Government
Institute for
Economic Research

# Policy Reports 12

## Implications of EU emission trading in the Nordic countries

*Janne Niemi*

*Juha Honkatukia*

Policy Reports 12 August 2011

VATT POLICY REPORTS

12

# Implications of EU emission trading in the Nordic countries

Janne Niemi
Juha Honkatukia

Valtion taloudellinen tutkimuskeskus
Government Institute for Economic Research
Helsinki 2011

Janne Niemi, Government Institute for Economic Research

Juha Honkatukia, Government Institute for Economic Research

ISBN 978-951-561-991-4 (nid.)
ISBN 978-951-561-992-1 (PDF)

ISSN 1798-0305 (nid.)
ISSN 1798-0313 (PDF)

Valtion taloudellinen tutkimuskeskus
Government Institute for Economic Research
Arkadiankatu 7, 00100 Helsinki, Finland

Oy Nord Print Ab
Helsinki, August 2011

Graphic design: Niilas Nordenswan

# Implications of EU emission trading in the Nordic countries

Government Institute for Economic Research
VATT Policy Reports 12/2011

Janne Niemi – Juha Honkatukia

## Abstract

This research report analyses the effects of EU emissions trading schemes on the Nordic energy intensive industries. We employ simulations with a modified version of the dynamic GTAP-model and a long-run baseline, constructed particularly for analysis of energy and climate policy. The analysis covers $CO_2$ mitigation costs and their impacts on industry competitiveness, the risks of carbon leakage, and the combined effects from energy efficiency improvements. We also evaluate the effect of subsidies allowed in the EU emission trading directive to industries for compensation of the loss of competitiveness.

According to the simulation results, the single most important factor affecting the cost of cutting $CO_2$ emissions is economic growth, as it is accompanied with increasing demand and price of energy. Other important factors include the ambition level and coverage of global climate agreement. For the permit price at emissions trading market and for climate policy effectiveness, advances in energy efficiency also have a significant impact. Energy efficiency and emission reduction targets are intertwined, and the reduction target alone leads to significant decrease in primary energy use. Global improvement in energy efficiency also reduces world emissions and carbon leakage. Unilateral EU policy seems ineffective for global emissions reduction, whereas commitment of all Annex I countries has a much larger impact. Subsidies to the EU industries for compensating the loss of competitiveness would limit the carbon leakage to other regions, and the overall impact on EU economies appears favourable.

Key words: competitiveness, emission trading, mitigation costs, carbon leakage

JEL classification numbers: F14 , H23, C68

# Tiivistelmä

Tässä tutkimusraportissa analysoidaan EU:n päästökauppajärjestelmien vaikutuksia Pohjoismaiden energiaintensiivisille teollisuudenaloille. Analyysissä hyödynnetään simulaatioita dynaamisesta GTAP-mallista kehitetyllä versiolla sekä pitkän ajan perusuralla, jotka on laadittu erityisesti energia- ja ilmastopolitiikkakysymysten arviointia varten. Tarkastelu kattaa hiilidioksidipäästöjen rajoittamisen kustannukset ja vaikutukset eri teollisuudenalojen kilpailukyvylle, mahdollisen hiilivuodon sekä yhteisvaikutukset energiatehokkuuden parannusten kanssa. Tutkimuksessa arvioidaan myös EU:n päästökauppadirektiivin sallimien, kilpailukyvyn heikkenemistä kompensoivien tukien vaikutuksia.

Simulaatiotulosten mukaan tärkein hiilidioksidipäästöjen vähentämisen kustannuksiin vaikuttava tekijä on talouskasvu, joka johtaa korkeampaan energian kysyntään ja hintaan. Muita tärkeitä tekijöitä ovat globaalin ilmastosopimuksen tavoitetaso ja kattavuus. Myös energiatehokkuuden paranemisella on huomattavia vaikutuksia päästöoikeuden hintaan päästökauppamarkkinoilla ja ilmastopolitiikan vaikuttavuuteen. Energiatehokkuus- ja päästövähennystavoitteet ovat osittain päällekkäisiä, ja päästövähennystavoitteen toteutuminen yksinään johtaa huomattavaan primäärienergian käytön laskuun. Maailmanlaajuisesti toteutuva energiatehokkuuden paraneminen myös vähentää koko maailman päästöjä ja hiilivuotoa. Koko maailman yhteenlaskettuja päästöjä tarkasteltaessa EU:n yksipuolinen ilmastopolitiikka vaikuttaa tehottomalta, kun taas kaikki Annex I - maat kattavalla politiikalla on selvästi suurempi vaikutus. Kilpailukyvyn heikkenemistä kompensoivat tuet EU-maiden teollisuudelle vähentäisivät hiilivuotoa, ja niiden kokonaistaloudelliset vaikutukset näyttävät suotuisilta.



Asiasanat: kilpailukyky, päästökauppa, kustannustehokkuus, hiilivuoto

JEL-luokittelu: F14 , H23, C68

# Executive summary

This research report commissioned by the Nordic Council of Ministers analyses the effects of EU emissions trading schemes on the Nordic energy intensive industries. The analysis covers $CO_2$ mitigation costs and their impacts on industry competitiveness, the risks of carbon leakage, and the combined effects from energy efficiency improvements. Implications of compensating subsidies to energy-intensive industries are also explored. The main findings are:

### GDP growth main determinant of mitigation costs

- Economic growth is the single most important factor affecting the cost of cutting $CO_2$ emissions, as reflected on international emission trading market. With the growing world economy, the unit price for emissions increase regardless of the reduction target, especially in the long run.
- Low and even negative growth in past few years affects the $CO_2$ permit prices observed in the EU Emission Trading System (ETS). We estimate that without the recession (assuming long term average growth rates), the market prices for emission permits would presently be about double (up to EUR 30 / tonne $CO_2$). However, the long-term impacts of the recession can be even cost-increasing for mitigation, and in any case the $CO_2$ market price will catch up as growth returns to normal.

### $CO_2$ prices in different regimes: ambition level and coverage of global climate agreement

- The coverage of participation in climate policy plays a considerable role, and its implications for the global competitiveness of different industries go beyond mere emission costs. With a global commitment, additional emission cuts can be achieved at relatively low additional cost, at least the EU's more ambitious 30% reduction target.
- The importance of the policy ambition level on $CO_2$ price is very high when the policy is implemented by only a few countries (Europe). The additional cuts become very expensive if implemented unilaterally. Economic recession lowers the mitigation costs only in the short run.

### Competitiveness of energy-intensive industries

- Many industries important to Nordic countries face increasing input costs in the period 2004–2020, whilst the world market price of these commodities remains virtually unchanged. This implies that whilst production may become more expensive, the export revenues do not increase in the same proportion. Therefore, especially export-oriented energy-intensive industries are, on one hand, at a disadvantaged compared to the foreign (often Chinese or Indian) competitors and, on the other hand, provide less profitable use of available production factors compared to other domestic industries.

- In addition to the loss of competitiveness due to $CO_2$ mitigation, energy-intensive industries in Nordic countries face fundamental, long-term changes in the global competitive environment as the demand increases in developing countries. Labour market developments and natural resources typical to Nordic countries also affect energy-intensive industries.
- The economic crisis has undoubtedly accelerated the decline of the heavy industries in the short run, but in a longer run, the crisis may prove beneficial to the Nordic industries as they can reach relatively better performance in the future following the recession thanks to their improved efficiency. Larger global climate policy coverage and improvements in energy efficiency would also be beneficial to Nordic energy-intensive industries.
- Facing the tightening regimes for green house gas emissions reduction, the Nordic countries have an advantage in the potential for clean energy production, which may imply lower energy price increases due to climate policies than in the rest of the world. The geographic and natural conditions in the Nordic countries give opportunities for energy production using renewable resources on land, along coasts, as well as wood and hydro power, and there is also potential for further wind and solar power.

## Energy efficiency and technology development

- Advances in energy efficiency have significant impact on the market price for $CO_2$ emissions. We estimate that an additional one per cent annual improvement in energy efficiency results in 18 per cent lower $CO_2$ prices in the long run.
- Effect of energy efficiency on total abatement costs depends on the investments required for the increased efficiency. Whether the investments are profitable to the industries depends on the investment costs compared to the $CO_2$ market price.
- Energy efficiency and emission reduction targets are intertwined, and while the increased energy efficiency does reduce the $CO_2$ market price, the reduction target alone leads to significant decrease in (fossil) primary energy use. Due to the economic crises, the 20 % reduction in the use of primary energy is achieved almost without further technology improvements for energy efficiency. This may increase mitigation costs in the long run.

