Interactions between energy efficiency policies and emission trading schemes: Modelling the effects on carbon prices and industrial competitiveness

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Abstract

Emission trading schemes and energy efficiency policies are two ways to reduce greenhouse gas emissions. While emission trading schemes settle a fixed sum of emissions, energy efficiency policies aim at reducing the energy consumption of end-users. This article explores the interactions between the two types of policy instruments by analysing the European electricity market, which is characterised by a fixed cap for carbon emissions in the electricity generation and the industrial sector. Allowances to emit greenhouse gases are traded under the European Emission Trading Scheme. At the same time, energy efficiency policies lead to reductions in end-use energy consumption. Our theoretical analysis shows that without adjustments of the fixed cap, these energy efficiency policies do solely reduce the carbon price but not the total emissions of sectors covered by the European Emission Trading Scheme. By using the simulation model DIMENSION, possible adjustments of the emission cap and their impact on carbon prices as well as on the marginal costs of electricity generation are quantified. The aim is to understand how energy efficiency and climate policies can persist as environmentally effective and economically efficient complements and to assess how different scenarios affect the industrial competitiveness in Europe. The overall finding is that alongside an effective energy efficiency policy, 30% of emission reductions may be achieved with similar or even less costs to industry than expected when setting the emission cap for phase III.

1 Introduction

Many economists and policy makers see carbon emission trading schemes (ETS) as the first-best climate policy instrument, because, assuming perfect market conditions, allowances to emit greenhouse gases (GHG) will be allocated efficiently between obliged actors. At the same time, there is no serious dispute that the improvement of end-use energy efficiency (EE) is the most cost-effective way to reduce CO_2 emissions. The upstream approach of emission trading schemes, however, stimulates investments in end-use EE measures only indirectly through increasing energy prices, while most barriers to EE remain unaddressed. In order to overcome these manifold barriers in the end-use EE markets, several policies have been developed in addition to ETS. In this context, the paper analyses how ETS and EE policies interact and if they can persist as environmentally effective and economically efficient complements. As a prominent example, the paper explores effects of the suggested Energy Efficiency Directive (EED) in the EU that had not been considered when fixing the level of carbon caps for phase III in the European ETS (EU-ETS) on carbon emissions and prices as well as on electricity wholesale market prices. The aim is to understand how the cost impact on European industry would change under different EE and climate policy scenarios. The present work establishes a theoretical reasoning for such policy interactions between EE policy and ETS and assesses them quantitatively with the supply-side electricity generation model DIMENSION.

The European Commission (EC) promotes the upcoming EED by emphasising its merits for improving EE. Accordingly, the improvement of EE is a key to reduce the need for further investments in energy infrastructure, to increase economic competitiveness, to improve energy supply security, to protect countries against import dependencies and finally to reduce price volatilities and energy price increases (EC 2011a). At the same time, the EU-ETS remains the corner stone of EU climate policy.

Interaction between EE policies in the EU and the EU-ETS are positive if the respective instruments act as complements, but negative if the policy instruments are overlapping, i.e. if the overall effects each instrument would achieve alone are reduced (Oikonomou et al. 2010). Interaction effects between energy efficiency and climate policies such as the EED and the EU-ETS are likely to be significant since "industrial installations already included in the Emissions Trading Scheme (ETS) will now also be covered by the new directive" (Neslen 2011). The EC is well aware that the measures induced by the EED might put pressure on carbon prices and has thus announced to carefully monitor carbon prices and to intervene if necessary.[1] Possible interventions to mitigate the downward pressure on carbon prices in the EU-ETS that have been proposed are the removal (set-aside) of a significant number of allowances from the auctions in Phase III of the EU-ETS, to establish a reserve price in allowance auctions or to increase the 21% CO_2 emissions reduction target in 2020 up to 30% (CS 2012).

The present study is structured as follows: Section 2 provides a literature review of research on policy interaction effects. Subsequent to that, the interaction of the EU-ETS and EE policies and the resulting impacts on carbon prices, emissions and cost impact on industry are assessed theoretically in section 3. Section 4 quantitatively estimates the potential effects with a long-term economic simulation of the European electricity market. In addition, the overall cost impact on the European industry sector due to the EU-ETS prior and after the introduction of EE policies is estimated and compared. Finally, the modelling results are discussed and conclusions are drawn.

2 Research on interactions of energy policy instruments

A variety of research studies deal with interactions of energy and climate policy instruments. A comprehensive overview of literature discussing interactions between climate and energy policy can be found in Oikonomou & Jepma (2007), Oikonomou et al. (2010), Sorrell & Sijm (2003) and Konidari & Mavrakis (2006). A common finding in research is that energy and climate policy interactions can have either positive or negative effects in achieving a specific emission target (Oikonomou et al. 2010). Therefore, several papers such as Fischer (2008) and Goulder & Mathai (2000) concentrate on assessing an optimal mix of policy instruments in order to achieve an emission target at a lower cost level than with a single policy. Recent articles that focus on the combination of end-use EE policy and the EU-ETS have been published by Cowart (2011) and IEA (2011). The main finding of IEA (2011) is that carbon pricing is a prerequisite for least-cost carbon reduction strategies, but that carbon pricing alone will not address all barriers in end-use EE. Further, IEA (2011) concludes, that in addition to carbon pricing, other policies are necessary to overcome the barriers in end-use EE. They identify several EE policies as complementary to carbon pricing. The possible downward impact of EE improvements on the carbon price that has been intensively discussed with regard to the EU-ETS is, however, not quantitatively analysed in this study.

