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# The Bonn Agreement and Marrakesh Accords: an updated analysis

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# Abstract

This report updates RIVM's earlier evaluation of the Bonn Agreement by incorporating the impacts taken up in the Marrakesh Accords. Compared to our previous report, the impact on both the environmental effectiveness and economic efficiency is rather limited. The main decision in Marrakesh involved the additional 15 MtC of Russian sinks from forest management. This will increase hot air supply by about 5 per cent and decrease the permit price by US$1/tC compared to our earlier calculations. In terms of $CO_2$ equivalents, the Marrakesh Accords bring Annex I emissions in 2010 without the US a ½ per cent under base year levels; this is *not* the same as compared to the 1990-level. If $CO_2$ removals through sinks are seen as efforts additional to emission reductions to capture the overall effect on atmospheric $CO_2$ built-up, the decrease of a ½ per cent would run up to over 4 per cent under base year levels. The intention of Kazakhstan to join the Kyoto Protocol has little impact on the outcome of the evaluation; it will lead to more supply of hot air and hence further increase pressure on permit prices. Putting the results of our updated evaluation in perspective, we see that Annex I abatement efforts relative to baseline emissions vary from 0 to 3 per cent, depending on the baseline scenario. If removals through sinks are again seen as additional to emission reductions, this range would increase to nearly 6 per cent. Lower baseline emissions than in the A1B-scenario forecast an oversupply of permits that pushes the permit price towards zero and undermines the development of an emission trading market. Our updated evaluation underlines one of the main conclusions from our previous report that without US participation, banking large amounts of hot air is of absolute importance to improve the environmental effectiveness of the Protocol and enhance the development of a viable emissions trading market. A strategy of curtailing and banking permit supply is also in the interest of the dominant seller, in this case the Annex I FSU region. Banking all of the hot air will increase Annex I abatement efforts to over 8 per cent below baseline emissions in the reference scenario. Banking will also raise the permit price, most likely to a level between US$15/tC and US$20/tC.

# Acknowledgements

This study was conducted at the RIVM National Institute of Public Health and the Environment for the Dutch Ministry of Housing, Spatial Planning and the Environment within the Climate Change Policy Support project (M/728001 Ondersteuning Klimaatbeleid). This document forms an update of our earlier report *Evaluating the Bonn Agreement and some key issue*s, which was presented at a side event at COP 7 in Marrakesh. We would particularly like to thank the members of the panel at the side event, John Drexhage of the International Institute for Sustainable Development, Jennifer Morgan of WWF International and Peter Vis of the European Commission, for their comments and contributions. The suggestions and discussions at the side event have certainly proved useful in improving the evaluation. The authors are further indebted to Bill Hare of Greenpeace International and Jonathan Pershing of the International Energy Agency for their comments and useful insights. We also thank our colleagues at the RIVM, in particular Marcel Berk, Bert Metz and Detlef van Vuuren for their comments and inputs and Ruth de Wijs for language-editing assistance.

# Contents

# Samenvatting

Deze rapportage is een vervolg op het RIVM rapport *Evaluating the Bonn Agreement and some key issues*. Het bevat een aantal correcties op de vorige exercitie en houdt rekening met de beslissingen van COP 7 in Marrakesh. De herziene evaluatie laat zien dat de uitkomsten voor de milieu-effectiviteit en kosten nauwelijks wijzigen. Het belangrijkste nieuwe element is dat Rusland 15 MtC extra aan sinks uit bosbouwmanagement heeft gekregen. Dit leidt tot nog meer hot air waardoor de prijs voor emissierechten met US$1/tC daalt in vergelijking met de vorige evaluatie. De Marrakesh Overeenkomst brengt de emissies van alle broeikasgassen van de Annex I landen in 2010 zonder de VS een ½ procent onder het niveau van het basisjaar; dit is *niet* hetzelfde vergeleken met het 1990-niveau. Als $CO_2$ opname door sinks wordt gezien als een additionele inspanning ten opzichte van emissiereducties om het gehele effect op de $CO_2$ concentratie in beeld te brengen, loopt de afname van een ½ procent op tot ruim 4 procent onder het niveau van het basisjaar. De mogelijke deelname van Kazakstan aan het Kyoto Protocol heeft een geringe invloed op de uitkomsten. Het leidt tot meer aanbod van hot air en zet de prijs op de internationale emissiemarkt nog verder onder druk. We hebben gevoeligheidsanalyses uitgevoerd om de uitkomsten van de evaluatie in perspectief te plaatsen. Afhankelijk van het scenario leiden de Annex I inspanningen om emissies te terug te brengen tot een reductie tussen 0 en 3 procent onder het referentiepad. Als sinks worden gezien als additioneel ten opzichte van emissiereducties, neemt deze range toe tot bijna 6 procent. Referentiescenario's met lagere emissies dan in het A1B scenario voorzien een overaanbod van emissierechten en dreigt de prijs richting nul te brengen. Dit kan de ontwikkeling van een internationale emissiemarkt ondermijnen. Onze herziene evaluatie onderstreept één van de hoofdconclusies uit de vorige rapportage dat zonder deelname van de VS het banken van hot air van cruciaal belang is voor het versterken van zowel de milieu-effectiviteit van het Protocol als de ontwikkeling van een internationale emissiemarkt. Een strategie gericht op het beperken en banken van het aanbod is ook in het voordeel van de belangrijkste aanbieder, dat is de Annex I FSU regio. Met het banken van alle hot air zullen de Annex I reducties 8 procent onder het referentiepad in het basisscenario uitkomen. Dit zal ook de prijs op de emissiemarkt versterken die naar verwachting ergens tussen de US$15/tC en US$20/tC zal uitkomen.

# 1 Introduction

This report forms an update of the RIVM report *Evaluating the Bonn Agreement and some key issues,* in which we evaluated the environmental effectiveness and economic efficiency of the Bonn Agreement.[1] The deliberations at COP 7 in Marrakesh focused on translating all the provisions of the Bonn Agreement into legal texts, resulting in the Marrakesh Accords, a document of 245 pages (UNFCCC, 2001). Section 2 summarises the main decisions at COP 7. Section 3 upgrades and updates our evaluation with some corrections on our earlier calculations and the decisions made in Marrakesh. In Section 4, we analyse the impact of Kazakhstan joining the Protocol. Section 5 puts our corrected and updated evaluation in perspective. Here, we compare the scenarios with recent developments to see to what extent they reflect historical trends. Furthermore, we have calculated the impact of different scenarios and key determining factors to present a plausible range of outcomes on the environmental effectiveness and economic efficiency. Section 6 comprises the conclusions.

[1] Den Elzen and de Moor (2001).

# 2 Main outcomes of COP 7

Box 1 presents the main outcomes of COP 7 and the most relevant for our evaluation.

*Box 1: Main outcomes of COP 7 (in Marrakesh)*

*Sinks*
- Rules were set for the use of credits from sinks activities in forestry and agriculture.
- Pending decisions on more detailed guidelines for monitoring and reporting (on the basis of IPCC recommendations) make reporting requirements for sinks limited.
- The Russian Federation has been granted credits for forest management up to a maximum of 33 MtC. Initially, this was nearly 18 MtC.