## Carbon leakage

- In the developing countries, fast economic growth is accompanied with increased emissions, and this increase accelerates with emission reduction policies implemented in other regions. However, emissions are growing fast not only in the developing countries but also in those Annex I countries not committed to international climate policy.
- Unilateral EU policy seems ineffective for global emissions reduction, whereas commitment of all Annex I countries has a much larger impact. Proportionally, the total leakage is smaller with a more covering climate policy regime, but in absolute terms, increase in the developing country emissions is higher, as the emission trading area and thereby its combined $CO_2$ reductions are higher. Carbon

leakage is estimated to be up to (theoretical maximum) 40 % in EU's unilateral commitments and 25 % with commitment of all Annex I countries.

- Global improvement in energy efficiency reduces world emissions and carbon leakage. Thus, effectiveness of a unilateral policy may improve if associated with technology spill-over in energy efficiency and other innovations reducing emissions.

## Compensating subsidies to energy-intensive industry

We were specifically asked to evaluate the effect of subsidies allowed in the EU emission trading directive to industries for compensation of the loss of competitiveness.

- A subsidy that would keep energy-intensive industries' outputs at the levels where they would be without emissions trading would cut the carbon leakage to other regions by almost half, thereby fulfilling at least part of the original rational for such compensatory policy.
- Subsidy would also impact the overall economies favourably, as the GDP levels would be about 1 % higher in 2020 than without the subsidies.
- The cost of the output to fully eliminate the decrease in output would be about 4 % of the total value of output at EU level, and 6 % for the Nordic industries in 2020. The subsidy policy would also imply about 25 % higher price for tonne of $CO_2$ at the emission trading market.
- The present Nordic electricity market setting passes carbon prices fully into the price of electricity, which increases the abatement costs particularly in the Nordic countries.

# Contents

# 1. Introduction

This research report commissioned by the Nordic Council of Ministers analyses the effects of EU emissions trading schemes on the Nordic energy intensive industries. The analysis covers $CO_2$ mitigation costs and their impacts on industry competitiveness, the risks of carbon leakage, and the combined effects from energy efficiency improvements. We also evaluate the effect of subsidies allowed in the EU emission trading directive to industries for compensation of the loss of competitiveness.

The analysis employs simulations with the GTAP applied general equilibrium model and database (see below). In additions for the new scenarios and simulations developed for the purposes of this report, the analysis builds on the scenarios and results recently acquired in two extensive research programmes: The Nordic Energy Perspectives multidisciplinary project (NEP 2010a,b)[1] implemented by an international consortium 2007–2010, and the scenario work for the Energy Vision 2050 publication (Lehtilä et al. 2009).

A mini seminar was organized in September 2010 to discuss the preliminary findings with stakeholders. At this occasion, presentations were also given on a recent ElFi study on the impact of EU ETS in the Nordic electricity market (Koskelainen 2010), and on the electricity market design proposed by the Finnish Technology Industries. The seminar participants included researchers, representatives of industries, regulatory authorities and relevant ministries from Finland, Sweden and Norway.

## 1.1 GTAP model and database

The world economy simulations employ the Global Economic Analysis Project (GTAP) database and models (e.g. Hertel and Tsigas 1997). The standard GTAP Model is a multi-region, multi-sector, computable general equilibrium model, with perfect competition and constant returns to scale. Bilateral trade is handled via the Armington assumption. The dynamic version of the model permits a recursive solution procedure, a feature that allows easy implementation of dynamics without imposing limitations on the model's size. It includes all the special features of the standard GTAP model, such as the sophisticated consumer demands and inter-sectoral factor mobility, as well as incorporating a new treatment of investment behaviour and additional accounting relations to keep track of foreign ownership of capital.

Dynamic Computable General Equilibrium models are widely used in research on long-term energy and climate policies. Whilst a range of models exist, their

[1] Related publications are available for download at http://www.nordicenergyperspectives.org/reports.asp

emphasis is clearly on energy products. For a more general evaluation of energy and climate related policies on e.g. evolution of production structures, in combination with changes in macroeconomic characteristics, like aging population and increased labour skill levels, the GTAP data and Dynamic Model provide an appealing tool. However, the latter does not take into account the special characteristics of the energy products and the policy instruments such as emission trade.

A modified version of the dynamic GTAP-model (Ianchovichina and McDougall 2001) and a long-run baseline, constructed particularly for analysis of energy and environment issues has been developed. The model incorporates $CO_2$ emissions accounting and trading, as well as substitution between alternative forms of energy – i.e. crude oil, natural gas and coal, as well as refined fuels and electricity – following the principles introduced in the special energy-environment version of the standard GTAP model (GTAP-E; Burniaux and Truong 2002). This includes energy substitution, a key factor in this chain of linkages, which is absent from the standard model specification. In addition, GTAP-E incorporates carbon emissions from the combustion of fossil fuels and provides for a mechanism to trade these emissions internationally.

The GTAP Data Base is the global data base representing the world economy for a given reference year-2004 for the GTAP 7.1 Data Base (updated from Narayanan & Walmsey 2008), which has been used in the scenarios presented in this report. The GTAP Data Base comprises several types of data: Behavioural parameters include elasticities of substitution between domestic and imported goods and elasticities of substitution between sources of imports. The main data file – derived from regional input-output tables, bilateral trade flows and protection data (taxes and subsidies) – represents the world economy as a system of flows of goods and services, measured as money values, in millions of 2004 U.S. dollars. Additional data is also provided on capital stocks, population and saving. Since most flows are measured at both tax-free and tax-paid prices, it also implicitly covers indirect taxation. On the other hand, it does not include price or quantity data, and does not include time series data. The energy volume data file contains data on energy purchases by firms and by households and bilateral trade of energy products.

The Data Base includes 117 regions and 57 commodities, and 5 endowments (i.e. production factors) land, skilled labour, unskilled labour, natural resources and capital.

# 2. Scenarios

A number of scenarios have been simulated with the GTAP model to assess the implications of various possible macro developments and policy options in medium and long run. All scenarios are for period 2004–2025, but the results in this report are usually reported beginning from 2010. There are no new policy measures for period 2020–2025 in any of the simulations, but e.g. emissions quotas are assumed to remain at 2020 levels.

Unless otherwise specified, the results are reported relative to the reference scenario that incorporates the European climate policies in place. Reference global growth rates follow the actual ones to date and the latest IMF projections for the rest of the simulation period. Characteristics of the various scenarios studied are as summarised in table 1.

*Table 1 Scenario characteristics*

A. "Baseline and macro scenarios"

*Reference case – EU 2020*

- Cutting of $CO_2$ emissions in EU by 20% by 2020 (compared to 1990), trading sectors
- Improve energy efficiency, cut primary energy use by 20% (for electricity production) in the EU
- ETS I & II 2004–2012 with annual caps, burden sharing between countries.
- From 2013 onwards, annual EU-wide reduction by 1,74%
- Rest of the world has no climate policy commitments
- Macro variables (Population, Labour force, Productivity growth) follow long term projections.
- Actual GDP growth rates 2004–2009 and updated projections 2010–2015

*No policy*

- No climate policies
- Macro variables as in the reference case

*No recession*

- Climate policies as in the reference case
- Actual GDP growth rates following long-term projections for productivity growth, no cyclical changes

B. "Policy scenarios"

*Unilateral EU -30%*

- From 2013, additional cuts to achieve 30% reduction in $CO_2$ emissions by 2020
- GDP can change compared to reference case (productivity growth fixed)
- Otherwise as reference case

*Global ETS + EU30*

- All Annex I countries engage in emission trading from 2013
- Annual cut of 1,74% for the whole emission trading area except EU
- From 2013, additional cuts to achieve 30% reduction in EU's $CO_2$ emissions (quota) by 2020
- GDP can change compared to reference case (productivity growth fixed)
- Macro variables as in the reference case

*EU -20% + subsidies*

- An output subsidy is introduced to keep the energy-intensive industries output at the same levels as in *No policy* case.
- Otherwise as *Reference (EU2020)* case.

