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RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

TETRIS – Final Report

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Contents

1 Introductory remarks

This final report contains the main results and conclusions of the project Technology Transfer and Investment Risk in International Emissions Trading (TETRIS) funded by the European Commission under the Sixth Framework Programme. The complete results of the project can be found in full technical detail in the submitted project deliverables. Furthermore, a more concise version of the results from the different work packages will be published as a collection of related papers in the academic Journal *Climate Policy* by *Earthscan*, UK. Due to the time necessary for the internal processes of the Journal the Special Issue is not available to date. The Special Issue represents a centrepiece of the project, as publication in an academic field journal serves as an external quality control and furthermore facilitates dissemination of the work and the corresponding results to the academic community within and beyond the European Union.

Once the Special Issue is available a number of copies will be provided to the European Commission.

2 Participants and workpackages

The TETRIS project aims to explore the economic and industrial impacts as well as the prospects for achieving technology transfer associated with International Emissions Trading, Joint Implementation (JI) and the Clean Development Mechanism (CDM). It has been carried out by a consortium of five European research institutes and consulting companies from June 2005 until November 2006.

Table 1 lists the participants of the TETRIS project, while Table 2 presents the different workpackages and deliverables.

Table 1: List of participants

Role*	No.	Participant name	Short name	Country	Date enter project	Date exit project
CO	1	Centre for European Economic Research	ZEW	D	Month 1	Month 18
CR	2	Economic Research and Policy Consultancy	Ecoplan	CH	Month 1	Month 18
CR	3	Energy Research Center of the Netherlands	ECN	NL	Month 1	Month 18
CR	4	Natsource-Tullet Europe	NTE	UK	Month 1	Month 18
CR	5	Center for Clean Air Policy	CCAP	CZ	Month 1	Month 18

*CO = Coordinator, CR = Contractor

Table 2: Work package list

WP No.	WP title	Lead contractor No.	Person-months[1]	Start month	End month	Deliv-erable No.
WP 1	Indicators of the investment climate	2	8	0	15	D4
WP 2	Technology transfer	4	13	0	15	D5
WP 3	Permit supply from the CDM	3	7	0	12	D1
WP 4	Linking other trading schemes to the EU ETS	2	7	0	12	D2
WP 5	Joint Implementation and emissions trading in Eastern Europe	5	6	0	12	D3
WP 6	Quantitative analysis of international emissions trading	1	17.5	3	18	D6
WP 7	Summary, conclusions, policy recommendations and dissemination of results	1	5.5	1 5	18	D7, D8
WP 8	Project management	1	4.00	0	18	
	TOTAL		**68**			

Figure 1 illustrates the interconnections between the different workpackages of the project.

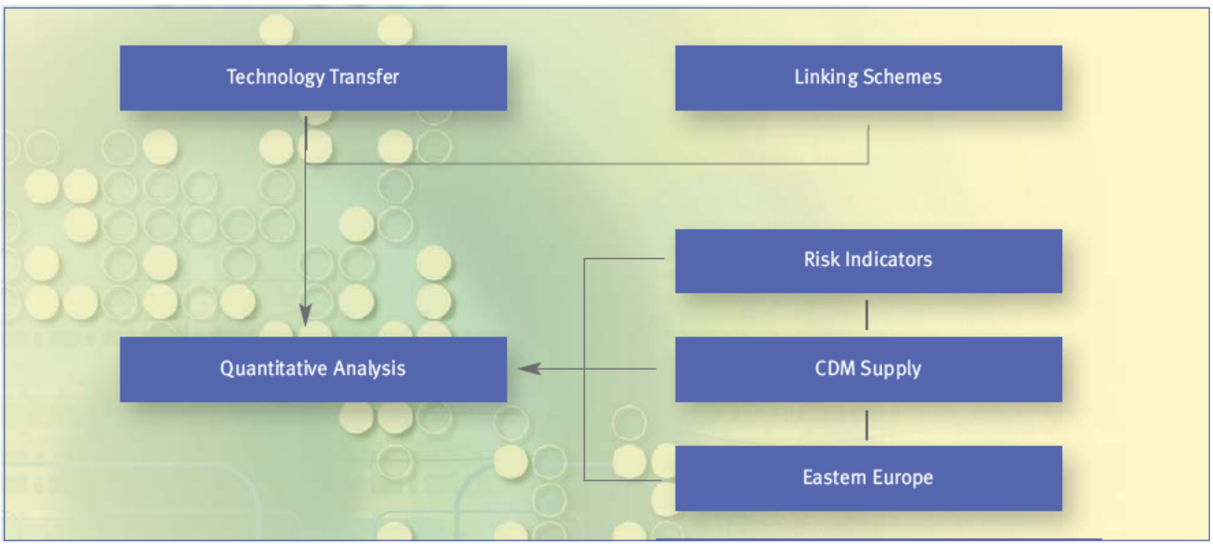

Figure 1: Links between the work packages of the TETRIS project

[1] The planned total number of person-months allocated to each work package.