*Transferability and bankability of credits (Article 7.4)*
- Emission credits from sinks projects under Article 3.3 and Article 3.4 will be labelled as removal units (RMUs). The RMUs cannot be banked for use in the second commitment period
- Assigned amount units (AAUs), credits from Joint Implementation (JI) (ERUs) and Clean Development Mechanism (CDM) (CERs) projects and/or RMUs can be used for complying with the Kyoto targets. Exchange of AAUs, ERUs, CERs and RMUs between Annex I Parties is allowed and unrestricted.
- AAUs may be carried over without restrictions into the second commitment period. However, ERUs and CERs can each be banked only up to a limit of 2.5 per cent of the initial AAUs.

*Participation*
- Turkey will soon be removed from the Annex II list and accede to Annex I of the Convention.
- Kazakhstan has reconfirmed its wish to join Annex B of the Kyoto Protocol; a target is still to be negotiated.

*Kyoto Mechanisms*
- Rules and modalities on the Kyoto Mechanisms were decided upon that will enable CDM projects to start immediately. International emissions trading can start as of 2008.

There are three outcomes that are of particular importance for the environmental effectiveness and economic efficiency of the Kyoto Protocol:
- The extra sinks credits from forest management for Russia; in Bonn the cap amounted to nearly 18 MtC but in Marrakesh this was raised to 33 MtC.
- There are some limitations regarding the transferability and bankability of credits, in particular with reference to credits from domestic sinks, and JI and CDM projects. On the other hand, the transfer of credits between Annex I Parties is free and thus, non-bankable unit can be exchanged with other Parties for bankable units. As there is no formal hierarchy in the use of the various permit types for meeting the Kyoto targets, non-bankable units can be used first to save bankable units, for example, by exchanging Removal Units (RMU) for Assigned Amounts Units (AAU).
- Kazakhstan has reconfirmed its wish to join the Kyoto Protocol. This would require the adoption of an emission target for Kazakhstan by all Parties. For the purpose of this evaluation, we have assumed a target similar to the Russian Federation and Ukraine, i.e. stabilisation of emissions at the 1990 level.

# 3 A corrected and updated evaluation

Before moving to the update of our evaluation, we made a few corrections to our earlier calculations. First, we have defined the Former Soviet Union (FSU) region more precisely, in line with the UNFCCC Annex I list. In our earlier analysis, the FSU region comprised, besides Russia and Ukraine, the other Newly Independent States as well. In this update report, the Annex I FSU region only includes Annex I countries, that is Russia, Ukraine, Latvia, Lithuania and Estonia. Second, there are some corrections that follow from specific Articles of the Kyoto Protocol and that lead to country-specific base years other than 1990.[2] One correction stems from Article 3.5, which allows some economies in transition to use base years other than 1990.[3] Related to Article 3.7 is the adjustment for Annex I Parties for whom land-use change and forestry constituted a net source of greenhouse gas emissions in 1990. They are allowed to add their 1990 emissions from deforestation to their base year emissions. This correction concerns mainly Australia.[4] Finally, Article 3.8 states that any Annex I Party may use 1995 as the base year for some non-$CO_2$ gases.[5] This is particularly relevant for Japan.

The last three corrections above follow from the Kyoto Protocol in which the targets for 2010 are related to base year emissions levels, not to the 1990 levels. This results in differences between base year and 1990 emissions and impacts on the environmental effectiveness when comparing the level of emissions in 2010 with those in 1990.[6] More precisely, the Kyoto targets for the whole of Annex I, including the US, will *not* be 5.2 per cent below 1990 but only 3.6 per cent. Relative to the base year emissions, however, emissions in 2010 will still come out 5.2 per cent lower. As some corrections also affect non-$CO_2$ gases, it no longer suffices to use only $CO_2$ emissions to express the relative environmental performance. We have therefore taken $CO_2$ *equivalents* emissions to reflect abatement efforts, relative to both 1990 and to base year levels (see Table 1).

For the analysis, we have again used the FAIR cost module to calculate the market-clearing equilibrium permit price (see Den Elzen and Both, 2001). Our reference scenario is the IMAGE 2.2 implementation of the IPCC SRES A1B scenario, which can be characterised as a scenario with rapid introduction of new and more efficient technologies and high economic growth. We use the same assumptions as in the earlier analysis (see Box 1 in Den Elzen and de Moor, 2001).

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[2] See UNFCCC (1998).
[3] This involves Bulgaria (1988), Hungary (average of 1985-1987); Poland (1988) and Romania (1989). Relative to 1990, this may effectively change the Kyoto targets for these countries, see UNFCCC (2000) and Appendix I.
[4] The Pronk paper (2001) and UNFCCC (2001, Table A.1) indicate base year emissions of 134.5 MtC/yr for Australia, which is used here. Relative to 1990, this raises the Kyoto target (QUELRs) to 126 per cent instead of 108 per cent relative to the base year, see Appendix I. Assuming 1990 emissions of 115.4 MtC/yr (UNFCCC, 2000), the Pronk paper seems to suggest that Australia is allowed to add the difference of 134-115=19 MtC/yr to its 1990 emissions. By contrast, Meinshausen and Hare (2001) add 33 MtC/yr of emissions from "forest and grassland conversion" to Australia's 1990 emissions.
[5] This concerns emissions of hydrofluorcarbons, perfluorocarbons and sulphur hexafluoride.
[6] See Appendix I for a country-level overview.

*Table 1: Environmental effectiveness and economic efficiency of the Marrakesh Accords*[7]

| | Environmental effectiveness | | | | | Economic efficiency | |
|---|---|---|---|---|---|---|---|
| | Annex I $CO_2$ abatement[#] | | Annex I $CO_2$ equivalent emissions excl. US compared to | | Domestic reduction Annex I | Internat permit price | Annex I costs |
| | MtC | in % | Base year (in %)[V] | 1990[8] (in %) | % | US$/tC | bUS$ |
| 3a. Bonn Agreement* | 130 | -3.0 | -1.1 | | 14 | 9 | 1.8 |
| 3b. Updated with corrections | 130 | -3.0 | -1.1 (-4.3) | +1.2 (-3.6) | 17 | 10 | 1.7 |
| 4a. Marrakesh Accords | 115 | -2.7 | -0.6 (-4.3) | +1.7 (-3.6) | 15 | 9 | 1.5 |
| 4b Participation of Kazakhstan | 81 | -1.8 | -0.6 (-4.2) | +1.6 (-3.5) | 11 | 6 | 0.8 |

* The Kyoto Protocol without the US, including sinks from Land Use, Land Use Change and Forestry (LULUCF) and international emissions trading.
\# This refers to reductions of anthropogenic $CO_2$ emissions only, in absolute terms and compared to baseline emissions (A1B scenario).
[V] The numbers between brackets include, besides abatement efforts through emission reductions, efforts to remove $CO_2$ through sinks to capture the overall effect on atmospheric CO2 built-up.

