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Interactions of the EU ETS with Green And White Certificate Schemes

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Contents

List of Tables

List of Figures

List of Boxes

Executive Summary

The European Union Emissions Trading Scheme ('EU ETS') began on 1 January 2005. The implementation of the EU ETS has raised interest in market-based approaches to achieving environmental and related public policy goals in the EU, particularly those related to promotion of renewable energy and energy efficiency. Indeed, national and regional markets in tradable green certificates ('TGCs') and (to a lesser extent) tradable white certificates ('TWCs') already exist. Green certificate schemes are established or proposed in a number of Member States (e.g., Belgium, the Czech Republic, Denmark, France, Italy, the Netherlands, Sweden and the UK) and form part of a growing portfolio of measures to achieve the renewable targets outlined in Directive 2001/77/EC. White certificate schemes are considerably less widespread, although schemes have been established in Italy and the UK and further activity may be stimulated by the Commission proposal on energy services (COM(2003)739). Both the renewables Directive and the energy services proposal envisage the possible evolution and harmonisation of these instruments into EU-wide certificate schemes.

Objectives of This Report

With the implementation of the EU ETS, the development of green and white certificate programmes raises some complex issues of policy interaction. The Directorate-General Environment of the European Commission (hereafter, 'EC' or 'the Commission') has sponsored the current study, which has two major objectives:

1. Analyse interactions among EU ETS and green/white certificate markets. The first major objective is to describe the interactions between green and white certificate programmes and the EU ETS.
2. Assess implications of interactions for the policy objectives of the EU ETS. The second major objective deals with the implications of green/white certificate programmes for the objectives of the EU ETS.

These two major objectives are linked, as insights regarding the interactions among the various schemes provide the basis for judgments regarding the implications of these programmes to the policy objectives of the EU ETS. Note that the study is not designed to evaluate the public policy desirability of green/white certificate programmes (or of emissions trading) or to describe their optimum designs—which would require a much wider scope. Instead, the aim is to consider the interaction of certificate programmes with emissions trading

The major point of intersection of these three policy instruments is in their effects on the electricity market. With this in mind, the current study attempts to do as follows:

§ Provide information on the EU ETS and its effects on electricity markets.

§ Describe green and white certificate programmes and how they affect electricity markets.

§ Evaluate how green and white certificate programmes interact with the EU ETS.

§ Provide conclusions regarding the design elements of green/white certificate schemes that might affect compatibility with the EU ETS, and vice versa.

This Executive Summary provides an overview of the major effects and interactions among the EU ETS and the green/white certificate programmes. The Technical Report provides additional details regarding these interactions, including effects of different circumstances (e.g., regulatory treatment of the electricity sector, geographic scope of the programmes) and programme designs (e.g., nature of target obligations) as well as effects on different groups (e.g., green electricity producers, electricity consumers). A companion Summary Report provides a non-technical summary.

EU ETS and Effects on Electricity Markets

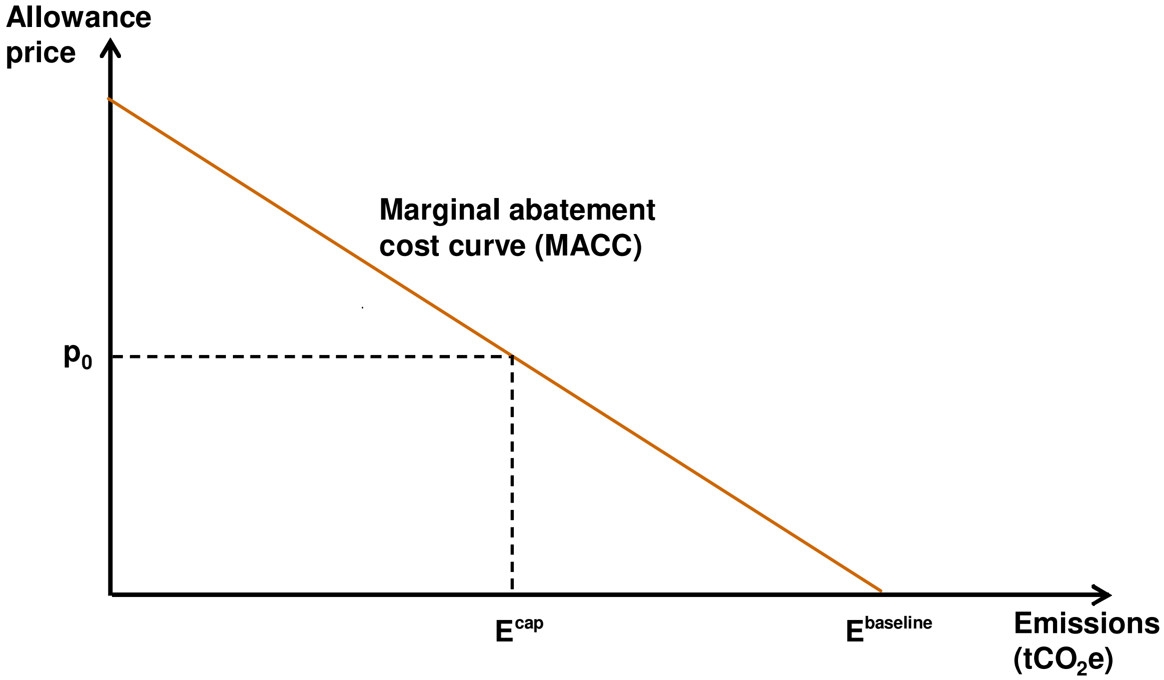
The EU ETS was established by the Emissions Trading Directive (2003/87/EC, subsequently 'EU ETS Directive') of the European Parliament and of the Council of Ministers in 2003. The EU ETS Directive was adopted as a cost-effective means of complying with the EU's commitment under the Kyoto Protocol to reduce its 2008-12 emissions of greenhouse gases ('GHGs') by eight percent, as compared to 1990 levels. The EU ETS is organised into phases. The first phase runs from 2005-07 and the second phase runs from 2008-12, thus coinciding with the first Commitment Period under the Kyoto Protocol.

The EU ETS is a cap-and-trade programme. The rules determine the nature of the installations to be covered under the various schemes, outline the general criteria for allocating initial allowances (i.e., rights to emit one tonne of CO_2) to the various installations, and stipulate an obligation on each participating installation to surrender allowances equal to its total emissions in each calendar year. Member States are given considerable discretion to implement these rules, with the allocation of allowances to installations contained in their National Allocation Plan ('NAP'), which requires approval of the Commission. Allowances are tradable, and thus participants whose emissions are lower than their allocation have surplus allowances that they can sell to other installations that need to purchase allowances.

Market for CO_2 allowances

The most immediate effect of the EU ETS is to establish a market for CO_2 allowances and thus a price for emitting CO_2 among the installations covered by the programme. Figure ES-1 illustrates the basic determinants of the CO_2 price. Without the programme, total CO_2 emissions from the participating facilities would be equal to the 'business as usual' ('BAU') level. The marginal abatement cost curve shows the marginal costs to the facilities of reducing CO_2 emissions, and the vertical line shows the overall cap set for all participating facilities. The traditional assumption that companies take advantage of trading to minimize the cost of meeting the overall EU ETS requirement leads to the setting of a price for CO_2 allowances, shown in Figure ES-1 as p_0.

Figure ES-1
EU ETS market for CO_2 allowances



There are some complications in the market for CO_2 allowances that should be noted, some of which can influence the effect of the CO_2 market on electricity prices. In addition to allowances allocated by each Member State to individual installations, allowances may also enter the Scheme through the 'linking Directive' (COM 2003/403), which allows emissions credits generated through the Flexible Mechanisms of the Kyoto Protocol to be valid for compliance within the EU ETS.[1] Furthermore, the schematic abatement cost curve depicted here abstracts from the specific types of abatement, which may include changes to electricity output that are not easily captured using the framework shown.

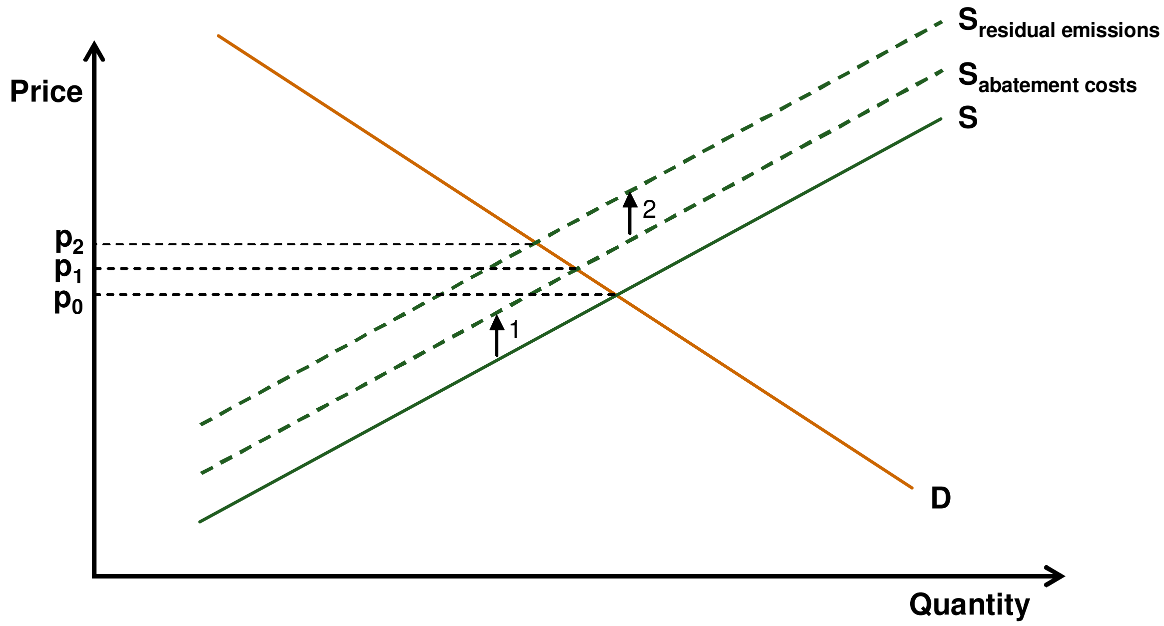
Effects of the EU ETS on electricity markets

The market for CO_2 allowances created by the EU ETS results in a price for CO_2 emissions that will affect the cost of providing electricity. Generators will react to the market for CO_2 emissions by undertaking efforts to reduce CO_2 emissions from their units—such as switching to lower-CO_2 sources or increasing the efficiency of their units—as long as the marginal abatement cost of these efforts is less than the CO_2 price. These abatement costs will affect the cost of providing electricity. In addition, the generators will incur costs for the residual CO_2 emissions that remain after the cost-effective abatement options are exhausted. Indeed, even if generators receive sufficient allowances 'for free' under their NAP to cover their residual emissions, every tonne of CO_2 emitted still results in a cost (an 'opportunity cost') because the allowance used to cover the tonne of CO_2 emitted could otherwise be sold at the market price.

1 Eligible Flexible Mechanisms include Joint Implementation ('JI') and the Clean Development Mechanism ('CDM').

Figure ES-2 shows the general effects of the EU ETS on prices for any good, such as electricity, whose production emits CO_2. The cap-and-trade programme has two effects on the supply (marginal cost) curve. The first effect is to increase costs as a result of measures to reduce CO_2 emissions, such as switching to low-CO_2 fuels or increasing the energy efficiency of operations. The second effect relates to the cost of covering the emissions that remain. As noted, the allowance price for CO_2 represents the cost of residual emissions, regardless of whether the allowances are purchased or are distributed for free. The EU ETS leads to an increase in the product price (e.g., electricity price) from p_0 to p_2, reflecting both the CO_2 abatement costs and the costs of covering residual emissions.

Figure ES-2
Effects of EU ETS on product supply and prices



Turning specifically to the electricity market, it is useful to distinguish the effects of the EU ETS on wholesale electricity prices from effects on retail prices. Impacts on retail prices may differ depending on the extent of electricity market liberalisation. In less liberalised markets, retail electricity prices may not be raised to reflect the opportunity cost of residual emissions if regulators ignore opportunity costs in calculating allowable electric rates. The magnitude of the effects on wholesale prices also depends on the nature of the electricity supply function, notably the cost and CO_2 intensity of various generation sources and the level of the CO_2 price.

Figures ES-3 and ES-4 illustrate the effects of the EU ETS on wholesale electricity prices under one set of generator cost assumptions and two different CO_2 price assumptions. Both cases assume potential generation includes nuclear, coal, and natural gas, with gas 'on the margin' (and thus setting price). The EU ETS leads to cost increases for coal and natural gas, reflecting the 'opportunity' cost of CO_2 emissions. Since the CO_2 emissions intensity (i.e., CO_2/MWh) is greater for coal than gas, the cost increase per MWh for coal is greater than for gas. In Figure ES-3, the CO_2 price is not sufficiently high to change the 'merit order' of the fuels, and thus the wholesale electricity price increase due to the EU ETS reflects the CO_2 intensity of the marginal fuel (i.e., gas). Figure ES-4 shows an alternative high CO_2 price case in which the addition of CO_2 costs causes the merit order to be shifted. In this case, gas becomes cheaper to operate than coal, and coal becomes the marginal fuel, with the wholesale price increase substantially greater than in the low-CO_2 price case.

Figure ES-3
Effects of CO_2 costs on the electricity generation merit order (low CO_2 cost)

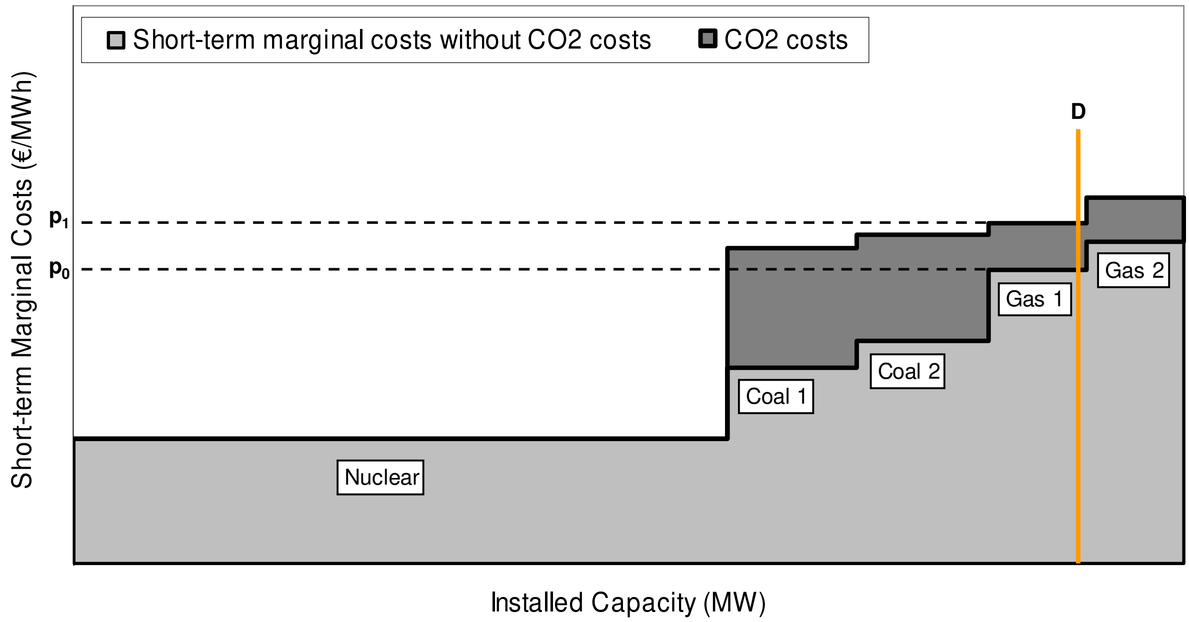
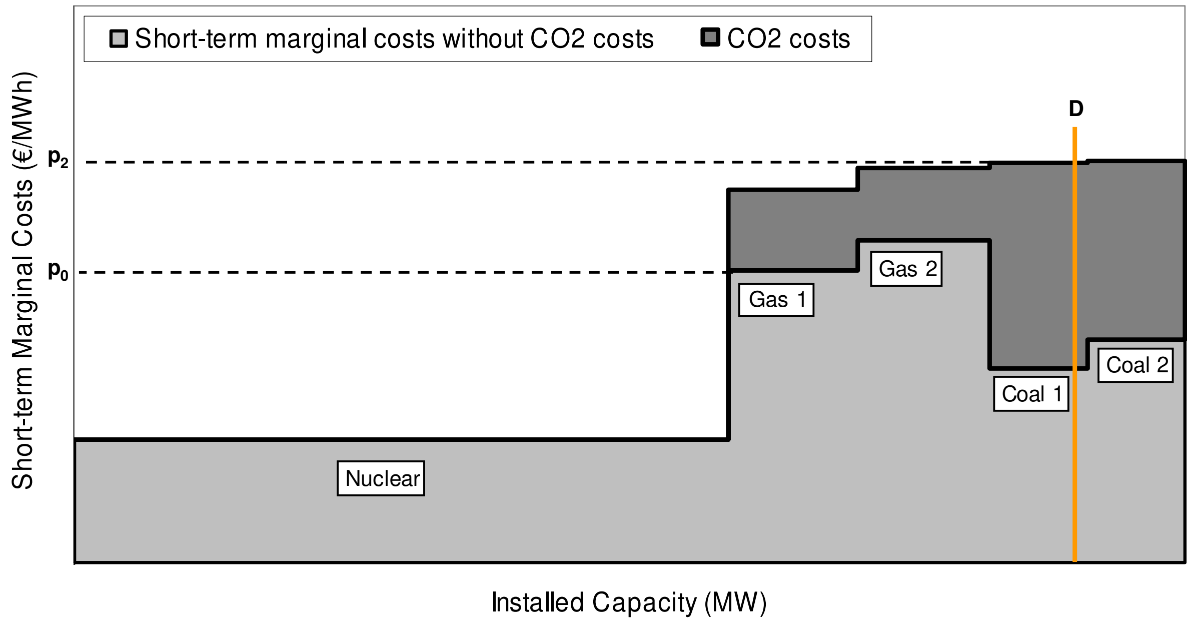


Figure ES-4
Effects of CO_2 costs on the electricity generation merit order (high CO_2 cost)



Figures ES-3 and ES-4 focus on the effects of different CO_2 prices on the wholesale electricity price in the short term and illustrate the possibility that the EU ETS may affect the merit order of different fuels. The figures abstract from several complications that can alter substantially the effects of the EU ETS on electricity prices. The following are brief summaries of these additional considerations.

- *Fluctuations in electricity demand.* The stylised representation presented above assumes that gas is the 'marginal' technology at all times. In fact, the marginal unit can change by hour of the day (e.g., peak versus off-peak) and day during the year (e.g., weekday versus weekend, summer versus winter). In many parts of the EU, coal or other technologies (and not gas), is the marginal unit at many times of the day.
- *Allowance allocation method.* Under certain methods of allowance allocation, electricity generators will not reflect the full cost of CO_2 allowances in the cost of electricity. For example, if future allocations are determined on the basis of future emissions (an 'updating' approach), generators have some incentive to increase output, which can offset to some extent the opportunity costs of emitting CO_2.
- *International trade in electricity.* If domestic generators face competition from foreign sources of electricity, the introduction of CO_2 costs can make domestic generators less competitive with foreign sources (e.g., if foreign sources have lower emitting technologies on the margin). This is particularly the case if foreign sources are not subject to CO_2 constraints (although that circumstance is unlikely in the EU).
- *Market power.* If individual market participants have some control over the price of electricity, this may affect the degree to which the full costs of CO_2 are passed on to consumers. Generators with market power might react to higher costs by price increases that are either greater or lesser than if the market were competitive.
- *Electricity regulation.* While the above analysis assumes that all electricity markets are liberalised, several markets in the EU remain regulated. Under regulated regimes, the extent of price increases will depend on regulators' treatment of CO_2 costs. Even in some liberalised markets, regulators have discussed proposals to prevent CO_2 costs from being passed on to electricity consumers.
- *Long-term contracts.* Because much electricity is sold via long-term contracts, this can delay the effects of CO_2 costs on market prices. However, these delays are likely to be of short duration.
- *Long-term market effects.* Over time, the long-term marginal cost of new generation will determine electricity prices. Because CO_2 costs are one component of the long-term marginal costs of new generation, the EU ETS can affect investment decisions, making low- or non-emitting technologies (e.g., gas, nuclear) more appealing relative to higher emitting technologies (e.g., coal). In addition, allocations to new entrants will serve to lower long-term marginal costs and therefore also long-term power prices.
- *Fuel market effects.* In both the short and long term, the EU ETS may affect the demand for different types of fuels. The most likely effects are an increase in the demand for natural gas and a decrease in the demand for coal. These demand changes can, in turn, affect fuel prices, serving to offset some of the cost advantages of natural gas relative to coal.

TGC Schemes and Effects on Electricity Markets

TGC schemes create a market for electricity provided from renewable and other 'green' sources.[2] Generation technologies that qualify as 'green' thus produce two distinct commodities: (1) electricity, which is sold in the normal electricity market; and (2) green certificates, which are traded in a green certificate market.

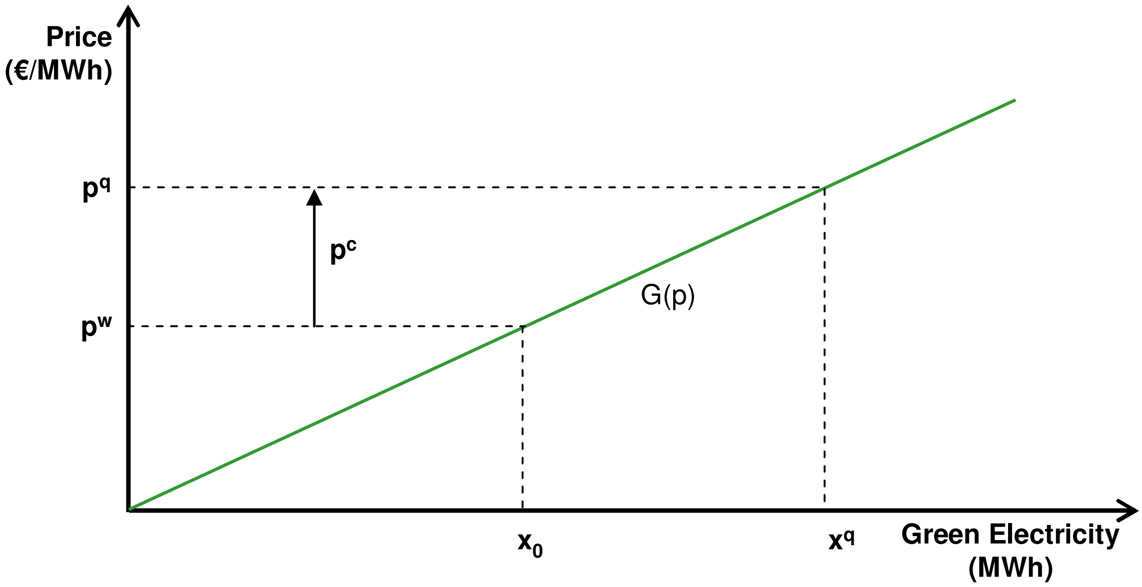
The market for tradable green certificates

TGC programmes establish requirements to produce/deliver a certain percentage of electricity using renewable and other 'green' sources. The details of the programmes can differ considerably; for example, programmes might classify 'green' differently, with one programme including hydropower as green and another excluding it.

Figure ES-5 provides a simple stylised description of the market for green electricity established under a green certificate programme. The figure shows the marginal cost of providing increasing MWh of green energy among all potential providers. The wholesale market price of electricity is assumed to be p^w absent a green certificate requirement. Thus, without an additional requirement, x_0 MWh of green electricity would be provided. A green certificate programme requires that a given percentage of electricity be provided by green sources, which translates into x^q MWh in Figure ES-5. In order for this level of green energy to be provided, the total price received by green producers would have to be equal to p^q. Although the requirement is enforced on each provider, TGCs are tradable and thus a market is created. Assuming optimal market response as depicted in Figure ES-5, the market price of green certificates would be equal to p^c. The price of certificates (p^c) is equal to the difference between the price that would be required to incentivise the required level of green generation (p^q) and the baseline electricity price (p^w).

[2] In the United States, green certificate programmes are referred to as 'renewable portfolio standards.'

Figure ES-5
Green electricity supply schedule with green certificates



Effects of TGC scheme on the electricity market

The presence of a green certificate programme can affect the electricity market in several ways that can most easily be appreciated by considering a stylised representation of the electricity market and proceeding in two steps. The first step is to consider the effect of the green certificate programme on the market for 'conventional' or 'non-green' generation, i.e., generation not encouraged by the green certificate programme.[3] The second step is add the supply of green electricity—in light of the support provided by the green certificate market—to develop implications for the overall price and quantity of electricity sold.

Figure ES-6 shows the first step, i.e., how the market for traditional electricity is affected by the green certificate programme.[4] The initial electricity market conditions are illustrated by point *X*, the intersection of the supply curve, $S(p^w)$, and the initial demand curve, $D(p^w)$. The initial conditions result in a wholesale price of p_0 and electricity generation of x_0.

Under the TGC programme, retail providers have to provide a set percentage of electricity from green sources. This leads to an effective 'tax' on traditional electricity (equal to the certificate price times the percentage requirement). In the wholesale electricity market, retail providers are actually the source of *demand* for electricity. Thus, the first effect of the certificate programme is to reduce demand for non-green wholesale electricity as a result of the 'tax effect', causing the demand curve to shift from D_1 to D_2. Because of the percentage requirement, however, there is an additional 'market share' effect, which limits the level of non-green electricity at any given price. This causes the demand curve to rotate to $D_{non\text{-}green}$,

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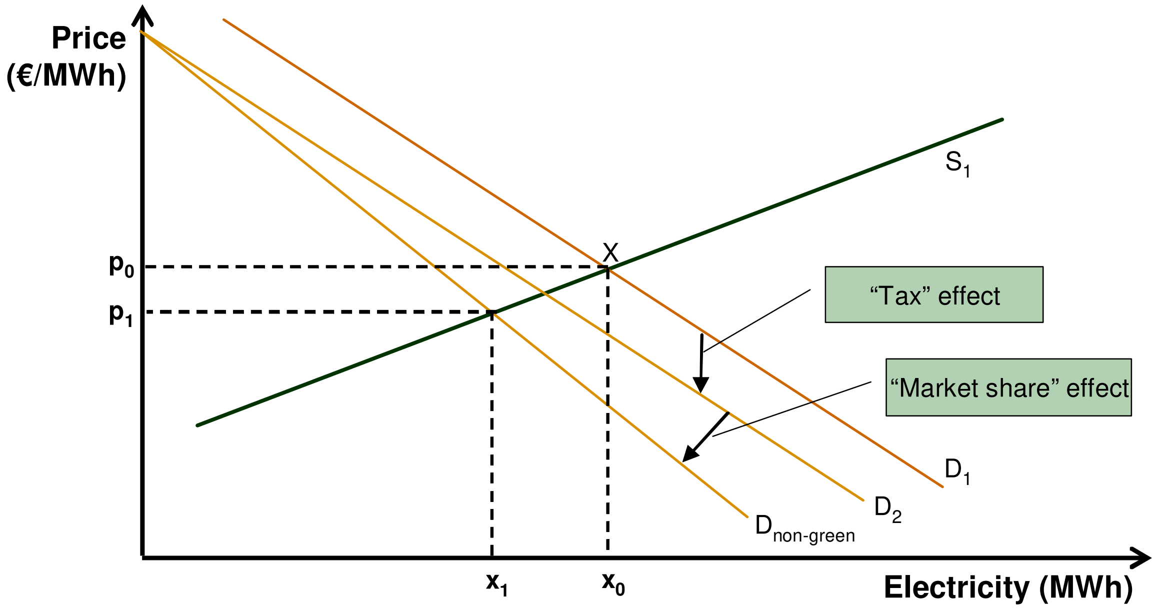
3 We refer to electricity generation that is not eligible for green certificates as 'non-green' generation. Non-green generation generally includes most fossil fuel-fired generation, but may also include renewables, nuclear, and other energy sources that are not eligible for certificates under a TGC scheme.

4 This characterisation draws on that in Bye (2002)

i.e., the demand available to non-green producers; this is equal to $(1\text{-}\alpha)*D_2$. Figure ES-6 shows that the net result of these two effects is to reduce the wholesale price of non-green electricity to p_1 and the level of non-green generation from x_0 to x_1.

Figure ES-6
Effect of TGC scheme on wholesale market for *non-green* electricity



Note that the fall in the wholesale electricity price does not translate into a decrease in the *retail* price faced by consumers, because consumers must also pay for the cost of the certificate programme, which is not reflected in the wholesale price of non-green electricity. Consumers will likely pay for the certificates required, as detailed below.

The second step is shown in Figure ES-7, which illustrates the effect of the green certificate programme on overall electricity prices and sales, including green electricity. The supply curve, S_{G0}, for green electricity is shown as starting above the original price of traditional electricity. This reflects the simplifying assumption that no green electricity would be provided absent the programme. As a result, the aggregate supply curve before the introduction of the TGC programme is represented by curve S_1, in which the supply of green electricity is 'tacked on' to the end of the supply curve for traditional electricity.[5]

The effect of the certificate programme is to shift the green supply curve down by the amount of the certificate price to curve S_{G1}. This results in a new aggregate supply curve, S_{total}. As shown in Figure ES-7, the new equilibrium electricity quantity (x_2) is given by point *V*, the intersection of this aggregate supply curve (S_{total}) and the demand curve that reflects the 'tax' due to the green certificate programme (D_2). This intersection also gives the new wholesale electricity price, p_1, which is equivalent to the price given in Figure ES-6. However, the *retail* price is equal to p_2, because consumers pay the 'tax' created by the green certificate requirement in addition to the electricity price.

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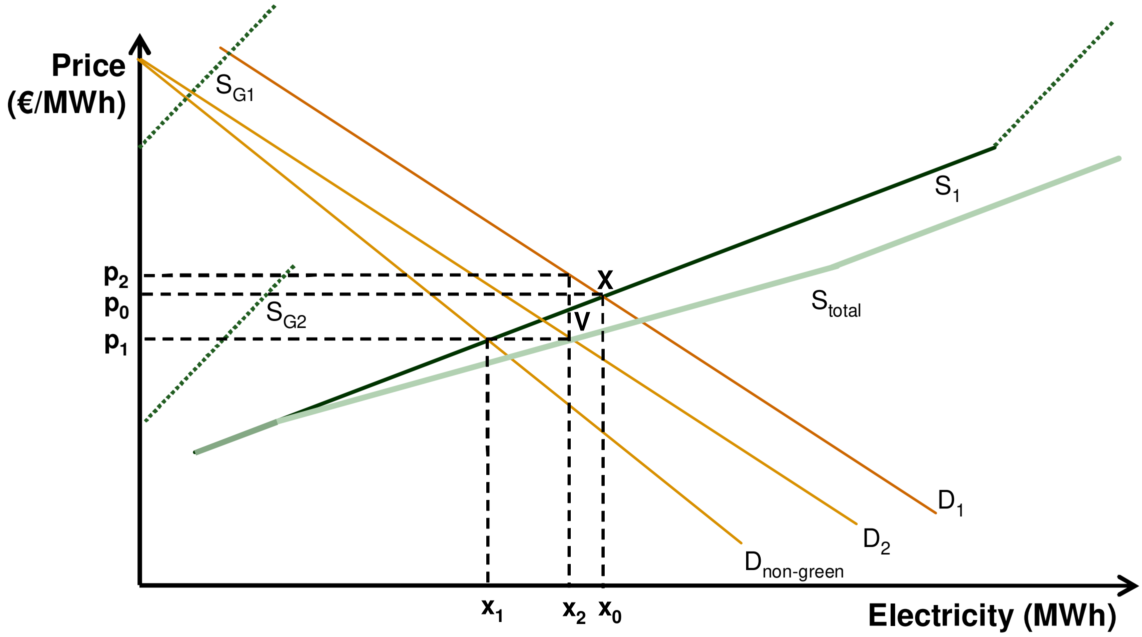
[5] The aggregate electricity supply curve is the horizontal sum of the conventional supply curve and the green supply curve.

Figure ES-7
New equilibrium in electricity market after the introduction of TGC scheme



This stylised example shows several effects of the green certificate programme on the electricity market:

§ Decrease in supply/generation of conventional ‘non-green’ electricity;

§ Increase in supply/generation of ‘green’ electricity;

§ Decrease in the wholesale electricity price received by non-green generators;

§ Increase in retail electricity price; and

§ Decrease in overall electricity generation/sales.

Although the first three effects are general implications of green certificate markets, the last two results depend to some extent upon empirical relationships between the supply of ‘green’ electricity, the supply of traditional electricity, and the level of the percentage requirement.[6]

This discussion establishes the basic effects of a TGC scheme and its interaction with the electricity market. The main text of this report discusses a series of cases that could cause the effects described to differ from the case presented. These issues include:

§ Separate markets for green and non-green electricity;

§ Inclusion of pre-existing or otherwise viable green electricity supply;

§ Regulation of certificate prices; and

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6 A green certificate programme may actually lead to lower retail electricity prices and higher electricity sales if the supply curve for ‘green’ electricity is relatively flat, if the supply for traditional electricity is relatively steep, and/or if the percentage requirement is relatively small (and thus the certificate price is low). The likelihood of this somewhat counterintuitive result diminishes as the size of the green requirement grows.

§ Differences in the geographic scope of TGC and the relevant electricity market.

For example, consider the effects of differences in geographic scope. The preceding discussion implicitly assumes similar geographic scope of the green certificate programme and the electricity market (e.g., both are relevant for a given Member State or for the EU as a whole). The electricity price effects may differ if the geographic scopes are not the same—for example, if a Member State instituted a green certificate programme on its own but was part of a larger regional or EU-wide wholesale electricity market. In this case, the green certificate programme may have no effect on wholesale electricity prices, but retail electricity prices would still increase to reflect the 'tax' required by the green certificate programme.

Tradable White Certificate Schemes and Effects on Electricity Markets

Tradable white certificate programmes create a market for energy efficiency improvements that affects the electricity market in several ways.

The market for tradable white certificates

The development of white certificate programmes is motivated by a belief that insufficient incentives exist for end-users of electricity (or other energy) to take actions to improve the efficiency with which they use electricity. According to this view, electricity prices (both current and expected) do not lead to 'optimum' investment in energy-saving technology, such as more efficient refrigerators or industrial processes, and thus there are public policy gains from mandating requirements for improved energy efficiency. Creating a market for tradable white certificates (each one of which represents a 'unit' of energy savings) provides a mechanism for reducing the cost of meeting the public policy target that is set for energy efficiency savings.

The development of a market for energy efficiency improvements is complicated by several factors, including the need to define the 'electricity savings' as a commodity and the fact that savings need to be measured relative to a baseline. Electricity savings from a given investment in energy efficiency (e.g., purchase of a more efficient heater) cannot be measured simply as a reduction in electricity use because the more efficient appliance reduces the price of 'comfort' (e.g., heat on a cold day) and thus may lead households to want more 'comfort' and thereby use more electricity.[7]

Figure ES-8 illustrates the conceptual framework that has been developed to characterise the market created by a white certificate programme. The market is defined in terms of energy efficiency measures ('EEM') measured relative to a given level of energy services; one unit of EEM represents one kWh/year that a customer saves, measured against the electricity consumption required to meet a given level of electricity service demand. The supply curve S_F reflects the marginal cost of providing greater energy efficiency (e.g., the *added* cost per kWh saved to purchase a more efficient heater). The introduction of the white certificate requirement shifts the demand curve up by an amount L and increases the amount of EEM consumed from F_1 to F_2.

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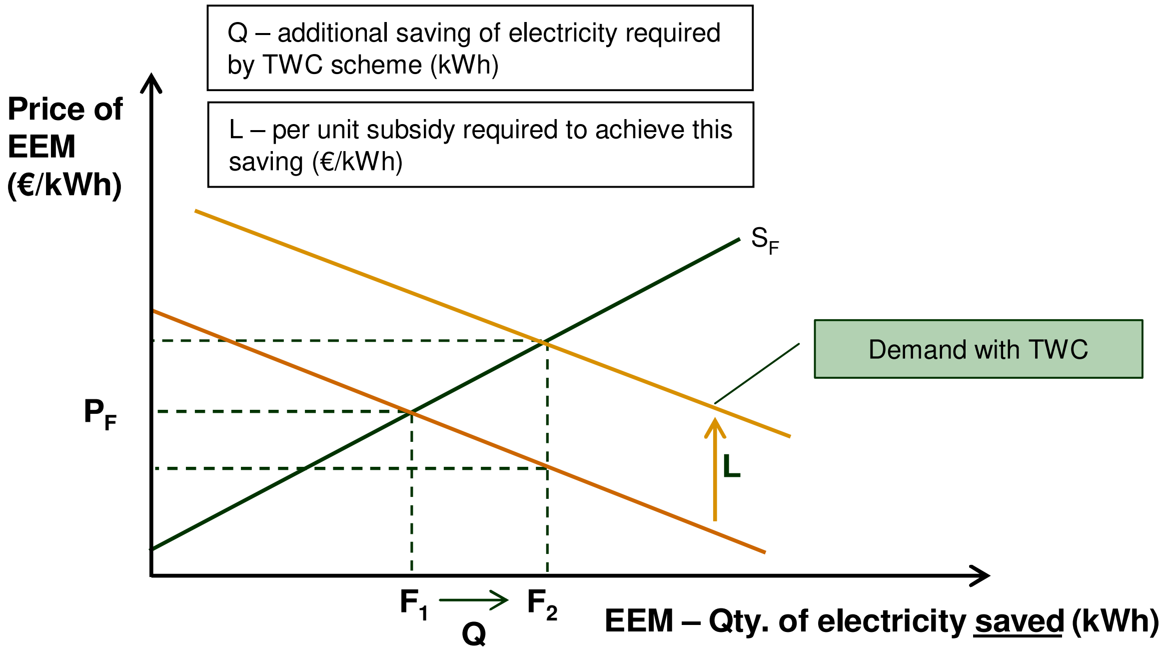
7 The effect of improvements in energy efficiency leading to increased electricity consumption often is referred to as the 'rebound effect.'

Figure ES-8
Effect on the EEM market of a tradable white certificate subsidy for efficiency investment



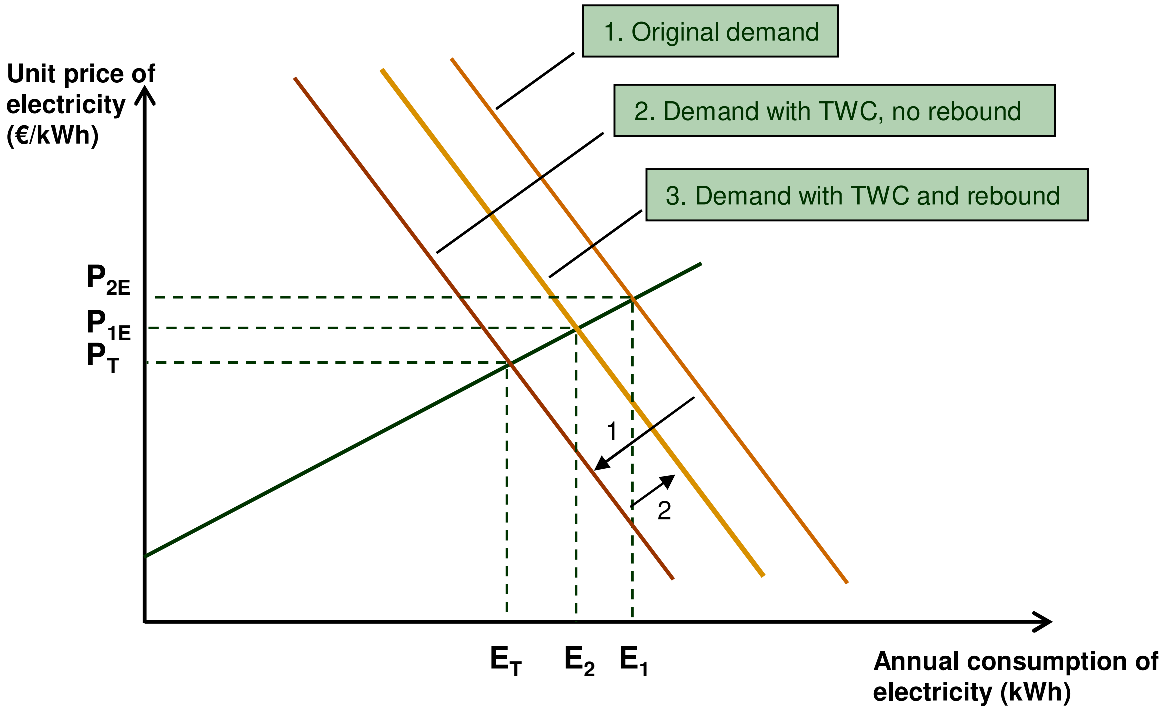
Some TWC schemes also incorporate provisions that seek to limit support for efficiency measures that would have been undertaken anyway, even in the absence of the TWC scheme. This is an important design feature that has implications for the potential interactions of TWC schemes with the EU ETS, as we discuss below.

Effects of tradable white certificate schemes on the electricity market

Increases in energy efficiency due to a white certificate programme will have two principal and offsetting effects on the demand for electricity. On one hand, investments in energy efficiency result in a reduction in the demand for electricity, because less electricity is needed to achieve a given level of 'electricity service' (e.g., heating comfort). On the other hand, the greater efficiency leads households and firms to increase the demand for electricity services—through the 'rebound effect'—and this effect leads to an increase in demand for electricity.

Figure ES-9 illustrates these two effects on the retail electricity market. The net effect on electricity price and sales is an empirical issue, although most studies suggest that the net effect is to decrease the demand for electricity (i.e., the rebound effect is less than the effect of improved energy efficiency).

Figure ES-9
Effect of a tradable white certificate subsidy on the retail electricity market, with and without rebound effect



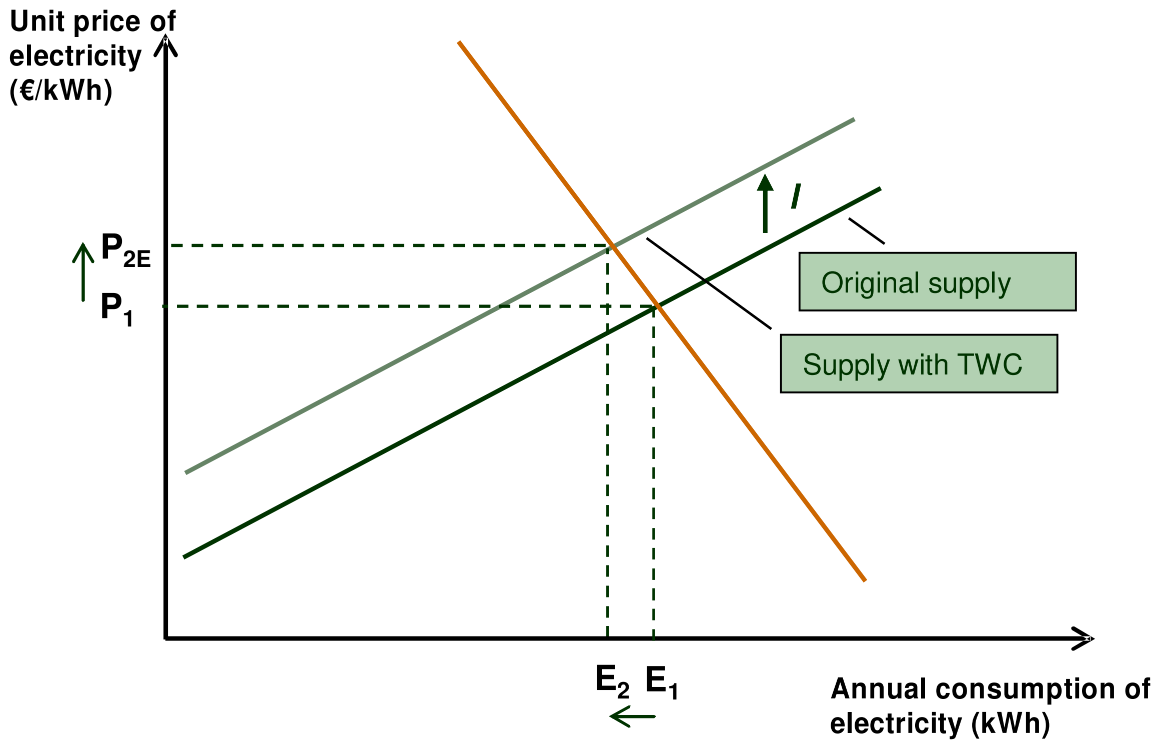
The electricity market also could be affected by the mechanism used to fund the subsidies provided to adopt energy efficiency programmes or investments. The extent of electricity market effect depends both on the nature of the regulation of retail electricity and the formula used to impose specific energy efficiency requirements on electricity suppliers.

§ *Nature of regulation.* If retail electricity companies are regulated using cost-of-service regulation, the costs of the white certificate programme presumably would be approved as allowable costs, and thus the costs would be passed on to ratepayers in the form of higher average electricity prices. In contrast, if the retail market is liberalised and the white certificate programme did not affect the marginal cost of providing electricity, shareholders might at least in the near-term absorb the costs of the programme.

§ *Nature of white certificate requirement.* If the requirement to generate energy efficiency savings were tied to electricity sales, and were not specified as an absolute number of kWh saved, the retail provider would incur added costs linked to added electricity sales. In this case, as with the equivalent green certificate programme, the white certificate programme would constitute a 'tax' on electricity sales.

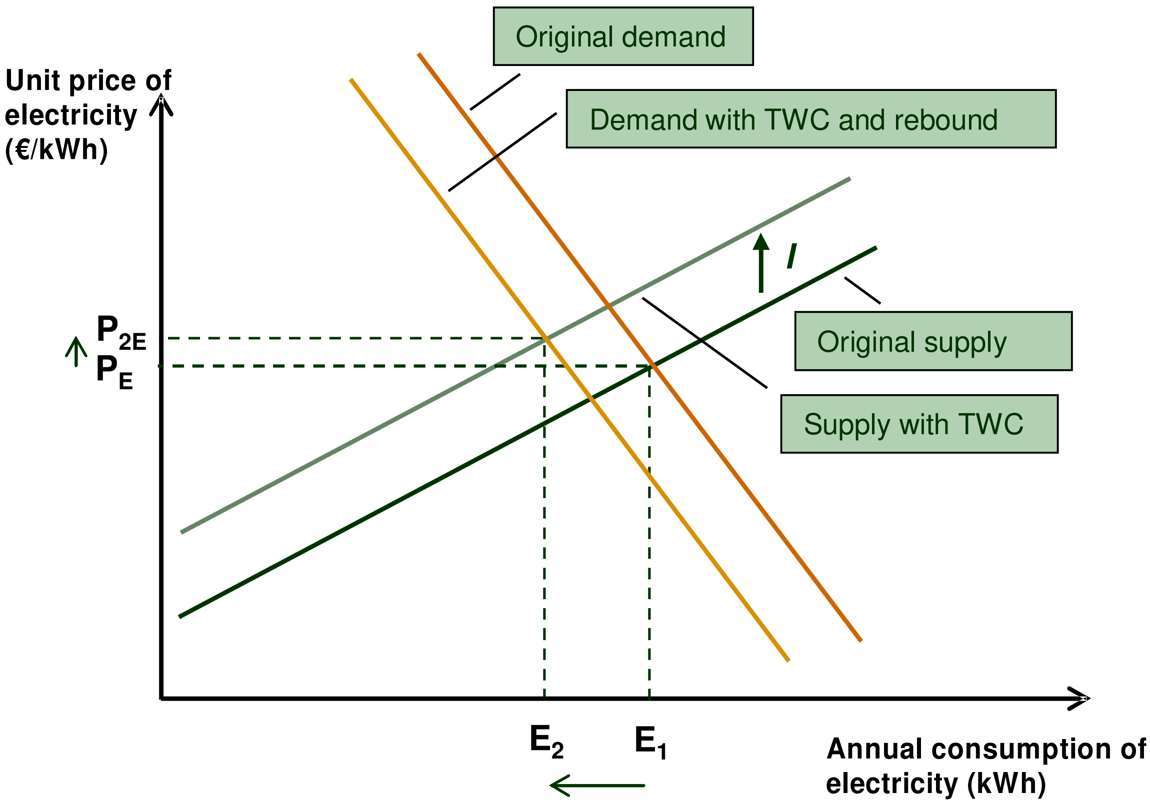
Figure ES-10 illustrates the effect of treating the cost of the white certificate programme as an increase in the per unit electricity cost to the retail provider, either because the provider is regulated or because the requirement is linked to electricity sales. This effect is to increase the electricity price and decrease the amount of electricity demanded.

Figure ES-10
Effect of a TWC scheme on the marginal cost of providing retail electricity service



The *net* effect of a TWC scheme on the retail electricity market will be to reduce the quantity of electricity demanded (assuming the rebound effect is relatively small). Whether the retail electricity price increases or decreases under a white certificate programme depends upon several factors, however, including the effectiveness of the energy efficiency projects financed, the elasticity of supply, and the elasticity of demand. Figure ES-11 illustrates one (likely) situation in which retail price increases and the quantity of electricity demanded decreases on balance as a result of the white certificate programme.

Figure ES-11
Net effect of a TWC Scheme on the retail electricity market



Interactions between the EU ETS and Tradable Green Certificate Schemes

Analyses of the independent effects of the EU ETS and TGC programmes provide the bases for assessing the interactions among the two schemes. (We consider interactions between the EU ETS and TWC programmes—some of which are similar to those of the TGC programmes—in the next section.) We consider first the effects of the TGC programmes on the EU ETS and electricity market, and then consider the opposite case of the effects of the EU ETS on the TGC programmes and its electricity market effects.