3 Executive summary

Subsequently, we briefly summarize the main results of the TETRIS project.

Indicators of the Investment Climate

We build a composite indicator for the risks of investing in climate change mitigation projects. The indicator contains variables from a broad range of sources measuring the institutional environment for the Kyoto mechanisms, the regulatory environment, and the economic environment. Based on the indicator scores for 143 countries, we produce rankings for JI and CDM host countries. We find that the risks of investing in JI projects are lowest in New Zealand, Denmark and Sweden. India, China, Mexico, Brazil, and Chile are in the top 5 of the CDM ranking. Our results are similar to other rankings for CDM, but not for JI host countries, mainly because we do not take the mitigation potential into account. The composite indicator can be used to incorporate investment risks into models of international emissions trading. It may also be helpful to investors in the carbon market for portfolio allocation and diversification.

Technology Transfer

We examine how CDM and JI facilitate technology transfer (TT), describe technology transfers, and evaluate CDM and JI projects to assess whether TT took place, and the origin and value of TT exports. We found that CDM and JI are facilitating TT – particularly technologies that are most competitive in terms of cost and risk – mainly by improving the ability of projects to secure financing. However, we find that lower- and non-emitting energy technologies face significant cost and risk hurdles, and recommend several approaches to help overcome them. For the first 63 CDM projects that were registered, transfer of technology hardware from industrialised countries is estimated at €472 million, of which €388 million is from the EU. For the 53 JI projects in the pipeline as of January 17, 2006, transfer of technology hardware from non-JI host countries is estimated at €778 million, of which €719 million is from the EU.

Permit Supply from the CDM

We collect information on potential and cost of 372 GHG emissions reduction technology options in 30 Non-Annex I countries. From this overview, Marginal Abatement Cost (MAC) curves were compiled. These MAC curves reveal that a significant amount of GHG abatement potential (2.0 Gt CO2e) exists at low costs in non-Annex I countries in 2010. Of this potential 66 per cent arises from options in only four countries, namely China, India, Brazil and South Africa. The high potential available at low cost makes the CDM an attractive instrument for parties with GHG emissions reduction commitments. However there are several limitations to aggregating the information obtained from the various abatement costing studies. In addition, CDM transaction costs have been included in the MAC curves. These costs are limited and range from US$ 0.01 to 0.70 per ton CO2e.

Linking other Trading Schemes to the EU ETS

We examine proposed and existing domestic emissions trading schemes in Canada, Japan, Norway, Switzerland and the United States, and assess their compatibility with the European Union Emissions Trading Scheme (EU ETS). The trading schemes in Norway and Switzerland are likely to be linked to the EU ETS in the near future. However, economic benefits from the linkage of these systems are very small. Linking the EU ETS with trading schemes in North America and Japan, in contrast, would greatly expand the market and provide significant economic benefits for all parties. Yet, for legal and technical reasons (price caps, eligibility of tradable units), linkage with trading schemes in North America and Japan is much less probable in the short term. Thus, the EU ETS will not be expanded to a uniform global carbon market in the years to come.

Joint Implementation and Emissions Trading in Eastern Europe

We assess JI and associated technology transfer in Eastern European countries based on data on emissions projection, allowance allocation, and possible GHG emissions reduction options using the GAINS model. With a few exceptions, the total GHG emissions in the ten new EU Member States are significantly below their base year emissions and therefore well below their Kyoto targets. Phase-II National Allocation Plans for Eastern European Countries will have a significant impact on these countries position in the EU ETS and JI considering their excess allocation under the Kyoto Protocol. In total, we estimate that the JI potential in these Eastern European countries amounts to 108 million t CO2e at less than €10 per ton CO2e and 124 million t CO2e at less than €17 per ton CO2e. We also examine interactions with planned and existing trading schemes for other pollutants (SO2, NOx).