C. "Technology scenarios"

*No energy efficiency*

- No improvement in energy efficiency in the EU (or other countries)
- Macro variables and climate policies as in the reference case

*Global energy efficiency*

- Energy efficiency improvement in whole world at the same rate as in the EU (reference case).
- Macro variables and climate policies as in the reference case

The reference case scenario aims at representing the macro-economic driver variables and international climate policies in a business-as-usual world. Therefore, it incorporates the actual population, labour force and GDP growth figures from international sources[2] until 2009, as well as the latest available projections until 2025. The population and labour force projections are same in all scenarios, while the GDP growth is determined (endogenously) by the model in most policy scenarios. The reference case also incorporates EU's emission reduction commitments and the ETS, and assumes technological development required to achieve the 20% reduction in primary energy use.

Four exploratory scenarios were simulated to illustrate the impacts of present policies, economic crisis, and technological development assumptions. The "*No policy*" scenario has all assumptions of the reference case macro variables (except GDP which is a simulation result) and technology change, but incorporates no policies aiming at emission reductions. The "*No recession*" scenario, in turn, is identical to the reference case except it assumes long-run, steady GDP growth rates for whole simulation period, i.e. considerably higher economic growth in 2004–2010. Two alternative technology scenarios differ from the reference case in terms of the technological development, namely energy efficiency improvement: the "*No energy efficiency*" scenario has no technological improvement in any region, and the "*Global energy efficiency*" assumes that all regions experience a technology improvement in energy production equal to the EU in the reference case.

*Table 2 Annual average growth rates. GDP (reference case) and population, %*

| | GDP | | Population | |
|---|---|---|---|---|
| | 2004–2010 | 2010–2020 | 2004–2010 | 2010–2020 |
| Africa | 5,1 | 6,2 | 2,3 | 2,1 |
| Australia-New Zealand | 2,7 | 3,9 | 1,0 | 0,9 |
| Canada | 1,5 | 3,3 | 0,9 | 0,8 |
| China | 10,3 | 10,4 | 0,6 | 0,5 |
| Russia and rest of FSU | 4,3 | 5,2 | -0,2 | -0,2 |
| Eastern Europe | 3,2 | 4,6 | -0,1 | -0,1 |
| India | 8,4 | 9,1 | 1,5 | 1,2 |
| Japan and Korea | 1,0 | 3,5 | 0,1 | -0,2 |
| Latin America | 3,7 | 5,1 | 1,3 | 1,1 |
| Middle-East | 4,1 | 4,5 | 1,8 | 1,6 |
| Other Developing Asia | 4,8 | 6,4 | 1,5 | 1,3 |
| United States | 1,5 | 3,1 | 1,0 | 0,9 |
| EU-15 and EFTA (excl Nordic) | 0,8 | 3,0 | 0,5 | 0,4 |
| Denmark | 0,4 | 3,5 | 0,3 | 0,3 |
| Finland | 1,1 | 3,3 | 0,3 | 0,3 |
| Norway | 1,5 | 2,9 | 0,8 | 0,7 |
| Sweden | 1,1 | 4,5 | 0,6 | 0,6 |

[2] IMF (2009), EUROSTAT (2008), United Nations (2006), ILO (2008), Carone (2005), Carone et al. (2006)

As shown in table 2, economic growth is assumed rather high when recovering from the crisis. The projections also have high labour force growth (immigration) for many Western European countries, which further increases the total GDP growth figures. While the work in this study builds on the scenario work in the Nordic Energy Perspective project, it has two important differences that affect all results. First, as explained above, the baseline growth figures are actual growth rates, whereas in NEP, the average long-term growth rates were used also in the beginning of the simulation period, which is equivalent to the "No recession" scenario in this study. Another enhancement is related to the database, which in this study is the recently released GTAP 7.1 with the input-output tables updated especially for many European countries and China. On one hand, this is reflected by better "base-competiveness" of European countries (more modern technology). On the other hand, the updated technology description is also valid for China, which is the fastest growing region and one of the most important competitors to many Nordic industries.

Policy scenarios include different options for future EU policy in different global regimes. The "*Unilateral EU -30%*" scenario includes additional cuts in EU's emissions from 2013, resulting in total 30% instead of 20% reductions by 2020. "*Global ETS + EU30"* scenario incorporates a more covering global commitment, with additional EU reductions as in the above unilateral policy scenario, and reductions in all other Annex I countries. This scenario has emission trading between all Annex I countries, and thus the actual emissions cuts take place wherever it is most cost-efficient. The *"EU -20% + subsidies"* scenario is simulated to study the costs end effects if the EU industries were compensated for the loss of competitiveness due to unilateral climate policies.

## 2.1 Commodity prices

No assumptions are made on the development of commodity prices, which come as simulation results in all scenarios (as usual in CGE simulations). World market prices of primary energy commodities in the reference case scenario show a raising trend until year 2015 or 2016. The increase of the crude oil price from 2004 base year to 2015 is about 35% after which the price starts to decline, but only slowly. European unilateral policies have little impact on world oil prices, so the scenarios with various European policy options all show very similar price development as the reference case. The natural gas price development is similar to oil, though the initial increase is clearly higher. Coal prices follow a similar pattern in the beginning, rising swiftly until 2015, but the subsequent decline is fast, resulting at the end of the simulation period in prices below the base year.

Global commitment does have a small but noticeable effect on oil price, making it decline faster after 2016. Coal prices are lower than in the reference case through the simulation period, with increasing difference towards the end. Impact on gas is much more significant, making it resemble the coal price development, and declining sharply after 2015. Global improvement in energy efficiency has a uniform, abating effect on all primary fossil energy prices, shown in 1.5% lower annual price rice (or greater decline). Compared to the reference case, this means 15% lower oil, gas and coal prices in 2020.

Simulated oil and coal prices correspond to historical development and forecasts in various sources. Natural gas price in the model, however, is generally higher and very sensitive to policy assumptions.

## 2.2 Technology changes in energy sector

The energy efficiency improvements that are assumed in various scenarios are given as exogenous drivers, as discussed above. In addition, all simulations also incorporate productivity growth. In the model, total economic growth is a product of labour, capital and productivity growths, which are all given as exogenous drivers except in the *reference case* and the "*no recession*" scenario, where the growth itself is given exogenously. In the energy sector, a nested production structure is modeled with substitution possibilities[3] between different energy commodities, and between aggregate energy and capital. As the energy sector description in the model and data is incomplete with regard to non-fossil fuel based energy, the capital-energy substitution also represents the switches between alternative energy sources. The simulations show that even without any climate policies or efficiency improvements, the share of fossil fuel based energy in electricity production in all industrialized countries would be from 7 to 13 per cent lower in 2020 compared to the base year 2004.

[3] We use substitution eleasticities reported in Beckman and Hertel (2009)

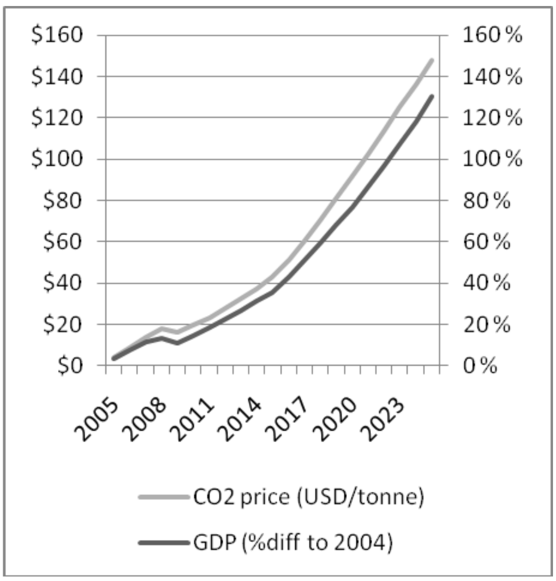
# 3. $CO_2$ emission market prices

Economic growth is the single most important factor affecting the cost of cutting $CO_2$ emissions, as reflected on international emission trading market. With the growing world economy, the unit price for emissions increase regardless of the reduction target, especially in the long run. While other factors have a clearly lesser contribution to the $CO_2$ price, the coverage of participation in the climate policy still plays a considerable role, and its implications for different industries, namely for their global competitiveness, goes beyond the mere emission costs. The market price is also affected to a great extent by advances in energy efficiency; however, the total cost effect is somewhat smaller than the market price, as the efficiency improvements require higher investments in technology. The importance of the policy ambition level on $CO_2$ price is very high when the policy is implemented by few countries (Europe), but reduces with more global coverage.