A quantitative estimation of effects of different EE policy options on the EU-ETS carbon price is for instance provided in the EU impact assessment for the EED (EC 2011e, 2011f). The modelling results obtained with the econometric E3ME model suggest that the introduction of EE policies may result in a significant depression in the carbon price (down to zero but magnitude depends on specific options analysed) of the EU-ETS (EC 2011e, 2011f). This result illustrates the possible severity of such interaction effects. A study that provides further insights into the current fear of collapsing carbon prices in the EU-ETS has recently been published by Climate Strategies (CS 2012). They conclude that the EU-ETS price development in Phase III could range widely from less than 10 €/tCO_2 to above 30 €/tCO_2 depending amongst others on the measures undertaken in future to strengthen the EU-ETS. Our paper builds on these approaches by estimating carbon prices with an electricity market simulation model for different emission reduction targets and efforts of EE. As an addition to previous studies on this topic, we further estimate the impact of the scenario results on the competitiveness of European industry.

[1] E.g., the EED Impact Assessment suggests respective downward pressure on EUA prices (EC 2011e, 2011f).

3 Interactions of energy and climate policy instruments

3.1 Aims of the European energy and climate policy

Since the establishment of a common energy policy, the EU dedicated its ambitions to three goals: sustainability, security of energy supply, and competitiveness (EC 2007). The European Commission justifies these goals with "[…] combating climate change, limiting the EU's external vulnerability to imported hydrocarbons, and promoting growth and jobs, thereby providing secure and affordable energy to consumers" (EC 2007, p. 5). In order to achieve these overarching energy policy goals, subordinate objectives have been set, especially the „20-20-20“ targets of the energy strategy 2011-2020 (EC 2010a).

3.2. Climate policy – the EU-ETS

In the framework of the European Council’s „20-20-20-decision“, a common climate policy for the European member states has been defined. The EU sets a binding target to reduce its GHG emissions until 2020 by 20% compared to the reference year 1990. If a binding international treaty for “similar climate reduction measures” should be signed, this target was planned to be tightened to 30% until 2020 (European Council 2007). This preamble to the climate policy target shows the will to reduce GHG emissions significantly without losing competitiveness and attraction to companies acting on global markets. This is one obvious conflict of objectives between the long-term goals of sustainable climate protection on the one hand and competitiveness of European industries through appealing energy prices on the other (EC 2010a).

From a pure welfare economic perspective with exclusive focus on the climate challenge, and under the assumption of a closed economy, GHG emissions that represent negative external effects should be reduced until the marginal abatement costs correspond to the marginal costs of damage. But marginal cost curves and the resulting optimum are hardly known.

In economic theory the cap-setting is usually assumed to be exogenous. In practice, however, the cap is rather set conditional on costs to industry in order to maintain competitiveness: The internalisation of external GHG emission costs by the EU-ETS puts additional costs on European companies, at least if emission rights are being auctioned (polluter-pays principle). Companies that are subject to international competition will therefore lose competitiveness, unless they are able to adapt to the targets by cost-effective emission reduction measures. Additional costs may provide an incentive to relocate parts of, or even the whole production process to other regions without obligations to pay for emissions. In the long run this might increase the emission levels in those regions. This effect is referred to as “carbon leakage” in the literature (Mustafa 2005).

The EU-ETS covers all electric power plants with an installed capacity of more than 20 MW and a large share of the energy intensive industries. Covered companies are obliged to hold certificates for their emitted GHG (European Parliament and Council 2003). Emissions from the transport, residential, public and commercial sectors are not covered by the scheme. In 2009, about 40% of total European GHG emissions were covered by the EU-ETS. By adding the aviation and other industrial sectors to the scheme, it will be extended to 43% of the gases in 2020 (EC 2009). In the third trading period starting in 2013, the cap will be reduced by 1.74% every year. More precisely, today’s annual cap of 2.08 billion tons of CO_2 per year will be reduced to 1.72 billion tons of CO_2 in 2020 (EC 2009).

The EU-ETS is a market-based cap-and-trade system. The scheme provides participating actors with incentives to reduce emissions to the point where the marginal costs of abatement equal the price of the certificates. In static terms, certificate trading would lead to an efficient allocation.[2] In a market with rational actors, the emissions will therefore be reduced at least cost. The monetary impact of climate policy is relatively higher for those companies that heavily emit GHG and thus need to purchase

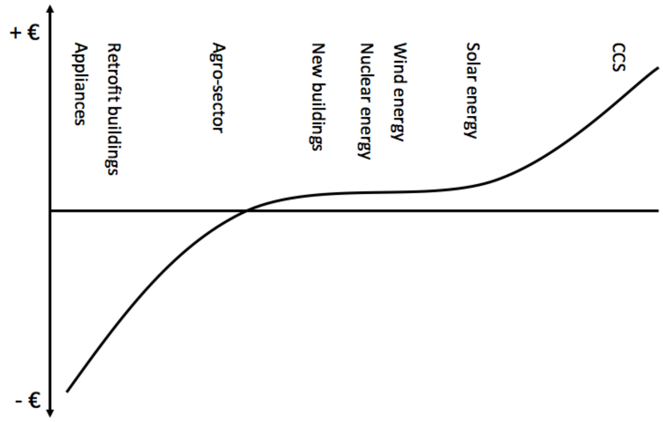
[2] Fischedick & Samadi (2010) discuss that ETS do not necessarily lead to an efficient allocation as dynamic processes and R&D remain unconsidered.

additional certificates on the market in order to comply.
The EU-ETS will achieve the emission target in the covered sector due to the fixed cap (EC 2009). The setting of the cap does, however, not consider changes in the political framework conditions that will occur *ex-post*. The inelastic supply of certificates does not take into account the results or implementation of other policy instruments. Interacting instruments only change the price for the allowances; their overall amount remains unaffected.[3] In sectors covered by the EU-ETS other policy instruments therefore have no direct impact on the emission level (Sijm 2005). Additional policy instruments may, however, influence the distribution of emissions and costs between individual firms operating under the EU-ETS due to pecuniary externalities. Finally, the dynamic incentives for companies under the EU-ETS to invest in more efficient technologies decrease with lower carbon prices.

