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## Achieving cost efficiency with the 30% greenhouse gas emission reduction target of the EU

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Title <b>Achieving cost efficiency with the 30% greenhouse gas emission reduction target of the EU</b>		
Abstract <p>This working paper analyzes the greenhouse gas reduction targets of the EU up to 2020, focusing on the cost efficiency of the targets. Using scenarios calculated with the integrated assessment model TIAM-Nordic, three separate cases of possible targets for the EU ETS and non-ETS sectors are assessed. The results indicate that should the EU shift to a more ambitious emission reduction target of 30% from 1990 levels by 2020, a large majority of the cost efficient emission reduction potential that is required for reaching the more ambitious target lies in the ETS sector.</p> <p>The calculated scenarios also underline the need for increased flexibility for carrying out the emission reductions in the non-ETS. Without flexibility between Member States in the reduction efforts, cost efficiency would be reduced remarkably. Moreover, as the actual reduction potentials of ETS and non-ETS sectors in 2020 can not be predicted accurately, cost efficiency can not be reached by a careful setting of separate targets for the ETS and Member States. Instead, flexibility mechanisms between the ETS and Member States' non-ETS sectors should be introduced.</p>		
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## **Preface**

Climate change mitigation requires clear targets for emission reductions, and ensuring economic well-being of both citizens and companies requires efficient climate policy. This report aims at supporting the ongoing discussion on how the EU should act to achieve cost efficient emission reductions, if a shift to a more ambitious climate policy is decided to take place.

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The views expressed in this report are those of the author, and do not necessarily represent the view of Finnish Ministry of the Environment.

Espoo, 27<sup>th</sup> of August, 2010

Tommi Ekholm

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## Summary

- The EU may raise its target for greenhouse gas emission reductions in 2020 from current 20% from 1990 levels to 30%.
- The target is split between the emissions trading system (ETS sector) and the national targets of the Member States (non-ETS sector). Achieving cost-efficient emission reductions requires that the emissions will be cut in both sectors in a manner that equalizes the marginal costs of emission reductions between the sectors.
- This report analyzes the cost-efficiency with the current 20% reduction commitments and the possible 30% reduction level using the TIAM-Nordic integrated assessment model.
- According to results, with the current 20% reduction target the marginal costs of the non-ETS sectors would be 15% higher than that of the ETS sector, should the Member States be allowed to trade the non-ETS emissions with each other. Without the option for emission trading in the non-ETS sector the marginal costs vary to a very large extent between the Member States.
- When shifting from the 20% target to the 30% target, the bulk of the cost-efficient emission reduction potential in the EU lies in the ETS. Should all additional reductions be allocated to the ETS, the marginal cost of the ETS would be 20% higher than with the non-ETS sector. On the other hand, should the additional reductions be allocated to the sectors in proportion to the current allocation of reductions, i.e. according to the proposition of the European Commission, the marginal cost in the non-ETS sector might be even 50% higher than that of the ETS. This implies that in order to reach cost efficiency within the whole EU in general, the additional reductions should be allocated mainly to the ETS.
- All of the assessed cases emphasized the role of flexibility mechanisms between the Member States in the non-ETS sector. Achieving cost efficiency within the whole EU would require substantial amounts of transfers between Member States with the non-ETS emission allocations. The calculated scenarios exhibited

## Summary

transfer volumes from 7% to 26% of Member States' non-ETS allocations in 2020, i.e. volumes which are substantially higher than the currently set cap for transfers, 5% of the annual allocation.

- There, however, are notable uncertainties associated with the emission reduction potentials in 2020. Using modelling results for determining the optimal allocation of reduction targets between the sectors, as was done in an impact assessment conducted by the European Commission, may yield results that differ notably from the actual cost efficient allocation in reality. In order to ensure cost-efficiency, flexibility mechanisms between ETS and non-ETS sectors would be necessary, e.g. a possibility to transfer ETS allowances to national non-ETS allocations, and vice versa.



