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The IFIEC method for the allocation of CO_2 allowances in the EU Emissions Trading Scheme

a review applied to the electricity sector

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Foreword

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SUMMARY

IFIEC Europe has developed an alternative allocation methodology for EU-ETS which aims at achieving the ETS climate targets while minimizing the adverse effects on EU industry's competitive position. The current study reviews an application of this method to the EU-ETS electricity sector. We show that the IFIEC method limits the CO_2 costs of electricity production to the actual costs of achieving a clean production level, as determined by a benchmark. This is different from the methods of auctioning and grandfathering in which the full costs (either real costs or so-called opportunity costs) of all CO_2 emissions are passed through into the electricity price. As a result, application of the IFIEC method reduces electricity costs for end-users in the order of, on average, 10-30% of industry's electricity bills and 5-20% of household bills. Within EU-ETS, the IFIEC method provides the same environmental incentives as auctioning and better incentives than the current system of grandfathering, provided that a single (not fuel-specific) benchmark is used for all electricity producers under EU-ETS. The lower electricity prices that result from the IFIEC approach, however, reduce the incentive for some low-carbon measures to be implemented outside EU-ETS.

Background

Based on the main lessons learned from experience with the EU Emissions Trading Scheme (EU-ETS) so far, the European Commission has recently proposed to improve the function of the scheme by amending the Directive which establishes the EU-ETS. The main changes proposed are the establishment of one EU-wide cap and the use of auctioning for a much greater share of allowances than is currently the case, replacing most of the allocation free of charge. The current allocation free of charge is based on historic production and emission levels, a grandfathering approach. The grandfathering approach raises so-called windfall profits for electricity generators that pass on the cost of allowances to their customers despite receiving them for free. Auctioning of allowances will eliminate these windfall profits.

Aim of this study

Against this background, IFIEC EUROPE, the international federation of industrial energy consumers, fears that auctioning of emission allowances will have negative impacts on the competitiveness of European industry. Therefore, IFIEC has developed an alternative allocation method, hereafter called the *IFIEC method*. The IFIEC method allocates allowances free of charge, based on actual production and a benchmark. This method should reduce the electricity cost increase for consumers, prevent windfall profits of electricity generators that fall under the EU-ETS, reduce the extra profits (producer surplus) that nuclear power producers receive from EU-ETS and deliver the same CO_2 emissions reductions as compared to the allocation systems of grandfathering and auctioning. IFIEC asked Ecofys to review their method, with particular reference to the aforementioned characteristics. The review was applied to the electricity sector that falls under the EU-ETS.

The IFIEC method
The IFIEC method allocates allowances for clean production free of charge. Here, clean production is defined by a benchmark of CO_2 emissions per unit of electricity production. Firms that produce lower-carbon electricity than the benchmark receive excess allowances, as a stimulus for this cleaner production. Firms that produce electricity with emissions levels above the benchmark have to compensate by purchasing allowances on the ETS market or investing in cleaner production.

Under the IFIEC methodology, the actual production level (MWh) of an installation, combined with the benchmark (t-CO_2/MWh) defines the quantity of free emission allowances. In practice, firms will receive allowances free of charge at the start of the calendar year, which is corrected later when data on actual production levels have become available (ex-post). The benchmarks are valid for the sector as a whole and would be set by the Commission at the start of a trading period. Benchmark-setting is done by taking the ratio of the annual sectoral CO_2 cap figures (t-CO_2) and the expected levels of fossil fuel based electricity generation (MWh). If required, the Commission would adjust benchmark values (downwards only) in the course of the trading period to ensure that the overall sectoral cap is maintained. Such adjustments would require timely announcement, for example for the year T+2.

Electricity cost-savings from IFIEC system
In the IFIEC method, the free of charge allocation in a certain year is based on the realised production in that same year. A lower production does not free up allowances to sell on the market, as is the case under the current grandfathering system in EU-ETS. As such, producing does not represent a lost opportunity to sell allowances and does not create opportunity costs to include in the electricity price. Therefore, in the IFIEC methodology electricity producers will not make windfall profits on their free allowances.

Under the IFIEC method, pass-through of CO_2 costs into electricity prices is therefore limited to the actual costs of achieving the clean production level, as defined by the benchmark, whereas under auctioning or grandfathering the full costs of all CO_2 emissions will be passed through into the electricity price. As a consequence, application of the IFIEC method will save electricity costs for all electricity consumers. The extent of the electricity cost savings achieved with the IFIEC method depend on the CO_2 price and the level of the benchmark.

In scenarios where the CO_2 price ranges between 20 and 60 €/t-CO_2 and the benchmark varies corresponding to a cap for the power sector of minus 20-40% (2020 cap as compared to 2005), we calculate electricity cost savings for consumers between 7.8 and 31 €/MWh. For electricity consumers this translates into savings on their final electricity bill, including taxes, of on average some 10-30% for industry and some 5-20% for households. Expressed in total amounts of electricity cost savings, the range of 7.8 to 31 €/MWh compares to 21 to 83 billion €/yr for the EU-27. We derived these numbers assuming that the future EU power market is fully competitive and electricity prices are governed by fossil fuel based electricity generation.

Environmental incentives within the EU-ETS system
Our review shows that allowance allocation via the IFIEC method, auctioning or grandfathering can give equal incentives to low-carbon electricity generation by *incumbent* electricity producers in the ETS-scheme. Unlike the current system of grandfathering, the IFIEC method gives undistorted incentives for clean *new entrants* in the EU-ETS and does not require special new entrant or closure arrangements. The same is also true for auctioning. Here, a condition for the IFIEC method is that a single benchmark is used for all electricity producers under the ETS-system. Application of a fuel specific benchmark in the IFIEC method clearly reduces incentives for low-carbon power production.

Trade- offs
The IFIEC method has a limited effect on electricity prices, while environmental incentives within EU-ETS remain. This saves electricity costs for consumers and minimises the risk of emissions increase outside the EU due to replacement of EU industrial production (so-called 'carbon leakage'). However, it also reduces low-carbon incentives in other parts of the economy, which should then be compensated for:

- *Industrial electricity users:* the IFIEC method reduces a potentially effective price signal for electricity savings. In the IFIEC approach this is compensated for by introducing benchmarks for industry that include efficient use of electricity. The design of such a system was not part of this study.
- *Household electricity savings*: incentives for electricity savings by households and services are reduced, as electricity prices are estimated to be 5-20% lower when the IFIEC method is applied. The restricted electricity price increase may have limited impact on electricity demand of households, as their demand-response to increased electricity prices is quite low. Instruments that improve the performance of products (lightning, electronics, etc.) and consumer awareness of these products (labelling) are likely to be more effective in stimulating electricity savings by households, than ETS-based electricity price changes.
- *Electricity from renewables:* under the IFIEC method, it will take longer for renewable electricity generation to be become fully competitive in the electricity market. Therefore, renewable support mechanisms in EU Member State would have to remain in place for longer periods.
- *Nuclear power*: the limited increase of electricity prices reduces the extra profits (producer surplus) that nuclear power producers receive, here estimated at potentially 8 to 31 billion €/yr. Whether these profits should be regarded as a negative incentive that leads to market concentration and an unlikely further growth of nuclear power or a positive incentive for increased long-term investment in this low-carbon technology, was beyond the scope of our study.

Monitoring and compliance
The IFIEC method does not increase the monitoring task for operators of EU-ETS power plants. The ex-post correction of allowances, however, does introduce an extra step in the compliance cycle. Note, however, that the organization of the auctions and possible recycling mechanisms also creates such extra so-called transaction costs. We did not assess and compare these extra transaction costs.

Recycling of revenues and other compensation mechanisms

Where full auctioning increases electricity costs, the revenues of auctioning can be recycled into the economy to be spent for example on further incentives for a low carbon economy, tax measures that feed back to households or compensation for loss of competiveness for exposed industry.

Compensation of exposed industry for higher electricity bills could be based on the principles of the IFIEC method, for example by extra allocation of allowances to exposed industrial electricity consumers relative to their electricity-use performance ("indirect" allocation) or recycling of auctioning revenues to exposed electricity consumers, also relative to their electricity-use performance. In the current study we only briefly touched upon such recycling options.

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1 Introduction

1.1 Definition of the study

Recently the European Commission has published a proposal to improve the function of the EU-ETS by amending the Directive which establishes the EU-ETS (EC, 2008c). The main changes proposed are the establishment of one EU-wide cap and the use of auctioning for a much greater share of allowances than is currently the case, replacing most of the allocation free of charge. Auctioning of allowances will eliminate the so-called windfall profits that occur under the current allocation free of charge that is based on historic production and emission levels; a grandfathering approach.

IFIEC EUROPE, the international federation of industrial energy consumers, asked Ecofys to review the method that IFIEC has developed in recent years to allocate CO_2 allowances in the EU emissions trading scheme (EU-ETS). According to IFIEC, their allocation method guarantees the same environmental outcome as other methods, without causing windfall profits and with lower risks of competitiveness loss for so-called exposed industrial users of electricity (e.g. Schyns, 2006[1]).

It was decided to focus this study on the European electricity sector. This was done for several reasons: CO_2 emissions from electricity generation cover a large part of the overall emission under EU-ETS, the electricity sector has a single well defined output (electricity) that can be used to illustrate the potential impact of the IFIEC benchmark based allocation approach, and electricity is a substantial cost factor for IFIEC members.

This evaluation covers many aspects of IFIEC's method and compares these with two other allocation methods: auctioning and historic grandfathering. Within the IFIEC method two example approaches are evaluated: a single benchmark for electricity production and fuel-specific benchmarks for coal and gas fired electricity production.

In the evaluation, we cover the following aspects:

- What is the IFIEC method; how does it differ from other allocation methods in character (chapter 2).
- What is the impact of different allocation methods, and the IFIEC method in particular, on electricity costs (chapter 3).
- What are the incentives for low-carbon electricity production under the different allocation methods (chapter 4).
- Uncertainty analysis of the IFIEC method (chapter 5).

[1] See also http://www.ifieceurope.org/documents.htm

2 The IFIEC allocation method

2.1 Definitions

In this report we discuss different methods to allocate CO_2 allowances in an emissions trading scheme (ETS). We define these methods as follows (Nera, 2007):

- *Grandfathering*: ETS-participants receive allowances for free. Originally this term refers to the allocation based on emissions levels in the past, typically an average of recent years (reference or base period)[2]. Grandfathering based on historical emissions data has been the main approach used to distribute free allowances to individual installations in the EU ETS in phase I and II (Ecofys et al., 2008).
- *Benchmarking:* free allocation can also be based on a technological standard or benchmark, expressed as unit CO_2 per unit input (e.g. energy) or output (e.g. tons of steel or MWh of electricity production). A majority of Member States used benchmarking for new entrants, mostly installation-specific referring to the "Best Available Technique" emission intensity (Ecofys et al, 2008).
- *Auctioning*: ETS-participants have to buy their CO_2 allowances via an auction. This approach does not require the development of benchmarks or information on historical emissions. It is necessary, however, to develop auction rules and procedures.

In the *IFIEC allocation method* allowances are granted for free, based on benchmarks and actual production levels. This is explained in more detail in the next paragraph 2.2. For all allocation methods discussed in this report it is assumed that they function under a cap-and-trade scheme; in this case a cap (emissions ceiling) for the electricity sector at the EU-level.

The following economic definitions are used in literature:

- *Windfall profits:* profits that occur unexpectedly as a consequence of some event not controlled by those who profit from it. In a more popular formulation: gaining profits without working for them. The additional profits that are a consequence of the pass-through of opportunity costs from freely-allocated emissions allowances are considered windfall profits (e.g. Sijm et al., 2005).
- *Producer surplus*: is the difference between costs and price of each unit sold. In competitive markets and at increasing marginal costs, there is a producer surplus for each unit sold up to the last one, where market price equals marginal costs. An additional producer surplus can occur if the market price of the last unit is above marginal costs. In peak hours of electricity production, for example, the production costs of gas-fired power plants set the electricity price, which creates a producer surplus for coal-fired production that has lower production costs.
- Producer surplus and windfall profits are also called *economic rents.*

[2] In this report and contrary to the current EU-ETS, it is assumed that this reference period will not be updated.

- *Costs of CO_2 allowances*:
  - *Real costs* of CO_2 allowances refer to the net costs for purchasing allowances via trading or auctioning.
  - *Opportunity costs*: is the cost of something in terms of an opportunity forgone or in other words the not-realised benefits of the second-best option. For a company, using emission allowances for production creates opportunity costs, as it is an opportunity forgone to sell these allowances, even if these were allocated for free.
  - The *full costs* of CO_2 allowances for companies are the sum of real and opportunity costs.

Note, that the terms *windfall profits*, *producer surplus* and *economic rents* have no generally accepted, clear-cut definition and are therefore interchangeable sometimes. In this report we use the following definitions:

- Windfall profits occur when firms receive emission allowances for free and treat these as opportunity costs.
- Producer surplus increases when firms do not receive emission allowances, like nuclear power producers, but rather profit from increased electricity prices due to pass-through of CO_2 costs by fossil-powered electricity producers.

The term economic rent is not further used in this report.

2.2 Description of the IFIEC method

The IFIEC method allocates allowances (t-CO_2) for free in year T based on realised production (MWh) and a benchmark (t-CO_2/MWh), both in year T. Allowances are given upfront at the start of year T based on forecasted or historical production, and ex-post corrected, based on realised production. A time series of benchmark values is set at the start of a trading period based on an ex-ante scenario of fossil fuel-based electricity production at the EU-level and the relevant emissions cap. When, in the course of time, the overall fossil fuel-based electricity production turns out to be higher than estimated, the benchmark values in later year (e.g. T+2) are adjusted downward accordingly. This way it can be ensured that the overall sectoral cap is maintained.

Detailed description

The IFIEC method allocates CO_2 allowances upfront at the beginning of a calendar year according to the following formula, given below for a single benchmark application of the method:

$$CO_2 \text{ allowances}_{T\text{-start}} \text{ (ton } CO_2) = \text{benchmark}_T \text{ (ton } CO_2/\text{MWh)} * \text{production}_{T\text{-est.}} \text{(MWh)} \quad [1]$$

The allocation is based on an estimate of the production in year T. At the start of the next calendar year, however, the number of CO_2 allowances over the year T are corrected based on realised production levels in the previous year T:

$$CO_2 \text{ allowances}_{T\text{-final}} \text{ (ton } CO_2) = \text{benchmark (ton } CO_2/\text{MWh)} * \text{production}_T \text{ (MWh)} \quad [2]$$

This correction is also known as an *ex-post* correction[3]. The result is, that each EU-ETS participant is assured that he receives for each realised production unit in year T (MWh) an allowance quantity equal to the benchmark in that year (t-CO_2/MWh).

Note, that the Dutch NO_x trading scheme is designed in accordance with the above principle (Staatsblad, 2005). Its application is somewhat different from the IFIEC method, however, in that allowances are not granted upfront and corrected based on realised production afterwards. Rather, the allowances are only granted ex-post based on realised production levels.

Derivation and ex-ante adjustment of the benchmark

A series of future benchmark values (t-CO_2/TWh) can be derived from expected electricity production (TWh) and a policy defined CAP (ton CO_2), as illustrated in Figure 1.

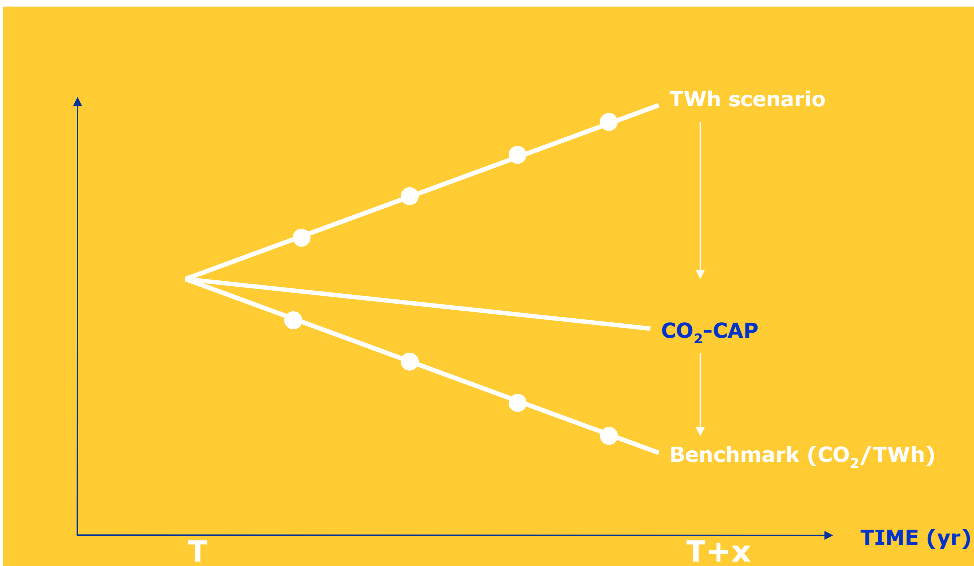

Figure 1 *Illustration of the ex-ante derivation of a benchmark series, based on an electricity production scenario (TWh) of the sector and a time series for the CO_2 cap as prescribed by policy decisions.*

The IFIEC method can be designed such, that an increase in production above the ex-ante expected levels can be corrected by downward adjustment of the benchmark in a future year. This is graphically illustrated in Figure 2.

[3] Note that ex-post adjustments in the National Allocation Plans of Member Sates have, until present, been rejected by the Commission. This rejection has recently been overruled by the European Court of First Instance. See Weishaar (2008, forthcoming) for an overview of jurisprudence on this matter.