Quantitative Analysis of International Emissions Trading

We quantify the macroeconomic impacts of international emissions trading with special regard to the project-based mechanisms of the Kyoto Protocol at hand of a large-scale computable general equilibrium model for 2010. Based on data generated within the TETRIS project, we incorporate project-based CDM supply curves, transaction costs and CDM-specific investment risks into the top-down modelling framework. The impact of transaction costs and CDM-specific risk on the international price for emission permits and macroeconomic impacts such as welfare and GDP change are simulated. We also compare different assumptions about other main determinants of the permit price, such as a restriction of Russian Hot Air on the one hand or additionality and supplementarity criteria limiting CDM supply and demand on the other. While in the simulations the inclusion of risk and transaction costs increases the international carbon price by typically less than 1 US$ per ton CO2, CDM restrictions via additionality or supplementarity criteria can be of the same order of magnitude or larger.

4 Background of the TETRIS project

During the last decade, emissions trading (ET) has emerged as the primary instrument for controlling anthropogenic emissions of greenhouse gases (GHG). Behind successful emissions trades, there are almost always technologies deployed in an energy, industrial or other setting that are creating the environmental commodity being traded. These technologies are sometimes taken for granted in emissions trading analyses, but they represent an important feature for policymakers and many stakeholders.

The Kyoto Protocol establishes an international market for tradable GHG emission permits. It can also be seen as the international frame for the European Union Emissions Trading Scheme (EU ETS) which is to date the largest and most comprehensive emissions trading scheme worldwide. It covers emissions of carbon dioxide (CO2) from large stationary sources including power and heat generators, oil refineries, ferrous metals, cement, lime, glass and ceramic materials, and pulp and paper in all member states. The system is expected to cover approximately 46% of total CO2 emissions in the European Union.

Given the advanced status and large size of the European GHG emissions trading scheme, linking or integrating their own national trading scheme (in)to the European system offers several advantages for other countries. The ET Directive explicitly states that “Agreements should be concluded with third countries [...] for the mutual recognition of allowances between the Community scheme and other greenhouse gas emissions trading schemes …” (Article 25). Advantages of linking or connecting their trading schemes for third countries include greater liquidity, lower volatility of prices, potentially lower prices, and a potentially higher market transparency.

Time and again, concerns have been expressed – mostly in Europe – that JI and the CDM could reduce the incentives for domestic action and slow the process of technological change in the EU. On the other hand, it should be noted that the Kyoto mechanisms also contribute to the diffusion of existing energy-efficient technology in developing and transition countries. The diffusion of solar home systems (SHS), for example, could be accelerated by carbon financing (see Lee et al., 2001). Additional resources from selling carbon credits can also contribute to a further reduction of the costs of such technologies.

While there have been numerous studies on the economic, ecological and distributional consequences of emissions trading, the integration and compatibility of different ET schemes has received less attention. Yet, the Kyoto Protocol leaves all signatory states full sovereignty regarding instrument choice. In other words, each country can decide whether to achieve its national emission target by means of technical standards, carbon taxes, tradable permits, or a combination of these instruments. Even if most countries choose the tradable permit approach, national systems may not be fully compatible, which limits the potential cost savings and could lead to economic distortions.

Moreover, most existing studies ignore the risks associated with investments in climate change mitigation and emissions trading. Yet, these risks are likely to be substantial. Springer (2003) and Böhringer and Löschel (2003) provide a first assessment of the impact of incorporating investment risks into the analysis of climate change policy and emissions trading. Applying an approach from financial economics, Springer (2003) compares a portfolio of mitigation options that balances risks and abatement costs with a portfolio based on cost-minimization alone. He finds that “taking risks into account alters the composition of the optimal global portfolios considerably […] Existing models which do not take investment risks into account thus overstate the cost-savings associated with international emissions trading.”[2] Böhringer and Löschel (2003) incorporate country specific investment risk into a global computable general equilibrium (CGE) model. Their main result is that incorporating risks into the analysis does not have a large effect on the magnitude and distribution of benefits from project-based emission trading. Yet, if investors are highly risk-averse, “there is a noticeable decline in the overall volume of emission crediting and the associated total economic benefits.”[3]

2 Springer (2003), p. 192.

3 Böhringer and Löschel (2003), p. 26.

5 Strategic objectives of the project

The overall strategic objective of our project is to enable European policy makers to fully exploit the economic and environmental benefits of emissions trading. To this end, we will explore the technology transfer related to the implementation of the Kyoto mechanisms, develop comprehensive indicators of the investment climate, assess the potential and problems of linking different emissions trading schemes, and analyze quantitatively the economic and industrial impacts of international emissions trading. Many of these issues, although of high importance for policy making, have hardly been dealt with in the past.

