# TRADING BIOMASS OR GHG EMISSION CREDITS?

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ABSTRACT: Global biomass potentials are considerable but unequally distributed over the world. Countries with Kyoto targets could import biomass to substitute for fossil fuels or invest in bio-energy projects in the country of biomass origin and buy the credits (CDM/JI). This study analyzes which of those options is optimal for transportation fuels and looks for the key variables that influence the result. In two case studies (Mozambique and Brazil), the two trading systems are compared for the amount of credits generated, land-use and associated costs. We found costs of 17 - 30 euro per ton of carbon for the Brazilian case and economic benefits of 11 to 60 euros per ton of carbon avoided in the Mozambique case. The impact of carbon changes related to land-use changes was found to be very important (both positive and negative) and can currently only be included in emission credit trading, which can largely influence the results. Whatever option is economically most attractive depends mainly on the emission baseline in the exporting (emission credit trading) respectively importing (physical trading) country since both bio- and fossil fuel prices are world market prices in large scale trading systems where transportation costs are low. Physical trading could be preferential since besides the GHG reduction one could also benefit from the energy: some advantages are the diversification in energy sources and possible job creation. It could also generate considerable income sources for exporting countries. This study could contribute to the development of a methodology to deal with bio fuels for transport, in ET, CDM and the certification of traded bio fuels.
Keywords: biomass trade, Clean Development Mechanism (CDM), $CO_2$ emission reduction

## 1. INTRODUCTION

All countries that ratified The Kyoto Protocol, committed themselves to a specific target to reduce GHG levels. They can reduce emissions within their country borders, but also some flexible mechanisms (e.g. CDM, JI and ET) were designed to cooperate with other countries to enhance cost-effectiveness. Biomass can be used as an energy source to substitute for fossil fuels or as a carbon reservoir, in both cases reducing $CO_2$. Worldwide biomass potentials are considerable [1], [2] and [3], but unequally distributed over the world. In this thesis, we explored two trading options for biomass: 1) Importing biomass (fuels) from a biomass producing country and final conversion within the importing country (physical trade). 2) Leaving the biomass in the country of biomass origin, conversion in exporting country and trading the credits (emission credit trade = CDM/JI). The main difference between the two trading option is that in physical trade the amount of emission reduction depends on the reference energy system of the buying country, whereas in emission credit trade the reference energy system of the selling country influences the possible emission reduction.

<u>Research questions:</u>
1) Given the large global bio-energy production potential, how should we make optimal use of this renewable source, regarding costs and avoided emissions, in the process of greenhouse gas mitigation under the Kyoto Protocol? (i.e. Which option is cheaper? What factors have the largest influence on the amount of emission reduced and its costs? How do other factors than € and tons of $CO_2$ influence the choice of trade? Under what circumstances should we either trade biomass or credits?

## 2. APPROACH

In the first phase of this study, a background research has been carried out, identifying all rules and methodologies currently in use to calculate emission reductions in both trading systems. It appeared that large differences exist between accounting for emissions in physical trading as compared to emission credit trading. Whereas in the first case only avoided emissions in the final conversion (tailpipe) are taken into account, registration of CDM and JI projects requires a detailed description of emissions in all parts of the chain, from land-use changes and leakage aspects to final energy conversion. Further differences exist in the build-up of costs along the chain. In physical trading, costs are mainly determined by production and transportation costs, whereas in emission credit trading transportation costs maybe lower, but extra costs involve transaction costs and insurance costs. Furthermore, if land-use changes are leading to changes in carbon storage, various approaches are recognized to account for these differences. From the many proposals, i.e. stock change average storage, ton-year and temporary crediting, the last one was decided upon for use in the first commitment period. All these factors ultimately influence the amount of carbon reduction (calculated) and the associated costs. With the factors that influence costs and emission reduction in both trading systems identified, 3 simple formulas were composed to calculate the costs of emission reduction in:

1) physical trading as calculated today

$$C_{avoidance} = \frac{C_B - C_R}{E_R}$$

where:
$C_{avoidance}$ = Costs per avoided GHG emission (€/$CO_2$-eq)

$E_R$ = GHG emissions for reference (fossil fuel) chain, excluding up-stream emissions ($CO_2$-eq)
$C_B$ = Costs for biomass chain (€)
$C_R$ = Costs for reference (fossil fuels) chain (€)