# 1. Introduction

The European Union (EU) is committed to reduce its greenhouse gas (GHG) emissions in 2020 by 20% from the level of 1990. The directive 2009/29/EC and the decision No. 406/2009/EC split the overall reduction target between the EU-wide Emission Trading System (ETS), which comprises electricity and heat production and the majority of industrial emissions, and the national targets of the Member States in the non-ETS sector, which comprises the remaining emissions controlled by the Kyoto protocol.

The directive and the decision include a possibility to increase the emission reduction target of the EU in future to the level of 30% from 1990, in a case of comprehensive international agreement on emission reductions. An increase in the overall reduction target requires a reassessment of both the ETS and non-ETS targets. Towards this aim the European commission has conducted an impact assessment of the 30% reduction (Commission, 2010a, 2010b).

Regardless of the chosen emission reduction target, maintaining economic efficiency requires that the emissions should be reduced with measures, with which the costs of emission reductions are as low as possible. An indicator for this is the marginal cost of emission reductions, which equals the highest cost per tonne that has been incurred in order to reach a given emission target. Cost efficiency would then require that the marginal costs are the same across all economic sectors, as otherwise the reductions within a sector with high costs could be replaced with reductions in a sector with lower costs. This report assesses the cost efficiency of emission reductions in the possible shift to a 30% reduction target. In particular the report focuses on the allocation of emission targets between the ETS and non-ETS sectors.

## 2. Meeting the current 20% target

The current target for GHG emissions, a 20% reduction from 1990 levels by 2020, is set in two parts: for the ETS sector in the directives 2003/87/EC and 2009/29/EC and for the non-ETS sector in the decision No. 406/2009/EC. The directive 2009/29/EC extends the coverage of the ETS from 2013 onwards, and the Commission was due to declare the amount of permitted emissions for the extended ETS sector in 2013 by 30 June 2010. At the time of writing, a cap which includes the new emission sources of the extended ETS has not been announced. Therefore there is currently no public or official information on the emission cap – in terms of tonnes CO<sub>2</sub> equivalent (t CO<sub>2</sub> eq.) – of the ETS for the years 2013 to 2020, and due to this estimates have been used instead for this purpose.

With the current overall EU emission target and the sectoral split between ETS and non-ETS, the emissions of the ETS will be reduced by 21% and those of the non-ETS by 10% from 2005 levels in 2020. This amounts to a reduction of 14% from 2005 levels, or equivalently 20% from 1990 levels, in 2020 by the EU in total. The sectoral targets declared in the directive and decision are based on an impact assessment (Commission, 2008), in which the cost efficiency of emission reductions was assessed with PRIMES and GAINS models.

The non-ETS targets of individual Member States in 2020 were set in the decision 406/2009/EC to range between -20% and +20% when compared to their 2005 emissions, based on the Member States' GDP per capita levels. The reduction target for Finland in 2020 is -16% from 2005 levels. The emissions of the Finnish non-ETS sector corresponding to the extended ETS sector definition of the directive 2009/29/EC were estimated as 33.0 Mt CO<sub>2</sub>-eq. Based on this the emission target in the Finnish non-ETS sector would be approximately 27.7 Mt CO<sub>2</sub>-eq.

## 2.1 An impact assessment with the TIAM-Nordic model

The impacts of the EU emission targets were analyzed with the global TIMES Integrated Assessment Model (TIAM) (Loulou and Labriet, 2008; Loulou, 2008), developed under the Energy Technology Systems Analysis Program (ETSAP) of the International Energy Agency (IEA)<sup>1</sup>. The model is a linear optimization model of the energy system that calculates a market equilibrium for energy production, transformation and end use under the given climate policies. The model includes all emissions and sources controlled by the Kyoto protocol and a large database of technologies for reducing these emissions.