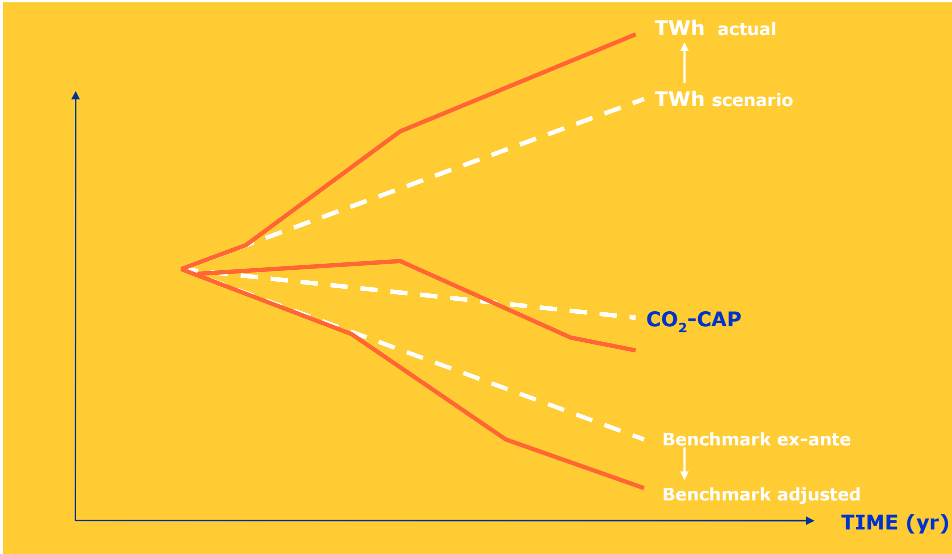

Figure 2 *Illustration of the ex-ante correction of a benchmark series in case electricity production of the sector is higher than expected. By adjusting the benchmark in future years, the total cap over a trading period is maintained.*

The adjustment of the benchmark can proceed as follows[4]:

- At the start of a trading period, a cap is defined for year T=1 to final year z. From the caps and the ex-ante production scenario for the sector annual benchmark values are derived (Figure 1).
- At the start of year T when monitoring data come available (ultimately 31 March of each year), the cap for year T-1 (t-CO_2) is compared with the product of the production (MWh) and the benchmark (t-CO_2/MWh) in year T-1.
- In case this product exceeds the cap, the excess (t-CO_2) is subtracted (in even parts) from the cap in years T+1 to z, and the benchmarks in these years are adjusted accordingly.
- The possible overshoot in the fore last and last years of the trading period are transferred into the cap values for the next trading period.

In formula, at the start of each year T when monitoring data over T-1 have become available, the benchmarks in *years T+1 to z* are adjusted according to[5]:

$$benchmark_{T+1} = \frac{cap_{T+1} - excess_{T-1} / (z-T)}{production.forecast_{T+1}}$$

Where:
excess = the quantity of CO_2 in excess of the cap
z-T = the remaining number number of years in the trading period

[4] See Schyns (2006), appendix 2 (page 4-5), for an example calculation.
[5] Schyns (2006), appendix 2 (page 4-5) illustrates that the method guarantees achievement of the overall cap during a trading period. See also paragraph 5.3 for more detailed information on the timing of ex-post and ex-ante corrections.

Note, that IFIEC propose their method such that the benchmark will only be adjusted downward from the original values i.e. made more stringent.

Single versus fuel-specific benchmark
In this report we will first focus on a single benchmark application of the IFIEC method, for CO_2 emissions from electricity production at the EU-level (see *textbox*). In chapter 4.2 we will address the application of a fuel-specific benchmark.

CO_2 performance of fossil-fuel based electricity production in the EU
In 1990, the average CO_2 performance of *fossil-fuel based* electricity production in the EU25 was some 0.9 to 1 ton of CO_2 per MWh electricity production. This value was dominated by coal and lignite fired electricity production. Between 1990 and 2005 the share of gas fired power production has grown from some 14% to 40% and the average CO_2 emissions have decreased to approximately 0.75 ton of CO_2 per MWh electricity production (EC, 2007a). In paragraph 5.1 we will show that under the current Commission ('20-20') proposals (EC, 2008a) the benchmark values may have to decrease down to values between 0.59 and 0.33 t-CO_2/MWh. Today, the CO_2 emissions of the newest coal and gas-fired power plants are around 0.75 and 0.37 t-CO_2/MWh respectively.

2.3 Opportunity costs

The grandfathering of CO_2 allowances in the current EU-ETS scheme creates opportunity costs: though granted for free, allowances are treated as costs, because producing and emitting CO_2 'consumes' CO_2 allowances, which is an opportunity forgone to sell these allowances. Today, there is strong empirical evidence that grandfathered CO_2 allowances in the electricity sector are indeed treated as opportunity costs and passed-through in electricity prices (e.g. Sijm et al., 2005, 2006). Therefore, the full cost of carbon for electricity producers covers the real costs for purchasing allowances and the opportunity costs of the allowances allocated for free. This so-called add-on rate of opportunity costs is in theory 100% (Sijm et al., 2005).

Thus, the full costs and pass-through CO_2 are in principle equal whether allowances are auctioned or grandfathered. This is illustrated in Figure 3.

Explanation of icons
Throughout this report, we illustrate our analyses with icons, as e.g. shown in Figure 3. The icons illustrate the CO_2 costs of gas- and /or coal-fired power plants and can be read either in relative units (€ /MWh) or in absolute units (€) for the case that production levels of gas and coal fired plants are the same.

In a liberalised and competitive power sector, the electricity price will be set by the marginal power generation unit that will include the full costs of carbon. Due to a variety of reasons, however, companies may not be able to fully pass-through these cost, for example when electricity prices are still subject to regulation (Matthes et al., 2005). Sijm et al (2005) observed from empirical data in the first half of 2005 pass-through rates between

40 and 70% in the Netherlands and Germany. In a later publication this rate is found to be between 60% and 100% (Sijm et al., 2006).

In this study we assume that the marginal production plant is able to pass-through the full costs of CO_2 into electricity prices (see paragraph 3.3 for more details).

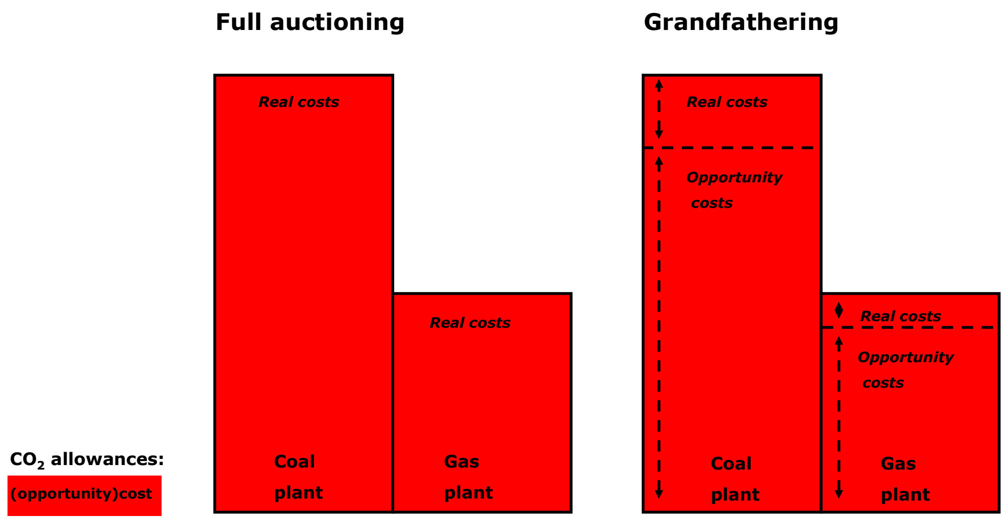

Figure 3 *Illustration of full CO_2 costs for a coal and gas fired power plant with same production levels. Full costs include opportunity costs and real costs to pursue CO_2 allowances that are not granted for free. Full costs are therefore the same under auctioning and grandfathering.*

An essential element of the IFIEC method is that, although allowances are granted free, no opportunity costs are created. This is because production 'generates' CO_2 allowances, as described by formula [2], contrary to grandfathering, where production 'consumes' allowances and represents a lost opportunity to sell these. This essential difference between grandfathering and the IFIEC methods is further illustrated in Figure 4.

Opportunity costs increase the electricity price and create windfall profits for electricity producers. It is important to note that one of the motivations of the European Commission to propose full *auctioning* as the guiding principle for EU-ETS is to eliminate such windfall profits (EC, 2008a).

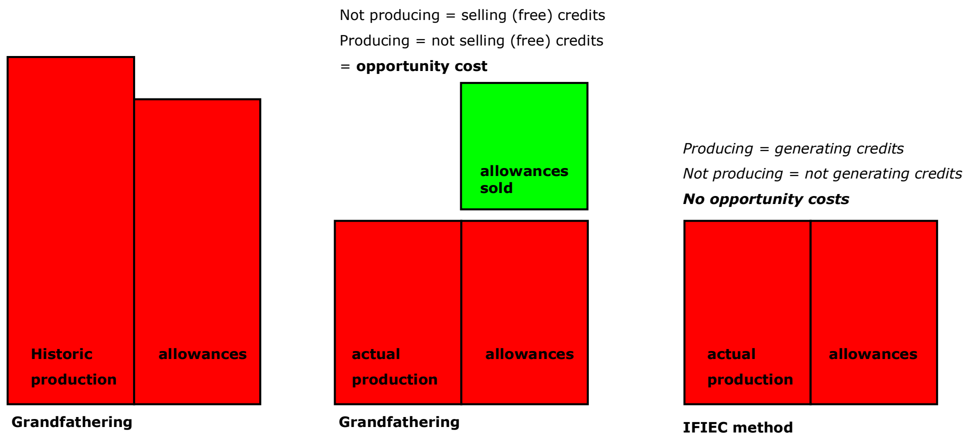

Figure 4 *Illustration of opportunity costs. The example shows the impact of reduced production (middle and right drawing) on a firm's carbon-balance under different allocation methods.*

2.4 Full costs of CO_2 allowances

In this section we graphically illustrate that the full costs of CO_2 allowances in the IFIEC method are rather different from auctioning and grandfathering. This is illustrated step-by-step in Figure 5. Auctioning and grandfathering, with the same full costs of CO_2, could be regarded as methods where zero emissions function as a benchmark for CO_2 costing (Figure 5, left icon). The IFIEC method takes a technology standard as a benchmark, in this illustration either the CO_2 emissions of gas-fired power plants (Figure 5 middle icon) or some value in between the CO_2 emissions of coal- and gas-fired plants (Figure 5 right-hand icon). As shown in paragraph 2.3, the free allowances in the IFIEC method create no opportunity costs. Real costs are only involved to the extent that actual emissions exceed the benchmark. Conversely, real benefits are involved –from selling allowances- to the extent that actual emissions are below the benchmark. This is illustrated by the red and green 'boxes' in the right-hand drawing in Figure 5.

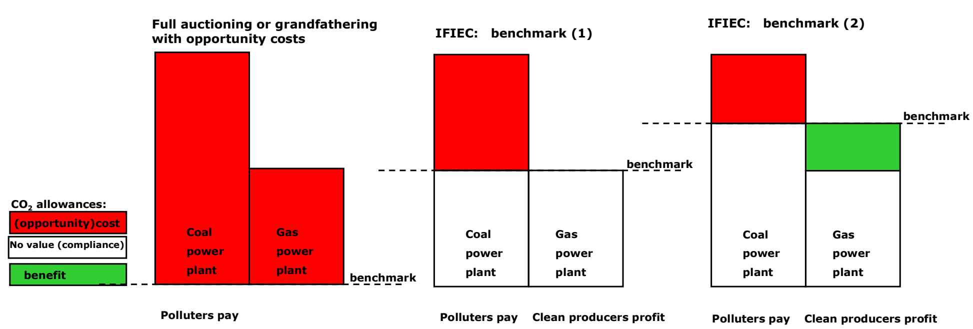

Figure 5 *Illustration of the full costing of CO_2 (real and opportunity costs) for a coal and gas fired power plant with similar production levels, under auctioning and grandfathering (left) and the IFIEC method (middle and right). For further explanation see main text.*

In this study, we look at the electricity sector which produces a very well-defined commodity: electricity. A single benchmark on the EU-level can easily be derived from total allowed (capped) CO_2 emission and total (TWh) production statistics at the EU level. The same holds true for a fuel-specific benchmark for electricity production. Application of a fuel-specific benchmark has different impact on the costing of CO_2 allowances, as illustrated in Figure 6. In paragraphs 4.2 and 4.3 we will discuss the impact of fuel-specific benchmarks on low-carbon incentives in the electricity market.

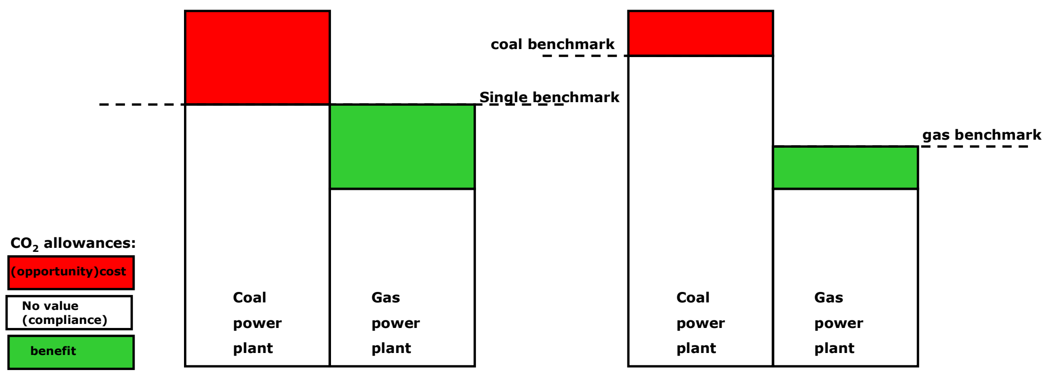

Figure 6 *Illustration of the IFIEC method using a single benchmark (left) and a fuel-specific benchmark (right).*

2.5 Conclusions

From this chapter we conclude that the full costs of CO_2 for electricity producers are much lower in the IFIEC method as compared to the allocation methods of auctioning or grandfathering. This is due to the fact that allocation free of charge in the IFIEC method creates no opportunity costs. The quantitative impacts on electricity prices and electricity costs for consumers at the member state and EU-level is subject of the next chapter 3.

3 Electricity prices

In this chapter we evaluate the impact of different allocation methods on electricity prices. We derive and apply a simple equation to calculate the electricity costs savings for consumers when the IFIEC method is applied rather than auctioning or grandfathering.

3.1 Allocation methods and electricity prices

Hereafter we assume a simplified market model. The market exists of only two different types of power producers (coal and gas), with uniform emission factors for each type[6]. Costs (e.g. fuel costs, operational costs, capital costs) may differ from plant to plant, and gas plants have higher variable costs than coal plants due to fuel price differences. A liberalised and competitive power sector is assumed, in which the electricity price will be set by the variable costs, mainly fuel and CO_2 allowances, of the marginal power generation unit. The marginal plant makes no additional profit and can just cover its variable costs by the power price. Power production equals –constant- power demand. The demand is high, and therefore both coal and gas fired plants produce.

In this market, emissions-trading is introduced and allowance are distributed either by grandfathering, auctioning or the IFIEC method. The CO_2 cap is the same for all allocation methods.

Figure 7 illustrates how in this simplified market model, the (variable) short run marginal costs develop as a function of the carbon price and allocation method. Under auctioning and grandfathering, the full costs of CO_2 allowances are the same (see chapter 2.4). All allowances are (treated as) costs, and passed through in the electricity price by the marginal production plant. At lower CO_2 prices gas is (still) marginal. As gas plants have lower CO_2 costs than coal-fired plants, the electricity price increase is more moderate than at high CO_2 prices, where coal-fired plants become marginal.

[6] A uniform emission factor means that all power plants of a certain type have the same CO_2 emission per unit of power production. Here, two types are distinguished, gas and coal-fired plants.

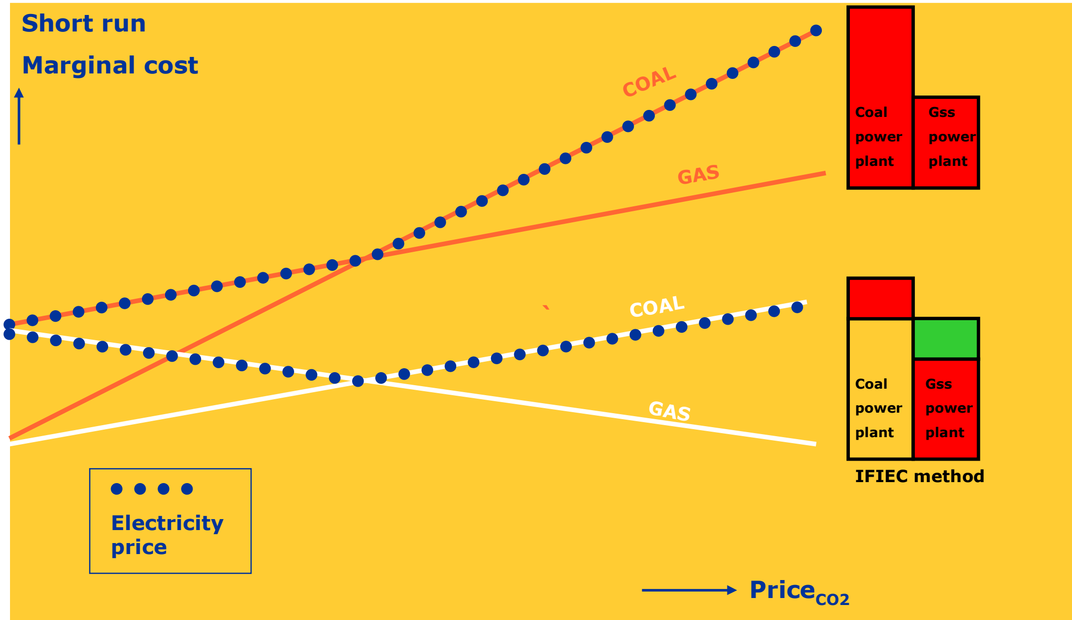

Figure 7 *Illustration of the impact of increasing CO_2 price on electricity prices, under grandfathering/auctioning (upper red lines) and the IFEC-method (lower white lines). The blue dotted line gives the electricity price as set by the marginal production plant. The icons symbolise the different levels of pass through of CO_2 cost of coal and gas, under different allocation methods. For explanation, see main text.*

The response of electricity prices to the IFIEC model is quite different, see Figure 7 (lower white lines). As long as gas is the marginal plant, these plants benefit financially from the fact that they produce electricity more cleanly than the benchmark. In a competitive market, this could even result in a decrease of the electricity price. In the real market the extent of such decrease would be dependent on the CO_2 efficiency of the marginal gas-fired unit. At increasing carbon prices, coal-fired plants will become marginal and electricity prices will increase, but much less than under grandfathering or auctioning. The red and red-green coloured icons in Figure 7 further illustrate the different basis of the electricity price responses.