## 3.1 Economic growth

As a rule of thumb, 1% global economic growth increases the total cost of mitigating a tonne of $CO_2$ by €1, due to increasing demand for energy and hence higher price for scarce fossil fuel resources. This holds if no technology improvement is achieved in energy efficiency. A hypothetical scenario where all Annex I countries engage in emissions trading and keep their emissions at 2004 level, i.e. the trading area has zero emissions growth, shows the close relationship with growth and mitigation costs, as illustrated in figure 1.

*Figure 1 GDP and $CO_2$ price development under global zero emission growth and trading.*



The simulation experiment with actual GDP growth figures 2004–2010 and updated medium term forecasts further illustrate the significance of growth: As shown in figure 2, the market prices for emission permits are about half compared to the baseline simulation with long term average growth rates. However, the long-term impacts of the recession can be even cost-increasing for mitigation, and in any case the $CO_2$ market price will catch up as the growth returns to normal.

In a recent analysis (European Commission, 2010), the European Commission has estimated that carbon price would rise from €14.5 per tonne $CO_2$ in 2008 to €25 by 2020. The effect of the recession is evaluated at 30%–50% reduction of cost per GDP for the total cost of the Climate and Energy Package implementation. The impact on carbon price is not assessed separately.

We estimate that without the recession (assuming long term average growth rates), the market prices for emission permits might presently be up to double (about EUR 30 / tonne $CO_2$). A more conservative evaluation for the average $CO_2$ price during the whole ETS II trading period suggests €21 per tonne without recession as opposed to €12 with actual growth figures[4]. Compared to the Commission estimate, the GTAP simulations show a considerably steeper $CO_2$ price increase towards 2020: the average carbon price during the 2013–2020 period would be €45 per tonne $CO_2$. The most important factor behind the differences in the estimates is that the models (PRIMES, GAINS) used in the Commission reports do not include world economy endogenously, which means that the demand and supply responses outside the EU are not accounted for, and the effect of global growth (especially Asia and Southern America) may not be fully incorporated. Another difference is that the reference case used by the Commission includes all Climate and Energy Package policies, some of which are not modeled within GTAP framework (such as renewables target).

However, the long-term impacts of the recession can be even cost-increasing for mitigation, and in any case the $CO_2$ market price will catch up as growth returns to normal. The simulated market prices, reflecting annual marginal mitigation costs are presented in figure 2. Indicative average ETS prices are shown in table 3 below. Assuming that the achieved emissions levels are maintained after 2020, the eventual ETS carbon market prices for subsequent periods would be considerably higher.

[4] The GTAP simulations do not take into account the possibility of banking allowances nor foresight of future policies, which leads to exaggerated annual fluctuations in carbon market prices. Therefore, averaging the USD or EUR prices over the whole trading period gives results that correspond better to the real life observations.

*Table 3* *Carbon prices. Simulated average prices per tonne of $CO_2$ for ETS periods*[5]*, €*

| *Scenario* | *2008–2012* | *2013–2020* |
|---|---|---|
| Reference - EU2020 | 11 | 37 |
| EU Unilateral -30% | 11 | 50 |
| Global ETS + EU30 | 11 | 44 |
| Subsidy | 12 | 44 |
| No recession | 18 | 57 |
| No energy efficiency | 14 | 59 |

## 3.2 Energy efficiency

According to the simulations, additional one per cent annual improvement in energy efficiency results in 18 per cent lower $CO_2$ prices in the long run. In the scenario with no energy efficiency improvement, carbon prices are 30–40% higher than in the reference scenario where the efficiency target is met. This can also be seen in figure 2. Energy efficiency and emission reduction targets are intertwined, and while the increased energy efficiency does reduce the $CO_2$ market price, the reduction target alone leads to significant decrease in (fossil) primary energy use. Thus, differences in energy efficiency improvement have only small direct impact on primary energy use, and whether it is profitable or not to invest in efficiency improvements obviously depends on the investment costs compared to the emissions permit cost.

Energy efficiency does, however, have further implications to the macro-economic performance, efficiency of climate policies (carbon leakage), and competitiveness of industries, as discussed in later sections of this report.

With the lower economic growth in the beginning period of EU's climate policy, the 20% reduction in the use of primary energy is achieved almost without further technology improvements for energy efficiency. This may increase mitigation costs in the long run.

## 3.3 Policy participation coverage and ambition levels

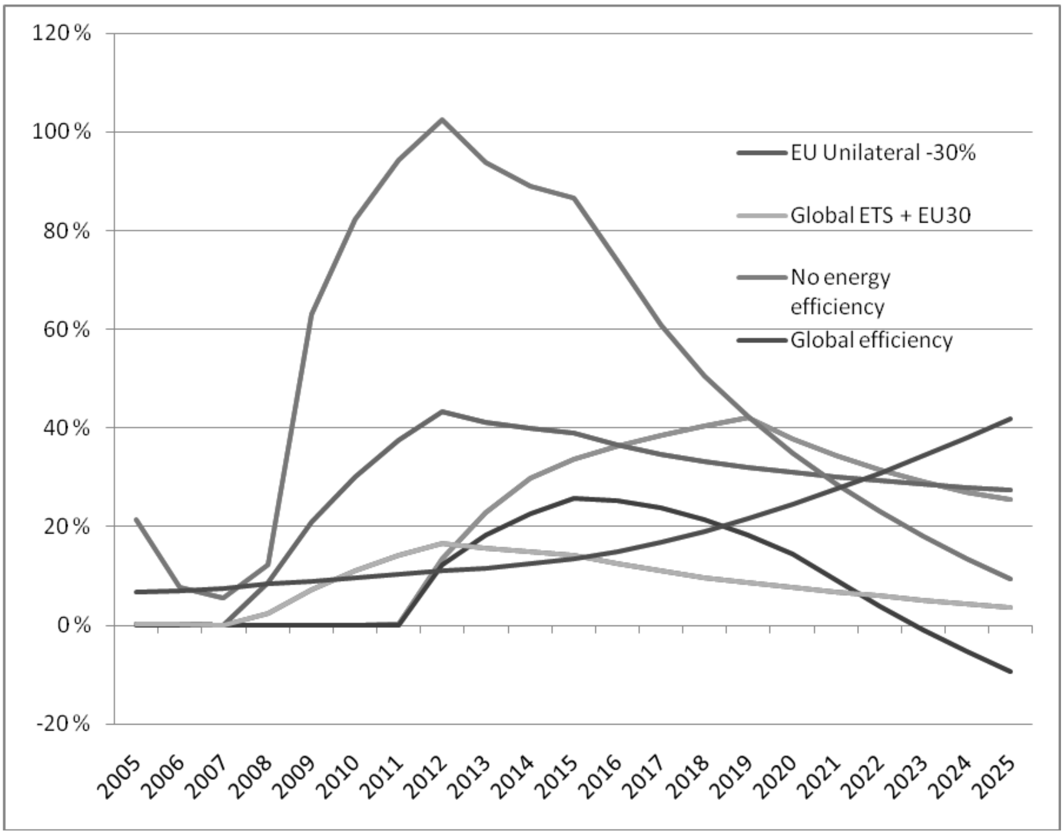
In the GTAP simulations, unrestricted trading of emission permits between regions and sectors guarantees the lowest $CO_2$ price at any time as the reductions always take place where they are least costly. As shown in figure 2, the Global

[5] The prices presented are converted from the base data USD values in 2004. As the GTAP model has no currency markets and exchange rate fluctuations, the converted Euro amounts are only indicative. For the Euro values presented in this report, the exchange rate is set to 1.2 USD/EUR, which corresponds to year 2004 average.

ETS scenarios show clearly lower emission permit prices compared to the EU's unilateral policies.

With a global commitment, additional emission cuts can be achieved at relatively low additional cost, at least the EU's more ambitious 30% reduction target. However, the additional cuts become very expensive if implemented unilaterally. In the short run, unilateral additional cuts can be achieved with relatively little extra cost because of the economic recession impact, but in the long run, these costs will exceed the reference case prices, as illustrated in figure 2.