The model has been updated at VTT to include five distinct regions in the EU: Finland, Sweden, Denmark, West Europe and East Europe. The two latter regions however include countries that are not members of the EU, but which are not separable from the region in the model structure. The effect of this inaccuracy for the results presented in this report is nevertheless negligible, but affects e.g. the results on the absolute amount of emissions, which therefore do not exactly match with those of the actual EU-27.

The emission cap of the ETS and Member States' non-ETS sectors was estimated from the results of the TIAM-Nordic model for the year 2005, assuming that all CO<sub>2</sub> from electricity and heat production, industry and refineries; and all N<sub>2</sub>O from industrial processes would be under the ETS. The rest of the emissions, excluding those from LULUCF, were allocated to the non-ETS sector. Resulting from the sectoral division of the TIAM-Nordic model, the coverage of the ETS in the model is close to, but does not exactly match the actual coverage. Therefore the absolute emissions of the ETS and non-ETS sectors may slightly differ from reality, but the effect of this difference on the analysis of cost efficiency is likely to be minor<sup>2</sup>.

The emissions in 2020 in a baseline scenario without any climate policies, as calculated with the TIAM-Nordic model, along with the emission targets for the ETS and Member States' non-ETS sectors are presented in Table 1. The baseline non-ETS emissions are comparable to the WEM scenarios reported by the Member States, as compiled by the EEA (2009). East Europe is, however, an exception on this, as the WEM scenarios of e.g. Poland, Czech Republic and Romania projected increasing emissions in the non-ETS sector, contrary to the results of the TIAM-Nordic model.

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<sup>1</sup> The model version used in this analysis is TIAM-Nordic, which has been developed at VTT from the version TIAM-2007 TOCSIN.

<sup>2</sup> As there are currently no official estimates on the emissions of the extended ETS for 2005, a comparison between actual and model values is not possible.

## Meeting the current 20% target

Table 1. Emissions [Mt CO<sub>2</sub>-eq.] of the Member States' non-ETS sectors and the EU ETS in the baseline scenario of the TIAM-Nordic model, along with the current reduction targets calculated from 2005 emissions of the model. The figures correspond to the extended coverage of the ETS. The regional and sectoral divisions of the TIAM-Nordic model differ slightly from the coverage of EU-27 and the ETS, and as a result the emission estimates might exhibit small differences to actual values.

		Baseline [Mt CO <sub>2</sub> -eq]		-20 % target by 2020		
		2005	2020	Mt CO <sub>2</sub> -eq	from 2005	from baseline
Non-ETS	Denmark	34.6	32.7	27.7	-20 %	-15 %
	Sweden	42.4	38.9	35.2	-17 %	-9 %
	Finland	33.0	30.2	27.7	-16 %	-8 %
	Western Europe	2204	2093	1906	-14 %	-9 %
	Eastern Europe	523	503	594	14 %	18 %
EU ETS		2565	3098	2026	-21 %	-35 %

The Member States are allowed to use flexibility mechanisms in order to meet their non-ETS commitments, including transfers in emission allocations between other Member States, temporal flexibility and, to a limited extent, CER credits from CDM projects. Of these mechanisms, only transfers between Member States are taken into account in this report. The decision No. 406/2009/EC limits the right of a Member State to transfer its emission allocation to another Member State to 5% of the seller's initial allocation. The scenarios presented in this report do not, however, accommodate for this limitation, and the Member States are allowed to transfer freely their non-ETS allocations with each other in order to achieve better cost efficiency.

The possibility to use CER credits both in the ETS and the non-ETS sectors is bound to reduce the marginal costs in both sectors. The allowed amount of credits usable in the ETS sector is limited to 10.5% of 2005 emissions (50% of the emission reduction between 2005 and 2020), and in the non-ETS sector to 3% or 4% of 2005 emissions, depending on the non-ETS reduction target of the Member State in question. The use of CER credits was not taken into account in the scenario of this report. As a qualitative analysis it can be noted, though, that due to the larger allowed share of CER credits in the ETS sector, the marginal costs in ETS are lowered more than in the non-ETS sector by this flexibility.