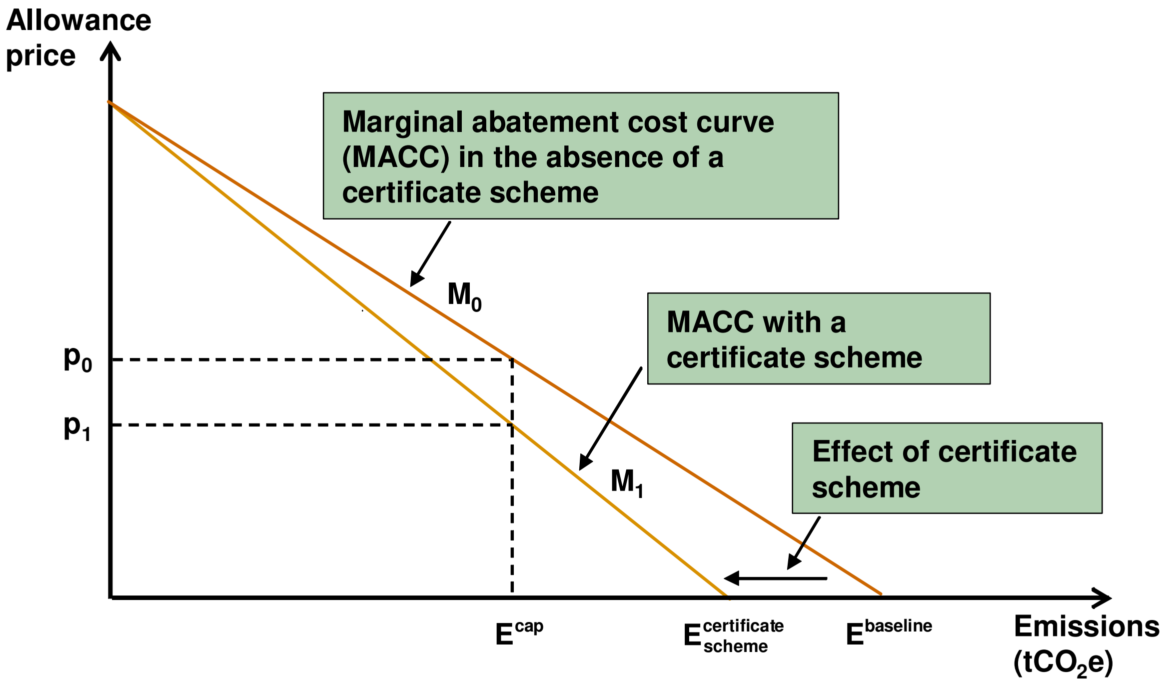
Effects of TGC schemes on the EU ETS and its electricity market impacts

A TGC scheme will affect the operation of the EU ETS in two principal ways. First, a green certificate programme changes the marginal cost curve for the abatement of CO_2 emissions, reducing baseline CO_2 emissions (i.e., the level of CO_2 emissions absent the EU ETS) and altering the set of abatement options available within the EU ETS. Second, a green certificate programme leads to reduced non-green electricity generation, which can change the likely effects of the EU ETS on wholesale electricity prices.

Effects of TGC schemes on market for CO_2 allowances

Figure ES-12 illustrates the first effect of a TGC programme on the CO_2 allowance market. The shift toward 'green' power reduces CO_2 emissions under the BAU case, reflecting the lower (or zero) CO_2 emissions from green power relative to traditional electricity. In addition, options to reduce CO_2 emissions within the EU ETS are reduced as some green generation is mandated and undertaken 'outside' the EU ETS, and the marginal abatement cost curve would therefore be steeper. The net effect is to reduce the CO_2 allowance price that would be established under the EU ETS, reflecting the fact that some CO_2 reductions have already been 'paid for' through the green certificate scheme. The cost of the EU ETS 'in isolation' would be lower with the green certificate programme in place, although the total cost of reducing CO_2 emissions, including costs related to the green certificate programme, would be higher (ignoring gains due to greater use of 'green' electricity that may be unrelated to the emission of CO_2).

Figure ES-12
Effect of a tradable green certificate programme on the EU ETS market for CO_2 allowances

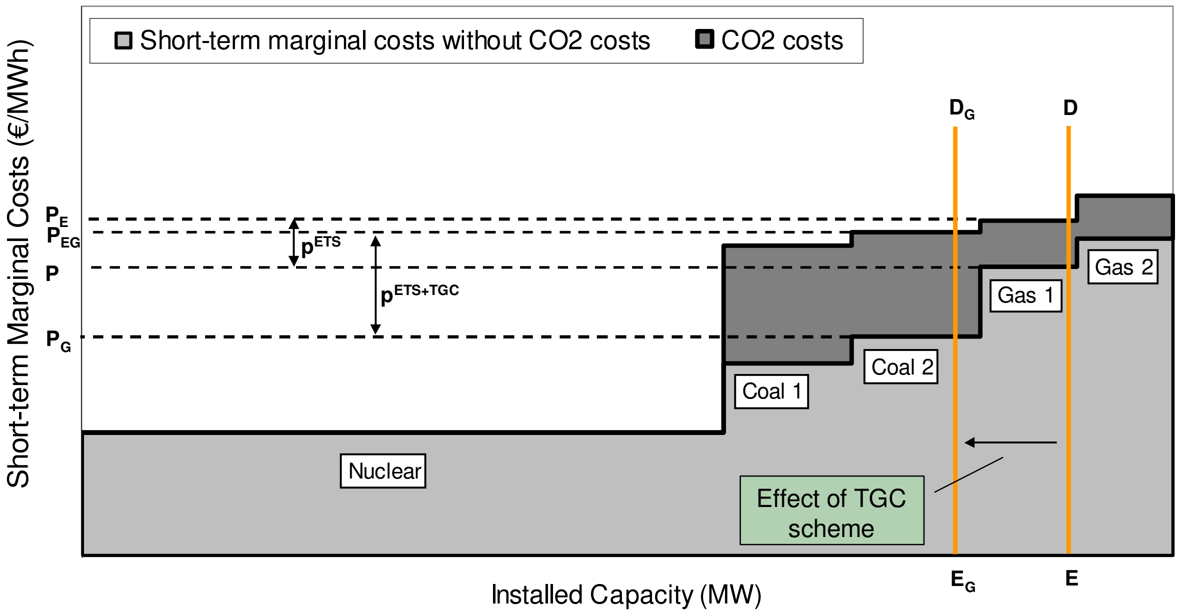


Effects of a TGC scheme on electricity market impacts of the EU ETS

The green certificate programme could alter the electricity market effects of the EU ETS in several ways. The lower CO_2 allowance price depicted in Figure ES-12 would lead to a smaller electricity wholesale cost increase, both because compliance costs would be smaller and because the costs of residual emissions would be lower.

The TGC scheme could have an even greater impact on the wholesale electricity price effects of the EU ETS if the TGC quota were large enough to displace substantial amounts of non-green generation. Figure ES-13 illustrates a situation in which the shift in demand away from non-green electricity due to the certificate programme is sufficient to change the marginal generation technology (from natural gas to coal in this example). Although the electricity price under this case (p_3) is lower than without the TGC scheme (p_1), the price *increase* due to the EU ETS is greater than if the TGC programme were not in place. This is because a more emissions-intensive technology is now on the margin (the precise effect will depend on the prevailing fuel mix of generation and merit order).

Figure ES-13
EU ETS wholesale electricity market impacts when a TGC scheme changes the fuel mix of generation



The quantitative significance of these effects of a green certificate programme depend on the stringency of the programme (e.g., the percentage of 'green' electricity required) as well as the geographic scope of green certificate programmes relative to the EU ETS. A single green certificate programme in a small Member State is likely to have relatively little effect on the CO_2 allowance price and thus on the electricity price impacts. In contrast, a stringent green certificate programme implemented at the EU level could displace considerable CO_2-emitting generation and lead to a substantial reduction in the CO_2 allowance price. The lower CO_2 price as well as the substantial displacement of traditional power due to the stringent Green Certificate programme could result in a reduction in the effect of the EU ETS on electricity prices.

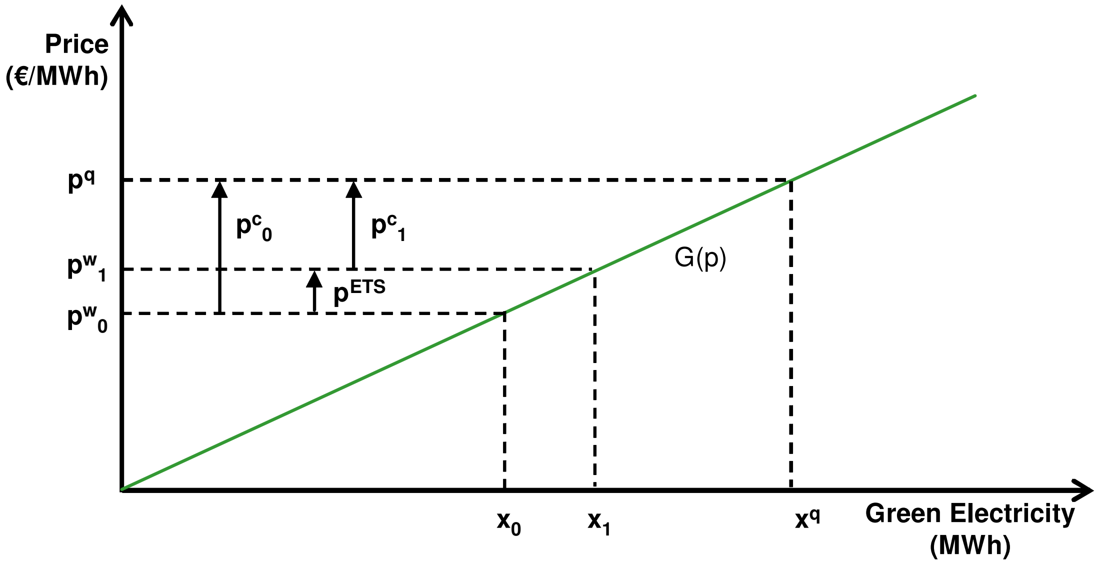
Effects of the EU ETS on a tradable green certificate scheme and its electricity market impacts

The presence of the EU ETS in turn will have effects on a tradable green certificate programme and its electricity market impacts.

Effects of the EU ETS on a tradable green certificate market

The EU ETS should lead to a lower price for TGCs because of the incentive it creates for the generation of some green electricity and because of the increase it generates in the wholesale electricity price. The increase in the wholesale electricity price will increase the green generation that would occur absent the Green Certificate programme, as green generators benefit from higher prices for their product without incurring higher costs (assuming they emit no CO_2). Because neither the green target (x^q) nor the price required to induce the required green generation (p^q) has changed as a result of the EU ETS, the price of TGCs will fall (to p_1^c). Figure ES-14 illustrates this effect of the EU ETS on the expected price of TGCs (which is equal to the difference between the electricity price required to induce sufficient green generation and the price that would prevail without the Green Certificate programme.

Figure ES-14
Effect of the EU ETS on the green certificate market



Effects of the EU ETS on electricity market impacts of the TGC scheme

The reduction in the TGC price due to the EU ETS will have the net effect of *reducing* the retail price effect of the TGC programme (relative to the effect in the absence of the EU ETS). As noted above, the certificate programme has two distinct and opposing effects on retail electricity prices: (1) a reduction in the amount of traditional power causes wholesale prices to fall; and (2) the certificate 'tax' leads retail prices to increase. Although the net effect of the two opposing effects for the TGC programme by itself depends upon the specifics of the electricity market, the presence of the EU ETS is likely to result in a greater proportion of the costs of green generation being borne by consumers than if the TGC scheme were operating on its own.

Effect of market and design features on the interactions

Some of the effects detailed above are modified with different assumptions about the environment in which the interactions take place. In particular, the effects may vary with the geographic scope of the programmes, the regulatory treatment of electricity markets, and with various design features of TGC programmes. We discuss each of these briefly below.

Effects of different geographic scope of regulations

The above discussion assumes that the geographic extent of the TGC scheme and the relevant electricity market are identical. The situation is different if the certificate scheme spans several electricity markets (with multiple electricity prices), e.g., if the Green Certificate scheme is international, or if a national Green Certificate scheme operates in an electricity market subdivided by transmission bottlenecks. One rationale for an international TGC scheme is to improve scheme efficiency by taking advantage of the varying resources for the production of green electricity across member states. Instead of constraining green generation to take place within a country, consumers (or other parties with a green quota obligation) could purchase TGCs from another country where they have a lower price.

However, imported TGCs do not have the effect of reducing national CO_2 emissions through the displacement of national non-green generation. Instead, if certificates are generated in country A but purchased and retired in country B, certificate consumers in country B are in effect 'paying for' the emissions reductions resulting from the displacement of non-green generation in country B. For a given national allocation plan, non-green generators in country A will have surplus allowances compared to the scenario without international trade in TGCs (they will also lose any producer surplus associated with the displaced generation). Similarly, the CO_2 emissions in country A will decrease while they are not affected in country B. This would interact with any national CO_2 reduction targets that may exist independent of the EU ETS.

Another important consequence is that, with unrestricted international trade in TGCs, a single certificate price would develop. However, unlike many other international markets, this does not imply that green generators with similar characteristics (including efficiency) will be equally competitive in the certificate market. This is because the certificate price required to make a green generator's production profitable is equal to the difference between the marginal cost of production and the wholesale price it can obtain in the electricity market it supplies. With different electricity prices, the certificate price required is also different. Also, even if the wholesale electricity price were originally the same in two different countries, the price impact of the EU ETS may be different in different locations. This may occur because the marginal technologies have different CO_2-intensity, or because the pass-through of cost from wholesale to retail prices differs. In sum, even with a common price of green certificates across electricity markets the level of support available for otherwise identical 'green' installations may therefore be different.

Conversely, if electricity markets have greater geographic scope than the certificate market, the interactions with the EU ETS may be affected. Generally speaking, the effect of the import and export of electricity is to moderate the impact of both the EU ETS and the Green Certificate schemes on wholesale electricity prices. This means that the impact of the EU ETS on Certificate prices may also be muted by international trade in electricity.

Effects of different regulatory treatment of electricity markets

Member States differ in the extent to which electricity prices are competitively determined, and in some cases regulators still determine prices. Some Member States have taken measures to limit the extent to which the (opportunity) cost increases of the EU ETS are reflected in retail electricity prices. Similarly, it is possible that the decrease in generation costs of non-green generators as a consequence of a Green Certificates scheme may not be fully reflected in retail prices in a regulated market. This may alter how cost increases associated with the joint implementation of the EU ETS and a Green Certificate Scheme are distributed.

Effects of different design features of Green Certificate programmes and the EU ETS

A number of features of green certificate schemes also affect the interactions with the EU ETS. This is a summary of the impact of some key parameters:

§ ***Sources of demand for TGCs***. In competitive markets it is not expected to make a difference whether the Green Certificate obligation is placed on consumers or other parties in the electricity market. This may change if there is not full pass-through of certificate costs, or if there is imperfect competition in the certificate market (e.g., if the obligation is placed on a very small number of parties). In these cases, the link between the EU ETS allowance price and the certificate price is no longer straightforward but may depend on strategic interaction in the Certificate market.

§ ***Absolute vs. relative green target***. The EU ETS may lead to a reduction in electricity demand and therefore to a smaller amount of green electricity being supplied under a relative quota. This would generally be associated with a lower cost of green generation (but ambiguous effect on the certificate prices). With an absolute (rather than relative) target for green generation, this effect does not take place.

§ ***Accounting for 'additionality'***. If green targets are set taking into account the support offered by the EU ETS—for example, by excluding green generation deemed to be economically viable when supported by the EU ETS alone – then there may be no decrease in certificate prices as a result of the EU ETS. On the contrary, achieving a given level of additional green generation may become more expensive as low-cost opportunities are exhausted.

§ ***Eligibility of CO2-emitting technologies.*** If generation from some CO_2-emitting technologies is eligible for certificates (e.g., fossil fuel-fired combined heat and power installations), the green merit order may be altered as the EU ETS makes such generation relatively more expensive than that from non-CO_2 emitting 'green' sources. Like all changes to the merit order this has the potential to alter the price of certificates as well as the composition of green electricity supply.

§ ***Eligibility of economically viable technologies.*** In addition, many Green Certificate schemes exclude as ineligible pre-existing or otherwise economically viable renewable generation sources. However, these sources *do benefit* from the price effects of the EU ETS, whereas those covered by the TGC scheme do not, as discussed.

§ ***Certificate price regulation.*** Some TGC schemes have explicit price ceilings and price floors aimed at reducing price volatility.[8] In a situation where a price ceiling is binding the EU ETS may offer additional support for green generation, as the certificate price is not free to adjust to reflect the level of support needed to meet the green quota. A high

8 Where non-compliance fines are set in absolute terms these effective define a price ceiling for certificates.

allowance price makes it less (more) likely that the certificate price ceiling (floor) will be binding in a particular period.

§ ***Intertemporal flexibility.*** Other things being equal, certificate price volatility is likely to be higher in the absence of banking and borrowing provisions that help smooth out variations in certificate supply over time. The EU ETS allows for banking within Phases (2005-2007, and five-yearly thereafter) and therefore provides greater scope for banking than most existing TGC schemes. The more support for green generators is provided by the allowance price rather than the certificate price, the more intertemporal flexibility is implicitly available to green generators.

§ ***Allowance allocation in the EU ETS***. If allowance allocations are offered to new entrants in the EU ETS and if these also are awarded to some 'green' generators, then the effect amounts to decreasing the long-run marginal cost of such technologies. If some but not all green technologies (e.g., biomass generation but not wind power) are eligible for allocations this may distort the choice of green technologies.

Interactions between Tradable White Certificate Schemes and the EU ETS

The analyses of the EU ETS and the TWC schemes provide the bases for assessing the interactions. We consider both sets of interactions, first the effects of the TWC programme on the EU ETS and its electricity market impacts, and then the opposite case of the effects of the EU ETS on the White Certificate programme and its impacts.

Effects of the TWC programme on the EU ETS and its electricity market effects

A TWC programme will affect the EU ETS in ways that are broadly similar to the effects of a Green Certificate programme. There are, however, some differences between the two certificate programmes, as noted below.

Effects of TWC scheme on the market for CO_2 allowances

The general effects of the TWC programme on the CO_2 allowance market are the same as for the TGC programme. Reductions in CO_2 emissions due to reduced electricity generation reduce BAU emissions of CO_2 and thus result in a lower CO_2 allowance price.

Note that as with TGC schemes, the lower CO_2 allowance price does not necessarily mean that the total costs of achieving the EU ETS CO_2 cap would be smaller than if the TWC programme were not in place. If non-CO_2 benefits from improved energy efficiency are ignored, the presence of a TWC programme would increase the overall cost of meeting the CO_2 cap (because the certificate programme would not necessarily incentivise the lowest cost combination of compliance alternatives to be chosen.)

Effects of a tradable white certificate scheme on the electricity market impacts of the EU ETS

The reduced CO_2 price under the White Certificate programme will lead to the same general effects as under the Green Certificate programme. The lower CO_2 allowance price means that compliance costs attributable solely to the EU ETS would be lower and the costs of residual emissions would be lower.

As with the Green Certificate programme, the White Certificate programme could affect the marginal generator, and thus change the implications for the electricity price of the EU ETS. For the White Certificate programme, this effect would be due to a reduction in overall electricity demand, rather than a shift away from non-green generation. To be comparable in magnitude to the effect shown for TGC schemes, the energy savings target would need to be at the same level as the (incremental) percentage target for green generation.

Note that as with the case of the Green Certificate programme, this result does not mean that the net effect on electricity prices of the EU ETS and the Green Certificate programme would be lower than the effect of the EU ETS by itself, but rather that the combined effect of the two programmes on electricity prices would be lower than the sum of their separate effects.

Effects of the EU ETS on a TWC schemes and their influence on electricity markets

The presence of the EU ETS will have effects on a TWC programme and change its implications for the electricity market. As explained below, these effects are somewhat different than those for the TGC programme because of differences in the way that targets are assumed to be set under the two certificate programmes.

Effects of the EU ETS on the tradable white certificate market

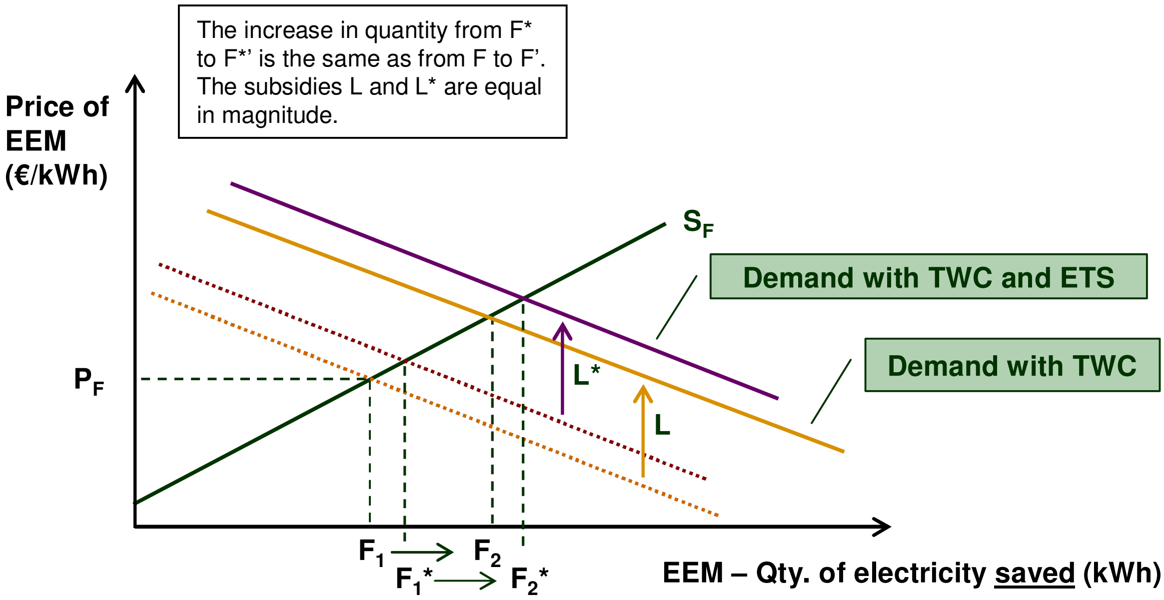
The EU ETS would increase the price of electricity, which could lead to a larger number of energy efficiency efforts being undertaken in the absence of the TWC programme. Under a TGC programme, the higher electricity price due to the EU ETS would have the effect of reducing the TGC price, because the target consists of a given quota of 'green' generation.

In contrast, the target under a TWC programme is based upon generating *additional* energy efficiency improvements, beyond those that would be achieved based upon the expected electricity price. Thus, if the expected electricity price were to change as a result of the EU ETS, some of the energy efficiency projects that would have been developed to meet the TWC requirement would be adopted 'naturally' and the programme would need to incentivise *additional* energy efficiency projects. Put differently, the formulation of targets in TWC schemes would take into account any change in the baseline energy efficiency measures occasioned by the EU ETS.

An analogous case could arise with a TGC scheme, if the definition of what constitutes 'green' energy were modified to exclude sources that would become viable due to the EU ETS. In practice, determining which measures fall into this category could be extremely difficult.

Whether this changed requirement would lead to an increase or decrease in the white certificate price depends on the shape of the supply curve for energy efficiency improvements in the region of the additional projects. If the supply curve were relatively elastic (i.e., the energy efficiency alternatives increase substantially for a given increase in cost), the price of certificates could decline. In contrast, if the supply curve were relatively inelastic (i.e., energy efficiency alternatives would increase only modestly for the increase in cost) the price of Certificates could increase. Figure ES-15 illustrates the effects of the EU ETS on the TWC price, showing a linear supply curve and thus an unchanging certificate price.

Figure ES-15
Effect on the EU ETS of a tradable white certificate scheme



Effects of the EU ETS on the electricity market impacts of the tradable white certificate programme

As outlined above, the electricity market impact of the TWC scheme is directly linked to the price of certificates. The EU ETS therefore alters the effects of the TWC scheme on the electricity market only to the extent that it affects certificate prices, and as discussed above this effect is ambiguous. Unlike in the case of TGC schemes, it is ambiguous what impact the EU ETS will have on the electricity market impact of a TWC scheme.

Effect of market and design features on the interactions

Generally speaking, a white certificate market of the sort outlined here is less directly linked to the EU ETS than is the green electricity market. The chief reason for this is that, as described here, the energy efficiency measures of a white certificate programme are by assumption *additional* to a pre-existing baseline. This baseline may include the retail electricity price, the effects of the EU ETS, or any other factors that affect the amount of energy efficiency measures undertaken.

Under this assumption, white certificate prices are not, generally speaking, lower with the EU ETS than without, and the EU ETS offers no additional support to certificate-generating activities. As a result, factors such as certificate price regulation, intertemporal flexibility, and other features that had the potential to change the results of the interactions in the case of a Green Certificate programme and the EU ETS, do not have an effect in the case of White Certificates. The adjustment of the baseline to include only additional energy efficiency measures removes many of the potential sources of interactions.

This means that the way the energy efficiency target is defined is a very important design parameter for the interaction with the EU ETS. If the baseline is defined differently (e.g., set in advance and not adjusted to account for the impact of the EU ETS or changes in the allowance price), then conclusions change and the effects of the EU ETS on energy saving behaviour will be reflected in the certificate price. As the effect of the EU ETS on energy prices causes end-users to undertake energy saving projects, a smaller ‘subsidy’ in the form of white certificates is necessary to meet the overall energy saving target, and white certificate prices fall. This situation is similar to that of green certificates.

A similar situation may arise as a result of practical difficulties in defining eligibility of projects. For example, it may be very difficult in practice to determine which energy saving projects are ‘additional’, and to eliminate ‘free-riders’ that would have undertaken energy savings anyway. This can also lead to a situation where white certificate prices are lower with the EU ETS than without, or affected by changes in the EU ETS allowance price.

If the effects of white certificates and the EU ETS on energy savings are complementary rather than additional, many of the interactions outlined in relation to green certificates above are relevant also in white certificate schemes. This includes the results concerning the effects of price ceilings, price floors, intertemporal flexibility, and the eligibility of energy efficiency measures.

Effect of updating allowance allocation on the interactions

The allocation approach used in the EU ETS has the potential to interact with the aim of the TWC scheme to encourage energy savings. In particular, some members states have discussed the potential to use a formula for allocation to electricity producers that incorporate past electricity production, combined with a benchmarked emissions intensity. If this is used within an ‘updating’ context, current output decisions may have the effect of increasing future allocations. This has the effect of lowering the total marginal cost of production, and would work as an effective subsidy to electricity production. Insofar as this results in increased demand in the medium to long term, it may result in lower electricity prices.

This has the potential to interact with the objectives of the TWC scheme. Most immediately, the demand for energy efficiency services may be affected by the lower electricity price, and a higher subsidy required to effect a given set of energy efficiency measures. This would result in a higher white certificate price. Also, consumers undertaking measures eligible under the TWC scheme may benefit doubly from the lower electricity price and the lower electricity price (while the higher price of certificates is shared among all consumers).

Implications of Interactions between Tradable Green and White Certificate Programmes and the EU ETS

The following are general implications of the interactions between the Green and White Certificate programmes and the EU ETS. More detailed conclusions are provided in the final chapter of this report.

§ TGC and TWC programmes generally would *not* affect EU-wide CO_2 emissions from EU ETS participating facilities, although the programmes would affect other facets of the EU ETS.

  – The CO_2 allowance price would be reduced.

- Overall costs of meeting the CO_2 cap would be increased (but this comparison does not take into account the non-CO_2 benefits and any 'technology-forcing' benefits of the two programmes).
- Changes in the location of CO_2 allowance purchases/sales due to the programmes could affect national CO_2 emissions and thus affect the Kyoto burdens of Member States.
- EU-wide CO_2 emissions from participating facilities *could in theory* be reduced below the overall cap if the Green and/or White Certificate programmes were sufficiently stringent; in this case, the EU ETS would not be binding and the CO_2 allowance price would be zero. (Of course, the cap could also be reduced if the presence of the Green/White Certificate programmes led policy makers to reduce overall allowances to the participating facilities.)
- Moreover, CO_2 emissions *outside* participating facilities could be reduced due to White Certificate programmes if non-electric efficiency projects were included (e.g., insulation programs that reduce household/commercial fuel use and thus CO_2 from oil/natural gas sources not covered by EU ETS).
- TGC and TWC programmes would reduce the effects of the EU ETS on wholesale electricity costs (because they reduce CO_2 compliance costs and the CO_2 allowance price); but this result does not imply that the *combined* electricity cost/rate increases of the EU ETS and the TGC and TWC programmes would be smaller than the effects of the EU ETS on its own.

§ The EU ETS generally has the effect of lowering the cost of implementing green (and white) certificate programmes, except where the targets of such programmes are defined to be additional to any effects of the EU ETS.

- The EU ETS offers support for green generation by raising wholesale electricity prices without increasing the cost of green generation. This will lower the cost of achieving a green generation target, as a smaller 'subsidy' is required. Generally speaking, high allowance prices therefore lead to lower green certificate prices and a lower cost of implementing the green certificate programme. For a given quota, the EU ETS does not result in additional green generation.
- The effects of the EU ETS on retail electricity prices can encourage energy savings. This will lower the white certificate price if this effect is not fully taken into account when the energy savings target is set, leading to a lower cost of implementing the white certificate programme. If, on the other hand, targets are set to be fully additional to any effect of the EU ETS, this effect does not occur and the effect of the EU ETS on the cost of implementing the white certificate programme is ambiguous. The amount of energy saving undertaken is only increased by the EU ETS if the energy saving target is adjusted to account for the effect on retail prices.
- A number of additional effects of the EU ETS on green/white certificate programmes may be in place as the total amount of electricity supplied changes. The exact effects are complicated and depend on the characteristics of the electricity market, including the electricity generation merit order and fuel mix and the nature of demand for electricity. Possible effects include changing the marginal generation technology, with concomitant changes to the price impact of the EU ETS as the CO_2 intensity of

the marginal generator changes. The effects depend also on the green electricity merit order and available supply of energy savings services, respectively.

– Design parameters such as price ceilings or floors, different rules for intertemporal flexibility, and the definition of green generation / energy savings targets may change some of the interactions and the conclusions about the complementarities of the EU ETS and the certificate programmes. However, these effects are generally likely to be small compared to the primary interactions mediated through the electricity and certificate markets. The primary sources of interactions are through the electricity and green/white certificate market prices.

§ Providing CO_2 credits for TGCs or TWCs would not be desirable.

– Providing such credits would represent double counting, which would have the effect of undermining the EU ETS CO_2 cap.

– Providing credits based on average CO_2 rates for Green or White Certificates would introduce inefficiencies since the average rates would not reflect the actual CO_2 emissions 'reduced' as a result of increased green generation or reduced generation.

1. Introduction and Background

1.1 EU ETS and Green/White Certificate Programs

The European Union Emission Trading Scheme ('EU ETS') began operation in January 2005. The preparation leading up to, and the subsequent advent of, the EU ETS has raised interest in the trading-based approach to achieving other key environmental goals in the EU, particularly those related to the promotion of renewable energy (so-called 'Tradable Green Certificate' or TGC schemes) and energy efficiency ('Tradable White Certificate' or TWC schemes). Indeed, national and regional markets in green and (to a lesser extent) white certificates already exist. Green certificate schemes are established or proposed in a number of Member States (e.g., the UK, the Netherlands, Italy, Belgium, Sweden, Austria, and Denmark) and form part of a growing portfolio of measures to achieve the indicative targets for renewable energy sources as outlined in Directive 2001/77/EC. White certificate schemes have been slower to develop, but schemes are now established in Italy and the UK and further activity may be stimulated by the Commission proposal on energy services (COM(2003)739). Both the renewables Directive and the energy services proposals envisage the possible evolution and harmonisation of these instruments into EU-wide certificate schemes.

1.2 Purpose and Scope of the Study

With the implementation of the EU ETS, the development of green and white certificate schemes raises some complex issues of policy interaction. The Directorate-General Environment of the European Commission (hereafter, 'EC' or 'the Commission') developed and Invitation to Tender for a project with two major objectives:

1. Interactions among EU ETS and green/white certificate markets. The first major objective is to identify and describe the interactions between green and white certificate schemes and the EU ETS.
2. Implications of interactions for the policy objectives of the EU ETS. The second major objective is to assess the implications of green/white certificate schemes for the objectives of the EU ETS.

These two major tasks are linked, as insights regarding the interactions among the various instruments provide the basis for judgments regarding the implications of green/white certificate schemes for the policy objectives of the EU ETS. Note that the study is not designed to evaluate the public policy desirability of green/white certificate schemes or to describe their optimum designs—which would require a much wider scope—but rather to consider the interaction of these schemes with the EU ETS.

The Commission commissioned NERA Economic Consulting in collaboration with Mr. Steven Sorrell of the University of Sussex (hereafter, 'NERA Team') to undertake the research project. The NERA Team has considerable experience in both environmental markets—including the EU ETS and the relevant green/white certificate markets—and in the energy sector. Energy sector experience is important because the interactions between the schemes will largely be mediated through their influences on electricity markets.

In conjunction with the Commission, the NERA Team developed the following specific objectives:

- Provide information on the EU ETS and its effects on electricity markets.
- Describe green and white certificate schemes and how they affect electricity markets.
- Evaluate how green and white certificate schemes interact with the EU ETS.
- Provide conclusions regarding the elements of green/white certificate schemes that might affect compatibility with the EU ETS.

1.3 Method of Approach

The interactions between the EU ETS and green/white certificate schemes are complex and sometimes counterintuitive. They are also mediated through multiple markets, and depend on design aspects of the various schemes as well as on specific market features and other individual circumstances.

In order to minimise complexity, this report abstracts from the empirical details of individual schemes and makes a number of simplifying assumptions regarding the operation of allowance, certificate and electricity markets. This permits the use of graphical analysis to identify the basic effects of each instrument and to explore the interactions between them. Having established the sign and potential magnitude of these effects, the report provides a qualitative discussion of the potential impact of various real-world market and design features. This is based on a review of the features of existing green and white certificate schemes, which is included in an Annex. While the primary focus throughout is the interaction between the EU ETS and national certificate schemes, a brief assessment is provided of the implications of international trade in certificates.

Most interactions between the schemes are mediated through electricity markets. This is clearly the case for green certificate schemes, since their primary objective is to promote electricity generation from renewable energy sources. It may be less clear in the case of white certificate schemes, since some of the 'energy savings' encouraged by such schemes may be from fuel use rather than electricity use. However, interactions with the EU ETS (and green certificate schemes) are nonetheless confined largely to electricity markets, since existing white certificate schemes primarily target from sources that are currently not covered by the EU ETS (notably, households). Focussing on the electricity market therefore captures virtually all the important interactions between the three instruments. A fuller assessment would require quantitative modelling, preferably within a general equilibrium framework.

To provide an organising framework, the study focuses on a small number of *price*, *quantity* and *distributional* variables. These are as follows:

Price variables:

- wholesale electricity prices;
- consumer electricity prices;
- EU ETS allowance price;

§ green certificate price; and
§ white certificate price.

Quantity variables:

§ electricity demand;
§ electricity generation not eligible for green certificates;
§ electricity generation eligible for green certificates;
§ carbon dioxide emissions;
§ investment in end-user energy efficiency; and
§ investment in renewable energy.

Distributional variables:

§ impacts on electricity producers; and
§ impacts on electricity consumers.

For distributional effects, the following sub-categories of producers and consumers are defined:

§ Electricity producers, including:
  – electricity generators not eligible for green certificates, divided into:
    – high-emitting producers, and
    – low-emitting producers; and
  – electricity generators eligible for green certificates
§ Producers of energy efficient equipment.
§ Electricity consumers, including:
  – beneficiaries of subsidies from white certificate schemes; and
  – non-beneficiaries of subsidies from white certificate schemes.

The impacts on each price and quantity variable are explored using simple graphical techniques, while the distributional impacts are assessed using standard measures of consumer and producer 'surplus'. We stress that the latter is *not* a 'welfare analysis' as it does not comprehensively assess the costs and benefits of each instrument. Neither market failures (e.g. environmental externalities, information externalities) nor secondary effects in other markets (e.g., fuel markets) are considered. Instead, the analysis simply illustrates how the electricity market costs of each instrument may be borne by producers and consumers of electricity.

In many cases, individual policy instruments or combinations of instruments may have a different effect at the national level than they do at an EU-wide level. For example, a policy instrument may reduce national carbon dioxide emissions, even where carbon dioxide emissions in the EU as a whole are unaffected. Hence, a distinction is made between national and EU-level effects where appropriate.

In sum, the approach of the study is then as follows:

§ Using a number of simplifying assumptions, we examine the potential effect on these variables of each scheme operating in isolation.

§ Using the same simplifying assumptions, we examine how these effects may be modified by the interaction between the schemes.

§ We then examine how various features of the schemes, such as their relative geographic scale, could affect the interactions.

In each case, we focus on whether the relevant variables are *increased*, *reduced* or *unaffected*, or whether the outcome is *ambiguous* and therefore depends on the individual circumstances. These results are summarised in tables at the end of each section and these tables provide a useful overview of the analysis. Where possible, commentary is provided on the likely magnitude of these different effects.

1.4 Outline of Report

The following six chapters are organised as follows:

§ Chapter 2: The nature and operation of the EU ETS is characterised, including its interaction with electricity markets and its effect on key variables.

§ Chapter 3: Green certificate schemes are characterised, including key design features, existing and proposed schemes in the EU, their interaction with electricity markets, and their effect on key variables.

§ Chapter 4: White certificate schemes are characterised, including key design features, existing and proposed schemes in the EU, their interaction with electricity markets, and their effect on key variables.

§ Chapter 5: The impact of certificate schemes on the EU ETS is discussed, including the overall implications for CO_2 emissions and the EU ETS allowance market. The effects of green and white certificate schemes are then considered separately, including the impact on key variables and the effect of various design features.

§ Chapter 6: The impact of the EU ETS on the functioning of green certificate schemes is explored, including implications for the green certificate market and the effect on key variables. The significance of different certificate scheme designs for interactions are considered.

§ Chapter 7: The differences between white and green certificate schemes are discussed, including the relative importance of regulatory decision-making. The impact of the EU ETS on the functioning of white certificate schemes is explored, including implications for the white certificate market and the effect on key variables. The significance of different certificate scheme designs for interactions are considered.

§ Chapter 8: The implications of these various interactions for the policy objectives of the EU ETS are assessed, together with the complications introduced by the regulatory treatment of the electricity sector, the geographic scope of the schemes and individual design features.

A review of existing and proposed certificate schemes in the EU is included in an Annex.

2 The European Union Emissions Trading Scheme

2.1 Characteristics of the EU ETS

The European Union Emissions Trading Scheme for Greenhouse Gases ('EU ETS', or 'the Scheme') was established by the Emissions Trading Directive 2003/87/EC of the European Parliament and of the Council of Ministers in 2003 (the 'Directive'). It has been adopted as a cost-effective and economically efficient mechanism to comply with the EU's commitment under the Kyoto Protocol to reduce its emissions of greenhouse gases ('GHGs') by 8 percent compared to 1990 levels over the period 2008-2012.

The EU ETS is a 'cap-and-trade' type scheme. Rules of the Scheme, as embodied in the Directive and implemented by individual Member States, identify the installations that are covered by the Scheme; determine how allowances to emit carbon dioxide ('CO_2') are to be distributed to these installations; and stipulate an obligation on each installation to surrender allowances equal to its total emissions in each calendar year. This amounts to the establishment of a cap on the carbon dioxide emissions from covered installations in the EU.[9]

In addition, allowances are tradable. Installations can generate surplus allowances by lowering emissions below their allocated allowance amount; conversely, they can comply by purchasing any necessary shortfall of allowances on the allowance market. Generally speaking and under standard assumptions about the functioning of the market, this flexibility helps distribute emissions reductions to those installations where they are cheapest to effect, thereby lowering the overall cost of achieving the cap on emissions.

2.1.1 The allocation of allowances under the EU ETS

The Scheme is organised in phases. The first phase of the Scheme runs from 2005-2007, after which the Scheme will operate in five-year phases. The second phase, 2008-2012, thus coincides with the first Commitment Period under the Kyoto Protocol.

The installations covered in the first phase of the Scheme are specified in Annex I of the Directive. They include large installations in certain industrial sectors (e.g., power generation, refining, iron and steel, cement, glass, lime, bricks, ceramics, pulp and paper). In particular, the Directive covers all combustion installations with a rated thermal input exceeding 20 MW.[10] Thus, the Directive covers almost the entire power generation sector. Altogether, some 12,000 installations, accounting for 45 percent of CO_2 emissions in the EU, will be covered by the Scheme. These installations currently emit over 2 Giga-tonnes of CO_2 per year. Some additional sectors with large emissions, including households, transport, and agriculture are not currently covered by the Scheme.[11]

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[9] In addition to allowances allocated by each Member State, allowances may also enter the Scheme through the 'Linking Directive' (COM 2003/403). This allows emissions credits generated through the Flexible Mechanisms of the Kyoto Protocol—Joint Implementation ('JI') and the Clean Development Mechanism ('CDM')—to be valid for compliance within the EU ETS.

[10] European Union (2003)

[11] European Commission (2005)

The allocation of emissions allowances is the task of each national government, which is required to publish a National Allocation Plan ('NAP') for each phase of the Scheme. In the first two phases, allowances must be awarded largely free of charge. All phase-one NAPs that have been adopted distribute permits either on the basis of historical emissions ('grandfathering') or using industry benchmarks. In contrast, it remains unclear what allocation methodologies will be adopted for the subsequent phases of the Scheme. One possible allocation methodology would involve basing allocations on future emissions, an approach commonly called 'updating.' As will be discussed below, this has significance for the effect of the EU ETS on electricity prices.

The NAP is subject to the provisions in Annex III of the Emissions Trading Directive. Among other things, this requires the total quantity of allowances allocated to be consistent with the Member State's obligations under the EU 'Burden-Sharing Agreement' (Decision 2002/358/EC) and the Kyoto Protocol, which specify the emissions reductions incumbent on each individual Member State. Member States also have the option of reserving a portion of total allowances for new installations, and many Member States have plans to give allocations to such new entrants in Phase 1 and beyond.

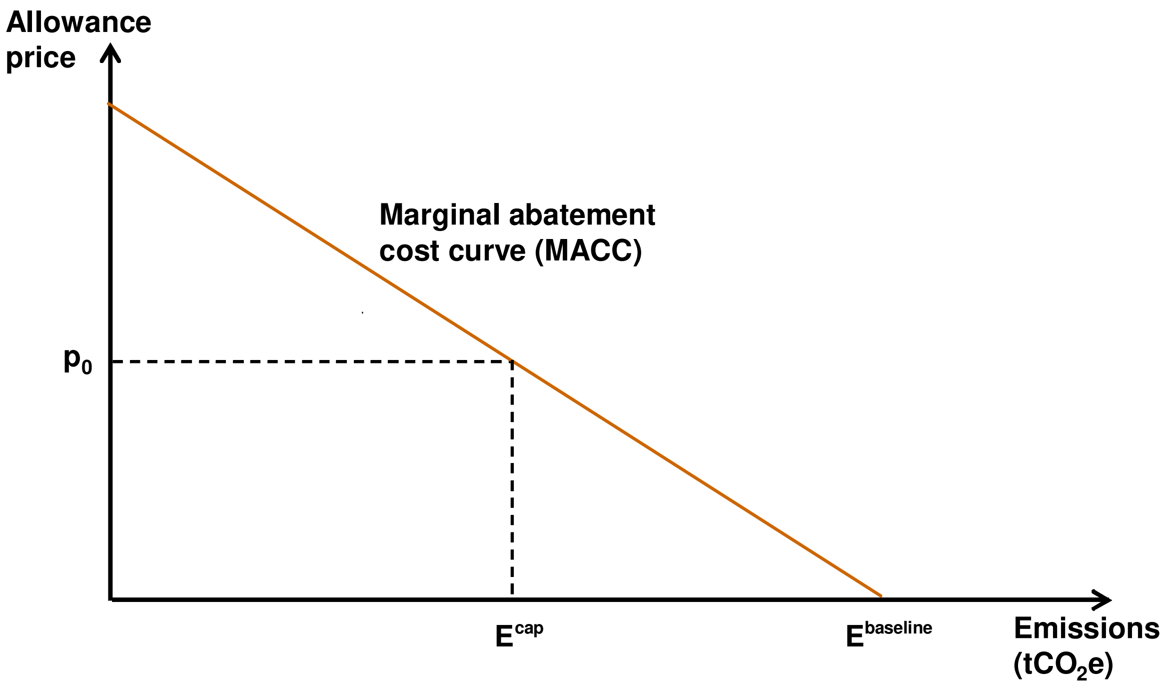
2.1.2 The market for allowances under the EU ETS

The most immediate effect of the EU ETS is to establish a price for carbon dioxide emission allowances (i.e., the right to emit a tonne of carbon dioxide) in the EU. The price established in the market is primarily a function of the following four factors:

1. *Baseline emissions ($E^{baseline}$).* This is the level of emissions that covered facilities would emit if they were not subject to the EU ETS cap on CO_2 emissions, that is, under 'baseline' emissions.
2. *Marginal abatement cost curve ('MACC').* The curve shows the cost of reducing CO_2 emissions by another unit (the marginal cost) based upon the reduction opportunities available to covered facilities.
3. *Emissions cap (E^{cap}).* This is the level to which covered facilities are required to reduce their emissions under the EU ETS.
4. *Allowance price (p_0).* This value represents the equilibrium market price of CO_2 allowances resulting from factors 1 to 3.

These four factors are illustrated in the figure below.

Figure 2.1
The market for EU ETS CO_2 allowances



The figure shows that the market price for CO_2 allowances is highly dependent on both the characteristics of the MACC and the level at which the cap is set.

2.2 Interaction of the EU ETS with a National Electricity Market

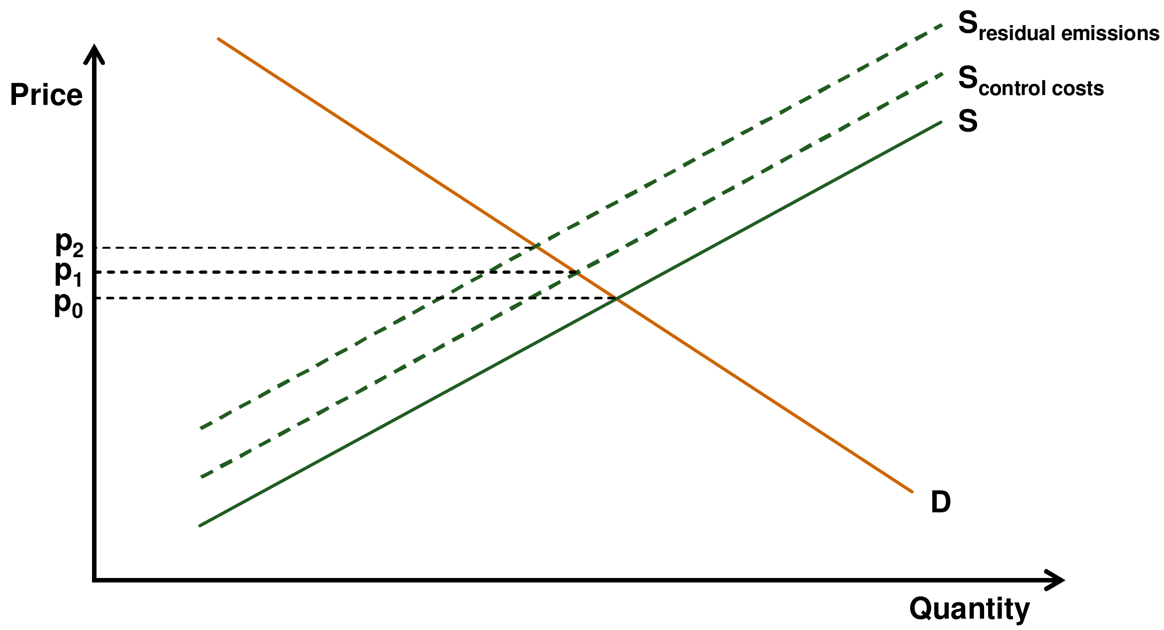
The EU ETS will cover the majority of the electricity generation plant in the EU and will have a significant impact on electricity markets. This section examines these impacts in some detail, focusing in particular on the price and quantity of electricity supplied and demanded. The analysis is stylised, but does introduce both short-term and long-term effects as well as the effect of various real-world market and regulatory features.

2.2.1 General effects of the EU ETS on product markets

The market for CO_2 allowances created by the EU ETS results in a market price for CO_2 emissions that will affect the cost of supplying goods for producers covered by the Scheme. Producers will react to the market for CO_2 emissions by undertaking efforts to reduce CO_2 emissions from their plant—such as switching to lower-CO_2 sources or increasing the efficiency of their plant—as long as the cost of reducing emissions by another unit (the 'marginal abatement cost') is less than the CO_2 price. These control costs will increase the cost of production. In addition, producers will incur costs for the residual CO_2 emissions that remain after the cost-effective control options are exhausted. Indeed, even if producers receive sufficient allocations for free to cover their residual emissions, every tonne of CO_2 emitted results in a cost (an 'opportunity cost') because the allowance used to cover the CO_2 tonne emitted could otherwise be sold at the market price.

Figure 2.2 shows the general effects of the EU ETS on prices for goods, such as electricity, whose production emits CO_2. The cap-and-trade programme has two effects on the marginal cost curve. Schedule *D* indicates the demand for the product, while the schedules labelled *S* indicate supply. The first effect of the EU ETS is to increase abatement costs, such as the cost of switching to low-CO_2 fuels or increasing the energy efficiency of operations. This is indicated by schedule $S_{control\ costs}$. The second effect relates to the cost of allowances needed for residual emissions after cost-effective emissions abatement has been undertaken, indicated by schedule $S_{residual\ emissions}$. As noted, the allowance price corresponds to the cost of residual emissions, regardless of whether the allowances are purchased or are distributed for free. In competitive markets, these increased costs as a result of the EU ETS lead to an increase in the product price (e.g., electricity price) from p_0 to p_2, reflecting both the CO_2 control costs and the costs of covering residual emissions.

Figure 2.2
Effects of EU ETS on product supply and prices



Turning specifically to the electricity sector, the effects of the EU ETS on electricity markets can be organised into three categories:

§ *Short-term cost impacts:* First, introducing a price on CO_2 emissions will increase the short-term marginal cost ('STMC') of certain forms of generation, making low-emitting technologies cheaper relative to high-emitting technologies.[12] This will shift the costs of different generation technologies, potentially altering the role of different types of generation.

§ *Short-term price impacts*: Second, these effects on the STMC of generation facilities ('units') will lead to impacts on wholesale electricity prices. To the extent that cost

[12] The short-term marginal cost is the change in the cost of production of an existing production facility when increasing (or decreasing) output by one unit. Long-term marginal cost also takes into account the costs of capacity expansion, and therefore includes fixed costs, investment costs, and operating costs.

increases are passed on to consumers, these will also lead to higher consumer (or retail) prices. Also, the relative profitability of units may change, depending on their emissions intensity of generation. The extent to which these considerations affect electricity prices will depend on a number of factors, including any shifts in the merit order (defined below), the electricity regulatory regime, and the market power of participants.

§ Long-term impacts: Finally, the relative long-term marginal cost ('LTMC') of different forms of generation may change. As discussed below, this potentially affects the investment incentives of different technologies, potentially shifting generation toward lower-emitting sources of CO_2 in the long term. Changes in the LTMC of different technologies may also have second-order effects in fuel market. By changing the demand for different types of fuel, the EU ETS could increase the cost of low-emitting fuels like natural gas and reduce the cost of higher-emitting fuels like coal. These fuel market effects are not included in the analysis that follow, which focuses solely on electricity markets.