3.2 Electricity cost savings IFIEC method: theory

In the previous section we illustrated that electricity prices are affected by the CO_2 price and that the size and direction of this response depends on the choice of the allocation method. In this paragraph we derive a formula to calculate the cost advantage for electricity consumers that occurs when the IFIEC method is applied rather than auctioning or grandfathering.

Electricity price dynamics can be considerable, and are not only a function of CO_2 price but also of merit order (so whether e.g. either a coal or gas-fired plant is marginal), electricity demand and fuel prices, which are all to some extent still member state-specific (Reinaud, 2007). Notwithstanding this complexity, we have derived a simple and generic formula to calculate the savings in electricity cost when applying the IFIEC allocation method, as opposed to auctioning or grandfathering. The generic formula is derived in two steps.

First we consider a typical nighttime situation with low electricity demand. Typically, in such a situation, coal-fired electricity production sets the electricity price in countries where large capacities of coal-fired facilities have been installed, like Germany, Estonia, Poland and the Netherlands. Figure 8 shows how in this situation CO_2 costs are passed through under auctioning or grandfathering (left) as compared with the IFIEC method (right). In a formula, and also shown in Figure 8, the difference in CO_2 and production costs can be expressed as:

$$\Delta \text{Production costs}_{\text{IFIEC vs other}} \ (€/\text{TWh}) = \text{Benchmark } (\text{t-}CO_2/\text{TWh}) * pCO_2 \ (€/\text{t-}CO_2)$$

And

$$\text{Cost savings}_{\text{consumers}}(€) = \text{Elec. consumption (TWh)} * \Delta \text{Production costs}_{\text{IFIEC vs other}} \ (€/\text{TWh})$$

Or

$$\text{Cost savings}_{\text{consumers}}(€) =$$
$$\text{Elec. consumption (TWh)} * \text{Benchmark } (\text{t-}CO_2/\text{TWh}) * pCO_2 \ (€/\text{t-}CO_2)$$

In short, this equation can be written as:

$$\textbf{Cost savings}_{\textbf{consumers}}\textbf{(€) = A*B*C} \qquad \textbf{[3]}$$

With
A = Electricity consumption (TWh)
B = Benchmark (t-CO_2/TWh)
C = Carbon price, pCO_2 (€/t-CO_2)

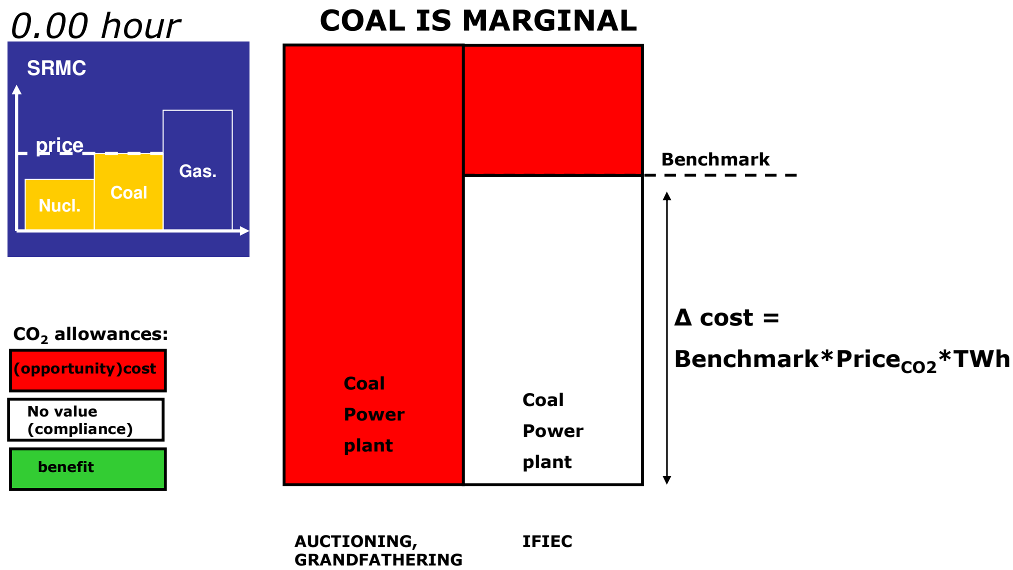

Figure 8 *Illustration of the CO_2 cost difference under different allocation methods, when coal-fired electricity production is marginal and determining the electricity price.*

Next, we consider a typical daytime situation with high electricity demand. Typically in such a situation, gas-fired technologies set the electricity prices e.g. in countries like the Netherlands, Italy and Spain (Reinaud, 2007). Figure 9 shows how in this situation CO_2 costs are passed through under auctioning or grandfathering whereas in the IFIEC-system, gas-fired plants benefit from selling excess allowances and reduce their marginal costs and electricity price.

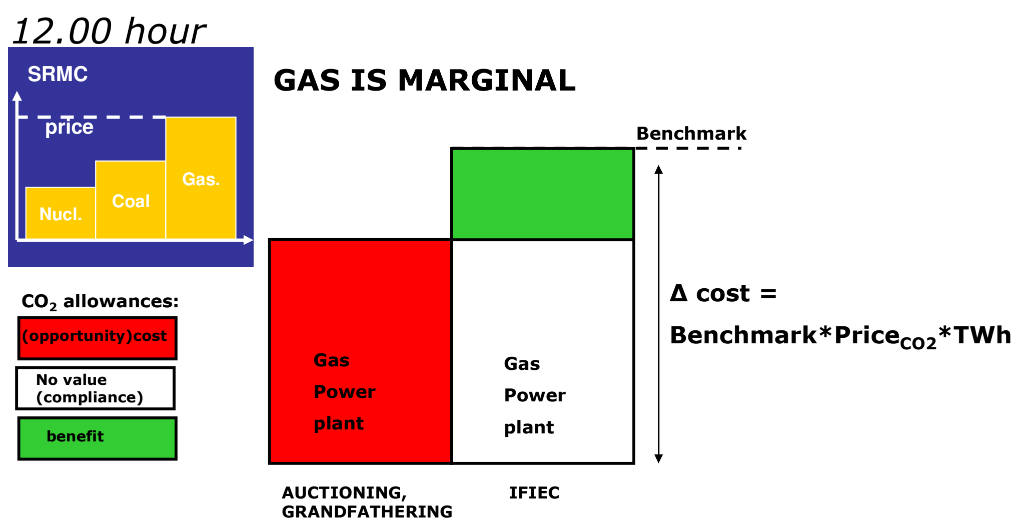

Figure 9 *Illustration of the CO_2 cost difference under different allocation methods, when gas-fired electricity production is marginal and determining the electricity price.*

The electricity cost savings from the IFIEC method can again be expressed by the formulas that were derived from the first typical situation.

Now equation [3] can be generalised, under the conditions that:
1. the marginal power plant is able to pass-through its CO_2 costs fully into the power price;
2. a fossil fuel based plant is marginal and setting the electricity price;
3. the IFIEC model applies a single sectoral benchmark.

Under the conditions 1-3, formula [3] can be used to calculate cost savings for electricity sers at the Member State, sector and EU-level easily. The results of such calculations are shown in paragraph 3.4. First, however, we will further explore adherence to the conditions 1 and 2 given above (see paragraph 3.3).

3.3 Validity check of the 'ABC' cost savings formula

In the previous paragraph we defined two market conditions under which the cost savings formula is valid. In this paragraph we take a closer look at the fulfillment of these conditions in the EU.

Condition 1: power producers fully pass-through the full CO_2 costs
Evidence for the pass-through of CO_2 costs in electricity prices has been provided from analysis of spot and forward electricity price dynamics on power exchanges (e.g. Sijm et al, 2005, 2006; Honkatukia et al., 2006; Voorspools, 2006). Reported pass-through rates vary between approximately 60 and 100%[7].

With the exception of Scandinavia and Spain, however, only a relatively small portion of the total electricity supply transits through the power exchanges (Reinaud, 2007). According to Reinaud (2007) "changes in electricity prices for industry installations cannot be simply attributed to day-ahead or future electricity prices variations, or indirectly to CO_2 cost movements". This is because there are significant differences in the way each industrial installation purchases its electricity. This can be done on organised exchanges, but also via bilateral contracts ('over-the-counter' or OTC), regulated tariffs or through self-generation of electricity by industrial consumers. Reinaud on the other hand also admits that 'precise data on the type of supply contracts is unavailable' (Reinaud, 2007, pg 11). Secondly, if significant arbitrage opportunity between electricity prices for industrial installations, the OTC markets and wholesale prices existed, they would be exploited by traders and hence reduced. Indeed, prices on power exchanges and OTC-markets in Germany are closely correlated (EC, 2007b). In our study we therefore assume that the ob-

[7] Note, that Voorspools (2006), reports 100% pass-through of EUAs in UK forward power prices during the first half of 2005. These prices were largely set by gas fired power plant as the marginal unit, which faced an allowance shortfall of 25%. Thus the 100% pass-through rate can be interpreted as a sign that power producers will indeed pass through the full costs (real and opportunity) of allowances under a more strict CO_2-cap.

served pass-through of CO_2 cost into electricity prices on power exchanges is -in the long run- representative for all electricity contracts.

(im)perfect competition
Under imperfect market competitions, electricity generators have scope to exercise market power by raising prices. In its recent energy sector inquiry, the Commission concluded that "At the wholesale level, gas and *electricity* markets remain national in scope, and generally maintain the high level of concentration of the pre-liberalisation period. This gives scope for exercising market power." (EC, 2006c; 2007b). Economic theory suggest that whereas electricity prices will increase under imperfect market conditions, the pass-through of CO_2 costs will be lower; in between 50% pass-through on a monopolistic market and 100% pass-through under perfect competition (Sijm et al., 2005; Lise et al, 2008).

From the above we conclude that our cost-savings calculations may be regarded as upper limits, as we assume *perfect* market behavior and *full* pass-through of CO_2 costs into electricity prices for all consumers.

Condition 2: a fossil fuel based plant is marginal and setting the electricity price
Our cost calculations are valid under the assumption that fossil fuel based electricity is the marginal technology that sets the electricity price. To what extent is this assumption valid?

Overall in the EU-27, 55% of power production in 2005 was fossil fuel based (EC, 2007a), see Table 1. Though the European market is gradually becoming integrated, it remains divided into national and regional markets (Reinaud, 2007). In countries where large capacities of coal-fired and/or gas fired facilities have been installed like Germany, Estonia, Poland, Netherlands, Italy and Spain, indeed gas or coal is marginal depending on the electricity demand level (Reinaud, 2007). However, countries like France, Sweden and Lithuania have 75 to more than 90% nuclear power production and Austria and Norway (no part of EU, but interconnected to other Scandinavian countries) have a renewables share in power production of 65% to almost 100% (Table 1). To what extent does fossil powered production affect electricity prices in these countries?

Table 1 *Shares of fossil and non-fossil powered electricity production in the EU (source EC, 2007a).*

	EU-27	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	IT	CY	LV
Fossil	55%	41%	47%	65%	71%	62%	99%	91%	88%	64%	11%	81%	100%	30%
non-fossil	45%	59%	53%	35%	29%	38%	1%	9%	12%	36%	89%	19%	0%	70%

	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE	UK
Fossil	24%	75%	56%	100%	87%	36%	96%	81%	57%	37%	29%	34%	2%	74%
non-fossil	76%	25%	44%	0%	13%	64%	4%	19%	43%	63%	71%	66%	98%	26%

Finon and Glanchant (2007, 2008) argue that in an insulated French market nuclear electricity production would be marginal in 60% of the time, whereas under current European integrated market conditions it is only 10% of the time. In other words, French wholesale electricity prices are increasingly determined by the marginal cost of fossil fuel based plants, either in France, or outside France. Indeed, French forward electricity prices closely follow German prices (CR, 2007).This phenomenon has strongly increased the producer surplus of French nuclear power producers. Also French and Dutch day-ahead prices differences have strongly decreased after coupling of the markets in November 2006 (source:APX, Powernext). Note, that Finon and Glanchant (2007, 2008) mention that some half of French electricity is still sold against regulated prices, however, they expect this measure (allowed in the transition towards a liberalised market) to end in 2010.

Honkatukia et al (2006) also observe that in the Scandinavian Nordpool spot market the electricity price is driven by the marginal cost of fossil fuel based power, even though the production is to a large extent based on hydro and nuclear power. As a consequence they observe that about 75% to 95% of the price changes in EU ETS are passed on to Finnish NordPool spot price[8]. The authors regard this as a sign of imperfect competition because under perfect competition conditions fossil fuel based electricity production would be marginal only under high electricity demand conditions. However, with the increasing interconnection capacity between the Nordic electricity system and the continental European UCTE network (Norned, Norger cables) a further price convergence between these systems is likely and hence the impact of fossil fuels on marginal electricity prices on the Nordpool market.

In summary

There are several electricity markets in Europe; geographically distributed markets, with different products (e.g. day-ahead and forward contracts) that are sold on power-exchanges or bilaterally (OTC). In addition, not all markets are fully competitive -and market power may be exercised- and in some countries prices are still regulated. Therefore, there is no general rule yet on, i) how carbon costs are transferred into these different electricity prices and ii) to what extent fossil fuel based electricity sets *all* electricity prices in the EU.

Based on the available and growing evidence of (almost full) carbon cost pass-through in electricity prices on power exchanges and the available evidence that fossil fuel based power production sets electricity prices even in countries like France, we in this study assume that i) full pass-through of carbon costs occurs in *all* electricity prices and ii) fossil fuel based power production is always marginal and setting the electricity price.

In other words, the reference for our calculations is a future single European electricity market, where –at least until 2020- fossil fuelled power is at all times the marginal production unit and in which carbon costs are fully passed through in the electricity price for all consumers. *In view of these assumptions, the cost calculations in this report should be regarded as (theoretic) upper limits.*

In the next paragraph the cost savings formula is applied to the EU and Member State level.

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[8] Note, that in Scandinavia, spot traded electricity is an important contract form (Reinaud, 2007).

3.4 Application of the 'ABC' electricity cost savings formula

In paragraph 3.2 we derived a simple 'ABC' equation to calculate the electricity cost savings for consumers when the IFIEC method is applied:

$$\text{Cost savings}_{\text{consumers}}(€) = A*B*C \qquad [3]$$

With
A = Electricity consumption (TWh)
B = Benchmark (t-CO_2/TWh)
C = Carbon price, pCO_2 (€/t-CO_2)

Aggregated results of its application on the EU-level are shown in Table 2. The cost savings calculations are affected by the electricity consumption level (A), the benchmark value (related to the cap) (B) and the CO_2 price (C), for which we used the following values.

Input parameters

- (A) Electricity consumption was assumed to stay constant at the 2005 level. This was done for the sake of simplicity, and the large spread in the costs calculations already introduced by the variable CO_2 price and benchmarks.
- (B) We chose three benchmark values. These values represent the CO_2-performance (t-CO_2/MWh) required to meet CO_2-reductions in the EU-ETS power sector of -20% to -40% (in 2020 compared to 2005). In paragraph 5.1 (Table 11) we discuss in more detail how we derived these benchmark values.
- (C) For the CO_2 price, we chose values of 20, 40 and 60 €/t-CO_2. The lower estimate reflects the current carbon price in EU-ETS. The middle estimate compares to the Commissions' impact assessment accompanying the final '20-20' proposals, including the 21% reduction target for EU-ETS (EC, 2008a). The high estimate is given e.g. by EEA (2005) and others[9].

[9] As an illustration, Point Carbon 13 March 2008: "European carbon prices will rise to a range of €50-70 by 2020, carbon market analysts told a Copenhagen conference on Wednesday, although they disagreed over the reasons behind the bullish sentiment."

Table 2 *IFIEC electricity cost savings in the EU-27 for industry, households & services and the total of both sectors (billion €/yr).*

Scenario[1)]:	-20%	-30%	-40%
Benchmark (t-CO_2/MWh):	0.515	0.455	0.39
CO_2 price (€/ton):	**Cost savings industry (€/yr) [2)]**		
20	*11.6*	*10.3*	*8.8*
40	*23.2*	*20.5*	*17.6*
60	*34.8*	*30.8*	*26.4*
	Cost savings households & services (€/yr) [3)]		
20	*16.0*	*14.1*	*12.1*
40	*32.0*	*28.3*	*24.2*
60	*48.0*	*42.4*	*36.4*
	Total cost savings (€/yr)		
20	*27.6*	*24.4*	*20.9*
40	*55.2*	*48.8*	*41.8*
60	*82.9*	*73.2*	*62.8*

1) reduction in 2020 compared to 2005
2) Final electricity use in 2005: 1127 TWh (Eurostat)
3) Final electricity use in 2005: 1554 TWh (Eurostat)

Results

Overall, Table 2 illustrates that the electricity cost savings under the IFIEC method increase with the CO_2 price and decrease when the benchmark is lowered. A decreasing future benchmark will reduce the electricity cost advantage of the IFIEC method. With decreasing benchmark values, the IFIEC method and auctioning or grandfathering become more and more alike, and the cost-difference disappears. This was already illustrated in Figure 5. It is likely, however, that a more ambitious reduction scenario (with lower benchmark values) will also increase the CO_2 price. This effect increases the cost-advantage of the IFIEC method.