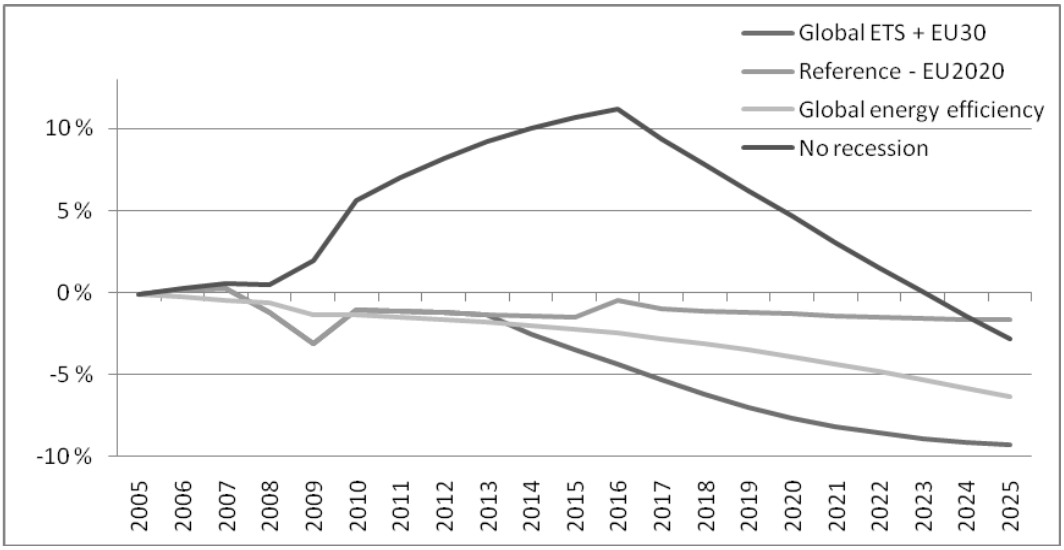
*Figure 2* *$CO_2$ market price. Development of the permit price at emissions trading market under different scenarios, % difference to the reference case (EU2020).*



# 4. Policy effectiveness and carbon leakage

The simulations also show evidence on *carbon leakage*. In the developing countries, fast economic growth is accompanied with increased emissions. In the reference scenario, developing countries account for 77% of total world $CO_2$ emissions growth in the period 2004–2020. However, emissions are growing fast not only in the developing countries but also in those Annex I countries not committed to international climate policy. Figure 3 shows the world emissions in different scenarios compared to a hypothetical scenario with no climate policies at all. The reported leakage figures represent theoretical maxima, i.e. since we assume that the technology improvement only takes place in Europe, while technology improvements in non-policy regions can significantly reduce carbon leakage, as illustrated in the *"Global energy efficiency*" scenario. Similarly, it is assumed that other regions engage in no climate policy measures at all.

*Figure 3 Global $CO_2$ emissions compared to no policy.*

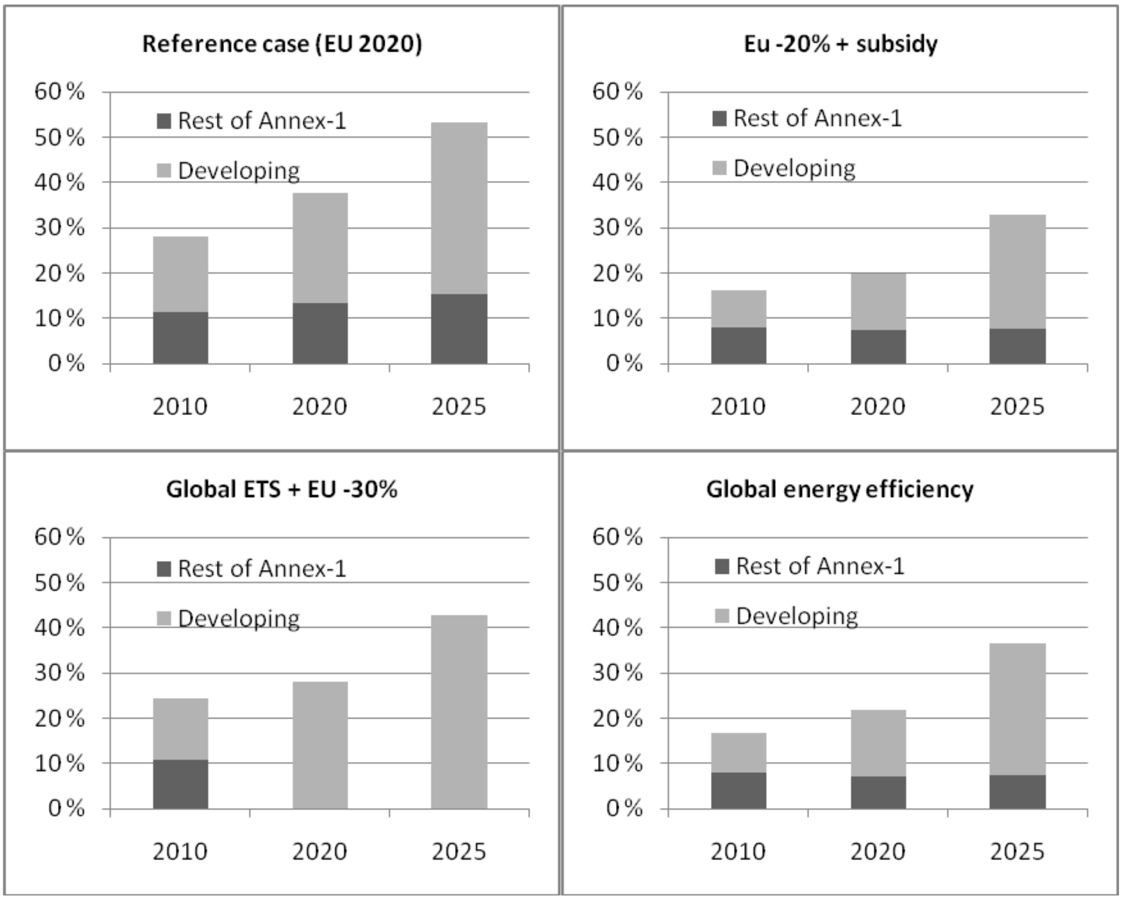



Analogous to the $CO_2$ market price development, the emissions growth is also primarily caused by the economic growth. The impact of economic crisis is a short-term decrease in emissions, but in the long run, lower investments during the crisis lead to an increase in annual emissions.

Unilateral EU policy seems ineffective for global emissions reduction in the model simulations, whereas commitment of all Annex I countries has a much larger impact. Effectiveness of a unilateral policy may, however, improve if it is associated with technology spill-over in energy efficiency and other innovations reducing emissions. As shown in the "Global energy efficiency" scenario, energy efficiency improvement directly reduces emissions.

Figure 4 shows the leakage as percentage of policy regions cuts, compared to the hypothetical scenario with no climate policies. Proportionally, the total leakage is smaller with a more covering climate policy regime, but in absolute terms, increase in the developing country emissions is higher, as the emission trading area and thereby its combined $CO_2$ reductions are higher. With the global improvement in energy efficiency, emissions decrease compared to no climate policy scenario in all regions, and the carbon leakage in relative terms is reduced by 40% . Subsidising energy-intensive industries in the EU to compensate for the cost of $CO_2$ mitigation seems efficient in reducing carbon leakage. This is discussed further in the later sections.

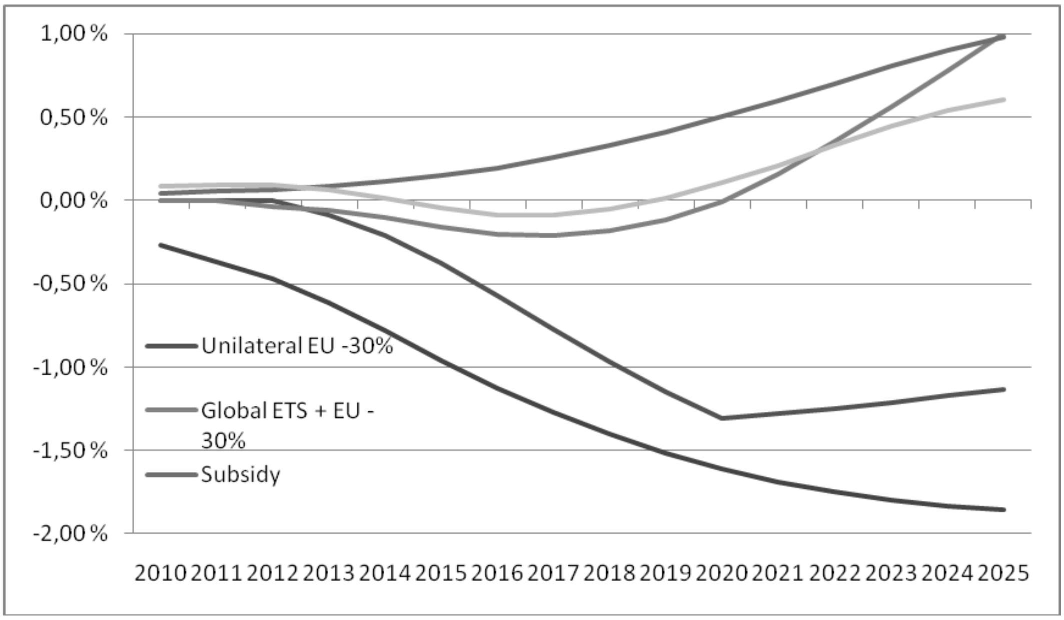
*Figure 4* *Carbon leakage. Additional increase in non-policy regions as percentage to reductions in the policy regions. Policy scenarios with actual growth including effect of crisis.*