2) physical trading, including also upstream emissions and carbon changes related to land-use change

$$C_{avoidance} = \frac{C_B - C_R +/- C_A}{E_R - E_B +/- E_A +/- E_L +/- E_K}$$

where:
$C_{avoidance}$ = Costs per avoided GHG emission (€/$CO_2$-eq)
$C_B$ = Costs for biomass chain (€)
$C_R$ = Costs for reference chain (€)
$C_A$ = Costs/benefits related to alternative use of residues (€)
$E_R$ = GHG emissions for reference (fossil fuel) chain ($CO_2$-eq)
$E_B$ = GHG emissions for biomass chain ($CO_2$-eq)
$E_A$ = Emissions (benefits) related to alternative fate of residues ($CO_2$-eq)
$E_L$ = Carbon gains or losses compared to reference land-use ($CO_2$-eq)
$E_K$ = Emissions (benefits) due to leakage ($CO_2$-eq)

3) emission credit trading (for bio-fuel projects, including land-use changes).

$$C_{avoidance} = \frac{C_B + C_T - C_R}{E_R - E_B +/- E_L +/- E_K - E_I}$$

where:
$C_{avoidance}$ = Costs per avoided GHG emission (€/$CO_2$-eq)
$C_B$ = Costs for biomass project (I en O&M) (€)
$C_T$ = Transaction costs (€)
$C_R$ = Costs for (avoided) reference energy (€)
$E_R$ = GHG emissions for reference system (= baseline emissions) ($CO_2$-eq)
$E_B$ = GHG emissions for biomass chain (= project emissions) ($CO_2$-eq)
$E_L$ = Carbon gains or losses compared to reference land-use ($CO_2$-eq)
$E_K$ = Emissions (benefits) due to leakage ($CO_2$-eq)
$E_I$ = Reduction of carbon credits due to insurance (buffer) ($CO_2$-eq)

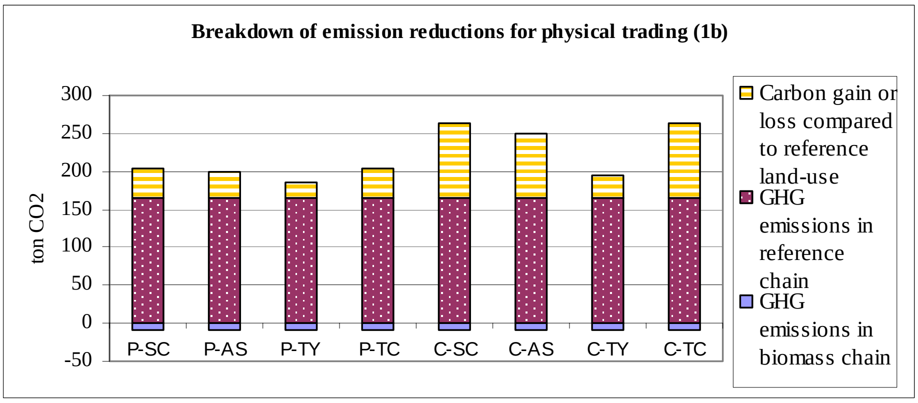
In the second part of the research, two case studies were analysed to calculate the costs and emissions in both trading system, according to the formulas and using chain analysis. Furthermore, the critical parameters were identified in a sensitivity analysis

## 3 CASE STUDY RESULTS:

Two case study countries were chosen: Mozambique and Brazil. For both countries, two fictional trading systems are analyzed: physical trading of biomass fuels from the country of origin to the Netherlands and the trade of emission credits derived from biofuel projects in the country of biomass origin. Transportation fuels are chosen in all cases since the transportation sector is a large contributor to global GHG-emissions, transportation fuels are easy to trade and there is a large potential for bio-based transportation fuels [4].

*Mozambique*: The fictive physical trading case includes the production and harvesting of eucalyptus in Mozambique. After harvest, the biomass is transported by trucks to a local gathering point where it is converted to pyrolysis oil. The pyrolysis oil is transported by trucks to the harbour for international shipping. In the Rotterdam Harbour, conversion into Fischer-Tropsch diesel via Entrained Flow gasification (1000 MWth) takes place. Finally, the FT-diesel is distributed to the fuel stations where cars are filled, after which the final conversion occurs in the car. The reference fuel is assumed to be (fossil fuel) diesel. Reference system 1a corresponds to the current calculation method, where emissions and land use changes of both system 1 and the reference system are ignored. Reference system 1b indicates the complete chain. The emission trading case denotes a fictive CDM project in Mozambique where a eucalyptus plantation is established. The harvested wood is transported by trucks to a local gathering point where chips are produced. The chips are transported by trucks to a conversion facility where Fisher-Tropsch diesel is produced via CFB gasification (387 MWth). The FT-diesel is finally transported to the fuel stations after which it is converted in the car. Reference system 2a corresponds to the baseline situation in Mozambique (To analyse the GHG-emission reduction costs for both physical trading and emission credit trading, data is used from [5]).