3.3. Energy efficiency policy – the role of the Energy Efficiency Directive

Besides the 20% GHG emission reduction target, the European energy strategy includes the objective to reduce primary energy consumption by 20% compared to the 2007 projections until 2020, which corresponds to primary energy savings of 368 Mio. toe (European Council 2007; EC 2011a). The aim of this target is to dampen the expected growth of energy prices, to mitigate GHG emissions and to improve energy supply security with respect to the dependency on energy imports (EC 2010a).[4]
The EC expects that under the current regulatory framework only half of the target of 20% primary energy reduction will be achieved by 2020 (EC 2010a; 2011b). Therefore, the EC proposed in June 2011 the EED that includes a set of EE measures and national targets for the member states (EC 2011a; EC 2011c). Amongst others, the measures include rules for retrofitting public buildings, the implementation of EE obligation schemes for energy companies, obligations for public bodies to purchase EE products (public procurement), rules for energy audits, energy management systems, smart metering and informative billing and the promotion of the energy service market. The objective of the EED is to induce EE investments in order to achieve the economic energy savings potential in the EU (EC 2011c). As presented in the "Roadmap for moving to a competitive low carbon economy in 2050" (EC 2011d), EE is the most cost-effective way to reduce the GHG in the EU, i.e. significantly more cost-effective than other options such as renewable energy supply, carbon capture and storage or reforestation. The exemplary marginal GHG abatement cost curve in figure 1 visualises the typical costs of several options to reduce GHG emissions.

Figure 1: Marginal GHG abatement cost curve



Source: Based on McKinsey (2009), Wuppertal Institute (2010), IEA (2010).

The cost-effective saving potential is not realised due to several market failures and barriers as well as

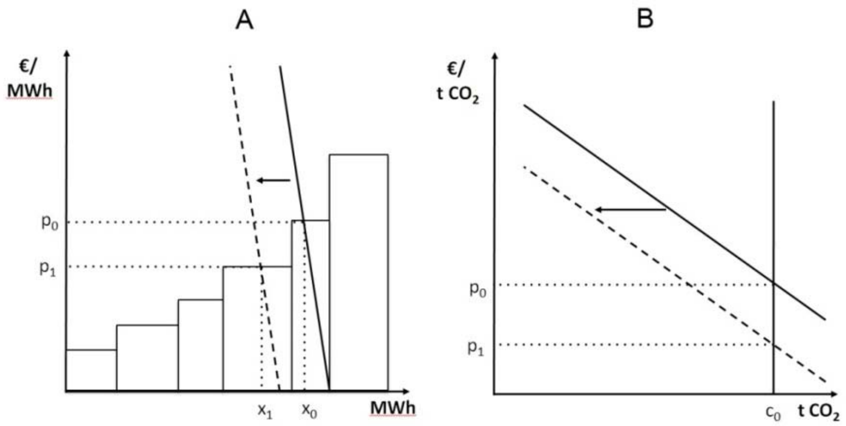
[3] This condition holds as long as the carbon price is larger than zero.
[4] In 2009, 53.9% of energy was imported. It increased significantly during the last ten years, especially the import share of oil (83,5%) and natural gas (64,2%) (Eurostat 2011), and is expected to increase further.

inefficiencies in public procurement. Market failures include imperfect and asymmetric information, principal-agent problems, split incentives, and behavioural failures due to bounded rationality. Like other EE policies, the EED proposal aims to decouple energy input from the level of energy services (heat, cold, etc.) provided, in which customers actually are interested in. A given service level can be obtained by different combinations of technologies and energy consumption. More EE technologies use for example less energy input in order to provide the same service level (Wuppertal Institute et al. 2000; Sorrell et al. 2009). Higher investment costs for those more efficient technologies are often overcompensated by lower variable costs for the energy input. EE policies support the implementation of these more efficient technologies by correcting market failures.[5]
With its instrument portfolio, the EED will achieve energy savings in the non-ETS areas of heating and transportation, and in the area of electricity consumption in the public, residential and commercial sector, which is subject to the EU-ETS only at generation level through electricity prices. Due to the reduced electricity consumption, the EED indirectly contributes to the achievement of the EU climate policy target, which the EC explicitly mentions in the EED (EC 2011a).

3.4. Interactions between energy efficiency policies (EED) and emission trading schemes (ETS)

If the EED is effective, it will lead to lower demand for emission allowances and decrease the prices on the ETS and the electricity market.[6] The magnitude of the reduced certificate demand depends on the CO_2-intensity of the electricity generation capacity. If the marginal power plant that determines the wholesale market electricity price in one hour and that will not be needed anymore represents, for example, an open cycle gas turbine, the reduction of certificates would be lower than if a coal plant would have generated the marginal electricity unit. Since the cap of the EU-ETS is fixed, i.e. the certificate supply is inelastic, a reduced certificate demand leads solely to a decreasing carbon price while the emissions remain at a constant level (see Fig. 2) – unless the cap is adjusted for the achieved energy savings.[7]

Figure 2: Schematic impact of the EED on the electricity market (A) and the EU-ETS (B)



The lower the carbon prices, the lower the economic incentives to reduce GHG emissions through investments in more efficient technologies. The resulting price effects lead to a crowding-in of more emission-intensive generation plants resulting in higher CO_2 emissions per MWh electricity produced at a constant absolute level of CO_2 emissions. A crucial consequence of the carbon price reduction is that the industry sector under the ETS benefits from reduced additional costs. All electricity consumers benefit from both reduced wholesale electricity prices due to lower demand and lower carbon prices.