Note, that from Table 2 the electricity cost savings from the IFIEC method can also be calculated in € per MWh, by simply multiplying the benchmark with the CO_2 price (see Table 3). Expressed in this way, cost savings range between 7.8 and 31 €/MWh. For electricity consumers, it is of interest to compare this number with the final electricity bill they pay, including taxes. Eurostat reports average wholesale prices (including taxes) for large industrial users in the EU-27 between 75 and 90 €/MWh in 2005-2007[10]. Average electricity prices for households in the EU-27 ranged between 130-150 €/MWh (including taxes and V.A.T). From these numbers, the IFIEC cost advantage for electricity consum-

[10] Prices refer to standard industrial consumers (class Ig) with an annual consumption of 24 GWh, a maximum demand of 4000kW and an annual load of 6000 hours. Prices include taxes.

ers can be tentatively translates into savings on their final electricity bills of on average some 10-30% for industry and some 5-20% for households[11].

Table 3 IFIEC electricity cost savings in the EU-27 (€/MWh) as a function of benchmark values and CO_2 price.

Benchmark (t-CO_2/MWh):	0.515	0.455	0.39
CO_2 price (€/ton):	*Cost savings (€/MWh)*		
20	*10.3*	*9.1*	*7.8*
40	*20.6*	*18.2*	*15.6*
60	*30.9*	*27.3*	*23.4*

Table 4 further details the calculations to the national level. This is done for a scenario with 20% CO_2 reduction in 2020 (corresponding benchmark is 0.515 t-CO_2/MWh, see paragraph 5.1) , compared to 2005, and a CO_2 price of 40 €/ton.

[11] We derived these estimate as follows, here demonstrated for industry:

- assume that the lower end of the average price range of 75-90 €/MWh represents current electricity costs *without* (current) ETS impacts
- assume constant future fuel prices
- assume that the IFIEC method does not affect future electricity prices

Under these conditions the future electricity costs under auctioning/grandfathering would increase to 75+8=82 or 75+31=106 €/MWh. The costs advantage of the IFIEC method then equals 1-75/82 and 1-75/106 or 10 to 30%.

Table 4 *Annual electricity cost savings from the IFIEC method according to equation [3]. Cost savings are calculated by multiplying columns A, B and C.*

	Electricity use industry 2020[1)] (TWh)	Electricity use househ. & services 2020 (TWh)	Electricity use total 2020 (TWh)	Benchmark (*10^6 ton CO_2/TWh)	CO_2 price (€/ton)	Cost savings industry (billion €/yr)	Cost savings househ. & services (billion €/yr)	Cost savings users total (billion €/yr)
	A1	A2	A3	B	C	A1*B*C	A2*B*C	A3*B*C
EU-27	1127	1554	2682	0.515	40	23.2	32.0	55.2
EU-25	1094	1525	2619	0.515	40	22.5	31.4	54.0
EU-15	994	1386	2380	0.515	40	20.5	28.5	49.0
Belgium	39	39	79	0.515	40	0.8	0.8	1.6
Bulgaria	10	15	25	0.515	40	0.2	0.3	0.5
Czech Republic	23	30	53	0.515	40	0.5	0.6	1.1
Denmark	10	23	33	0.515	40	0.2	0.5	0.7
Germany	232	269	501	0.515	40	4.8	5.5	10.3
Estonia	2	4	6	0.515	40	0.04	0.08	0.12
Ireland	8	17	24	0.515	40	0.2	0.3	0.5
Greece	14	36	51	0.515	40	0.3	0.7	1.0
Spain	105	132	237	0.515	40	2.2	2.7	4.9
France	134	276	410	0.515	40	2.8	5.7	8.5
Italy	145	146	291	0.515	40	3.0	3.0	6.0
Cyprus	1	3	4	0.515	40	0.01	0.07	0.08
Latvia	2	4	6	0.515	40	0.04	0.08	0.11
Lithuania	3	5	8	0.515	40	0.06	0.10	0.16
Luxemburg	4	2	6	0.515	40	0.08	0.04	0.12
Hungary	9	22	31	0.515	40	0.19	0.5	0.6
Maltha	1	1	2	0.515	40	0.01	0.02	0.04
Netherlands	42	61	103	0.515	40	0.9	1.3	2.1
Austria	24	29	54	0.515	40	0.5	0.6	1.1
Poland	41	54	95	0.515	40	0.9	1.1	2.0
Portugal	17	29	46	0.515	40	0.4	0.6	0.9
Romania	24	14	37	0.515	40	0.5	0.3	0.8
Slovenia	7	5	13	0.515	40	0.15	0.11	0.26
Slovakia	11	11	22	0.515	40	0.23	0.23	0.46
Finland	43	37	80	0.515	40	0.9	0.8	1.7
Sweden	58	71	129	0.515	40	1.2	1.5	2.6
United Kingdom	119	218	337	0.515	40	2.4	4.5	6.9

1) See main text, electricity consumption in 2020 is set at 2005 values.

2) The Commission assumes a carbon price of 39 €/t-CO_2 in its impact assessment that accompanies the final 2008 climate package proposal (EC, 2008b).

3.5 Conclusions

In this chapter we have derived a simple and precise formula to calculate the cost savings for electricity consumers when the IFIEC allocation method is applied, rather than auctioning or grandfathering. Electricity cost savings in the EU-27 could range between 7.8 and 31 €/MWh, dependent on the assumed CO_2 price and benchmark value.

Again, the outcomes are valid under the assumption that CO_2 costs are fully (100%) passed through in the electricity price. Lower pass-through rates would decrease the cost savings under the IFIEC method accordingly.

Most important however, is the question whether the IFIEC model gives the same incentives for low-carbon electricity production as the auctioning or grandfathering model. This will be analysed in the next chapter 4.

4 Environmental effectiveness

In this chapter we look at the environmental effectiveness of the IFIEC method. We do this stepwise: in paragraph 4.1 we discuss impacts on incumbents in EU-ETS, in paragraph 4.3 on new entrants in EU-ETS, in paragraph 4.4 we evaluate the impacts on power production outside EU-ETS and in paragraph 4.5 we discuss the impacts on electricity users. In this chapter we also evaluate the effectiveness of the application of fuel-specific benchmarks rather than a single benchmark for all electricity generations (paragraph 4.2).

Why focus on fuel shift?
In this chapter we focus on fuel shift as a CO_2 mitigation option. To generate the same amount of electricity, burning coal emits twice as much CO_2 as burning gas. Today, some 52% of conventional electricity generation in the EU is from coal fired power plants. Fuel shift is therefore an important option to reduce CO_2 emissions. It is also a cost-effective option. All major scenario studies therefore recognise fuel shift as a crucial CO_2 mitigation option (e.g. EC, 2006b; EEA, 2005; Den Elzen et al., 2007). The extent to which fuel shift is stimulated under the different allocation mechanism considered here, is therefore an important indicator of their environmental effectiveness.

4.1 Fuel shift between existing power plants

Here we take a closer look at the simplified market model that was already introduced in chapter 3.1. The market exists of only two different types of power producers (coal and gas), with uniform emission factors for each type. Costs (e.g. fuel costs, capital costs, profit margin) may differ from plant to plant, and gas plants have higher costs than coal plants. A competitive market is assumed, so no individual company has substantial market power. Power production is constant and equals constant power demand.

The incentive under the different allocation methods for a fuel shift from coal to gas is investigated by means of the CO_2 price that is required to overcome the cost difference between coal fired and gas fired electricity production.

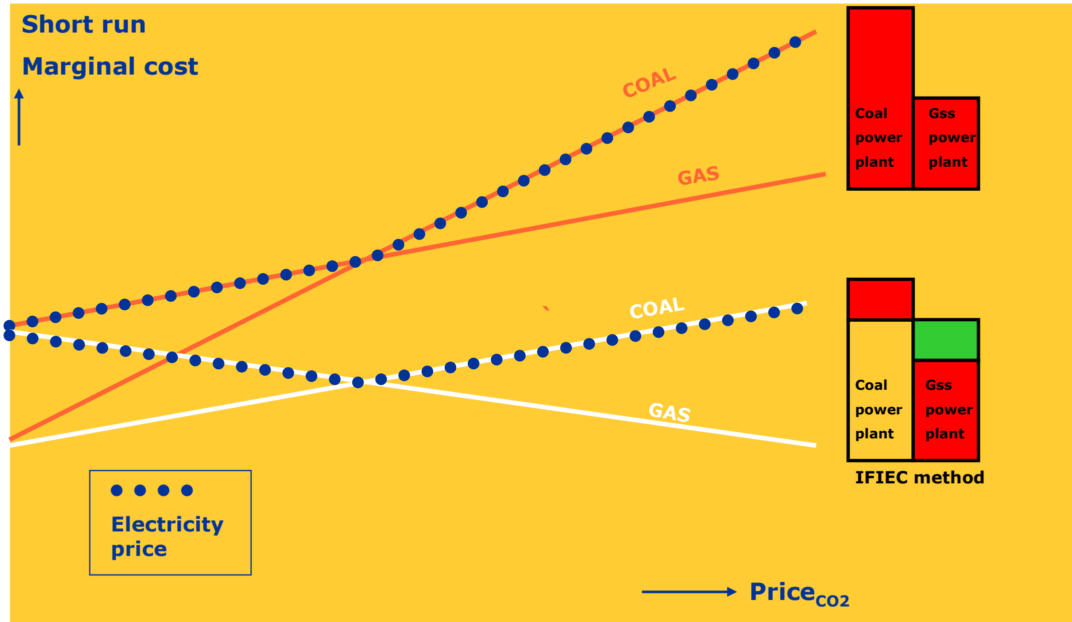

Figure 10 *Illustration of the impact of increasing CO_2 price on electricity power prices, under different allocation methods. The blue dotted line reflects the electricity price as set by the marginal production plant. The icons symbolise the different CO_2 cost pass-through of coal and gas under different allocation methods. For explanation, see main text.*

IFIEC method

First, we apply the IFIEC method by using a single benchmark for the electricity sector. A shift from gas to coal fired power production will occur when the production cost of the marginal coal plant (the first one that will go out of production) equals the production costs of the marginal gas fired plant (the first one that will go into production), see also Figure 10.

$$SRMC_{coal} + pCO_2*(EF_{coal}\text{-benchmark}) = SRMC_{gas} - pCO_2*(\text{benchmark-}EF_{gas})$$

With:

- SRMC = short run marginal costs, excluding carbon costs (€)
- pCO_2 = CO_2 price (€/t-CO_2)
- EF = Emission factor (t-CO_2/MWh)
- Benchmark (t-CO_2/MWh)

From this it follows that:

$$pCO_2 = [SRMC_{gas}\text{-}SRMC_{coal}]/[EF_{coal}\text{-}EF_{gas}]$$

Note, that the benchmark (which is directly related to the cap) is no part of the formula, as we consider only one reduction option here (fuel shift), that will occur at a certain CO_2 price, regardless the benchmark or cap. In a carbon market with more reduction options, the CO_2 price will be a function of the carbon cap and the reduction costs will increase with decreasing cap.

Auctioning and grandfathering
Under auctioning and grandfathering all CO_2 emissions are included in the (carbon) costs calculation:

$$SRMC_{coal} + pCO_2 * EF_{coal} = SRMC_{gas} + pCO_2 * EF_{gas}$$

From this it again follows that:

$$pCO_2 = [SRMC_{gas} - SRMC_{coal}]/[EF_{coal} - EF_{gas}]$$

Thus, the IFIEC method (single benchmark), auctioning and grandfathering give the same incentives for fuel shift between existing power plants. This is also shown in Figure 11.

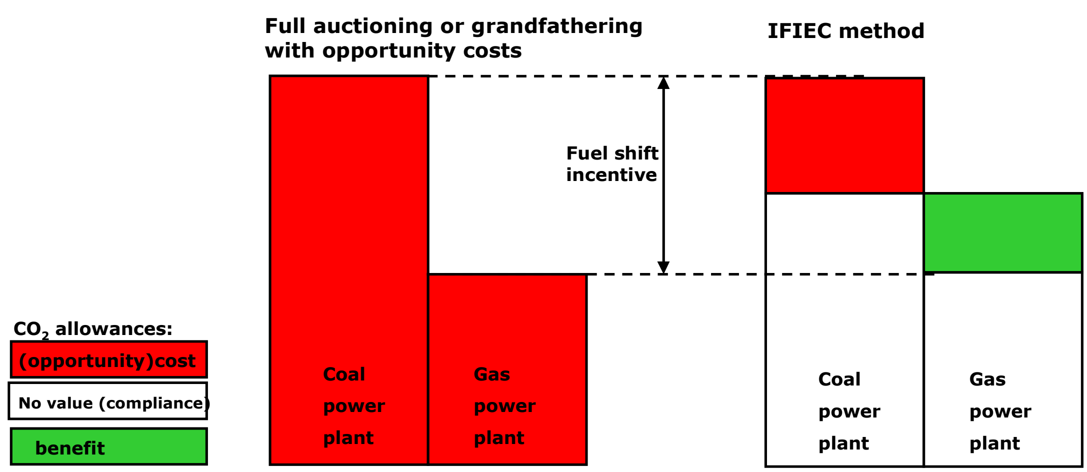

Figure 11 *Illustration of (same) fuel shift incentive under auctioning/grand-fathering and the IFIEC method (single benchmark).*

Table 5 gives some illustrative calculations of the CO_2 price at which a coal to gas fuel shift may occur. Such estimates are sensitive to fuel prices and to the extent at which the marginal producers are able to add a so called ‘mark-up’ to their short run marginal costs, to cover e.g. fixed costs or create a profit margin. Under conditions of perfect competition and ample supply of electricity generation capacity, the mark-up of the marginal producer will be zero. Under non-perfect competition or conditions of scarce supply a mark-up can be added. An indication of such mark-up can be derived from the so called dark and spark spreads. The dark and spark spread are the differences between the market price for power and the costs of the coal respectively gas to generate that power. Spread data available from the Dutch, German and UK market indicate a spread of around 7 €/MWh for gas fired power production and 15 €/MWh for coal fired power production (Sijm et al., 2005; Voorspools, 2006[12]). In the light of these uncertainties, Table 5 illustrates that fuel shift may occur in a CO_2 price range between 22 and 48 €/ton CO_2.

Conclusion

Auctioning, grandfathering and the IFIEC allocation method give in theory the same incentives for fuel shift between existing fossil fuel based power plants, as measured from the CO_2 price that is required to induce fuel shift between existing plants[13]. The incentive for fuel shift is determined by the cost difference between the coal and gas fired plant, which remains the same under the different allocation methods. The costs difference exists of:

a) Fuel costs differences –the main part of the SRMC- between the marginal gas plant and the marginal coal plant. The higher the fuel costs for gas, compared to coal, the higher will be the CO_2 price that is required to induce a fuel shift from coal to gas.
b) The CO_2-costs, as determined by the CO_2-efficiency difference between coal and gas. The higher the efficiency difference, the higher the cost difference and the stronger the incentive for fuel shift.

Table 5 *Some illustrative calculations of CO_2 price required for coal-gas fuel shift.*

		2005 fuel price indication			
		Gas	**Coal**	**Gas**	**Coal**
Emission factor	t-CO_2/MWh	0.4	0.9	0.4	0.9
Fuel price at plant	€/GJ	7.0	2.8	7.0	2.8
Efficiency	%	0.49	0.37	0.49	0.37
Fuel costs	€/MWh	51.4	27.2	51.4	27.2
Mark-up[a]	€/MWh	7.0	15.0	0.0	0.0
Short run marginal costs	€/MWh	58.4	42.2	51.4	27.2
CO_2 price - fuel shift	Euro/ton CO_2	**32**		**48**[b]	
CO_2 costs	€/MWh	12.9	29.1	19.3	43.5
Overall marginal costs	€/MWh	71.4	71.4	70.8	70.8
		2007 fuel price indication			
		Gas	**Coal**	**Gas**	**Coal**
Emission factor	t-CO2/MWh	0.4	0.9	0.4	0.9
Fuel price at plant	€/GJ	5.0	1.8	5.0	1.8
Efficiency	%	0.49	0.37	0.49	0.37
Fuel costs	€/MWh	36.7	17.5	36.7	17.5
Mark-up[a]	€/MWh	7.0	15.0	0.0	0.0
Short run marginal costs	€/MWh	43.7	32.5	36.7	17.5
CO_2 price - fuel shift	€/ton CO2	**22**[b]		**38**	
CO_2 costs	€/MWh	9.0	20.2	15.4	34.6
Overall marginal costs	€/MWh	52.7	52.7	52.1	52.1

[a] for explanation, see main text

[12] Data refer to so called carbon-adjusted spreads
[13] Note, that in our simple illustrative model , we did not consider updating (also called 'moving baseline'), i.e. renewed grandfathering at the start of trading period based on a more recent (set of) base year(s). According to Matthes et al. (2007) such updating undermines incentives for a shift from coal to gas.

[b] variants used in Figure 13

4.2 Fuel-specific benchmarks

Next, we apply the IFIEC method by using fuel-specific benchmarks. Now, only the CO_2 emission in excess of the *fuel-specific* benchmark are included in the marginal cost increase (see Figure 12, right-hand side).

Figure 12 *Illustration of the IFIEC method using a single benchmark (left) and a fuel-specific benchmark (right).*

The CO_2 price where the marginal costs of gas and coal intersect and fuel shift will occur can be calculated as:

$$SRMC_{gas} + pCO_2*(EF_{gas}-benchmark_{gas}) = SRMC_{coal} + pCO_2*(EF_{coal}- Benchmark_{coal})$$

Or

$$pCO_2 = \frac{SRMC_{gas} - SRMC_{coal}}{EF_{coal} - EF_{gas} - (Benchmark_{coal} - Benchmark_{gas})} \quad [4]$$

The behavior of equation [4] is illustrated in Figure 13. The starting points of the curves in Figure 13 refers to a single benchmark situation with upper and lower CO_2 prices as derived in Table 5. Figure 13 illustrates how increased fuel specificity of the benchmarks reduces the incentive for fuel shift, as expressed by the higher CO_2 price that is required to induce fuel shift. The simple explanation for this is, that the CO_2-cost or CO_2-benefit incentive from the ETS is reduced when a fuel-specific benchmark is introduced and thus a higher CO_2 price is required to overcome the cost difference between coal and gas fired power production.