The breakdowns of carbon gains (Figures 1) show that emissions in the reference energy system have the largest share in the total emission reductions in both trading systems. Carbon gains due to a switch in land use also have a great contribution, especially in the cropland baseline scenarios. Compared to the physical trading system, the emission reduction due to the fuel switch is larger in the emission credit system due to the higher emission in the reference system in Mozambique (206 gCO2/km), compared to the Netherlands (164 gCO2/km). The carbon gains associated with the change in land use are almost equal for both systems. The total emission reductions are still almost equal for both systems due to the considerable amount of carbon credits reserved for insurance in system 2.




Baseline vegetation: P= pasture ; C = cropland
Sc = Stock Change method; AS = Average storage method; TY= Ton-Year Method; TC = Temporary crediting method

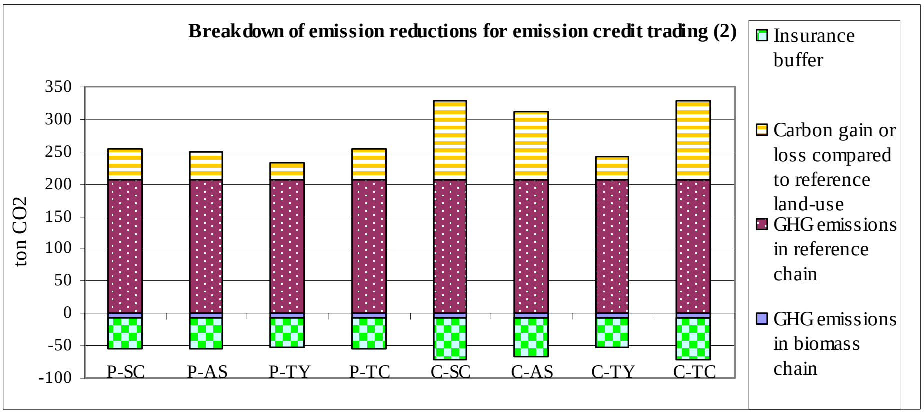



Figure 1. Mozambique: Breakdown of emission reductions for physical trading (1b) and emission credit trading (2)

The costs of CO2-avoidance for the two trading systems can be calculated by filling out formulas 1-3. Since in all cases the costs of the bio-fuels are lower than the costs of the reference systems, there is a benefit for every ton of carbon avoided. The results are shown in Figure 2. The results show that for all scenarios the physical trading systems deliver carbon credits with the highest benefits although the uncertainties are high. Due to the largely fluctuating oil prices, economic benefits can turn into costs as soon as diesel prices start to drop.

Although the benefits per ton of carbon avoided can be a good indicator for the performance of the respective trading systems, other indicators can also be helpful in analyzing the trade-off between both systems. Therefore, we also analyze the financial returns per hectare for different carbon prices. Since both bio-energy trading systems are cheaper than their reference energy system, benefits are experienced in both direct money (FT-diesel costs minus fossil diesel costs plus transaction costs) and emission reduction credits. The total amount of money that could be earned by implementing the trading systems depends on the carbon price to be received per ton of carbon avoided. Figure 3 shows the financial returns for both trading systems for different carbon prices.