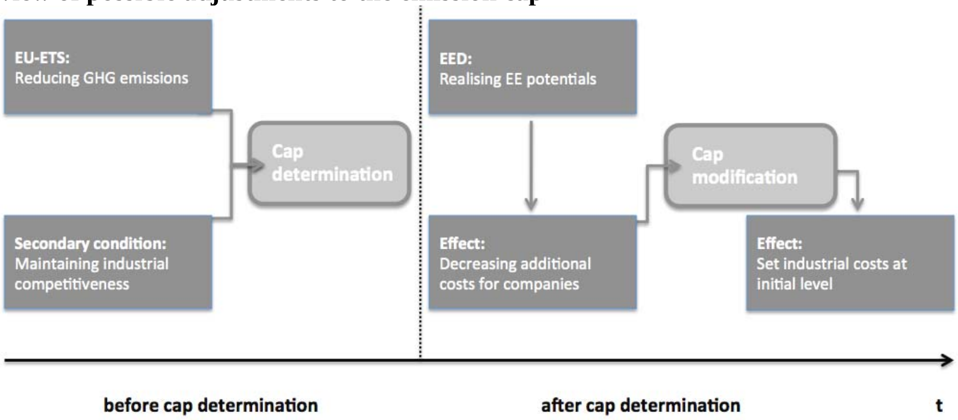
[5] One important limit to effective EE policies is the “rebound effect“ (see for example Greening et al. 2000). More efficient technologies often lead to increased usage and thus reduce the overall savings.
[6] Regarding promotion of renewable energy technologies, this impact is known as the merit-order effect (Sensfuß et al. 2008).
[7] Emissions would decrease at a carbon price of zero representing an ineffective ETS.

Moreover, industrial companies that are subject to the EU-ETS benefit from reduced European Allowance (EUA) prices. They consequently would increase their economic competitiveness vis-à-vis their competitors from outside the EU. This is one important aim of European energy policy.
The cost impact resulting from the 21% emission cap reduction has been agreed on as an adequate burden for the European industry. The EED would therefore change the balance between policy targets towards economic competitiveness. In the following it will be scrutinised if and to what extent the aims of climate protection can be increased without changing the competitiveness of industries in the EU.

3.5. Adjustments of policy instruments

A quantification of the synergy effects of policy instruments is essential in order to take the interdependencies of the European energy and climate targets into account. The EED lowers the burden for industrial companies, which results in higher competitiveness. Under the assumption that the monetary burden of companies due to the climate policy targets was earlier rated as being acceptable, an adjustment of these targets may be considered. In order to strengthen the EU-ETS, the European Parliament’s Committee on the Environment, Public Health and Food Safety (ENVI) suggested in December 2011 to set aside 1.4 billion CO_2 certificates (ENVI 2011). Prior to that, the commission suggested to reduce the number of certificates if the price stays below a certain benchmark or if the target of 30% emission reduction is announced (EC 2010b, 2011a).
Figure 3 presents possible adjustments of the emission cap following the effects of the EED. The aim should be to find the right balance between tightening the cap on the one hand without lowering the economic competitiveness of the industrial sector on the other.[8] In the following, we will use scenario analysis to assess the possibilities for achieving such a balance.

Figure 3: Overview of possible adjustments to the emission cap



4 Modelling energy efficiency policy effects

Two basic research questions will be discussed subsequently: What is the effect of EE policy on the EU-ETS, i.e. on carbon prices, and how does the overall cost impact on EU industries[9] change when introducing EE policy? Our methodological approach follows these questions. The first question will be answered by feeding estimated effects of the EED into the high-resolution electricity supply model DIMENSION of the Institute of Energy Economics EWI at Cologne University (Richter 2011). The resulting outputs (carbon and electricity prices) will be used to answer the second question on overall cost impacts on industry.

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[8] If EE policy instruments do not directly address market or policy failures, they cause additional costs in form of allocative inefficiencies, which may reduce the competitiveness of industry.
[9] In this analysis, only industries other than the electricity generation sector are analysed. For an encompassing definition of the industry sector see Eurelectric (2010).

4.1 Effects on electricity and carbon prices

The carbon intensity of the power generation sector is estimated by DIMENSION, a long-term simulation model for 27 European electricity markets, essentially in the EU (Malta and Cyprus are not shown, while Switzerland and Norway have been entered). For this paper, the model has been simplified to encompass nine European regions.[10] All power plants and energy storage facilities for these countries have been entered into a database that EWI updates on an ongoing basis.

DIMENSION operates in two steps. At first, the dispatch of the power plants for typical days is estimated for each of the simulated years. The utilisation of power plants operation is limited by technical restrictions, mainly by the ramp up speed and load gradients. Trade is limited by interconnector capacity between the simulated regions. Assumptions about fuel prices and capacity additions are similar to Prognos et al. (2011). A fixed cap is set on the total emissions of the dispatched power plants according to our scenarios for cost estimation. Different caps and demand scenarios are then modelled. The simulation allows for banking, so that the emissions of the electricity sector are determined by European legislation for the entire third ETS period.

In a second step, DIMENSION simulates the future development of installed capacities and power storage facilities in Europe and resulting electricity prices[11] and EUA prices.[12] Depending on the estimated full load hours that an additional generation unit is able to achieve, new power plants are added to the starting fleet. When only a few hours are worked at full load each year, investment is made in power stations with low capital and high variable cost, e.g. gas-fired power plants, while stations with lower variable costs are preferred for a high annual utilisation. It is assumed that the European markets will achieve the cost-minimising mix of different technologies, a market result that is set in full competition and perfect information. Under these assumptions and because exogenous demand shocks are not modelled, estimated EUA prices remain constant throughout the third trading period. Although for this analysis developments in the upcoming EU-ETS period only are of interest until 2020, decisions were modelled until 2040 in order to simulate long-term investments in power plants.

4.2 Cost impact on European industry

The idea is to compare the estimated costs for industry (electricity costs + EUA costs) in various scenarios. It will be evaluated, how much the additional EE policies reduce the costs for industries (through both decreasing electricity and EUA prices) and thus allow further cap reductions at constant industrial competitiveness. The output of the DIMENSION model is combined with Eurelectric industrial electricity consumption data (Eurelectric 2010).