Collectively, the corrections for a different FSU region and for the specific Articles in the Protocol tend to outweigh each other; they change the outcomes of the earlier evaluation of the Bonn Agreement to a limited extent. Only the total emission reductions relative to *1990* levels are different.

The Marrakesh update has a limited impact on the environmental effectiveness compared to our earlier calculations. The additional sinks for Russia of 15 MtC decreases Annex I abatement without the US to 115 MtC. This follows from our methodology, in which abatement is defined as the total emission reductions through domestic policies, international emissions trading, and JI and CDM. In this context, sinks are not regarded as abatement efforts. However, sinks *remove* $CO_2$ and hence decrease the atmospheric $CO_2$ built-up. Therefore, we have included both, abatement through emission reductions as well as $CO_2$ removals through sinks in Table 1 to capture the overall effect on the atmospheric $CO_2$ built-up. Without removals through sinks, the Marrakesh Accords bring Annex I $CO_2$-equivalent emissions in 2010 without the US more than a ½ per cent *below* base year level. This is different compared to the 1990 level; Annex I emissions come out nearly 2 per cent *above* the 1990 level. Including removals through sinks the total decreasing effect on $CO_2$ built-up would run up from a ½ per cent to over 4 per cent under base year levels.

The additional Russian sinks credits increases the supply of hot air by 5 per cent and hence, the permit price will be about US$1/tC lower compared to our earlier calculations. Annex I costs are slightly reduced to $1.5 billion, assuming a strict least-cost approach. Hot air becomes even more dominant than indicated in Den Elzen and de Moor (2001). As explained in our previous report, it is in the interest of the Annex I FSU to curtail permit supply and bank the credits for better times.

Updating our earlier results for the A1B scenario, Annex I FSU financial revenues from permit trading would now be maximised by banking 40 per cent of the hot air

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[7] See Den Elzen and de Moor (2001) for the exact definitions.
[8] In the previous report, we calculated Annex I $CO_2$ emissions without the US at –0.1 per cent below 1990 level but this was *only* $CO_2$. Table 1 now refers to $CO_2$ *equivalent* emissions.

(see Figure 1). As supply is curtailed, the permit price will rise from US$9/tC onwards (see triangled line) and revenues will increase as well. This process continues up to the point where the price increase is outweighed by the decrease in the traded volume, and revenues will fall. In the lower baseline scenario B1, the optimum for banking runs up to 70 per cent of hot air.

However, the decisions on transferability and bankability of credits imply that banking is not unrestricted (see Box 1). In particular, credits from sink projects are non-bankable and should be sold before the end of the first commitment period. For the Annex I FSU region this is about 35 MtC or about 15 per cent of the total hot air. On the other hand, the transfer of credits between Annex I Parties is free: thus, the non-bankable unit can be exchanged with other Parties for bankable units (see Section 2).[9] Even if there were insufficient options to do so, this would not affect the overall strategy of the Annex I FSU region to curtail and bank permit supply.

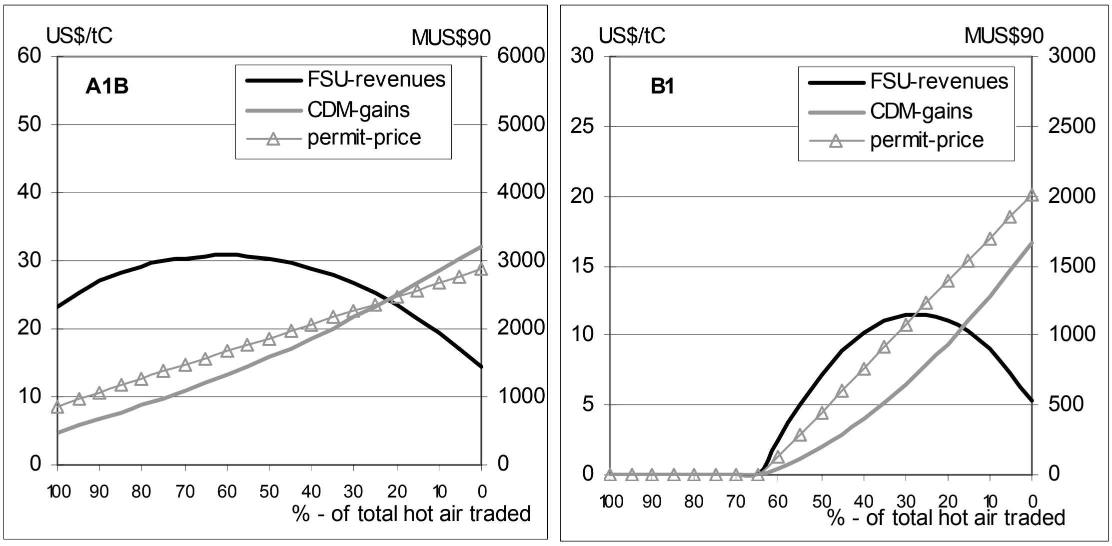


*Figure 1: The revenues of the Annex I FSU region and non-Annex I countries, and the international permit price in the A1B scenario (left) and B1 scenario (right) for different percentages of hot air traded under the Marrakesh Accords (update of Figure 4, Den Elzen and de Moor, 2001)*

[9] Although there is no formal hierarchy, countries may prefer bankable units, which may lead to a market driven hierarchy in permit types.

[10] Although there is no formal hierarchy, countries may prefer bankable units, which may lead to a market driven hierarchy in permit types.

# 4 Participation of Kazakhstan

Kazakhstan has reconfirmed its intention to join the Kyoto Protocol. We have assumed a target for Kazakhstan similar to the Russian Federation and Ukraine, i.e. stabilisation of emissions at the 1990 level. Table 1 shows that this would decrease the environmental effectiveness and Annex I abatement costs. As more hot air enters the market, Annex I abatement is further reduced by 35 MtC to 81 MtC. Compared to 1990 emissions, Annex I $CO_2$-equivalent emissions without the US work out to the same values as in the Marrakesh Accords, i.e. ½ per cent below base year levels. As the participation of Kazakhstan increases the supply of hot air by about 10%, the permit price drops to a level of US$6/tC.[11] As a consequence, the dominance of hot air further increases and threatens the viability of the Kyoto Mechanisms even more than concluded in Den Elzen and de Moor (2001).

[11] Hot air runs up to 300 MtC. Still, this is about 5 per cent lower than the earlier calculations in Den Elzen and de Moor (2001), based on the FSU and including all Newly Independent States.