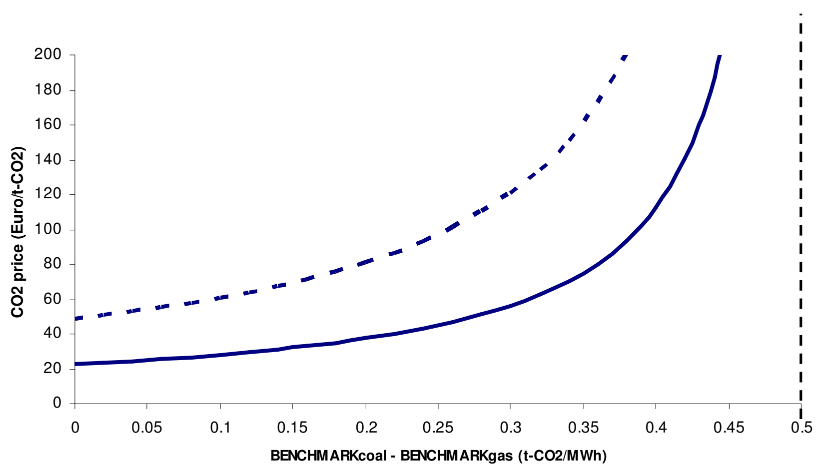

Figure 13 *Illustration of CO_2 price at which fuel shift will occur in IFIEC-system with a coal and gas specific benchmark. The x-axis shows the difference between the coal and gas benchmark (t-CO_2/MWh). Input data for the upper and lower curve are given in Table 5.*

Simplified market model versus the real world
Note, that in the simplified and 'closed' system under study, the cap under a fuel specific or single benchmark is the same and will enforce the same emissions reductions. Though the system 'equilibrates' at a different CO_2 price, the overall costs are the same. After all, in the simple model only one reduction option –fuel shift- is available. In a *real world* situation however, in a multi sectoral ETS-system that includes JI/CDM-allowances as well, cheaper CO_2 reduction options than 'fuel shift under a fuel-specific benchmark system' will set the CO_2 –price. Therefore, in a real world situation indeed the incentive for fuel shift is (strongly) reduced when a fuel-specific benchmark is introduced, as shown in Figure 13.

4.3 New entrants in EU-ETS

In the previous chapter we described how the operation of *existing* power plants is based on marginal variable (short run) costs. According to economic theory, a company adds the full costs of CO_2 allowances to its marginal variable (short run) costs when it is making short term production decisions. These full costs include the real costs for acquisition of CO_2 allowances on the market as well as opportunity costs of (free) allowances to be surrendered for plant operation (see Figure 3).

In this chapter we look at incentives for investments in *new* power plants. For new investments the *real* CO_2-costs is the decisive parameter for investment decisions (Matthes et al., 2005). These real costs are dependent on the allocation mechanism applied. Hereafter, we derive –for the different allocation methods- formula's to calculate the CO_2 price at which investment in new plants may becomes attractive. The lower the CO_2 price at which such investments occur, the higher the incentives from the ETS scheme. Again, illustrations are used to support the analysis. Table 6, at the end of this paragraph, presents some illustrative quantitative results.

New investments become attractive when total (fixed, variable and CO_2) costs from the new investment are equal to or lower than total (fixed, variable and CO_2) costs from the old running plant:

Auctioning

$$TC_{new\ plant} + pCO_2 * EF_{CO2,new\ plant} = TC_{old\ plant} + pCO_2 * EF_{CO2,old\ plant}$$

With:

- TC = total fixed plus variable costs, excluding CO_2 (€/MWh)
- $pCO_2 = CO_2$ price (€/t-CO_2)
- EF = Emission factor (t-CO_2/MWh)

The CO_2 price at which new investments become attractive equals:

$$pCO_2 = (TC_{new\ plant} - TC_{old\ plant}) / (EF_{CO2,old\ plant} - EF_{CO2,\ new\ plant})$$

IFIEC method: single benchmark

For the IFIEC method total costs of new and standing plants compare as follows:

$$TC_{new\ plant} - pCO_2 * (benchmark_{CO2} - EF_{CO2,new\ plant}) = TC_{old\ plant} + pCO_2 * (EF_{CO2,old\ plant} - benchmark_{CO2})$$

The CO_2 price at which new investments become attractive equals:

$$pCO_2 = (TC_{new\ plant} - TC_{old\ plant}) / (EF_{CO2,old\ plant} - EF_{CO2,\ new\ plant})$$

Again, the pCO_2 formulas for auctioning and the IFIEC method illustrate that these methods give the same incentives for investments in new low-CO_2 technology. This is also shown in Figure 14. Note, that this conclusion is valid for participants *within* the ETS-system, in chapter 4.4 we will show that the IFIEC method gives lower incentives for investments in electricity generation from renewables, which is outside the ETS-system.

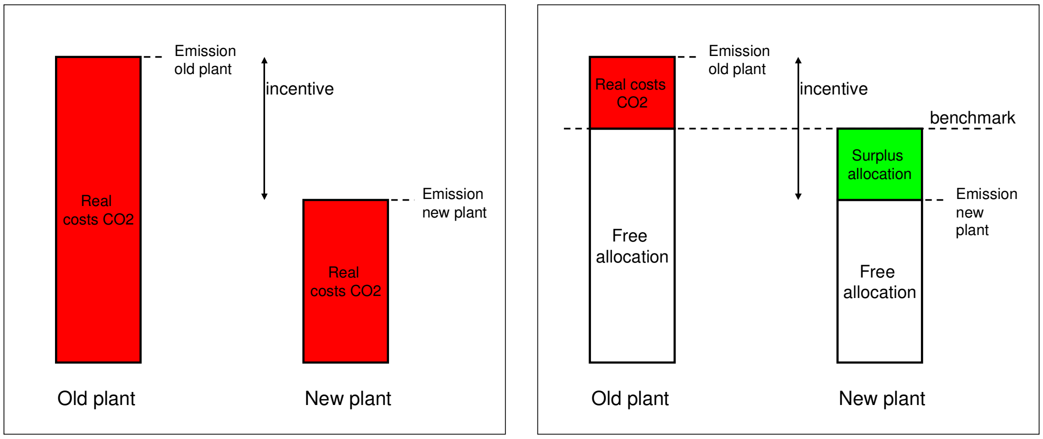

Figure 14 *Illustration of real CO_2-costs or benefits (red, green) for an old plant and new investments, under auctioning (left hand graph) and the IFIEC method (single benchmark, right hand graph). In the example, the new plant has a 50% lower CO_2 emissions per MWh.*

IFIEC method: fuel-specific benchmark

For the IFIEC method with fuel-specific benchmarks, total costs of new and standing plants compare as follows:

$$TC_{old\ plant} + pCO_2*(EF_{CO2,old\ plant} - benchmark_{CO2,old\ plant}) = TC_{new\ plant} - pCO_2*(benchmark_{CO2,\ new\ plant} - EF_{CO2,new\ plant})$$

The CO_2 price at which new investments become attractive equals:

$$pCO_2 = (TC_{new\ plant} - TC_{old\ plant}) / (EF_{CO2,old\ plant} - EF_{CO2,\ new\ plant} – [benchmark_{CO2,old\ plant} - benchmark_{CO2,new}])$$

In the case of replacement of an old coal fired plant by a new gas fired plant, the extra 'benchmark' term in the denominator of the above equation causes a rise of the CO_2 price at which new investments in the gas plant become attractive. In other words the fuel-specific benchmark reduces incentives for new investments in fuel shift. This is because fuel-specific benchmarks reduce the cost-advantage of a new gas fired plant. This is also shown in Figure 15 (left-hand side).

In case a new gas or coal plant replaces and old plant with the *same* fuel input, the old and new plant have the same benchmark and the above equation simplifies to:

$pCO_2 = (TC_{new\ plant} - TC_{old\ plant}) / (EF_{CO2,old\ plant} - EF_{CO2,\ new\ plant})$

Here, incentives remain similar to auctioning or the single benchmark application of the IFIEC method. See also Figure 15 (right-hand side).

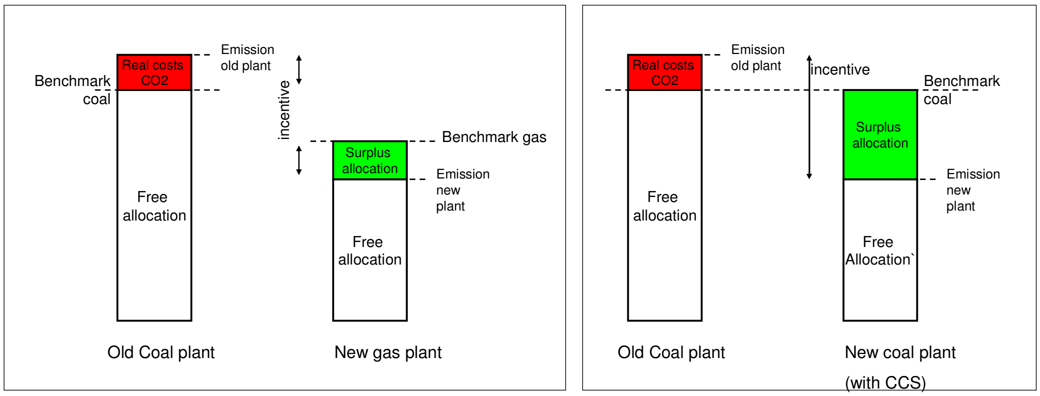

Figure 15 *Illustration of real CO_2-costs or benefits (red, green) for the replacement of an old coal plant by a new clean gas plant (left-hand illustration) or coal fired power plant (right-hand illustration). The allocation is based on the IFIEC method using fuel-specific benchmarks. In the example, the new plant has a 50% lower CO_2 emissions per MWh.*

Grandfathering

A majority of Member States uses some benchmarking approach for new entrants in EU-ETS (Ecofys et al, 2008). Still, under current EU-ETS rules Member States have great freedom in establishing country specific allocation rules for new entrants. Under grandfathering, Member States have the option to allocate a surplus of allowances to new low-CO_2 power plants, to allocate precisely the quantity of required allowances for free and thus create no real CO_2-costs, or even to allocate a shortfall of allowances to new low-CO_2 entrants. In fact, this wide variety of allocation rules to new entrants is indeed applied in different Member States (see e.g. Matthes et al., 2005).

For grandfathering, total costs of new and standing plants compare as follows (see also Figure 16):

$$TC_{old\ plant} + pCO_2*(1\text{-}cf)*EF_{CO2,old\ plant} = TC_{new\ plant} - pCO_2*S$$

With

cf = correction factor, e.g. 90%, applied to historical emissions

S = surplus or shortfall allocation to new entrant

The value of S can vary and can either create either a surplus (benefit) for the new entrant or a shortfall (real cost). Figure 15 illustrates three variants of allocation to new entrants.

From the previous equation, it follows that:

$pCO_2 = (TC_{new\ plant} - TC_{old\ plant}) / ((1\text{-}cf)*EF_{CO2,old\ plant} + S)$

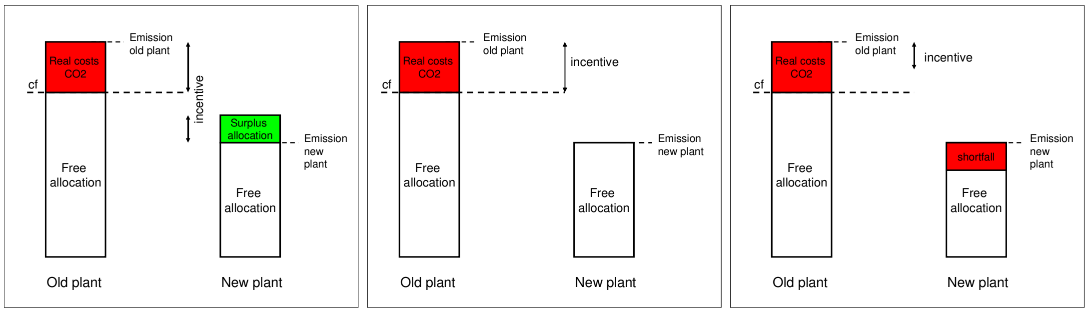

Figure 16 *Three examples of new entrants provisions under grandfathering. See main text for explanation.*

When one compares Figure 16 with Figure 14, it is clear that incentives for low-CO_2 new entrants under grandfathering are lower than under auctioning and the IFIEC method (single benchmark). Matthes et al. (2005) showed that in practice, for phase-I of EU-ETS, no Member State was able to apply grandfathering to new entrants without creating distorting low-CO_2 incentives in EU-ETS.

The previous analyses are illustrated by some quantitative examples in Table 6. Inputs to these calculations are given in Appendix 1.

Table 6 *Illustrative calculations of the CO_2 price (€/t-CO_2) at which it becomes financially attractive to replace old plants by new ones.*

	Auctioning	IFIEC method single benchmark	IFIEC method fuel-specific benchmark[1]	Grand-fathering[2]
CO_2 price for old coal-to-new coal-switch	146	146	146	180
CO_2 price for old coal-to-new gas-switch	38	38	51	222
CO_2 price for old gas-to-new gas-switch	40	40	40	80

[1] in the case of a single benchmark a value of 0.66 t-CO_2/MWh is used, in the fuel specific case this is specified into a benchmark of 0.74 for coal and 0.59 for gas.
[2] the example is calculated for the situation where the new entrants receives precisely the amount of allowances required for production, see middle illustration in Figure 16

New entrant and closure rules?
The current system of grandfathering requires rules to deal with new entrants and closures, like; what is the size of the allowances reserve set aside for new entrants, to what extend do low-carbon new entrants receive excess allowances, will allowances allocated to an installation removed or transferred to a new existing installation?, etc.. Such rules have been set on the Member State level and have introduced many arbitrary and non-harmonised features in EU-ETS (Matthes et al., 2005; 2007). In the case of auctioning and the IFIEC method, new entrants reserves and closure rules are not necessary because decisions about purchase of allowances (auctioning) or free allocation (IFIEC) is based on a system that gradually integrates and includes new installations and closures. In both systems the overall cap is set and the prices are determined on the changes in demand for the allowances such that new entrants and closures are implicitly included.

Conclusions

In this chapter we concluded that the IFIEC allocation model, provided that a single benchmark is used, and auctioning give the same incentives for investments in new clean power plants *within* the EU-ETS. Also, these methods do not require special new entrant and closure provisions. These allocation methods are therefore superior to the currently applied grandfathering.

In the next two paragraphs we will take a broader view and evaluate impacts of the allocation methodology on incentives (partly) outside the EU-ETS scheme; nuclear and renewable electricity generation (paragraph 4.4) and electricity savings by electricity users (paragraph 4.5).

4.4 Nuclear power production and renewables

The economic rationale behind the EU-ETS scheme is that the price of emissions should be reflected in final prices, to encourage lower consumption, and producers use their increased profits (producer surplus) to invest in cleaner power production (Reinaud, 2007). Such investments will on the longer term change the merit order of power production and consequently decrease power prices. Important modes of low-carbon power production are nuclear power and renewables, which are not included in the ETS scheme, but do receive important incentives from the system.

Nuclear power production

In the existing power market, nuclear energy may receive large financial profits from EU-ETS as their so called producer surplus increases. Nuclear power producers produce at low variable costs and have no CO_2-costs. They therefore optimally profit from the fact that marginal, prices setting, fossil fuelled plants will pass-through their CO_2-costs into the electricity price (see *textbox* for an estimate of producer surplus of nuclear power producers under the IFIEC method)[14].

This extra producer surplus is no incentive for extra nuclear powered production from standing plants, as standing nuclear power plants already run 'full power' (except for maintenance or unexpected shutdowns). However, the extra producer surplus is an incentive for investments in new nuclear power plants. E.g. Lise et al (2008) show by means of a modelling analysis that indeed under CO_2-restrictions nuclear technologies are an attractive option for future investment. Others argue, however, that such ideal economic response is not likely to occur in France, as nuclear power capacity in France would need to double in order to affect prices on the interconnected European markets, which seems unlikely because of political restrictions on investments in new power plants (Finon and Glachant, 2007). Also, the large, and increasing, production surplus of nuclear power producers, e.g. EdF, may lead to market concentration, i.e. less and larger producers on the power market, that threatens market competition. Lise et al. (2006, 2008) illustrate that electricity prices can rise considerably when market power is exercised.

The textbox below gives an example calculation of the reduced producer surplus for nuclear power producers under the IFIEC method. Whether the large producer surplus under auctioning (or grandfathering) should be regarded as a negative incentive that leads to market concentration and an unlikely further growth of nuclear power or a positive incentive for increased long-term investment in this low-carbon technology, is beyond the scope of our study.

[14] Note: a similar line of reasoning can be applied to the large-hydro power sector.

IFIEC method reduces producer surplus of nuclear power

Under the IFIEC method electricity prices, as set by fossil fuel based electricity generation, increase less than under auctioning and grandfathering. This results in a lower producer surplus for the nuclear power sector in the EU. The decrease of producer surplus for nuclear power producers, when the IFIEC method is applied to electricity producers within the ETS-scheme, can be calculated according to equation [3]:

Δproducer surplus $\text{nuclear}_{\text{IFIEC vs other}}$ =
nuclear power production (TWh) * Benchmark (CO_2/TWh) * pCO_2 (€/ton CO_2)

Here, the benchmark refers to the fossil fuelled power producers within the ETS scheme.

Taking 2005 nuclear power production data (1000 TWh: Eurostat) and a range of possible benchmark and CO_2 prices this calculation results in the range of cost estimates shown in Table 7. Expressed in € per MWh, the reduction of the producer surplus ranges between 7.8 and 31 €/ton CO_2 (see also paragraph 3.4).