Following the simple formula of *cost* = *price* x *quantity* ($C = p$ x q), there are four direct channels how EE and climate policies affect costs of industries:[13] electricity prices, industrial electricity demand, EUA prices and demand of EUAs outside the electricity generation sector:

$$C = c^{el} + c^{EUA} = p^{el} q^{el}_{ind} + p^{EUA} q^{EUA}_{ind} \qquad (1)$$

Our analysis estimates those four price and quantity parameters for the years 2012-2020 for nine different scenarios with and without EE policies in order to compare the overall costs. The input parameters for total electricity demand and total amount of available emission allowances are variable.

[10] A table of the simulated regions is provided in the Annex.

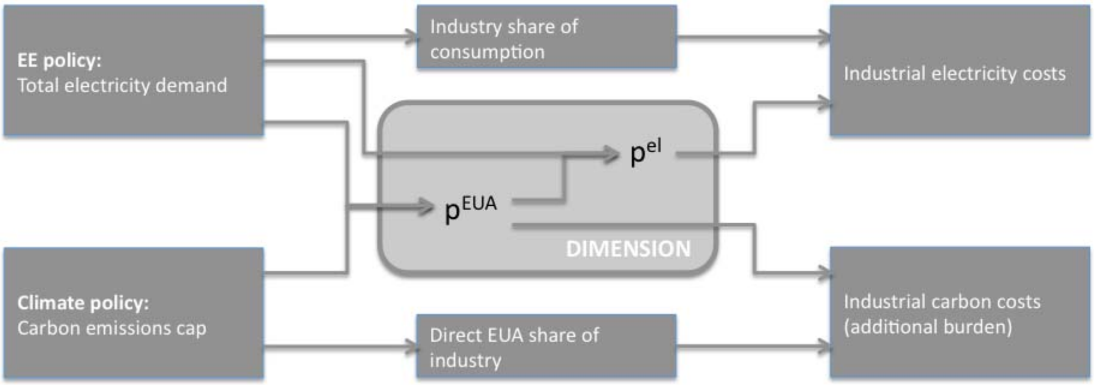
[11] DIMENSION models marginal generation costs. These costs approximate wholesale market prices net of transmission and distribution tariffs and taxes.

[12] DIMENSION assumes costs for EUAs within the power generation sector to be fully passed on to end-users via electricity prices (assumption of perfect competition). In practice, this assumption may not be met in certain markets. Therefore, total electricity costs may to some extent be overestimated, but *differences* in costs from different scenarios are unbiased.

[13] We assume, that the EED targets only private households and the public sector and not industrial energy demand. Therefore, industry incurs no EED investment costs and does not benefit from reduced energy demand through EE.

EWI's DIMENSION is accompanied by two factors estimating industrial electricity consumption and EUA demand quantities. The industrial share of total electricity consumption α with estimations until 2020 is obtained from Eurelectric statistics (2010) for 27 EU member states, Norway and Switzerland. To obtain overall industrial consumption, it is multiplied by a vector of estimated total consumption (depending on scenarios) q^{el}_{it}. Total costs are obtained by multiplying the electricity price p^{el}_{it} provided by DIMENSION with the overall industrial consumption $q^{el}_{it}\,\alpha$.

Figure 4: Modelling effects of EE and climate policies



The share of EUA buy-ups from non-electricity generation sectors β is derived from statistics of EEA (2012). In 2010, 26.4% of the verified emissions have been emitted in industrial installations (EEA 2012).[14] Additionally, about 10% of the "combustion" sector can be assigned to the industrial sector (Trotignon & Delbosc 2008). We therefore assume that in 2010 32.8% of the ETS emissions have been caused outside of the electricity generation sector. Because of various processes with no further CO_2 reduction potential in the industrial sector, the total number of certificates in this sector decreases at a rate of 0.5% per year, while the total cap is reduced by 1.74% per year. Consequently, we model total costs of industry as the sum of two products where costs are summed up for regions i = 1,…,n and years t = 2012,…,2020:

$$(2)\quad C = \sum_{t=2012}^{2020} \sum_{i=1}^{n} p^{el}_{it} q^{el}_{it} \alpha_i + p^{EUA} q^{EUA} \beta$$

To estimate the industries' incurred cost due to the EU-ETS, we firstly estimate the total costs of industries without a CO_2-trading system (no cap) and compare this situation with the business-as-usual (BAU) scenario of 21% cap reduction until 2020 with possible banking of EUAs remaining from the second trading period (scenario noETS). With respect to EE policy, interaction effects to the cap-and-trade system are under scrutiny. Thus, effects of ex-post EE policies, such as the EED, on the sectors covered by the EU-ETS, have to be estimated, since they determine the possible changes to the total emission cap.

The effects of the EED are modelled as a reduction in electricity demand. Unfortunately, information about the expected effects of the EED on electricity demand is hardly available.[15] As a result of the suggested instruments, we assume a decrease in electricity demand of 5 to 10 percent until 2020 relative to the BAU scenario. We estimate the effect of this reduction in demand on electricity prices and on the marginal costs for emission allowances in separate scenarios. Because already a 5% electricity demand decrease yields modelled EUA prices of 0, we discuss further scenarios setting aside remaining phase II-

[14] Numbers 2 – 9 In the Community Independent Transaction Log (CITL) (EEA 2012).

[15] The EED impact assessment includes quantitative estimates of the effects on primary energy consumption, but not on electricity consumption (EC 2011e, 2011f). The authors were not allowed to provide the estimations of reduced electricity demand for confidentiality reasons. An analysis of accumulated primary energy savings for EED scenarios in the impact assessment as preferred by the EC yielded no sensible conclusions.

certificates (modelled as a 355 Mt reduction of EUA).
Because the revision of the ETS Directive is not a probable near-time policy, adjustment of the cap e.g. to a 30% cap reduction is not viable. However, as the EU-parliament's Committee on the Environment (ENVI 2011) proposed, setting aside the respective EUA quantities for phase III might be an option. Still, we model (and term) this as cap reduction – resulting EUA prices may be interpreted as reserve auction price in the Climate Strategy sense (CS 2012).