Figure 1 presents the marginal costs in 2020 in the non-ETS sectors of Member States with the current non-ETS targets, in cases where the Member States are either allowed to freely transfer their non-ETS allocations (blue line) or when this is not allowed (bars). The figure also portrays the marginal cost – or equivalently the price of allowances – in the ETS sector (green line) in the same scenario.

## 2. Meeting the current 20% target

The results portrayed in Figure 1 state that if the flexibility in emission reductions between Member States is not possible, the marginal costs in Nordic countries and western Europe may rise to relatively high levels, whereas the marginal cost would be zero in eastern Europe. Should the unused non-ETS allocation and cost efficient reduction measures of eastern Europe be utilized through the possibility for transfers, the marginal cost of non-ETS reductions in the EU would be approximately at 44 €/t<sub>CO2</sub>, i.e. at a slightly higher level than the price of allowances in the ETS, which was at 38 €/t<sub>CO2</sub> in the scenario.

The results indicate that with the current targets, the marginal costs in the non-ETS are likely to be slightly higher than in the ETS in 2020, if free transfers in non-ETS allocations are allowed. Without this flexibility the cost level in the non-ETS sector will be remarkably higher than the level in the ETS, except in eastern Europe, and the allocation of emission targets is far from efficient. The transfers in non-ETS allocations plays a crucial role in levelling the marginal costs between Member States, and the transfer flows in the allocations are notable – from 7% to 26% of the Member States’ allocation for 2020 – as can be also seen from Figure 1.

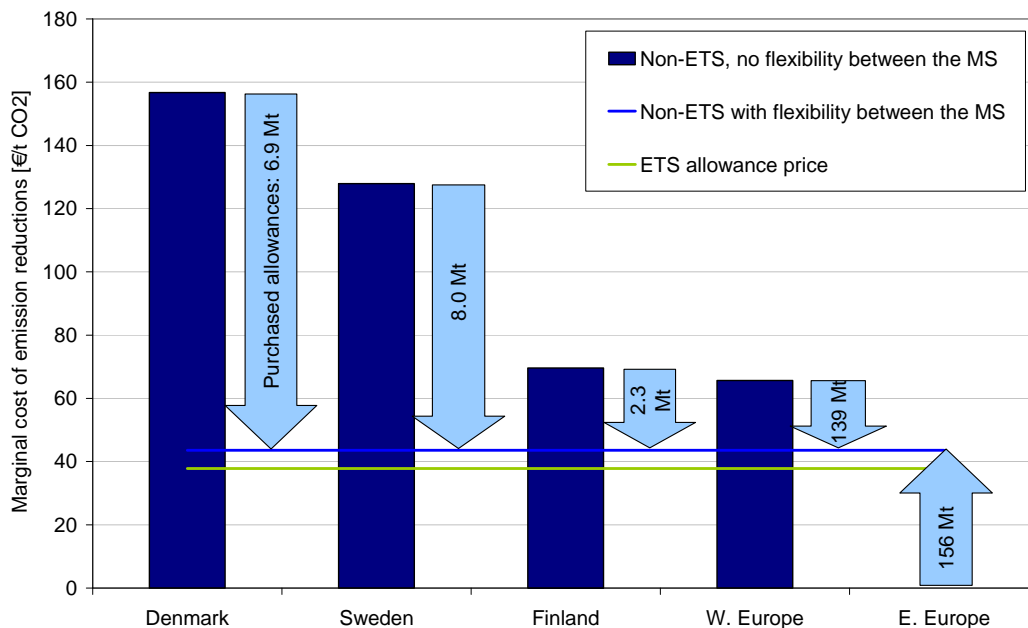


Figure 1. An estimate with the TIAM-Nordic model on the marginal costs of emission reductions for reaching the ETS and non-ETS targets under EU -20% overall reductions in 2020. The marginal cost of non-ETS sector is calculated both without (blue bars) and with (horizontal blue line) transfers in emission allocations between the Member States. The marginal cost of the ETS is lower than the non-ETS marginal cost in Nordic countries and western Europe. The light blue arrows display the amount of transferred non-ETS allocations in each region. The marginal costs for the non-ETS sectors of Denmark and Sweden involve large uncertainties, due to the model calibration.