# 5 Putting the evaluation in perspective

In our earlier report, we showed the results for the environmental effectiveness and economic efficiency to depend critically on key assumptions and model parameters. In particular, the baseline scenarios and banking of hot air can have a strong impact on the outcomes.[12]

First of all, in this chapter we have looked at the historical development in energy-related $CO_2$ emissions and compared it with the forecasted IMAGE 2.2 baseline emissions of the four IPCC SRES scenarios (IMAGE-team, 2001). Both emission data from British Petroleum (BP) and from UNFCCC are presented in Figure 2, which shows that the simulated 1970-1995 trend in all scenarios are in line with historical developments, in particular for the BP and International Energy Agency (IEA) data. The differences with UNFCCC emission data are slightly larger, although still relatively small, but they may give cause to assume lower baseline emissions than the A1B-scenario.[13] After 2000, the scenario projections tend to diverge. The A1B scenario forecasts a relatively sharp increase in emissions of 1.5 to 2 per cent annually, while the B1 scenario projects the growth of emissions at one percentage point lower, between 0.5 and 1 per cent a year.

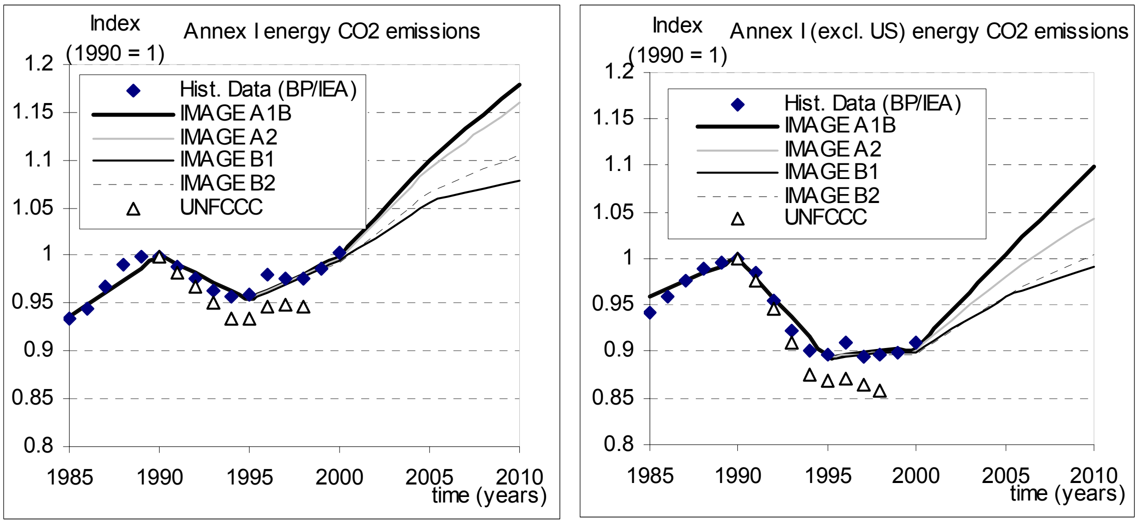


*Figure 2: Energy-related $CO_2$ emissions for Annex I, with the US (left) and without the US (right), the range of IMAGE 2.2 IPCC SRES scenarios compared with the historical emissions data of BP and UNFCCC.*

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[12] For the environmental effectiveness, we will focus on Annex I abatement relative to baseline emissions and for economic efficiency on the permit price.

[13] Emissions data for the Russian Federation have been taken from UNFCCC (2001) but this only contains the years 1991, 1992, 1993, 1997 and 1998; for other years, the emission trends of IEA statistics have been used. A similar approach was followed for Romania (1995-1998) and Japan (1999). There are differences between the BP and UNFCCC data due to differences in energy activity data and calculation methods. Also, the emissions inventories submitted to the UNFCC may have been adjusted for temperature and electricity trade. In particular the adjustment for temperature could cause differences in the year 1990, since 1990 had a warm winter and less energy was used. A detailed evaluation of the causes for the differences can be found in IEA (2001). The BP data correspond with the IEA emission trends.

The earlier report already demonstrated the Annex I abatement efforts as being largely determined by baseline scenarios. The differences with UNFCCC data may be an additional reason to carefully analyse the impact of different scenarios on the results of the evaluation. Furthermore, we have shown that the banking of hot air is of key importance for the environmental effectiveness. Therefore, we have calculated emission reductions for a range of scenarios through abatement efforts only, and including $CO_2$ removals through sinks. We have used the B1 scenario to indicate the low end of this spectrum and the A1F scenario for the high end. The reference A1B scenario is represented in Figure 3 by the dot on the arrows. This figure also shows the impact of hot air banking and the participation of Kazakhstan.

Figure 3 shows that abatement efforts range from 0 to 3 per cent under baseline developments. Our reference A1B scenario, at nearly 3 per cent, is found at the higher end of the spectrum (see also Table 1). If sinks are seen as efforts additional to emission reductions, the overall decrease on the atmospheric $CO_2$ built-up would vary from 0 to nearly 6 per cent. More important, Figure 3 reconfirms the significance of hot air banking, which would substantially improve the environmental effectiveness. Banking all hot air will increase abatement efforts to over 8 per cent below baseline emissions in the reference scenario, or close to 11 per cent if sinks are seen as efforts additional to emission reductions. With full banking, even in the lowest B1 scenario, there will be an abatement effort of at least 4 per cent. Finally, the participation of Kazakhstan reduces the (range of) environmental effectiveness by bringing even more hot air to the market, hence underlining the absolute importance of banking.

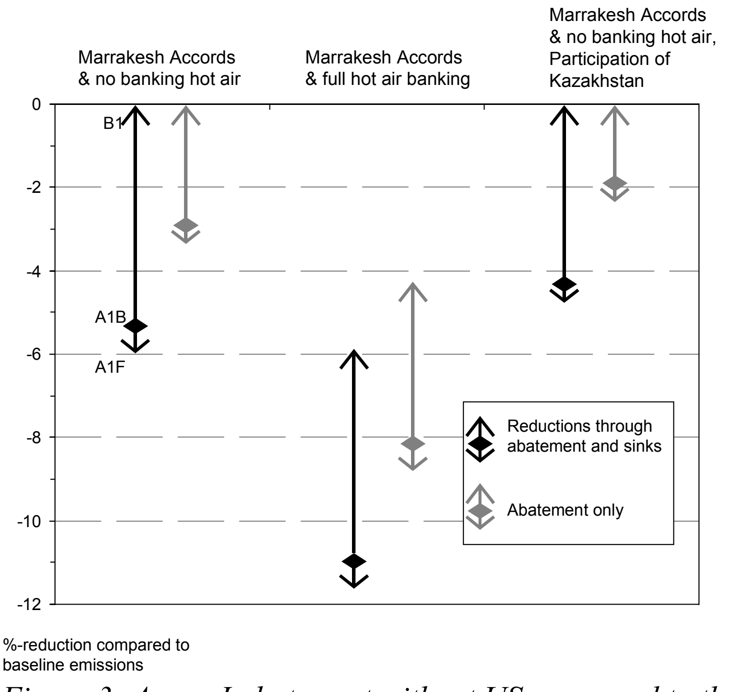


*Figure 3: Annex I abatement without US compared to the baseline emissions (including and excluding removals through sinks) for the Marrakesh Accords for no banking of hot air, full banking of hot air and the participation of Kazakhstan.*

*Box 2: A sensitivity analysis on the results for the permit price.*

The following key factors and associated assumptions were chosen for the analysis:

- *Baseline emissions:* LOW reflects the B1 scenario and HIGH the A1F scenario (IMAGE-team, 2001); our reference is the A1B scenario.
- *Hot air banking:* the LOW case reflects no banking of hot air while in the HIGH case, all hot air is banked; the reference case is one in which hot air banking is optimal for the Annex I FSU (see Figure 1 in Section 3).
- *Marginal Abatement Curves (MACs):* the MACs of WorldScan are used in the reference case while the MACs of the POLES model represent the HIGH case.
- *Participation Annex I:* at the LOW end, we examined the participation of Kazakhstan while the HIGH end reflects US re-entry.
- *Sinks:* a LOW case has been constructed by assuming CDM sink credits capped to 0.5 per cent of base year emissions (instead of 1 per cent), carbon credits from forest management based on data submitted by the Parties (which are lower than the reported values in Appendix Z, see Pronk, 2000) and low estimates for carbon credits from agricultural and grassland management using the ALTERRA ACSD model (see Nabuurs et al, 2000). The HIGH case reflects sinks credits based on high ACSD estimates for agricultural and grassland management and maximum carbon credits from forest management as reported in Appendix Z. In total, the LOW case implies 70 MtC while the HIGH case 195 MtC of carbon credits from sinks-related activities. The Marrakesh Accords represent the reference case of 120 MtC.
- *CDM accessibility factor:* this reflects the operational availability of viable CDM projects and is set at 10 per cent of the theoretical maximum in the reference case. In the LOW case, we assume no accessibility, while in the HIGH case the factor is set at 30 per cent.
- *Transaction costs*: the transaction costs associated with the use of the Kyoto Mechanisms is set at 20 per cent in the reference case, at 10 per cent in the LOW case and at 30 per cent in the HIGH case.

A similar analysis has been conducted to put the results for economic efficiency in perspective, focusing in particular on the permit price. We have calculated the outcomes for several scenarios and key factors that determine the permit price by choosing assumptions that reflect the low and the high end of the spectrum (see Box 2). Figure 4 shows the impacts on the permit price with our reference case pinpointed at US$8.5/tC. In Figure 4, the shaded areas in each bar reflect the most likely outcome.

From Figure 4, it can be concluded that the main factors determining the permit price are the baseline scenarios, the banking of hot air supply and the re-entry of the US. Baseline scenarios other than A1B forecast a lower permit demand, far under supply. The oversupply is threatening to push the permit price towards zero, hence undermining the emissions trading market and the viability of the Kyoto Mechanisms. Banking hot air supply has the largest and strongest impact on the permit price; it will significantly raise the permit price, up to a maximum of nearly US$30/tC. However, considering the interests of the dominant sellers and the optimum for banking, the most likely outcome is a permit price between US$15/tC and US$20/tC. US re-entry has in quantitative terms a similar effect, potentially raising the price to US$30/tC. Obviously, however, the potential for re-entry is largely determined by the domestic political environment.

Using the higher marginal abatement curves from the POLES model, the permit price will double to about US$16/tC. The impact of the use of sinks on the permit price is small compared to hot air banking and US re-entry. Assuming a low use of sinks, the permit price may rise to about US$14/tC. However, where use of the sinks potential is high, permit demand is further reduced and the price may approach zero. The other factors concerning CDM accessibility and transaction cost have a very limited impact.

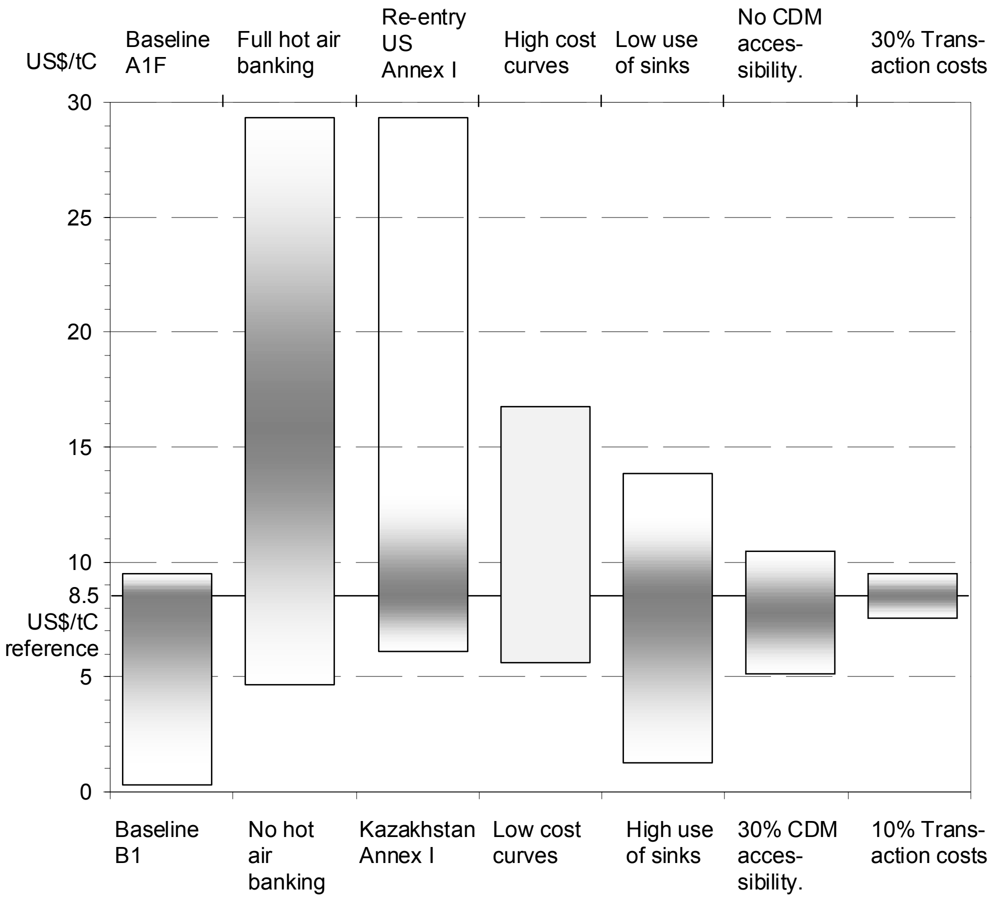


*Figure 4: Key factors with their impact on the permit price compared to a level of US$8.5/tC.*

# 6 Conclusions

Compared to our earlier Bonn Agreement evaluation, the impact of the Marrakesh Accords on both the environmental effectiveness and economic efficiency is rather limited. The main decision in Marrakesh altering the outcome is concerned with the additional 15 MtC of Russian sinks from forest management. This is about 5 per cent of the hot air and will decrease the permit price by about US$1/tC. In terms of $CO_2$ equivalents, the Marrakesh Accords bring Annex I emissions without the US ½ per cent under base year levels; this is different compared to the 1990 level. Also, assuming a stabilisation target at 1990 levels, the impact of Kazakhstan joining the Protocol is relatively small. Its joining would lead to more supply of hot air and hence further increase pressure on permit prices. Putting the results of our updated evaluation in perspective, the spectrum of outcomes indicates that:

- The environmental effectiveness measured by Annex I abatement efforts relative to baseline emissions varies between 0 and 3 per cent, depending on the scenario. If sinks are seen as efforts additional to emission reductions to capture the overall decreasing effect on $CO_2$ built-up, this range would increase to nearly 6 per cent.
- The baseline scenarios also have a strong impact on the permit price. Lower baselines than the A1B scenario forecast a lower permit demand – far under supply. This oversupply pushes the permit price towards zero, hence undermining the emissions trading market and the viability of the Kyoto Mechanisms.
- Banking large amounts of hot air is of absolute importance to improving the environmental effectiveness and enhancing the development of a viable emissions trading market. A strategy of curtailing and banking permit supply is also in the interest of the dominant seller, the Annex I FSU region. Banking all hot air will increase Annex I abatement efforts to over 8 per cent below baseline emissions in the reference scenario, or close to 11 per cent if sinks are seen as efforts additional to emission reductions. Full banking, even in the lowest B1 scenario, will lead to an abatement effort of at least 4 per cent.
- The current evaluation underlines one of the main conclusions from our previous report that without US participation, hot air banking is of crucial importance to the development of a viable international emissions trading market. Hot air banking has the largest and strongest impact on the permit price and may raise the price up to a maximum of nearly US$30/tC. The outcome in the "middle" is a permit price between US$15/tC and US$20/tC.
- In quantitative terms, US re-entry has a similar effect, potentially raising the permit price to US$30/tC but, obviously, the potential for re-entry will be largely determined by the domestic political environment.

# References

BP (2001): The statistical review of World Energy 2001, British Petroleum, http://www.bp.com/centres/energy/index.asp.

Elzen, M.G.J. den and Both, S. (2001): Analysing emissions trading and abatement costs with FAIR: using the TIMER and WorldScan Marginal Abatement Curves (MACs), National Institute of Public Health and the Environmental (RIVM), Bilthoven, the Netherlands (in preparation).

Elzen, M.G.J. den and de Moor, A.P.G. (2001): Evaluating the Bonn Agreement and some key issues, RIVM Report no. 728001016, National Institute of Public Health and the Environment, Bilthoven, the Netherlands. The report can be downloaded from http://www.rivm.nl/ieweb, or directly http://www.rivm.nl/ieweb/ieweb/Reports/Rap728001016.pdf.

IEA (2001): $CO_2$ emissions from fossil fuel combustion 1971-1999, Paris, France

IMAGE-team (2001): The IMAGE 2.2 implementation of the IPCC SRES scenarios. A comprehensive analysis of emissions, climate change and impacts in the 21st century. RIVM CD-ROM publication 481508018, National Institute for Public Health and the Environment, Bilthoven, the Netherlands.

Meinshausen, M. and Hare, B. (2001): Extended quantitative analysis of the COP-6 President's text, UNFCCC Conference of the Parties Sixth Session (Part Two), Greenpeace International.

Nabuurs, G.J., A.J. Dolman, E. Verkaik, P.J. Kuikman, C.A. van Diepen, A.P. Whitmore, W.P. Daamen, O. Oenema, P. Kabat & G.M.J. Mohren: Article 3.3 and 3.4 of the Kyoto Protocol (2000): Consequences for industrialised countries' commitment, the monitoring needs, and possible side effects, Environmental Scientific Policy, 3, pp. 123-134.

Pronk, J. (2001), New Proposals by the President of COP6, April 2001, The Hague, the Netherlands, pp. 1-24.

UNFCCC (1998): The Kyoto Protocol to the Convention on Climate Change, Climate Change Secretariat/UNEP, UNEP/IUC/98/2, June 1998.

UNFCCC (2000): National Communications from Parties included in Annex I to the convention: greenhouse gas inventory data from 1990 to 1998, Report on national greenhouse gas inventory data from Annex I Parties for 1990 to 1998, FCCC/SBI/2000/11.

UNFCCC (2001): The Marrakesh Accords & The Marrakesh Declaration, advance text, http://www.unfcccc.int/cop7/documents/accords_draft.pdf

# Appendix I: Summary QUELRs of Annex I Parties

*Table I.1 Quantified emission limitation or reduction commitment, in per cent of base year or 1990 emissions of all greenhouse gases ($CO_2$ equivalent)*