Table 1: Scenario assumptions

Scenario	Set aside compared to current legislation (Mt)	Equivalent to a cap reduction relative to 2005 (%)	Electricity demand decrease rel. to BAU (%)
noETS	-	-	-
21 BAU	-	21	-
21 EE5%	-	21	5
21 BAU-355	355	21 (+355 Mt)	-
21 EE5%-355	355	21 (+355 Mt)	5
21 EE10%-355	355	21 (+355 Mt)	10
30 BAU-355	355+1045	30	-
30 EE5%-355	355+1045	30	5
30 EE10%-355	355+1045	30	10

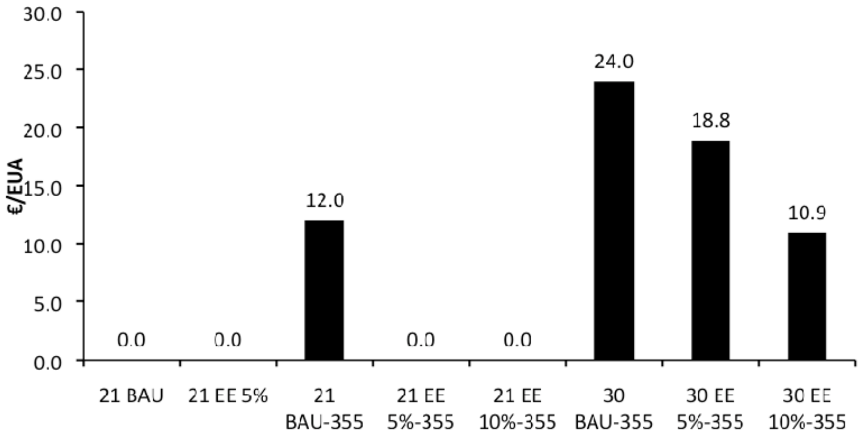
5 Results

5.1 Electricity and carbon prices

As the EED is currently still in the negotiation process, it will not be translated into national legislation before 2013. We assume that national implementations of the EED regulations show effects from 2015 on. Consequently, the following figures display model estimations and our calculations (as well for cumulated costs) from 2013 until the end of the third trading period of the EU-ETS in 2020. As our model allows intra-period-banking and calculates optimal decisions, EUA prices are constant for the whole trading period, reflecting a given supply and demand of third-period EUA quantities. The estimated EUA prices show the expected tendencies.
The BAU scenario assumes the EU-ETS to remain in place with a 21% reduction target by 2020. The carbon cap is accordingly adjusted by 1.74% per year and no additional EE policies enacted. If period II-EUAs will be banked (and respective quantities not set aside), CS argues, that residual "emissions [are] already below [the] cap so prices could be low" (CS 2012, 16). For this oversupply case, our modelled EUA prices collapse to 0. If the 355 Mt remaining from phase II will be set aside from period III-quantities, a price of 12€ is modelled, which, however, falls to 0 with a 5% demand-reducing EE policy. If now, additionally to a 355 Mt-set aside, 1 Mt were set aside as proposed (equivalent to a 30% GHG reduction target), EUA prices would rise: CS (2012) estimated EUA prices around 20€, our model yields 24€. But again, with an effective EE policy, they may be kept at the level of a BAU scenario with set-asides.[16]

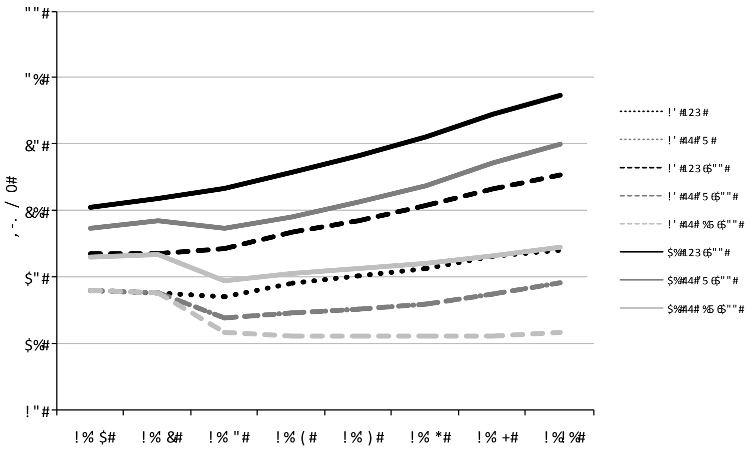
[16] For a comparison of carbon price estimates see EC (2012), CS (2012), Deutsche Bank (2011) and UBS (2011).

Figure 5: Estimated EUA prices (€/tCO_2)



To most industries, electricity prices are of higher importance than solely carbon prices. These electricity prices are determined by a large set of variables and assumptions in the simulation. Technologies, fuel prices, electricity demand and carbon prices are among the important impact factors. Net electricity prices show the expected behaviour (figure 6). In the BAU scenario, because the cap is not binding, prices are lower than in scenarios, where the marginal costs of allowances are passed through to the electricity customers. With stricter caps, prices continuously rise. A demand decrease due to EE policy however brings them down again: They are lowest in the high-EE 21% cap scenario. Interestingly, even with a 30% cap reduction (and high-EE), electricity prices are only slightly higher than in the BAU scenario.