Table 7 *Reduced producer surplus for nuclear power production in the EU-27 (billion €): IFIEC method compared to auctioning or grandfathering.*

scenario*:	-20%	-30%	-40%
Benchmark (ton CO_2/MWh):	0.515	0.455	0.39
CO_2 price (€/t-CO_2)			
20	*10.3*	*9.1*	*7.8*
40	*20.6*	*18.2*	*15.6*
60	*30.8*	*27.2*	*23.3*

*CO_2 reduction in 2020 compared to 2005 of the ETS electricity sector

This estimate is valid as long as:
- A fossil fuelled based plant is marginal and determining the electricity price.
- The marginal power plant is able to pass-through its CO_2 (opportunity) costs fully into the power price.
- A single sectoral benchmark is applied in the IFIEC model.

Renewables

Hereafter, we qualitatively assess the impact of the different allocation methodologies on incentives for renewable energy (which is outside the ETS scheme)[15].

Short term incentives

The cost price of most renewables in the EU currently is still higher than the wholesale electricity price (Optres, 2007). In a number of Member States specific support schemes exist to overcome this cost difference and promote the growth of electricity from renewables (e.g. Optres, 2007). Under these conditions, the costs or volume of renewable techniques are in principle independent of the allocation method that is applied to the ETS

[15] Assessment of the overall cost balance of different routes to promote renewables (e.g. via a CO_2-component in the electricity price of fossil fuel based production, or via support schemes for renewables) was beyond the scope of this study.

sectors. So, on the short term, the incentives that arise from ETS might not affect renewables.

Figure 17 illustrates, for the German system of feed-in tariffs, that a lower wholesale price of electricity in case of application of the IFIEC method, leads to extra costs for consumers through the 'premium' that they pay for the guaranteed feed-in tariff for renewable electricity producers. These extra costs for consumers, however, are less than the cost advantage they receive from the lower wholesale price. So, there remains a net cost-advantage for consumers under the IFIEC method. There is a longer term trade-off, however, see *next*.

Long-term incentives
On the longer term the costs of electricity from renewables source are likely to reduce to levels of or below the wholesale electricity price and will be able to compete with current technologies. For example costs of wind-powered electricity production have halved between 1990 and 2005 and prices of on-shore wind powered electricity are reaching down to levels comparable with (fossil fuelled) wholesale market prices (Optres, 2007).

In a situation where auctioning or grandfathering is applied to the ETS-sectors, electricity prices will rise compared to application of the IFIEC method and (decreasing) production costs of electricity from renewables will sooner reach to market-conform levels. As a result, a situation of a free and competitive electricity market including renewables will be reached sooner when auctioning or grandfathering is applied to the ETS-electricity sector.

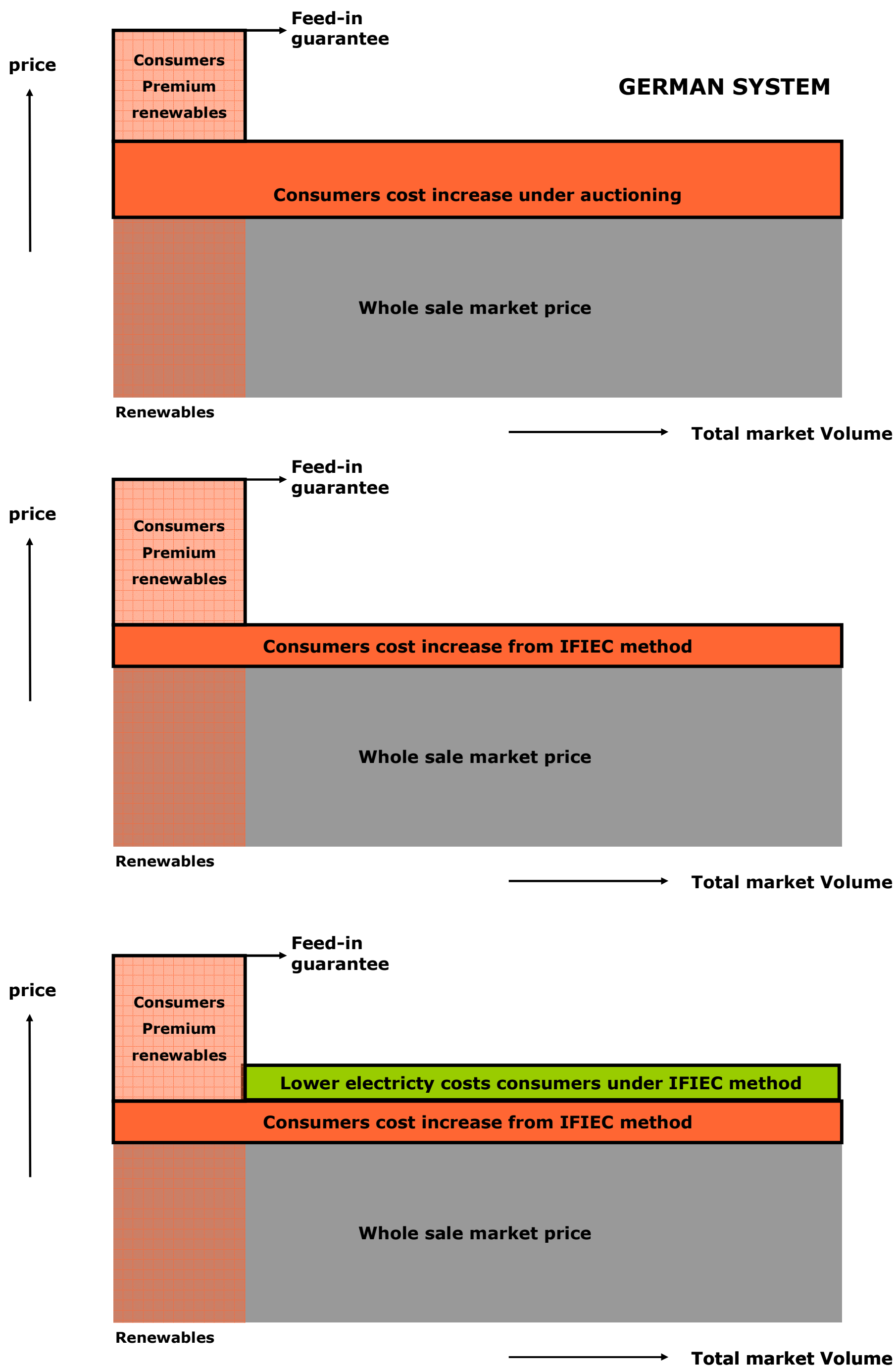

Figure 17 *(stylised) Animation of electricity costs for consumers in Germany, under auctioning (upper figure) and the IFIEC allocation method (middle figure). The green bar in the lower figure indicates the net electricity cost reduction for consumers under the IFIEC method.*

4.5 Electricity users

In this paragraph we discuss the impacts of the IFIEC method on electricity users; households & services and industrial users. Here, two parameters are of special interest, i) the sensitivity of electricity consumption levels to increasing electricity prices and ii) the risk of losing market-share to competitors outside the EU(-ETS).

Households and services

The additional costs of carbon passed through in electricity prices provides a stimulus to save electricity for those purchasing electricity. As such, the IFIEC method provides lower incentive for electricity saving than other allocation methods. Note, that a lower stimulus for electricity savings, and a resulting increase in demand, does not increase CO_2 emissions from electricity generation, because their cap is maintained, see paragraph 2.2.

Price elasticity

The price elasticity of energy use is the relative change in use upon a relative change in energy price. A price elasticity of -0.1 means that an increase of the energy price with 1% will lead to a decrease of energy use with 0.1%. Jeeninga (ECN, 2001) and Linderhof (UG, 2001) have extensively researched foreign literature on elasticity of gas and electricity use of households. These studies give a very wide range of results, as results depend strongly on the methodology to derive elasticity (e.g. bottom-up or top-down), the number of explanatory variables, the (length of the) time period investigated and the electricity price level in those periods. Establishing 'the' price elasticity of electricity use of households remains therefore an expert opinion. ECN (2001) derives average values of -0.15 for the short term and of -0.25 for the long term. Ecofys (2004) used a value of -0.1 to calculate policy effects of a 7 year period.

Based on Ecofys' experience in this field, we used a price elasticity of -0.1 to calculate the extra CO_2-reductions and costs involved for the electricity sector to compensate for the lost incentive for electricity savings by households, when the IFIEC method is applied (see *textbox*).

Note, that though the Commission regards appropriate and cost-reflective price signals as essential for improving energy efficiency (EC, 2006d), its policy focus is on EU directives with requirements on end-use efficiency & energy services, eco-design of energy-using products and energy labeling of domestic appliances. These directives should improve the performance of for example boilers, electronics and ligthing and increase consumer's awareness of these products.

Lower price signal for households creates fairly small economic inefficiency
Previously, we calculated the loss of electricity price-incentive under the IFIEC method, compared to auctioning or grandfathering in a range of 7.8 to 31 €/MWh (see paragraph 3.4). This translated into savings of households on their final electricity bills, including taxes, of some 5-20%. As an average indication, we assumed that the IFIEC method results in a 10% lower electricity bill for households and services, compared to EU-ETS with auctioning or grandfathering.

At an assumed price elasticity of -0.1, such price decrease would create a 1% increase in electricity demand. On the level of the EU-27, a 1% increase in electricity demand of household & services in 2005 equals 15 TWh (source: Eurostat). When the (future) electricity sector under EU-ETS performs at an average emission intensity of 0.515 Mt-CO_2/TWh (see Table 2), the lost incentive at the electricity consumers side means that the electricity sector has to reduce an extra 7.7 Mt of CO_2 (15TWh * 0.515 Mt-CO_2/TWh).

The amount of 7.7 Mt is a small extra reduction compared to the overall reduction effort of the electricity sector (in Table 11 estimated at 273 Mt CO_2 in the 21% reduction scenario). Also, the extra CO_2 abatement costs for these 7.7 Mt involved, because of missed measures in households that are cheaper than the abatement measures in the electricity sector, would be quite small in relation to the overall CO_2 reduction costs of the electricity sector. For example if we assume an EU-ETS market price of 40 €/t-CO_2, then the most expensive measures taken by households would have been taken at this price. The average costs may be somewhere between 0 and 40 €/t-CO_2, e.g. 10 €/t-CO_2. The extra costs would then be 7.7 Mt-CO_2 * (40-30) €/t-CO_2 = € 231 mln. This is a small amount of money compared to the electricity cost savings for households and services when the IFIEC-method is applied (although amounts have a different character).

Industrial electricity users
The additional costs of carbon passed through in electricity prices provides a stimulus to save electricity for those purchasing electricity. As such, the IFIEC method provides lower incentive for electricity saving than other allocation methods. Again note, that a lower stimulus for electricity savings, and a resulting increase in demand, does not increase CO_2 emissions from electricity generation, because their cap is maintained, see paragraph 2.2.

Price elasticity
Sectors that produce commodities like steel, aluminum, plastics and paper are energy intensive and generally produce for a worldwide market (EC, 2008b). Their response to energy prices is very elastic, though precise data are very hard to obtain. Global, and often complex, economic models are required to estimate the net impacts on sectors of unilateral increasing energy/electricity prices, responding increase of electricity saving measures (to limit the increasing electricity costs) and the overall result on their market position, compared to competitors outside EU-ETS. A loss of market share to non-ETS participants outside the EU runs the risk of a more than proportional emissions increase outside the EU due to less stringent regulations elsewhere (so called ‘carbon-leakage’).

As an illustration, results of such a model exercise are shown in Table 9, where CPB (2003) calculated the consequences of a 6.5% electricity price increase, resulting from the introduction of EU-ETS in the electricity sector, for production of basic industries in

Western Europe[16]. Input to this exercise are so-called import and –export elasticities, see Table 8 (CPB, 2000).

Table 8 *Price elasticity of export and import of raw materials in Western Europe (CPB, 2000; CBP/RIVM, 2001)[a].*

	Export	Import
Steel	-4[b]	2
Aluminum	-3	2
Petrochemicals (monomers)	-5	4
Petrochemicals (polymers)	-5	2
Paper	-2	2
Nitrogen fertilizer	-4	4
Phosphorous fertilizer	-4	4

a) data for Western Europe do not necessarily extrapolate to the EU-27.
b) example calculation: a 5% increase of cost of steel production in Western Europe (relative to other regions) leas to a decrease of export to a level of 100/(100+5*4)=83%, so a decrease in export of 17%.

Table 9 *Consequences of electricity price increase of 6.5% on production levels in basic industries (CPB, 2003)[a].*

	Total production	Primary production	Secondary production	Energy use
Steel	-2.5	-5	0.5	-5
Aluminum	-2	-4	0.5	-6
Plastic	-2	-2	n.a.	-4
Paper	-0.25	-0.5	0.25	-5
Nitrogen	-2	-0.4	n.a.	-4

a) calculations were made on the scale of Western Europe, which compared probably to the EU-15. Calculations on the EU-27 scale would result in lower reductions of production levels in response to ET ETS-induced increases in electricity prices.

Conclusions

This paragraph showed some consequences of increasing electricity prices under EU-ETS. The IFIEC method, which limits electricity price increases, also limits incentives for users to save electricity. We expect, however, a limited response of 'small' electricity users to price increase. The economic inefficiency created appears to be fairly small and other instruments might be more effective in stimulating electricity savings by households than ETS-based electricity price increases.

By means of a modelling example from literature, we illustrated the sensitivity of the energy intensive industry for production as a result of electricity price increases. In the next paragraph 4.6 we will list policy options that can reduce the risks on competitiveness loss, while maintaining incentives for electricity savings by industrial users.

[16] Note, that we calculated possible electricity price effects of the IFIEC method of 10-30% (paragraph 3.4). The quantitative examples in this paragraph (Table 9) suggest that such price effects may indeed have a strong effect on competitiveness. However, the size of these impacts, at a 10-30% electricity price increase, should not be extrapolated from Table 9.

4.6 Variants on the IFIEC method

In this paragraph we shortly discuss allocation variants that are related to the IFIEC method. The variants aim, like the IFIEC method, to reduce the competitive disadvantage for industry, while maintaining environmental incentives. The practical feasibility of implementing these variants was not investigated.

Recycling of auctioning revenues to electricity *producers*
Auctioning has the effect that each plant has to buy emission allowances according to its emission intensity (gas plants buy fewer allowances, coal plants buy more). So the carbon costs of the plants reflect their emission intensities and the cost differences reflect the emission intensity differences (Figure 18, left-hand icon).

The IFIEC method gives each plant an amount of allowances (per production unit). This way, the absolute costs are reduced (which leads to net income for gas plants), but the cost differences stay the same (Figure 18, right-hand icon). The IFIEC method could therefore be seen as a "production-and-benchmark-relative" revenue recycling. Auctioning of allowances during a calendar year T and recycling of auctioning revenues to electricity producers up to the level of [$production_T$ x $benchmark_T$] results in production and electricity costs increases that are precisely the same as in the IFIEC method (see Figure 18, from left to right).

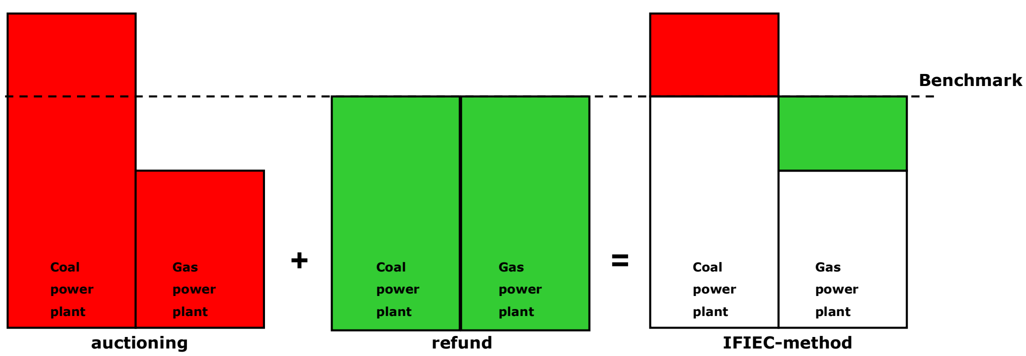

Figure 18 *Auctioning (left) plus refunding of revenues, based on actual production levels and benchmark (middle), equals the IFIEC method (right).*

The processes of the IFIEC method and auctioning-with-revenue-recycling-to-producers are of course very different from each other, most notably because costs and revenues occur at different times in the latter. However, if well organised the net effects for the plants in terms of cost increases could be (very much) the same, i.e. the electricity price increase will be limited and windfall profits may not occur.

This variant resembles tax-and-refund systems, as for example applied in NO_x-abatement in Sweden (Sterner and Höglund Isaksson, 2006).

Extra allocation of allowances to industrial electricity users

In this variant, industrial electricity consumers receive extra CO_2 allowances, to compensate for their loss of competitiveness due to increased electricity prices. The number of allowances that the electricity sector has to obtain via an auction, would decrease accordingly[17]. This variant is also known as "indirect" allocation, or allocation based on indirect CO_2 emissions of electricity users. The overall number of allowances that becomes available for industry (excluding the auctioned allowances for the electricity sector) would be based on sectoral benchmarks that include direct emissions (the "normal" allocation) *and* indirect CO_2 emissions from electricity use (the "indirect" allocation). Thus, electricity users receive an incentive for electricity savings via a benchmark approach rather than via the (increased) electricity price.

Recycling of auctioning revenues to the exposed industrial consumers of electricity

As an alternative to the previous variant, revenues from auctioning in the electricity sector could be recycled to industrial electricity consumers, in order to compensate for their loss of competitiveness due to increased electricity prices. To maintain an incentive for electricity savings, such recycling could again be based on sectoral benchmarks for industrial electricity users. Note, that such auction revenues may differ strongly per member state, dependent on their CO_2-intensity of their electricity generation. For example France may not receive enough revenues to compensate industrial electricity users.