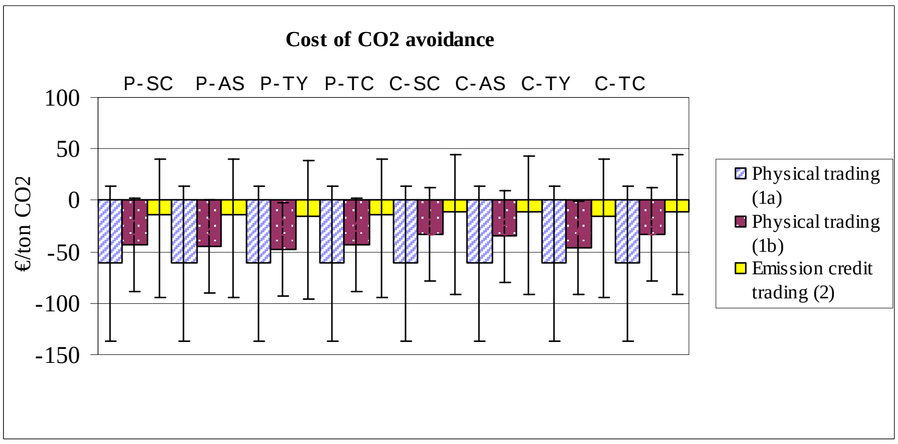



Figure 2.Mozambique: Cost of $CO_2$ avoidance

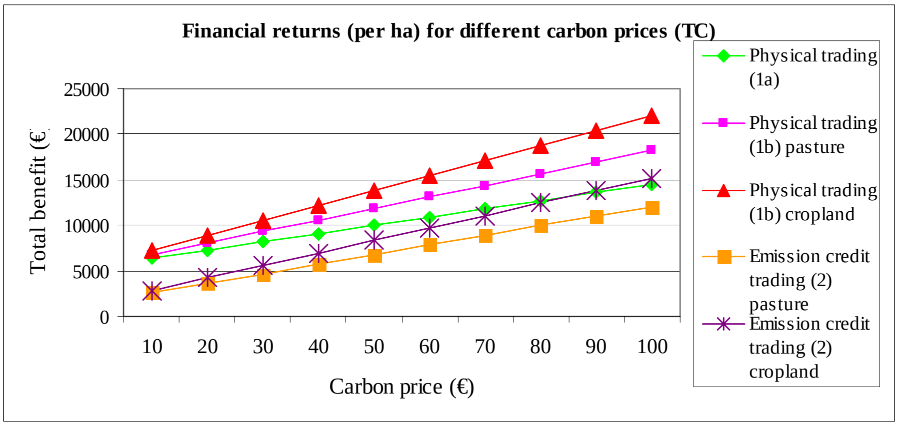
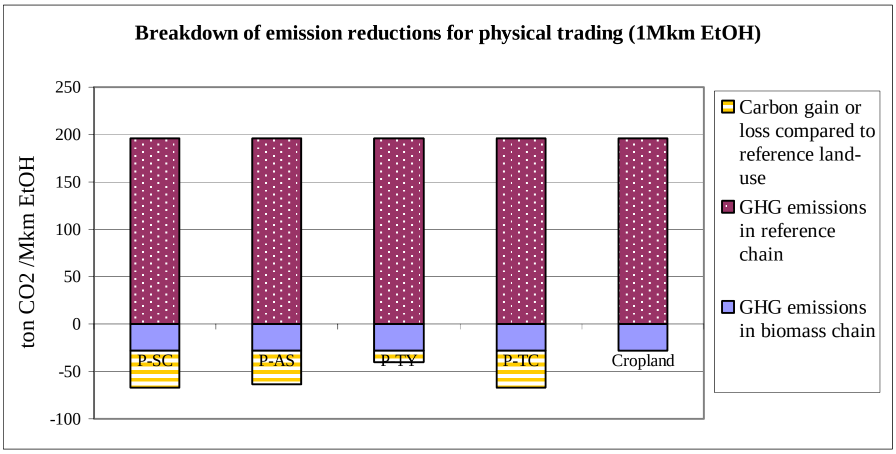



Figure 3.Mozambique: Financial returns (per ha) fo rdifferent carbon prices, using the Temporary Crediting Method

*Brazil:* Physical trading is represented as system 1. Here, ethanol, produced from sugarcane in Brazil, is transported overseas to the Rotterdam harbour where it is mixed with conventional gasoline to form a blend fuel (5% which is the current blending maximum). The fuel is transported to fuel stations where cars are filled and final conversion occurs in the vehicle. Reference system 1a corresponds to the tailpipe emissions of conventional gasoline cars in the Netherlands, whereas in reference system 1b also upstream emissions of gasoline production and reference land use are taken into account.Since alcohol production for the blend of up to 25% is not a candidate for CDM projects in Brazil (it corresponds to a baseline before the base year for the Kyoto Protocol) we consider as the emission credit trading scenario a project where ethanol vehicles (100% hydrated) are subsidized. System 2, therefore, represents the production of hydrated ethanol (100%) from sugarcane in Brazil and the conversion in the alcohol vehicle. Reference system 2a indicates the baseline situation in Brazil: the production of anhydrous ethanol and gasoline that are mixed in a blend of 25% and converted in the car.