| | Base-year | 1990 emis-sions | Assigned Amounts Kyoto '97 | Sinks credits (Marra-kesh) | Assigned Amounts including sinks | QUELR Compared to base | | QUELR Compared to1990 | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | KP | Marrakesh | KP | Marrakesh |
| Annex I Parties | MtC/yr | MtC/yr | MtC/yr | MtC/yr | MtC/yr | Base year = 100 | Base year = 100 | 1990 = 100 | 1990 = 100 |
| Australia | 134.54 | 115.4 | 145.30 | 3.53 | 148.8 | 108 | 110.6 | 125.9 | 128.9 |
| Austria | 21.04 | 20.6 | 19.36 | 0.84 | 20.2 | 92 | 96.0 | 94.1 | 98.2 |
| Belgium | 37.24 | 37.2 | 34.37 | 0.40 | 34.8 | 92 | 93.1 | 92.4 | 93.4 |
| Bulgaria | 42.84 | 37.6 | 39.42 | 0.79 | 40.2 | 92 | 93.9 | 105.0 | 107.1 |
| Canada | 166.17 | 166.8 | 156.84 | 18.66 | 175.5 | 94 | 105.2 | 94.0 | 105.2 |
| Czech Rep. | 51.74 | 51.8 | 47.63 | 0.84 | 48.5 | 92 | 93.6 | 92.0 | 93.6 |
| Denmark | 19.08 | 19.0 | 17.55 | 0.33 | 17.9 | 92 | 93.7 | 92.5 | 94.2 |
| Estonia | 11.10 | 11.1 | 10.22 | 0.21 | 10.4 | 92 | 93.9 | 92.0 | 93.9 |
| Finland | 20.51 | 20.5 | 18.87 | 0.37 | 19.2 | 92 | 93.8 | 92.0 | 93.8 |
| France | 148.96 | 151.0 | 138.95 | 2.37 | 141.3 | 92 | 93.6 | 92.0 | 93.6 |
| Germany | 330.28 | 329.7 | 303.85 | 4.54 | 308.4 | 92 | 93.4 | 92.2 | 93.5 |
| Greece | 29.28 | 28.7 | 26.94 | 0.38 | 27.3 | 92 | 93.3 | 93.8 | 95.1 |
| Hungary | 27.72 | 23.6 | 26.05 | 0.57 | 26.6 | 94 | 96.0 | 110.3 | 112.7 |
| Iceland | 0.70 | 0.7 | 0.77 | 0.07 | 0.8 | 110 | 119.5 | 110.0 | 119.5 |
| Ireland | 14.59 | 14.6 | 13.42 | 1.10 | 14.5 | 92 | 99.6 | 92.0 | 99.6 |
| Italy | 141.64 | 141.4 | 130.36 | 2.07 | 132.4 | 92 | 93.5 | 92.2 | 93.6 |
| Japan | 334.78 | 330.9 | 314.71 | 16.35 | 331.1 | 94 | 98.9 | 95.1 | 100.1 |
| Latvia | 9.73 | 9.7 | 8.95 | 0.44 | 9.4 | 92 | 96.5 | 92.0 | 96.5 |
| Liechtenstein | 0.07 | 0.1 | 0.07 | 0.00 | 0.1 | 92 | 93.0 | 91.9 | 92.9 |
| Lithuania | 14.06 | 14.1 | 12.93 | 0.42 | 13.4 | 92 | 95.0 | 92.0 | 95.0 |
| Luxembourg | 3.67 | 3.7 | 3.37 | 0.05 | 3.4 | 92 | 93.3 | 92.0 | 93.3 |
| Monaco | 0.03 | 0.0 | 0.03 | 0.00 | 0.0 | 92 | 93.0 | 92.8 | 93.8 |
| Netherlands | 59.77 | 59.4 | 54.99 | 0.63 | 55.6 | 92 | 93.1 | 92.5 | 93.6 |
| New Zealand | 19.90 | 19.9 | 19.93 | 8.04 | 28.0 | 100 | 140.3 | 100.0 | 140.3 |
| Norway | 14.22 | 14.2 | 14.36 | 0.56 | 14.9 | 101 | 105.0 | 101.0 | 105.0 |
| Poland | 153.89 | 125.2 | 144.66 | 2.36 | 147.0 | 94 | 95.5 | 115.5 | 117.4 |
| Portugal | 17.12 | 17.4 | 16.02 | 0.39 | 16.4 | 92 | 94.2 | 92.0 | 94.2 |
| Romania | 72.24 | 62.5 | 66.46 | 1.82 | 68.3 | 92 | 94.5 | 106.4 | 109.3 |
| Russia | 826.56 | 829.1 | 829.11 | 41.3[14] | 870.4 | 100 | 105.0 | 100.0 | 105.0 |
| Slovakia | 20.79 | 20.8 | 19.15 | 0.71 | 19.9 | 92 | 95.4 | 92.0 | 95.4 |
| Slovenia | 5.24 | 5.2 | 4.82 | 0.41 | 5.2 | 92 | 99.9 | 92.0 | 99.9 |
| Spain | 84.13 | 83.4 | 77.40 | 1.51 | 78.9 | 92 | 93.8 | 92.8 | 94.6 |
| Sweden | 19.25 | 18.9 | 17.71 | 0.77 | 18.5 | 92 | 96.0 | 93.6 | 97.7 |
| Switzerland | 14.46 | 14.5 | 13.30 | 0.65 | 14.0 | 92 | 96.5 | 92.0 | 96.5 |
| Ukraine | 250.70 | 250.7 | 250.70 | 3.62 | 254.3 | 100 | 101.4 | 100.0 | 101.4 |
| UK | 208.84 | 202.2 | 186.81 | 3.27 | 190.1 | 92 | 93.6 | 92.4 | 94.0 |
| USA | 1655.4 | 1649.7 | 1539.5 | 54.75 | 1594.3 | 93 | 96.3 | 93.3 | 96.6 |
| Total with US | 4982.3 | 4901.4 | 4724.9 | 175.0 | 4900.0 | 94.8 | 98.3 | 96.4 | 100.0 |
| Total w/o US | 3326.9 | 3251.7 | 3185.4 | 120.0 | 3306 | 95.7 | 99.4 | 98.0 | 101.7 |
| Annex I regions | | | | | | | | | |
| Canada | 166.17 | 166.8 | 156.8 | 18.66 | 175.5 | 94.0 | 105.2 | 94.0 | 105.2 |
| USA | 1655.4 | 1649.7 | 1539.5 | 54.75 | 1594.3 | 93.0 | 96.3 | 93.3 | 96.6 |
| West.Europe | 1184.9 | 1177.2 | 1088.5 | 20.30 | 1108.8 | 92.2 | 93.8 | 92.5 | 94.2 |
| East. Europe | 374.46 | 326.7 | 348.2 | 7.50 | 355.7 | 92.9 | 95.0 | 106.6 | 108.9 |
| Annex I FSU | 1112.1 | 1114.7 | 1111.9 | 46.00 | 1157.9 | 99.8 | 103.9 | 99.7 | 103.9 |
| Oceania | 154.4 | 135. | 165.2 | 11.56 | 176.8 | 106.8 | 114.5 | 122.1 | 130.6 |
| Japan | 334.78 | 330.9 | 314.7 | 16.35 | 331.1 | 94.0 | 98.9 | 95.1 | 100.1 |
| Annex I | 4982.3 | 4901.4 | 4724.9 | 175.0 | 4900.0 | 94.8 | 98.3 | 96.4 | 100.0 |

[14] At the time of the Bonn Agreement this value was 25.9 MtC/yr (Den Elzen and de Moor, 2001)

# Appendix II: Detailed model results

*Table I.1: Emissions trading, abatement and costs for the Bonn Agreement (reference case) after corrections*

| | NO TRADE | | | | | | TRADE | | | | | | | | | GAINS TRADE | | PER CAPITA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REGIONS | Reference | Target | Reduc-tion | Burden | MAC | Costs | Emissions | Dom./ Total | MAC | Dom Act | Trade | Dom costs | Trade costs* | Total costs* | %-GDP | Gains trade | % | Target | Emission |
| | MtC | MtC | % | MtC | US$/tC | MUS$ | MtC | % | US$/tC | MtC | MtC | MUS$ | MUS$ | MUS$ | % | MUS$ | % | tC/cap | tC/cap |
| Canada | 153 | 124 | -19 | 29 | 50 | 727 | 147 | 19 | 9.7 | 6 | 24 | 27 | 294 | 322 | -0.04 | 406 | 56 | 3.71 | 4.42 |
| USA | 1739 | 1739 | 0 | 0 | 0 | 0 | 1739 | 0 | 9.7 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0 | 0 | 5.74 | 5.74 |
| OECD Europe | 1088 | 828 | -24 | 260 | 96 | 11252 | 1058 | 12 | 9.7 | 31 | 230 | 149 | 2818 | 2967 | -0.02 | 8285 | 74 | 2.04 | 2.61 |
| Eastern Europe | 318 | 304 | -4 | 13 | 8 | 53 | 305 | 99 | 9.7 | 13 | 0 | 52 | 45 | 97 | -0.01 | -44 | -83 | 2.45 | 2.45 |
| Former USSR | 549 | 804 | 46 | -255 | 0 | 0 | 513 | 0 | 9.7 | 0 | -291 | 150 | -2704 | -2554 | 0.32 | 2554 | 100 | 2.65 | 1.69 |
| Oceania | 124 | 119 | -3 | 4 | 9 | 19 | 119 | 100 | 9.7 | 4 | 0 | 19 | 18 | 37 | -0.01 | -18 | -93 | 3.81 | 3.81 |
| Japan | 372 | 295 | -21 | 77 | 66 | 2432 | 360 | 15 | 9.7 | 12 | 65 | 58 | 800 | 858 | -0.01 | 1574 | 65 | 2.21 | 2.70 |
| Annex I | 4343 | 4213 | -3 | 130 | 26 | 14484 | 4240 | 17 | 9.7 | 66 | 27 | 456 | 1271 | 1727 | -0.01 | 12757 | 88 | 3.16 | 3.18 |
| Non-Annex I | 4141 | 4141 | 0 | 0 | 0 | 0 | 4113 | 0 | 9.7 | 0 | -27 | 11 | -587 | -576 | 0.00 | 253 | 100 | 0.75 | 0.74 |
| World | 8483 | 8354 | -2 | 130 | 1 | 14484 | 8354 | 17 | 9.7 | 66 | 0 | 467 | 684 | 1151 | 0.00 | 13010 | 90 | 1.21 | 1.21 |