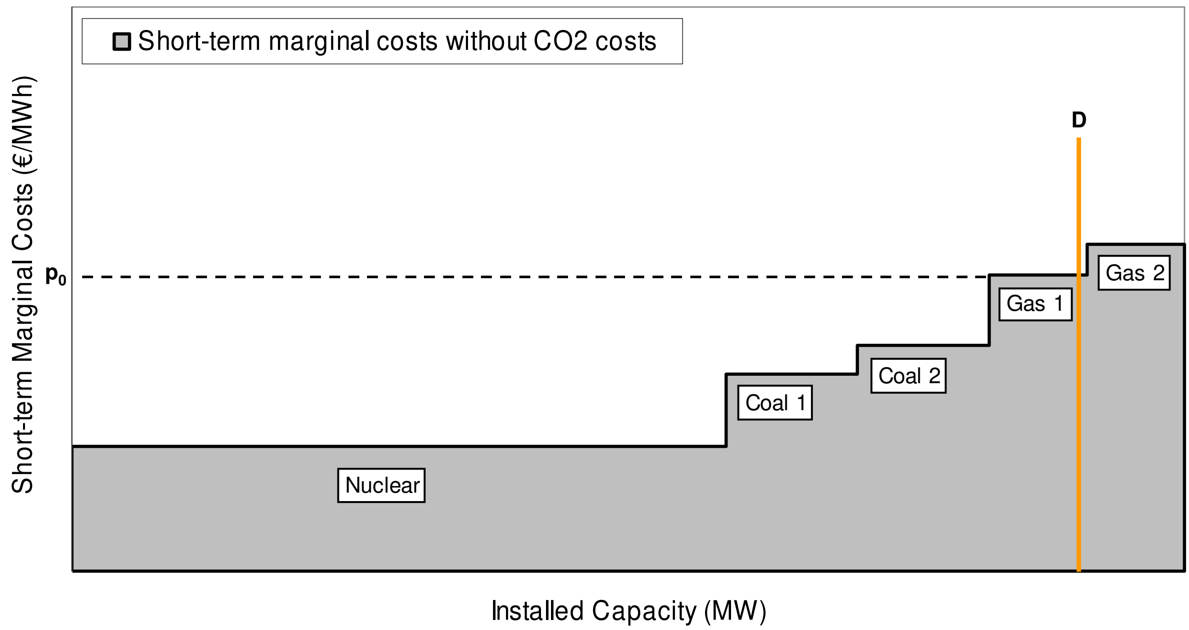
The following sections discuss short-term cost, short-term price and long-term effects in detail.

2.2.2 Short-term effects of the EU ETS on generation costs

As suggested above, the supply of electricity at any particular time is determined by the short-term marginal cost of generation facilities. That is, a generator is unwilling to 'bid in' to the market unless the wholesale electricity price at least equals its STMC. For this reason, units naturally enter the market in order of increasing STMC; the ordering of all available units by increasing STMC is referred to as the 'merit order'. In the aggregate, the merit order forms a supply curve, or an indication of the cost of supplying different amounts of power, given all other relevant parameters.

Figure 2.3 illustrates a highly stylised hypothetical merit order for three different fuels: nuclear, coal, and natural gas. In addition, the coal and gas units differ in electric efficiency (the rate at which fuel input is converted to electricity output), so unit 'Coal 1' has a lower marginal cost of generation than does 'Coal 2', and 'Gas 1' a lower cost than 'Gas 2'. In reality, a merit order contains a much grater number of units with slightly different marginal costs, and the actual supply curve is much smoother than shown here. Nonetheless, this illustration is instructive. As illustrated in the figure, the nuclear unit have the lowest short-term marginal cost and natural gas powered plants the highest, with 'Gas 2' the most expensive to run. In a competitive setting, coal plants will only be used to supply power once nuclear capacity is exhausted, and gas will come on line once all coal capacity has been used. It is reasonable to assume that demand, indicated by the vertical schedule D, is fixed in the short run.

Figure 2.3
Example of electricity generation technology merit order



In a competitive wholesale electricity market, the spot market price is equal to the short-term marginal cost of the *marginal producer,* i.e., the last producer to bid into the market (the one with the highest short-term marginal cost among those suppliers that meet demand). The wholesale price cannot be *lower* than this level, as producers will not generate if they cannot recover the short-term cost of producing electricity. Similarly, in a competitive market with excess capacity, we also do not expect wholesale prices to be *higher* than the short-term marginal cost of the marginal producer, as prices will be bid down as producers compete for customers.[13] In our example, gas unit 'Gas 1' is the marginal producer for the given level of demand, and the line p_0 indicates the spot-market price in the figure.

2.2.2.1 Effect of increased CO_2 costs

The introduction of a price for CO_2 emissions will increase the short-term marginal cost of all producers that emit carbon dioxide. Costs increase because firms need to retire allowances to cover their remaining CO_2 emissions; as discussed, this cost arises even if the firm receives the allowances for free. (These costs are referred to as 'opportunity costs' because they reflect the cost of forfeiting the opportunity to sell the allowances at the price obtainable in the allowance market) Note that the extent of the increase in costs can depend on the methodology used to allocate free allowances, as discussed below.

To demonstrate why costs increase when a CO_2 price is introduced, it is helpful to consider a simple example. Consider two generation units, one with gas as its primary fuel and the other using coal. Various indicative parameters for each of these units are shown in the table

13 Generators also require some payment to cover their capacity costs. This is discussed further down.

below. As the table shows, the CO_2 emissions factor of gas as a fuel (0.19 tCO_2/MWh) is significantly lower than the factor for coal as a fuel (0.34 tCO_2/MWh). In addition, the gas unit is more efficient than the coal unit, meaning that it captures a higher proportion of the energy stored in the fuel. When these two components are accounted for, the emissions factor for electricity generation from the coal unit (0.85 tCO_2/MWhe) is more than twice the corresponding factor for the gas unit (0.35 tCO_2/MWh). For every MWh of electricity generated from gas, 0.35 tonnes of CO_2 emissions are created, while for every MWh of electricity generated from coal, 0.85 tonnes of CO_2 emissions are created. Assuming a CO_2 permit price of €10/tonne, then, the CO_2 cost of generating a MWh from coal is €8.50, while the cost of generating from gas is less than half that, at €3.50.

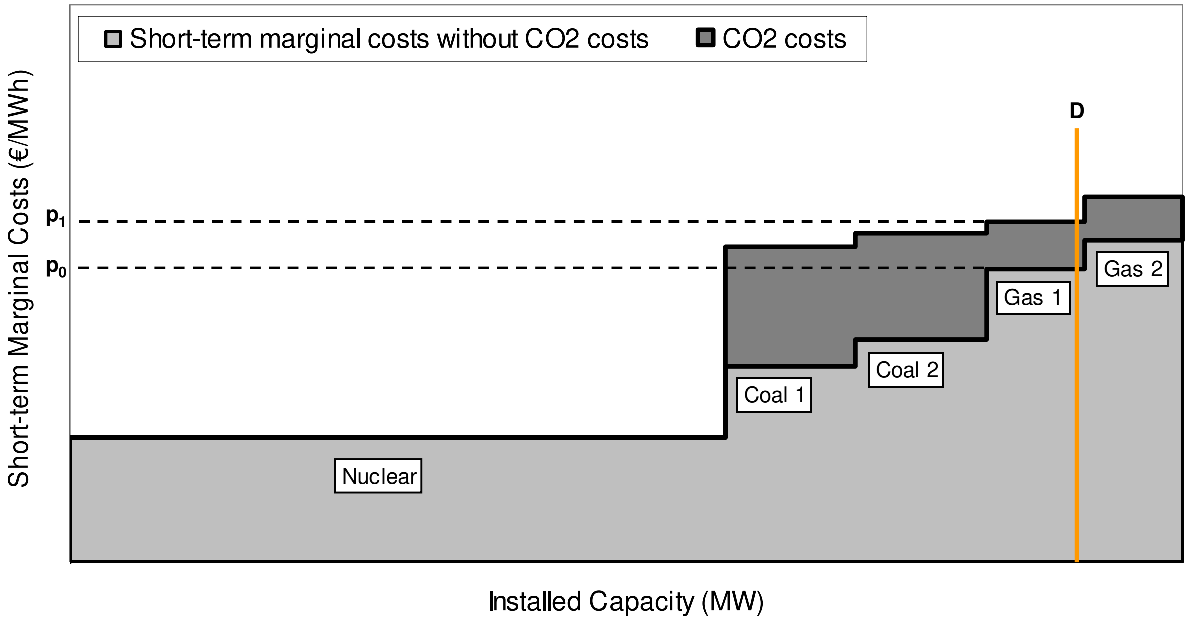
Table 2.1
The cost of CO_2 emissions: a simple example

Variable	CCGT	Coal
Input emissions factor (tCO_2e/MWhth)	0.19	0.34
Efficiency	0.55	0.40
Output emissions factor (tCO_2e/MWhe)	0.35	0.85
Allowance price (€/tCO_2e)	€ 10	€ 10
Cost of CO_2 (€/MWhe)	€ 3.50	€ 8.50

Source: NERA estimates and calculations

The CO_2 costs described in this example affect the STMC of generation facilities that emit CO_2, which can influence the merit order. In Figure 2.4, the thick line represents the STMC power generation after CO_2 costs are accounted for. The figure shows that the STMC of nuclear power does not increase, because nuclear units effectively do not emit CO_2. In contrast, both gas and coal generators see an increase in the cost of generation. Coal has higher emissions intensity than gas, emitting roughly twice the CO_2 per MWh generated. As in the example above, the coal units' increase in STMC is more than twice the increase experienced by gas generation.

Figure 2.4
Example of electricity generation technology merit order including CO_2 costs

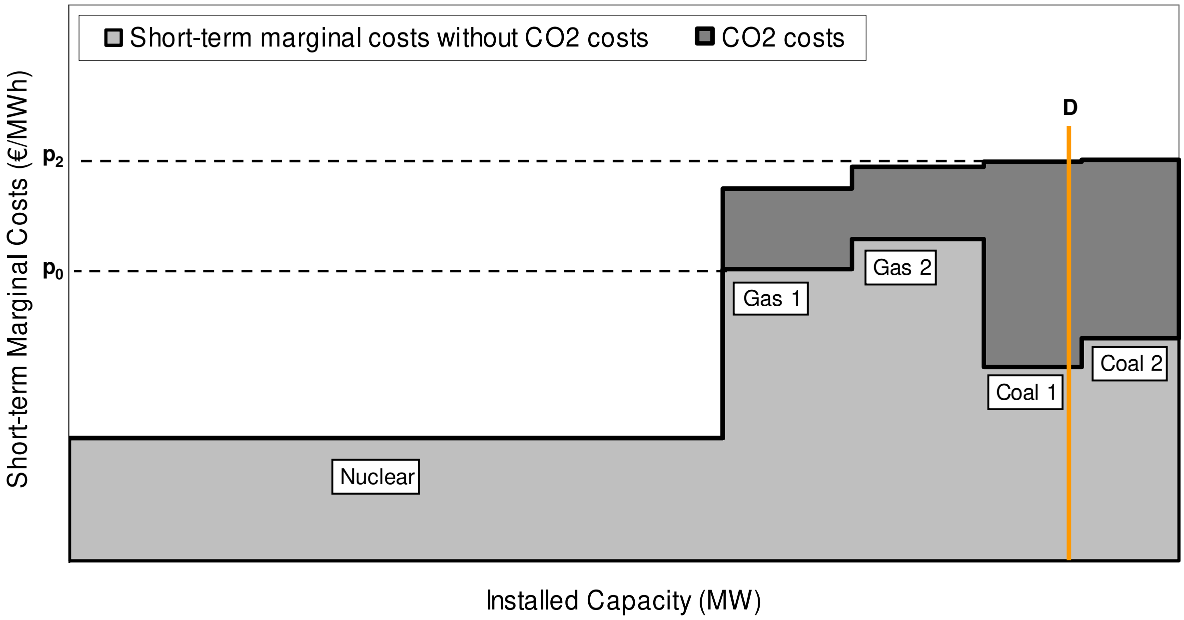


The increase in CO_2 costs also causes short-term wholesale prices to increase, from p_0 to p_1. This rise is equivalent to the CO_2 cost per MWh of gas-fired generation. In reality, the extent to which cost increases are passed through to wholesale markets will depend on a number of factors, including the structure of the electricity market) and the rules for CO_2 allowance allocation (see discussion below).

2.2.2.2 Changes in the merit order

With sufficiently high CO_2 costs and large variation in CO_2 intensity, the merit order of production changes when the CO_2 price is introduced. As noted, many coal plants produce almost twice the amount of CO_2 emissions per MWh of those from a modern combined cycle gas turbine ('CCGT') plant. This is illustrated in Figure 2.5. In the example shown below, the introduction of the CO_2 price causes the STMC of coal to increase above that of gas. Although this is not shown in the figure, the two change place in the generation technology merit order, causing coal to become the marginal generation technology and therefore to set the wholesale price.

Figure 2.5
Change in the electricity generation merit order with CO_2 costs



Reinaud (2003) explores what values for CO_2 could be expected to cause the STMC of coal to rise above that of gas. She finds that a price of €20/tCO_2 might be expected to effect this switch in a generalised EU setting.[14] It should be noted that these results are very sensitive to assumptions about fuel prices, plant efficiency rates, and the impact of other relevant environmental regulation (e.g., the Large Combustion Plant Directive).

These potential changes to profitability and the merit order mean that both the composition and the cost of electricity generation can change. In the short term, this can cause less CO_2-intensive technologies to operate more frequently. In the long term, this can lead to shifts in the type of generation built to operate in future. These longer-term effects are discussed further below.

2.2.2.3 Summary

The introduction of a CO_2 price as a result of a cap-and-trade programme will raise short-term wholesale electricity prices by increasing the cost of the (CO_2-emitting) marginal producer. A sufficiently high CO_2 price can also have the effect of changing the merit order of generation units. The effect on individual producers depends on the CO_2 intensity of their portfolio of generation. Those with average CO_2 intensity lower than that of the marginal producer may stand to gain from increased electricity prices by having costs increase less than prices.

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[14] In 2003 and 2004, prices ranged from €6/tCO_2 to €14/tCO_2, levelling out at about €9/tCO_2 after June 2004. Prices rose steeply in early 2005, however, topping €24/tCO_2 in July 2005 (PointCarbon, Natsource).

2.2.3 Short-term effects of the EU ETS on electricity prices

While it is clear that the *cost* of generation always includes the cost of the CO_2 allowances used up, it is not clear what proportion of these costs (or opportunity costs) will be passed on in the form of a rise in the short-term electricity *price*. This depends on market conditions, including the extent of liberalisation, market concentration and existing spare generation capacity, the fuel mix in the power market, and the allocation method used to distribute allowances. While the outcome in a particular market cannot always be predicted *a priori*, without reference to actual market conditions, we briefly discuss the role of these factors below.

2.2.3.1 Effect of changes in the merit order

In competitive markets, the change in wholesale price after the introduction of the CO_2 trading scheme will be the difference between the STMC of the marginal producer *before* the introduction of the trading scheme and that of the marginal producer *after* the scheme's introduction. If there were no change in the merit order of generation, the outcome under perfect competition would be a full pass-through of the marginal producer's additional CO_2 costs into the wholesale price for electricity. This is because the cost of the marginal producer will reflect the combined direct and opportunity cost of CO_2 allowances. The marginal producer would not be maximising profits if it did not raise its electricity 'offer price' to include this CO_2 cost. This is like the situation in Figure 2.4, where the price change ($p_1 - p_0$) is equal to the CO_2 cost of gas generators.

The situation is different if the trading scheme causes a change in the merit order. In Figure 2.5, the STMC of coal plants is higher than that of gas plants, and the resulting wholesale price p_2 therefore depends on the STMC of coal, rather than gas, plants. This means that the increase in the wholesale price is equal to the difference between the STMC of gas-fired plants *excluding* CO_2 costs, and the STMC of coal-fired plants *including* CO_2. In the example in Figure 2.5, this difference is smaller than the CO_2 cost of coal-fired generation on its own. Somewhat paradoxically, although the marginal generator changes to one with higher CO_2 costs, the price increase is only modestly higher than that when no change took place (as in Figure 2.4).

These considerations imply that, even in a setting of perfect competition, absent any complicating market effects, and with full cost pass-through in short-term markets, the exact price effects of the trading scheme may depend on any changes to the merit order.

2.2.3.2 Effect of allowance allocation methodology

Allowance allocation can be another factor that complicates the relationship of the EU ETS to electricity markets. Allowances for the first (2005-2007) phase of the EU ETS have been allocated to participants using a number of different methodologies. In nearly all cases, the amount allocated to individual installations has taken into account the historical emissions of those installations. Members States have not yet determined what methodology they will use to allocate allowances for the second (2008-2012) phase or for future phases.

As stated above, allowance allocation does not generally affect the impact of the EU ETS on electricity prices, as the opportunity cost of CO_2 emissions is the same regardless of the *current* level of allocation. However, there are allocation approaches that have the potential to change *future* allocations, often referred to as 'updating' aspects of allocation. Notably, if future-period allocations depend on current-period operating decisions (e.g., if allocations in Phase 2 are based on emissions or generation levels in Phase 1), then current activity may lead to higher future allocations. This effectively decreases the opportunity cost of emissions, as the current cost of emissions is offset by a future benefit. As a consequence, the impact on current prices is therefore also lower than it would be without updating. Since the 2^{nd} phase NAPs are due in mid-2006, the scope for such updating may be limited in practice, since it should not be possible to link allocations to emissions in either 2006 or 2007.

The allocation methodology could also affect the electricity price impacts of the EU ETS if companies treat freely distributed allowances differently from those they must purchase in the allowance market. As mentioned above, the full cost of generation includes the opportunity cost of allowances: allowances that are 'used up' by generation could have been sold on the market. In maximising their profit, producers would optimally take this cost into account. Reinaud (2003) suggests that companies might make a distinction between allowances that they receive for free and those for which they have to pay.

2.2.3.3 Effect of differing base and peak-load generation technologies

In many electricity markets different generation technologies are at the margin at different times of the day, week and year. The introduction of a CO_2 cost price can therefore affect the spread between prices in different periods. For example, if coal-fired generation has the lower short-term marginal cost and is the marginal technology serving base load, but gas-fired generation is the marginal technology during peak hours, then we would expect the gap between the marginal costs to narrow as the costs of electricity from coal (the more CO_2-intensive technology) increases more than those of electricity from gas. This also means that the *average* rise in electricity prices depends on whether the marginal technology varies with season or time of day. For example, coal-fired generation is the marginal technology in most of the Nordic electricity market at most but not at all times; we would therefore expect the average rise in electricity prices to be lower than the increase in the short-term marginal cost of coal generation.

2.2.3.4 Effect of market power and market concentration

Producers with a degree of market power (i.e., the ability to set prices, rather than take them as given) may react differently to cost increases due to the EU ETS. Market power may lead to greater or smaller price increases than if the markets were perfectly competitive. The precise effects of market power on electricity price increases would depend on the nature of demand conditions and the possibility of entry.

2.2.3.5 Effect of market structure

Liberalisation of the European electricity industry initially reduced vertical integration, but privatised utilities have exhibited a strong tendency toward vertical (re)integration through mergers and acquisitions. A vertically integrated utility may be reluctant to pass costs (in particular, opportunity costs) onto retail consumers, since this may encourage some customers to switch to competitors (ILEX, 2003). Alternatively, companies may discriminate between large and small customers, since the former may be more likely to switch. Similarly, companies with a portfolio of low-CO_2 generating plant may be able to subsidise their retail businesses from increased profits in the generation sector, resulting in lower price increases to consumers.

2.2.3.6 Effect of electricity regulation

Wholesale markets are now liberalised in the EU, but still highly concentrated in many Member States, while retail (or 'supply') markets are at varying stages of liberalisation. The Electricity Market Directive requires all customers to be able to choose their energy supplier by 1st July 2007, but this is subject to a review in 2006 to assess obstacles to a single market. Hence, since consumer electricity markets are still subject to economic regulation in many Member States, the conclusions we have described above may differ.

In a regulated environment, electricity prices are determined by the regulator rather than by the effects in the electricity market. Generally speaking, regulators set prices either on the basis of costs plus a specified rate of return, or on the basis of (benchmarked) price caps and accounting for efficiency improvements. In both frameworks, the effect on retail prices depends on how the regulator treats increases in generators' costs due to the EU ETS. Specifically, regulators may only allow the direct costs to be passed on to consumers. As a result, although generators' STMC will still increase by the full cost of allowances, including opportunity costs, the costs deemed 'allowable' by regulators for the purpose of determining electricity prices may not. The overall price impact thus depends on how the regulator treats allowances that are received for free. In particular, there is a possibility that grandfathered allowances may be valued at zero for purposes of setting electricity prices.

2.2.3.7 Effect of long-term contracts

In many electricity wholesale markets, a large proportion of electricity is sold under long-term arrangements. In the short term, this often means that wholesale prices can take some time to adjust to significant changes in market conditions. In the long term, however, contracts will be revised to reflect any changes in market conditions created by the EU ETS.

Even in the short term, though, there are several reasons why long-term contracts may not delay changes in electricity prices for very long. First, negotiated prices may be subject to revision under special circumstances, possibly including regulatory changes such as the EU ETS. In addition, even long-term contracts are often tied to the development of the short-term wholesale price. Finally, it has been known for some time that the EU ETS would be introduced, and the expectation of higher future CO_2 costs is likely to have been incorporated to some extent in futures or long-term contracts already.

2.2.4 Long-term effects of the EU ETS on fuel mix and investment

The previous sections focussed on the *short-term* marginal costs of operating different types of generation. The STMC includes only the added costs of generating electricity from a given unit but without making changes to that unit. As noted, a unit's STMC determines whether or not the operator is willing to generate an additional MWh for a given electricity wholesale price. As such, the STMC is also the key determinant of the spot price of electricity.

At the same time, investors are continuously considering whether to build *new* generation facilities and how to manage major capital decisions for existing facilities. These include decisions about the addition of new capacity, decommissioning of old plants, 'mothballing' of old plants, and refurbishment and retrofitting of existing facilities.

In this context, investors consider the *long-term* marginal cost ('LTMC'), including the costs of constructing, operating, and maintaining facilities. LTMC includes all of the components of STMC as well as capital costs, fixed operation and maintenance costs, and any other fixed costs such as grid connection fees and taxes.

Investors tend to build new facilities or refurbish existing ones if the LTMC of these actions is no higher than the expected future wholesale price. Thus, in liberalised markets, the expected LTMC also serves as an upper limit on wholesale prices. If the wholesale price is higher than the LTMC of new units, additional units will be built, lowering the electricity price in the long term.

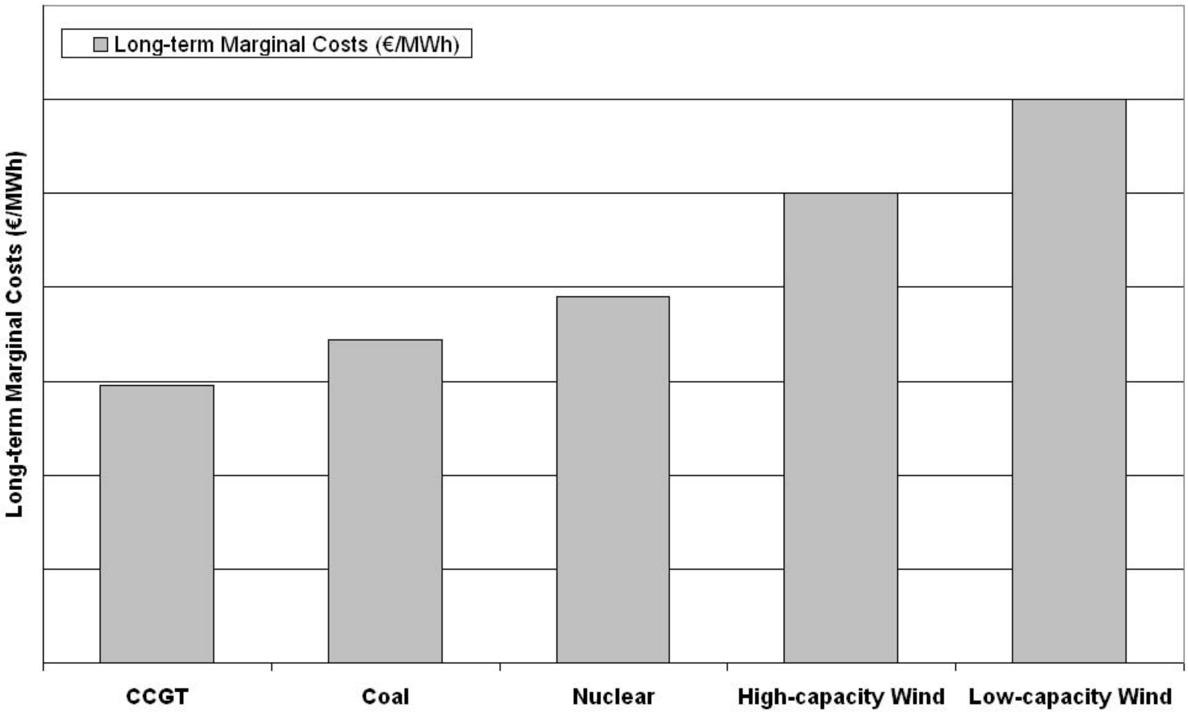
The introduction of a CO_2 price has an effect on LTMC similar to its effect on STMC. In the long term, the CO_2 price affects investment decisions and thus the price and demand for electricity. These effects can lead to secondary impacts on fuel markets. The subsequent sections discuss each of these issues in turn.

2.2.4.1 The addition of new capacity and changes to the fuel mix of generation

Broadly speaking, new power generation capacity will only be added if the expected wholesale electricity prices are at least as high as the expected long-term marginal cost of generation. Because CO_2 costs influence both electricity prices and the LTMC of generation, the introduction of the EU ETS can shift investors' choices about what types of generation to build.

The figure below provides indicative LTMCs of five major generation options—a combined cycle gas turbine ('CCGT'), a coal unit, a nuclear facility, and two types of wind units. The two wind units represent wind sited in two different locations—one allowing a high capacity factor and a second only allowing a more limited capacity factor.

Figure 2.6
Long-term marginal costs of different generation technologies (excluding CO_2 costs)



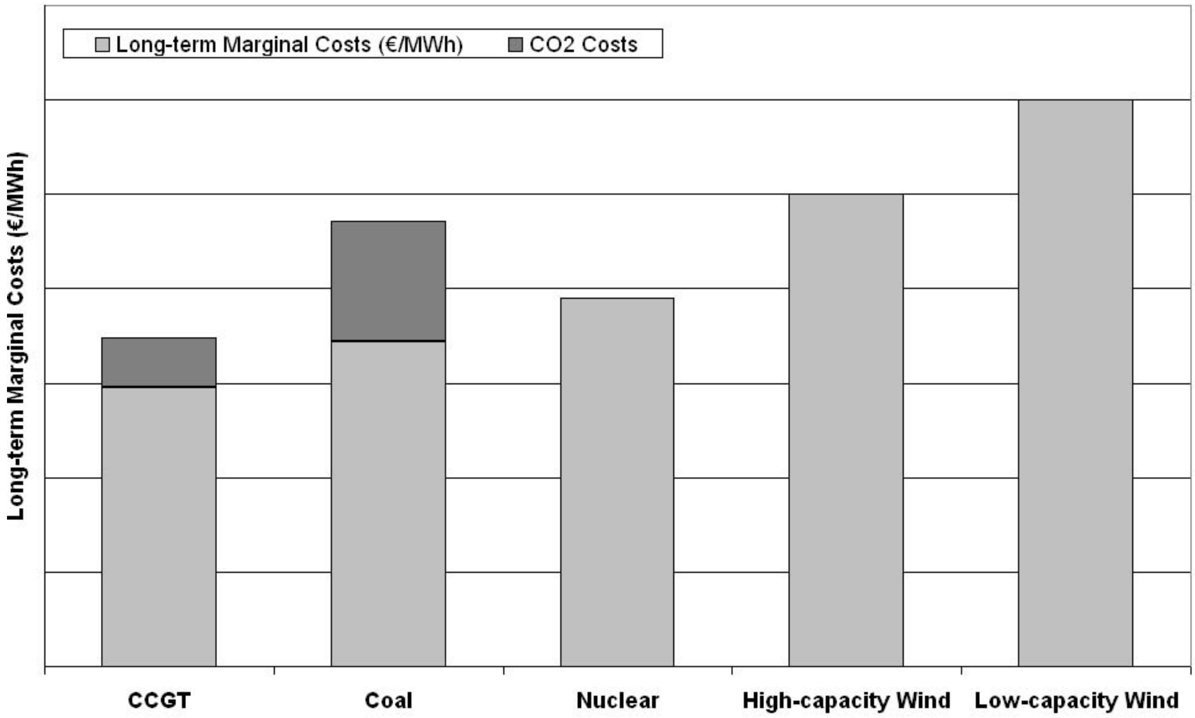
Source: The LTMC costs values are based on the results from Reinaud (2003).

In this simplified representation, CCGT is the most affordable new generation technology, followed by coal, nuclear, and then the two wind units. Thus, in this simple example, when no CO_2 cost is included, investors would find CCGT most attractive, followed by coal. Note that many studies suggest that, absent CO_2 costs, coal would be the lowest-cost option in many circumstances.[15]

Figure 2.7 shows the impact of introducing a CO_2 cost. The CO_2 price causes the LTMC of both CCGT and coal to increase, but leaves the LTMC of the nuclear and wind units unchanged (because they do not emit CO_2). Introducing the CO_2 price has the effect of making the LTMC of coal units greater than that of nuclear or high-capacity wind. This will have the effect of making nuclear and wind units relatively more desirable and making coal less desirable.

[15] See Laughton (2003) for some examples.

Figure 2.7
Long-term marginal costs of different generation technologies (including CO_2 costs)



These illustrative cost comparisons indicate that the introduction of CO_2 prices can influence the types of generation being built at the long run. The CO_2 allowance price will make CCGT and coal more expensive that non-CO_2 emitting options such as nuclear and renewables.

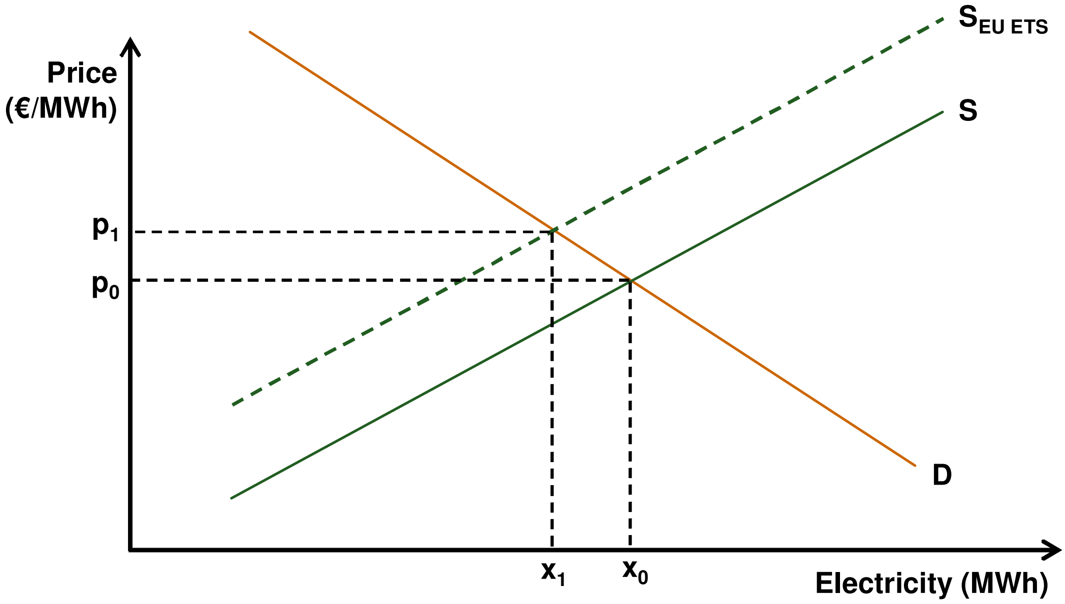
2.2.4.2 Long-term price increases and adjustments to electricity demand

As noted, the LTMC of new capacity sets an upper limit on the wholesale price of electricity in the long term. Because the CO_2 price affects the LTMC of new generation and thus investment decisions, the introduction of a price on CO_2 emissions will affect electricity prices in the long term. (We have already noted that CO_2 costs will also affect electricity prices in the short term.)

As CO_2 prices push up the price of electricity, electricity demand may also be affected. As noted, electricity demand is relatively unresponsive to changes in price (i.e., it is inelastic) in the short term. However, if price increases are sustained over time, demand responds. For example, residential consumers may invest in more efficient appliances, and industrial consumers may reduce the energy intensity of their processes, thus reacting to higher electricity prices by reducing the amount demanded.

Most studies of electricity demand response suggest that even long-run demand is fairly unresponsive to changes in price (which would be reflected by a very steep demand curve). Nonetheless, significant increases in electricity prices could have a sizeable impact on demand. Any impacts on demand could influence generators profits and further influence the fuel mix. This effect is illustrated in the figure below. As the figure demonstrates, the introduction of the EU ETS leads to a shift in the long-term supply curve, *S*. Because the demand-curve is downward sloping in the long term, this causes electricity demand to fall from x_0 to x_1 and price to rise from p_0 to p_1.

Figure 2.8
Effect of shift in long-term electricity supply on electricity demand



2.2.4.3 Second-order effects in fuel markets

As noted, the introduction of a CO_2 price is likely to shift long-run investment decisions away from coal and toward CCGT. In addition, existing gas units will come higher in the merit order, and therefore be run more often.

The combination of these two effects will lead to an increase in the demand for natural gas, which could in turn increase the price of natural gas fuel, thereby increasing the cost of generation from gas fuels. These general equilibrium effects could mitigate the shift to natural gas generation.

2.2.4.4 Long-term effects of allowance allocation

The effects of allowance allocation may also affect the long-term operation of the electricity market. Many member states award free allowances to new installation commencing operation after 2005. This effectively decreases the cost of new entry, and therefore may also reduce long-term electricity prices. In addition, the long-term composition of generation (and therefore merit order and also prices) may depend on the rules governing allocations to sites that close. Incentives for closure may be reduced if closed sites forfeit their allocations, and this in turn may influence the development of electricity prices over the longer term.

Both new entrant allocations and shutdown forfeiture are in effect 'updating' forms of allowance allocation, as current decisions (whether to enter the market, whether to cease operation) affect the size of the allocation received in future periods.

2.2.5 Summary of price and quantity effects in a national electricity market

The table below provides a summary of the impacts of the EU ETS on our 'price and quantity' variables.

Table 2.2
Summary of price and quantity effects of the EU ETS in a national electricity market

Variable	Effect of EU ETS	Comments
Wholesale electricity price	Increased	The EU ETS introduces an opportunity cost for CO_2 emissions. This in turn results in a higher marginal cost of electricity production for CO_2-emitting generation. The increase in generation costs results in higher wholesale electricity prices. The extent of the price rise depends on the CO_2-intensity of the marginal producer, i.e., the most expensive producer to meet demand. These effects could be reduced by an 'updating' allocation method.
Retail electricity price	Increased	Retail prices increase as wholesale price increases are passed-through to end-users. These effects may be reduced by electricity rate regulation or in situations of imperfect competition.
Electricity demand	Reduced	Higher retail prices lead to a reduction in electricity demand, although effects may be small in the short term.
Non-green generation	Reduced	Total 'non-green' generation decreases both because of an overall decrease in electricity demand, and because new investment in green generation may become more profitable.
Green generation	Likely Increased	The proportion of renewable generation is likely to rise, as higher wholesale prices with no additional costs create additional incentives for renewable generation. However, these effects may be offset by reductions in electricity demand. The outcome depends on the situation of existing renewables in the electricity generation merit order.
CO_2 emissions	Reduced	CO_2 emissions decrease as compliance with the enforcement of the EU ETS emissions cap.
Investment in conventional generating capacity	Varies	Lower demand may lead to less need for new investment. Free allocations to new entrants may lower the wholesale electricity price at which entry starts to occur. Conversely, confiscation of allowances upon shutdown may delay exit, and hence cause new entry to be postponed.
Investment in end-user energy efficiency	Increased	Investment in energy efficiency increases as the retail price of electricity increases.
Investment in new renewables	Increased	Higher wholesale electricity prices but unchanged costs of renewables generation help make investment in new renewables more attractive increase. More generally, the relative competitive position of low-emitting generation technologies is improved.

The most direct effect of the EU ETS will be to reduce aggregate CO_2 emissions from participating sources to the level mandated by the cap. As described above, the introduction of a CO_2 price into the electricity market will make it more costly for generators to operate units that emit CO_2. In a liberalised and competitive generation market, the impact of these costs on the marginal generators should lead to an increase in wholesale prices. The extent to which this occurs in practice will depend on a number of factors, including the degree of market concentration. Higher wholesale prices should also translate into higher retail prices for consumers. Again, this effect may be mitigated in some circumstances by regulation of consumer prices.

Higher electricity prices should encourage consumers to reduce their electricity consumption, both through behavioural changes and new investment. This should reduce aggregate electricity demand compared to a counterfactual scenario in which the EU ETS was not introduced. Whether demand will decrease in absolute terms compared to the level prior to the introduction of the EU ETS will depend on the stringency of the cap relative to the underlying drivers of demand growth.

The altered incentives for CO_2 emissions will not only affect the price of electricity but also the type of generation being used to meet demand. The EU ETS will reward electricity generators with lower CO_2 emissions, shifting the fuel mix toward lower-emitting CO_2 units. In particular, gas may replace coal in the generation mix.

The impact on the output of *existing* renewables generators will depend on their location within the plant merit order. Most existing renewables should have low STMC and hence should take preference in the merit order. Small reductions in electricity demand are therefore unlikely to affect their output. At the same time, higher electricity prices should make investment in new renewable sources more attractive, since these will not be subject to a CO_2 penalty. Independent producers investing in new renewables will benefit solely from the higher electricity price, while producers investing in new renewables may also benefit from the sale of surplus allowances (or from reduced allowance purchases), as a result of displaced generation from their existing portfolio of plants. The magnitude of this effect will depend on the size of the increase in wholesale prices compared to the generation cost of new renewables. In practice, the effect could be marginal for many renewable technologies since their generation costs are high compared to current wholesale prices.

The introduction of CO_2 prices will also encourage producers to improve the operating efficiency of existing and new generation units. First, more efficient units have lower CO_2 emissions, which will be rewarded under the EU ETS. Second, more efficient units produce more electricity, which will be incentivised by the higher electricity prices under the EU ETS. Of course, there is always an incentive to improve efficiency, but that incentive will be augmented as electricity prices increase.

2.3 Interaction of the EU ETS with an International Electricity Market

The above analysis assumed that the national electricity market was isolated from international trade. But international trade in electricity is common in the EU and is increasing in volume following market liberalisation and additions to transmission capacity (Tennback 2000). This section explores how the impact of the EU ETS may be modified as a result of international trade in electricity. The analysis will be confined to the case where the host country is a net importer of electricity, since the implications are very similar when the country is a net exporter of electricity. Two sets of variables will be explored: effects at the national level, and effects at the EU level.[16]

2.3.1 Electricity supply and demand when a country is a net importer

A country may expect to be a net importer (exporter) of electricity if the national marginal generation cost is higher (lower) than the international wholesale price of electricity (net of transmission losses) at the current level of national demand. But the volume of imports and exports will depend on the available transmission capacity.

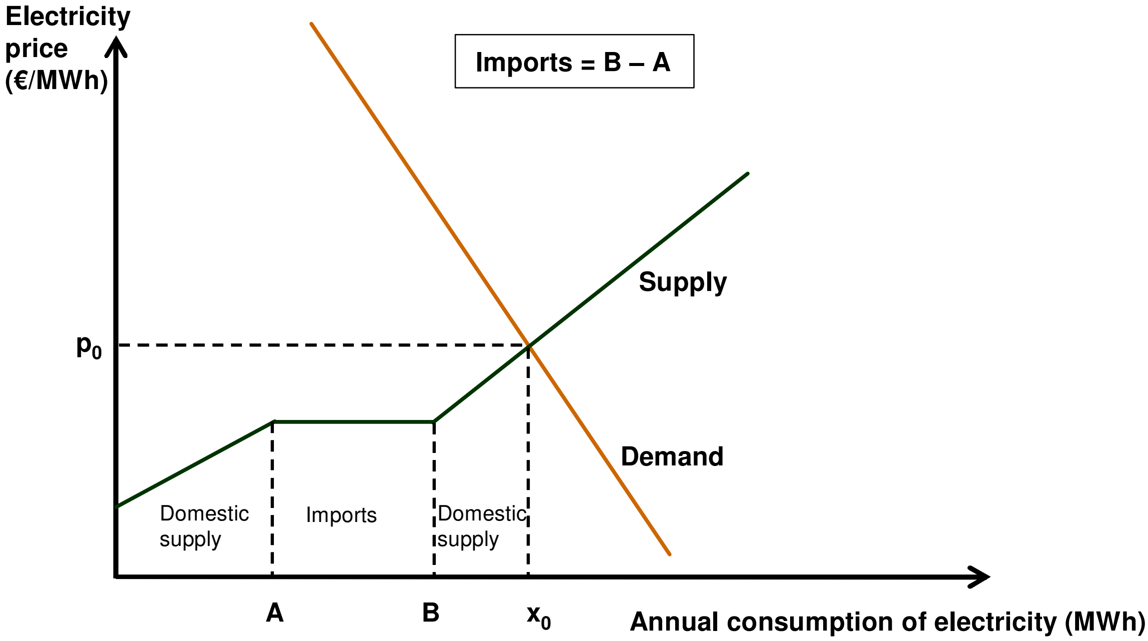
One possible situation is illustrated in Figure 2.9. Here, 'domestic' demand is met by domestic producers up to point A, at which point the wholesale electricity price is equal to the price of imported electricity. There is then a 'flat' segment in the supply schedule in which additional electricity supply is available through increased imports, instead of more expensive domestic generation. If electricity demand in the importing country is small relative to that supplied by the international market, these additional imports will not affect the international wholesale electricity price - in other words, the host country is a price taker on the international electricity market.

It is assumed that no further electricity can be imported beyond point B, where constraints on transmission capacity start to bind. Beyond point B, additional supply is met by domestic producers, with increasing marginal cost. The domestic wholesale price (P_E) is set by domestic producers at demand E, with imports being used to full capacity. In practice, the utilisation of imports may vary with demand (E), which in turn will vary with the time of day and year. In a situation such as this, the volume of imports should be unaffected by small reductions in domestic electricity demand. These will instead displace marginal generating plant located within the host country, in a similar manner to an isolated national system.

Figure 2.9 is a good approximation to the UK situation. The UK electricity system is connected to France via a cross-channel inter-connector. During most time periods, the UK is a net importer from France since UK supply costs are higher than the wholesale price in the French electricity market (net of transmission losses). Hence, the French imports are effectively base-load on the UK system.

16 The discussion in this section is based upon Bye (2003).

Figure 2.9
Net imports of electricity where the marginal producer is domestic



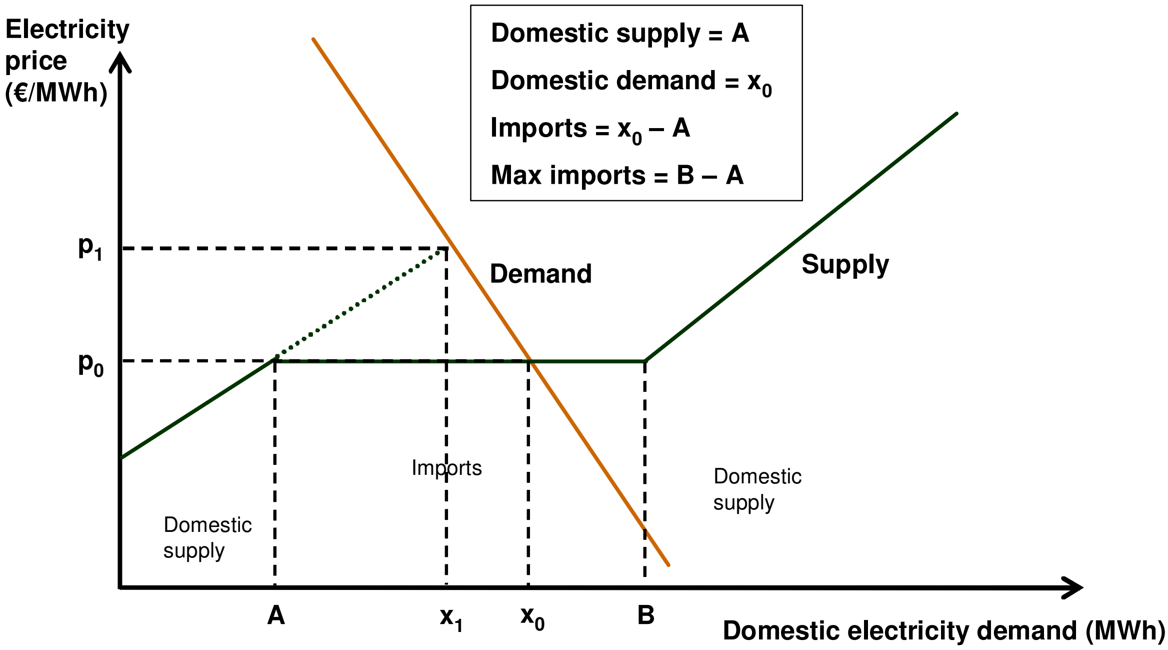
In some circumstances, imported (exported) electricity may act as the marginal producer (consumer) on a national system. This is unlikely to be the case for most European countries, but may apply to the Nordic countries for at least part of the year.

Figure 2.10 illustrates a situation where a country is a net importer of electricity and where imported electricity acts as the marginal producer. Here, demand is met by domestic producers up to point A, at which point the wholesale electricity price (P_E) is equal to the price of imported electricity. There is then a 'flat' segment in the supply schedule in which additional electricity supply is available through increased imports. Again, it is assumed that these imports do not affect the international wholesale electricity price (P_E). Hence, domestic demand (E) is supplied by mix of domestic producers (A) and imports (E-A) at a price P_E that is equivalent to the international wholesale price for electricity. Note that if imports were not available, a higher domestic demand (D) would be supplied at a higher price P_D.

It is again assumed that no further electricity can be imported beyond point B, where transmission constraints bind. Beyond point B, additional supply is met by domestic producers, with increasing marginal cost.

In a situation such as this, the volume of imports *will* be affected by small reductions in importing country's electricity demand. These will displace marginal generating plant located in the exporting country and hence affect electricity producers and consumers located in that country.

Figure 2.10
Net imports of electricity where marginal producer is imported electricity



2.3.2 Effects of the EU ETS when the country is a net importer

The introduction of the EU ETS should increase the wholesale price for electricity in both the importing and exporting countries by an amount corresponding to the opportunity cost of CO_2 emissions of the marginal producer on their respective systems. But the marginal producer on the importing system may be more or less CO_2 intensive than the marginal producer on the exporting system. Hence, the EU ETS may change the relative cost effectiveness of imports.

In Figure 2.11, it is assumed that the EU ETS has a *smaller* impact on the price of imported electricity than on the price of nationally generated electricity (i.e., the marginal producer on the importing system is more CO_2 intensive than the corresponding marginal producer on the exporting system). In practice, it is equally possible that the opposite will be the case or that the magnitude of the price impacts will be broadly similar.

In these circumstances, the impact of introducing the EU ETS is as follows:

- electricity demand in the importing country is reduced from x_0 to x_1;
- imports are increased from (B-A) to (B-A_E);
- electricity prices in the importing country increase to p_1;
- electricity generation in the importing country is reduced by [(A-A_E)+(x_0-x_1)];
- electricity generation in the exporting countries is increased by (A-A_E);
- CO_2 emissions in the importing country are reduced; and
- CO2 emissions in the exporting countries are increased.

In this example, the reduction in electricity generation in the importing country derives from two sources: the reduction in electricity demand from x_0 to x_1, the size of which depends upon the elasticity of demand);[17] and the increase in electricity imports from (B-A) to (B-A_E).

Imports increase if the marginal producer on the importing system is more CO_2 intensive than that on the international system, and decrease if it is less. Hence, in other circumstances, imports could decrease and domestic generation increase. The latter could be greater or less than the reduction in generation that results from the reduction in demand. Hence, the net effect is ambiguous: the following variables could either increase or decrease as a consequence of introducing the EU ETS:

- the absolute quantity of imports and the share of imports in total demand;
- the absolute quantity of generation within the importing country and the share of this in total demand;
- the CO_2 emissions from the importing country's electricity sector;
- the absolute quantity of generation within the exporting countries; and
- the CO_2 emissions from the exporting countries electricity sectors.

If imports increase then domestic generation decreases and vice versa. However, *total* electricity demand and electricity generation should fall as a consequence of introducing the EU ETS. In the case of CO_2 emissions, any increase in emissions from increased electricity generation should be offset by a shift towards lower CO_2 generation. In all cases, however, aggregate CO_2 emissions in the EU should fall as a result of the scheme.

If the national system has much lower CO_2 intensity than the international system, imports could be eliminated altogether and the country could shift to becoming a net exporter. In practice, the balance between imports and exports will vary with the time of day and year.

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[17] In the short term, this is likely to be very small.