[17] Some 40%, 1127 MWh, of total electricity use in the EU-27 is by industry (see Table 4). In the case where all these users would receive compensation allowances for their electricity use, a number of allowances of 1127 MWh * 0.515 Mt-CO_2/TWh = 580 Mt CO_2, would be available for compensation. Here, the value of 0.515 is the benchmark value for the electricity sector in 2020 in the 21% reduction scenario (Table 11). This volume of allowances of the electricity sector would not be auctioned, but rather allocated free of charge to exposed industrial electricity users based on benchmarks for efficient electricity use. Note, that in practise not all industrial users are exposed to international competition, so the volume of allowance required to compensate those electricity users that are exposed, might be (much) smaller than the 580 Mt example give here.

5 Uncertainty analysis

A principle difference between auctioning/grandfathering and the IFIEC method is, that in the latter case the benchmark may need to be adjusted during a trading period, in case the actual production of the sector is higher than expected. The method to do this was explained in paragraph 2.2. In this chapter we look into the possible extent of benchmark adjustment (paragraph 5.1) and elaborate on its potential impacts on market liquidity (paragraph 5.2).

Note, that we focus in this chapter on a rather specific aspect of uncertainty in EU-ETS; the benchmark adjustment. More in general, uncertainties with respect to future scarcity on the carbon market depend on many factors (cost development of low-CO_2 techniques, fuel prices, volume and price of CERs, etc.[18]). The uncertainty in these factors is in principle the same under any allocation system, provided that the total cap is the same.

5.1 Uncertainty in benchmark development

The general principle of the ex-ante calculation of a time series for a single benchmark for the electricity sector under EU-ETS was shown in paragraph 2.2 (Figure 2): a benchmark time series is derived from a policy decision on a future CO_2 cap and an electricity production scenario for the power sector under EU-ETS. For policy makers as well as ETS-participants, it is relevant to know the level of uncertainty in the electricity production scenario, as this determines the level of possible future adaption of the benchmark that might be required to maintain the cap (in case actual electricity production is higher than assumed in the scenario).

In this paragraph we therefore elaborate on three questions:

- What are future benchmark values for the power sector in EU-ETS, under different cap scenarios?
- What is the uncertainty in the electricity production scenario from which the benchmark is derived?
- And related to that, what is the necessity and extent of possible future adjustment of the benchmark in case actual production deviates from the ex-ante scenario?

For this purpose we use scenario results from PRIMES as used by the European Commission (EC, 2006a, 2006b). As a reference development, we took the PRIMES *base line* scenario (EC, 2006a). In line with the baseline philosophy, policy initiatives related to climate change are included only to the extent that they are agreed policy measures up to 2004.

[18] As an illustration, Point Carbon 13 March 2008: "European carbon prices will rise to a range of €50-70 by 2020, carbon market analysts told a Copenhagen conference on Wednesday, although they disagreed over the reasons behind the bullish sentiment."

The Primes base line scenario predicts a continues increase of electricity demand and supply in the EU (see Figure 19): 'The increasing number of processes, appliances and applications that can use energy only in the form of electricity, but also issues related to the favorable characteristics of electricity (easy controllability, cleanliness at the point of use, etc.), lead to the increasing use of electricity in the EU-25 energy system. This projection is in line with the well-established long-term trend towards increased electrification in most sectors of developed economies' (EC, 2006a).

The base line scenario predicts only small increases of CO_2 emissions from fossil fuel based electricity production, despite increasing production levels, see Table 10 (base line). This is due to a strong growth of gas fired power production at the cost of coal fired production: 'Technological advances and the progressive deregulation of electricity markets – with smaller companies entering the market preferring plants with shorter lead times, lower capital costs and higher efficiency - are projected to cause significant growth in the use of gas for electricity generation. This is mainly through the extensive use of gas turbine combined cycle units. Thus, installed capacity of gas fired plants is projected to increase dramatically, especially in the period to 2020' (EC, 2006a).

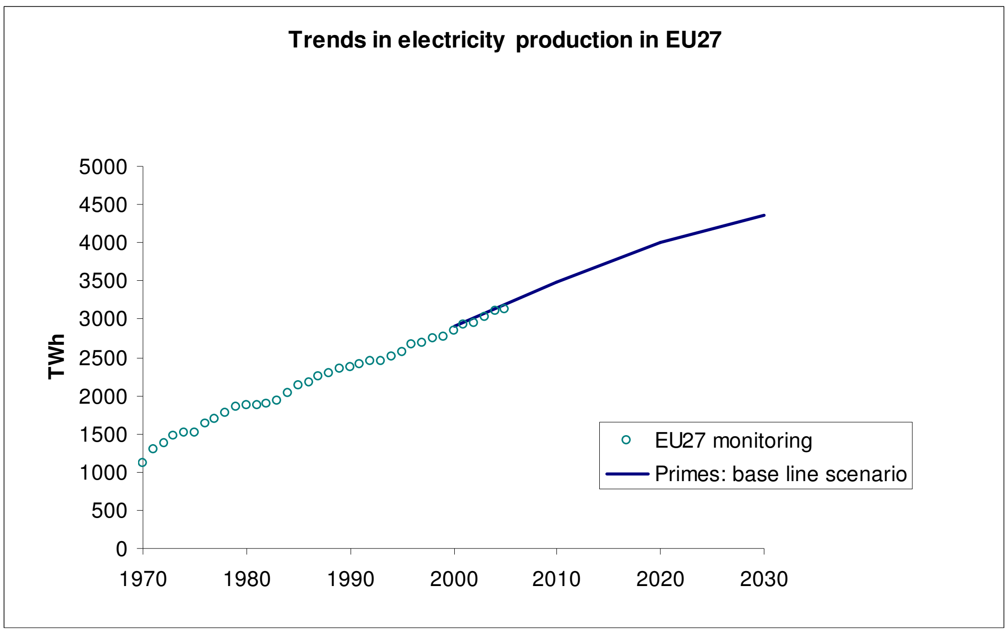

Figure 19 *Trends in electricity production in the EU 1970-2030. Monitoring data are from IEA and Eurostat. Scenario is from Primes (EC,2005).*

Figure 19 illustrates that time trends of electricity production (and consumption) over the 1970-2005 period in the EU are very consistent. As apparent from Figure 19, annual variations in production –e.g. by cold or warm weather or annual changes in economic conditions- are, on the EU-27 level, only very small compared to the overall production trend. We therefore assume that such variations add also little uncertainty to the production scenario. A much larger uncertainty factor is the impact of new climate polices (EC, 2007, 2008a) on future fossil fuel based electricity production.

This is illustrated in Figure 20. This figure again shows monitoring and PRIMES base line predictions, now for fossil fuel based electricity production in the EU-25. The lower uncertainty bound shows the predicted fossil fuel based electricity production in the case of the 'Combined high renewables and efficiency' scenario[19] (EC, 2006b). The assumptions in this scenario compare well to the EU's policy targets of a 20% share of renewable energies in EU energy consumption by 2020 and the goal of saving 20% of energy consumption by 2020 through energy efficiency.

The upper uncertainty bound was tentatively set at some 10% above the base line scenario. PRIMES has actually not produced scenarios above the base line level. Factors that might cause a rise of fossil fuelled electricity production above base line levels are e.g. prolonged incentives for new coal fired power production through so-called transfer provisions[20], closure rules and fuel-specific allocation (Matthes et al., 2005; Lindboe et al, 2007). Note, that the Commission's proposal for revision of the EU-ETS aims to remove these perverse incentives (EC, 2008c).

For our sensitivity calculations we decided not to take the 'extreme' upper and lower poduction bound, but somewhat more realistic values. As the upper bound we chose the base line scenario and as lower bound a production level that remains constant at the 2005 level. The uncertainty bound used or the benchmark calculations is shown by the shaded area in Figure 20.

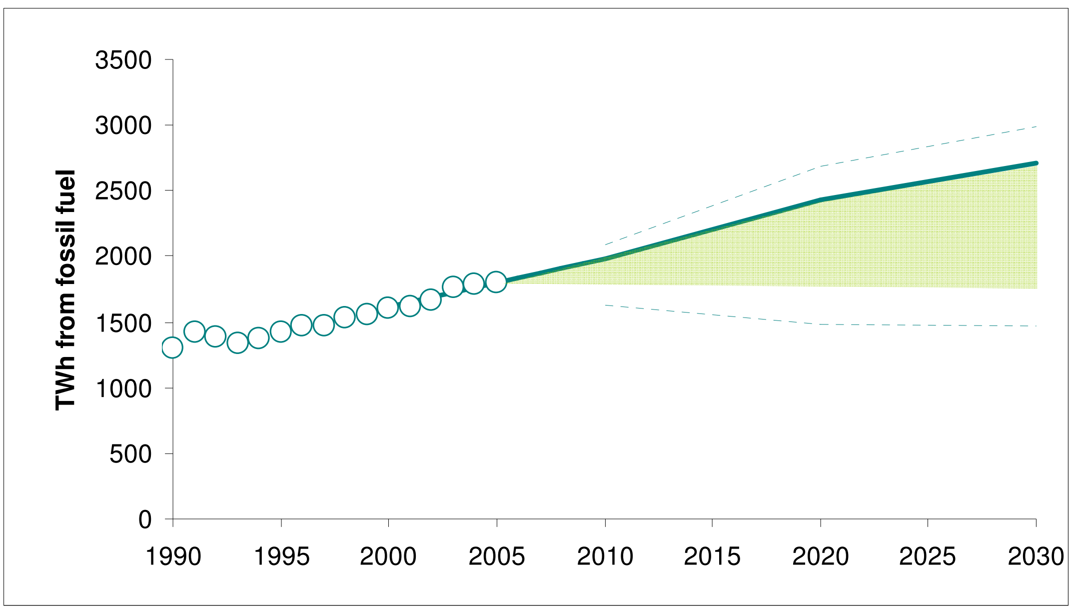

Figure 20 *Fossil fuelled electricity production in theEU25, monitoring data, PRIMES base line scenario (EC, 2006a) and upper and lower uncertainty bounds. Shaded area was used for the calculation of the uncertainty in the future CO_2 benchmark. For explanation, see main text.*

[19] Data are from Figure 1.4-3 (EC, 2006b)

[20] Example of transfer provision in phase I and II of EU-ETS: a new coal plant that replaces an existing one receives allowances up to the level of the old plant. As the new plant is likely to be more CO_2 efficient, the new plant receives a financial bonus.

Table 10 and Table 11 show results of the uncertainty analysis. To reach a 21% emission reduction in 2020, the benchmark should decrease to values between 0.44 and 0.59 t-CO_2/MWh. For reductions down to 40%, the benchmark has to decrease accordingly down to values between 0.33 and 0.45.

Table 10 *Electricity production (fossil fuelled), CO_2 and benchmark scenarios for the EU25. For explanation, see main text.*

Base line	**1990**	**2000**	**2005**	**2020**
TWh (fossil fuelled) base line	1403	1620	1791	2436
CO_2 (Mton)	1363	1295	1342	1333
Benchmark (Mton CO_2/TWh)	0.97	0.80	0.75	**0.55***
-21% CO_2 in 2020 compared to 2005				
TWh (fossil fuelled) base line	1403	1620	1791	2436
CO_2 (Mton)	1363	1295	1342	1060
Benchmark (Mton CO_2/TWh)	0.97	0.80	0.75	**0.44**
TWh (fossil fuelled) –lower bound	1403	1620	1791	1791
CO_2 (Mton of CO_2)	1363	1295	1342	1060
Benchmark (Mton CO_2/TWh)	0.97	0.80	0.75	**0.59**
-30% CO_2 in 2020 compared to 2005				
TWh (fossil fuelled) base line	1403	1620	1791	2436
CO_2 (Mton of CO_2)	1363	1295	1342	939
Benchmark (Mton CO_2/TWh)	0.97	0.80	0.75	**0.39**
TWh (fossil fuelled) –lower bound	1403	1620	1791	1791
CO_2 (Mton of CO_2)	1363	1295	1342	939
Benchmark (Mton CO2/TWh)	0.97	0.80	0.75	**0.52**
-40% CO_2 in 2020 compared to 2005				
TWh (fossil fuelled) base line	1403	1620	1791	2436
CO_2 (Mton of CO_2)	1363	1295	1342	805
Benchmark (Mton CO_2/TWh)	0.97	0.80	0.75	**0.33**
TWh (fossil fuelled) –lower bound	1403	1620	1791	1791
CO_2 (Mton of CO_2)	1363	1295	1342	805
Benchmark (Mton CO_2/TWh)	0.97	0.80	0.75	**0.45**

* the reduction in the benchmark value, compared to 2005, in the base line scenario results from the PRIMES assumptions on further 'gasification', see main text..

Table 11 *Benchmark values at different CO_2 reduction and electricity production scenarios. Summary data of Table 5.*

Benchmark values (Mt-CO_2/ TWh)	**-21% CO_2 emission 2020 compared to 2005**	**-30% CO_2 emission 2020 compared to 2005**	**-40% CO_2 emission 2020 compared to 2005**
High TWh scenario (baseline)	0.44	0.39	0.33
Low TWh scenario	0.59	0.52	0.45
Uncertainty	0.14	0.13	0.12
Average benchmark value[a]	0.515	0.455	0.39

a) these values are used for the costs savings calculations in paragraph 3.4

Conclusion

This paragraph showed, based on the PRIMES scenarios used by the Commission, that the main uncertainty in the scenarios for fossil fuelled electricity production until 2020 come from the future effectiveness of new EU-climate policies.

In the IFIEC allocation method, uncertainty in the production scenario introduces an uncertainty with respect to what future benchmark values (t-CO_2/MWh) are required to maintain the CO_2 cap. Here this uncertainty was quantified to maximum values of 0.12 to 0.14 benchmark units (t-CO_2/MWh).

In practice, the European Commission and industrial stakeholders might face the following considerations to deal with, and reduce, these uncertainties:

- In case the Commission chooses to take a high production scenario as a reference, she fully ensures cap achievement or even over-achievement (in case actual production is lower than expected). On the other hand, in doing so, the Commission would express low confidence in policies outside EU-ETS that aim to reduce fossil fuel based electricity production, like energy savings and renewables policies.
- Power producers in EU-ETS may argue for a low(er) production scenario to derive benchmarks for a trading period, and rather adjust benchmarks in the course of the trading period in case actual production exceeds expectations. This method guarantees cap achievement (for a methodology to do so, see paragraph 2.2), however also introduces an uncertainty for ETS-participants and new entrants, with respect to the precise value of the future benchmark (see next paragraph).

The topic of benchmark adjustment is further discussed in the next paragraph 5.2.

5.2 Liquidity of ETS-market

An efficient carbon market, either European or global, is characterised by a high liquidity and fast and accurate price discovery. In other words, such a market assures that the CO_2 prices truly reflect the costs of the marginal CO_2-reduction option and the chance of mis-pricing is small. In this paragraph we evaluate to what extend implementation of the IFIEC method in EU-ETS might affect liquidity. Here, we refer to the IFIEC method with as single benchmark for the electricity sector.

Here, we define the following aspects of market liquidity. In a liquid market,

- there is a constant and considerable trade volume;
- there are many participants, and these are willing to buy and sell at all times. This increases the probability that many of them will ascribe similar values to the good;
- individual (large) transactions can be carried out timely and do not affect the (short term) price. This is also called a 'deep' market with relative small 'volatility';
- a certain degree of short term price fluctuations is required. A fully predictable market without uncertainties and surprises would not be interesting for liquidity providers like banks. Such fluctuations may arise from a certain degree of uncertainty in production levels, technology developments or weather conditions (e.g. increasing power production levels);
- an acceptable profit-to-risk ratio exists, without strong and unexpected price changes and –most important- with regulatory certainty for the coming years (if not decades).

Could application of the IFIEC method affect the liquidity of the EU-ETS scheme?
This is a complicated question, not in first place because the development of the current, still young, EU-ETS is very much about building a stable and transparent system with low regulatory uncertainty. Suggestions for alternative allocation systems may therefore intuitively receive a negative response as they might undermine the trust in the system. The liquidity aspects discussed below are based on a few interviews with experienced emissions' and electricity traders. The analysis reflects different views on possible impacts of the IFIEC method on liquidity. The analysis is not conclusive.

Trade volume
On first sight interviewees argued that the lack of opportunity costs in the IFIEC method, resulting from the fact that reducing production does not free up allowances to sell on the market, may also reduce the trade volume (dependent on how ambitious the benchmark is set). However, in practice trade activity is not determined by this potential free up of allowances, but rather by surplus or shortage positions of individual participants. As an example, the current EU-ETS is based on (expected) relative *small* surplus or shortage positions of individual participants, already sufficient for a growth in EU-ETS trade volumes from some 320 Mt in 2005 to1600 Mt in 2007 (Point Carbon, 2008). This volume now almost equals the total amount of annual allowed emissions in the system. So in fact, the 'active' part of the market volume -determining the overall trade volume- is likely to be independent of the allocation model, provided that the cap and thus the CO_2 prices are the same.

Liquidity requires a certain degree of short term uncertainty in the ETS
In an auctioning scheme there could in theory be no trading if firms' projections of production and CO_2 emissions for the forthcoming period are exactly correct. In such case, the periodic auctions would be a sufficient platform for firms to acquire their CO_2-allowances for compliance. By contrast, in the IFIEC method the benchmark does always create trade as demand and supply have to meet for compliance (see figure 18, right-hand side; for compliance on the sectoral level, allowances from the 'green' box have to be traded to the 'red' box). If, however, actual production deviates from predictions, e.g. increased electricity production from cold winters or hot summers, its effect on the carbon credit balance of a firm is higher in grandfathering or auctioning schemes than under the IFIEC method. This is because not the full CO_2 emission of each unit (MWh) of production requires extra allowances, but only the amount that exceeds the benchmark emission.