# 5. Macro economic development

The emission reduction policies affect macro-economic performance in developed countries relatively little even with high reductions in $CO_2$ emissions. However, how the distribution of welfare losses are divided between countries is greatly influenced by how much of the industrialised world that is covered by the climate policy regime. The gross domestic product in 2020 in Nordic countries would be about 1% higher with the Annex I policy than in the reference case. Energy efficiency improvements are beneficial to the overall economy, and the global efficiency improvement is reflected as growth also in the Nordic countries in the long run.

*Figure 5* *GDP in the Nordic countries. Difference to the reference case (EU2020)*

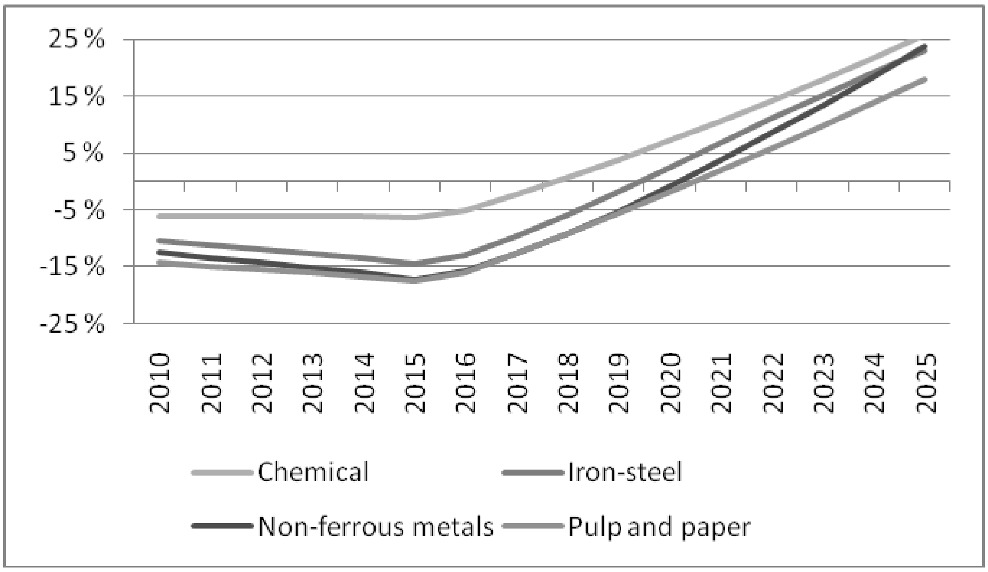


# 6. Energy-intensive industries – Nordic competitiveness

Many industries important to Nordic countries face increasing costs under all the scenarios in the period 2004–2020, whilst the world market price of these commodities remains virtually unchanged. This implies that whilst the production may become more expensive, the income earned at world market does not increase in the same proportion. Therefore, especially export-oriented energy-intensive industries are, on one hand, becoming less advantaged compared to the foreign (often Chinese or Indian) competitors and, on the other hand, provide less profitable use of available production factors compared to other domestic industries.

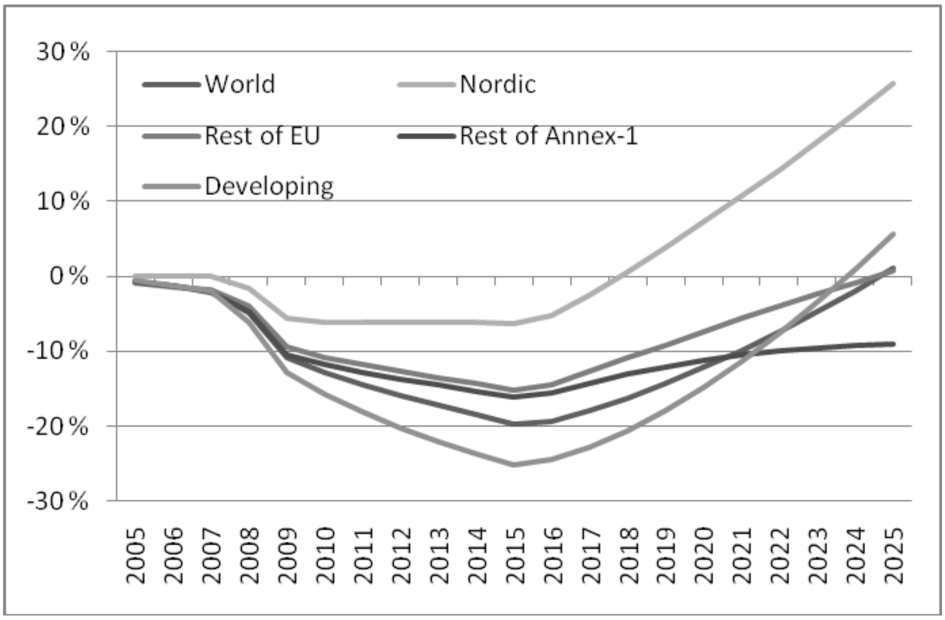
The loss of comparative advantage of energy-intensive industries in Nordic countries is a long-term trend present in most scenario simulations, and seems confirmed by real life observations. Though the economic recession undoubtedly has accelerated the decline, there are more fundamental, long-term changes in the global competitive environment and local Nordic primary factor markets that are affecting energy-intensive industries. However, in longer run, the crisis may prove beneficial to the Nordic industries. Figure 6 shows the output of energy-intensive industries in the Nordic countries compared to the reference case; it seems that these industries may reach relatively better performance in the future following the recession. A better global climate policy coverage and improvements in energy efficiency are also beneficial to Nordic energy-intensive industries.

*Figure 6 Crisis and Nordic industries. Outputs per region in the Reference case (EU2020) compared to the 'No recession' scenario.*



The role of the economic crises is further illustrated in figure 7 that shows the simulated development of chemical industry output in different regions.

*Figure 7 Crisis and chemical industry. Outputs per region in the Reference case (EU2020) compared to the 'No recession' scenario.*




## 6.1 Energy production

Facing the tightening regimes for green house gas emissions reduction, the Nordic countries have an advantage in the potential for clean energy production, which may imply lower energy price increases due to climate policies than in the rest of the world. The geographic and natural conditions in the Nordic countries give opportunities for energy production using land, coasts, forests and hydro power, and there is also unused potential for further wind and solar power.

The model simulations suggest a considerable increase of electricity generation especially in Sweden and Norway, which may not be plausible within the time frame in reality. This, however, emphasizes the role of clean energy potential. As the electricity sector is taking up more production factors, other industries in Norway and Sweden tend to decline somewhat, though this is partly offset by increased competitiveness thanks to low energy prices compared to other regions.

In Finland, energy-intensive industries clearly benefit from the Nordic electricity market, and overall Finnish energy-intensive industries perform better than their Nordic and European counterparts. This result is, however, highly dependent on the electricity market: Other simulations with different electricity market specification (see for example the Nordic Energy Perspectives final reports[6]) give an opposite picture where the Finnish industries are more vulnerable than Swedish and Norwegian ones.