Figure 2.11
Effect of the EU ETS on the electricity market when the country is a net importer

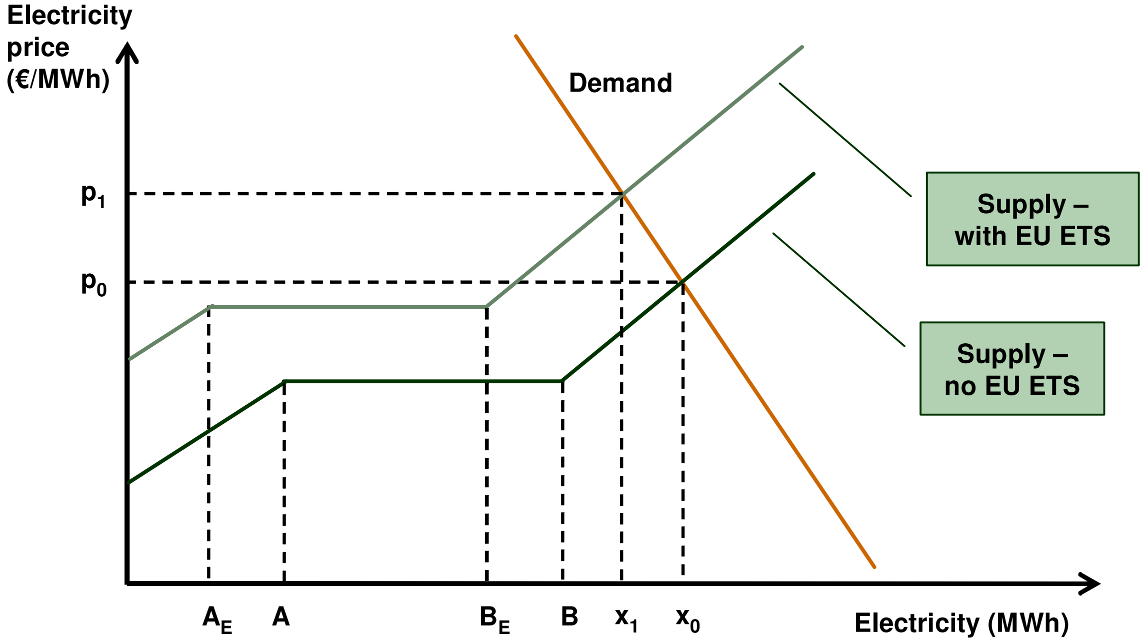
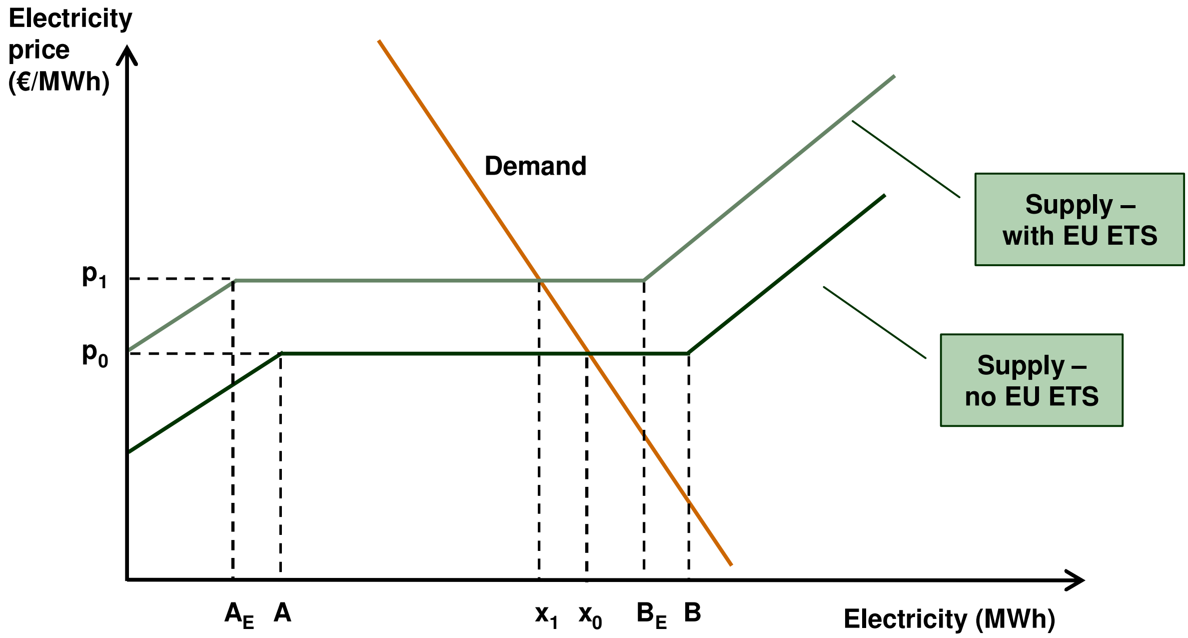


Figure 2.12 shows the impact of the EU ETS when imports actors the marginal producer on the system. Again it is assumed that the marginal producer on the national system is more CO_2 intensive than the corresponding marginal producer on the exporting system. In these circumstances:

- electricity demand in the importing country is reduced from x_0 to x_1;
- imports change from (x_0-A) to (x_1-A_E);
- electricity prices in the importing country increase to p_1, (the wholesale price on the exporting system);
- electricity generation in the importing country is reduced by (A-A_E);
- electricity generation in the exporting countries changes from (x_0-A) to (x_1-A_E);
- CO_2 emissions in the importing country are reduced; and
- CO_2 emissions in the exporting countries are increased.

Figure 2.12
Effect of the EU ETS on the electricity market when the country is a net importer and marginal producer is imported electricity



2.3.3 Summary of price and quantity effects in an international electricity market

Table 2.3 summarises the effect of the EU ETS on the 'price and quantity' variables in a situation where a country is a net importer of electricity, the change in imports remains within transmission constraints and the country is sufficiently small to be a price taker in the international electricity market. The results apply equally to the situation where imports are 'base load' on the national system and where they act as the marginal producer.

The third column summarises the impact on key variables in the importing country, while the fourth column summarises the impact on the same variables in the exporting countries. The second column repeats the earlier results for an isolated national electricity system, thereby providing a 'base scenario' for comparison.

It is notable that CO_2 emissions from electricity generation in either the importing or exporting countries could potentially increase as a consequence of introducing the EU ETS. However, the scheme ensures that overall EU CO_2 emissions are reduced, the cap is met and Member States comply with their EU ETS obligations.

Table 2.3
Summary of price and quantity effects of EU ETS in an international electricity market

Variable	Effect in importing country if no electricity trade	Effect in importing country if electricity trade	Effect in exporting country/countries if electricity trade	Comments
Wholesale electricity price	*Increased*	Increased	Increased	CO_2 price increases wholesale price on both systems, but the magnitude of the price change may be different.
Retail electricity price	*Increased*	Increased	Increased	Pass-through of higher wholesale prices to end-users.
Electricity demand	*Reduced*	Reduced	Reduced	Demand reduced in response to higher consumer prices.
Non-green generation	*Reduced*	Varies	Varies	Share of domestic generation in total generation may either increase or decrease. This is in addition to (small) reduction in demand from higher consumer prices. Net effect is ambiguous. Similar comments apply to exporting country.
Green generation	*Likely Increased*	Likely Increased	Likely Increased	Net effect in both countries depends on the balance between the effect of wholesale price increases and reduced demand on the profitability of renewables generation. The impact depends on the position of green generation in the merit order.
CO_2 emissions	*Reduced*	Varies	Varies	CO_2 emissions reduced by lower demand and shift to a low-CO_2 generating mix. But domestic generation and hence emissions could increase as a result of reduced imports. Net effect therefore is ambiguous. Similar comments apply to exporting country. Total CO_2 emissions should be reduced.
Investment in end-use efficiency	*Likely Increased*	Increased	Increased	Incentive to invest from higher consumer prices
Investment in new renewables	*Likely Increased*	Increased	Increased	Incentive to invest from higher wholesale prices

2.4 Distributional Effects of the EU ETS

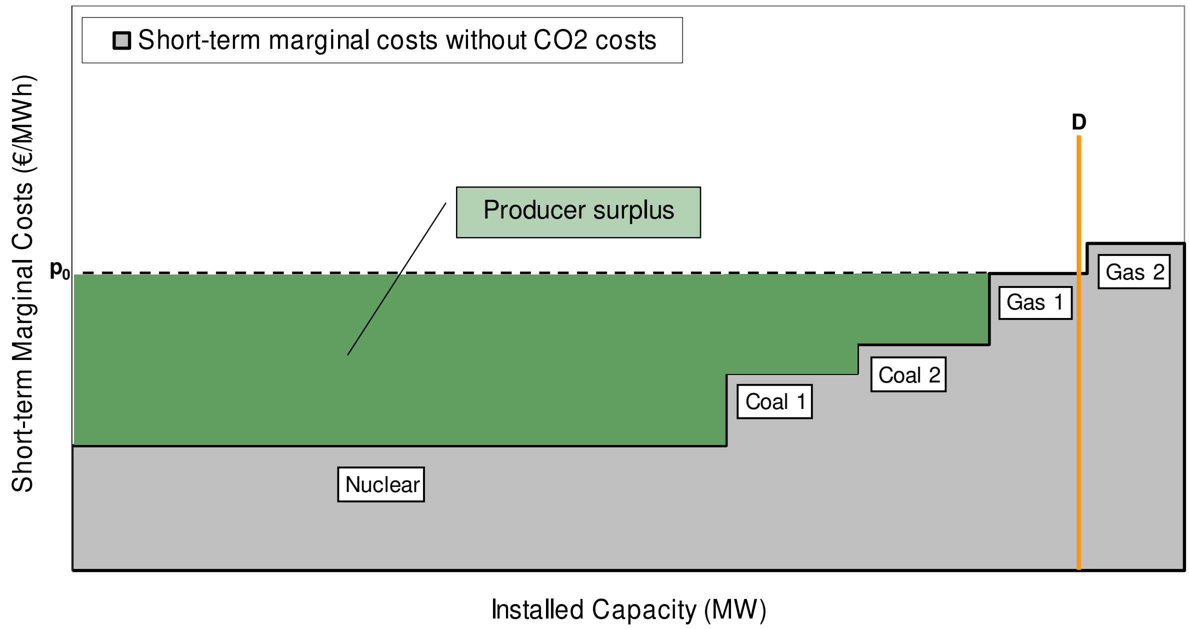
This section investigates how changes in quantities and prices in the electricity market affect consumers and producers. We consider standard measures of consumer and producer 'surplus', that is, how the prices obtained by producers compare to their marginal costs, and how the prices paid by consumers compare to their marginal willingness to pay.

We stress that this is not a 'welfare' analysis. We confine our discussion to the electricity market, and do not consider the social or environmental benefits of CO_2 reductions or the other costs and benefits from low-emitting generation. We also do not consider the effects in the allowance market or the second order effects in fuel and other markets (e.g., the markets for different types of generating technology). Thus, this analysis is not intended to analyse the overall costs and benefits of the EU ETS, but rather to assess how costs of the EU ETS are borne by producers and consumers in the electricity market.

2.4.1 Effects on producers in the electricity market

In virtually all EU electricity markets, the marginal generating technology burns either coal or natural gas, both of which emit CO_2. The figure below provides a highly stylised illustration of the market for electricity in the short term, absent any CO_2 costs. In the figure, the thick black line traces out the short-term supply curve for electricity, while the vertical line represents the level of demand. As shown in the figure, the producer surplus is equivalent to the shaded area below the price line and above the supply curve. The surplus arises because these plants are not on the margin, and thus are able to obtain a price higher than their cost of production. This producer surplus is not necessarily 'excess' profit but rather required to pay for capital and other fixed costs.

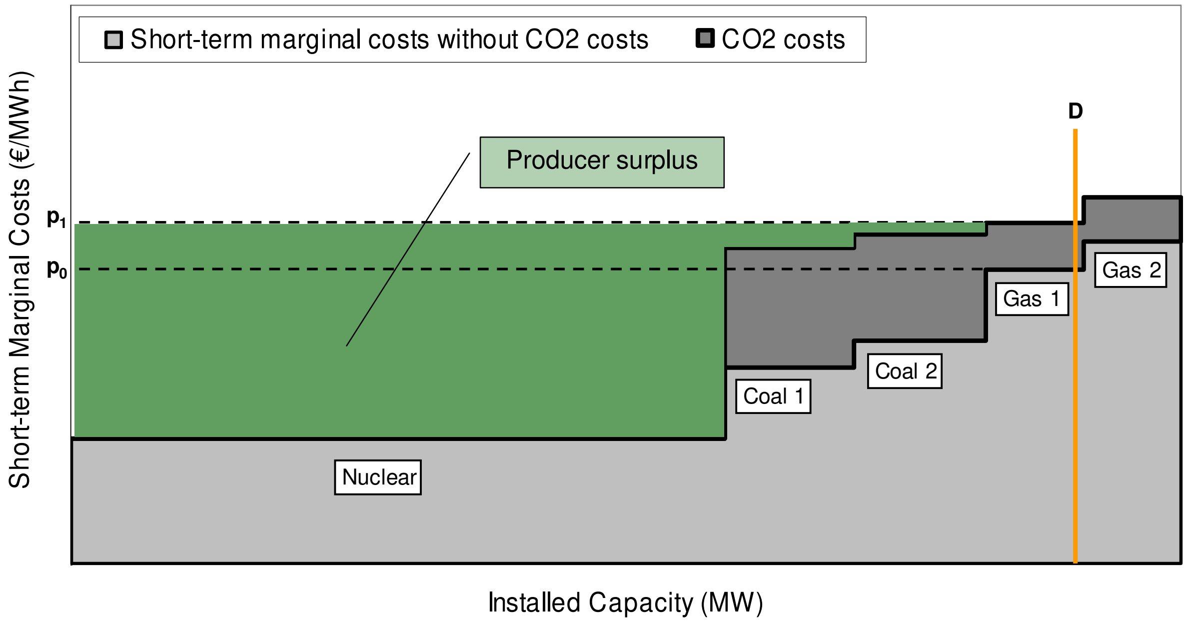
Figure 2.13
Producer surplus in the short-term electricity market (no CO_2 costs)



As discussed, the introduction of the CO_2 price causes electricity prices to rise in the short term. The introduction of the CO_2 cost also causes the STMC of both coal and gas units to rise; however, because demand is essentially fixed in the short term, there is no reduction in the quantity of electricity produced.

These effects are depicted in the figure below. As the figure illustrates, the producer surplus increases for nuclear units, because the price rises but costs do not change. Coal units experience an increase in revenues and an increase in costs, with the costs outweighing the revenue because of their high CO_2 emissions rates. The surplus of cost-fired units therefore decreases. The figure also shows gas units' surplus remaining at zero, with their cost increase being exactly offset by the price increase. Generally speaking, the effects on any individual unit in the electricity market can be calculated by comparing its CO_2 emissions intensity to that of the marginal unit: those with emissions intensity higher than the marginal unit will lose producer surplus, and those with emissions rates lower than the marginal unit will gain.

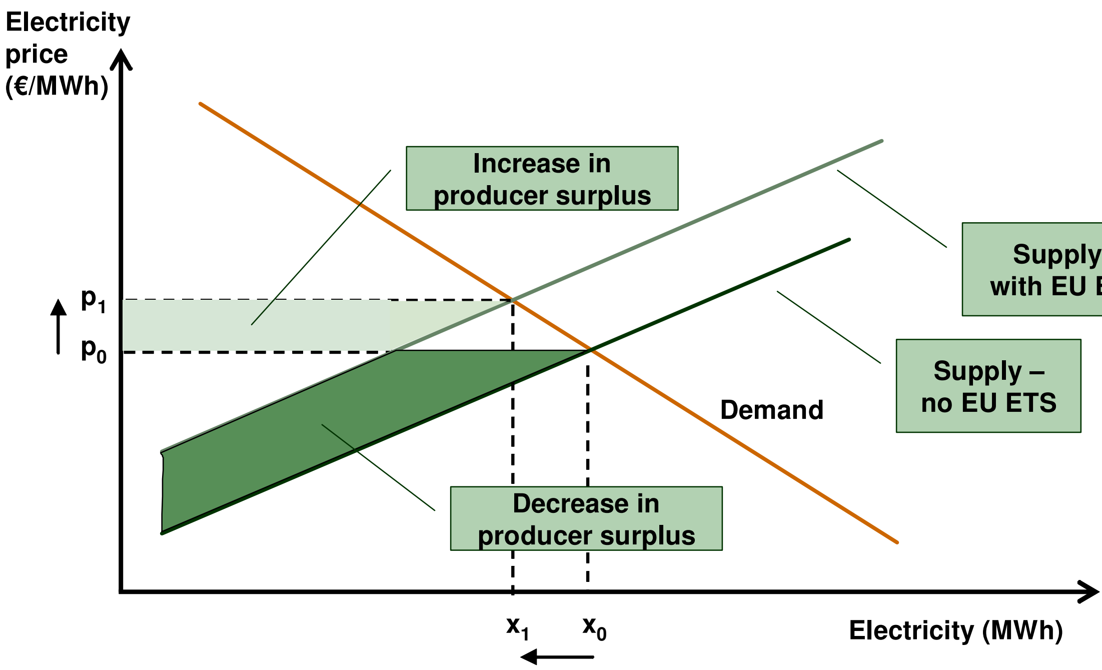
Figure 2.14
Producer surplus in the short-term electricity market (including CO_2 costs)



The merit order figure presented above depicts the impacts on electricity producers in the spot market for electricity—i.e., in the short term. As we have described, however, the introduction of CO_2 prices will also affect the long-term marginal costs of electricity generation. Since the LTMC of new generation provides an upper bound on electricity prices in the long term, producer surplus gains for *new* entrants are not affected (although they could be affected by changes in CO_2 prices). However, *existing* infra-marginal units will continue to obtain rents in the electricity market. Thus, existing units with low CO_2 emissions will experience long-run increases in producer surplus, while competition should limit the gains available to new units in the long-run.

In addition, as prices rise over the long term, consumers will reduce their demand for electricity. These demand reductions will mean smaller overall generation, which will generate some offsetting reductions in producer surplus. This effect is shown in Figure 2.15, which represents a stylised view of the long-term impact on producers of the EU ETS. Here, the dark shaded area represents an *increase* in aggregate producer surplus as a consequence of the higher wholesale price of electricity. As indicated above, generators with low CO_2 emissions largely capture this increase. At the same time, the light shaded area represents a *decrease* in aggregate producer surplus as a consequence of: first, lower electricity demand; and second, higher generating costs. The first is borne by all generators while the second is largely borne by generators with high CO_2 emissions. The net change in aggregate producer surplus is represented by the sum of these two areas. This may either be positive or negative, depending upon the CO_2 price, the CO_2 intensity of the marginal generator and the relative slope of the demand and supply curves. In practice, any reduction in demand is likely to a small.

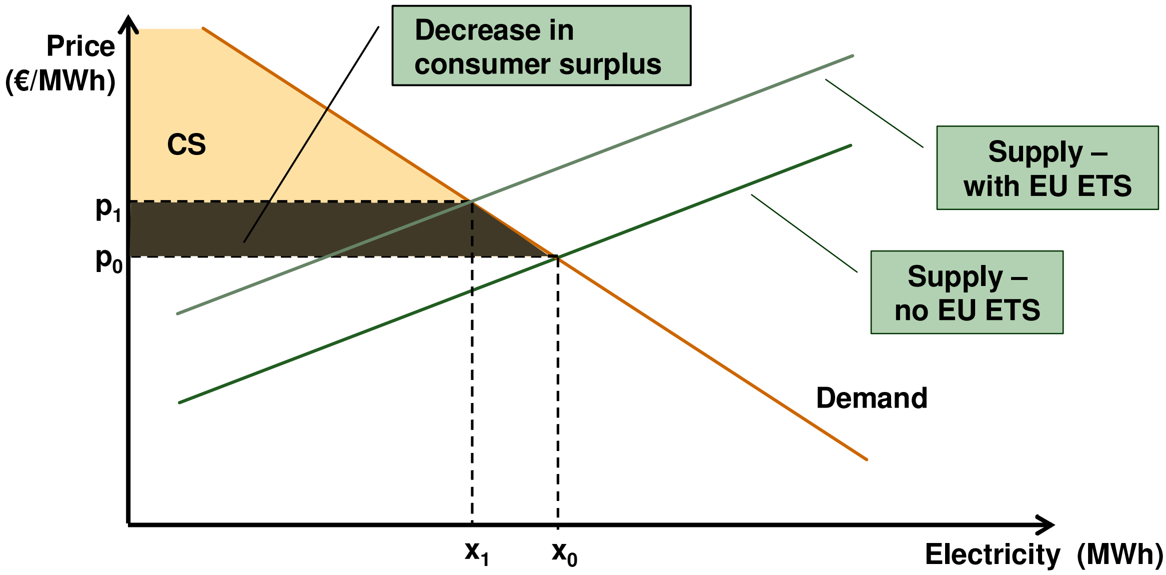
Figure 2.15
Long term effects of the EU ETS on producer surplus in the wholesale electricity market



2.4.2 Effects on consumers in the electricity market

In a similar manner, the figure below provides a highly stylised view of the impacts on consumers of a long-term increase in electricity prices.

Figure 2.16
Long term effects of the EU ETS on consumer surplus in the electricity market



As producers' marginal costs increase, prices rise. Consumers respond by reducing their demand for electricity over the long term. This is illustrated in the figure by the shift in electricity demand from x_0 to x_1. This causes a reduction in the surplus obtained by consumers, as reflected by the crosshatched trapezoidal area. Electricity consumers as a whole experience a decline in surplus for two reasons. First, they will lose consumer surplus because higher prices mean that they are consuming less electricity and thus lose the consumers surplus from that change. Second, the electricity that they continue to use is available at a higher price.

Overall, electricity consumers experience a net loss in the electricity market due to the EU ETS. As noted, however, this does not consider the effects in other markets or the environmental benefits of the EU ETS.

2.4.3 Other considerations

This discussion has considered the effects of the EU ETS on producers and consumers in the electricity market. The discussion is predicated on several assumptions about the nature of the electricity market and several caveats are worth considering:

§ The extent to which consumers bear the burden of increased CO_2 costs depends heavily on the regulatory environment. If regulators prevent increased costs from being passed on to consumers, then producers will bear more of the burden and the overall costs of the CO_2 cap will increase.

§ Both the methodology used to allocate allowances and the competitive environment can also influence the extent to which electricity prices increase.

§ The size of the price increase depends significantly on the marginal generating technology. If coal rather than gas were the price-setting fuel in the baseline, then introducing a CO_2 price would have much greater impacts on the electricity price and thus both producer and consumer surplus.

§ The impacts also depend on the extent the electricity sector operates in an international market. If domestic electricity generators are competing with international generation that is not CO_2 constrained (e.g. outside the EU), then consumer impacts will be mitigated while domestic producers facing higher CO_2 costs would reduce output. This is unlikely to be an issue for most EU countries as the EU ETS is EU-wide. However, as discussed in Section 2.3, the EU ETS can be expected to modify the pattern of electricity trade between Member States with low-CO_2 producers in exporting countries gaining market share at the expense of high-CO_2 producers in importing countries.

2.4.4 Summary of distributional effects

The effect of the EU ETS on producers and consumers in the electricity market is summarised in Table 2.4.

Table 2.4
Summary of distributional effects of the EU ETS in a national electricity market

Variable	Effect	Comments
Producer surplus – high-emitting producers	Reduced	Increase in costs outweighs increased revenues from higher wholesale prices.
Producer surplus – low-emitting producers	Increased	Increase in revenues from higher wholesale prices outweighs increase in costs
Producer surplus – overall	Varies	Depends on relative slope of demand and supply curves
Consumer surplus - overall	Decreased	Consumers lose from consuming less electricity and paying a higher price for what they do consume

2.5 Summary

As of January 2005, the EU ETS requires electric generators and major industrial sites to be subject to an overall cap on CO_2 emissions, establishing a market for CO_2 emissions allowances. On the basis of the costs of available CO_2 abatement measures, a price for CO_2 allowances is established in the market. This CO_2 price is then reflected in the electricity market as an added cost to facilities that emit CO_2.

The increased cost to generators causes an increase in the short-term marginal cost of electricity generation. This can have several effects, depending on the market conditions and the extent of the cost change. Under high CO_2 prices, this can lead to a change in the 'merit order'—or the ordering of facilities by their increasing marginal costs. These effects in turn can translate into impacts on the price of electricity, to the extent that the price of electricity is set by the short-term marginal cost of the marginal electricity generator (i.e., the last one to bid into the market).

The introduction of CO_2 constraints also affects the cost of electricity generation over the longer term. Indeed, as investors determine what types of new generation to build, they consider all of the long-term marginal costs of electricity generation, including CO_2 costs. As a result, CO_2 costs can shift the types of generation investment that occur over the long term.

Because the long-term costs of electricity generation determine the price over time, CO_2 costs can lead to permanent increases in electricity prices. Consumers may be expected to respond with reductions in their electricity demand.

Many Member States either import or export electricity to their neighbours, although in most cases the volume is constrained by transmission capacity. The EU ETS may be expected to change the pattern of these imports and exports since the CO_2 intensity of neighbouring electricity systems will differ. Increased exports would lead to increased generation within the exporting country and possibly to increased CO_2 emissions from the electricity sector, while generation and emissions from the importing country could fall. But transfer of allowances under the EU ETS will ensure aggregate compliance with the overall cap.

Changes in electricity prices and demand will affect the surplus that both producers and consumers obtain in electricity markets. For existing generation units, the impacts will vary significantly by generation technology. In general, the impact on any particular unit will depend on how its CO_2 emissions intensity compares to that of the marginal generation unit. Units with low CO_2 emissions per electricity generated will tend to benefit, while units with higher CO_2 emissions will tend to lose. For new generation units, the electricity price will reflect the long-term marginal costs of generation over the long term, including CO_2 costs.

The impacts from the EU ETS will unambiguously reduce consumer surplus obtained *in the electricity market*. This decline occurs both because higher prices mean lower electricity use and because higher prices mean paying more for electricity that is used.

All of these effects can vary significantly depending on the specific circumstances of the market. Among the factors that are relevant include: the extent of electricity market liberalisation, the regulatory environment, the degree of international competition, the allowance allocation methodology, and the competitive environment.

3 Green Certificate Schemes

This chapter explores the nature and operation of tradable green certificate ('TGC') schemes and their interaction with the electricity market. It is essential to understand how these schemes operate before their potential interactions with the EU ETS can be assessed. The interaction of TGC schemes with the electricity market is often complex and can lead to some counterintuitive outcomes.

Section 3.1 introduces the basic elements and objectives of TGC schemes and outlines their main design features. These include the choice of target group and the certification of qualifying renewable technologies. It then briefly assesses the current state of development of TGC schemes in the EU and elsewhere and summarises the key features of existing schemes in a table. More details on these schemes are provided in the Annex.

Section 3.2 introduces an idealised TGC scheme operating within an isolated, liberalised and competitive electricity market. It conducts a simple partial equilibrium analysis of this scheme and assesses its effect on key variables such as electricity demand and CO_2 emissions.

Section 3.3 extends this analysis to examine the implications of international trade in electricity, focusing in particular on the case where import act as the marginal producer on the national system. It assesses how this trade changes the effect of the TGC scheme on key variables within the importing country, and also how the scheme affects the exporting countries.

Section 3.4 examines how the costs of a TGC scheme may potentially be borne by producers and consumers of electricity in an isolated and liberalised electricity market. As elsewhere, this is not a full assessment of the costs and benefits of such a scheme, since market failures (including environmental externalities) and secondary effects in other markets are ignored.

The results of the analysis in each of these sections is summarised concisely in a tabular form. These tables are used subsequently in Chapter 5 to explore the nature of the interactions between a TGC scheme and the EU ETS.

3.1 Characteristics of Green Certificate Schemes

3.1.1 Basic elements of green certificate schemes

Many Member States have in place mechanisms for the support of electricity generation from energy sources that have environmental and other benefits ('green electricity'), but which are not commercially viable without special policy intervention. Such mechanisms include feed-in tariffs or guaranteed prices, tax-exemptions, credit guarantees, tendering systems, and research and development (R&D) programmes. Variants of these have been in place since the 1970s.[18]

In recent years, a number of countries have added TGC schemes as one of these support mechanisms. A green certificate can be defined as:

[18] See IEA (2004) for a comprehensive review of OECD countries.

'An official record proving that a specified amount of green electricity has been generated. Green certificates represent the environmental value of renewable energy production. The certificates can be traded separately from the energy produced.' (Haas 2001)

A key characteristic differentiating TGC schemes from other support mechanisms thus is that the desired outcome (certain forms of electricity generation) is separated from the product market. Eligible electricity generation thereby produces two distinct products of value: i) electricity, which is sold as usual in the normal electricity market; and ii) green certificates, which are traded in an entirely separate market.

Figure 3.1 illustrates the basic components of a stylised TGC scheme. The electricity market functions as it would without a TGC scheme, with all producers trading in a single wholesale market, and all consumers buying electricity on the same basis regardless of the technology used for its generation. That the main difference in the electricity market is therefore the participation of green generators that would not otherwise produce electricity

Meanwhile, the TGC scheme regulator is charged with ensuring the functioning of the certificate market. Certain forms of generation are certified as 'green' and are eligible to receive green certificates if they generate and sell electricity. These certificates are normally denominated in terms of an amount of electricity generated from an eligible source (e.g., one certificate for a certain quantity of MWhe).

Certificates are purchased by a group of consumers. These may be electricity end-users or any other party participating in the supply chain for electricity, including retailers, generators and transmission companies (Box 3.1).[19] Demand for certificates can be generated in a number of ways, although compulsory quotas for green electricity are typically the driver. The regulator is then responsible for ensuring that obligations of the scheme are met.

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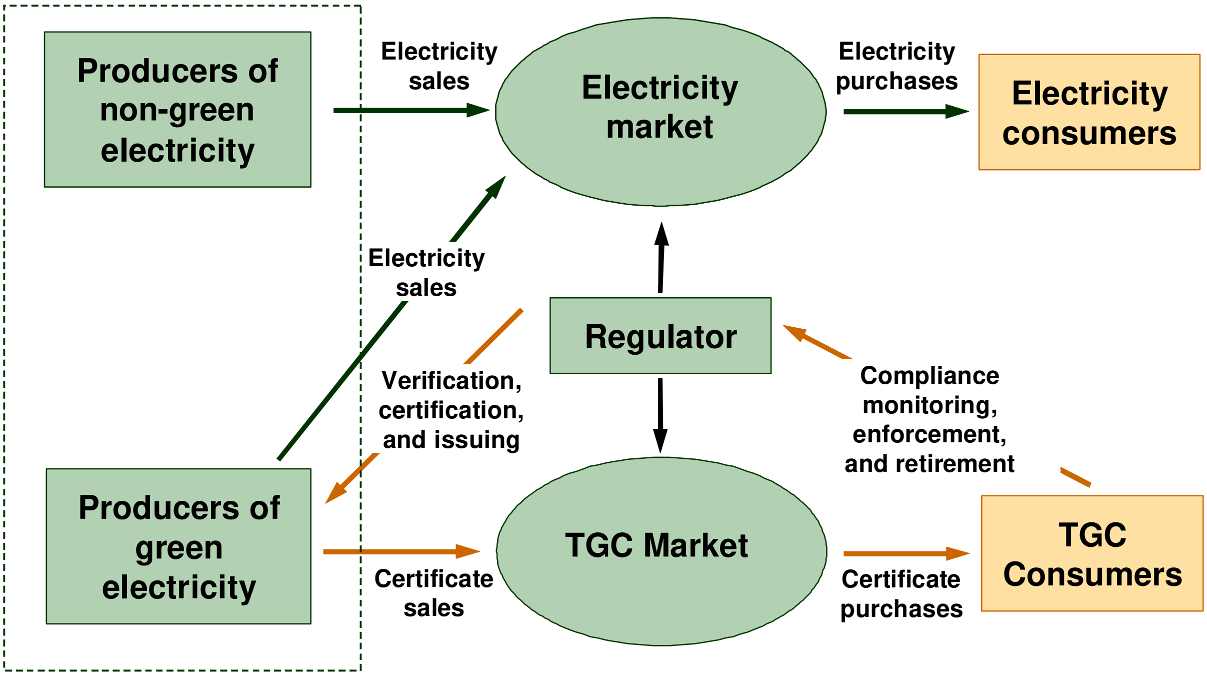
19 We use the terms consumers and end-users interchangeably, and these may be households or other agents.

Figure 3.1
Basic elements of a tradable green certificate scheme



Source: Adapted from de Lovinfosse and Varone (2003)

Box 3.1
The supply chain for electricity

The supply chain for electricity is conventionally divided into generation, high-voltage transmission, low voltage distribution and retail (or supply). The last involves the purchase of electricity in the wholesale market and the sale of this electricity to final consumers.

Both transmission and distribution have natural monopoly elements and therefore are subject to economic regulation if the relevant companies are privately owned. In contrast, both generation (the wholesale market) and retail (the consumer market) are potentially competitive. Liberalisation of electricity markets in the EU has involved the vertical unbundling of these activities, the introduction of competitive wholesale and retail markets, the establishment of independent regulators for natural monopoly elements (including provision for third-party access), and changes in ownership through privatisation. This process is incomplete and ongoing, leaving a variety of market structures in different Member States. Distribution and retail frequently remain under single ownership and are subject to various forms of legal, management or accounting separation through economic regulation.

These diverse structures give a range of options for targeting environmental regulations such as a TGC scheme. For example, obligations to purchase green certificates could be placed upon distribution companies in one Member State and retail/supply companies in another.

The use of a market mechanism—the tradable certificate—helps to ensure that green electricity capacity is added where it is most efficient to do so, thereby minimising the cost of meeting the objectives of the scheme. In place of trading, regulators could require that all producers of electricity generate a certain proportion of their electricity from green sources. Under this 'command-and-control' approach, each producer would add new green generation by the most efficient means available to it, but this would not allow optimisation across producers or the economy as a whole. By contrast, a tradable green certificates scheme has the ability to support green electricity generation while preserving competition among producers as they compete to generate certificates at the lowest price.

The major alternative to TGC schemes is Feed In Tariffs (FIT), which provide renewable generators with a fixed price subsidy that is additional to the wholesale price of electricity. There is much debate regarding the relative merits of TGC and FIT schemes[20] and it should be recognised that the choice between them is analogous to the choice between price-based and quantity based instruments more broadly (e.g. CO_2 taxes versus CO_2 emissions trading).[21] A key advantage of a TGC scheme is that it allows a particular target for renewable electricity generation to be achieved at least cost. But a necessary corollary is that TGC schemes primarily encourage those technologies that are nearest to being competitive without special support, such as onshore wind. As a result, they may offer little or no support for technologies that are further from market deployment, such as photovoltaics. Member States have proposed or introduced a variety of mechanisms to overcome this perceived weakness, including the use of parallel R&D and subsidy schemes.

3.1.2 Objectives of green certificate schemes

Many TGC schemes in the EU are aimed to aid compliance with Directive 2001/77/EC, which lays down common EU objectives for the promotion of renewable energy sources:

> *'The Community recognises the need to promote renewable energy sources as a priority measure given that their exploitation contributes to environmental protection and sustainable development. In addition this can also create local employment, have a positive impact on social cohesion, contribute to security of supply and make it possible to meet Kyoto targets more quickly.'*
>
> *(Directive 2001/EC/77)*

All of these aims are found in varying degrees in Member States' renewable energy policy documents, and they are also reflected in the design of individual TGC schemes. As noted, we do not consider the objectives of green certificate schemes in any detail in this report.

To the extent that some of the benefits of renewables are local, the ability to meet these stated objectives may be compromised if the TGC scheme allows for international trade in certificates. Conversely, for those benefits that are global, it should not matter much where the green electricity is generated, and international trade in certificates should have no

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20 For a comprehensive discussion, see (Huber, Faber *et al.*, 2005).

21 See Finon and Menanteau (2004) for a discussion of the efficiency and incentive properties of different policies for the support for green generation.

adverse impact. In practice, one or two EU schemes have made provisions for the import of certificates in recognition of the difficulties of reaching national targets solely through domestic efforts. Moreover, imported certificates sometimes must be accompanied by a corresponding amount of electricity imports, to ensure that generation takes place in neighbouring countries.

The absence of provisions for international trade in most schemes is an indication that local benefits are felt to be important, but it may also reflect concerns about the 'double-counting' of renewable generation as well as the absence of universally accepted standards for certification.

3.1.3 Design features of green certificate schemes

TGC schemes are relatively complex policy instrument with a large number of design variables. In this respect they are no different from emissions trading schemes. But unlike GHG emissions trading, green certificate trading has yet to be harmonised at the European level. A number of TGC schemes have been adopted by Member States and these exhibit both close similarities and important differences. This section identifies the most important design features of a TGC scheme and groups these under the following five headings:

§ sources of demand for certificates;

§ defining and allocating targets;

§ defining and certifying qualifying activities;

§ compliance procedures and enforcement; and

§ market characteristics and operations.

3.1.3.1 Sources of demand for certificates

The rationale of the TGC scheme is to offer market incentives for activities that would not otherwise be commercially viable. For this to happen, the scheme must have provisions to generate demand for certificates. This is normally achieved by imposing obligations on a *target group* to purchase a specified number of certificates in each target period. The choice of target group must take into account the objectives of the instrument and the ability of the group to meet those objectives. Other relevant considerations include the costs and benefits to different parties and the associated administrative requirements.

Some TGC schemes have operated on the basis of end-user obligations. This imposes challenges with the monitoring of compliance, if for no other reason than that consumers are very numerous. In practice, schemes with end-user obligations have relied on supply companies to manage the certificate obligation on behalf of consumers, while preserving the right of consumers to manage their own obligation if they choose to. Available experience suggests that only very large consumers have chosen to do so. Another issue has been that of the appropriate fee charged by supply companies for certificates and their administration. If these are administered and accounted for separately from electricity sales, price comparison between suppliers may become more difficult.

If the obligation is imposed upon energy companies, a choice is required of the appropriate location of the obligation within the supply chain (Box 3.1). Various existing schemes have imposed obligations on parties at all points in the supply chain, including electricity generators, transmission operators, and retail suppliers. Separate companies may carry out these functions, or there may be differing degrees of vertical integration. In practice, the location of the obligation may be of little consequence in electricity markets that function competitively and therefore have appropriate incentives for cost pass-through. On the other hand, if prices are regulated or if markets are not competitive, the choice of target group could affect the results.

Another concern that has been raised in the context of green certificate schemes is that end-users may be able to circumvent obligations if they are not directly subject to them. For example, if the scheme places obligations on suppliers, very large electricity consumers may be able to purchase electricity directly from the wholesale markets, thereby avoiding the obligation altogether. It is unclear how substantial this problem is in practice, and a potential solution is simply to define supplier as a company providing electricity to an end-user.

Having chosen the target group, some more detailed decisions are also required. For example, a size threshold could be considered, so that only those companies that serve a certain number of consumers or supply a certain amount of electricity are included. If there is cross-border trade in electricity, another question is whether the same obligations apply to imported electricity, and, if so, whether they will be imposed upon energy companies in other Member States or on ones in the national market.

3.1.3.2 Defining and allocating targets

Green certificates are typically denominated in terms of units of renewable electricity generated (e.g., kWh or MWh[22]). The scheme rules also need to determine the denomination or target metric of the certificate. The national targets to which Member States are subject under Directive 2001/77/EC are expressed in terms of the proportion of total electricity consumption. Most TGC schemes follow this template, but some Member States have used instead an absolute amount of green electricity to be generated in a given time period. A relative target may be better at adjusting the TGC scheme to fluctuations in the electricity market. This relates to the concern that the use of a quantity instrument of environmental regulation can create cost uncertainties when the price of achieving the quantity is uncertain.[23] Nonetheless, insofar as total electricity demand is predictable, the two forms of target may be broadly equivalent. Of course, the two are not mutually exclusive, as the overall aim of renewable energy policy can be expressed in absolute terms, but this can be translated to a relative quota for the purposes of compliance with the scheme, and adjusted to reflect any discrepancies that arise.

The size of the certificate denomination is also of some consequence for the ability of the scheme to function. There has been some concern that the use of a very large unit, such as

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[22] In this report, TWC schemes are assumed to denominate certificates in kWh.

[23] See Finon and Menanteau (2004) for a discussion of the difference between price and quantity based instruments for the promotion of generation from renewable energy sources.

MWh or even GWh, may make it difficult for small operators to enter certain national certificates markets, and some countries therefore allow for sub-division of certificates.

An alternative to denominating the certificates in electricity would be to denominate them in terms of one or several of the objectives of the scheme. For example, certificates could be defined in terms of the pollution reductions achieved, or any other objective that can be quantified and appropriately verified.[24] One variation on this approach that has been used in practice is to denominate certificates in terms of the amount of CO_2 emissions avoided (as compared to benchmark emissions from an efficient CCGT plant). Although this characterisation would make TGCs tradable with the EU ETS, allowing separate credits would raise concerns about double counting.

A related consideration is the time-horizon of targets. Most schemes have aimed to provide potential investors and operators with some certainty by positing a final target at a future date. Common practice is then to define in advance the step-wise increments to the quota that are necessary to reach this level (see for details of an existing scheme in this regard). There are limitations to what long-term assurances can be given, however. In several countries, TGC schemes have been discontinued, and uncertainty about continued political support may deter potential investors from undertaking projects that would rely on the TGC scheme for financial viability.

3.1.3.3 Defining and certifying qualifying activities

Having established the target group and denomination, it is important to consider which forms of generation will qualify as 'green' for the purposes of generating certificates. There are two main aspects of this: the generation technology itself, and the characteristics of the individual installations. These are discussed in turn below.

3.1.3.3.1 Qualifying technologies

Most TGC schemes in the EU broadly follow the definition in Directive 2001/77/EC of renewable energy sources as 'renewable non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases)'. Nonetheless, this definition leaves open several important considerations.

One objective may be to exclude technologies that are economically viable without support from the certificate scheme. Otherwise, certificate schemes will reward participants for activities that would have occurred anyway and thus yield no net environmental benefit. Regulators may also wish to avoid a situation in which infra-marginal green producers (those with a lower marginal cost of production than the revenue obtainable by the combined electricity and certificate price) gain from the TGC scheme.

One form of provision that aims to address this issue takes the form of capacity or generation size limits. For example, most schemes impose an upper limit for qualifying hydro-power of 10-20 MW capacity. This highlights the difficulty of determining whether capacity expansion at existing facilities would have been viable without some form of support.

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[24] See Kunsch et al. (2004) for a discussion of such 'zero-emission certificates'.

Depending on local conditions, there may be other technologies that have substantially lower costs than others and which are therefore excluded from the scheme. Of course, specific provisions of this kind are contrary to the principle of letting the certificate market allocate the addition of new capacity in the most efficient way.

Another aspect is the co-existence of the TGC scheme with existing regulation. For example, if regulatory requirements already stipulate that landfill gas must be used for electricity generation, the inclusion of landfill gas as an eligible technology might be thought unjustified. There may also be situations where some technologies, even if they have immediate environmental benefits, conflict with other aims of the scheme. For example, if the objective is to create a generation portfolio that is sustainable in the long-term, or does not rely on the import of fuel, the inclusion of biomass (or biomass co-firing with fossil fuels) may not be desirable in the absence of a domestic supply chain for biofuels.

There are also examples of TGC schemes that include energy sources not encompassed in a strict definition of 'renewable' energy, such as 'good-quality' combined heat and power ('CHP') installations. This choice suggests these schemes' objectives include abating CO_2 emissions and encouraging energy efficiency, as much as promoting renewable energy per se. This is an example of how the objectives of promoting renewable energy and encouraging energy efficiency sometime intersect. Insofar as the perceived benefits of non-renewable technologies are different from those of renewable energy sources, it may be difficult to ensure that scheme rules are consistent with all the objectives of the scheme.

3.1.3.3.2 Qualifying installations

There may also be reason not to include all installations that use similar generation technologies. Notably, many green technologies are characterised by high investment costs but low marginal cost of operation. Existing facilities presumably are commercially viable without extra support. Including such sites in the scheme would raise the issue of potentially inequitable 'windfall gains' to facilities.

Thus, insofar as the aim is to use the efficiency of the TGC market to provide incentives for *new* capacity expansion, it has sometimes been argued that TGC schemes should only include new capacity.[25] Some Member States have implemented this principle by only including in the TGC schemes installations constructed after a specific cut-off date. An alternative approach is only to allow sites to generate credits for a certain number of years after they begin operation.

This last provision is potentially in conflict with other requirements of a well functioning scheme, including the need to provide assurance of long-term support to mitigate investment risks. Some countries have therefore introduced legislation to guarantee support for a time period corresponding to the lifetime of new capacity additions (20-25 years).

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25 See Huber et al. (2004) for a variant of this argument.

3.1.3.4 Compliance procedures and enforcement

The effectiveness of the TGC scheme and the credibility of the certificate market will depend on a mechanism to ensure compliance with the scheme rules. Participants must comply with the monitoring, verification and reporting protocols for projects and the trading rules for certificates, while obligated parties must meet their individual targets for green electricity.

The scheme requires a regulator with sufficient authority to ensure its proper functioning. It is common for the electricity market regulator to also manage TGC schemes, but in some cases transmission companies have been given this authority. Certification of project eligibility is normally carried out by the scheme regulator, but in principle this could be carried out by any body awarded the authority to do so. Monitoring is generally straightforward, as it is a simple calculation weighing green generation, total generation, and the number of certificates retired against each other. Once green generation has been certified, these data are normally readily available.

In most schemes compliance is required on a yearly basis, although longer compliance periods have been used in some cases. Longer compliance periods can help mitigate fluctuations in the supply of green electricity (e.g., due to weather conditions) that may otherwise lead to a volatile certificate market. But longer compliance periods may also create uncertainty about total supply and make it harder to evaluate the efficiency and effectiveness of the scheme.

Appropriate penalties are needed to ensure compliance by the obligated parties. The penalty can be specified as a fixed fee per certificate not obtained, or it may be linked to some multiple of the prevailing market price. As noted below, such a ‘price ceiling’ mechanism has been used in some Member States as a way of ensuring that failure to meet the quota does not become disproportionately costly, rather than as a penalty for non-compliance. Another potential penalty mechanism is to impose more stringent quotas on non-compliant operators in future periods.

There is also the question of how to treat revenues from non-compliance charges. Some schemes recycle the revenues from non-compliance charges so they accrue to compliant holders of certificates. Another version of this is to have a ‘renewables fund’ that is used for other support mechanisms for renewable or green electricity, such as sponsorship of research and development.

Developers of renewable projects may be exposed to considerable project risk. If certificate obligations are imposed high up in the supply chain where the number of participants is small, the default of one party may significantly alter the value of certificates (as either supply or demand could suddenly drop). This has been a serious problem for the credibility and stability of some existing schemes.

3.1.3.5 Market characteristics and operation

Regulators also need to provide rules for trading, which can include price restrictions and rules for inter-temporal transfers.

3.1.3.5.1 Price regulation

The promotion of green energy through a quantity-based regulation such as a green quota is complicated by the fact that generation from renewable energy sources is less predictable and more variable than more conventional forms of generation. For example, hydro power depends very heavily on the amount of precipitation, and wind power on the weather conditions. Countries that rely heavily on these forms of generation generally have backup generation in the form of standby capacity or electricity imports from countries where the amount of electricity generation is more easily controllable or uncorrelated to domestic generation conditions.

These and other considerations create uncertainty about how to integrate green generation into an electricity grid, which also creates uncertainty for investors.

One common way to reduce price uncertainties is to introduce some form of regulation of prices in the certificate markets. Both price floors and price ceilings are found in existing schemes.

Price floors normally take the form of a guarantee by the government to purchase certificates at a certain minimum price, or by a requirement of the party on which the quota is imposed to pay no less per certificate than a stipulated minimum. This approach provides a mechanism to change a quantity-based regulation into a price-based regulation at a critical point. Such regulation may lower risk and help to attract investors, especially if the certificate market is not well developed.

Price ceilings provide a means to avoid excessively high certificate prices. The same effect would occur with non-compliance fines. Where fines are in proportion to the certificate price, however, no automatic price ceiling exists. Price ceilings may alleviate concerns that the quota is too stringent and that the costs to producers and consumers of electricity are too high.[26]

3.1.3.5.2 Temporal flexibility

In theory, well-developed futures and other derivative markets should help ensure that variations in green certificate supply and demand can be smoothed out over time. However, liquid derivative markets often require a high volume and market liquidity to develop, and these features may not apply in national TGC schemes.

Another way to reduce the price risk associated with green electricity is to allow for some form of temporal flexibility in compliance. Many emissions trading schemes allow participants to 'bank' allowances, making certificates or allowances generated in one year valid for compliance also in subsequent years. (In principle, it would also be possible to allow the opposite form of compliance, borrowing against future generation of certificates or allowances, though such provisions are far less common.) As discussed by Ellerman, Joskow, and Harrison (2003), there is evidence that temporal flexibility has helped reduce the cost of emissions trading in the United States. In particular, it helps market participants smooth out

[26] For a discussion of the analogous use of price ceilings within emissions trading, see (Jacoby and Ellerman, 2004).

price fluctuations over time, and avoids the development of price spikes. By reducing the risk premium attached to certificates/allowances, temporal flexibility has the potential to lower the overall costs of emissions trading schemes. Given the variability in green electricity supply, it is also likely to be a useful feature in TGC schemes.

Many existing certificate schemes provide for some form of restricted banking. Restrictions include limited validity periods of certificates, discounting of the value of previous years' certificates for the purposes of compliance, or stipulations that a certain proportion of certificates surrendered for compliance must be generated within the relevant compliance year.

3.1.4 Characteristics of existing green certificate schemes

TGC schemes are currently in operation in Belgium, the Netherlands, Italy, Sweden and the United Kingdom. In addition, several countries, including Finland and Denmark, have had trial schemes in operation. There are also plans to introduce schemes in other countries, including the Czech Republic and Poland. A summary of the key features of existing TGC schemes in the EU is provided in. More details on these schemes are provided in the Annex.

TGC schemes are a relatively new policy instrument, and the schemes listed in Table 3.1 are to some degree experimental. Many are in the process of being reviewed or modified as new experience becomes available. As the table suggests, a prime concern has been to design schemes that give certainty to market participants and potential investors, using mechanisms such as price caps, banking provisions and long-term targets.

Other green certificate schemes have been implemented outside Europe. Australia, for example, has established a Mandatory Renewable Energy Target that stipulates that 9,500 GWh of extra electricity from renewable energy must be created by 2010. Generators of renewable energy receive a certificate for each MWh they produce, and suppliers must satisfy individual quotas for renewable energy either by direct purchase of renewable energy or by purchase of certificates. In the United States, many states have similar schemes, referred to as Renewable Portfolio Standards (RPS). For a more detailed discussion of these schemes, see the Annex

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Table 3.1
Features of green certificate schemes in EU Member States

Country (Scheme)	Date of introduction	Administrator	Target	Obligation (Demand driver)	Average price of TGC	Inter-temporal flexibility	Price mechanism	Plant eligibility	International trading	Notes
Belgium (Flanders)	2002	Regulator (VREG)	Rising to 6% in 2010	Suppliers (Quota)	€85 in 2003, €108 since 04/2004	5 years' banking	Price ceiling	Excl. some hydro and all fossil fuels	Regional trading, may be extended to international	
Belgium (Wallonia)	2003	Regulator (CWAPE)	Rising to 8% in 2010	Suppliers (Quota)	€85 in 2003	5 years' banking	Price floor and ceiling	Incl. efficient CHP	Regional trading, may be extended to international	Certificate metric is CO_2 equivalents
Italy	2002	Transmissions System Operator (GRTN)	Currently 2%	Generators (Quota)	€99 in 2003 €97 in 2004	No international (national allowed?) banking	No price restrictions	Excl. fossil fuels; only facilities built after 04/1999; eligibility lasts 8 years	Allowed for import of certificates	
Netherlands (Certificates)	2000	Transmission System Operator (TenneT)	N/A	Consumers, voluntary (Tax Exemption)	€55 in 2000 but falling thereafter	N/A	Limits effectively set by tax incentive	All renewables, detailed 'calibration' of eligibility	Allowed for import of electricity	Ended in 2005 because of difficulties in establishing market
Netherlands (Groen label)	1998	Industry association (EnergieNed)	1,700 GWh over five years	Generators, based on past generation (Voluntary Quotas)	€20 in 2000	N/A	No price restrictions	All renewables, including large hydro	Allowed for import of electricity	Ended in 2001 partly because no new voluntary agreement was made
Sweden	2003	Regulator (STEM)	10 TWh annual production (defined as relative quota of 17%) in 2010	Consumers (Quota)	€25 in 2005	Unlimited banking	Price floor and ceiling being gradually phased out	Incl. only non-fossil fuel energy; some hydropower sites ineligible	Compatible with RECS, no international trading.	Not yet permanent; review in 2005
United Kingdom	2002	Regulator (Ofgem)	Rising to 10.4% in 2011	Suppliers (Quota)	€40 in 2004-5	Max 25% of obligation from banked certificates	Price ceiling close to anticipated market price; 'smearback'	Excl. large hydro and some biomass co-firing	No international trading	Scheduled to be in place until 2027. Allows Levy Exemption Certificates.