Ex-ante benchmark adjustment: regulatory uncertainty?
Interviewees responded negatively to the possible ex-ante adjustment of benchmarks in the IFIEC system, as this introduces an uncertainty factor: "as a firm you want to know precisely how many allowances you will get or have to obtain". The critical aspect mentioned, was the fact that a possible downward adjustment of the sectoral benchmark is outside the span of control of an individual company. When big firms produce more fossil-fuelled electricity than expected, *all* participants face the resulting consequence of a downward benchmark adjustment: and "this is not fair". It was also argued that power companies purchase their fuel contracts up to 3 years ahead, so they want to do the same with CO_2 allowances, thus they want to know the benchmark in advance for at least 1-3 years. Though the above argumentation is not directly related to liquidity, it reflects a perception that might affect trust in the market as well as investment decisions. In the *textbox* we further explore this uncertainty.

Upward and downward phases in the economy
In a situation where the overall economic or sectoral growth is higher than expected, a situation of unexpected scarcity of CO_2-allowances will occur that increases the pressure on the carbon market. In an auctioning or grandfathering system such increased pressure is forwarded directly into the CO_2 price. Interviewees expected the IFIEC model to respond to a lesser extend and partially delayed because the number of allowances would on the short term be allowed to grow with production and –via the benchmark- adjusted afterwards to maintain the cap. IFIEC, however, proposes its method such that increase of allowances due to unexpected growth and the benchmark correction as a result of that occur at the same moment in the year 'T+2'. This is described in the next paragraph 5.3.

IFIEC method does not introduce demonstrable extra financial uncertainties for firms
Does the IFIEC system introduce extra financial uncertainties for an *incumbent* electricity producer and are these different from a system of auctioning? As discussed in the previous chapter, the extent of the uncertainty in the benchmark adjustment is dependent on the ex-ante production scenario that will be used to set initial benchmark values for the trading period. In paragraph 5.1 we derived uncertainty bounds for the benchmark adjustment. The uncertainty in the benchmark value for 2020 has maximum value of 0.14 t-CO_2/MWh (see Table 11). At a price of 40 €/t-CO_2 this translates into an uncertainty in variable costs of 5.6 €/MWh. This uncertainty can be compared to:

- The uncertainties under a system of auctioning. Such a system faces extra CO_2 costs compared to the IFIEC system, to the amount of: benchmark (t-CO_2/MWh) * pCO_2 (€/t-CO_2) (see equation [3], paragraph 3.2). At a benchmark value of 0.515 t-CO_2/MWh and a price of 40 €/t-CO_2, these extra costs amount to 20.6 €/t-CO_2 (see Table 11). These extra costs also introduce an extra uncertainty, as compared to the IFIEC method, as the future price of CO_2 is not known. To give an example, a future price of 50 rather than 40 €/t-CO_2 already introduces a financial uncertainty under an auctioning system that is equal to the financial uncertainty from benchmark adjustment under the IFIEC system. In other words, when big firms produce more fossil-fuelled electricity than expected, *all* participants face the resulting consequence of an increasing CO_2 price. Thus, uncertainties under the IFIEC and auctioning system are quite comparable.
- Uncertainties in fuel prices, which for example in the period 2005-2007 increased with some 10-15 €/MWh (see Table 5).

Note, that for investments in *new plants*, the possible future adjustment of the benchmark does not affect the overall CO_2-cost advantage of the new plant, which is the same under auctioning or the IFIEC method. This was discussed in paragraph 4.3 and shown in Figure 14.

In a situation where the overall economic or sectoral growth is (much) lower than expected, scarcity on the carbon market could reduce under a cap-and-trade system. The IFIEC method, in which the benchmark is *not* adjusted upwards, guarantees continued technology improvement also at lower economic growth (though in times of recession pressure on politics to increase the benchmark value would be high). Thus, in this situation CO_2 prices under the IFIEC method will probably not fall but maintain at higher levels. If prices are higher (or at least if they are not very low) the transaction costs are lower in relation to the financial risk of a suboptimal allowance position. Because of that, adjusting one's own allowance position is more important, so trading will occur more often and liquidity will be higher.

Ex-ante benchmark adjustment as a control on liquidity?
One interviewee argued that an adjustable sectoral benchmark at the EU-level, under the condition that adjustment are announced timely, could be regarded as a 'control' on a stable price development in EU-ETS and the development of a liquid market. Rather than focusing on precise cap achievement – a typical environmental regulators perspective- a system with adjustable benchmarks could be used to optimise a stable ETS-market, in response to potential instabilities unexpected economic developments but also in response to uncertain developments in CERs from CDM-projects. In such as view, the benchmark should be regarded as an instrument that could not only be adjusted downwards, but also upwards.

Conclusions
In this paragraph, we discussed certain aspects of liquidity as brought forward by interviewees. The perception of interviewees that the IFIEC method introduces additional uncertainties, with negative impacts on liquidity, could not be confirmed by theory. Again note, that we only looked at a rather specific aspect of uncertainty in EU-ETS. Other uncertainties may have a higher impact on the future liquidity of the EU-ETS market, such as uncertain cost development of low-CO_2 techniques, fuel prices and volume and price of CERs. These uncertainties are in principle the same under any allocation system, provided that the cap is the same.

5.3 Monitoring and compliance cycle

Here, we consider the following steps in the compliance cycle of EU-ETS; issuance of allowances, monitoring and reporting of emissions, ex-post correction of allowances and the surrendering of allowances. The subsequent steps are also shown in Figure 21.

Issuance of allowances
The annual issuance of allowances in the IFIEC method would be the same as under the current issuance under grandfathering and has to happen at 28 February of each year. So an EU ETS installation will receive the allowances for the year 2009 at 28 February of that same year. Note, that the IFIEC method requires that issued allowances for EU-ETS installation are updated each year[21], whereas in the current national allocation plans these are set for the whole trading period.

Monitoring and reporting of CO_2 emissions
Each installation under the EU ETS requires a permit to operate. The monitoring protocol is the central part of this permit. The protocol contains a detailed description of the CO_2 sources in an installation, the way fuel use is measured and the estimated accuracy of those measurements. When the IFIEC method is applied, one specific parameter has to be added to the monitoring protocol; this is the annual production level to which the benchmark value relates (in case of electricity generation this refers to the MWhs of electricity generation). This is a simple provision that does not impose an additional monitoring burden[22]. Each year, before 31 March, the operator of an EU ETS installation has to report the amount of CO_2 emissions that have been emitted in the previous year *and* the production level that was realised.

Ex-post correction of allowances
The IFIEC method introduces one additional step in the compliance cycle. After the monitoring report over the foregoing year T has been published (before 31 March of year T+1) the quantity of CO_2-allowances over the foregoing year T are 'ex-post' corrected based on realised production levels in that year:

[21] See proposed method in paragraph 2.2.
[22] Conclusion drawn from the Dutch NOx-trading scheme, in which the IFIEC method is applied.

CO_2 allowances$_{T,.final}$ (t-CO_2) = benchmark$_T$ (t-CO_2/MWh)* production$_T$ (MWh)

This means that installations may have to give back allowances or may receive extra allowances, such that they receive for each realised production unit in year T (MWh) an allowance amount equal to the benchmark of that year (t-CO_2/MWh). To avoid an extra administrative step this ex-post correction is actually executed at 28 February of T+2, together with the issuance of new allowances for the year T+2 (see Figure 21)[23]. In this way, the ex-post adjustment towards actual production is always executed at the same time with an adjustment of the future benchmarks, if needed. With these repeated ex-ante allocations the total cap of a trading period is never exceeded.

Surrendering of allowances

In the final step in the compliance process, (verified) emissions of EU-ETS installations have to be matched with an equal amount of allowances. This is called 'surrendering' of allowances. Each EU ETS installation has to surrender the allowances (of the previous year) before 30 April of the ongoing year. This process would be the same regardless which allocation mechanism EU-ETS applies.

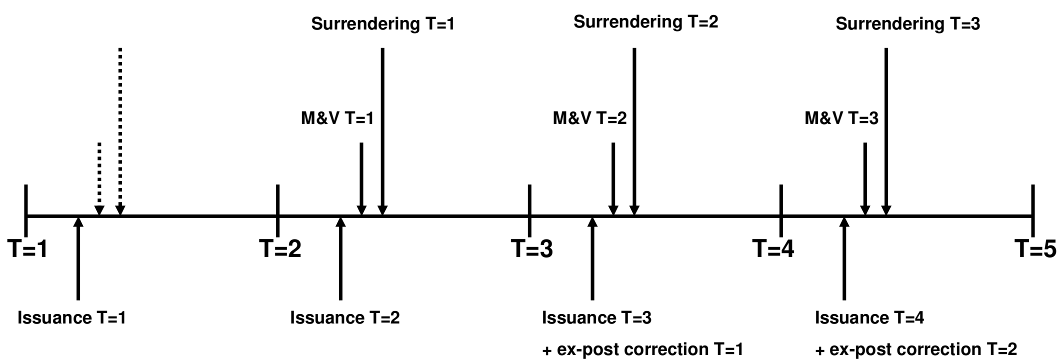

Figure 21 *Subsequent steps in the compliance cycle (M&V is monitoring and verification, for further explanation see main text).*

Conclusion

The IFIEC method does not increase the monitoring task for operators of EU-ETS power plants. The ex-post correction of allowances, however, does introduce an extra step in the compliance cycle. Note, however, that the organization of the auctions and possible recycling mechanisms also creates such extra so-called transaction costs. We did not assess and compare these extra transaction costs.

[23] Note, that this additional step in the compliances cycle could be timed differently. Execution of the ex-post correction in T+1 would, however, introduce an extra administrative step. On the other hand, no ex-post correction would be required when all allowances are issued ex-post, based on actual production, rather than corrected ex-post. This occurs under the Dutch NO_x trading scheme. This mechanism however requires special provisions with respect to the operator holding account of an EU-ETS installation.

6 Summary and conclusions

IFIEC Europe has developed an alternative allocation methodology for EU-ETS which aims at achieving the ETS climate targets while minimizing the adverse effects on EU industry's competitive position. The IFIEC method allocates allowances free of charge, based on actual production and a benchmark. The current study reviewed an application of the IFIEIC allocation method to the EU-ETS electricity sector.

This is different from the methods of auctioning and grandfathering in which the full costs (either real costs or so-called opportunity costs) of all CO_2 emissions are passed through into the electricity price. As a result, application of the IFIEC method reduces electricity costs for end-users in the order of, on average, 10-30% of industry's electricity bills and 5-20% of household bills.

Within EU-ETS, the IFIEC method provides the same environmental incentives as auctioning and better incentives than the current system of grandfathering, provided that a single (not fuel-specific) benchmark is used for all electricity producers under EU-ETS. The lower electricity prices that result from the IFIEC approach, however, reduce the incentive for some low-carbon measures to be implemented outside EU-ETS. Though the IFIEC method introduces an uncertainty -the possible adjustment of the benchmark at T+2- compared to the systems of grandfathering or auctioning, we showed that this does not increase the overall uncertainties in the emission trading scheme.

In summary, the IFIEC method efficiently promotes clean production within EU-ETS, but has no, or limited, effect on production and consumption decisions in other parts of the economy. This is a crucial difference with a system of auctioning, which affects other parts of the economy via the (increased) electricity price and recycling of auctioning revenues (e.g. to further incentives for a low carbon economy, compensation for loss of competiveness for exposed industry or tax measures that feed back to households). This difference is once more illustrated in Figure 22.

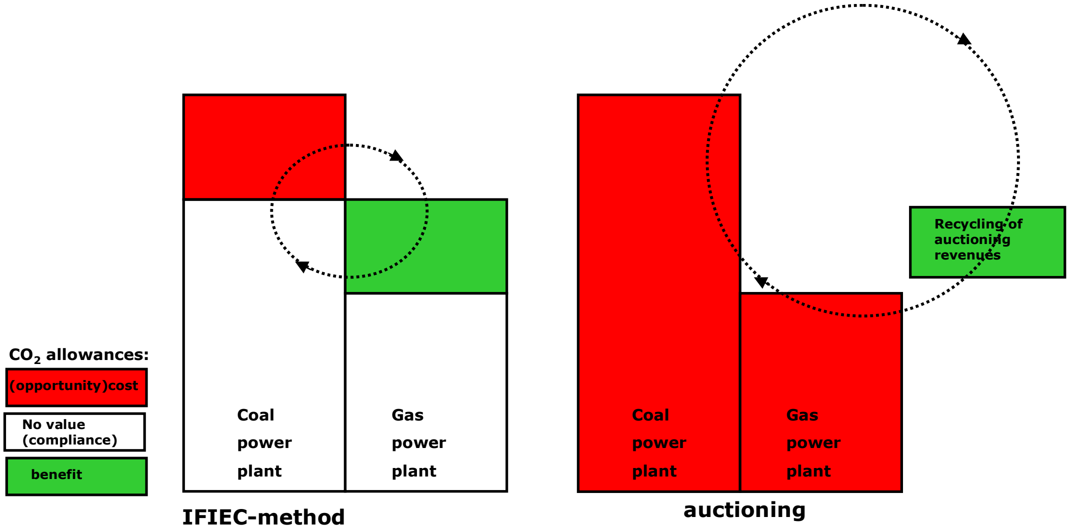

Figure 22 *Illustration of the CO_2 costs and benefits in the IFIEC system (short-cycle) versus an auctioning system (long-cycle).*

The current study focuses on the electricity sector, for which the Commission foresees full auctioning from 2013 on (EC, 2008c). Lessons from our study may, however, also be applicable to other, exposed, sectors for which a certain degree of free allocation and a benchmark approach are suggested by the Commission. Such lessons are e.g.:

- A single output-based benchmark per sector can provide undistorted low-CO_2 incentives.
- Free of charge allocation as proposed in the IFIEC method can prevent the occurrence of opportunity costs.
- Compensation of exposed industry for higher electricity bills could be based on the principles of the IFIEC method, and designed as follows[24]:
    - Recycling of auctioning revenues to electricity *producers,* relative to their CO_2 performance (resembling a tax-and-refund system). In a fully competitive electricity market, this would reduce electricity prices, in theory down to the prices governed by the IFIEC method.
    - Extra allocation of allowances to exposed industrial *electricity consumers* relative to their electricity-use performance (“indirect” allocation, based on benchmarks).
    - Recycling of auctioning revenues to exposed *electricity consumers,* relative to their electricity-use performance.

[24] Such variants were only briefly, and theoretically, touched upon in this study.

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Appendix 1

Input characteristics for calculation of the CO_2 price at which investment in new plants become attractive. These prices are derived from the equations given in paragraph 4.3. Results are summarised in Table 6 of the main text. In the calculations it is assumed that coal and gas are assumed to have an equal share in power production of the old plants. Old plants are at the end of their life time and have zero fixed costs.

Auctioning		**Old coal plant**	**Old gas plant**	**New coal plant**	**New gas plant**
Fixed costs	(€/MWh)	0	0	20	10
Variable costs (fuel costs)	(€/MWh)	18.5	36	16	30
CO2 emissions	(t/MWh)	0.97	0.5	0.85	0.4
Allocation	(t/MWh)	0	0	0	0
CO2 with real costs	(t/MWh)	0.97	0.5	0.85	0.4
Net costs (fixed + variable, without CO2)	(€/MWh)	18.5	36	36	40

Results:
CO_2 price for old coal-to-new coal-switch (EUR/tCO2): 146
CO_2 price for old coal-to-new gas-switch (EUR/tCO2): 38
CO_2 price for old gas-to-new gas-switch (EUR/tCO2): 40

IFIEC method single benchmark		**Old coal plant**	**Old gas plant**	**New coal plant**	**New gas plant**
Fixed costs	(€/MWh)	0	0	20	10
Variable costs (fuel costs)	(€ /MWh)	18.5	36	16	30
CO_2 emissions	(t/MWh)	0.97	0.5	0.85	0.4
Allocation*	(t/MWh)	0.66	0.66	0.66	0.66
CO_2 with real costs	(t/MWh)	0.31	-0.16	+0.19	-0.26
Net costs (fixed + variable, without CO_2)	(€/MWh)	18.5	36	36	40

*Benchmark based on -10% reduction, same as in the grandfathering example

Results:
CO_2 price for old coal-to-new coal-switch (EUR/tCO2): 146
CO_2 price for old coal-to-new gas-switch (EUR/tCO2): 38
CO_2 price for old gas-to-new gas-switch (EUR/tCO2): 40

IFIEC method fuel-specific bench-mark		Old coal plant	Old gas plant	New coal plant	New gas plant
Fixed costs	(€/MWh)	0	0	20	10
Variable costs (fuel costs)	(€/MWh)	18.5	36	16	30
CO_2 emissions	(t/MWh)	0.97	0.5	0.85	0.4
Allocation*	(t/MWh)	0.74	0.59	0.74	0.59
CO_2 with real costs	(t/MWh)	0.23	-0.09	+0.11	-0.19
Net costs (fixed + variable, without CO2)	(€/MWh)	18.5	36	36	40

*Benchmark based on -10% reduction, same as in the grandfathering example

Results:

CO_2 price for old coal-to-new coal-switch (EUR/tCO2): 146

CO_2 price for old coal-to-new gas-switch (EUR/tCO2): 51

CO_2 price for old gas-to-new gas-switch (EUR/tCO2): 40

Grandfathering		Old coal plant	Old gas plant	New coal plant (no surplus allocation)	New gas plant (no surplus allocation)
Fixed costs	(€/MWh)	0	0	20	10
Variable costs (fuel costs)	(€/MWh)	18.5	36	16	30
CO_2 emissions	(t/MWh)	0.97	0.5	0.85	0.4
Allocation (-10% target)	(t/MWh)	0.873	0.45	0.85	0.4
Net CO_2 balance	(t/MWh)	0.097	0.05	0	0
Net costs (fixed + variable, without CO2)	(€/MWh)	18.5	36	36	40

Results:

CO_2 price for old coal-to-new coal-switch (EUR/tCO2): 180

CO_2 price for old coal-to-new gas-switch (EUR/tCO2): 222

CO_2 price for old gas-to-new gas-switch (EUR/tCO2): 80