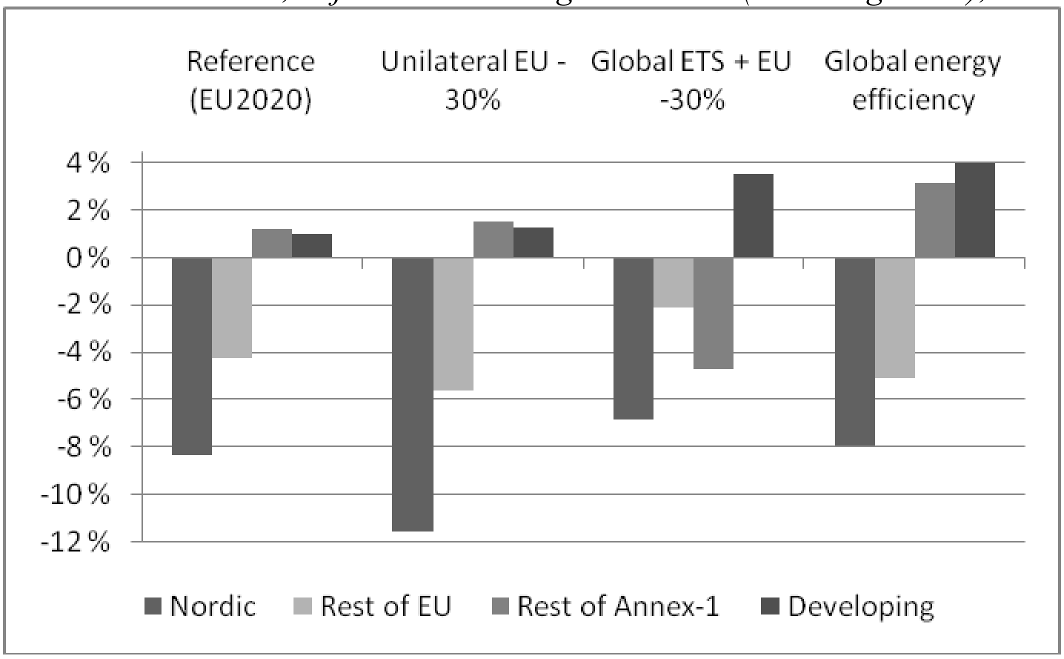
On aggregate Nordic level, the results are robust. The electricity market specification mostly affects the distribution of industries within the Nordic countries.

## 6.2 Policy and technology impacts

Figure 8 shows the impacts of different climate policy regimes for energy-intensive industries' outputs relative to the hypothetical 'no policy' case with recession in the Nordic countries, rest of the EU and globally in 2020. For most industries (with the exception of non-metallic minerals sector), both positive and negative impacts on Nordic industries are stronger than to the rest of the EU.

Looking into more detailed results on output and export responses, we note again that the long-term impacts of the economic crisis in the Nordic countries seem less negative than in the rest of the world, or even positive. Gains from energy efficiency are particularly high in Nordic metal industries and paper and pulp sector.

*Figure 8* *Impact of climate policies on energy-intensive industries 2020. Outputs compared to 'no policy' or 'EU -20% with subsidies' case, adjusted to actual growth rates (including crisis), in 2020.*




[6] NEP 2010a,b, and in particular: Niemi & Honkatukia 2010a,b.

Figure 9 and figure 10 shows the different energy intensive industries in Nordic countries under various policy options and global energy efficiency improvement scenario. The results are shown as percentage difference to the hypothetical “no policy” scenario (or the output subsidy scenario), and as differences in output values (millions of base year 2004 USD). The policy scenarios have similar impacts on all four industries: the additional unilateral commitments lead to further decreased output, whereas global commitment is beneficial despite the higher EU ambition level. The global policy if especially favourable to chemical and metal industries, paper and pulp sector benefiting only slightly. Global energy efficiency improvement has a mixed effect, as it makes the foreign industries relatively more competitive, as the gains from improved efficiency are not restricted to Europe. As a result, in the Nordic countries, chemical industry shows lower outputs, whereas non-ferrous metals as well as paper and pulp seem to gain.

*Figure 9* *Impact on Nordic industries 2020 - % difference. Outputs compared to ‘no policy’ or ‘EU -20 % with subsidies’ case, adjusted to actual growth rates (including crisis), in 2020.*

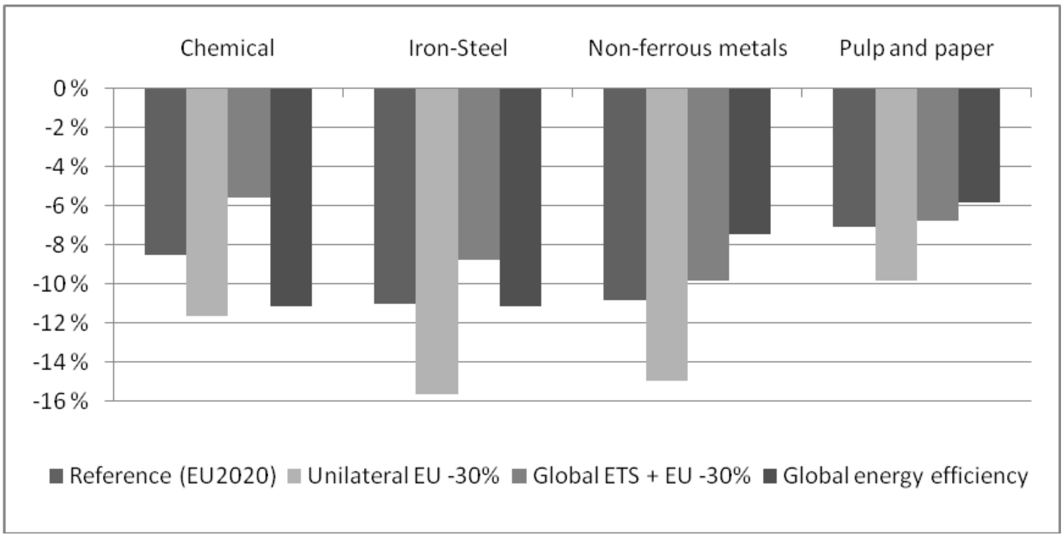
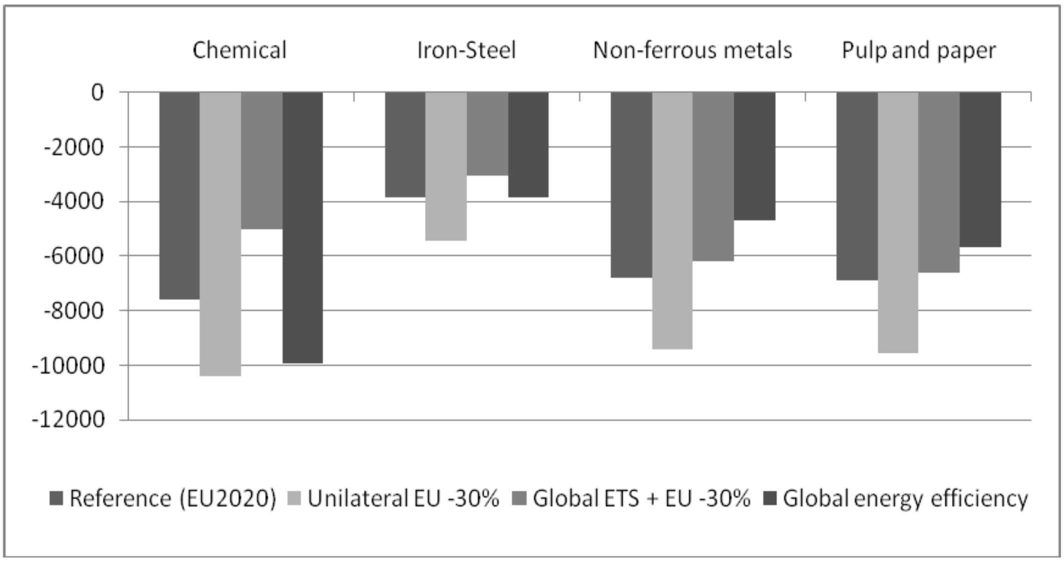


*Figure 10 Impact on Nordic industries 2020 – difference in millions of USD. Outputs compared to 'no policy' or 'EU -20 % with subsidies' case, adjusted to actual growth rates (including crisis), in 2020.*



# 7. Subsidy schemes for EU industries

As illustrated in previous sections, the policies to cut $CO_2$ policies affect the competitiveness of the energy-intensive industries in Europe, and in the Nordic countries in particular. The *EU -20% + subsidies* scenario was simulated to assess the implications of subsidies to compensate the energy-intensive industries for their increased costs due to the $CO_2$ mitigation.