## 2.2 Some earlier studies on the implications of the 20% target

A previous VTT research report (Ekholm, 2010) analyzed the non-ETS target in Finland using the current coverage of the ETS. Converting this previous analysis to accommodate the extension of the ETS starting from 2013, the baseline emissions of non-ETS sector in Finland would be 30.8 Mt CO<sub>2</sub>-eq. From this baseline, a reduction of 3.1 Mt CO<sub>2</sub>-eq would thus be required to meet Finland's non-ETS target. Using the marginal cost curve developed in the report, this would result with marginal costs slightly above 60 €/t<sub>CO2</sub>. The report did not assume any flexibility mechanisms, and the result is therefore well in line with the marginal cost of 70 €/t<sub>CO2</sub> presented in Figure 1.

A large number of estimates have been presented on the price level of ETS allowances in 2020 with the current climate policy. A review by Bole (2009) presents a range of estimates between 20 and 48 €/t<sub>CO2</sub>. The ETS price level presented in Figure 1, 38 €/t<sub>CO2</sub>, therefore lies in the middle part of this interval. On the other hand, the non-ETS marginal cost of 44 €/t<sub>CO2</sub> – when assuming flexibility between Member States – lies in the high end of this interval, indicating that previous estimates on ETS price level mostly are below our estimate on the level of EU-wide marginal costs in the non-ETS sector.

### 3. The -30% target – assumptions and impacts

Should the EU shift to the more ambitious emission reduction target of 30% from 1990 levels in 2020, the additional reductions that are required to reach the stricter target can be, in principle, allocated to either the ETS or the non-ETS sector. The proposal “COM(2008) 17 final” from the European Commission stated that the additional reductions should be allocated to these sectors in the same proportion compared to the current reduction targets of the sectors. However, this notion was not included in the decision No. 406/2009/EC of the EU Parliament and Council on effort sharing between Member States.

Were the new 30% reduction target made on the basis of the proposal “COM(2008) 17 final”, the reduction target of the EU ETS would be 35% and that of the non-ETS sector -17% on average in the whole EU. In the case of Finland, the non-ETS target would mean 23.3% reduction from 2005, which – using our emission estimates from Table 1 – would equal 25.3 Mt CO<sub>2</sub>-eq.

An impact assessment (Commission, 2010a, 2010b) of the 30% reduction target with PRIMES and GAINS models, commissioned by the EU Commission, reported overall marginal costs of 55 €/t<sub>CO2</sub> resulting from cost efficient emission reductions. This cost optimal strategy would correspond to reductions of 34% in the ETS and 16% in the non-ETS sector, from 2005 levels in 2020. These targets therefore correspond very accurately to the sectoral targets planned already in 2008. It should however be noted that compared to the previous impact assessment (Commission, 2008), on which the proposal “COM(2008) 17 final” was based on, the updated assessment (Commission, 2010b) was carried out with updated versions of the PRIMES and GAINS models and uses updated assumptions which take into account e.g. the current financial crisis. Therefore the remarkable similarity in the sectoral emission targets between the old and the new impact assessment seems rather surprising.

In this work the TIAM-Nordic model was used in assessing cases where the additional reductions from implementing the 30% target are either allocated entirely to the ETS sector, or – as suggested in “COM(2008) 17 final” – to the ETS and national non-ETS sectors of Member States. It was again assumed that the emission reductions will

be carried out internally inside the EU and that free transfers in non-ETS allocations between Member States are either allowed or not.

Figures 2 and 3 portray the marginal costs resulting from the 30% reduction target in the TIAM-Nordic model. In the case where the additional reductions are allocated in their entirety to the ETS sector (Figure 2), the marginal costs of non-ETS sector would be very close to the 20% case, as can be noted by comparing Figures 1 and 2. In the ETS the price would increase to 53 €t<sub>CO2</sub>, i.e. to a slightly higher level than in the non-ETS sector, should full flexibility with non-ETS reductions be allowed.

