINI, Aline CHIABAI and Lucija MUEHLENBACHS: <u>Using Expert Judgment to Assess Adaptive Capacity to Climate Change: Evidence from a Conjoint Choice Survey</u></i>
CTN	107.2005	<i>Michele BERNASCONI and Matteo GALIZZI: <u>Coordination in Networks Formation: Experimental Evidence on Learning and Saliency</u></i>
KTHC	108.2005	<i>Michele MORETTO and Sergio VERGALLI: <u>Migration Dynamics</u></i>
NRM	109.2005	<i>Antonio MUSOLESI and Mario NOSVELLI: <u>Water Consumption and Long-Run Urban Development: The Case of Milan</u></i>
SIEV	110.2005	<i>Benno TORGLER and Maria A. GARCIA-VALIÑAS: <u>Attitudes Towards Preventing Environmental Damage</u></i>
SIEV	111.2005	<i>Alberto LONGO and Anna ALBERINI: <u>What are the Effects of Contamination Risks on Commercial and Industrial Properties? Evidence from Baltimore, Maryland</u></i>
SIEV	112.2005	<i>Anna ALBERINI and Alberto LONGO: <u>The Value of Cultural Heritage Sites in Armenia: Evidence from a Travel Cost Method Study</u></i>
CCMP	113.2005	<i>Mikel GONZÁLEZ and Rob DELLINK: <u>Impact of Climate Policy on the Basque Economy</u></i>
NRM	114.2005	<i>Gilles LAFFORGUE and Walid OUESLATI: <u>Optimal Soil Management and Environmental Policy</u></i>

NRM	115.2005	<i>Martin D. SMITH and Larry B. CROWDER</i> (Ixxvi): <u>Valuing Ecosystem Services with Fishery Rents: A Lumped-Parameter Approach to Hypoxia in the Neuse River Estuary</u>
NRM	116.2005	<i>Dan HOLLAND and Kurt SCHNIER</i> (Ixxvi): <u>Protecting Marine Biodiversity: A Comparison of Individual Habitat Quotas (IHQs) and Marine Protected Areas</u>
PRCG	117.2005	<i>John NELLIS</i> : <u>The Evolution of Enterprise Reform in Africa: From State-owned Enterprises to Private Participation in Infrastructure — and Back?</u>
PRCG	118.2005	<i>Bernardo BORTOLOTTI</i> : <u>Italy's Privatization Process and Its Implications for China</u>
SIEV	119.2005	<i>Anna ALBERINI, Marcella VERONESI and Joseph C. COOPER</i> : <u>Detecting Starting Point Bias in Dichotomous-Choice Contingent Valuation Surveys</u>
CTN	120.2005	<i>Federico ECHENIQUE and Mehmet B. YENMEZ</i> : <u>A Solution to Matching with Preferences over Colleagues</u>
KTHC	121.2005	<i>Valeria GATTAI and Corrado MOLteni</i> : <u>Dissipation of Knowledge and the Boundaries of the Multinational Enterprise</u>
KTHC	122.2005	<i>Valeria GATTAI</i> : <u>Firm's Intangible Assets and Multinational Activity: Joint-Venture Versus FDI</u>
CCMP	123.2005	<i>Socrates KYPREOS</i> : <u>A MERGE Model with Endogenous Technological Change and the Cost of Carbon Stabilization</u>

- (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 4<sup>th</sup> 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
- (lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003
- (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
- (lxx) This paper was presented at the 9<sup>th</sup> Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004
- (lxxi) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by Fondazione Eni Enrico Mattei and Consip and sponsored by the EU, Rome, September 23-25, 2004
- (lxxii) This paper was presented at the 10<sup>th</sup> Coalition Theory Network Workshop held in Paris, France on 28-29 January 2005 and organised by EUREQua.
- (lxxiii) This paper was presented at the 2nd Workshop on "Inclusive Wealth and Accounting Prices" held in Trieste, Italy on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics
- (lxxiv) This paper was presented at the ENGIME Workshop on “Trust and social capital in multicultural cities” Athens, January 19-20, 2004
- (lxxv) This paper was presented at the ENGIME Workshop on “Diversity as a source of growth” Rome November 18-19, 2004
- (lxxvi) This paper was presented at the 3rd Workshop on Spatial-Dynamic Models of Economics and Ecosystems held in Trieste on 11-13 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics
- (lxxvii) This paper was presented at the Workshop on Infectious Diseases: Ecological and Economic Approaches held in Trieste on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics.

#### 2004 SERIES

<b>CCMP</b>	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti )
<b>GG</b>	<i>Global Governance</i> (Editor: Carlo Carraro)
<b>SIEV</b>	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Anna Alberini)
<b>NRM</b>	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
<b>KTHC</b>	<i>Knowledge, Technology, Human Capital</i> (Editor: Gianmarco Ottaviano)
<b>IEM</b>	<i>International Energy Markets</i> (Editor: Anil Markandya)
<b>CSRM</b>	<i>Corporate Social Responsibility and Sustainable Management</i> (Editor: Sabina Ratti)
<b>PRA</b>	<i>Privatisation, Regulation, Antitrust</i> (Editor: Bernardo Bortolotti)
<b>ETA</b>	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)
<b>CTN</b>	<i>Coalition Theory Network</i>

#### 2005 SERIES

<b>CCMP</b>	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti )
<b>SIEV</b>	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Anna Alberini)
<b>NRM</b>	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
<b>KTHC</b>	<i>Knowledge, Technology, Human Capital</i> (Editor: Gianmarco Ottaviano)
<b>IEM</b>	<i>International Energy Markets</i> (Editor: Anil Markandya)
<b>CSRM</b>	<i>Corporate Social Responsibility and Sustainable Management</i> (Editor: Sabina Ratti)
<b>PRCG</b>	<i>Privatisation Regulation Corporate Governance</i> (Editor: Bernardo Bortolotti)
<b>ETA</b>	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)
<b>CTN</b>	<i>Coalition Theory Network</i>