Existing models that consider the risks of investing in climate change mitigation do so only to a limited extent. We intend to develop innovative indicators of the investment climate in developing countries. These methods could be applied by financial sector companies (banks, insurance companies), for example in the design of investment vehicles such as carbon funds. A broad variety of carbon funds has been announced or set up recently. Most of these funds apply risk diversification principles, but none of them does so in a systematic manner.

For policy makers both at the national and European level, the compatibility of emissions trading schemes is a timely and important topic. The EU ETS will be reviewed by the Commission before the end of the first period (2005-2007). Our project may deliver helpful results for a potential adaptation or redesign of the scheme. Moreover, several Parties to the Kyoto Protocol which are not part of the European Union have shown strong interest in linking their countries to the EU ETS (Canada, Japan, Switzerland). Policy makers from these countries may benefit from insights on how to design their climate policy in a way which is compatible to the EU ETS. Such efforts, in turn, also benefit EU member states, since they enhance the liquidity and flexibility of the European emissions trading market. Since the EU ETS will cover all EU Member and Acceding States, it is necessary and adequate to carry out this research at the European level.

The main strategic objectives of the project were:

- To explore technology transfer related to the implementation of the Kyoto mechanisms in developing and EU accession countries
- To develop composite indicators of the investment climate for GHG abatement projects and incorporate them into the analysis of emissions trading markets
- To assess the potential and problems of linking different emissions trading schemes
- To analyze quantitatively the economic and industrial impacts of international emissions trading

6 Detailed research approach

This section presents the detailed research approach of the TETRIS project, structured according to the work packages of the project.

6.1 Indicators of the Investment Climate

Numerous studies have shown that flexible mechanisms yield great cost savings compared to a non-trading scenario. However, most existing studies ignore the risks associated with investments in climate change mitigation, which are part of JI and the CDM. Yet, these risks are likely to be substantial. Taking investment risks into account can reduce the likely benefits and scope of the flexible mechanisms as well as the regional distribution of climate change mitigation considerably. We develop a composite indicator of the risk associated with investments in climate change mitigation for a broad range of countries. Our indicator covers all relevant country-related risks and consists of three components: i) the institutional environment for JI and CDM activities, ii) the political environment, and iii) the economic environment. For each component, we collect between 3 and 10 variables for all countries.

Based on the total scores, ratings for Annex I countries (potential JI host countries) and Non-Annex I countries (potential CDM host countries) have been produced. At the top of the Annex I ranking are mostly highly developed countries such as New Zealand, Denmark, Sweden and Finland. Only two Eastern European countries, namely Slovakia and Czech Republic, made it into the top ten due to their excellent institutions dealing with JI projects and a good track record of projects. At the bottom end of the ranking are mostly Eastern European countries that not only lack institutional capacity but also have a poor political and economic environment. These countries often have a high potential for low-cost emission reductions, but also involve considerable risks for investors. The ranking of the Non-Annex I countries shows India, Mexico, China, Chile and Brazil at the top. According to several studies, three of them (India, China and Brazil) are among the CDM host countries with the highest emission reduction potential. Our analysis also shows that a number of countries with poor investment conditions have succeeded in attracting CDM-related investments by setting up credible domestic institutions and policies (e.g. Uganda, Nicaragua and Peru).

6.2 Technology Transfer

Technology transfer is often mentioned as one of the ancillary benefits of project-based emissions trading under the Kyoto Protocol. It can also serve as an important driver for innovation in greenhouse gas reducing technologies in countries with a stringent climate policy, such as the member states of the European Union (EU). We examine real technology transfers associated with CDM and JI in three case studies, and provide a review of the shares of specific technologies in the market to date. We estimate the scope for further TT to key host countries, particularly from EU technology-exporting countries.