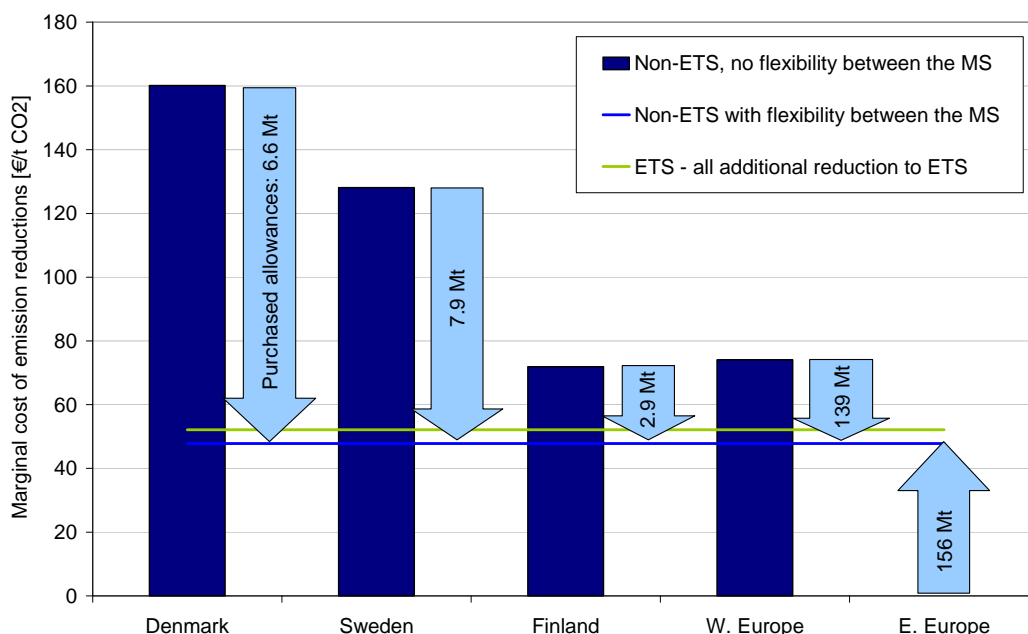


Figure 2. An estimate with the TIAM-Nordic model on the marginal costs of emission reductions for reaching the ETS and non-ETS targets under EU -30% overall reductions in 2020 in a case where *additional emissions are allocated entirely to the ETS*. The light blue arrows display the amount of transferred non-ETS allocations in each region. The marginal costs for the non-ETS sectors of Denmark and Sweden involve large uncertainties, due to the model calibration.

In the case that the additional reduction resulting from the 30% are allocated to the ETS and non-ETS sectors proportionally to the sectors' current reduction targets (Figure 3), the marginal cost in the non-ETS sector increases considerably from the cases presented in figures 1 and 2. Full flexibility in emission reductions between Member States would level the marginal costs at 77 €t<sub>CO2</sub>. Without this flexibility the costs would again be remarkably higher in Nordic countries and western Europe. It should be noted, however, that the results regarding the marginal costs for the non-ETS sectors of Denmark and Sweden involve large uncertainties, due to the model calibration. In the ETS the price of emission allowances would be at 51 €t<sub>CO2</sub>, i.e. only slightly lower than in the case presented in Figure 2, where all additional reductions are allocated to the ETS. When the



### 3. The -30% target – assumptions and impacts

results of Figure 3 are compared to the aforementioned updated impact assessment – in which the reduction targets of the ETS and non-ETS sector were the same – the marginal cost of ETS reductions are similar between the studies, but the non-ETS marginal costs are comparatively higher, by 40%, in the TIAM-Nordic scenarios.