3.1.5 Summary

This section has demonstrated that all TGC schemes have several features in common, including the certification and generation of green certificates and the establishment of a certificate market. Nonetheless, as for other policy instruments, Member States have a wide range of design options available. Several design parameters, such as the qualifying technologies and installations, target group and denomination, and source of demand for green certificates can be adapted to correspond to local conditions. They may also be tailored to reflect the policy objectives of the particular TGC scheme, which frequently differ across Member States. As TGC schemes are relatively new, differences in design may be attributable not just to different objectives and conditions, but also to uncertainty about what design will give the best result. Many Member States have undertaken or are carrying out comprehensive reviews and evaluations of their TGC schemes, with the aim of adapting them in the light of experience.

There has been a convergence in the EU towards TGC schemes with a compulsory quota obligation defined in proportion to overall electricity supply. This is likely in part a reflection of the suitability of this framework to achieving compliance with the provisions under Directive 2001/77/EC, which defines national obligations in these terms. Given the prominence of this model, this is the framework that is discussed in the next section, where the interaction of TGC schemes with the electricity market is analysed.

3.2 Interaction of Green Certificate Schemes with a National Electricity Market

3.2.1 Approach and assumptions

This section discusses the interaction of the green certificate market with the electricity market. We consider a system of green certificates where the obligation to purchase certificates is imposed upon electricity retailers (or suppliers). Retail companies are obliged to purchase green certificates corresponding to a proportion α $(0<\alpha<1)$ of the total electricity sold. It is assumed that appropriately dissuasive penalties are in place to ensure that retail providers are always in compliance. For simplicity, we initially disregard complicating factors that are features of real-world schemes, such as price caps, 'smearback' mechanisms, temporal flexibility, or especially complicated definitions of targets or obligations. (These features are discussed separately below.) The electricity market is also represented in a very simplified form, assumed to operate under (restrictive) conditions of perfect competition, and absent complicating features such as long-term contracts and derivative markets.

To construct a simple model of the electricity market, we define *non-green* electricity as any electricity generated by methods that do not qualify for the generation of green certificates. This generally includes most fossil-fuel fired plants, but also nuclear plants and renewable sources such as large hydropower installations that are excluded from the TGC scheme. The supply of such electricity is denoted $S(p^w)$, where p^w is the price of electricity obtainable by producers in the wholesale market. Demand for electricity by consumers is denoted $D(p^p)$, where p^p is the purchase price of electricity faced by end-users.

In practice the purchase price of electricity (p^p) should equal the wholesale price (p^w) plus appropriate charges for transmission, distribution and retail.[27] But in this simplified analysis we assume that these charges are zero. This allows the demand for electricity by consumers (the retail market) and the supply of electricity by producers (the wholesale market) to be represented together on a single framework. It also facilitates the analysis of a green certificate scheme, since one of the consequences of a certificate obligation is the development of a difference between the retail prices (p^p) and the price obtained by producers of non-green electricity (p^w) even when the market is in equilibrium.

As outlined above, a defining feature of a green certificate scheme is that the 'green' attribute of electricity generated from renewable energy sources is separated from the electricity itself. The electricity generated from green sources is therefore supplied alongside non-green electricity in a single wholesale power market, where it too sells at p^w. In addition to revenue from the electricity generated, green producers obtain green certificates, the price of which is denoted p^c. The supply of green electricity, G, therefore depends both on the price of electricity and on the price of certificates—i.e., it can be denoted $G = G(p^w + p^c)$.

This also means that retail companies are obliged to buy a quantity α of certificates for every unit of electricity they provide. Hence, in addition to the wholesale price p^w they also pay αp^c for the cost of the associated certificates. The total price paid per unit electricity is therefore $p^w + \alpha p^c$. Under the assumption of perfect competition, this price is passed to consumers:

$$p^p = p^w + \alpha p^c.$$

Table 1.2 provides a summary of these terms and definitions.

Table 3.2
Summary of notation for description of the electricity market

Variable	Explanation
α	Green quota, i.e., proportion of energy required to be accompanied by a green certificate, such that ($0<\alpha<1$).
p^w	Wholesale price of electricity faced by electricity producers
p^p	Purchase price of electricity faced by consumers
p^c	Price of green certificates
$S(p^w)$	Supply of non-green electricity
$D(p^p)$	Demand for electricity
$G(p^w+p^c)$	Supply of green electricity

27 For household consumers, transmission, distribution and retail charges can form the bulk of the purchase price.

3.2.2 Price and quantity effects in a national electricity market

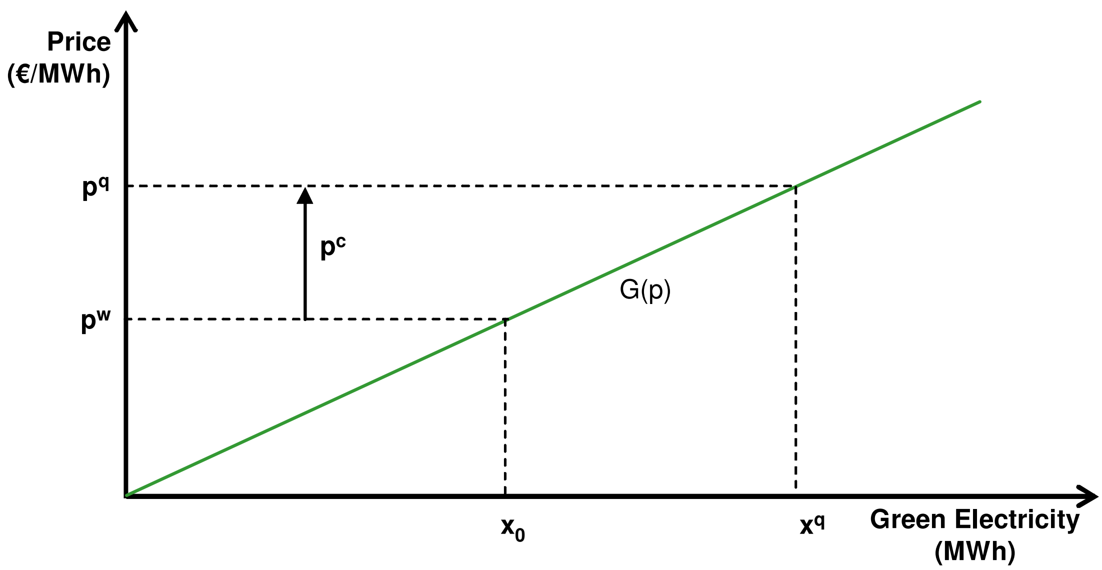
3.2.2.1 Determination of the certificate price

The price of green certificates is determined by the characteristics of the electricity market. In a competitive market, we expect prices to adjust to the level required to meet the quota. This is illustrated in Figure 3.2, which shows a stylised supply curve of renewable electricity, *G(p)*, where *p* is the total price obtainable by green producers. The wholesale electricity price is indicated by p^w, and at this level a quantity x_0 of renewable electricity is supplied. These technologies are competitive without any extra support, and by our assumptions about the green certificate scheme they would not be eligible as 'green' technologies.

The quota of the certificate scheme is set at a quantity x^q. For this amount of generation to take place, a price p^q would be required, corresponding to the marginal cost of the last green generator to meet demand (the marginal green producer). There is thus a 'green cost gap' between the marginal cost of the marginal green generator p^q and the wholesale price p^w. In a competitive certificate market, this gap will be exactly filled by the price of green certificates. Certificate prices could not be lower than this amount, or the quota will not be met as some green generators will not find it profitable to enter the market and generate. Conversely, prices would not exceed this level, as higher prices would be bid down through competition between green producers to supply certificates. In a functioning market the certificate price will therefore be equal to the green cost gap (the difference between p^w and p^q)

One important consequence of this is that the certificate price should be self-adjusting. With no increase in the cost of green generation, higher electricity prices should lead to lower certificate prices while lower electricity prices should lead to higher certificate prices. Certificate prices should also be reduced by any improvements in the efficiency of green technology that lower the marginal cost of generation.

Figure 3.2
Green electricity supply schedule and determination of the green certificate price



This characterisation of the certificate price is concerned with the short run. In the longer run, where both electricity demand the stock of generation units may change, the relationship between electricity and certificate prices is more complicated. This is discussed in more detail below.

3.2.2.2 Effect of a green certificate scheme on the demand for non-green electricity

Figure 3.3 illustrates a simplified model of the electricity market. The demand curve $D(p^p)$ represents the marginal benefit of electricity consumption to consumers, or, equivalently, their marginal willingness to pay for electricity. We assume that there is a negative relationship between electricity consumed and electricity prices, represented by a downward-sloping demand schedule. The slope of this schedule indicates the price-sensitivity of electricity demand, with a steep slope equivalent to low price sensitivity. Note that the demand schedule is constructed for a given value of all other relevant factors, and as such only a partial representation of the interactions in the market. Also, the price-sensitivity of demand is typically very low in the short term, and only in the medium- to long-term electricity market is the demand schedule likely to have a flatter slope such as that depicted in the figure (the figure is not drawn to scale, but for illustration only).

We assume that the electricity market is competitive and that electricity is supplied at marginal cost. Supply of non-green electricity is illustrated by the schedule $S(p^w)$. This is upward-sloping, such that higher prices make possible higher levels of generation. The reason for this is that generation technologies have different marginal costs; as the quantity of electricity supply increases, technologies with progressively higher marginal costs come online. The slope of the supply schedule is an indication of the price-sensitivity of supply, with a steep slope equivalent to low price-sensitivity.

In this framework, the electricity price is determined by the marginal cost of the marginal producer, i.e., the last producer to meet market demand when producers are ordered by increasing marginal cost.[28] The corresponding equilibrium is a quantity x_0, supplied at price p_0, indicated by the point *X* in Figure 3.3.

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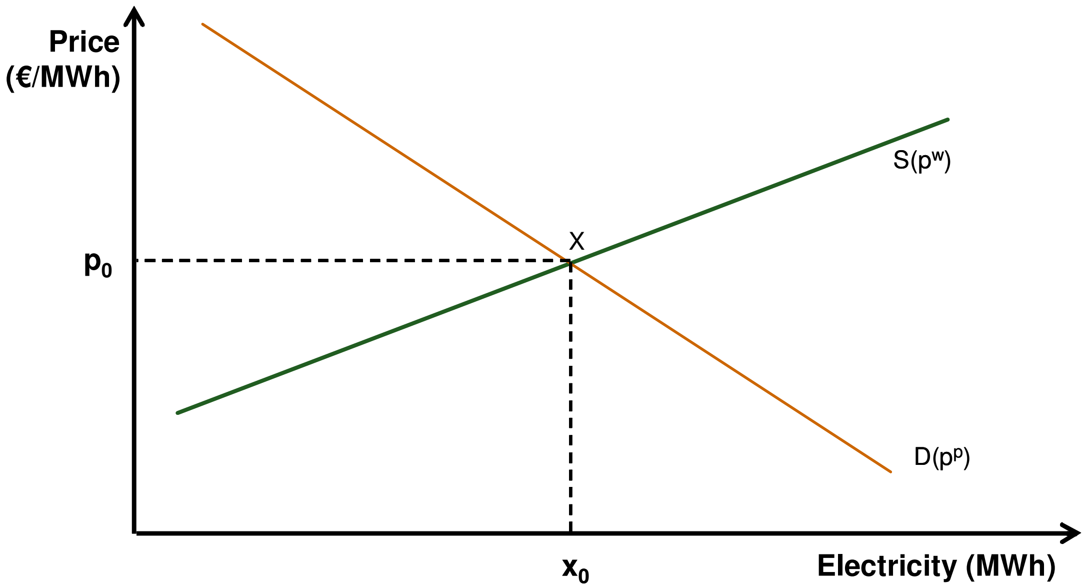
28 Formally the negative association of price and demand can be written $D' = \partial D/\partial p^p < 0$; and the positive association of supply with price as $S' = \partial S/\partial p^w > 0$; $G' = \partial G/\partial(p^w+p^c) > 0$.

Figure 3.3
Electricity market prior to the introduction of the TGC scheme



When a green quota is introduced it imposes an obligation that for every unit of electricity generated or sold, some fraction (α) of it must be green. Since green electricity is by assumption more expensive to produce than non-green electricity (otherwise, a TGC scheme would not be necessary for the promotion of such energy sources), this means that every unit of non-green electricity sold in effect must subsidise a fraction of a unit of green electricity. The overall price faced by consumers therefore becomes the sum of the price of wholesale electricity and the relevant fraction of the price of a green certificate, or $p^w + \alpha p^c$.

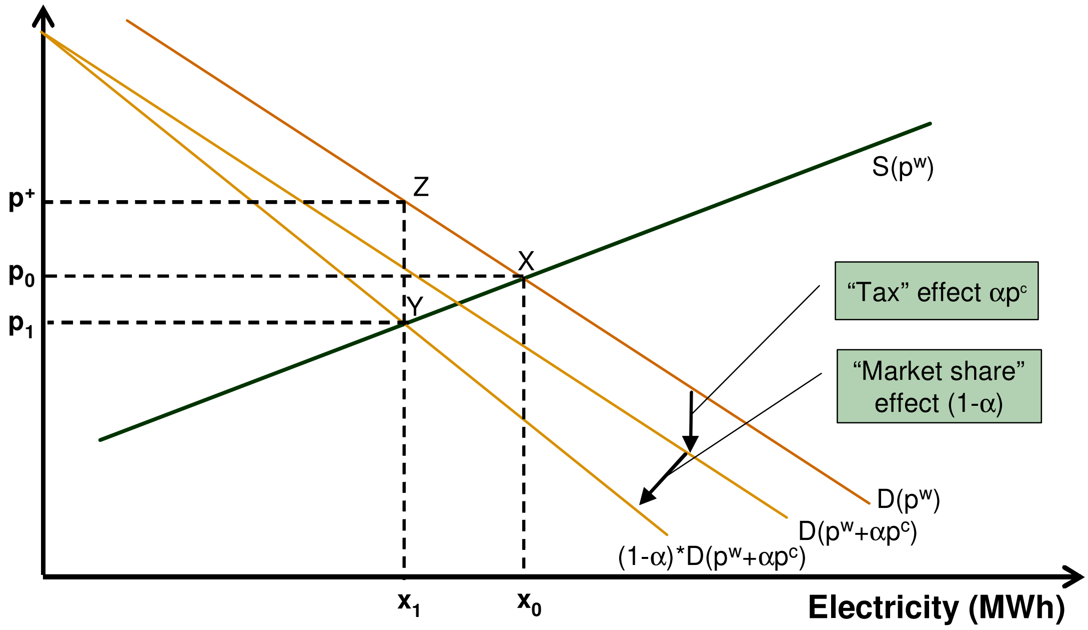
As discussed in Bye (2003), the introduction of a green quota in this framework has two separate effects on the demand for non-green electricity (note that this is distinct from the effects on demand for electricity overall).

§ First, demand changes from $D(p^w)$ to $D(p^w + \alpha p^c)$, as electricity consumers have to purchase green certificates for a proportion α of the amount of electricity consumed. This is similar to a tax on non-green energy.

§ Second, the quota restricts the market share of non-green producers, since these only are permitted to supply a proportion $(1-\alpha)$ of total demand. This changes the demand for non-green electricity from the 'taxed' level $D(p^w+\alpha p^c)$ to $(1-\alpha)*D(p^w+\alpha p^c)$.

These effects are shown in Figure 3.4. The 'tax' effect is equivalent to a downward shift of the *overall* demand curve, indicating that consumers now pay $p^w+\alpha p^c$ where they previously paid only p^w. The 'market share' effect is equivalent to a rotation of the demand schedule for *non-green* electricity to a steeper slope, taking account of the term $(1-\alpha)$. The resulting non-green electricity market equilibrium is an amount x_1 supplied at price p_1, indicated with Y in the figure. This is the amount supplied by non-green energy producers. Note that the shift of the demand schedule, and therefore the amount x_1, depends partly on the certificate price, p^c, which is determined simultaneously by the characteristics of the green power market and the share, α, as discussed above.

Figure 3.4
Effect of TGC scheme on the demand for non-green electricity



The net effect is a decrease in the amount of non-green electricity supplied, from x_0 to x_1. With an upward-sloping demand schedule, this entails a switch to a lower-cost marginal producer, and a concomitant decrease in the equilibrium wholesale electricity price from p_0 to p_1. Note that this is not equivalent to a decrease in the purchase price faced by consumers. Consumers also have to pay for the certificates required, as detailed below. Nonetheless, a difference develops between the new equilibrium wholesale price for electricity, p_1, and associated aggregate willingness to pay, p^+ (i.e., the price associated with the amount x_1 on the original demand schedule, $D(p^w)$).

3.2.2.3 Effect of a green certificate scheme on electricity prices and total energy supplied

To understand the total effects on the amount of electricity demanded and on prices, we need to consider the supply of green electricity. By assumption, certificates are only awarded to electricity generation that is not viable without some form of support mechanism. Green energy supply is therefore depicted as the right-hand side of the supply schedule $S(p^w)$. The schedule $G(p^w)$ is an identical parallel segment shifted to the left, and it represents the supply of green electricity in the absence of any green certificate scheme. This corresponds to the representation of the supply schedule for renewable energy in Figure 3.2 above. In this example, no green electricity would be supplied without the green certificate program.[29] In

[29] Alternatively, the example can be characterised as one in which TGCs are only awarded to new renewables, so that even though existing renewables already supply power to the grid, they are treated exactly the same as 'conventional' generation.

addition, as shown in the figure, the slope of green certificate supply is steeper than that of the non-green electricity supply schedule, i.e., the marginal cost of expanding green electricity supply is higher than that of expanding non-green electricity supply.

The green quota changes this supply situation. An amount corresponding to the certificate price p^c accrues to green energy producers for each unit of electricity produced. The resulting supply schedule is $G(p^w+p^c)$, a downwards shift of the schedule $G(p^w)$ by an amount p^c. This is similar to a per-unit subsidy of green electricity, and serves to fill the green cost gap to make generation by green generators profitable.

The price at which the supply of green electricity becomes viable is indicated as p_a in the figure. From this point on, the aggregate electricity supply schedule faced by consumers is the sum of the non-green and green energy supply schedules. This is indicated by the light green schedule $S(p^w) + G(p^w+p^c)$. Note that the new schedule is 'flatter' than the original supply schedule, indicating the joint supply of non-green electricity and subsidised green electricity.

Figure 3.5
Effect of green certificate 'subsidy' on electricity supply

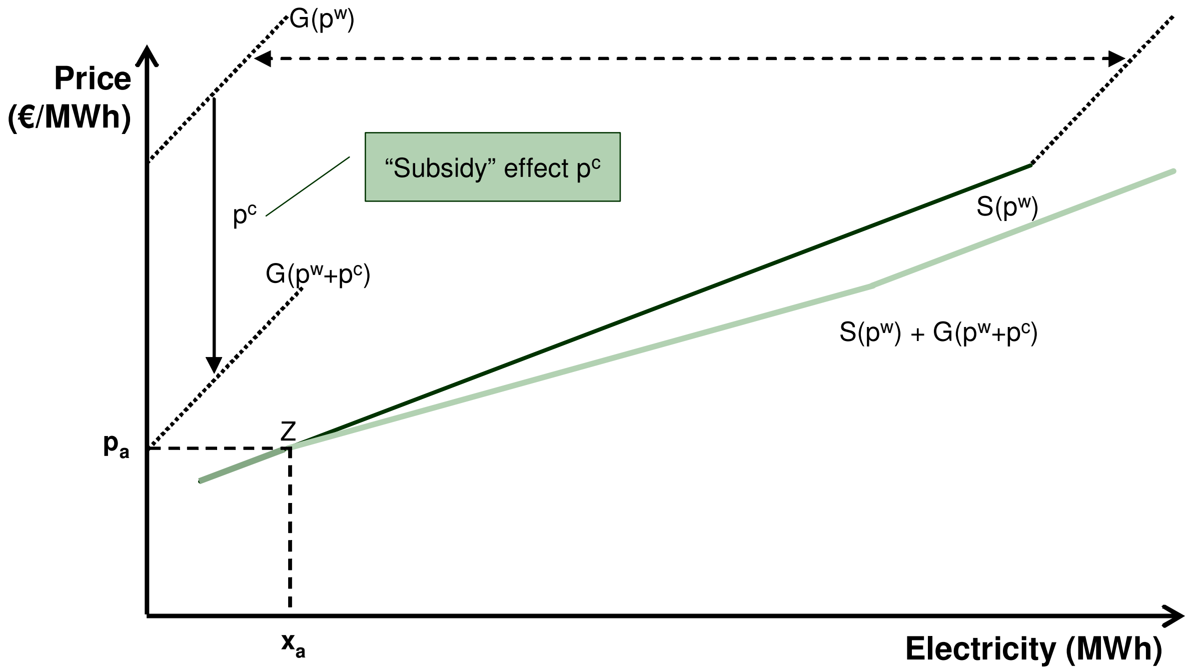
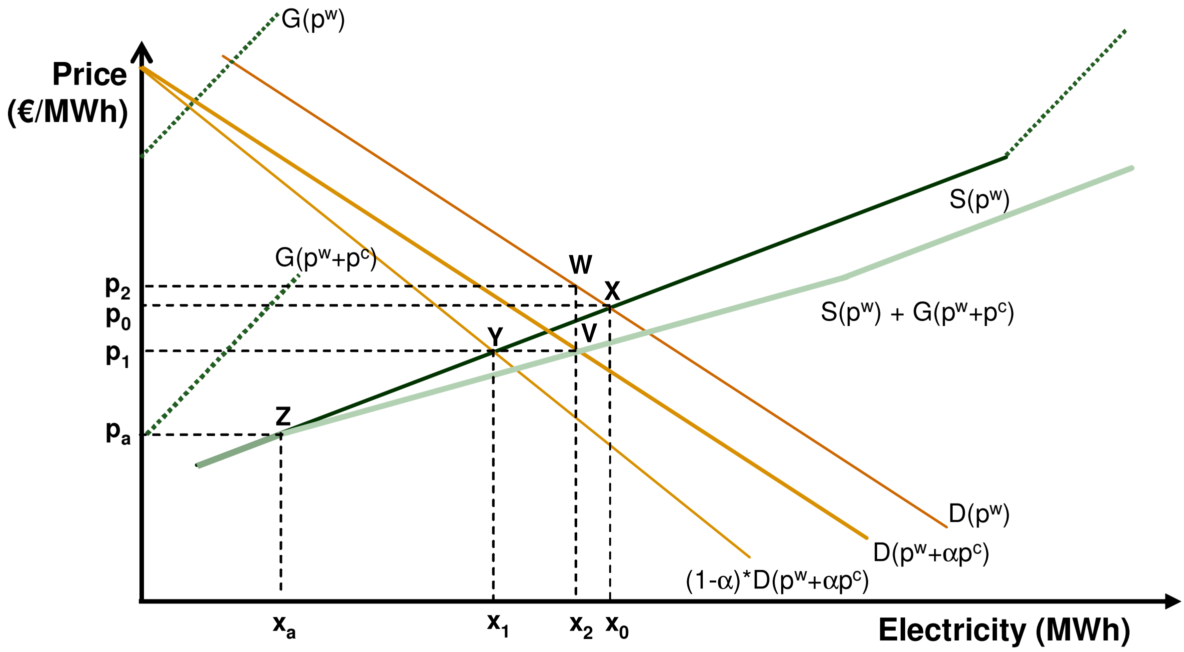


Figure 3.6 shows the resulting new electricity market equilibrium, combining the demand effects described in Figure 3.4 with the supply effects outlined Figure 3.5. The total amount of electricity supplied and demanded is determined by the intersection of aggregate supply $S(p^w)+G(p^w+p^c)$ with '*taxed*' demand $D(p^w+\alpha p^c)$, given as point V in the figure. The wholesale electricity price decreases from p_0 to p_1, as depicted in Figure 3.4, above. The corresponding amount demanded is x_2. Thus the amount received by electricity generators for producing non-green electricity falls.

However, consumers also have to pay the premium for green certificates, corresponding to the vertical shift of demand from $D(p^w)$ to $D(p^w+\alpha p^c)$. The total price paid is therefore that of point *W*, i.e., p_2. As illustrated in this figure, the total effect of the green certificate scheme is to raise purchase prices from p_0 to p_2, and decrease total electricity consumption from x_0 to x_2.[30] Non-green electricity generation is reduced to x_1 and a total of $(x_2\text{-}x_1)$ of green electricity is generated.

Figure 3.6
New equilibrium in electricity market after the introduction of the TGC scheme



In sum, the price and quantity impacts of the introduction of the green quota are (with reference to Figure 3.6):

- § Non-green energy supply decreases by the amount $x_0 - x_1$. A portion $(x_2 - x_1)$ of this is replaced by green energy, while the remainder $(x_0 - x_2)$ represents a real reduction in demand. The market available to non-green energy producers therefore decreases due to both the displacement of non-green by green electricity and the response by consumers to higher electricity prices.
- § Green energy supply increases by $x_2 - x_1$ (no green energy was produced before the introduction of the quota).31 Green electricity thereby displaces non-green energy as a result of the mandated quota.
- § Total demand for electricity decreases by an amount $x_0 - x_2$. The final demand for electricity is x_2.
- § The wholesale electricity price decreases from p_0 to p_1, determined by the intersection of aggregate (green and non-green) electricity supply and 'taxed' demand, indicated by *V* in

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30 Consumers pay $p^p = p^w + ap^c$, and the final price p_2 is therefore such that $p_2 - p_1 = \alpha p^c$.

31 This follows directly from the definition of the quota, $\alpha = (x_2 - x_1)/x_2$. Total electricity supplied after the introduction of the quota is x_2 and the amount of green electricity is $\alpha x_2 = (x_2 - x_1)/x_2 * x_2 = x_2 - x_1$. The figure is not necessarily drawn to scale.

the figure. This occurs because less non-green energy is demanded, causing a switch to a lower-cost marginal producer.

§ The electricity purchase price paid by consumers increases by $p_2 - p_1$ above the new wholesale price. This increase corresponds to the expenditure on certificates mandated by the quota obligation and is equal to αp^c.

§ The net effect on purchase prices is an increase of $p_2 - p_0$. Consumers therefore face higher electricity prices after the introduction of the quota.

3.2.2.4 Determinants of the direction and magnitude of the change in retail electricity prices

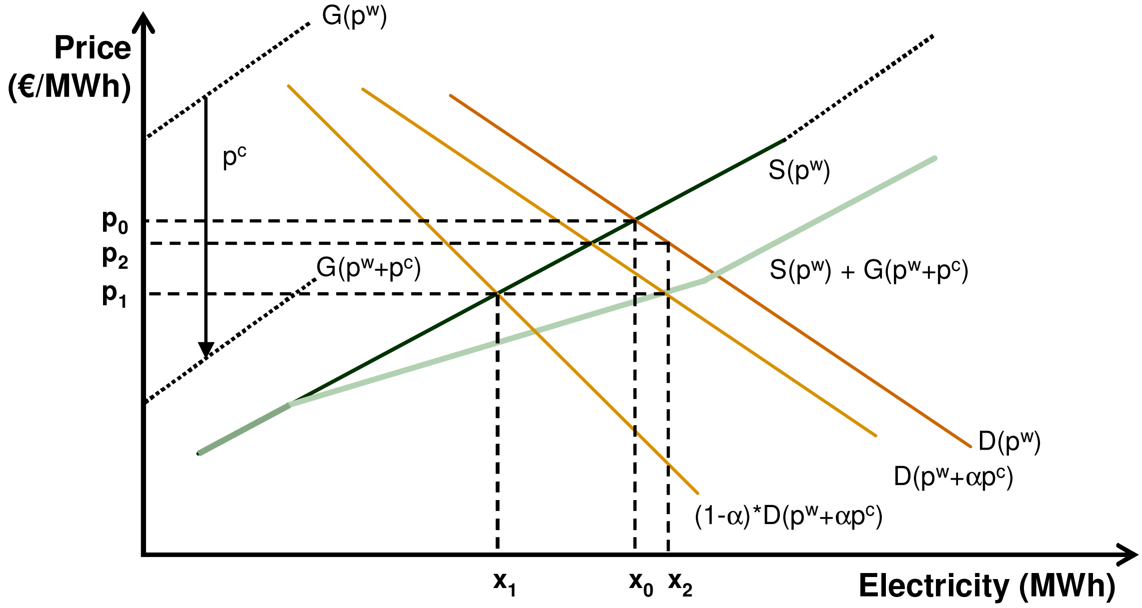
The above analysis shows that the net effect of the quota on the electricity purchase price is the sum of two countervailing effects. The price of wholesale electricity is pushed down as a result of the TGC scheme, but the mandatory expenditure on certificates that support a less efficient generation technology lifts retail prices higher. In the above example, the latter effect outweighed the former, resulting in a net increase of electricity purchase prices. However, it is possible to construct examples of parameters such that the decrease in wholesale prices outweighs the expense on certificates, causing the overall purchase price to *decrease* as the green quota is introduced. This is perhaps a counter-intuitive result: consumers can face *lower* electricity prices even if the quota obligation were to rest wholly on consumers.[32]

Figure 3.7 gives an example of such a situation. Compared to Figure 3.6, the price sensitivity of green electricity is greater, while that of non-green energy is smaller. This means that the addition of new green electricity is relatively less costly per unit, but it does not necessarily mean that the *absolute* cost difference between green and non-green electricity is any smaller. The effect of this is to cause the aggregate supply schedule, $S(p^w) + G(p^w+p^c)$, to be flatter than in Figure 3.6. In addition, the quota is smaller, resulting in a smaller 'tax' effect on demand, less of a market share for non-green electricity, as well as several other secondary effects (including a lower certificate price).

As above, there is a decrease in wholesale electricity prices, corresponding to $p_0 - p_1$. However, this decrease now outweighs the increase in purchase prices caused by the certificate purchase obligation (equal to $p_2 - p_1$). The net effect, $p_0 - p_2$, is therefore *negative*, and retail prices go down. The price decrease faced by consumers in turn results in an *increase* in the total amount of electricity demanded, indicated by x_2.

32 A number of papers discuss this effect in different formats, including Jensen and Skytte (2002) and Bye et al. (2002). The possibility appears to be well-established, although its realisation in practice is much harder to observe, and may be limited to a small range of parameter values.

Figure 3.7
Example of a decrease in the retail electricity price caused by a TGC scheme



Box 3.2 provides a more analytical account of the effect of the TGC scheme on electricity prices. The main result is that the retail price faced by consumers can go down as well as up following the introduction of a TGC scheme. Retail prices are more likely to go down when:

§ the supply of non-green electricity is insensitive to price (i.e., low elasticity);

§ the supply of green electricity is sensitive to price (i.e., high elasticity);

§ the green quota is relatively small.

The relevance of this result to 'real-world' TGC schemes is unclear. Bye (2003), for example, uses a calibrated model of the Norwegian electricity system to show that the counterintuitive result of lower consumer prices and higher demand may well apply when the green quota is less than 25 percent – as is likely to be the case in practice.

Box 3.2
A closer look at the response of retail electricity prices to a TGC scheme

Bye (2003) provides an analytical derivation of a relationship between the effect on the purchase price faced by consumers, p^p, and changes to α. Defining:

§ $S' = \partial S/\partial p^w$, the rate of change of non-green electricity supply with the wholesale electricity price.

§ $G' = \partial G/\partial(p^w+p^c)$, the rate of change of renewable electricity supply with the selling price for renewable electricity (wholesale electricity price + green certificate price)

Bye shows that a sufficient condition for purchase prices to increase as the quota is increased is that:

$$\frac{G'}{S'} < \frac{\alpha}{1-\alpha}$$

Hence, purchase prices are more likely to increase when:

§ *G'* is low: i.e., the supply of green electricity is insensitive to price;

§ *S'* is high: i.e., the supply of non-green electricity supply is sensitive to price; and

§ α is large: i.e., green electricity forms a large part of total electricity supply.

Note that a *high* value for *G'* and *S'* corresponds to *flat* schedules in the above figures. The intuition behind this equation is as follows:

§ A small value for *G'* (small change in *G* for large changes in p^w and p^c) corresponds to a steep supply schedule for green energy in Figure 3.6. This implies that large price rises are needed to effect increases in green energy. The cost of increasing further green generation (increasing α) is therefore high. Note that, while the figure uses a simplified linear schedule, in practice the magnitude of *G'* depends on what renewable capacity is available to install, and therefore partly on what opportunities have already been exhausted (and indirectly thus on α).[33]

§ Meanwhile, a large value for *S'* implies a very flat supply schedule for non-green energy in Figure 3.6. There is therefore a small change in the marginal cost of the marginal producer as non-green energy is replaced with green energy. The decrease in the price for non-green power caused by the increase in the quota will therefore be small, increasing the chances that the total power purchase price (including certificate charges) goes up.

[33] An increasing marginal cost curve for green energy is not a sufficient condition for the price of certificates to increase when the quota increases. The quota requirement is relative and could theoretically therefore be met purely through a reduction in the production of conventional energy, in which case the nature of the marginal cost curve for green energy is not important.

§ Finally, the ratio of green to non-green energy (determined by the size of the quota) is also of importance. The higher the quota, the more likely overall prices will rise. This is because the price increase affects only a proportion α of the electricity consumed, while the decrease in wholesale prices affects all of the remaining proportion $1-\alpha$. A larger α therefore makes a price increase more likely. Put differently, the *difference* in price between non-green and green electricity grows as the quota increases.

3.2.2.5 Additional effects on long-run electricity and certificate prices

3.2.2.5.1 Long-run development of wholesale electricity prices

The above analysis shows how wholesale electricity prices were depressed by the introduction of a green quota, and how this contributed to lower retail prices than would have prevailed in the absence of this effect. In the long-run, however, this effect may be modified, as adjustments are made both to electricity demand and to the stock of generation capacity.

In actual markets, the extent of the depression of wholesale prices depends on whether the rate of investment in additional green capacity occasioned by the TGC scheme exceeds the growth in demand. In this case, a situation of excess capacity will ensue, as existing non-green capacity exceeds the needs of its market, as restricted by the green quota. In this situation, the green quota forces the premature displacement and (ultimately) of existing plants that would otherwise have remained in remunerative service. The associated lower wholesale prices will further decrease the benefit of keeping excess capacity open.

In practice, the costs of keeping plant available are low compared to building new capacity, so prices may remain lower than required to stimulate new investment. In this situation, excess capacity and depressed prices may remain for many years. This in turn is associated with higher certificate prices, but potentially also with lower overall prices to consumers, as detailed in the previous section.

Gradually, it will become unprofitable to keep open existing non-green generation capacity. If the costs are higher than current of expected future prices it will be closed down. This will lower the amount of excess capacity available, and prices will start to rise. In the longer run, wholesale prices will rise to the level required to incentivise investment in new generation capacity.

3.2.2.5.2 Long-run development of retail prices

The discussion above showed that, for a given capacity, retail electricity prices may either decrease or increase as a result of a TGC scheme, depending on the extent to which falling wholesale prices counterbalance the increased costs associated with green certificates. In the longer run, however, the wholesale price decrease will not persist. Instead, wholesale prices will depend on the long-run marginal cost of adding new generation capacity. This suggests that long-run consumer prices will unambiguously increase, as there is no mechanism to offset the increased costs of green certificates.

3.2.2.5.3 Long-run development of certificate prices

As outlined above, the short-run certificate price is self-adjusting, so that an increase in electricity prices (without increase in green generation costs) is exactly offset by a corresponding decrease in certificate prices. This result is valid in short-term competitive markets.

In the longer run, however, additional adjustments occur in the electricity market. Notably, the total level of demand decreases as increased wholesale prices result in higher retail prices. This means, that further adjustments also occur to the certificate price. At a lower level of demand, a smaller absolute amount of green electricity is supplied for a given quota. With an upward-sloping green supply schedule, this entails a lower marginal cost of the marginal green producer. This in turn means that the certificate price decreases *more* than the increase in the wholesale price.

As in the case of retail prices, the magnitude of this effect will depend on the size of the green quota and on the responsiveness of non-green electricity supply, green electricity supply and electricity demand to changes in wholesale prices. Specifically, the certificate price should respond more to changes in the wholesale electricity price when:

- the supply of non-green electricity is sensitive to price.
- the supply of green electricity is insensitive to price.
- the green quota is small.[34]

The relationship also depends closely upon the price sensitivity of electricity demand (Box 3.3), but here the sign of the relationship is ambiguous.

The above result implies that an increase (decrease) in wholesale prices will lead to a decrease (increase) in the revenue obtained by green producers (equal to the sum of wholesale and certificate prices). This is because, as the level of demand contracts, the *absolute* amount of green generation required to meet the quota also decreases. This in turn means that lower marginal revenue is required by green producers, and that the certificate price falls.

[34] Jensen and Skytte (2002) investigate the relationship between certificate prices and the green quota, keeping the wholesale price constant. They derived the counterintuitive result that, for a particular value of wholesale price, a more ambitious green quota can lead to either a higher or lower certificate price, depending upon the relative slope of the demand and supply schedules. In practice, a change in the green quota will lead to a change in *both* wholesale and certificate prices.

Box 3.3
A closer look at the long-run response of certificate prices to a TGC scheme

Balancing demand and supply, we have:

$$D(p^w + \alpha p^c) = S(p^w) + G(p^w + p^c)$$

Differentiating with respect to the wholesale electricity price (p^w) and denoting the derivatives of each function as *D'*, *S'*, and *G'* respectively, we can obtain the following expression relating certificate prices to wholesale electricity prices:

$$\frac{\partial p^c}{\partial p^w} = -\frac{S' + G' - D'}{G' - \alpha D'}$$

Since $S'>0$, $G'>0$, $D'<0$ and $\alpha>0$, the overall expression is negative: i.e., the certificate price goes down if the wholesale price goes up, and vice versa. If the supply curve is flat ($S'=0$), the expression reduces to: $-(G'-D')/(G'-\alpha D')$. For any non-zero value of the green quota (α), the magnitude of this expression is greater than 1, while if $S'>0$, the magnitude increases further. Thus: *an increase (decrease) in wholesale prices leads to a* <u>*greater*</u> *change in certificate prices, but in the opposite direction.*

The parameters *D'*, *S'*, and *G'* represent the sensitivity to wholesale prices of demand, non-green supply and green supply respectively. The relationship between the ratio $\partial p^c/\partial p^w$ and each of these can be obtained by further differentiation of the above expression. The results are as follows:

The certificate price responds more when the supply of non-green electricity is sensitive to price (S' is large). A fall in wholesale electricity prices increases electricity demand, increases the demand for green electricity, and drives up certificate prices. The larger the price sensitivity of non-green electricity, the larger is the increase in green supply and hence certificate prices.

The certificate price responds more when the supply of green electricity is insensitive to price (G' is small). Price insensitivity of green electricity supply is equivalent to a high cost for increases in output. As the green quota is fixed, the average cost of green electricity increases more as total demand expands in response to the change in wholesale prices.

The certificate price responds less if the quota (α) is large. The larger the quota, the smaller the share of non-green electricity in total supply, and therefore the smaller is the effect of a price change in this sector. To see this, consider the extreme case when α approaches 1, i.e., when nearly all electricity is green electricity. A change in the price for non-green electricity has little effect in this situation, as it forms a smaller part of overall electricity supply.

The impact of demand price sensitivity is ambiguous (D') There are two countervailing effects of the reduced demand following reductions wholesale prices. High price sensitivity will lead to a larger increase in demand, with a concomitant rise in demand for green electricity and higher certificate prices (*D'* term in numerator). On the other hand, the higher certificate price will translate into higher total electricity prices, thereby reducing the demand for electricity and hence also the price of certificates (α*D'* term in denominator).[35]

3.2.3 Price and quantity effects with different market and design features

The above exposition establishes the fundamental effects of a TGC scheme and its interaction with the electricity market. However, as outlined in section 3.1.3, a number of different certificate scheme designs are possible, and some design parameters may change the nature of the interactions with the certificate market. In this section, we discuss how the above effects may be modified by the existence of three real-world complexities and design parameters, namely:

§ voluntary market for green electricity;

§ the size of green quota;

§ the sources of demand for green certificates;

§ fungibility of green certificates across Member States;

§ provisions for intertemporal flexibility ('banking' and 'borrowing' of certificates);

§ including of pre-existing or otherwise viable renewables;

§ restrictions on the number of suppliers of certificates; and

§ regulation of certificate prices through price floors or price ceilings.

3.2.3.1 Voluntary market for green electricity

Several European countries have markets for green electricity driven by *voluntary* demand by consumers and these markets exist either alongside or in place of the market supported by TGC schemes and other instruments. Some Member States support this by offering tax breaks or other support to consumers to partially cover the additional cost of renewables, leaving the remainder to be paid voluntarily.

The interactions between voluntary demand for green electricity and a TGC scheme could have a variety of effects. It is possible that the TGC scheme would reduce voluntary demand. For example, consumers who would voluntarily purchase green energy without the TGC scheme may feel that, with a TGC scheme, enough green electricity is being generated even without their individual, voluntary purchases. Also, the TGC scheme raises the marginal cost of additional green generation, and it may therefore drive the cost above the willingness to pay of voluntary green electricity consumers. Both possibilities have the effect of 'crowding out' private demand for green energy. Thus, the gains made by a TGC scheme would not include the full green quota, but only the portion that surpassed voluntary demand.

In another scenario, consumers, rather than using the TGC market, make use of separate 'guarantees of origin' (GOs) for green electricity. An important question is whether and to what extent the guarantees of origin overlap with green certificates, with the consequent

35 The relative importance of these to affect depends upon the ratio of the respective price sensitivities of green and conventional electricity supply, and the ratio of green to conventional electricity.

potential for 'double counting'. Here green generation could be rewarded twice: first through the TGC scheme and second through the premium price paid by voluntary consumers for green electricity with a certified GO. In this case, no additional generation would ensue, but generators eligible for both TGCs and GOs could benefit from increased revenue. The impact on the green certificate market would depend on whether GOs and TGCs were made interchangeable, in which case certificate prices could be lowered. The net effect would be a transfer of payments from one sub-group of consumers (voluntary purchasers of green electricity) to another group of consumers, without any additional green generation.

Such an outcome has been felt to be undesirable in several Member States, and as a consequence there have been efforts to offer certification services to help ensure that GOs apply only to generation above and beyond that brought about by TGC schemes.

In sum, voluntary demand for green electricity could be reduced by a TGC scheme, but could also impact the market for green certificates. The outcome depends on the precise nature of the guarantees of origin. Given the high cost of renewable electricity, the effect of voluntary demand is likely to be small in most countries.

3.2.3.2 Effects of different size of green quota

The effects of a larger green quota were outlined in the general analysis above, equivalent to a larger value for α. This is clearly a key parameter of TGC scheme design, and in sum the effects of a larger quota on key variables are:

§ higher certificate prices as a higher-cost marginal green producer is required at grater volumes of green generation;

§ lower wholesale electricity prices (though long-run wholesale prices are determined by the cost of new entry and unaffected by the TGC scheme, as discussed);

§ higher consumer prices, as number of certificates required as well as cost of each certificate increases; and

§ lower total electricity demand, as consumers respond to the increase in retail prices.

Overall scheme costs therefore increase both because the total expenditure of certificates is higher and because consumer and producer surplus decreases as the overall level of electricity produced contracts (this is discussed further below).

In addition, an increase in the size of the quota does not translate one-to-one to an increase in the amount green generation. This is because a larger quota increases the long-term total increase in the retail price, and therefore results in a lower overall level of electricity demand. As the quota is set in proportion to total electricity consumed/supplied, this in turn means that the absolute amount of green generation is lower than it otherwise would have been.

3.2.3.3 Effects of different sources of demand for green certificates

Another important design parameter is the source of demand for green certificates. As outlined above, under conditions of perfect competition this is of little importance to the effects on the electricity market. In such competitive markets, agents higher up in the supply chain would pass on any increase in costs to their customers, and end-users would ultimately pay the full cost of certificates.

If markets are either regulated or imperfectly competitive this may change. In the case of regulation, the effect on end-users depends on the regulatory treatment of expenditure on certificates. However, it seems likely that both cost-of-service and price-cap regulation would include certificate expenditure as a direct cost, and therefore allow it to be passed on to end users.

In imperfectly competitive markets, the relationship between the added costs of the green certificate programme and prices is more complex than with in a perfectly competitive market. The price increase could be more or less than that under competitive conditions, depending upon the specific demand conditions.

Note that the certificate market might also be imperfectly competitive if, for example, there are few buyers and thus certificate buyers may enjoy some market (monopsony) power. This would lead to a lower certificate price and therefore reduce the incentives for investment in green capacity. These conditions also could undermine the cost-effectiveness of the green certificate programme.

In practice, the source of demand for certificates is almost always electricity suppliers, and the use of an end-user obligation has proven unwieldy in some schemes. Experience therefore suggests that administrative and transaction costs may be important in the choice of the source of certificates.

3.2.3.4 Effects of different extents of fungibility of green certificates

The analysis above is concerned chiefly with a national TGC scheme, i.e., where green generation and certification takes place within the same country as the consumption of these certificates. It is also possible that certificates would be fungible across Member States and TGC schemes, as is the aim of the Renewable Energy Certificate System (RECS) project.

One consequence of fungibility across Member States is the development of a single market for certificates, with certificate prices equalising. This has consequences for the distribution of investment in green generation, the total cost of achieving a given amount of green generation, and for certificate prices.

With a single certificate market, investment will take place where the green cost gap is smallest. As the size of this gap will differ across Member States, those with high availability of cheap green generation opportunities would be able to generate more green electricity than required by their national quota and export the associated green certificates to countries where the same green generation would be more expensive to effect. This would lower the overall cost of achieving a given amount of green generation across the relevant Member States. The total 'subsidy' paid to green generation through certificates would be lower than in the case of purely national schemes achieving the same amount of green generation.

The distribution of generation will depend on the green cost gap in different locations, and as discussed above this depends on two factors. First, the cost of green generation is likely to vary across Member States. Other things being equal, there therefore would be more investment in locations where green generation is cheap than where it is expensive. Second, the certificate price depends on the wholesale price of electricity, which also is likely to vary across Member States. Even if costs were identical, therefore, investment opportunities would not necessarily be the same, but two installations in different electricity markets would require different amounts of subsidy to the extent that wholesale prices differed.

The effect on certificate prices also differs across Member States. Member States generating in excess of their national quota and exporting certificates would experience *higher* certificate prices than in the case of a purely national scheme. This results because the total amount of generation would be larger, with associated higher costs of green generation. Somewhat paradoxically, consumers in countries with better-than-average green generation resources would therefore pay *more* in an international scheme than in a purely national one. Non-green generators would also be worse off as more generation is displaced (electricity would not be exported, by the assumption of segmented electricity markets). The situation would be the opposite in Member States where there are few cheap green generation options and which would therefore import certificates. As discussed, the *total* cost across Member States would also be lower than in separate national schemes.

In sum, the overall cost across would be lower with certificates fungible across electricity markets. Meanwhile, green generation volumes, certificate prices, the cost to electricity consumers, the cost to non-green producers would all be higher in countries that exported certificates, and lower in ones that imported certificates.

This analysis is limited to the electricity market. In reality, the decision whether to make certificates fungible is likely to depend on numerous other factors. Notably, to the extent that the benefits of green generation are local international trade in certificates may be thought undesirable.

3.2.3.5 Effects of provisions for intertemporal flexibility

Another design parameters of importance are provisions for intertemporal flexibility, notably the ability to use current-period certificates for future-period compliance (‘banking’), and conversely to use expected future-period certificates for current-period compliance (‘borrowing’).

The rationale for such provisions is to smooth out volatility in the certificate price and reduce overall cost. This may be especially important in the case of renewable energy such as wind power, where underlying electricity supply is highly volatile. At times of low supply of green electricity there is otherwise a risk for price spikes and very large associated impact on electricity prices. Also, it can be shown that more flexibility serves to bring down average certificate prices as green generation is distributed optimally over a longer period of time.

As with other factors leading to lower certificate prices, banking and borrowing provisions therefore are likely to lead to a smaller impact of the TGC scheme on retail electricity prices. This in turn will lead to less of a contraction of electricity demand. This does not affect the short-term effect of TGC schemes on wholesale prices, which depends only on the size of the quota and consequent restrictions places on the market available for non-green electricity. In the longer run, however, lower demand is likely to be associated with lower wholesale prices (always subject to the constraint that prices need to be sufficiently higher encourage new entry).

3.2.3.6 Effects of restrictions on the eligibility of certain forms of generation

3.2.3.6.1 Effects of excluding pre-existing or otherwise viable renewables

In the above analysis it was assumed that green certificates only were issued to generation technologies that were not commercially viable without the support of the TGC scheme. However, most Member States have existing capacity (notably, renewables) that potentially qualifies for the objectives of TGC schemes. In practice, it may not be easy to distinguish commercially non-viable green technologies from those that are viable.

The effect of including commercially viable green technologies is to transfer (potentially substantial) rents to infra-marginal producers, i.e., those producers whose marginal cost of generation is lower than that of the marginal green producer. These producers receive the certificate price associated with the most expensive green technology available, but may have significantly lower costs. In most markets such rents are limited by competition and new entry, but these mechanisms may not be present in TGC markets. With existing and amortised installations, the rents may arise in the first place because these installations have benefited from previous policy support.

As mentioned above, some TGC schemes have addressed this issue by excluding existing installations from the TGC scheme. In the analytic framework introduced above, the effect of such provisions is to change the green supply schedule. Excluding some low-cost options means that the schedule *G* shifts to the left, resulting in a higher-cost marginal green producer for a given green quota. The result is therefore likely to be a higher certificate price.

Another option is to constrain the period for which an installation qualifies for the generation of certificates. This limits the period during which the initial cost of investment can be recouped, equivalent to an increase in the marginal cost of generation. The effect is therefore similar to an upward shift of the green supply schedule *G*. [36]

In both cases, higher certificate prices are likely to ensue, with corresponding greater impact on retail electricity prices and the level of demand. Wholesale prices are not directly affected, except through the reduction in overall demand.

The provisions may also change the green merit order by limiting the forms of technologies that can be supported through the TGC scheme. Technologies such as wind or hydro-power are characterised by high investment costs but very low short-term marginal costs. For such technologies, support for a limited period after build could work, provided it is sufficiently high. If, however, the technology is one with short-term marginal cost that is higher than the wholesale price of electricity (e.g., biomass), the time limit may mean that the technology cannot be effectively supported by the scheme. Once eligibility for certificates ceases, it may no longer be profitable to continue generation.

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[36] The certificate price will rise to the point where, at the end of the period for which the installation can generate certificates, the remaining cost of servicing the investment is equal to the (discounted) future expected revenue.

It is unclear that these considerations should directly influence the choice of eligible technologies. The choice of which technologies to include in a TGC scheme will presumably be reflective of scheme objectives.

3.2.3.6.2 Effects of a limited number of certificate suppliers

As noted above, the cost-effectiveness of a TGC scheme depends to a large extent on the establishment of a competitive certificate market. In highly concentrated wholesale electricity markets this may be difficult to achieve. As noted, in the case of very few consumers of certificates prices may be *lower* than optimal, in the case of a very small number of suppliers of certificates the resulting prices may be *higher* than optimal. Notably, a single supplier would be able to extract monopoly rents.