We find that “carbon value” in CDM and JI transactions is helping to overcome financing hurdles for clean technologies at the project level. Overall, however, the market is pursuing CERs and ERUs from projects that are deemed to provide a strike a competitive balance between delivery risk and price, and that typically use existing technologies that are cost-competitive. Non-CO2 GHG reduction projects, particularly HFC23 and N2O destruction and landfill gas capture projects, account for the majority of the volume of reductions from all projects. Clean energy technologies, which have higher marginal costs, are particularly challenged by the absence of an international agreement on post-2012 emission reduction targets. Cutting off the stream of marketable reductions at 2012 prevents many clean energy projects from attaining the hurdle rate for the project, given prevailing market prices for GHGs.

In order to better understand whether technology transfer from the EU and elsewhere is occurring through the Clean Development Mechanism (CDM) and Joint Implementation (JI), we assess technology transfer in 63 registered CDM projects (as of 1 January 2006) and 53 projects in the pipeline for JI (as of 26 January 2006). Acknowledging the ongoing debate in the scientific literature and among policymakers on what exactly constitutes "technology transfer", this paper takes a broad view, and evaluates projects on three levels.

In the 63 CDM projects, technology originates from outside the host country in almost 50% of the projects. In the projects in which the technology originates from outside the host country, 80% use technology from the European Union. The remaining 20% use technology from countries such as Japan, China and the United States. Technologies used in non-CO2 greenhouse gas reducing projects, such as HFC destruction, N2O avoidance, and landfill gas projects, mainly originate from outside of the host country. All wind energy technology and a substantial share of the hydropower projects use foreign technology. Biogas and biomass projects mainly use local technology. It is striking that technology transfer, often associated with sustainable development in the energy sector, mainly takes place in projects outside of the energy sector, and is observed in large-scale projects rather than in small-scale projects.

In the 53 JI projects in Eastern Europe, the EU accounted for 76% of the projects with technology transfer (61% from the EU-15 and 15% from the EU-10), led by Germany, Denmark, and Austria. Among new member states and accession countries, the Czech Republic, Poland, Bulgaria and Romania exported technologies to neighboring Eastern European countries. After the EU, the United States accounted for the next largest exporter of technologies in JI projects in Eastern Europe at 16%. More technology transfer—both "hard" and "soft"—took place in energy distribution, methane capture, N2O destruction, and fugitive emission utilization JI projects, whereas relatively little technology transfer took place in biomass, fossil fuel switching, and geothermal JI projects. More than half of JI projects in Bulgaria were identified with both "hard" and "soft" technology transfer, whereas JI projects in Russia, Romania, and Ukraine had little technology transfer.

6.3 Permit Supply from the CDM

The Clean Development Mechanism (CDM) can be considered as an important option for achieving (a part of) the Annex I GHG emissions reduction target. To analyze the impact of the supply of credits from the CDM on the European Union Emission Trading System, Marginal Abatement Cost (MAC) curves have been developed for the non-Annex I region.

Potential and costs of GHG emissions reduction options from 30 country abatement costing studies have been collected, reviewed, evaluated and aggregated to construct an aggregated MAC curve which covers some 80 per cent of the non-Annex I region. A simple extrapolation method has been applied to derive the MAC curve for the whole non-Annex I region. In addition, separate MAC curves have been constructed for the largest non-Annex I countries and regions and for specific sectors in these countries.

In a parallel activity, cost information – including transaction costs – from proposed and/or approved CDM projects has been gathered from more than 60 CDM projects. One would expect to get more detailed and accurate cost information from concrete CDM projects, which have been submitted to the UNFCCC. This CDM project information is compared with the information obtained from the abatement costing studies for the 30 countries.

The identified GHG emissions reduction potential in non-Annex I countries is significant. The inventory of reduction options reveals that the reduction potential in 2010 for all non-Annex I countries together at costs up to 50 $/ton CO2 eq is approximately 2.5 Gt CO2 eq. Approximately .9 Mt CO2 eq is achievable at net negative marginal costs and about 1.9 Gton CO2 eq can be realized at cost less than US$ 4 per ton CO2 eq. This potential can be realized in a limited number of non-Annex I countries. The identified abatement potential in India and China already constitute about 64 per cent of the total identified reduction potential.

6.4 Linking other Trading Schemes to the EU ETS

The most severe obstacles to linkage are price caps, the voluntary nature of certain programs, and diverging rules for the import of credits from the Kyoto mechanisms. Relative targets also pose compatibility problems, but these can be solved by technical measures. The linkage of GHG trading schemes based in the United States raises legal issues, since U.S. allowances are not valid for compliance under the Kyoto Protocol. We have not encountered any problems related to differences in the scope of trading schemes (coverage of GHG or sectors) or allocation methods.