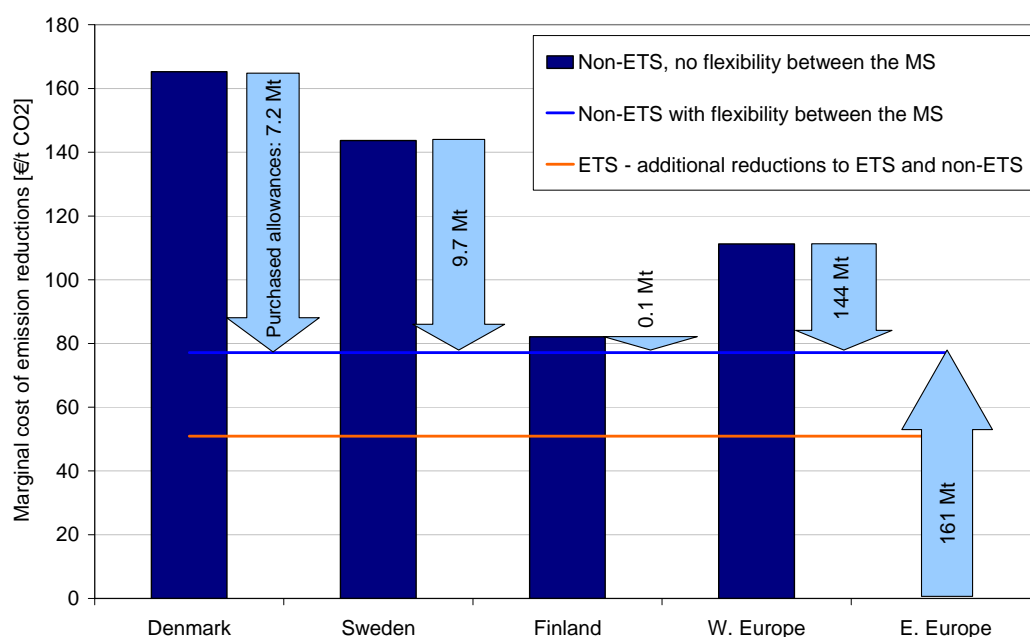


Figure 3. An estimate with the TIAM-Nordic model on the marginal costs of emission reductions for reaching the ETS and non-ETS targets under EU -30% overall reductions in 2020 in a case where *additional emissions are allocated according to the proposal “COM(2008) 17 final”*. The light blue arrows display the amount of transferred non-ETS allocations in each region. The marginal costs for the non-ETS sectors of Denmark and Sweden involve large uncertainties, due to the model calibration.

The amount of cost effective emission reductions in different non-ETS sub-sectors depends to a large extent on the overall non-ETS target and the ability to flexibly share the reduction effort between Member States. On the EU level, the reductions in the TIAM-Nordic scenarios are mostly carried out in transportation, household and waste sectors, and also in fuel production. An overview of sub-sectoral emission reductions with the 30% overall EU target is presented in Table 2.

The -30% target – assumptions and impacts

Table 2. The range of emission reductions in the non-ETS sector by sub-sector in 2020 in four scenarios with a 30% overall reduction in the EU. The range of reductions corresponds to the differences in reduction allocation between ETS and non-ETS and whether full flexibility in reductions between Member States is assumed or not.

	EU		Finland	
	Reduction from baseline	Share from total non-ETS reductions	Reduction from baseline	Share from total non-ETS reductions
Households	6 % to 27 %	9 % to 24 %	29 % to 31 %	33 % to 38 %
Waste	13 % to 22 %	2 % to 4 %	24 %	11 % to 15 %
Transportation	10 % to 12 %	32 % to 41 %	3 % to 4 %	26 % to 30 %
Agriculture	4 % to 5 %	5 % to 9 %	5 % to 6 %	20 % to 21 %
Other	32 % to 47 %	36 % to 39 %	32 % to 47 %	4 % to 6 %