Such situations may have the effect of raising the total cost of the scheme, with higher certificate prices and associated impacts on the electricity market. With sufficiently high certificate prices and a maximum price (e.g., in the form of a penalty for non-compliance) the scheme may in fact cease to operate as a certificate scheme and more resemble a direct subsidy scheme, as consumers prefer to pay the non-compliance penalty to purchasing certificates.

3.2.3.7 Effects of regulated certificate prices

Several existing TGC schemes operate some form of price regulation of the certificate market to mitigate fluctuations and provide investors, producers, or consumers in the electricity market with a greater degree of certainty. The regulations typically operate as either price floors or price ceilings.

Figure 3.8 illustrates the situation where a price floor is imposed on green certificates. As in Figure 3.2, the certificate price required to meet the target of x^q of green generation is given by the difference between the marginal cost of the marginal green producer and the wholesale electricity price, or p^q-p^w in the figure. However, if the price floor p^c_{floor} is sufficiently large, the certificate price is in fact *higher* than p^q. This may encourage aggregate over-compliance with the green quota, with $x_{floor} > x^q$. Such a situation could arise if the government overestimated the marginal cost of deploying renewables when setting quota and the price floor.

Figure 3.8
Effect of a certificate price floor on the TGC scheme

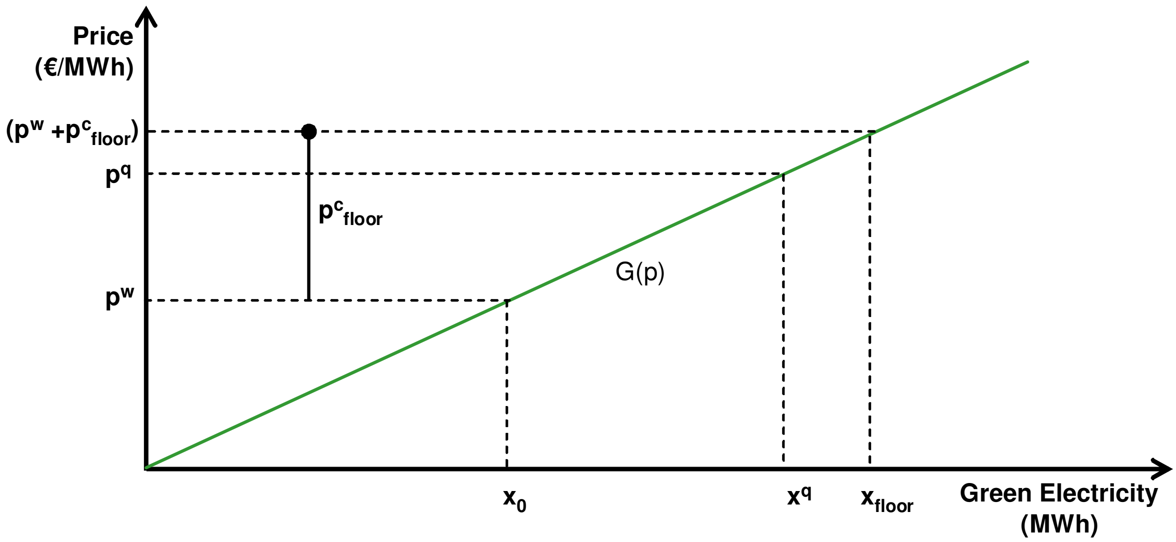
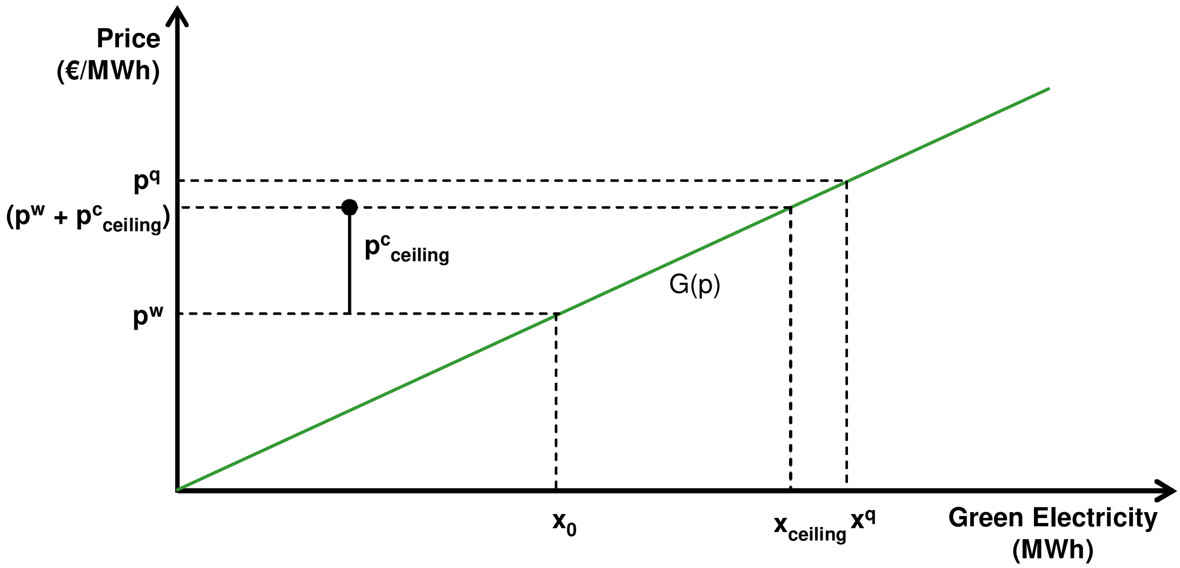


Figure 3.9 shows the impact of a price ceiling in the market. The price required to achieve the quota is p^q but the regulation limits this to p^w+$p^x{}_{ceiling}$. This means that those green generators required to provide a volume larger than $x_{ceiling}$ no longer find it profitable to operate, and the quota will not be met.

In many TGC schemes, fixed penalties for non-compliance effectively serve as price ceilings.

Figure 3.9
Effect of a certificate price ceiling on the TGC scheme



3.2.3.8 Effects of factors affecting the risk faced by of green investors

In addition to the above factors, there are various aspects of scheme design that affect the risk faced by investors in green capacity. Investment will take place when the total cost of generation, including any initial investment costs, are at least balanced by (discounted) expected future revenues. However, these revenues are subject to uncertainty, and investors are therefore likely to demand a premium to compensate for the risk they undertake when investing in green capacity on the back of a TGC scheme. Other things being equal, the certificate price required to incentivise new investment to meet the green quota will therefore be higher the more uncertain or volatile is future revenue.

Some design features have the potential to affect this uncertainty. Relevant considerations include:

§ the legal basis for the scheme – the risk that support will be discontinued may be smaller if the scheme is laid down in primary legislation;

§ length of commitment periods – setting quotas for longer time periods may provide greater certainty about future demand for certificates, and therefore certificate prices;

§ target and eligibility definitions – well defined targets and eligibility criteria may decrease the uncertainty about future supply for certificates, and therefore certificate prices; and

§ monitoring and enforcement mechanisms – provisions for reliable monitoring and enforcement may help ensure that scheme operation is predictable.

3.2.4 Summary

Table 3.3 provides a summary of the impacts of a TGC scheme on key 'price and quantity' variables.

Table 3.3
Summary of price and quantity effects of a TGC scheme in a national electricity market

Variable	Effect of TGC scheme	Comments
Wholesale electricity price	Reduced in short-term	Short-term wholesale price decreases as the amount of price-setting non-green generation decreases.
	Unaffected in long-term	In the long-term, wholesale electricity prices are determined by the cost of adding new generation capacity.
Retail electricity price	Varies in short-term	Net effect depends on balance of decreased wholesale prices and 'tax effect' of certificate obligation.
	Increased in long-term	In the long-term, wholesale prices do not decrease, so retail prices unambiguously increase because of the added cost of certificates.
Electricity demand	Varies in short-term	Demand may increase or decrease, depending on the net effect on retail prices. In the very short-term, electricity demand is likely to be unchanged.
	Reduced in long-term	In the long-term, electricity demand decreases in response to higher long-term retail prices.
Non-green generation	Reduced	Non-green generation is reduced both by the green quota reserving a share of the market for green electricity, and by the overall reduction in electricity demand.
Green generation	Increased	Renewable generation increases as mandated by the green quota.
CO_2 emissions	Reduced	CO_2 emissions decrease as green generation replaces more CO_2-intensive non-green generation.
Investment in conventional generating capacity	Reduced	New green generation capacity leads to less need for the addition of other new conventional capacity.
Investment in end-user energy efficiency	Varies in short-term	Investment in energy efficiency is affected by the retail price of electricity, the effect on which is ambiguous in the short-run.
	Increased in long-term	In the long-term, retail electricity prices rise, producing increased incentives for investment in energy efficiency.
Investment in new renewables	Increased	Investment is increased until generation meets the green quota.

3.3 Interaction of Green Certificate Schemes with an International Electricity Market

As discussed in Chapter 2, most Member States are part of an electricity market that extends beyond their national borders (an 'international market'). This means that the electricity price in the national wholesale market depends not only on domestic conditions and policy, but also on the conditions prevailing in countries with which it is interconnected. The volume of electricity imports and exports will be constrained by the existing transmission capacity and this varies widely between different regions of the EU.

The existence of such interconnections may have important consequences for the interaction of a TGC scheme with the electricity market. The significance of international trade will depend on the share of imports and/or exports in total electricity consumption and could be particularly important within the Nordic electricity market,[37] which has a single market-wide wholesale price for most of the year (von der Fehr, Amundsen *et al.*, 2005). The Nordic countries have also pioneered the introduction of TGC schemes and are considering a Nordic-wide TGC market. As a result, the implications of international trade in electricity for the operation of Nordic TGC schemes have been the focus of some attention (Morthorst, 2003, ; Unger and Ahlgren, 2005).

This section examines the implications of introducing a national TGC scheme in a country that is a net importer of electricity. It is assumed that imports provide the marginal supply on the national system and continue to do so after the introduction of the TGC scheme. It is also assumed that the importing country is sufficiently small that its imports do not affect the international wholesale price for electricity. This is a special case, but serves to illustrate the potential implications of electricity trade quite well. As before, the electricity market is represented in a highly simplified and stylised form. We also briefly consider the case of a net exporter of electricity, which leads to very similar results to the case of a net importer.

3.3.1 Introduction of a green certificate scheme in a country that is a net importer of electricity

A stylised representation of the electricity market in a country that is a net importer of energy is shown in Figure 3.10. The wholesale price for electricity is p_0, and this is also the price of electricity in the international market. Electricity demand is met by domestic producers up to point A, corresponding to amount x_a. At this point, there is a 'flat' segment in the supply schedule at which additional electricity supply is available through imports instead of increasingly expensive domestic generation. The supply schedule is flat because the importing country is assumed to be a price taker on the international market (i.e., its demand is small relative to the total demand on the system). No further electricity can be imported beyond point B because transmission capacity constraints start to bind. Beyond point B, additional supply is met by domestic producers with increasing marginal cost.

Note that, in real-world markets, the region A to B may be very small. The representation in this figure is a special case, where the more generic one is simply a 'flatter' (rather than flat) supply schedule.

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[37] Comprising Denmark, Finland, Norway and Sweden.

To see the impact of participation in the international electricity market, Figure 3.10 illustrates the situation where the marginal producer prior to the introduction of the quota is a participant in the international market. In addition, we assume that the country stays a net importer also after the introduction of the quota, i.e., that demand stays between x_a and x_b. The key implication of this is that the wholesale price remains at the level of the international electricity price. Meanwhile, consumers still face the obligation to purchase a certain amount of certificates. With no reduction in wholesale electricity prices to offset the additional expenditure on certificates, the purchase price faced by consumers unambiguously increases to p_2.

The effects of introducing a TGC scheme in these circumstances can be summarised as follows:

§ electricity demand in the importing country is reduced from x_0 to x_2;

§ wholesale electricity prices in the importing country remain at p_0;

§ retail electricity prices in the importing country increase to p_2;

§ non-green electricity generation in the importing country is unchanged at x_a;

§ green electricity generation in the importing country increases from zero to (x_2-x_1);

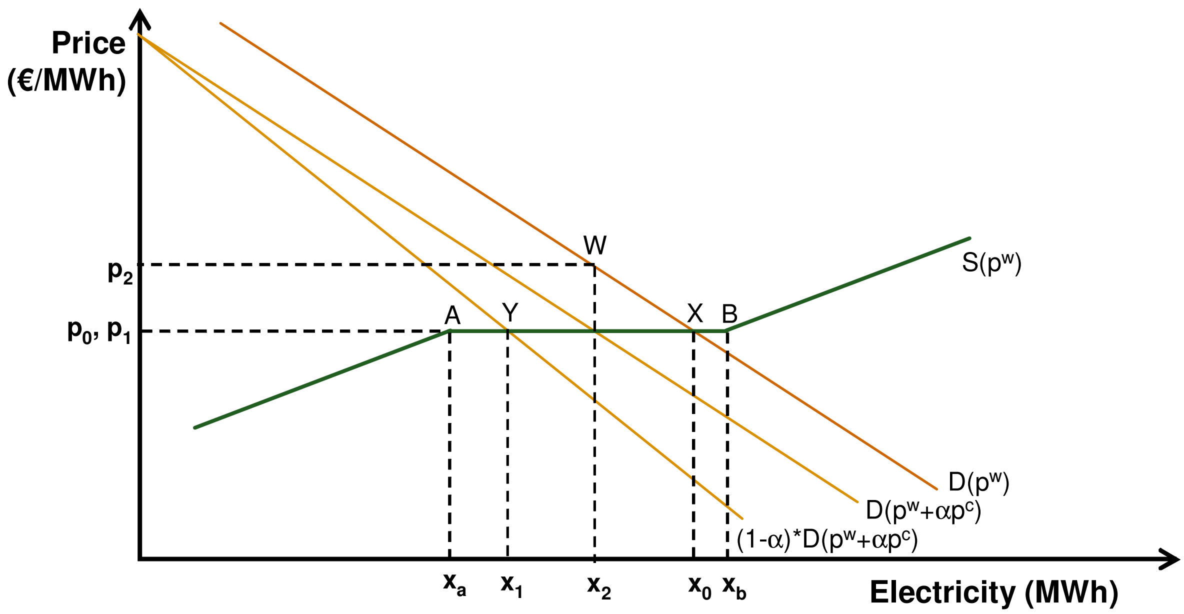
§ imports are reduced by (x_0-x_1);

§ electricity generation in the exporting countries is reduced by (x_0-x_1);

§ CO_2 emissions in the importing country are unchanged; and

§ CO_2 emissions in the exporting countries are reduced.

Figure 3.10
Introduction of a TGC scheme where the country is a net importer of electricity



Unlike in the example without international trade, the domestic non-green power producers do not lose from the introduction of the quota. Instead, domestic non-green production remains at the same level (x_a) as the mandated green electricity displaces imported electricity rather than any domestically produced non-green electricity. Imports decline from $(x_o\text{-}x_a)$ to $(x_1\text{-}x_a)$, with $(x_2\text{-}x_1)$ being displaced by green electricity and with $(x_o\text{-}x_2)$ being lost through reduced demand.

Since the country is still a net importer of electricity, the wholesale power price is still determined by the international market price and the post-quota wholesale price is the same as it was before the quota's introduction (i.e., p_0 and p_1 are the same). However, retail prices increase to p_2.

With domestic power production unaffected by the TGC scheme, the effect is wholly on consumer prices. End-users face an unambiguously higher electricity price, without the mitigating effect of falling wholesale prices, and consume a smaller amount of electricity as a result.

Since non-green generation within the importing country is unaffected by the TGC scheme, there is no reduction in national CO_2 emissions. Instead, the subsidised green generation displaces non-green generation in the exporting countries and hence leads to a reduction in CO_2 emissions there.[38] This means that the TGC scheme contributes nothing towards meeting the Kyoto targets of the host country.

The outcome is very similar in the case of a net exporter. In this case the green quota's displacement of non-green generation in the domestic market leads to increased exports, provided transmission capacity allows for this. Wholesale prices therefore do not decrease.

3.3.2 Summary

Table 3.4 summarises the effect of a national TGC scheme on our 'price and quantity' variables in the situation where: a) a country is a net importer of electricity; b) imports are the marginal producer on the national system; c) the change in imports following introduction of the TGC scheme remains within transmission constraints; and d) and the country is sufficiently small to be a price taker in the international electricity market.

It should be emphasised that this represents an extreme case and real-world situations may differ. If imports were 'base-load' on the national system, and if they remained so after the introduction of the TGC scheme, the impact of the TGC scheme would be identical to that within an isolated national system. Alternatively, if imports provided the marginal supplier but the importing country was not a price taker on the international market, then a national TGC scheme could reduce the international wholesale price of electricity – but by less than in a corresponding isolated national market.

[38] The volume of emission reduction may be greater or less than would have been achieved within an isolated national market, depending upon the relative carbon intensities of the displaced plant on the two systems.

The general point is that the existence of electricity imports or exports can potentially modify the effect of a TGC scheme and may reduce its contribution to meeting national targets for CO_2 emissions. With greater integration of national electricity systems in Europe, this is one reason for the increasing interest in international TGC schemes.

Table 3.4
Summary of price and quantity effects of TGC scheme in an international electricity market – case where imported electricity is on the margin

Variable	*Effect in importing country if no electricity trade*	Effect in importing country if electricity trade	Effect in exporting country/countries if electricity trade	Comments
Wholesale electricity price	*Reduced (short term)*	Unchanged	Unchanged	Under the assumption that the importing country is a price taker on the international market
Consumer electricity price	*Varies (short-term)*	Increased	Unchanged	Consumer prices are increased by the certificate obligation, with no offsetting reduction in wholesale prices
Electricity demand	*Varies*	Reduced	Unchanged	Lower demand due to higher consumer prices
Non-green generation	*Reduced*	Unchanged	Reduced	Green generation displaces imports, so non-green generation in imported country is unchanged and that in exporting countries is reduced
Green generation	*Increased*	Increased	Unchanged	Renewable generation increases as mandated by the green quota.
CO_2 emissions	*Reduced*	Unchanged	Reduced	In this special case, the scheme has *no effect on CO_2 emissions in the host country*, but instead reduces emissions in the exporting countries
Investment in end-use efficiency	*Varies*	Increased	Unchanged	Higher consumer prices lead to increased investment.
Investment in new renewables	*Increased*	Increased	Unchanged	Increased as required to meet green quota.

3.4 Distributional Effects of Green Certificate Schemes

This section investigates how changes in quantities and prices in the electricity market affect consumers and producers. To do so, we consider standard measures of consumer and producer 'surplus', that is, how the prices obtained by producers compare to their marginal costs, and how the prices paid by consumers compare with their marginal willingness to pay.

It is again important to stress that this is not a 'welfare' analysis. The analysis is confined to the electricity market only, and it does not take into account the environmental and other benefits of green generation, or the effects in secondary markets such as those for fuel or renewable generating technologies. This is an important caveat, as it means that this analysis is *not* an assessment of the overall costs and benefits of introducing a TGC scheme.

3.4.1 Effects on producers and consumers in the electricity market[39]

Figure 3.11 is a simple illustration of consumer and producer surplus in the electricity market prior to the introduction of a TGC scheme. Consumers pay price p_0 and the surplus enjoyed is given by the trapezoidal area bounded by the y-axis, the horizontal price line p_0, and the demand schedule $D(p^w)$. Intuitively, the surplus in the electricity market derives from the fact that some consumers benefit from paying a price that is lower than their willingness to pay (which is implied by the downward-sloping demand curve.)

Producer surplus in the non-green electricity sector is given by the darker trapezoidal area bounded by p_0, the supply schedule $S(p^w)$, and the y-axis. The upward-sloping supply schedule of non-green electricity implies that producers have different costs of production, and the surplus in the electricity market derives from low-cost producers obtaining a higher price than their own marginal cost of production. Producers of green electricity do not participate in this market, as we assume that their technology is not economically viable without the quota and certificate system. Their electricity market surplus is therefore zero prior to the introduction of the quota.

[39] This section draws on Bye et al. (2002).

Figure 3.11
Consumer and non-green producer surplus with a TGC scheme

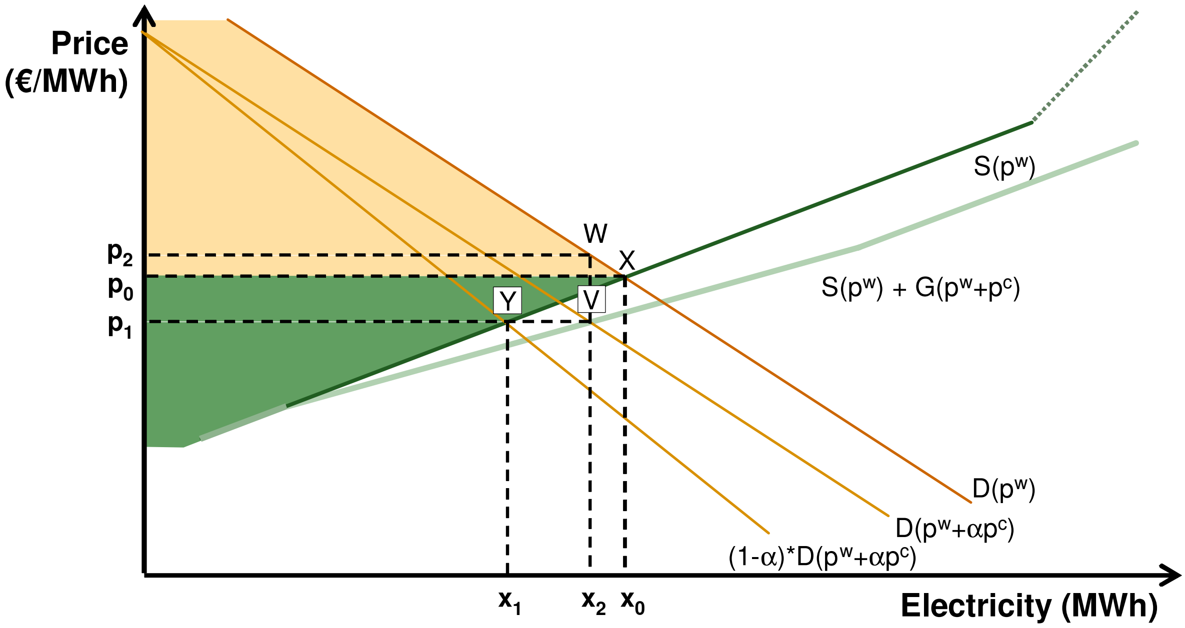


Figure 3.12 depicts the situation after the quota is introduced. As explained above and outlined in Figure 3.6, consumption of electricity falls as the purchase price increases. The new equilibrium is that indicated by *W* in the figure, taking account of both taxed demand $D(p^w+\alpha p^c)$ and the price of certificates. Consumer surplus therefore decreases by the area p_2WXp_0.

The surplus of non-green energy producers also decreases, as production of non-green electricity decreases from x_0 to x_1 and the price received from p_0 to p_1. The equilibrium in the non-green electricity market is therefore that indicated by *Y*, at the intersection of the supply schedule of non-green energy, $S(p^w)$, and the demand schedule net of both the 'tax' and 'market share' effects, i.e., $(1-\alpha)*D(p^w+\alpha p^c)$. This reflects both the decrease in electricity demand $(x_0– x_2)$ and the displacement of non-green electricity by green electricity, $(x_2– x_1)$. Producer surplus in the non-green electricity sector decreases by the area p_0XYp_1.

Figure 3.12
Changes to consumer and non-green producer surplus with the introduction of a TGC scheme

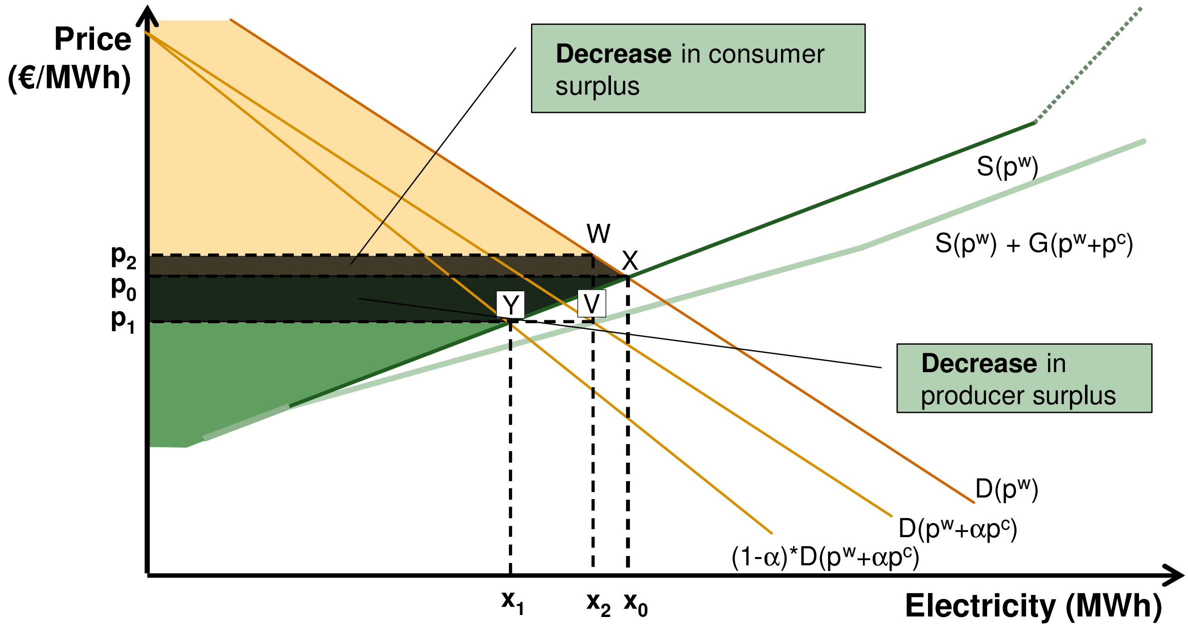


Figure 3.13 shows the situation faced by producers of green electricity after the introduction of the quota. There are two distinct sources of revenues contributing to surplus:

1. The 'transfer' of generation from non-green producers to green electricity producers mandated by the quota. This is given by the amount of green electricity produced $(x_2\text{-}x_1)$ times the wholesale electricity price (p_1). It is represented by area YVx_2x_1 and is labelled (*A*) in Figure 3.13.
2. The revenue from certificates. This corresponds to the implicit surcharge $(p_2\text{-}p_1)$ imposed on all electricity production through the quota requirement times the amount of electricity produced, x_2 (note that $p_2\text{-}p_1 = \alpha p^c$). This is equivalent to the area p_2WVp_1 in the figure and is labelled (*B*).

These two areas are equivalent to the dark green rectangle next to the y-axis labelled (*C*).[40]

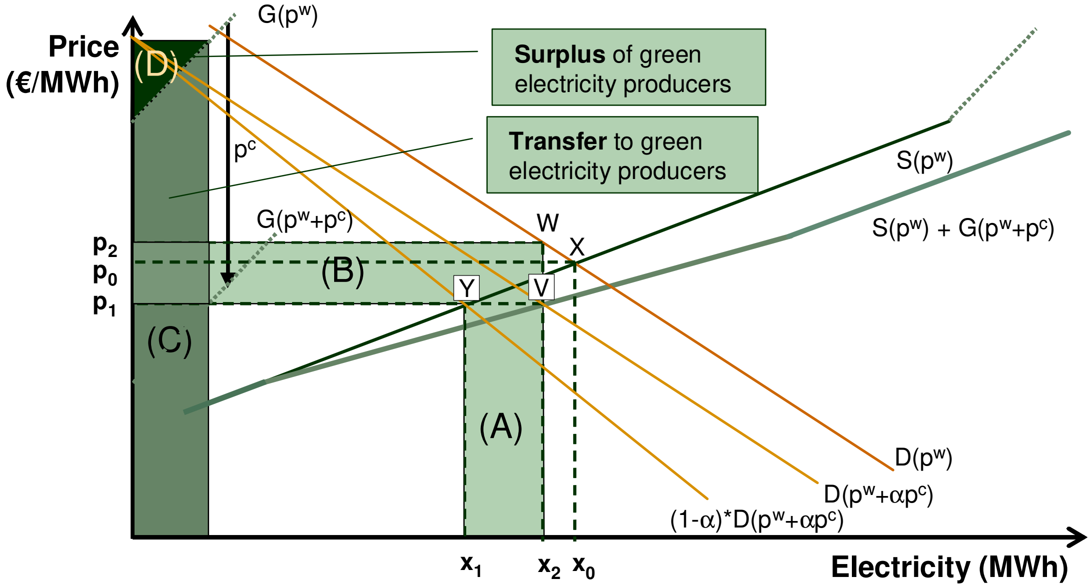
However, only a small fraction of the value represented by this area remains a producer surplus. Green electricity producers only obtain a surplus insofar as their cost is lower than the price obtained by the combination of the electricity price and the certificate price. This is

40 To see this, note that the dark green rectangle is equal to the amount of green electricity produced, $x_2\text{-}x_1$, times the sum of the electricity price and the certificate price, $p_1 + p^c$, i.e., $(p_1 + p^c)*(x_2\text{-}x_1)$. Meanwhile, area of the light grey area is given by $p_1*(x_2\text{-}x_1)+\alpha p^c*x_2$. To see the equivalence of the two, note that:

$$\alpha = \frac{(x_2 - x_1)}{x_2} \Rightarrow p_1 * (x_2 - x_1) + \alpha p^c * x_2 = (p_1 + p^c)(x_2 - x_1)\,.$$

indicated by the small black triangle above the green supply schedule, labelled (*D*) in the diagram.[41]

Figure 3.13
Change in the producer surplus of green electricity producers with the introduction of a TGC scheme

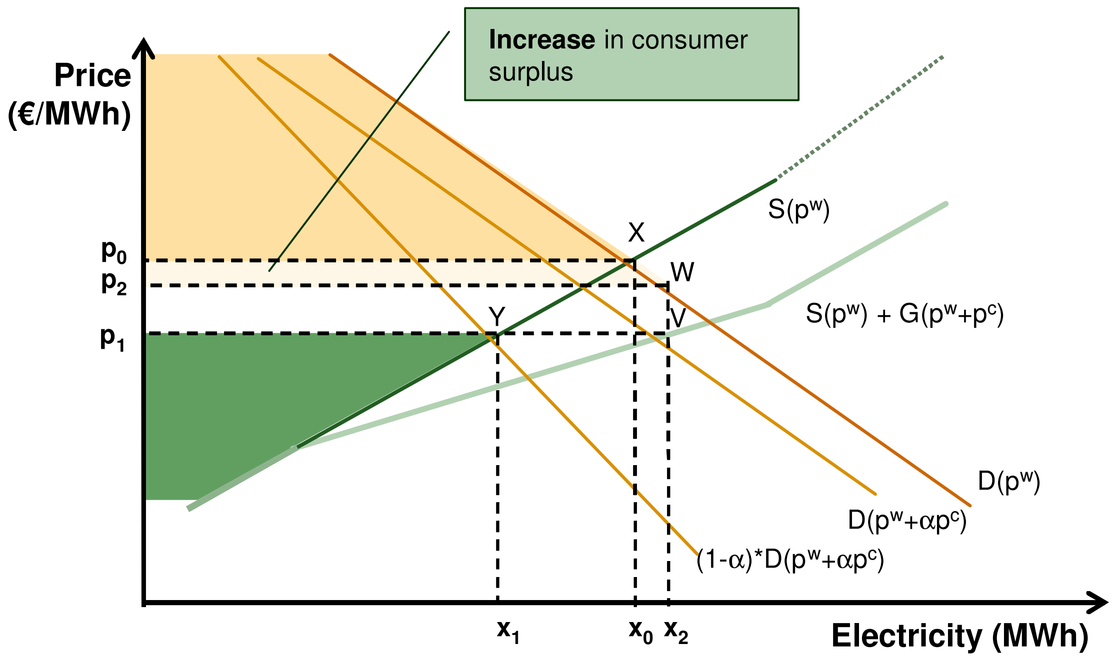


3.4.2 Effects when the introduction of the scheme causes the electricity price to decrease

As noted above, there may be circumstances in which the electricity purchase price decreases upon the introduction of the quota. In this case, consumer surplus *increases* when the quota is introduced. This is illustrated in Figure 3.14, which is similar to Figure 3.7 above. In this case, electricity price fall from p_0 to p_2, and the total amount of electricity produced increases from x_0 to x_2. The increase in consumer surplus is equivalent to the area p_2XWp_0.

[41] Note, however, that a steep green electricity supply schedule implies that operators of more efficient green technologies (especially any eligible incumbent technologies whose costs have already been written off) can benefit from a significant windfall gain. This feature of green certificates schemes has sometimes been criticised; Huber et al. (2004), Verbruggen (2004), NAO (2005), and others suggest that it may undermine the political acceptability and credibility of TGC schemes, thereby increasing political risk and limiting investment.

Figure 3.14
Example of increase in consumer surplus with the introduction of a TGC scheme



In sum, as with prices and quantities, the impact on consumers, producers of non-green electricity, and producers of green electricity are not clear-cut, but depend in an intricate way on the relative price sensitivity of the green and non-green electricity production, the price sensitivity of electricity demand, and the size of the quota.

It is clear that an upward-sloping green electricity supply schedule means that some producers of green electricity always gain from the introduction of the quota. Consumers may bear only small losses in surplus (and may even gain, in cases of small quotas and specific properties of supply and demand). Non-green energy is always displaced with the introduction of the scheme, and producers always receive lower wholesale electricity prices. Indeed, it is possible that the electricity market costs associated with the introduction of the scheme are borne mainly or even wholly by the non-green electricity production sector, even if the quota obligation is imposed on retail providers.

3.4.3 Summary

The effects of a TGC scheme on producers and consumers in the electricity market is summarised in Table 3.5.

Table 3.5
Summary of the distributional effects of a TGC scheme in a national electricity market

Variable	Effect	Comments
Producer surplus – non-green generators	Reduced	Due to lower wholesale price and loss of market share to green generators
Producer surplus – green generators	Increased	Combined revenue from certificate and electricity markets exceeds marginal costs
Consumer surplus - overall	Decreased	Sign depends upon whether retail electricity prices increase or decrease. In practice, price increase is most likely, leading to transfer payments from consumers to green generators. I

3.5 Summary

This section has provided an introduction to the theory and practice of TGC schemes. By exploring the implications of a TGC scheme in isolation, it has provided a basis for studying the interactions between TGC schemes and the EU ETS. Specifically, this section has:

§ Introduced the basic elements and objectives of a TGC scheme.

§ Discussed the most important design features of a TGC scheme, including the choice of target group, the denomination of the targets and the certification of renewable technologies.

§ Assessed the current state of development of TGC schemes in the EU and elsewhere.

§ Analysed the operation of an idealised TGC scheme that is introduced into a liberalised national electricity market, isolated from international trade. This includes the effect of this scheme on a number of ‘price and quantity’ variables, including wholesale and retail electricity prices.

§ Analysed the impact of various scheme parameters on the interaction of a TGC scheme with the electricity market;

§ Analysed how the presence of international trade in electricity may modify the operation of this idealised scheme.

§ Conducted a simplified analysis of the how the costs of this scheme are distributed between producers and consumers in the electricity market.

Table 3.3 summarises the effect of an idealised TGC scheme in an isolated national market, Table 3.4 does the same for an electricity market open to international trade and Table 3.5 summarises the distributional effects. In Chapter 6, this analysis is used as a basis to explore the nature of the interactions between a TGC scheme and the EU ETS.

Ultimately, a TGC scheme transfers resources from electricity consumers and producers of non-green electricity to producers of green electricity, thereby enabling the production of electricity from sources that would not otherwise be commercially viable. This transfer is mediated through the electricity and certificate markets, but the exact form of the interactions can be complex. In principle, a TGC scheme should lower wholesale electricity prices over the short term and this should to some extent offset the increase in retail prices resulting from the pass-through of the certificate costs. Indeed, in some circumstances retail prices may actually fall. Whether this is likely in practice is unclear, however, and the long-term effects may be substantially different from those in the short term. Similarly, the scale and nature of resource transfers will depend in a complex way on the precise conditions in both the certificate and electricity market. In all cases, the impact of a TGC scheme will be strongly influenced by the relative elasticity of supply for green and non-green electricity and the structure of the electricity market.

The above discussion also noted that a number of different design parameters have the potential to influence the interaction of a TGC scheme with the certificate market. Most design parameters do not influence the *form* of interactions, but rather their *magnitude*, notably through their effect on the certificate prices. Important issues identified include:

§ A higher green quota increases the price of certificates while also making it less likely that wholesale price reductions will offset the cost of certificates. It therefore increases the probability that retail prices will increase.

§ Different sources of demand for certificates may lead to different electricity price outcomes in imperfectly competitive electricity markets. This potentially leads to a smaller effect on electricity prices and demand, insofar as the cost of certificates is not fully passed on to end-users.

§ International fungibility of certificates can decrease the total cost of achieving a given amount of green generation across Members States and electricity markets. However, the impact varies across Member States depending on their availability of green generation opportunities.

§ Greater scheme intertemporal flexibility, such as certificate ‘banking’ across compliance periods, may reduce certificate prices and therefore lead to smaller impacts of TGC schemes on electricity markets.

§ Regulation of certificate prices may partially ‘unlink’ electricity and certificate price, as the difference between the two no longer represents only the green cost gap. Price regulation may make it more difficult to attain the green quota, or may lead to over-compliance. It may also distort price signals that help ensure scheme cost-efficiency.

§ Including pre-existing or other commercially viable technologies may lead to lower certificate price by decreasing the green cost gap, but their inclusion could also reduce the support available for new renewables, whose development TGC schemes are typically designed to foster.

§ Uncompetitive certificate markets may result if either the number of buyers or sellers of certificates is small. In such cases, the cost-effectiveness of TGC schemes may be jeopardised.

§ Factors contributing to greater scheme certainty—such as a longer commitment periods, smaller regulatory risk, and clearly defined targets—may decrease the risk premium demanded by investors and therefore also the certificate price.

As noted above, these factors have only been discussed on the basis of their relevance to electricity markets. Costs and benefits unrelated to the electricity markets, such as the local benefits of green generation, administrative aspects of the scheme, or the specifics of scheme objectives have not been taken into account. This means that these conclusions do *not* constitute an adequate basis for recommendations about optimal scheme design. Rather, they should be seen as a stepping-stone to the analysis of the interaction of TGC schemes with the EU ETS and tradable white certificate schemes in subsequent sections of this report.

4 White Certificate Schemes

This chapter explores the nature and operation of tradable white certificate ('TWC') schemes. As for TGC schemes, it is essential to understand how these schemes function before their potential interactions with the EU ETS can be assessed.

Section 4.1 introduces the basic elements and primary objectives of TWC schemes and outlines their main design features. These include the choice of target group and the certification of energy efficiency activities. It then assesses the current state of development of TWC schemes in the EU and summarises the design and operation of two existing schemes in Italy and the UK and a proposed scheme in France. More details on these schemes are provided in the Annex.

Section 4.2 analyses the operation of an idealised TWC scheme that is confined to electricity retailers operating within an isolated, liberalised and fully competitive electricity market. In practice, TWC schemes are unlikely to be confined to electricity, and electricity markets are unlikely to be fully competitive. But this analysis allows the basic impacts of a TWC scheme to be assessed, before 'real-world' complicating features are introduced. This section conducts a simple partial equilibrium analysis of this idealised scheme and assesses its effect on key variables such as electricity demand and CO_2 emissions. In contrast to the previous two chapters, the analysis includes both the electricity market and the market for energy efficiency.

Section 4.3 extends this analysis to examine the implications of international trade in electricity, focusing in particular on the case where imports act as the marginal producer on the national system. It assesses how this trade changes the impact of the TWC scheme on key variables within the importing country, and also how the scheme affects the exporting countries.

Section 4.4 examines how the costs of a TWC scheme may potentially be borne by producers and consumers of electricity, as well as by producers of energy efficient equipment. As elsewhere, this is not a full assessment of the costs and benefits of such a scheme, since both market failures and secondary effects in other markets are ignored. The implication of international trade in electricity for the distribution of costs and benefits is also briefly assessed.

The results of the analysis in sections 4.2 and 4.3 are summarised concisely in a tabular form. These tables are used subsequently in Chapter 6 to explore the nature of the interactions between a TWC scheme and the EU ETS.

4.1 Characteristics of White Certificate Schemes

4.1.1 Basic elements of white certificate schemes

A Tradable White Certificate (TWC) scheme allows 'energy savings' from energy efficiency improvements to be traded in a market. This can allow an aggregate target for 'energy saving' from a particular target group to be achieved more cost effectively.

TWCs are a relatively new form of regulatory instrument and at present there are only two schemes in operation (in the UK and Italy) and one proposed (in France). This means that there is little practical experience with the design and implementation of TWC schemes and little theoretical analysis of their behaviour and effects. However, TWC schemes have much in common with three more established regulatory instruments, namely: TGC schemes for renewable electricity; Demand Side Management ('DSM') schemes for electricity and gas companies; and project-based emissions trading schemes, including Joint Implementation and the Clean Development Mechanism. As a consequence, the design and analysis of TWC schemes can draw upon the experience gained with each of these.

Many of the elements of a TGC scheme (or a cap and trade emissions trading scheme) have a direct parallel in a TWC scheme. These include: the definition of the tradable commodity; the allocation of the obligations; the definition and certification of qualifying activities; the monitoring and verification of those activities; the procedures for compliance and enforcement; and the mechanisms for trading, registration and tracking. Given these similarities, the analysis of TWC schemes in this chapter will follow the same structure as the analysis of TGC schemes in Chapter 3, highlighting both the similarities and the differences.

A TWC scheme also has similarities with a traditional DSM scheme in that both impose targets upon energy companies to deliver a specified quantity of 'energy savings,' with the costs of these investments typically being recovered through increased energy prices. Design issues that are common to both DSM and TWC schemes include: the estimation of energy savings from individual projects; the monitoring and verification of energy saving activities; the treatment of 'free-riders'; and the treatment of 'rebound' effects (see Box 4.1). Also, since both DSM and TWC schemes require energy companies to invest in projects that decrease the demand for their product, they both have rather complex incentive and distributional effects. But while DSM schemes have traditionally been applied to vertically integrated energy utilities operating as regulated monopolies, TWC schemes are more often applied to unbundled companies operating within liberalised and competitive energy markets. Hence, while the cost recovery mechanisms for DSM have traditionally been under the control of a regulator, cost recovery for TWC schemes is less likely to be under regulatory control.

A TWC scheme also has similarities with *project-based* emissions trading schemes, in that the relevant tradable commodities (white certificates or emission reduction credits) are generated by individual, certified projects that reduce emissions or energy consumption below a counterfactual baseline.[42] For example, a certified project to improve the thermal insulation of a group of households may generate a specified quantity of white certificates over a specified period of time. Since the 'value' of the tradable commodity (e.g., kWh energy savings, tCO_2 avoided emissions) cannot be measured directly, but only calculated with respect to a counterfactual baseline (e.g., kWh energy consumption), this introduces uncertainty into each scheme. There is a consequent risk that the 'additionality' of individual

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42 The relevant analogy is to project-based emissions trading schemes, rather than the more general category of 'baseline and credit' trading schemes. With the latter the baseline could be a fixed emissions limit, with credits awarded to participants that reduce emissions below this limit. Since there is no uncertainty in this baseline, there are fewer grounds for challenging the credibility of the relevant credits. In contrast, the baselines in project–based schemes are based upon *projections* of future emissions or energy use. These projections are inherently uncertain and open to challenge.

projects and/or the assumptions for baseline energy consumption will be disputed, thereby undermining the credibility of the scheme (Jackson, Begg et al., 2001). Other features common to both project-based and TWC schemes include: the timeframe for crediting energy-saving projects; the system boundaries for those projects; the risk of leakage (where, for example, decreased energy consumption within the project boundary is offset by increased consumption outside); and the trade-off between accuracy and transaction costs in the monitoring, verification and certification of individual projects.

In its pure form, a TWC scheme has four main elements (as depicted in Figure 4.1):

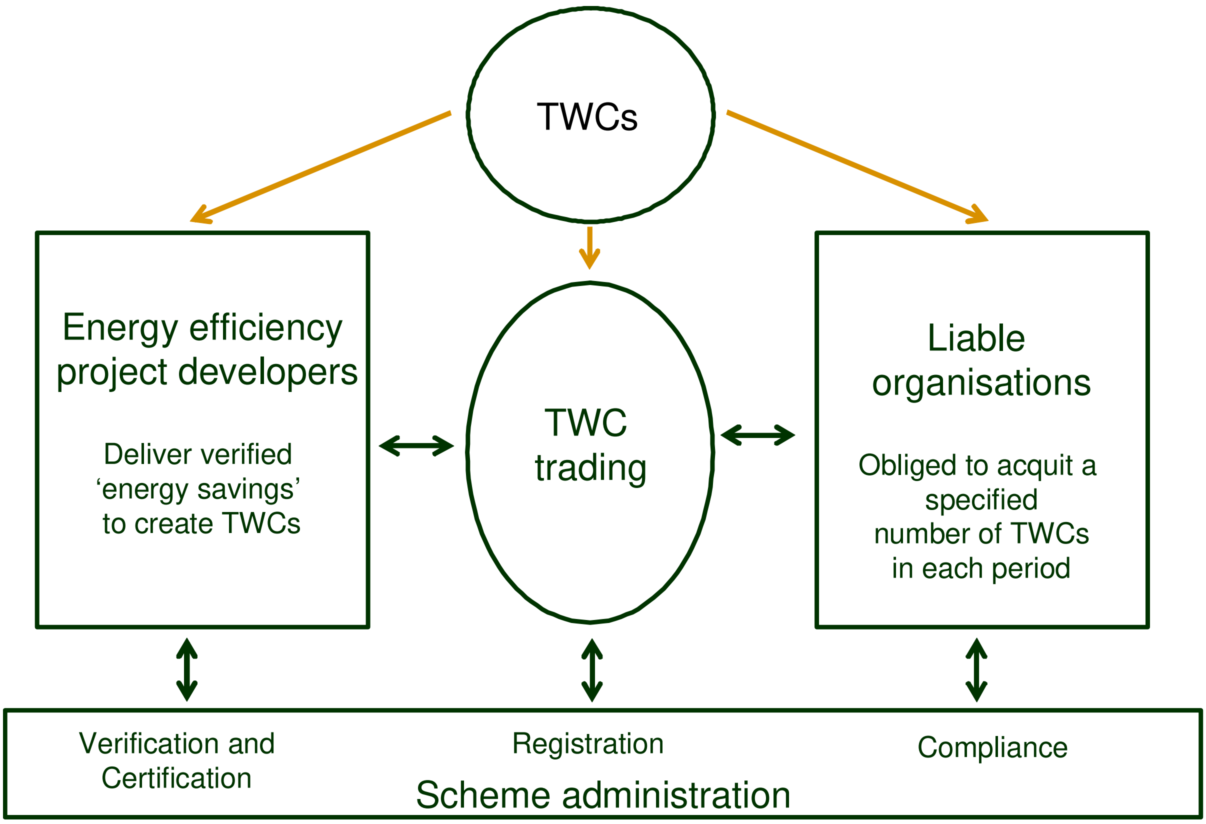
§ Tradable White Certificates (TWCs) representing a measured and verified unit of 'energy savings' from energy efficiency activities undertaken by some party.

§ A legal obligation upon a target group to achieve a certain level of measured and verified energy savings, demonstrated through the delivery of a certain quantity of certificates to the regulator at the end of each compliance period.

§ Parties able to undertake energy efficiency activities that can be measured, certified and verified.

§ Trading mechanisms, so that the target group can choose to buy certificates from other parties as an alternative to creating certificates from their own energy efficiency activities.

Figure 4.1
Basic elements of a tradable white certificate scheme



Several features of this framework should be noted. First, the obligated parties are defined in general terms and need not be restricted to any particular energy carrier (e.g., electricity, gas) or any particular location within the energy supply chain (e.g., generation, transmission, distribution, retail, consumption). Second, the energy efficiency providers are also defined in general terms, and may include both the target group itself (e.g., energy retailers) as well as non-obligated actors such as energy service companies (ESCOs). Third, the white certificates serve both as an accounting tool, to demonstrate that a specified amount of energy has been saved, and as a tradable commodity to enable parties to achieve their obligations in the most cost-effective way. Finally, the scheme requires that responsibilities be assigned for monitoring, verification, registration, tracking and enforcement, and these activities may be undertaken in a number of ways by a variety of public or private sector organisations.

4.1.2 Objectives of a white certificate scheme

The immediate objective of a TWC scheme is to encourage the adoption of energy efficient technologies, typically (but not necessarily) by final users of energy. Underlying this may be several more fundamental objectives, including:

§ *Supply security*: The scheme may reduce primary energy consumption and reduce reliance on energy imports.

§ *Environmental:* The scheme may reduce the environmental costs associated with energy production and consumption and contribute to targets for CO_2 and other emissions.

§ *Technology policy*: The scheme may support energy efficient technologies that are not competitive under current market conditions, but could become competitive through market support (e.g. micro CHP).

§ *Market failures:* The scheme may overcome failures in the 'market' for energy efficiency, such as asymmetry of information between buyers and sellers.[43]

Investment in energy efficiency may have two countervailing effects. First, less energy will be required to deliver the same level of energy service (heat, light, motive power etc.). Second, consumers may increase their consumption of energy services (and hence their consumption of energy) since the effective price for those services will be lower. This so-called *rebound effect* will act to reduce the 'energy savings' that are achieved from a particular investment (Box 4.1).[44] Rebound effects are relevant both within the project boundaries (direct rebound) and, to a greater extent, within the economy as a whole (indirect rebound).

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43 The traditional rationale for DSM schemes in regulated utilities was to minimise the total social cost of supplying electricity services, taking into account the avoided cost of electricity generation. But for TWC schemes in liberalised energy markets, this rationale has less relevance and prominence.

44 The relative importance of these two effects may be expected to vary between different energy services and target groups, although empirical evidence suggests that the former dominates in most cases (Greening, Greene et al., 2000).

Box 4.1
The 'rebound' effect

The so-called 'rebound effect' of energy efficiency investment has three elements, each of which may reduce the energy savings from improved energy efficiency.

Direct rebounds: Improved efficiency should reduce the price of supplying an energy service, which in turn should increase consumption of that service. For example, a more efficient heating system may allow higher levels of thermal comfort to be enjoyed. This increase in consumption will partly offset the energy savings that are achieved.

Indirect rebounds: Cost savings from improved energy efficiency should increase disposable income, thereby increasing spending on other goods and services. For example, the savings from lower heating bills may be put towards an overseas holiday. These other goods and services will also involve the consumption of energy, and this will further offset the energy savings achieved

Economy-wide rebounds: Entirely analogous direct and indirect effects are applicable to improvements in energy efficiency by manufacturers. Furthermore, a fall in the real price of energy services will reduce the price of products throughout the economy and lead to series of adjustments, with energy-intensive goods and sectors gaining at the expense of less energy-intensive ones. Energy efficiency improvements should also increase economic growth, which should itself increase energy consumption by some second-order fraction.