The domestic emissions trading schemes of Norway and Switzerland stand a good chance of being linked to the EU ETS in the near future. While the Norwegian and Swiss economies can be expected to gain substantially from linkage, the benefits for EU Member States are negligible given the small increase of market size resulting from linkage. Linkage to GHG trading schemes in North America and Japan, in contrast, would greatly expand the market and produce considerable economic benefits. However, such a scenario is much less likely given the legal, economic and technical problems associated with a linkage to these countries.

Our analysis offers some insights for the design and further development of emissions trading schemes. First, the path dependency of climate policies should be taken into account. Once a certain policy instrument has been implemented or proposed, it is likely to persist. This can be seen in Norway and Switzerland, where carbon taxes and voluntary agreements are still in place. Therefore, new policies should be carefully designed and evaluated.

Second, linkage requires that emissions trading schemes have key elements such as participation or compliance rules in common. If schemes in different countries shall be connected, they cannot be developed independently of each other.

In the near term, the EU ETS is unlikely to be expanded to a uniform global carbon market. In the long term, however, chances for linkage with schemes outside Europe seem to be greater. As the EU ETS will be expanded to other sectors and gases, it will be more similar to the comprehensive trading schemes proposed in the United States. Moreover, a coordinated approach to avoid competitive disadvantages for companies covered by the EU ETS becomes more important with increasingly tight targets in the future. Therefore, the willingness of the EU commission to adapt the EU ETS or consider linkage with other scheme that may not be fully compatible is also likely to increase.

6.5 Joint Implementation and Emissions Trading in Eastern Europe

This study develops estimates of Joint Implementation (JI) for Eastern European countries in 2010 — focused on Poland, Czech Republic, Slovakia, Hungary, Bulgaria, Romania, Russia and Ukraine. We first considered emissions reduction potentials and mitigation costs in these countries using the results of the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model (Klassen et al., 2004). The results from the GAINS modelling exercise are then discussed with reflections given the existing constraints (e.g., additionality demonstration requirement) and market realities (e.g., size of emissions reductions from the project type) of JI, using Poland as a case study. For instance, one may be discouraged to develop a JI project in the sectors and gases covered by the European Union Emissions Trading System (EU ETS) due to a complex process of converting emissions reduction units (ERUs) accrued from a JI project into European Union Allowances (EUAs) from the EU ETS. Further the GAINS results were aimed at developing an assessment of the full range of emissions reductions in these countries, while a JI criteria may limit the technical potentials assessed in GAINS. We then develop and estimate of JI potential in these Eastern European countries based upon these realities.

In total, a large technical potential exists for JI in these countries—an amount that exceeds the estimated compliance gap under the Kyoto Protocol. Many of these reductions are available at less than €10 per ton CO2e—roughly the current JI market price. Further practical realities may imply that this technical potential would not materialize at this price, but this assessment provides a useful "first order" estimate of the total technical potential.

6.6 Quantitative Analysis of International Emissions Trading

We analyse the economic and industrial impacts of international emissions trading using a large-scale computable general equilibrium model of international trade and energy use. The CGE model is further developed to represent the European market for tradable CO2 allowances according to the EU ET directive. National allocation plans of the second EU ETS phase are taken into account. The investigation of quantitative effects induced by the EU ETS directive serves as a benchmark for the subsequent analysis.

In a second step, the model is extended to represent a world-wide ET system encompassing JI and CDM with transition and developing countries under realistic conditions, i.e. including investment risks. The calibration of marginal abatement cost curves – including transaction costs – is based on the explicit marginal abatement cost curves and risk indicators developed within the project. The risk indicators are implemented as a country-specific risk premium or added cost to genuine (marginal) abatement costs. Furthermore, the potential of technology transfer through JI and CDM is addressed via a two-step procedure: The equilibrium permit price resulting from the model simulations yields regional marginal abatement costs, which in turn yield the underlying abatement technologies employed by (and transferred to) developing countries. The comprehensive ET system is then compared to the benchmark case.

Integrating JI and the CDM further enhances the cost effectiveness of emissions trading. Besides this, industrial impacts (by sectors), allowance prices, and, particularly, the impact of investment risk on the magnitude and regional distribution of emissions trading are assessed.

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