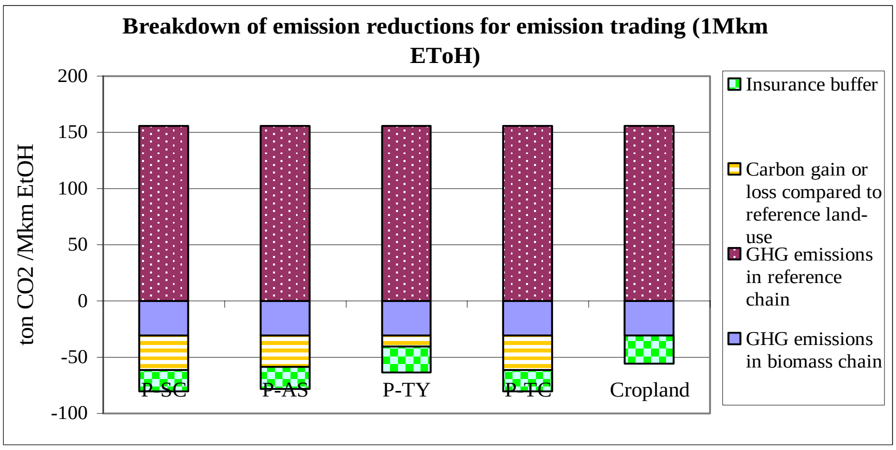




Figure 4. Brazil: Breakdown of emission reductions for physical trading (1b) and emission credit trading (2)

Figure 4 shows that (avoided) emissions in the reference system account for the largest part of the emission reductions Emission in the biomass chain (WTT) and emissions related to land-use change (mainly SOC) account for a decrease in the avoided emissions. The emissions in the reference energy system in emission trading (E25 Brazil) are considerably lower than the emissions in the physical trading reference system. The reason is that in the baseline (E25) already 25% of gasoline is replaced by ethanol, leading to lower baseline emissions. GHG emissions in the biomass chain and carbon losses due to land-use change are similar to the physical trading scenario. However, additional losses result from the extra emission credits reserved in an insurance buffer in credit trading.

In Figure 5, the costs of CO2 avoidance are displayed. The results show that in contradiction to the Mozambique case study, here, for all scenarios costs are associated with CO2 avoidance. Costs of CO2 avoidance in physical trading are mainly given by relative differences in oil and ethanol prices (taxes and import tariffs were not taken into account). With current gasoline and ethanol prices, the physical trading systems produce carbon credits with a price of 20-30 euros, but due to fluctuating oil prices, uncertainties are high. With increasing oil prices, the costs of physical trading will be reduced. The costs of carbon credits in the emission credit trading scenario are largely given by the investment of 40,000,000 dollars that is foreseen to facilitate the purchase of a new fleet of 100,000 ethanol vehicles. In the physical trading scenarios, no such investments are necessary for the cars, since the fuel can be used in the currently available vehicles. Uncertainties in the emission credit trading system (2) are related to the uncertainties in the amount of CO2 avoided. That is, amongst others, determined by the amount of kilometres that the fleet will drive, the lifetime of the cars and the fuel efficiency of the fleet.

Figure 6 shows the financial returns per hectare, at different carbon prices, for both trading systems with pasture as baseline vegetation scenario. Emission credit trading provides the highest financial returns (or lowest financial debts) for low carbon prices. With increasing carbon prices physical trading becomes more financially attractive. The switching point, with current oil and ethanol prices, lies around 30 € per ton of carbon, for system 1a and around 70€ per ton of carbon for system 1b (including upstream emissions and land-use changes).