A reduction in energy consumption may contribute to the supply security and environmental objectives of a TWC scheme. But an increase in energy service consumption, notably in heating, may also be desired in order to improve the quality of life of certain groups such as low-income households. These *social* objectives are particularly prominent in the UK TWC scheme, which seeks to reduce 'fuel poverty'. But those investments that lead to the greatest increase in energy service consumption (meeting social objectives) may contribute the least to reducing aggregate energy consumption (meeting environmental and supply security objectives). Hence there may be tension between the different objectives of a TWC scheme.

A further point is that many objectives will be specific to the country introducing the TWC scheme (e.g. improving supply security) and some may be specific to individual sectors (e.g. reducing fuel poverty). Hence, the trading of white certificates between different countries, or even between consumer groups in different sectors, could be problematic.

4.1.3 Design features of a white certificate scheme

TWC schemes involve a similar number of design variables to TGC and emissions trading schemes, and the choices made for these variables may have an important influence on efficiency and effectiveness. The relevant choices may usefully be grouped under six headings:

1. Sources of demand for certificates;
2. Defining and allocating targets;
3. Defining and certifying energy efficiency activities;
4. Monitoring and verifying energy activities;
5. Compliance procedures and enforcement; and
6. Market characteristics and operation.

4.1.3.1 Sources of demand for certificates

A key decision in the development of a TWC scheme is the choice of *target group:* that is, the organisations and/or individuals on whom the obligation to acquit certificates is to be imposed.

One possibility would be to impose obligations upon energy consumers. But smaller consumers, and particularly households, may lack the capacity to meet the obligation and the administrative requirements could be onerous. Hence, it may be more realistic to impose obligations on a smaller number of actors further up the energy supply chain - for example, on energy retailers.[45] If the intention is to encourage energy efficiency improvements by both large consumers (e.g., industry) and small consumers (e.g., households), it may be feasible to have large consumers participating directly in the scheme, with energy retailers taking on obligations on behalf of smaller consumers. In practice, the current and proposed TWC schemes all impose obligations upon energy companies, rather than end-users.

If energy companies are the target group, a decision is required on whether the obligation should cover suppliers of all the energy carriers used by final consumers (e.g., coal, oil, gas, electricity), or merely a subset of these. The most common targets for TWC schemes are gas and electricity markets, since these have natural monopoly elements and have historically been the focus of economic regulation. But if the obligation is confined to one or both of these, suppliers of other energy carriers may gain a competitive advantage in areas where different fuels compete (e.g., household heating).

If the obligation is imposed on gas and electricity companies, a choice is required on the appropriate location of the obligation within the supply chain. For example, in electricity production it may be possible to impose the obligation upon either electricity generators, transmission operators, distribution operators or retailers (Box 3.1) (Langniss and Praetorius, 2003). Separate companies may carry out these functions, or there may be differing degrees

[45] This could make it more difficult for the scheme to encourage efficiency improvements for technologies that use non-commercial sources of energy, such as industrial energy sources.

of vertical integration. Generation companies may be a poor choice for an obligation, since they tend to have limited knowledge of, or involvement with, end-use efficiency. Similarly, transmission and distribution companies may not be the best choice since they remain natural monopolies and have (in theory) less incentive to minimise costs. They also have less contact with final consumers and would require changes to the price control mechanisms to ensure that the costs of the scheme can be recovered. In contrast, electricity retailers can operate within competitive markets and can use their direct contact with energy consumers to facilitate energy efficiency programmes. In practice, retail electricity markets are at different stages of liberalisation in the EU and the industry is characterised by varying degrees of vertical integration.

After a target group is chosen, some more detailed decisions will also be required. For example, will all retail companies be required to participate, or only those that exceed a certain size threshold in terms of consumer numbers or kWh supplied? How will changes in the target group be accommodated: for example, movements above or below the size threshold over time, or new entrants to the retail market? If there is cross-border trade in gas and electricity, will the same obligations be imposed upon retailers located in other countries and selling in the national market?

Most importantly, if the obligation is imposed upon regulated companies with natural monopoly elements, a set of rules will be required regarding the recovery of the costs of the scheme from consumers. While such rules will not be required if the target group operates in a competitive market, the cost implications for energy consumers will still be a dominant concern. As with DSM, a TWC scheme is likely to include an element of cross-subsidy between those consumers that benefit from the energy saving investments and those that do not, since the second group is likely to contribute to the cost of the scheme through higher energy prices.

4.1.3.2 Defining and allocating targets

If the primary objective of the TWC scheme were to reduce energy consumption, the most appropriate denomination of the target would be the quantity of energy saved. As discussed in the following section, the scheme must define *where* this energy can be saved, with the most obvious choice being by the customers of the energy companies who hold an obligation. In principle, these energy savings could be measured against a historic or counterfactual baseline of aggregate energy consumption (kWh) by this customer group. This would translate into a cap on total energy consumption by that group. Alternatively, the energy savings could be measured relative to total customer numbers (kWh/customer).

In practice, the current and proposed TWC schemes follow neither of these approaches. While they specify a target in terms of total kWh energy savings, they make no reference to historic or counterfactual baselines for aggregate consumption by a consumer group. Instead, the targets refer to the total energy savings required from investment in individual energy saving *projects*, such as the installation of cavity wall insulation in a certain number of households. Each individual project leads to a corresponding quantity of kWh energy savings that is either estimated using standard factors or measured against a project-specific counterfactual baseline. The specification of a required quantity of energy savings effectively translates into a required quantity of investment in energy saving projects – but with flexibility regarding what these projects are and where they can be located. Such investments should reduce initial energy consumption below what would have occurred in the absence of these projects, although the ultimate impact on aggregate energy consumption is ambiguous.

All existing and proposed TWC schemes take this project-based approach, but vary in both the denomination of the overall targets and the denomination of the tradable certificates. For example, the New South Wales Greenhouse Benchmark scheme has been described as a TWC scheme, but here the targets are denominated in terms of avoided CO_2 emissions (MacGill and Outhred, 2003). In practice, this scheme may be better described as a project-based CO_2-trading scheme, with CO_2 reduction obligations placed upon electricity utilities.

Targets for energy savings may be classified according to three criteria:

1. *Primary versus final*: The targets may refer to primary energy consumption or final energy consumption. In the former case, fixed or variable conversion factors will be required to translate reductions in end-use electricity consumption into reductions in primary energy consumption, taking into account the fuel mix in electricity generation and the losses in conversion, transmission and distribution.[46] The choice between primary versus final energy consumption may depend on the relative priority given to different policy objectives, such as supply security and fuel poverty.
2. *Periodic versus single*: Targets may be specified for a number of compliance periods, such as each year of the scheme, or a single target may be specified for the end of the scheme. Periodic targets may increase in stringency each period, since projects established in one year will continue to deliver energy savings in the following year and for the duration of the project's life.
3. *Cumulative versus lifetime*: The targets may refer to the savings in energy consumption achieved during the relevant compliance period, or may refer to the total energy savings achieved during the lifetime of the projects that have been installed. In the case of the former, the savings in each compliance period result both from projects installed within the current period and projects installed within previous periods. In the case of the latter, total lifetime energy savings are calculated by taking into account the performance of each project, the date of installation and the estimated lifetime (e.g., 40 years for cavity wall insulation). Lifetime energy savings is the most appropriate measure when there is a single target specified for the end of the scheme. The savings in future years may or may not be discounted. One important consequence of lifetime savings target is to increase the incentive to install long-lived projects, such as thermal insulation.

The denomination of targets in the UK TWC scheme clearly demonstrates the multiple objectives of the scheme. First, the targets are denominated in terms of kWh 'energy benefits' rather than energy savings, to reflect the fact that investment in household energy efficiency may improve comfort levels without necessarily reducing energy consumption (Box 4.1). Energy benefits are quantified for different categories of energy efficiency project and remain positive even when these projects lead to no reduction in energy consumption. Second, these energy benefits are calculated for the lifetime of the relevant projects, with

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[46] For example, a 1kWh reduction in the consumption of electricity by end users may lead to an approximately 3kWh reduction in the consumption of primary energy (Verbruggen, 2003)

future savings discounted at 6 percent annually. Third, the energy benefits are 'fuel-weighted,' to reflect the relative contribution of different energy carriers to reductions in primary energy consumption at the national level.[47] Finally, for the second phase of the scheme the 'fuel-weighting' is adjusted to allow for the relative CO_2 content of different fuels (DEFRA, 2004). Improvements in the efficiency of coal used for household heating will therefore be credited with more kWh energy benefits than improvements in the efficiency of gas use. The scheme is therefore biased towards reducing CO_2 emissions rather than reducing energy consumption per se, but at the same time has objectives that go beyond CO_2 abatement alone and which may not be delivered by a pure CO_2-trading scheme.

Aggregate targets need to be defined for the duration of the scheme, which in turn should be long enough to ensure adequate returns for investors in energy efficiency projects. The problems of market and regulatory risk are analogous to those faced with TGC schemes, but may be less pressing. Energy efficient technologies are closer to being cost-effective than renewables at current energy market prices, so they offer higher rates of return and should require shorter contract lengths. Also, most energy efficiency projects are small-scale and near term, and may be financed partly by the host consumer and third parties and partly by energy retailers through debt or retained earnings. In contrast, renewables projects often require project financing. The difference is evident in the UK, where concern about regulatory risk has led the UK government to extend the TGC scheme as far as 2027, while the second phase of the TWC scheme runs only to 2008.

Aggregate targets need to be allocated to the individual companies (e.g., electricity retailers) participating in the scheme. One possible basis is to divide the targets according to the number of customers that each of them serves within the relevant customer groups, or by the aggregate sales to these customers. A minimum size threshold for participation in the scheme is a possibility, in order not to deter new entrants. Similarly, if there is reason to believe that larger retailers' benefit from economies of scale in delivering energy efficiency programmes, there may be ground for applying more stringent targets to these retailers. As indicated above, rules for the treatment of new entrants and changes in market share may also need to be devised. Several of these issues are analogous to those faced within cap and trade emissions trading schemes, although since targets are being allocated rather than tradable commodities with a market value, there are also some important differences (Harrison and Radov, 2002).

The tradable certificates should be denominated in the same units as the aggregate targets themselves (e.g., kWh primary energy savings). Decisions are required on the size of each certificate (for example, 1 kWh or 100 kWh), which in turn relates to the size of the anticipated projects and the desire to avoid discriminating against smaller projects. As with emissions trading schemes, each certificate will need to have an associated year of issue, serial number and length of validity, and may also embody additional information, such as the relevant energy carrier.

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[47] Interestingly, this weighting is also applied to measures whose benefits are largely taken up in improved comfort levels and hence lead to no reduction in primary energy use.

4.1.3.3 Defining and certifying energy efficiency activities

A key issue in TWC schemes is the eligibility of projects that generate certificates. In principle, a wide definition of eligibility should maximise the opportunity for cost saving and minimise the costs to energy retailers and consumers. At the same time, it may conflict with some of the broader objectives of the TWC scheme and may increase the administrative costs associated with monitoring and verification. Assuming that the obligated actors in the TWC scheme are energy retailers, decisions are required on the following questions:

1. Only energy efficiency activities, or also activities that achieve related objectives, such as fuel switching or non-CO_2 abatement? Since TWC schemes focus primarily on energy efficiency improvements, wider GHG abatement activities are likely to be excluded. Similarly, fuel switching may only be included in so far as it reduces aggregate primary energy consumption.
2. Only investment in energy efficient technology, or also behavioural change? Behavioural change is difficult to monitor and verify, and may have only a limited and temporary influence on energy consumption.
3. Only verified investment, or also activities that 'passively' encourage such investment, such as information campaigns? The latter are difficult to monitor and verify, and present serious difficulties in demonstrating 'additionality' (see below).
4. Only activities within the host country, or also those in other countries? Investment abroad may not contribute to many of the objectives of the TWC scheme.
5. Only activities that affect particular energy carriers, or also those that affect other carriers? For example, if the scheme is confined to electricity retailers, should eligible activities be confined to those that improve electricity efficiency, or should efficiency improvements for gas, oil and/or coal be allowed? Similarly, if the scheme includes both electricity and gas retailers, should electricity retailers gain credit from investing in gas efficiency and vice versa? The Italian TWC scheme requires gas retailers to obtain 50% of their certificates from projects that improve gas efficiency, and electricity retailers to obtain 50% of their certificates from projects that improve electricity efficiency. This rule requires certificates to be labelled by energy carrier, reduces the scope for cost saving, restricts the fungibility of certificates and increases administrative costs.
6. Only activities that improve end-use efficiency, or also those that affect other parts of the energy supply chain? This choice depends upon whether savings in primary energy consumption are the primary objective, or whether improvements in end-use efficiency are desired for other reasons (e.g., overcoming fuel poverty).
7. Only activities that improve end-use efficiency in particular sectors, or activities in all sectors? Smaller consumers (both households and SMEs) face the biggest barriers to improving energy efficiency, while large consumers are often targeted by other policy measures. Also, with no restriction on sectors, a TWC scheme may lead to low-income consumers subsidising energy efficiency improvements in large industrial and commercial organisations. Considerations such as these may lead policymakers to confine qualifying projects to smaller consumers.
8. Only activities that affect particular groups within those sectors, or activities in all consumer groups? A requirement that retailers invest solely in projects that reduce the

energy consumption of their own customers would run counter to the cost-savings objective of a TWC scheme. Regulators may require a proportion of projects to be located within own-customer premises, although the logic of this is unclear.48 But it is quite possible that restrictions will be introduced on other grounds, requiring some or all of the investment to take place in low-income households. As with restrictions on energy carriers, this would require certificates to be labelled by project location, reduce the scope for cost saving, restrict the flexibility of certificates and increase administrative costs.

9. Only certain types of energy efficient technology, or all technologies? The regulator will need to ensure that all qualifying projects achieve 'additional' energy savings, while there may also be other objectives such as promoting certain categories of technology. One possibility is to establish a list of qualifying technologies (e.g., cavity wall insulation, compact fluorescents), with associated methodologies for calculating the energy savings those technologies achieve in different types of application. Technologies not included on the list would not be eligible. A more flexible option would be to allow participants to propose additional technologies or site-specific projects, provided that they are able to demonstrate 'additional' and quantifiable energy savings. The issues here are analogous to those for project based emissions trading schemes, such as JI and CDM (Jackson, Begg et al., 2001). However, it is likely that the projects encouraged by a TWC scheme will be smaller than most JI/CDM projects.

4.1.3.4 Monitoring and verifying energy activities

The monitoring and verification of energy-saving projects within TWC schemes is much less straightforward than the monitoring of renewable electricity generation within TGC schemes. This is because the quantity of energy 'saved' cannot be directly measured, but must be estimated by comparing measured or calculated energy consumption with a counterfactual baseline. The credibility and success of the scheme depends upon how these baselines are calculated for different types of project, and this may be a focus of controversy (MacGill and Outhred, 2003). The regulator will wish to ensure that qualifying projects achieve energy savings that are *additional* to those that would have been achieved in the absence of the TWC scheme. This *additionality* criterion is analogous to that used within DSM programs and project-based emissions trading schemes, but presents a number of methodological difficulties.

4.1.3.4.1 Principles of additionality, baselines and monitoring

The certification of energy savings from energy efficiency projects involves two types of risk (Chomitz, 1998, p. 4). First, there is the risk of certifying energy savings that are not additional, in that they would have occurred in the absence of the TWC scheme (a Type II error). Second, there is the risk of not certifying energy savings that are genuine (a Type I error). Type II errors reduce the energy savings achieved by the TWC scheme and divert subsidies away from projects that provide genuine savings, while Type I errors deny funding

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[48] ` Retailers that invest in energy efficiency measures with their own consumers must take into account the opportunity costs of reduced energy sales. This will not apply to certificates bought on the market. Retailers must compare the market price of certificates with the direct and opportunity costs of own customer efficiency improvements, taking into account the transaction costs associated with each.

to worthwhile projects and increase aggregate costs. The methodology for estimating baselines and verifying additionality must achieve an appropriate balance between the two.

There are at least two interpretations of 'additionality' in the literature (Baumert, 1998). The first, *financial additionality*, refers to whether a project would have taken place in the absence of financial support from (in this case) the TWC scheme. One possibility is that a project would not have been financially viable in the absence of subsidies from the scheme, while another is that various non-price barriers, such as lack of information, would not have been overcome.

Making this criterion operational is problematic, not least because the most cost-effective projects are the least likely to be additional. Possibilities include:

§ accepting any energy-saving project supported by the participating companies as financially additional;

§ accepting any project that falls within certain technical or other categories (e.g. micro CHP) as financially additional;

§ requiring a demonstration of additionality through financial analysis; or

§ requiring a demonstration that specific barriers to implementation are overcome.

The first two approaches are restrictive while the latter two are potentially costly and prone to manipulation.

The second interpretation, *environmental additionality,* is not a yes/no decision but relates to the quantified energy savings that can be attributed to a particular project over a specified period of time. In other words, it represents the difference between a *baseline scenario* for energy consumption and the *measured or estimated consumption* following implementation of the energy-saving project. The key to environmental additionality is therefore the standardised or project-specific baseline, which may be based upon historical data or forecasts, and may refer to either relative (e.g. kWh/tonne) or absolute (e.g. kWh) energy consumption.

There is considerable experience with baseline construction in DSM schemes (Chomitz, 1998), project-based emissions trading schemes (Jackson, Begg *et al*., 2001) and the 'performance contracting' industry, where energy service companies (ESCOs) contract to provide energy saving projects to clients (Goldman, Hopper *et al*., 2005). TWC schemes may draw upon this experience, but may require relatively simple rules.

A key issue for baseline construction is whether the baseline is fixed (*static baseline*) or whether it is updated on a regular basis to allow for changes in various factors that affect energy consumption (*dynamic baseline*). These could include weather conditions, occupancy patterns and user behaviour and these would need to be monitored at the appropriate level. More controversially, the baseline could be updated to allow for changes in those factors that could reduce or eliminate the financial additionality of the energy-saving project. For example, increases in energy prices could make it more likely that a consumer will invest in energy efficiency, or higher standards of energy efficiency may be required by government regulation. Such ex-post changes could increase the 'environmental integrity' of the scheme, by increasing the probability that the certified energy savings are additional. At the same time, it would introduce uncertainty over the value stream from energy-saving investments and increase the risk to potential investors.

Related to the baseline is the *crediting lifetime*, or the period over which certificates can be generated by a project. This may be expected to vary with between technologies and may be less than the technical lifetime of the project. Since uncertainty over energy savings may be expected to increase over time, a specified crediting lifetime may potentially be combined with *discounting* the number or value of certificates at a fixed percentage rate (e.g. 5%/year). Alternatively, the number or value of certificates may be discounted according to the quality of the system for establishing baselines and/or monitoring and verifying actual energy consumption. For example, in the Conservation and Verification Protocols for the US Acid Rain Program, utilities are given the choice between using a comparison group method to establish net energy-savings,[49] inspecting regularly to ensure that measures remain in place, and using a default method which requires no inspection. The emission credits are discounted at 0%, 25% and 50% respectively in these three approaches.

4.1.3.4.2 Additionality, baselines and monitoring in TWC schemes

TWC schemes are normally targeted at small-scale energy-saving projects for which sophisticated approaches to monitoring and verification are likely to be inappropriate. This is evident in the existing scheme in Italy, which has a strong emphasis on:

1. standardised factors or formulae for estimating energy savings, based upon easily measurable data that is available at the time of making the investment;
2. static baselines that are not (or only rarely) adjusted for subsequent changes in exogenous factors such as occupancy patterns and energy prices; and
3. estimation of actual energy consumption following the investment, rather than on-site measurement.

The approach in the UK scheme is even simpler, in that certificates are awarded once for the estimated *lifetime* energy savings of an individual project, rather than for the energy-savings within the current compliance period (as in the Italian scheme). If the lifetime savings approach is adopted, the only option is to combine a static (rather than dynamic) baseline with estimated (rather than measured) energy savings.

As an example, the UK scheme specifies that the installation of cavity wall insulation in a detached house save an average of 5.24 MWh per year over a period of 40 years. This figure:

§ varies with easily measurable variables such as the type or age of house, but does not vary with hard to measures variables such as the thickness of loft insulation;

§ implies a static baseline that does not vary in response to subsequent changes in key variables such as house occupancy, energy prices or changes in building regulations.

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49 There are two possibilities here (Chomitz, 1998). First, conducting a before and after comparison of the energy consumption of consumers participating in the TWC scheme. Second, comparing the energy consumption of participants with those of a control group. Both approaches require the use of baselines that are not pre-specified but observed during project execution (dynamic baselines). Both are also subject to methodological difficulties and entail considerable monitoring costs.

- § is an estimate of energy savings and does not depend on measurements of actual consumption within individual households;

Where standard formulae are used, it may be necessary to adjust the estimated savings to account for estimated rebound effects (e.g., where the occupants enjoy higher internal temperatures as a result of the insulation) and for the location of the project in the energy supply chain (e.g., end-use projects save more energy that those further up the supply chain). Such adjustments may be expected to vary with the type of project (e.g., rebound effects are larger for heating systems than for lighting) and its location (e.g., rebound effects are larger for low-income households than for high-income households). But the attraction of this approach is that monitoring and verification is greatly simplified: the regulator merely needs to ensure that a specified number of installations have taken place to an acceptable technical standard. This may be achieved through some form of sampling.

In cases where energy savings depend heavily upon particular variables, such as the number of hours of use, project-specific rather than standardised baselines may be necessary, combined with the monitoring of relevant variables at the level of the individual project. This combination of dynamic baselines with measured consumption would allow adjustment of energy savings over time as well as providing an incentive to maximise those savings. A relevant model here is the performance contracts for energy efficiency, used extensively in US public and commercial buildings (Sorrell, 2005).

In other cases, a project developer may argue that standard factors are inappropriate for a particular project, and may wish to propose an alternative methodology and demonstrate its validity. The same applies to energy saving technologies for which standard factors have not been developed. These options increase the monitoring and verification costs for both project developer and regulator, but these must be traded off against the potentially greater energy savings. In practice, more than one monitoring and verification methodology may be required: for example, simple approaches for small-scale, standardised projects in the household sector, and more complex approaches for larger projects in industry where the energy savings are site-specific.

In all cases, the methods chosen for monitoring and verification must trade-off administrative costs against the risk of Type I and Type II errors. A bias towards straightforward methods will economise on monitoring and verification costs while increasing the risk of Type II errors.

4.1.3.5 Compliance procedures and enforcement

Adequate compliance and enforcement mechanisms will be necessary to ensure both the credibility of the TWC scheme and the effective operation of the certificate market. Participants must comply with the monitoring, verification and reporting protocols for projects and the trading rules for certificates, as well as meeting their individual energy saving targets.

Compliance with targets may be enforced through a financial penalty that can be specified as a fine for each kWh of energy ‘not’ saved. This penalty may be fixed, or it may be linked to the market price of certificates. A fixed fee effectively creates a ceiling on certificate prices, which translates to a ceiling on the cost of the scheme for energy consumers. A relatively low penalty may mitigate the price risks of the scheme, while at the same time creating the parallel risk that the energy saving target will not be achieved (Jacoby and Ellerman, 2004). If the penalty is close to the anticipated market price of certificates, the TWC scheme becomes analogous to the hybrid tax/trading mechanism proposed by Roberts and Spence (1976) and used, for example, in the UK TGC scheme (the 'Renewables Obligation'). But since the price risk associated with 'cost effective' investment in energy efficiency should be less than that associated with investment in renewables, a 'hybrid' tax/trading mechanism may be less appropriate for a TWC scheme than for a TGC scheme.

Alternatives to a fixed penalty could include the mandatory purchase of certificates at a multiple of the market price, or the imposition of more stringent energy saving targets for subsequent compliance periods. Compliance may be assessed at the end of each compliance period (for a cumulative savings target) or at the end of the scheme (for a lifetime savings target), and in both cases a reconciliation period may be used, to give participants an opportunity to acquire additional certificates if they have failed to comply. If participants remain out of compliance at the end of the reconciliation period, more severe penalties could be imposed.

4.1.3.6 Market characteristics and operation

Additional rules may be required on the fungibility of different types of certificate, the banking and borrowing of certificates and the registration and tracking of certificates. These are analogous to the mechanisms within TGC and emissions trading schemes

The certificate market will work best if certificates are fully fungible, but fungibility may be restricted to achieve certain policy objectives. For example, the Italian TWC scheme requires electricity retailers to achieve 50 percent of their energy saving targets through reductions in electricity consumption, while the remainder may be achieved through reductions in any form of primary energy. Similar rules applied to gas retailers. These restrictions are implemented through the use of three types of certificate - electricity, gas and other fossil fuels - that are only partially fungible.

A certificate represents an absolute quantity of energy saving (e.g., kWh) that is 'used up' when applied against a participant's energy saving target for the current compliance period. Banking allows certificates created in one period to be used to meet targets in subsequent periods. Experience with emissions trading suggests that this additional temporal flexibility can increase the scope for cost saving (Ellerman, Joskow et al., 2000). Banking may be unrestricted, or there may be restrictions imposed on the number or proportion of banked certificates that can be presented for redemption in a given period (although the rationale for such a restriction is unclear). Banking is only possible where certificates have a lifetime that exceeds one compliance period. An individual certificate may have an indefinite lifetime, or it may expire after a specified number of years.

Borrowing allows a participant to under-comply during one compliance period provided that they over-comply during the subsequent compliance period. The equivalent of an interest rate may be imposed. As with emissions trading schemes, existing and proposed TWC schemes have included banking but have not included borrowing, owing to concerns about long-term non-compliance. However, borrowing may be effectively included through the compliance regime. For example, the punishment of non-compliance through the imposition of more stringent energy saving targets for subsequent periods amounts effectively to a form of borrowing.

Banking and borrowing can occur between periods if compliance is assessed at the end of each period (e.g. for a cumulative savings target). But if compliance is only assessed at the end of the scheme (e.g. for a lifetime savings target), their use is more problematic. While it may be anticipated that the scheme will be extended and that banked credits will have value, this will be subject to some uncertainty. Generally, a TWC scheme with periodic assessment of compliance is likely to generate significantly more trading activity than one with a single assessment of compliance at the end of the scheme.

4.1.3.7 Summary

The design of a TWC scheme is in many ways analogous to the design of a TGC scheme, and many common elements can be identified. However, certain features of a TWC scheme introduce additional complexity, such as the need to estimate energy savings through comparison with a counterfactual scenario. The potential denomination of the target in terms of lifetime energy savings (rather than savings in the current compliance period) also represents a substantial departure from typical TGC schemes, as well as from cap and trade emissions trading schemes. The multiple objectives of a TWC scheme can also introduce difficulties, since this may complicate the design, reduce the scope for cost saving, restrict the fungibility of certificates and increase administrative costs.

We may expect TWC schemes to vary in their objectives, scope and design between different countries. This in turn may make it difficult for the Commission to develop a harmonised EU-wide scheme. At the same time, the relative cost effectiveness of energy efficiency investment should mean that TWC schemes impose lower costs on energy consumers than TGC schemes for a comparable level of CO_2 saving.

The experience gained with TGC schemes, DSM programs, project-based emissions trading and performance contracting can all be used to inform the design of TWC schemes. This is important, given that practical experience with TWC schemes is very limited to date. The next section briefly reviews this experience.

4.1.4 Characteristics of existing white certificate schemes

Italy has the only fully-fledged TWC scheme Europe, and the Italian model has informed debate on the topic throughout the EU (Pavan, 2002). The UK Energy Efficiency Commitment (EEC) has many of the elements of a TWC scheme, but does not actually include tradable certificates. Instead, a more limited form of trading is available (of either targets or verified savings) with each trade being subject to the approval of the regulator.[50] Proposals for a French TWC scheme are at an advanced stage of development, but implementation of this scheme has been delayed until 2006 (Moisan, 2005).

The development of TWC schemes in other Member States appears at best to be at a rudimentary stage. While several Member States (e.g., Belgium, Ireland) have imposed

[50] The relationship between the UK EEC and a 'full' TWC scheme is analogous to the relationship between the early US Emissions Trading Programme and more recent schemes such as the US Acid Rain Programme.

energy efficiency obligations upon energy companies, these have yet to incorporate trading. There is interest in the concept in Norway and Sweden, but as yet no firm proposals. A working group at the International Energy Agency is promoting the concept, but only a handful of countries are participating.[51] Perhaps the most promising development is the recent establishment of a two-year research project on white certificate schemes, funded by the European Commission.[52]

Outside the EU, there is a so-called Energy Efficiency Certificate Trading scheme in New South Wales (MacGill and Outhred, 2003), but closer inspection reveals this to be a project based GHG emissions trading scheme. The concept has been discussed in the US, but to date there have been no practical proposals for implementation (Swisher, 2002). The proposed Directive on Energy End-use Efficiency and Energy Services (COM(2003)739) commits the Commission to examine the scope for a separate Directive on white certificates, but this is not required before 2012.

Table 4.1 summarises the key design features of the Italian, UK and French schemes. A more comprehensive discussion is provided in the Annex.

[51] Under Task 14 of the IEA DSM Project (IEA 2005)

[52] The Euro White Cert Project began in April 2005 and involves 14 research institutions from around Europe.

Table 4.1
Features of TWC schemes in EU Member States

Country	Date of Introduction	Admini-strator	Target group	Target denomination	Target savings (End of period)	Project restriction by energy carrier	Project restriction by location	Monitoring and verification	Compliance
Italian	2005-2009	Regulator (AEEG)	Electricity and gas distributors	Cumulative savings in primary energy consumption	2.9Mtoe	Electricity (gas) distributors must achieve 50% of savings through electricity (gas) projects	All types of end user	Choice between 'deemed savings,' engineering and comprehensive approach	Penalty in €/MWh related to certificate price
French (Proposed)	2006-2008	Government agency (ADEME)	Electricity, gas, fuel oil and heat retailers	Discounted lifetime savings in primary energy consumption	54TWh	None	All types of end user	Choice between 'deemed savings' and engineering approach, but only the first is developed	Fixed penalty of €20/MWh
UK	Phase 1: 2002-2005 Phase 2: 2005-2008	Regulator (OFGEM)	Electricity and gas retailers	Discounted lifetime 'energy benefits' to household consumers, weighted by primary energy & CO_2 content	Phase 1: 64TWh Phase 2: 130TWh	None	Households only; 50% of projects in low income households	'Deemed savings' approach only	Penalties related to qualification for the supply licence

4.2 Interaction of a White Certificate Scheme with a National Electricity Market

4.2.1 Approach and assumptions

This section provides a simplified, partial-equilibrium analysis of the interaction of an idealised national TWC scheme with the market for 'electricity services', such as lighting and motive power. Since these services are provided by a combination of electricity commodities and electricity conversion technologies, the implications for both of these markets need to be explored. Throughout this section, it is assumed that the national electricity market is isolated from international competition. The implications of international trade in electricity are explored in Section 4.3.

This section explores the effect of the scheme on a number of variables at the national level, including electricity demand, electricity prices and CO_2 emissions. The analysis uses simple graphical techniques to identify whether a TWC scheme will have a positive, negative or ambiguous effect on these variables. This analysis is highly stylised and assumes that both markets are perfect, with the commodities being supplied at marginal cost. The aim is to understand the basic implications of a TWC scheme, without complicating the analysis with market and design features than vary from scheme to scheme.

For the purpose of our analysis, we assume that the TWC scheme imposes efficiency obligations *solely* on the electricity sector. Note that, as discussed above, existing and proposed TWC schemes are not confined to electricity markets. While the Italian, UK and French schemes all impose obligations on electricity companies, they also impose obligations on the retailers of other energy carriers, such as gas. Furthermore, the electricity companies themselves can meet their obligations by investing in projects that affect energy carriers other than electricity. This means that confining the idealised TWC scheme to electricity markets represents a considerable simplification of real-world schemes. However, this simplification allows us to isolate those effects that are most relevant for studying the interactions of a TWC scheme with the EU ETS. The implications of widening the scope of a TWC scheme are explored further in Chapter 6.

Our analysis also assumes that obligations for efficiency improvements fall on *retailers* of electricity. These are responsible for the purchase of wholesale electricity and the sale to end-users, but since they do not own the distribution network they have no monopoly elements. Retailers are assumed to be operating in a liberalised and competitive market where electricity is supplied at marginal cost. The TWC scheme imposes obligations on retailers to achieve a certain quantity of 'energy saving' through investment in electricity efficiency projects located within the premises of electricity consumers. No restriction on the type of projects or the location of consumers is assumed. Each project is assumed to involve some form of subsidy to the host consumer, to encourage them to adopt the relevant technologies. These subsidies are provided by the electricity retailers, who recover the costs by increasing electricity tariffs for all consumers.

As the above description suggests, a TWC scheme is analogous to a DSM scheme in that it requires electricity companies to invest in projects that reduce the demand for their product. In this sense, the tradable certificates simply provide a mechanism for achieving the energy savings target at least cost. This means that the conceptual analysis of a TWC scheme can draw upon the extensive literature on the economics of DSM schemes (Gillingham, Newell *et al.*, 2005). The following discussion draws in particular upon the work of Braithwait and Caves (1994).

4.2.2 Price and quantity effects in a national electricity market

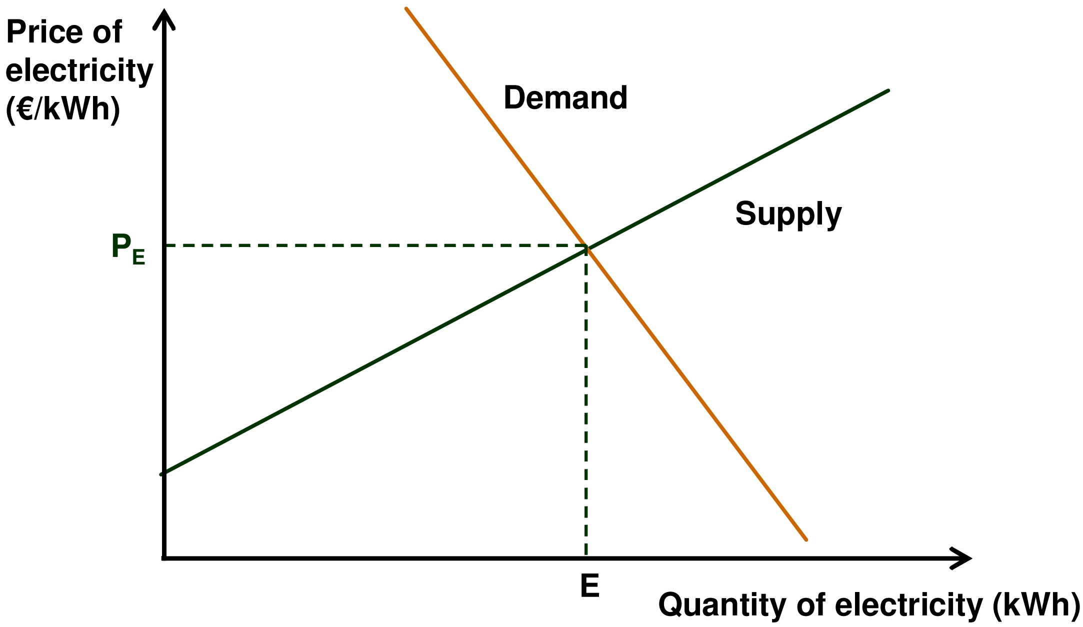
The demand for electricity and electricity conversion equipment is derived from the demand for the services (heat, light, cooling) that these, in combination, provide. The same level of electricity service can be provided from an inefficient conversion technology with higher electricity use, or an efficient conversion technology with lower electricity use. Hence, the attribute of conversion technologies that is of interest is their energy efficiency, and this can be represented as a 'market' for energy efficiency measures ('EEM'). In practice, consumers rarely purchase 'energy efficiency' in isolation, but instead purchase products and services that have multiple attributes, including energy efficiency. The notion of a market for energy efficiency measures is therefore an abstraction, but nevertheless a useful one.

Household consumers are assumed to purchase the combination of electricity and EEM that maximise their welfare. Firms and commercial organisations are assumed to purchase the combination that minimises their production costs. Market failures in both markets are initially ignored.

4.2.2.1 The electricity market

Figure 4.2 illustrates the initial *retail* electricity market. Prior to introduction of the TWC scheme, a quantity of electricity E is supplied at price P_E.

Figure 4.2
Electricity market prior to the introduction of a TWC scheme



The demand curve represents the marginal benefit of electricity consumption to consumers, and the area below the demand curve and above the price line between 0 and E represents the consumer surplus in this market. The supply curve represents the marginal cost of supplying electricity, which is the sum of generation, transmission, distribution and retail costs. The area above the supply curve and below the price line represents the producer surplus in this market—where the producers are the electricity generators, transmitters, distributors and retailers.

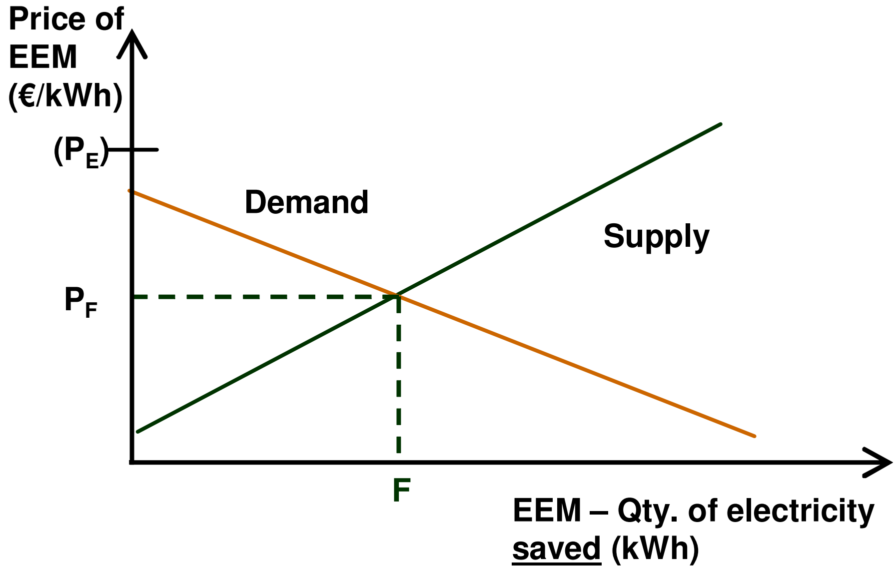
The demand and supply curves apply to the short-term, when the underlying capital stock is largely fixed. The supply curve is conditional on the existing set of generation plant, while the demand curve is conditional on the existing set of energy-using equipment that embodies a certain level of efficiency in the use of electricity (in other words, a certain level of EEM). Both curves are theoretical constructs that represent the relationship between price and quantity that would exist in the electricity market if the prices of all other goods—including energy efficiency—were held constant.

In the short term, electricity generators will only supply electricity if the wholesale price exceeds their marginal cost. Increases and decreases in wholesale electricity prices will change the plant mix used to meet demand. Similarly, electricity consumers will only consume electricity if the retail price exceeds their marginal valuation. Consumers will respond to increases (or decreases) in the retail electricity price by decreasing (or increasing) their consumption of electricity through measures such as turning lights off. In practice, the short-term demand curve for electricity is highly inelastic and could potentially be represented by vertical line.

4.2.2.2 The energy efficiency market

Figure 4.3 illustrates the market for those EEM that influence consumers' electricity consumption. Here, one unit of EEM represents one kWh/year that the measure allows the customer to save. The savings are measured against the electricity consumption required to meet a corresponding level of electricity service demand with a less efficient technology.

Figure 4.3
Energy efficiency market prior to the introduction of a TWC scheme



The demand curve represents the marginal benefit of investment in energy efficiency to consumers, or their marginal willingness to pay for energy efficiency measures. This is assumed to decline with the level of EEM installed. As with electricity, the demand curve represents the relationship between price and quantity that would exist in the EEM market if the prices of all other goods—including electricity—were held constant.

Cost is measured in €/kWh saved and represents the present value of capital and installation costs of the EEM for an additional kWh saved. For those investments, such as thermal insulation, which are 'pure' energy efficiency measures, the cost represents the full costs of the measure. For those investments, such as refrigerators, where energy efficiency is simply one attribute of a technology, this represents the additional cost of an energy efficient option.[53]

In the absence of the TWC scheme, consumers purchase a quantity F of energy efficiency measures at a price P_F. The area below the demand curve and above the price line represents the consumer surplus in the EEM market. It is assumed that the EEM market is competitive and measures are supplied at marginal cost. Then the supply curve represents the marginal cost of supplying energy efficiency measures and the area above the supply curve and below the price line represents the producer surplus in this market—where the producers in this case are the suppliers of EEM.

4.2.2.3 The effect of a white certificate scheme on the energy efficiency market

It is assumed that the TWC scheme specifies a target in terms of the total saving required in electricity consumption (Q), but (as in existing and proposed TWC schemes) this target

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53 Costs will differ for premature or natural replacement of technologies, but the analysis does not consider such complexities.

makes no reference to historic or counterfactual baselines for aggregate consumption by a consumer group. Instead, the target refers to the electricity saving required from investment in individual electricity saving projects (EEM), such as the installation of energy-efficient light bulbs. Each individual project leads to a corresponding quantity of electricity savings that is measured against a project-specific counterfactual baseline. In principle, these electricity savings should be *additional* to those that would have taken place in the absence of the TWC scheme. But whether this is the case in practice will depend on how the requirement for additionality is implemented.

With this formulation, a target quantity of electricity savings effectively translates into a target demand for EEM. An important consequence of the additionality criterion is that the required demand for EEM (F') should be *independent* of the demand in the absence of the scheme (F). In principle, the demand for EEM would be higher if electricity prices were higher (demand curve shifts up) and lower if electricity prices were lower (demand curve shifts down).[54] But in each case, the TWC scheme should lead to *additional* investment in EEM, above and beyond what would have taken place in the absence of the scheme. Total energy savings with the TWC scheme (F') should then exceed the energy savings without the TWC scheme (F).

The energy-saving target is represented in Figure 4.4 by the quantity Q. If the demand for EEM in the absence of the scheme is F, the required total demand for EEM is F+Q=F'. This implies a shift of the demand curve for EEM to the right, so that more is demanded at a given price. The increased demand for EEM may be achieved in one of two ways:

1. Participants in the TWC scheme (electricity retailers) may offer consumers a subsidy to encourage them to take up energy efficiency measures. This subsidy may cover a portion of the cost of these measures or all of the cost, depending upon the circumstances. Those energy savings that are certified as additional by the regulator would generate white certificates and would be available for compliance (or, in the case of over-compliance, for sale to other participants in the white certificate market).

2. Participants in the TWC scheme may purchase white certificates from other participants or from third parties such as ESCOs. These certificates represent energy savings that have been certified as additional by the regulator and are available for compliance. From the perspective of a third party developer, the white certificates provide an additional revenue stream.

Competition should encourage the least cost option to be chosen. At this point, the required subsidy to electricity consumers per unit of electricity saved (Option 1) should equal the additional revenue to third-party project developers per unit of electricity saved (Option 2). This value corresponds to the market price of white certificates (in € per kWh of electricity saved) and is represented in Figure 4.4 by *L*. It what follows, we refer primarily to Option 1 (subsidising consumers) since this is familiar from the operation of DSM schemes.

A subsidy on investment in energy efficiency will allow consumers to purchase higher cost energy efficiency measures. If the subsidy were available for *all* investment in energy

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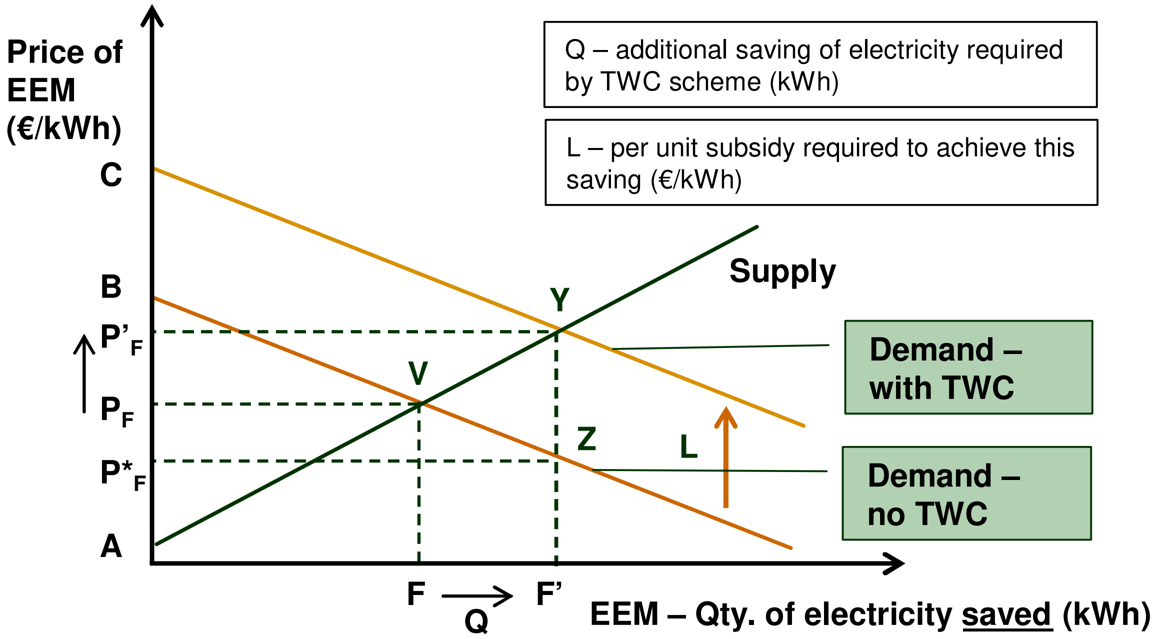
54 Such changes could also be stimulated by other factors, such as the introduction of minimum efficiency standards.

efficiency by *all* consumers, it would effectively shift the demand curve for EEM upward by the amount L—as shown in Figure 4.4 Consumers would then invest in additional energy efficiency measures such that the additional energy saved equalled Q and the total energy saved equalled F'. The price received by EEM producers would rise from P_F to P'_F.

Figure 4.4
Effect on the EEM market of a TWC subsidy on all efficiency investment

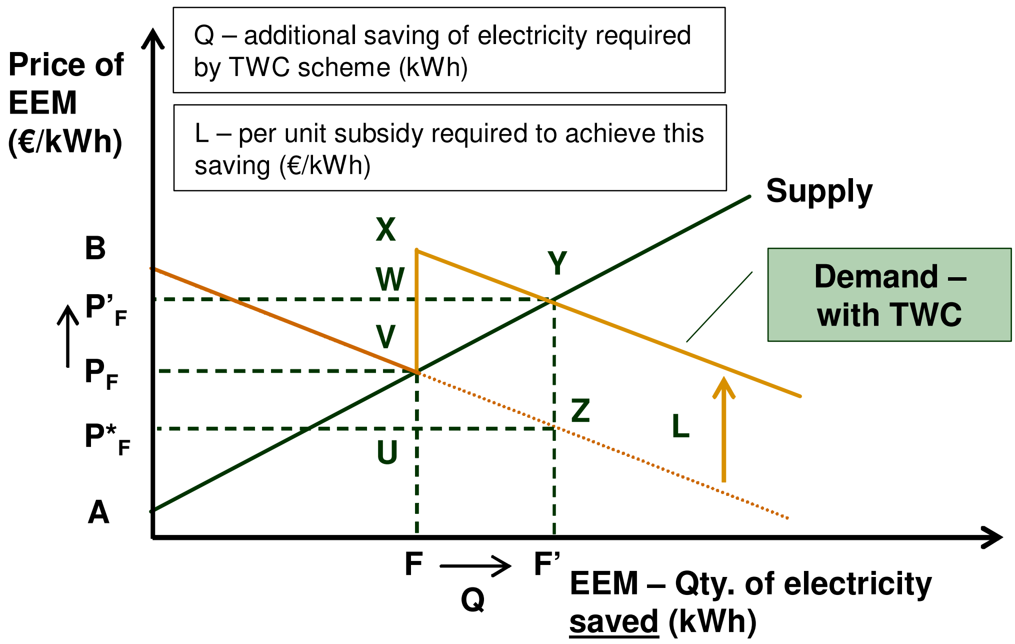


However, it is assumed that the scheme is administered such that free-riders (i.e., consumers who would have purchased EEM in the absence of the subsidy) are excluded. As a result, the subsidy (L) is assumed to be only available for additional investment in EEM beyond the baseline level (F). This can be represented by a 'kinked' demand curve, as shown in Figure 4.5. For EEM below F, no subsidy is available and the demand curve is the same as in Figure 4.4. For EEM above F, a subsidy of L €/kWh is available for investment in electricity efficiency and the demand curve shifts to the right.

The result in terms of EEM investment is the same as in Figure 4.4: consumers invest in additional energy efficiency measures such that the total kWh saved equals F'. The price received by EEM producers rises from P_F to P'_F.

The result in terms of total subsidy payments is different, however. In Figure 4.4, the total subsidy payments are equal to L*F', or the area $P'_F YZP^*_F$. A large portion of this (L*F) represents subsidies to 'free-riders' – consumers that would have demanded a quantity F of electricity saving in the absence of the subsidy. In contrast, the total subsidy payments in Figure 4.5 are only L*(F'-F), or the area VXYZ (equivalent to Area UWYZ). But while the retailers participating in the TWC scheme may aim to exclude free-riders, this may prove difficult to achieve in practice.

Figure 4.5
Effect on the EEM market of a TWC subsidy on additional efficiency investment



4.2.2.4 The determinants of white certificate prices

The market price of white certificates (€/kWh of electricity saved) will be determined by the per-unit subsidy (L) required to achieve a particular energy-saving target (Q). More (less) stringent energy-saving targets should lead to higher (lower) certificate prices.

In the above formulation, the supply and demand curves for energy efficiency are assumed to be linear over the region of interest. In these circumstances, the required per unit subsidy (L) and hence the price of white certificates will depend on the relative slope of these curves. Specifically, certificate price will be higher if:

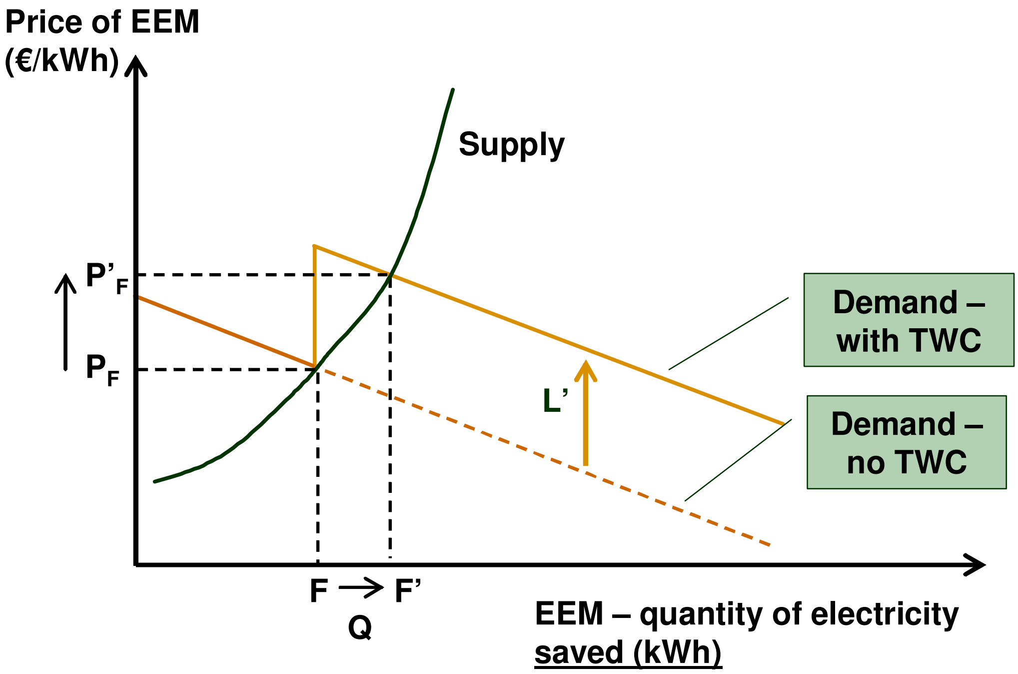
§ the supply of EEM is sensitive to price (supply curve is steep); and

§ the demand for EEM is sensitive to price (demand curve is steep).