Figure 6: Average marginal costs of electricity generation (€/MWh)[17]



5.2 Carbon intensity of electricity generation

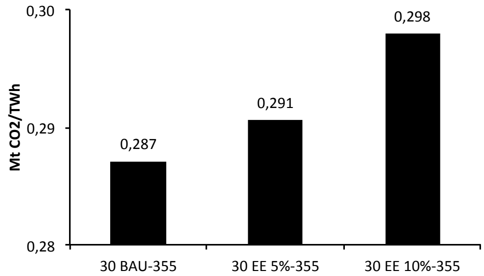
An illustrative indicator for the climate impact of electricity generation and developments in technology is carbon intensity. This indicator is of low relevance to actors within business (as primarily costs matter) and for the climate (as only total emissions matter). This figure might nevertheless be of value to policymakers and analysts alike. We have operationalised carbon intensity as the relation of Mt CO_2 equivalents to TWh electricity consumption.

As the total amount of allowed emissions is determined by policy in our model and industrial electricity consumption is assumed to be a share of the Eurelectric BAU scenario, the pathways of carbon intensity development rather depict the consequences of our assumptions than being predictions. Nevertheless,

[17] Because both the 21 EE 5% and the 21 EE5%-355 scenarios have no binding GHG cap, outcomes are almost identical and cannot be distinguished in the following figures.

figure 7 serves to emphasise the argument: while additional EE policies enhance efficiency and decrease electricity demand, it leads (as long as EUA prices are above 0) to a crowding-in of carbon-intensive technology while emissions remain constant.[18]

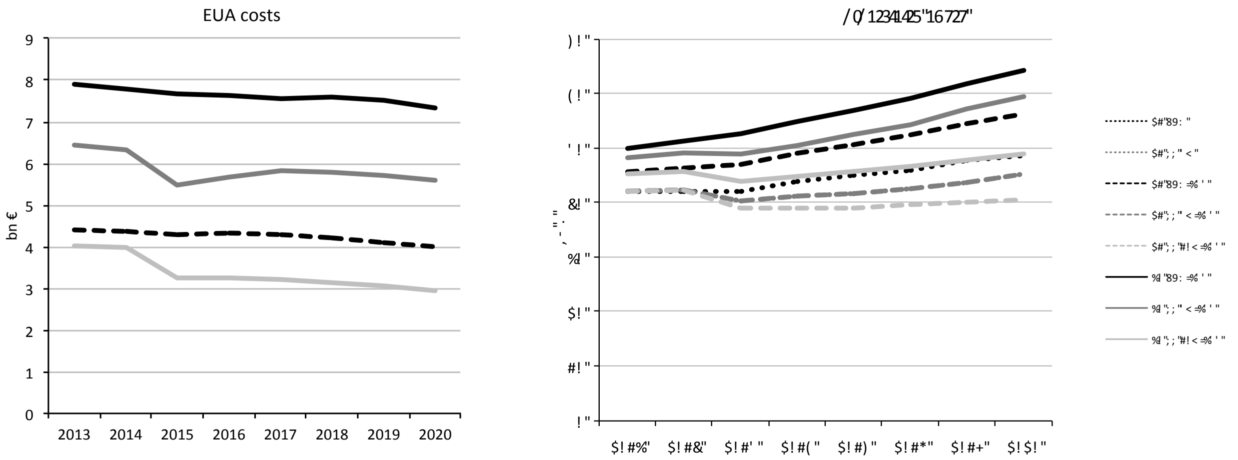
Figure 7: Carbon intensity of electricity generation for 30% cap reduction scenarios



5.3 Estimation of EUA and electricity costs for EU industry

In this section, we sum up the costs incurred by European industry through both EUA purchases (for certificates used directly for industrial process emissions) and industrial electricity consumption. Our cost estimation neglects other costs or benefits for industry due to EE or climate policy.[19] Figure 8 plots both cost elements in total bn. € per year.

Figure 8: EUA and electricity costs (bn € per year)



The picture is clear: High BAU costs are reduced by the introduction of EE policies. The more effective these policies are, the lower the costs. If the emission cap is not adjusted accordingly, the increased efficiency leads only to lower EUA and electricity prices, pushing competitiveness. From an ecological perspective however, there is no impact in terms of reduced emissions. As the previous chapter has shown, the carbon intensity (Mt CO_2/MWh) would even rise.

Before turning to overall costs for industry, the general relation of the cost elements can be roughly observed. While yearly net electricity costs range from 39 to 64 bn €, expenses for EUA are between zero for the scenarios with a EUA oversupply and around 8 bn € maximum in a 30% GHG cap reduction scenario without any EE policy. At this point, two important estimation problems have to be highlighted:

[18] In the simulation, the effect can only be observed in the 30% cap reduction scenarios, where the cap is binding even if electricity demand is reduced by 5 or 10%. In the 20% cap reduction and the BAU scenarios, with demand reduction, EUA demand decreases below available EUA supply, leading to prices of zero. Consequently total emissions are reduced and the crowding-in pattern cannot be observed.

[19] To this end, this analysis may be further elaborated in the future.

First, the cost burden of the ETS is not only *directly* reflected in EUA costs. The energy generation sector passes the abatement costs on to end-users via electricity prices and hence to industrial companies as well. Second, as electricity costs are calculated net of tariffs and taxes, they represent a severe underestimation of real industrial electricity expenses.

We therefore draw on a difference-in-cost design: we use a calculation of net electricity costs with no ETS in place as a baseline scenario. Assuming constant transmission and distribution tariffs and taxes,[20] subtraction of this baseline costs from the modelled scenario costs (EUA+electricity) yields an unbiased estimation of the *additional* costs to industry relative to a scenario without an ETS. These additional costs are displayed in figure 9 and table 2.

Industrial competitiveness was an important political argument when setting the emission cap *ex-ante* to the EE policy. We therefore argue that while holding competitiveness (abatement costs) constant, the climate target may be further increased and emission limits tightened.