*Table I.2: Emissions trading, abatement and costs for the Marrakesh Accords (reference case)*

| | NO TRADE | | | | | | TRADE | | | | | | | | | GAINS TRADE | | PER CAPITA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REGIONS | Reference | Target | Reduc-tion | Burden | MAC | Costs | Emissions | Dom./ Total | MAC | Dom Act | Trade | Dom costs | Trade costs* | Total costs* | %-GDP | Gains trade | % | Target | Emission |
| | MtC | MtC | % | MtC | US$/tC | MUS$ | MtC | % | US$/tC | MtC | MtC | MUS$ | MUS$ | MUS$ | % | MUS$ | % | tC/cap | tC/cap |
| Canada | 153 | 124 | -19 | 29 | 50 | 727 | 148 | 17 | 8.5 | 5 | 24 | 21 | 264 | 285 | -0.03 | 442 | 61 | 3.71 | 4.44 |
| USA | 1739 | 1739 | 0 | 0 | 0 | 0 | 1739 | 0 | 8.5 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0 | 0 | 5.74 | 5.74 |
| OECD Europe | 1088 | 828 | -24 | 260 | 96 | 11252 | 1061 | 10 | 8.5 | 27 | 234 | 114 | 2500 | 2614 | -0.02 | 8638 | 77 | 2.04 | 2.62 |
| Eastern Europe | 318 | 304 | -4 | 13 | 8 | 53 | 304 | 100 | 8.5 | 13 | 0 | 53 | 38 | 91 | -0.01 | -38 | -72 | 2.45 | 2.45 |
| Former USSR | 549 | 818 | 49 | -269 | 0 | 0 | 517 | 0 | 8.5 | 0 | -301 | 114 | -2443 | -2329 | 0.29 | 2329 | 100 | 2.70 | 1.71 |
| Oceania | 124 | 119 | -3 | 4 | 9 | 19 | 120 | 93 | 8.5 | 4 | 0 | 17 | 19 | 36 | -0.01 | -16 | -83 | 3.81 | 3.82 |
| Japan | 372 | 295 | -21 | 77 | 66 | 2432 | 361 | 14 | 8.5 | 10 | 67 | 44 | 714 | 758 | -0.01 | 1674 | 69 | 2.21 | 2.72 |
| Annex I | 4343 | 4227 | -3 | 115 | 26 | 14484 | 4251 | 15 | 8.5 | 60 | 24 | 363 | 1091 | 1454 | 0.00 | 13029 | 90 | 3.17 | 3.19 |
| Non-Annex I | 4141 | 4141 | 0 | 0 | 0 | 0 | 4117 | 0 | 8.5 | 0 | -24 | 8 | -483 | -475 | 0.00 | 193 | 100 | 0.75 | 0.74 |
| World | 8483 | 8368 | -1 | 115 | 1 | 14484 | 8368 | 15 | 8.5 | 60 | 0 | 371 | 608 | 979 | 0.00 | 13222 | 91 | 1.21 | 1.21 |

*Table I.3: Emissions trading, abatement and costs for the Marrakesh Accords including participation of Kazakhstan (reference case)*

| | NO TRADE | | | | | | TRADE | | | | | | | | | GAINS TRADE | | PER CAPITA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REGIONS | Reference | Target | Reduc-tion | Burden | MAC | Costs | Emissions | Dom./ Total | MAC | Dom Act | Trade | Dom costs | Trade costs* | Total costs* | %-GDP | Gains trade | % | Target | Emission |
| | MtC | MtC | % | MtC | US$/tC | MUS$ | MtC | % | US$/tC | MtC | MtC | MUS$ | MUS$ | MUS$ | % | MUS$ | % | tC/cap | tC/cap |
| Canada | 153 | 124 | -19 | 29 | 50 | 727 | 150 | 11 | 5.7 | 3 | 26 | 9 | 189 | 198 | -0.02 | 529 | 73 | 3.71 | 4.49 |
| USA | 1739 | 1739 | 0 | 0 | 0 | 0 | 1739 | 0 | 5.7 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0 | 0 | 5.74 | 5.74 |
| OECD Europe | 1088 | 828 | -24 | 260 | 96 | 11252 | 1070 | 7 | 5.7 | 18 | 242 | 51 | 1739 | 1791 | -0.01 | 9461 | 84 | 2.04 | 2.64 |
| Eastern Europe | 318 | 304 | -4 | 13 | 8 | 53 | 308 | 72 | 5.7 | 10 | 4 | 27 | 51 | 79 | -0.01 | -26 | -48 | 2.45 | 2.48 |
| Former USSR | 634 | 937 | 48 | -303 | 0 | 0 | 609 | 0 | 5.7 | 0 | -328 | 59 | -1796 | -1736 | 0.22 | 1736 | 100 | 3.09 | 2.01 |
| Oceania | 124 | 119 | -3 | 4 | 9 | 19 | 121 | 63 | 5.7 | 3 | 2 | 8 | 21 | 29 | 0.00 | -10 | -50 | 3.81 | 3.86 |
| Japan | 372 | 295 | -21 | 77 | 66 | 2432 | 365 | 9 | 5.7 | 7 | 70 | 20 | 503 | 523 | -0.01 | 1909 | 79 | 2.21 | 2.74 |
| Annex I | 4427 | 4346 | -2 | 81 | 25 | 14484 | 4362 | 11 | 5.7 | 41 | 16 | 175 | 708 | 883 | 0.00 | 13601 | 94 | 3.26 | 3.27 |
| Non-Annex I | 4056 | 4056 | 0 | 0 | 0 | 0 | 4041 | 0 | 5.7 | 0 | -16 | 4 | -278 | -274 | 0.00 | 85 | 100 | 0.73 | 0.73 |
| World | 8483 | 8402 | -1 | 81 | 1 | 14484 | 8402 | 11 | 5.7 | 41 | 0 | 179 | 430 | 609 | 0.00 | 13685 | 94 | 1.22 | 1.22 |

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