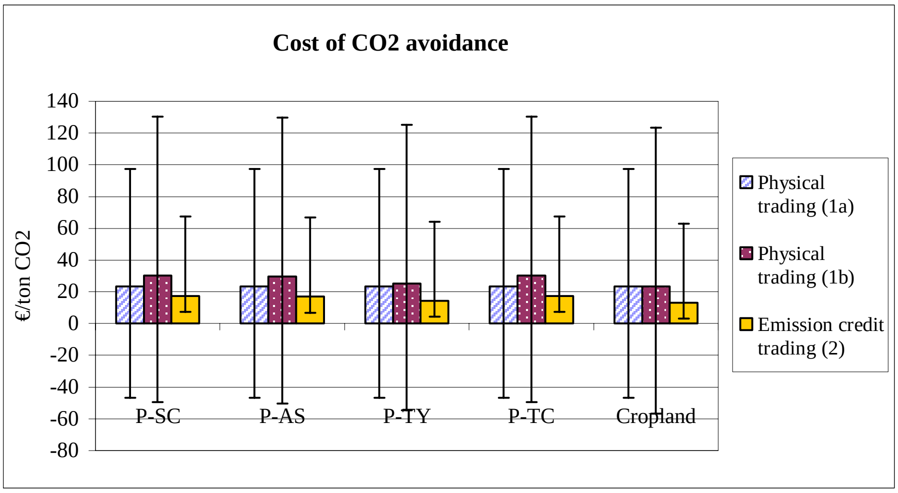



Figure 5. Brazil: Cost of $CO_2$ avoidance

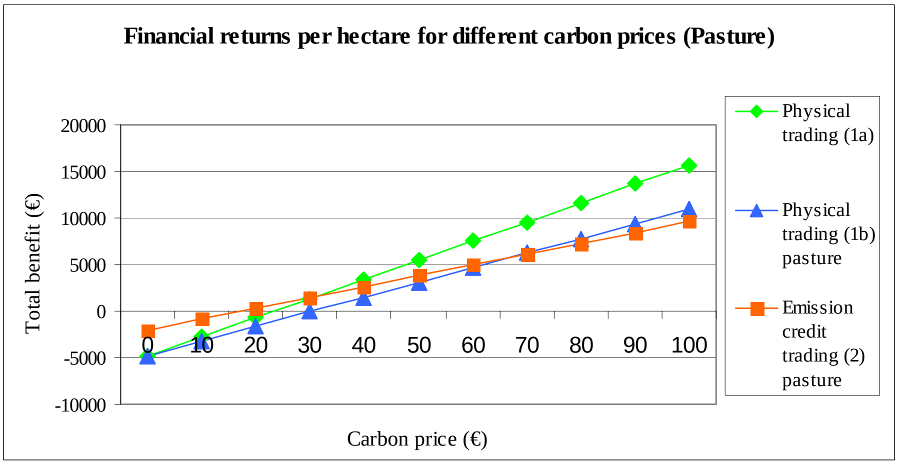



Figure 6. Brazil: Financial returns (per ha) fo rdifferent carbon prices, using the Temporary Crediting Method

## 4 DISCUSSION AND CONCLUSIONS

Whereas in emission credit trading, due to the strict rules for registration of a CDM or JI project, all carbon fluxes related to the project must be taken into account, in physical trading, current practice is to only consider the avoided emissions related to the conversion of the substituted fossil fuel. Especially when the land-use change leads to carbon losses, this current approach can be very precarious. The influence of different baseline vegetation on emission reduction is substantial; especially related to soil carbon content. Unfortunately, data on SOC were difficult to gather and in most cases assumptions had to be made. The chosen timescale to account for carbon gains or losses also appeared to have a determining influence on the results. The temporary crediting method seems a good accounting alternative, although it might become difficult to deal with temporary credits in bookkeeping systems of the various parties. Land-use changes are currently not accounted for in physical trading. Taking into account their influences on total system emissions (reductions), a solution needs to be found to prevent carbon losses during biomass production. A certification system might be a good option.

Transportation and transaction costs have a negligible influence on the financial results in large scale trading systems as explored in this study. With increasing trading scales, the cost of transportation decreases and fuel prices become world market prices. In that case, the most effective trading system to reduce GHG-emission depends mainly on 1) the amount of GHG-emission that can be avoided in the exporting respectively importing country, where the balance between the emissions in the baseline and the emissions in the bio-fuel system turns out to be most important and 2) the associated cost of the bio-fuel system in either of those countries. If the conversion of biomass is cheaper in the importing country, physical trading would be beneficial. If conversion is cheaper in the country of biomass origin, both emission credit trading and physical trading are good alternatives since transportation costs are found to be negligible at large trading scales. It then depends on other choices, which trading option is favourable. All other things being equal, physical trading could be the preferred trading alternative, because with the same amount of money and emission credits, you can also benefit from the energy. Advantages are mainly the diversification in energy sources and possible job creation. Poorer countries could also benefit from the establishment of a global biomass market that can provide consistent demands and generate considerable income sources for these countries.

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