Figure 9: Total electricity and EUA cost impact on EU industry (per year and cumulative 2013-2020)

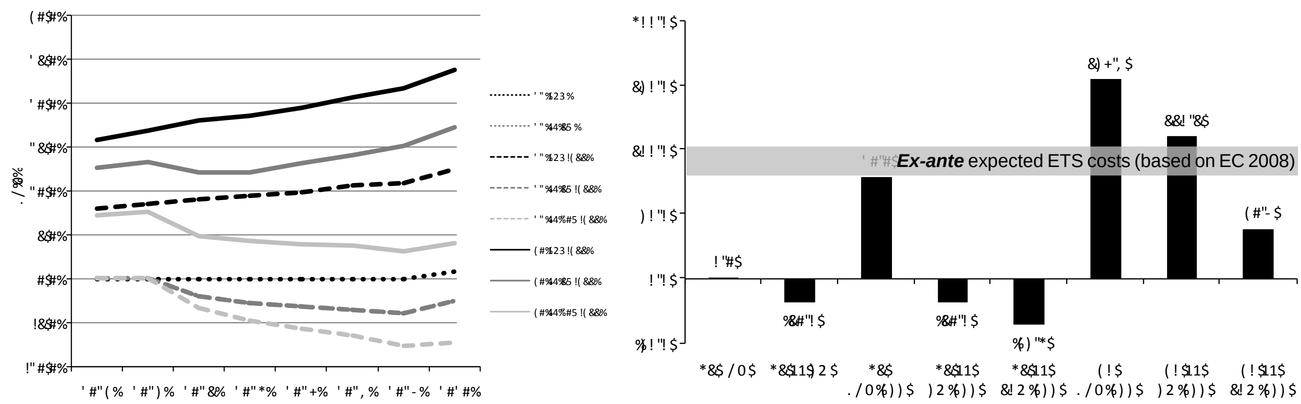


Table 2: Total estimated electricity and EUA cost impact on EU industry (bn €)

Scenario	2013	2014	2015	2016	2017	2018	2019	2020	cumulative
21 BAU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8
21 EE5%	0.1	0.1	-2.0	-2.8	-3.3	-3.6	-3.9	-2.6	-18.0
21 BAU-355	8.0	8.5	9.1	9.5	9.9	10.6	10.8	12.5	78.8
21 EE5%-355	0.1	0.1	-2.0	-2.8	-3.3	-3.6	-3.9	-2.6	-18.0
21 EE10%-355	0.1	0.1	-3.3	-4.8	-5.8	-6.5	-7.6	-7.3	-35.2
30 BAU-355	15.8	16.8	18.0	18.5	19.4	20.7	21.6	23.8	154.6
30 EE5%-355	12.6	13.3	12.1	12.3	13.2	14.1	15.2	17.2	110.1
30 EE10%-355	7.2	7.6	4.8	4.3	4.0	3.8	3.1	4.1	38.9

Because electricity represents a large portion of the overall costs, the picture strongly resembles the electricity prices. The straightforward findings are: Irrespective of the chosen cap, EE policy reduces costs for industry both directly through decreasing EUA prices and indirectly through lower electricity market prices (merit order-effect and less EUA-price pass-through). The more effective the policy, the higher would be the cost reductions for industrial sectors. As a result, the competitiveness of EU industry at world markets increases.

Model simulations and calculations yield accumulated ETS-induced costs to industry (2013-2020) between -35 to 155 bn €. Total costs are highest (155 bn €) in a 30% GHG reduction scenario without any EE policy. Under the assumption of 5% effective electricity savings, costs to industry are reduced to

[20] Taxes are typically a constant fraction of the price rather than a constant amount.

110 bn € and if EE policy is 10% demand-effective to 39 bn €. For comparison, if in the BAU scenario EUA prices reached 30–35 € as expected in EC (2008), costs would have amounted to about 85–100 bn €.
Figure 9 shows, that with a set-aside (-355-scenarios), with EE policy, industry costs are reduced even below levels without an ETS. Most interestingly, a set-aside and *additional* 30%-reduction-cap is to be achieved at lower costs to industry than initially expected by EC (2008), if combined with effective EE policies. This means, that annual GHG emissions may be reduced according to these findings by a 355 Mt set-aside plus another roughly 400 Mt of CO_2-equivalents compared to April 2012 policy state (the 30%-target). In addition, if policy does not react accordingly, low EUA prices[21] would threaten EE investments and discourage further EE investment.

6 Conclusion

This analysis estimated the effects of EE policy (operationalised as electricity demand decrease) on EUA and electricity prices with a comprehensive supply-side electricity generation model. Model results have been used to calculate the cost impact on European industry for eight scenarios: a reference scenario with no EU-ETS in place, a BAU scenario with the EU-ETS aiming at 21% emission reductions, a BAU scenario setting aside the estimated 355 Mt EUAs remaining from the second trading period and several combinations of the 21% and 30% cap-reduction scenarios with an EE-induced decrease in electricity demand of 5% and 10% respectively.
Estimations and calculations show that EE policies decrease total industrial costs through 1) reduced EUA quantities, 2) lower EUA prices and 3) electricity market prices. The more effective a policy reduces electricity demand, the higher the cost relief to industry. Results additionally demonstrate, that if EE policy is not accompanied by reductions of emission certificates, carbon intensity of electricity generation rises. The overall finding is that alongside an effective energy efficiency policy, 30% of emission reductions may be achieved with similar or even less costs to industry than expected when setting the emission cap for phase III. Our analysis concludes that ambitious emission targets are necessary if the EU-ETS shall persist as effective climate policy instrument.

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Annex

Region	**Countries**
UKI	UK and Ireland
North	Sweden, Norway, Finland, Denmark
Baltic	Estonia, Latvia, Lithuania
Iberia	Spain and Portugal
CWE (Central Western Europe)	France, Netherlands, Belgium and Luxembourg
CE (Central Europe)	Germany and Austria
CEE (Central Eastern Europe)	Poland, Hungary, Czech Republic and Slovakia
SCE (South Central Europe)	Italy, Switzerland, Slovenia
SEE (South Eastern Europe)	Bulgaria, Romania, Greece (Cyprus, Malta)