## 4. Conclusions and discussion

Based on Figures 2 and 3, it can be concluded that according to the scenarios calculated with the TIAM-Nordic model, the additional emission reductions resulting from a shift to a 30% reduction target by the EU should – based on cost efficiency considerations – be allocated to a large extent to the ETS sector. An economically efficient allocation would require that the marginal costs of emission reductions are equal in the ETS and non-ETS sectors in all Member States. In Figure 2, which portrays a case where all additional reductions are allocated to the ETS sector, the marginal cost of the ETS is only slightly higher than in the non-ETS sector, assuming that there is full flexibility in non-ETS reductions between the Member States. If the higher allowed amount of CER credits in the ETS sector would be taken into account, the marginal cost in the ETS might be reduced below the non-ETS cost level. The marginal costs in the scenarios with the 30% are summarized in Table 3.

Table 3. A summary of marginal cost estimates [ $\text{€}/\text{t}_{\text{CO}_2}$ ] for emission reductions in the ETS and non-ETS sectors with the TIAM-Nordic model and in the impact assessment for the European Commission (Commission, 2010a, 2010b).

	ETS	Non-ETS	
		Flexibility between MS	No non-ETS flexibility
TIAM, additional reductions for ETS	53	48	0 - 161
TIAM, additional reductions for both sectors	51	77	0 - 165
COM 2010, add. reductions for both sectors	55	55	-

It is good to note the crucial role of the flexibility between Member States' non-ETS targets in reaching cost efficiency. Without the flexibility mechanism the marginal cost of non-ETS sector would be considerably higher than the ETS cost in Nordic countries and Western Europe. At the same time the non-ETS targets in eastern Europe would be ineffective, if there are no transfers in non-ETS allocations. In the scenarios with this non-ETS flexibility the volume of transferred non-ETS allocations exceeds the 5% cap

for transfers, set down in the decision No. 406/2009/EC. Therefore cost efficiency in the non-ETS sector would require greater freedom for the Member States to transfer their non-ETS emission allocations with each other.

As the transfers of non-ETS allocations function on the level of Member States on an irregular basis, it can be assumed to work in a less efficient manner than the market for ETS allowances, on which the actors operate on a continuous basis minimizing their costs from emissions. Therefore it is possible that transfer mechanism for non-ETS allocations does not equalize the marginal cost as efficiently as has been assumed in this report. Therefore a larger allocation of emission reductions to the ETS would also minimize the risk for excessive costs resulting from this market inefficiency.

The underlying problem in achieving cost efficient emission reductions is, however, the separation of the ETS and non-ETS targets itself. The effort sharing between the two sectors in the communications “COM(2008) 17 final” and “COM(2010) 265 final” are based on cost efficiency estimates calculated with two models. Should the predictions of the models deviate substantially from the reality in 2020; the separated emission targets pose a risk for excessive costs, if there exists no flexibility in emission reductions between the sectors.

Equalizing the marginal costs between these two sectors, towards which the impact assessments of the Commission have also aimed at, would indeed require a flexibility mechanism between the ETS and non-ETS sectors. As the emission allocations in both of the sectors are already transferable – either between actors in the ETS or Member States – a possible mechanism would e.g. enable transfers between the EUA credits of the ETS and national non-ETS allocations. Such mechanisms have been called for already previously, as also have been free transfers in the non-ETS allocations between the Member States. The effects of added flexibility in EU climate policy have been investigated by e.g. Tol (2008), who concluded that a single, complete market for all emissions – instead of 28 separate emission targets – would be the most preferable option.

In the long very term, the emission reductions will induce structural change in the economic system. If a difference in marginal costs between the ETS and non-ETS – such as that presented in Figures 1 and 3 – is maintained for long periods of time, this would drive economic resources from the non-ETS to the ETS. While this might benefit e.g. companies under the ETS competing on global markets, it would create unnecessary strain on e.g. households and agriculture. Thus the imbalance in the marginal costs would be inefficient for the European economy as a whole, and creating mechanisms for levelling the imbalance would be a welcome improvement.

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