The simulation was run with an output subsidy that would take industries' outputs at the levels where they would be (according to simulation) without emissions trading or other $CO_2$ mitigation measures. The results show that this would cut the carbon leakage to other regions by almost half, as illustrated in figure 4, thereby fulfilling at least part of the original rational for such compensatory policy. It would also impact the overall economies favourably, as the GDP levels would be about 1% higher in 2020 than without the subsidies.

The cost of the output to fully eliminate the decrease in output would be about 4% of the total value of output at EU level, and 6% for the Nordic industries in 2020. At the simulated output values for 2020, this would imply a total annual cost of 150 billion Euros for the whole EU and 17 billion for the Nordic region (including Norway). The subsidy policy would also imply about 25% higher price for tonne of $CO_2$ at the emission trading market (see figure 2).

In the simulation, the subsidy was implemented in the way that would be the most efficient for achieving the desired outcome, i.e. as a direct subsidy on the production output. However, this type of scheme may not be possible in real world in compliance with the WTO rules. Indirect subsidies (e.g. on primary production factors) would make the policy less efficient, thus increasing its cost.

As the present Nordic electricity market setting passes carbon prices fully into the price of electricity, which increases the abatement costs particularly in the Nordic countries, industries have also suggested an alternative electricity market design. This would eliminate the windfall profits at Nordic electricity markets and reduce the effect of ETS carbon price on the final market price for electricity. It is not possible to implement this design with the simulation tools in use for this research, so its implications have not been further studied.

# 8. Discussion

Simulation results in this study indicate high mitigation costs from European climate policies and a negative impact on the competitiveness of energy intensive industries in the Nordic countries. It can be argued that the simulation setting excludes certain factors that would, in reality, diminish these unfavourable effects: countries outside Europe are assumed to take no policy measures to reduce their own emissions (except in the “Global ETS” scenario); availability of alternative energy form is not fully accounted for; and the technology improvements are only given as exogenous assumptions. Climate policy measures in other countries would, indeed, affect the competitiveness of the European industries favourably. However, as seen in the “Global energy efficiency” scenario, the technology improvements that may be induced by emission cuts compensate some of the losses (this, of course, is also true for the European industries in the unilateral policy case, but the reported results are already the net effects).

Technology improvements that are given exogenously are reflected in the simulation results as the additional investments that the industries are willing to pay for such improvement. If technology advances are, in reality, available for lower cost this will set a boundary to the mitigation costs and carbon market prices. In the Nordic Energy Perspectives project, the energy system model results, which take such investment options into account, it was estimated that to reach the 2 degree global warming target, the $CO_2$ price should rise to 50–90 EUR by 2040, which is comparable to the scenarios in this study for the period until 2020 and would imply $CO_2$ price of EUR 30–45 in 2020. Thus, the evidence from these studies suggests that the mitigation costs are nevertheless going to increase considerably from today’s level.

# References

Beckman, J. – Hertel, T. (2009): "Why Previous Estimates of the Cost of Climate Mitigation Might Be Too Low". Paper presented in the 11th Annual Conference of Global Economic Analysis, Santiago de Chile.

Burniaux, J.M. – Truong, T. (2002): "GTAP-E: An Energy-Environmental Version of the GTAP Model", GTAP Technical Paper No. 16. https://www.gtap.agecon.purdue.edu/resources/res_display.asp RecordID=923.

Carone, G. (2005): "Long-term labour force projections for the EU25 Member States: a set of data for assessing the impact of ageing", European Commission, Economic Papers No. 235, European Commission, Directorate General for Economic and Financial Affairs.

Carone, G. – Denis, C. – McMorrow, K. – Mourre, G. – Röger, W. (2006): "Long-term labour productivity and GDP projections for the EU25 Member States: a production function framework". European Economy-Economic Papers, European Commission-DG ECFIN 253 pp. 1–92.

Center for Global Trade Analysis (2006): "Global Trade, Assistance, and Production: The GTAP 6 Data Base", ed. Dimaranan, B.V., Center for Global Trade Analysis, Purdue University.

CPB (1999): "WorldScan: the Core Version," CPB Netherlands Bureau for Economic Policy Analysis, December.

European Commission (2010): "Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage – Background information and analysis", Part II, Brussels.

Eurostat (2008): EUROPOP convergence scenario, population forecast 2008–2050.

Hertel, T. – Tsigas, M. (1997): "Structure of GTAP: In Global Trade Analysis", ed. Hertel, T., Cambridge University Press.

Ianchovichina, E. – McDougall, R (2001): "Theoretical Structure of Dynamic – GTAP", GTAP Technical Paper No. 17. https://www.gtap.agecon.purdue.edu/resources/res_display.asp RecordID=480.

ILO (2008): LABORSTA Internet, Labour Statistics Database, Geneva. http://laborsta.ilo.org/

IMF (2009): World Economic Outlook Database. http://www.imf.org/external/pubs/ft/weo/2009/01/weodata/index.aspx

Koskelainen, A. (2010): "The impact of EU ETS in the Nordic electricity market 2005 -2009", Suomen ElFi Oy.

Lehtilä, A. – Honkatukia, J. – Koljonen, T. – Niemi, J. (2009): ”Scenarios on future energy uses” in Energy Visions 2050, VTT-Edita, Helsinki.

Narayanan, B.G. – Walmsley, T.L. (2008): “Global Trade, Assistance, and Production: The GTAP 7 Data Base”, Center for Global Trade Analysis, Purdue University.

NEP (2010a). Rydén, B. (ed.): “Ten Opportunities and Challenges for Nordic Energy - Towards a Sustainable Nordic Energy System”. Nordic Energy Perspectives project.

NEP (2010b) Unger, T. (ed.): “Coordinated use of energy system models in energy and climate policy analysis”. Nordic Energy Perspectives project.

Niemi, J. – Honkatukia, J. (2010a): “International climate policy participation critical for Nordic industry competitiveness”, in Rydén B. (ed.) "Towards a Sustainable Nordic Energy System", pp. 191–198.

Niemi, J. – Honkatukia, J. (2010b): “Broader participation required for successful emissions reduction as global energy demand increases”, in Rydén B. (ed.) "Towards a Sustainable Nordic Energy System", pp. 209–216.

United Nations (2006): World Population Prospects: The 2006 revision population database, New York. http://esa.un.org/unpp/

**VATT VALMISTELURAPORTIT -SARJASSA ILMESTYNEITÄ**

**PUBLISHED VATT POLICY REPORTS**

1. Janne Tukiainen – Ville Mälkönen: Jätekuljetuksen sopimusmallien yritysvaikutukset. Helsinki 2010.
2. Antti Moisio – Heikki A. Loikkanen – Lasse Oulasvirta: Public services at the local level – The Finnish way. Helsinki 2010.
3. Juha Halonen – Timo Rauhanen – Erkki Siivonen: Julkisten organisaatioiden veroetuudet. Helsinki 2010.
4. Tuuli Ylinen: Työkyvyttömyyseläkkeet ja työnantajan omavastuuperiaate TEL:sta TyEL:iin. Helsinki 2010.
5. Outi Kröger – Timo Rauhanen (toim.):Verotuet Suomessa 2009. Helsinki 2010.
6. Jenni Pääkkönen: Koulutuksen markkinoilla – arvioita ammattikorkeakoulujen tehokkuuseroista ja niiden syistä. Helsinki 2010.
7. Antti Moisio: Metropolialueen hallintomallit taloustutkimuksen näkökulmasta. Helsinki 2011.
8. Heikki Pursiainen – Markku Siikanen – Janne Tukiainen – Ville Mälkönen: Asfalttikartellin kunnille aiheuttamien vahinkojen arviointi – Loppuraportti. Helsinki 2011.
9. Tanja Saxell – Janne Tukiainen – Markku Siikanen: Asfalttikartellin valtiolle aiheuttamien vahinkojen arviointi – Loppuraportti. Helsinki 2011.
10. Antti Moisio: Finanssipolitiikan säännöt ja kuntatalous. Helsinki 2011.
11. Iida Häkkinen Skans: Kotitalouspalveluiden verovähennykset Suomessa ja Ruotsissa. Helsinki 2011.

VALTION TALOUDELLINEN TUTKIMUSKESKUS
STATENS EKONOMISKA FORSKNINGSCENTRAL
GOVERNMENT INSTITUTE FOR ECONOMIC RESEARCH

Valtion taloudellinen tutkimuskeskus
Government Institute for Economic Research
P.O.Box 1279
FI-00101 Helsinki
Finland

ISBN 978-951-561-991-4
ISSN 1798-0305