However, the certificate price required to achieve a particular energy-saving target (Q) should be *independent* of the marginal cost of energy efficiency investment required to meet that target (P'_F). The latter is determined by the TWC target (Q) in combination with the current demand for energy efficiency (F), which in turn depends upon exogenous factors such as the current level of electricity prices. Higher (lower) levels F lead to higher (lower) marginal costs, but should *not* affect the price of white certificates. Since Q is a relative target, the price of white certificates is determined by the difference in marginal cost between F' and F (represented by $P'_F – P_F$) rather than the absolute value (P'_F).

This conclusion would be modified if the supply and demand curves for energy efficiency were non-linear over the region of interest. Figure 4.6 illustrates one possibility, where the supply curve for energy efficiency is inelastic (i.e., energy efficiency alternatives increase only modestly for a given increase in price). In this case, the per-unit subsidy (L) required to achieve the TWC target (Q) will *increase* as the underlying demand for EEM (F) increases. This means the total cost of the subsidy will also increase, together with the price of white certificates. Conversely, if the supply-curve for energy efficiency was relatively elastic (i.e., the energy efficiency alternatives increase substantially for a given increase in price), the required subsidy and hence the price of white certificates could *decrease* as the underlying demand for EEM (F) increases.

Figure 4.6
Effect of TWC scheme on the market for energy efficiency when the supply of energy efficiency measures is inelastic



To ensure compliance with their targets under the TWC scheme, individual participants must obtain white certificates representing energy savings that have been certified as additional by the regulator. Assuming the regulator can accurately estimate the 'true' counterfactual level of EEM demand (F), this corresponds to Q in Figure 4.5. But as indicated above, it is possible that individual participants will subsidise or purchase energy savings that are subsequently ruled to be non-additional by the regulator ('free-riders'). This corresponds to EEM demand below F in Figure 4.5.

It is typically the case that the regulator decides whether the achieved energy savings are additional before awarding white certificates *ex post*, while the individual participant decides whether anticipated energy savings are likely to be additional before providing a subsidy *ex ante*. If the regulator 'pre-approves' the compliance activities of a participant, the two should coincide. But in the absence of pre-approval, or with the use of dynamic rather than static baselines, the two may not coincide and the participant runs the risk that the subsidised or purchased energy savings will be disallowed.

Very similar comments issues arise from investment in energy saving activities by third parties who seek to be awarded white certificates. If the regulator rules that the estimated energy savings from these activities are non-additional, the anticipated revenue stream from white certificates will not be available. However, in this case the loss is borne by the third party, rather than the electricity retailer. This suggests an asymmetry of risk between two compliance options: subsidising energy efficiency activities directly carries the risk that these will subsequently be ruled non-additional, while purchasing certified energy savings in the form of white certificates does not. In practice however, risks may be mitigated in a variety of ways.

While the price of white certificates depends upon the energy-saving target Q, the attainment of this target depends upon regulatory decisions regarding the additionality of energy savings from individual projects. In principle, therefore, variations in the interpretation of additionality could affect the price of white certificates. For example, if the regulator used a very strict definition of additionality, it is possible that 'real' energy savings would be disallowed. Since the energy-saving target (Q) would be more difficult to achieve (Q is effectively increased), the price of white certificates (L) would increase. Similarly if the regulator used a lax definition of additionality, the price of white certificates would decrease.

In contrast, the price of white certificates should not depend on the ability of participants to eliminate free-riders when implementing their subsidy schemes. This is evident from Figures 4.4 and 4.5, where L is the same. However, the number of free-riders will influence the *total* cost of the scheme and hence the costs borne by consumers through increases in electricity prices. This is discussed further in the following sections.

In summary, the price of white certificates (L) will depend on:

§ the energy-saving target (Q);

§ the price sensitivity of EEM supply;

§ the price sensitivity of EEM demand;

§ the current level of EEM demand (only if supply and/or demand curves are non-linear); and

§ regulatory decisions on the additionality of energy savings from individual projects.

Since the last factor depends upon administrative decision-making procedures rather than market forces, it introduces a significant element of uncertainty into the price setting process. The relationship between additionality and white certificate prices is explored further in Chapter 6.

4.2.2.5 The effect of a white certificate scheme on the electricity market

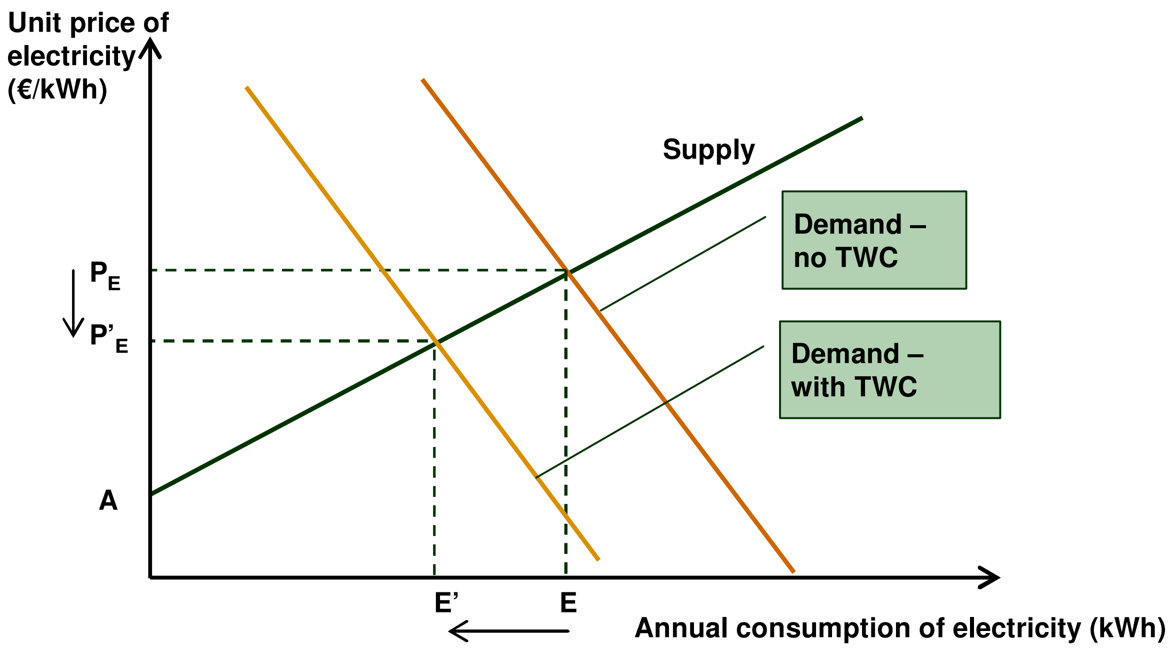
The investment in additional energy efficiency measures means that a lower level of electricity consumption is required to achieve the same level of electricity services. A subsidy on EEM should therefore <u>reduce</u> the demand for electricity and hence reduce the price of electricity.

But at the same time, investment in EEM should *increase* the demand for electricity services. Households, for example, may choose to increase their comfort levels following investment in energy efficiency, rather than save money through reduced electricity consumption. To the extent that greater consumption of electricity services requires greater consumption of electricity, a subsidy on energy efficiency investment should increase the demand for electricity and hence increase the price of electricity.

Investment in EEM therefore has two countervailing effects on the electricity market. First, less electricity is required to deliver the same level of electricity services (the technological effect). Second, consumers will increase their consumption of electricity services (and hence their consumption of electricity) since the effective price for those services is lower (the rebound effect). The technological effect leads to reduced consumption of electricity, while the rebound effect leads to increased consumption of electricity. The relative importance of each effect will depend on the elasticity of substitution in each market (Birol and Keppler, 2000). It is assumed here that the rebound effect is not sufficiently large to overcome the technological effect, so the net effect is a reduction in electricity consumption.[55]

The net effect of the subsidy on the electricity market is shown in Figure 4.7. Investment in EEM shifts the demand curve for electricity to the left. The new equilibrium gives a lower electricity price ($P'_E < P_E$) and a lower quantity of electricity demand (E'<E)—which is assumed to be the intention of the TWC scheme.

Figure 4.7
Effect of TWC subsidies on the electricity market – no cost recovery



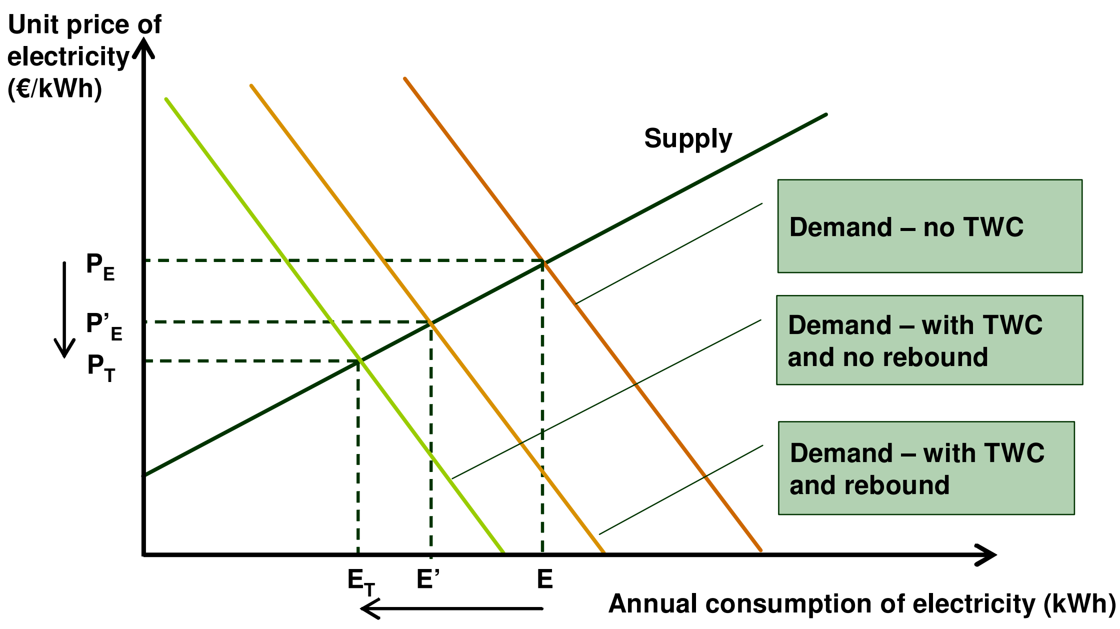
55 A so-called 'backfire' effect, where the energy efficiency improvement actually leads to increased consumption of energy, is theoretically possible in some circumstances, both at the micro and macro level (Saunders, 2000). However, empirical studies suggest that it is unlikely to occur in practice (Greening *et al*, 2000).

Figure 4.8 compares this situation with a hypothetical alternative in which an increased level of EEM does not lead to any increase in the consumption of electricity services. The reduction in electricity consumption when the rebound effect is zero (E^T-E) will be more than the reduction in consumption when the rebound effect is positive (E'-E), since there will be nothing to offset the technological effect of improved efficiency. The magnitude of the rebound effect can then be defined as:

$$b = \frac{E' - E^T}{E - E^T}$$

Note that b may be less than, equal to or greater than one and that the rebound effect is defined relative to a counterfactual (E^T) that must be estimated.

Figure 4.8
Effect of TWC subsidies on the electricity market– with and without rebound effect



This may not be the end of the story. Since electricity and EEM are (partial) substitutes, the reduction in electricity prices should (in principle) encourage consumers to switch from EEM consumption to electricity consumption, so the demand for EEM should fall (a leftwards shift in the EEM demand curve). However, investment in EEM tends to be *irreversible*, at least in the short-term. For example, having installed loft insulation, a consumer is unlikely to remove it following a fall in electricity prices. This suggests that, to a first approximation, any secondary effects in the EEM market can be ignored.

4.2.2.6 The effect of cost recovery on the electricity market

The TWC scheme needs to be paid for in some way. In addition to the cost of the per-unit subsidy (L*Q), there will be administrative costs (AC) such as those for marketing, auditing and verification. Hence, to a first approximation the total costs (TC) are given by:

$$TC = L*Q + AC$$

Electricity retailers incur this cost initially, although the eventual costs may be borne by electricity consumers, providers of production inputs, or shareholders. The ultimate distribution of costs will depend on market conditions.

For simplicity, we assume that the cost is wholly borne by electricity consumers through a per unit levy (*l*) on retail electricity prices (€/kWh). *Importantly, this will increase retail electricity prices, but will not affect wholesale electricity prices or the price received by electricity generators.* However, wholesale prices will be affected by any changes in the demand for electricity, including that created by the cost recovery itself. The situation is analogous to that described for green certificates in Chapter 3, where consumers paid for green certificates over and above the price of electricity. Here, consumers pay for white certificates, in the form of a levy imposed by electricity retailers, over and above the price of electricity.

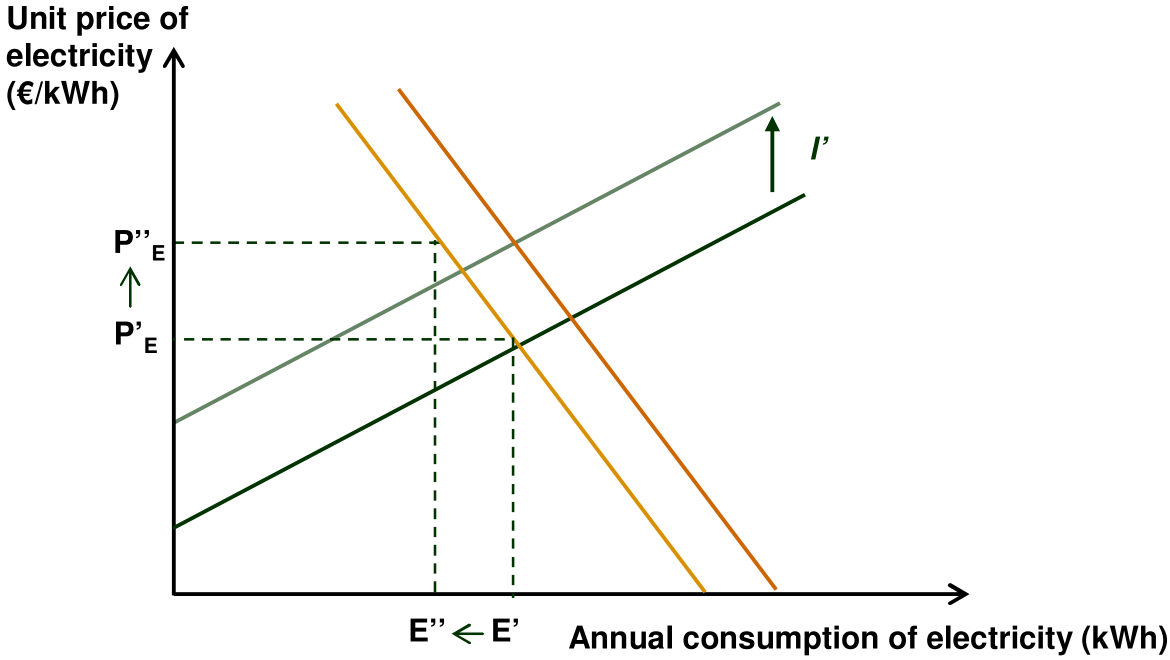
The levy is assumed to be identical for all consumers, implying that consumers pay for the total costs of the TWC scheme in proportion to their electricity consumption. This is in contrast to the benefits of the investment, which will be received by only a subset of consumers. If consumer demand were completely unresponsive to the imposition of a levy (i.e., demand remained at E'), the required per unit levy would be:

$$l = \frac{TC}{E'} \text{ (€/kWh)}$$

However, since the demand curve is not wholly inelastic, a price increase of l (€/kWh) would reduce electricity demand below E'. This means that a levy of *l* would not recover all of the costs. If the costs were to be fully recovered, a larger price increase of l' would be required (Figure 4.9). Hence, following cost recovery by the electricity producers, a total of E" kWh of electricity will be supplied at a price P''_E. Then:

$$TC = l' * E''$$

Figure 4.9
Effect of TWC subsidies on the electricity market – <u>with</u> cost recovery



4.2.2.7 The final effect of a white certificate scheme

The net result of the TWC scheme can now be assessed. Prior to the introduction of the scheme, a quantity E of electricity was supplied at a price P_E (Figure 4.2). Following the introduction of the TWC scheme, a quantity E" of electricity is supplied at a price P''_E (Figure 4.9). This final equilibrium results from a combination of two factors:

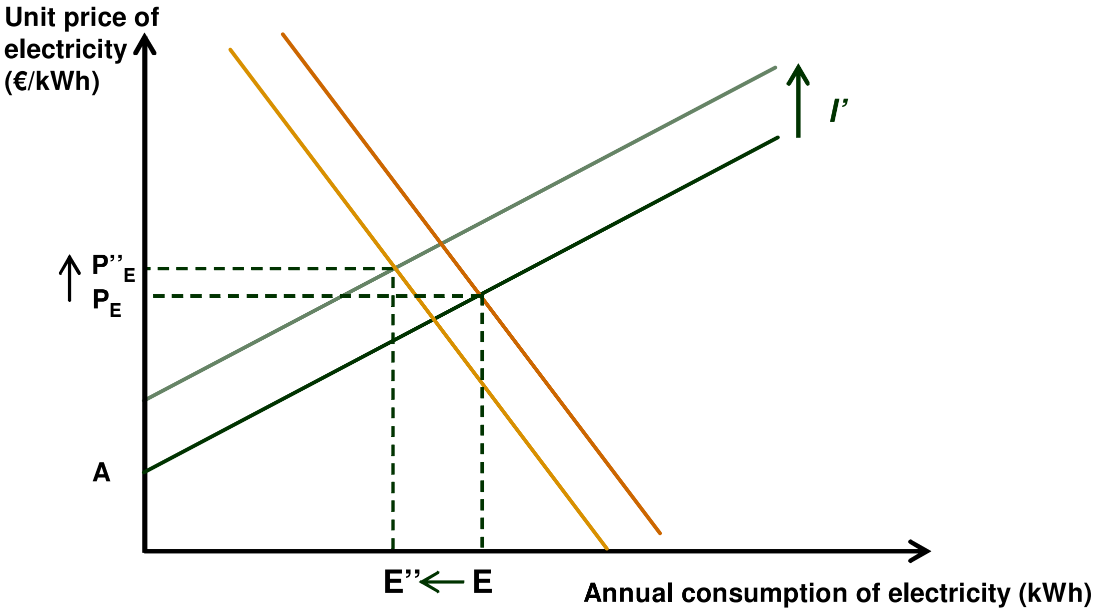
1. A *reduction* in electricity demand, with a corresponding *reduction* in electricity prices following the investment in energy efficiency. This is represented by a leftwards shift of the demand curve (Figure 4.7).

2. An *increase* in electricity prices, with a corresponding further *reduction* in electricity demand, following cost recovery. This is represented by an upward shift of the supply curve (Figure 4.9).

The initial and final equilibrium in the electricity market are compared in Figure 4.10. In total, electricity demand has *reduced* from E to E" and consumer electricity prices have *increased* from P_E to P''_E. But while a reduction in electricity demand is an unambiguous outcome of the TWC scheme, the final electricity price (P''_E) may be greater or less than the original electricity price (P_E). It all depends upon whether the reduction in prices from (1) outweighs the increase in prices from (2). This in turn depends upon relative slope of the demand and supply curves.

In practice, the electricity supply curve may be relatively flat over the region of interest. This may be the case if the TWC scheme covers only a subset of final consumers and/or the energy-saving targets are not demanding. In this case, the reduction in electricity demand following investment in energy efficiency (shift of the demand curve) would have little or no effect on electricity prices (i.e., $P_E \approx P'_E$ in Figure 4.10). In contrast, cost recovery (shift of the supply curve) would still lead to an increase in energy prices (i.e., $P''_E > P'_E$ in Figure 4.10) since this is independent of the slope of the supply curve. Since there would be little or nothing to offset the cost recovery, consumer prices would increase overall.

Figure 4.10
Initial and final equilibrium in the electricity market with a TWC scheme



The above graph indicates the situation in the electricity *retail* market, where E" kWh of electricity is supplied at a price P''_E. But the situation will be different in the electricity *wholesale* market, since it is assumed that generators cannot add the levy on to their price. The wholesale price will solely determined by electricity demand (E").

In analysing the TGC market in Chapter 2, it was assumed that transmission, distribution and retail costs were zero and that the only difference between wholesale and retail electricity prices was the additional cost imposed by the TGC scheme—as represented by the certificate price. This allowed wholesale and retail prices to be represented on the same graph. If a similar approach were taken here, the wholesale price would be given by the intersection of the new demand curve with the original supply curve. The difference between the wholesale and retail electricity prices would then be given by *l'*. The relationship between the increase in retail electricity prices (*l'* - €/kWh electricity consumed) and the price of white certificates (*L* - €/kWh electricity saved) is given by:

$$l' = \frac{L * Q + AC}{E''}$$

Or if administrative costs can be ignored:

$$l' = \frac{L * Q}{E''}$$

Hence, the increase in retail electricity prices (*l'*) is proportional to the product of the price of white certificates (*L*) and the energy-saving target (*Q*), and inversely proportional to aggregate electricity consumption (*E"*). With the assumption of linear supply and demand curves for EEM, the price of white certificates is a linear function of the energy-saving target. Hence, the increase in retail electricity prices will be proportional to the *square* of the energy-saving target:

$$l' = k * \frac{Q^2}{E''}$$

Where *k* is a constant that depends upon the relative slope of the supply and demand curves for EEM.

The above equations assume that free-riders are eliminated in the administration of the subsidy scheme. But as indicated earlier, if free-riders are not eliminated the total costs of the TWC scheme will exceed *L*Q* and *l'* will be greater. Hence, whilst the presence of free-riders will not affect the price of white certificates (*L*) it will affect cost recovery (*l'*) and hence the impact of the TWC scheme on the electricity market.

4.2.3 Summary

This section has analysed the price and quantity effects of an idealised TWC scheme that is confined to electricity retailers. These retailers were assumed to be operating within a liberalised and competitive national electricity market, in which there was no international trade. Specifically, this section has:

1. Characterised the market for electricity services in terms of separate markets for electricity and energy efficiency measures (EEM).
2. Shown the impact of an idealised TWC scheme on each of these markets, illustrating both the technological and the rebound effect of investing in energy efficiency and the implications of cost recovery.
3. Shown how the required subsidy for energy efficiency investment will determine the price of white certificates and how this depends on the elasticity of supply of demand in the energy efficiency market.

Table 4.2 summarises the effect of the scheme on a number of 'price and quantity' variables, including electricity demand, electricity generation and consumer and wholesale prices.

Table 4.2
Summary of price and quantity effects of a TWC scheme in a national electricity market

Variable	Effect in host country	Comments
Wholesale electricity price	Reduced in the short-run	For an existing generation merit order, lower electricity demand leads a lower-cost marginal generator, and hence lower wholesale prices.
	Unaffected in the long-run	In the long run wholesale electricity prices are determined by the cost of adding new generation capacity.
Retail electricity price	Likely increased	Increased by costs of energy efficiency investment, although may be somewhat offset by lower wholesale prices.
Electricity demand	Reduced	Investment in electricity efficiency reduces demand, although extent depends on the balance between 'rebound effect' and 'technology effect'. Additional change in demand may result from consumer response increased retail electricity price.
Non-green generation	Reduced	Due to lower total electricity demand. Marginal plant likely to be non-green.
Green generation	Likely unchanged	Effect depends on the position of green generating units in the merit order. Most existing renewables have low short-run marginal cost and therefore are unlikely to be affected by reduced demand.
CO_2 emissions	Reduced	Decreased non-green electricity generation leads to lower emissions. Size of effect depends on the emissions intensity of marginal plant.
Investment in conventional generating capacity	Reduced	Lower long-term demand and wholesale prices mean lead to less new investment.
Investment in end-use efficiency	Increased	Increased due to obligation and availability of subsidy. May also be increased by price response if consumer prices increase.
Investment in new renewables	Reduced	Lower wholesale electricity prices leads to less investment in generating capacity overall, including new renewables.

4.3 Interaction of a White Certificate Scheme with an International Electricity Market

As discussed in Chapters 2 and 3, most Member States are part of an electricity market that extends beyond their national borders (an 'international market'). This means that the electricity price in the national wholesale market depends not only on domestic conditions and policy, but also on the conditions prevailing in countries with which it is interconnected. The volume of electricity imports and exports will be constrained by the existing transmission capacity and this varies widely between different regions of the EU.

This section explores the implications of international trade in electricity for the operation of the idealised national TWC scheme. The analysis examines how the impact of the scheme on key variables is modified as a result of this trade. Since the TWC scheme affects neighbouring EU countries as well as the host country, two sets of variables need to be explored: effects at the national level, and effects at the EU level. The analysis will be confined to the case where the host country is a net importer of electricity, since the implications are very similar when the country is a net exporter.

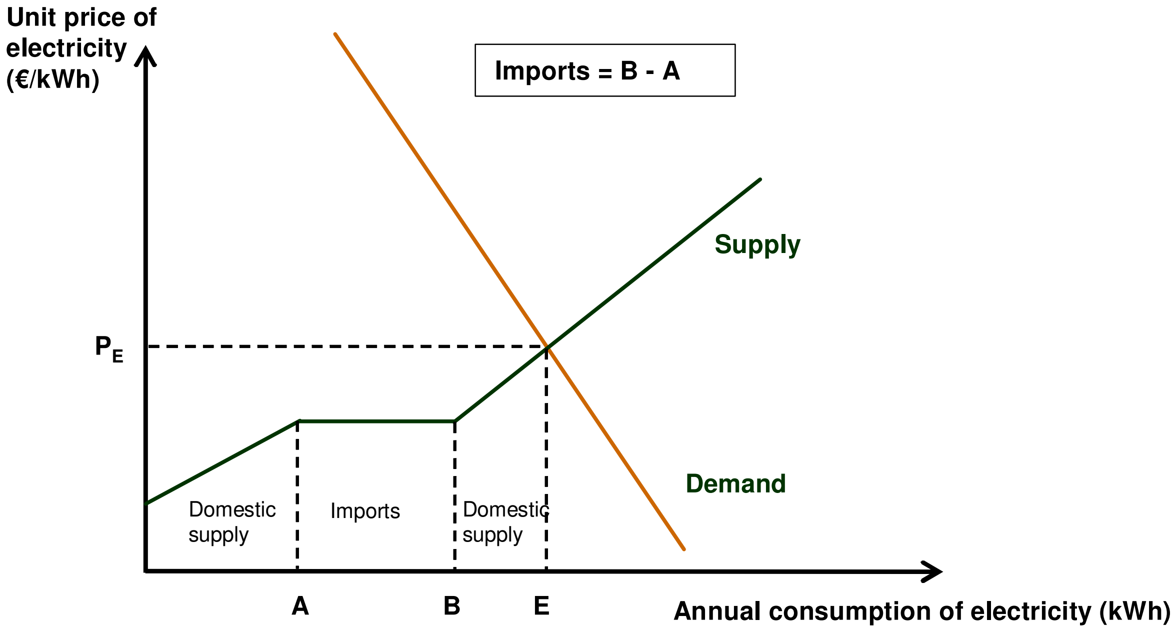
4.3.1 Electricity supply and demand when a country is a net importer

A country may expect to be a net importer (exporter) of electricity if the national marginal supply cost is higher (lower) than the international wholesale price of electricity (net of transmission losses) at the current level of national demand. But the volume of imports and exports will depend on the available transmission capacity.

One possible situation is illustrated in Figure 4.11. Here, domestic demand is met by domestic producers up to point A, at which point the wholesale electricity price is equal to the price of imported electricity. There is then a 'flat' segment in the supply schedule in which additional electricity supply is available through increased imports, instead of more expensive domestic generation. If electricity demand in the host country is small relative to that supplied by the international market, these additional imports will not affect the international wholesale electricity price - in other words, the host country is a price taker on the international electricity market.

It is assumed that no further electricity can be imported beyond point B, where constraints on transmission capacity start to bind. Beyond point B, additional supply is met by domestic producers, with increasing marginal cost. The domestic wholesale price (P_E) is set by domestic producers at demand E, with imports being used to full capacity. In practice, the utilisation of imports may vary with demand (E), which in turn will vary with the time of day and year.

Figure 4.11
Net imports of electricity where marginal producer is domestic



In a situation such as this, the volume of imports should be unaffected by small reductions in domestic electricity demand – such as those created by a TWC scheme. These will instead displace marginal generating plant located within the host country. As a result, a domestic TWC scheme should not affect electricity producers and consumers located in other countries.

More generally, if domestic generators are the marginal plant on the national system and if they *remain* the marginal plant after the introduction of a TWC scheme, then the scheme has no implications for consumers and producers located in neighbouring countries. The price, quantity and distributional effects then reduce to those analysed in section 4.2.

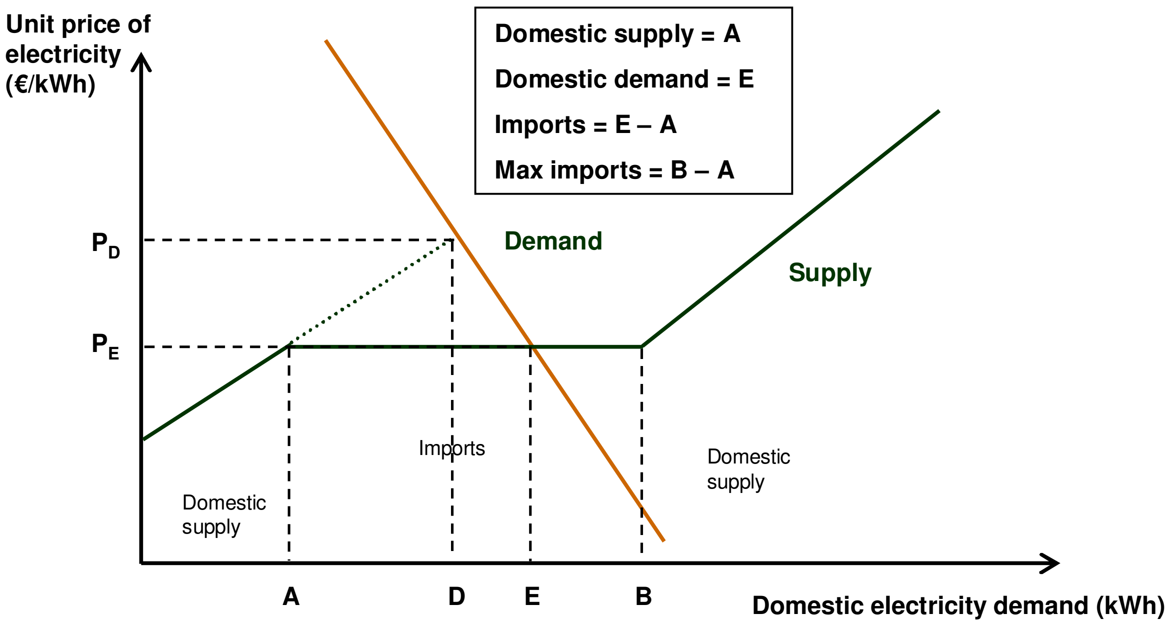
A more interesting possibility is where imported (exported) electricity acts as the marginal producer (consumer) on a national system. As discussed in Chapter 3, this situation may apply in particular to the Nordic electricity market. In these circumstances, a reduction in electricity demand as a result of the TWC scheme will either reduce electricity imports or increase electricity exports. In both cases, the scheme will affect producers and consumers in other countries.

Figure 4.12 illustrates a situation where a country is a net importer of electricity and where imported electricity acts as the marginal producer. Here, demand is met by domestic producers up to point A, at which point the wholesale electricity price (P_E) is equal to the price of imported electricity. There is then a ‘flat’ segment in the supply schedule in which additional electricity supply is available through increased imports. Again, it is assumed that these imports do not affect the international wholesale electricity price (P_E). Hence, domestic demand (E) is supplied by mix of domestic producers (A) and imports (E-A) at a price P_E that is equivalent to the international wholesale price for electricity.

Note that if imports were not available, a higher domestic demand (D) would be supplied at a higher price P_D. Hence, the availability of imports leads to a redistribution of producer and consumer surplus between the importing and exporting countries. Specifically, consumer surplus increases in the importing country and decreases in the exporting country, while (electricity) producer surplus decreases in the importing country and increases in the exporting country. Overall, social surplus increases.

Again, it is assumed that no further electricity can be imported beyond point B, where transmission constraints bind. Beyond point B, additional supply is met by domestic producers, with increasing marginal cost.

Figure 4.12
Net imports of electricity where marginal producer is imported electricity



In a situation such as this, the volume of imports *will* be affected by reductions in the importing country's electricity demand – such as those created by a TWC scheme. These will displace marginal generating plant located outside the importing country and hence affect electricity producers and consumers located in other countries.

4.3.2 Effect of a white certificate scheme when a country is a net importer

This section analyses the price and quantity effects of an idealised TWC scheme under the following conditions:

- the country is a net importer of electricity;
- the imports provide the marginal supply on the system (Figure 4.12);
- the change in demand from the TWC scheme is sufficiently small for imports to remain within transmission constraints; and

§ the host country is sufficiently small to be a price taker in the international electricity market.

Subsidised investment in energy efficiency will lower electricity demand as before (Figure 4.7). Figure 4.13 represents the effect of this investment on the electricity market *prior* to cost recovery by the electricity retailers. The main effects are:

§ domestic electricity demand is reduced from E to E';

§ imports are reduced from (E-A) to (E'-A);

§ domestic electricity prices remain at the international wholesale price (P_E);

§ domestic electricity generation is unaffected and remains at A;

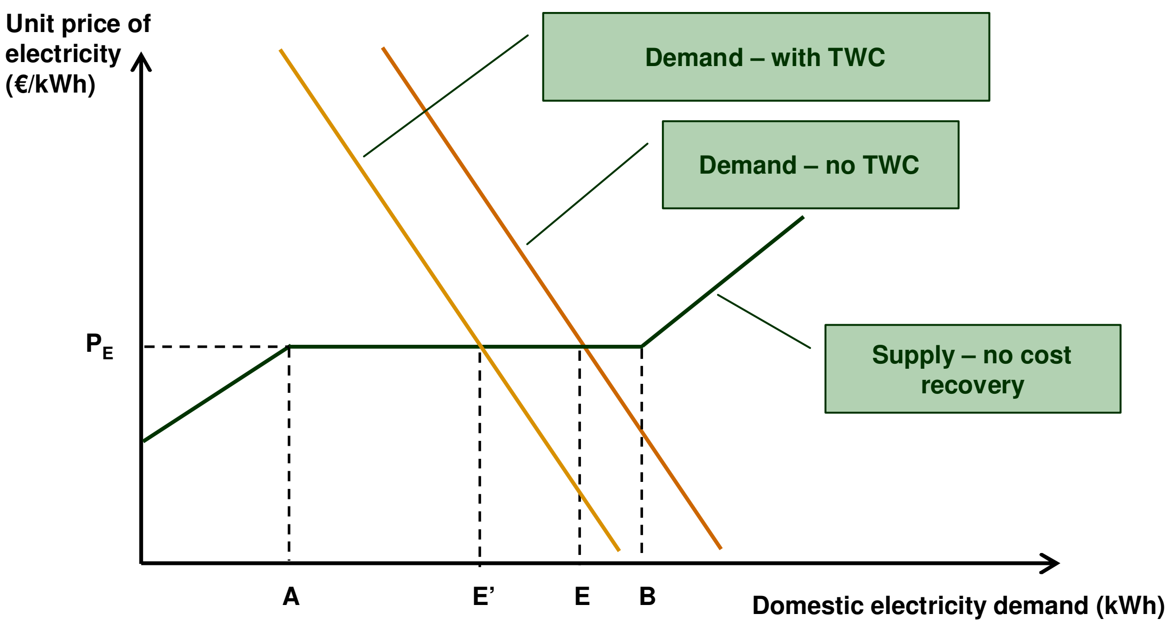
§ electricity generation in the exporting countries is reduced by (E-E');

§ domestic CO_2 emissions are unaffected; and

§ CO_2 emissions in the exporting countries are reduced.

Note that if (E-E') is greater than (E-A), imports are eliminated altogether. Domestic electricity prices would then be reduced, but by less than in the absence of imports.

Figure 4.13
Effect of TWC subsidies on the electricity market when country is net importer – no cost recovery



As before, the electricity retailers are assumed to recover the full costs of the TWC scheme by imposing a levy (*l*) on consumer prices. This is illustrated in Figure 4.14, which combines consumer and wholesale prices in a single diagram. Here, consumer prices increase from P_E to P''_E by the imposition of the levy (*l*). But wholesale prices are unchanged and remain at P_E. As a result of the increase in consumer prices, domestic demand falls further to E''.

Hence, once cost recovery is allowed for, the effects of the TWC scheme are:

§ to reduce domestic electricity demand from E to E";

§ to reduce imports from (E-A) to (E"-A);

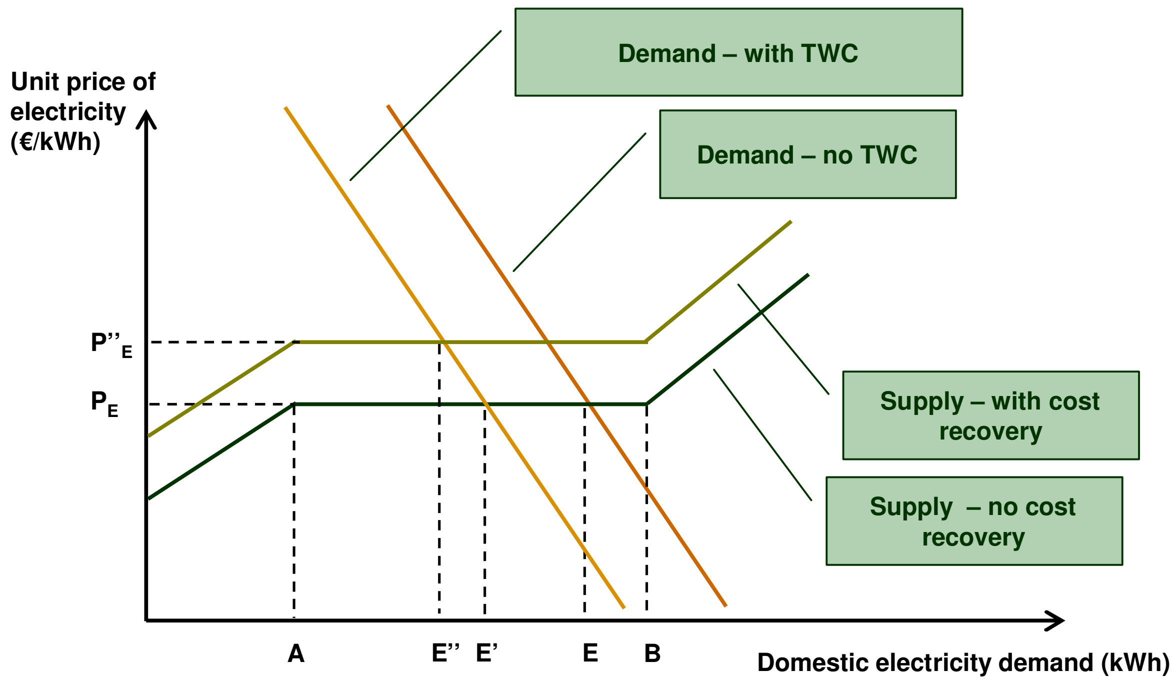
§ to increase consumer electricity prices from P_E to P''_E;

§ to reduce electricity generation in the exporting countries by (E-E"); and

§ to reduce CO_2 emissions in the exporting countries.

While *retail* prices have increased, *wholesale* prices are unaffected and remain at the level of the international price - P_E (assuming again that the host country is small relative to the international market). In contrast to a situation without electricity imports, the volume of domestic electricity generation is unaffected and remains at A. Domestic CO_2 emissions are also unaffected. Retail electricity prices unambiguously increase and this increase is more than would have occurred in the absence of electricity imports, since the supply curve is horizontal rather than sloping over the region of interest.

Figure 4.14
Effect of TWC subsidies on the electricity market when country is net importer – with cost recovery



4.3.3 Summary

Table 4.3 summarises the effect of the TWC scheme on a number of 'price and quantity' variables for the particular circumstance of electricity imports providing the marginal supplier on a national system. The third column summarises the impact on key variables in the host (importing) country, while the fourth column summarises the impact on the same variables in the exporting countries. The second column repeats the results obtained earlier for a TWC scheme with no international trade in electricity, thereby providing a 'base scenario' for comparison.

It is important to note that the analysis focuses on an idealised situation, which may not obtain in practice. For example, changes in electricity demand in the host country may be sufficiently large to reduce the international price for wholesale electricity. In this case, electricity consumers in the host country will be paying for consumer price reductions in the exporting countries. Similarly, the assumption that imports provide the marginal supplier may in practice obtain for some time periods, but not for others.

Nevertheless, the results provide a good benchmark to assess the implications of international trade in electricity. The fact that a TWC scheme does *not* reduce national CO_2 emissions in these circumstances is of particular importance, since the contribution to national GHG targets may be a primary objective of such a scheme. Climate change benefits are achieved from the scheme, since CO_2 emissions are reduced in neighbouring countries and hence globally. But these benefits contribute towards the Kyoto targets of the exporting countries, rather than the host country. Furthermore, the quantity of emissions reduced may be greater or less than if the reductions took place in the host country, since the CO_2 intensity of the marginal generation plants in the exporting country may differ from that in the host. Note that this analysis *ignores* the effect of the EU ETS which may modify this conclusion. The joint effect of the TWC scheme and the EU ETS is analysed in Chapter 6.

It should be clear that this is a generic consequence of a situation where electricity imports are displaced as a consequence of national environmental policy and similar comments apply to other pollutants such as sulphur emissions. But the implications for CO_2 emissions are of particular interest and importance.

Table 4.3
Summary of price and quantity effects of a TWC scheme in an international electricity market - case where imported electricity is on the margin

Variable	***Effect in host country if no electricity trade***	**Effect in host (importing) country if electricity trade**	**Effect in exporting country/countries if electricity trade**	**Comments**
Wholesale electricity price	*Reduced (short-term)*	Unchanged	Unchanged	If host country is a price taker in the international market, the scheme has no effect on wholesale prices – despite lowering aggregate demand.
Consumer electricity price	*Likely Increased*	Increased	Unchanged	Increased by cost recovery. Unlike the 'no trade' case, there is no fall in prices from lower demand to offset the cost recovery, so the price increase is greater.
Electricity demand	*Reduced*	Reduced	Unchanged	Due to the subsidised investment in electricity efficiency. The reduction demand is slightly greater than in the 'no trade' case.
Non-green generation	*Reduced*	Unchanged	Reduce	Generation reduced due to lower electricity demand. Marginal plant likely to be non-green. All reduction takes place abroad.
Green generation	*Likely Unchanged*	Unchanged	Unchanged	Depends on marginal conditions on spot market and location of renewables in the merit order. Many existing renewables have low short-term marginal cost, so are unlikely to be affected by reduced demand.
CO_2 emissions	*Reduced*	Unchanged	Reduced	Due to lower non-green generation. Depends upon emission characteristics of marginal plant, which may be different in exporting country than in host country. Note that none of the CO_2 benefits are captured by the host country.
Investment in end-use efficiency	*Increased*	Increased	Unchanged	Due to obligation and availability of subsidy.
Investment in new renewables	*Reduced*	Unchanged	Unchanged	Since wholesale price unchanged, incentive for investment in renewables is unchanged.

4.4 Distributional Effects of a White Certificate Scheme

This section investigates the effects of a TWC scheme on consumers and producers in both the electricity and EEM markets. Standard measures of consumer and producer surplus are employed, measuring how the prices obtained by producers compare to their marginal costs, and how the prices paid by consumers compare with their marginal willingness to pay. The analysis is slightly more complex than that conducted for the EU ETS and TGC schemes, because the effects in both the electricity and EEM markets need to be explored.

It is again important to stress that this is not a full assessment of the costs and benefits of a TWC scheme, since market failures (including environmental externalities) and secondary effects in other markets are ignored. The neglect of failures in the energy efficiency market is of particular importance, since these provide a primary rationale for the introduction of a TWC scheme.

The first three sections analyse the effects of a scheme operating in a national electricity market, while the fourth section assesses the impact of international trade in electricity on these distributional effects.

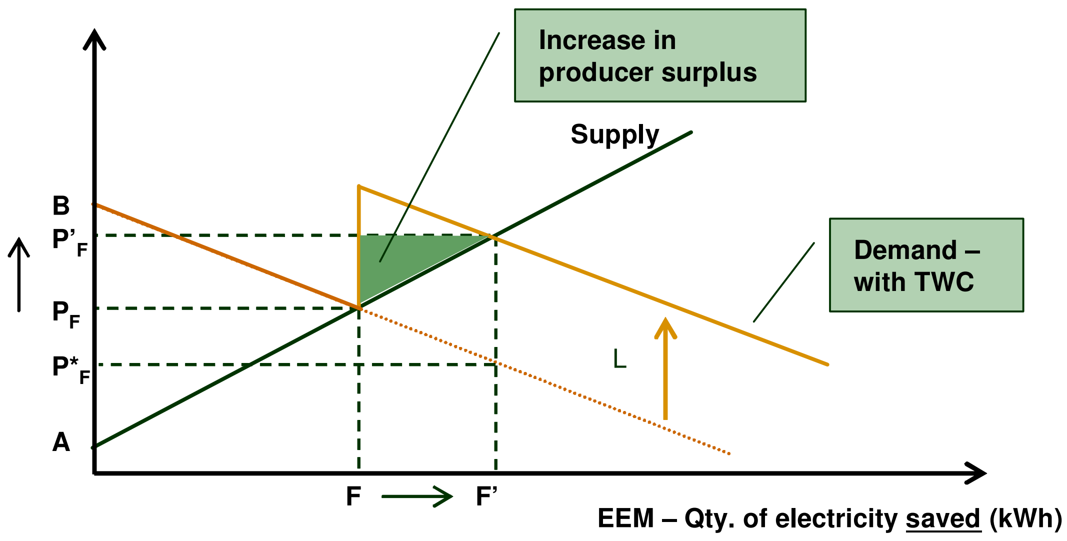
4.4.1 Effect on energy efficiency producers

Producers of energy efficiency equipment gain from the TWC scheme, by an amount equal to the shaded area in Figure 4.15. Following the subsidy of energy efficiency investment by electricity retailers, an amount F' of 'energy savings' is sold at a price P'_{F}. The area between the supply curve and this price between F and F' equals the additional benefit to EEM producers.

This benefit results from the increase in price for dedicated energy efficient equipment (such as insulation) and for energy efficient conversion technologies (such as refrigerators). The beneficiaries are those producers that manufacture equipment and technologies that qualify for the subsidy, and these may be located either within the host country or abroad. Furthermore, the benefits only result when the increase in demand from the TWC scheme is sufficiently large to increase equipment prices. If the energy saving target is relatively un-ambitious, and/or a range of energy efficient technologies can contribute to this target and/or these technologies are internationally traded[56], the supply curve may be flat over the range of interest. In this case, while demand for qualifying technologies would increase, there would be no gain in producer surplus.

[56] In other words, the country in which the TWC scheme is introduced provides only a small portion of the market for the relevant energy efficient technologies.

Figure 4.15
Benefits of TWC scheme to EEM producers



4.4.2 Effect on consumers

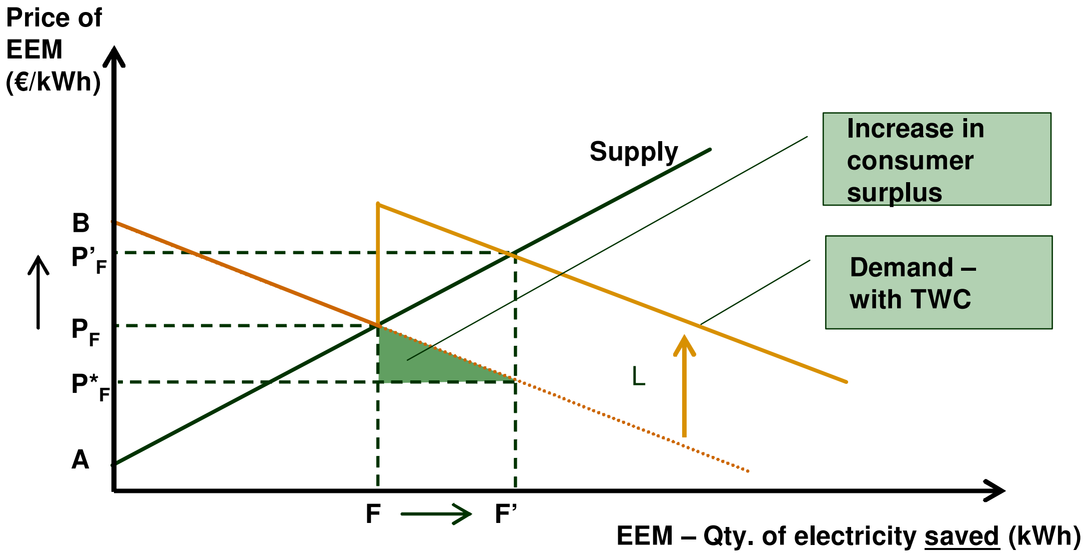
Consumers are affected in three ways by the TWC scheme:

- They gain directly from the investment in energy efficiency.
- They gain indirectly from the lower electricity prices that result from the lower electricity demand.
- They lose indirectly from the higher electricity prices and corresponding lower electricity demand that result from the cost recovery mechanism.

The net effect of the TWC scheme to consumers is given by the sum of these three effects.

The shaded triangle in Figure 4.16 shows the direct benefits to consumers from the subsidised investment in energy efficiency. Here, the consumers benefiting from the extra investment are assumed to pay a price P^*_F and a total cost of P^*_F (F'-F). The remainder of the costs, represented by P'_F (F'-F), are paid for by the subsidy. But the value of this extra investment to the beneficiaries is equal to the area under the demand curve between F and F'. The shaded area in Figure 4.13 therefore represents the difference between the cost paid by the beneficiaries and the value of the investment to them – and hence the net increase in consumer surplus.

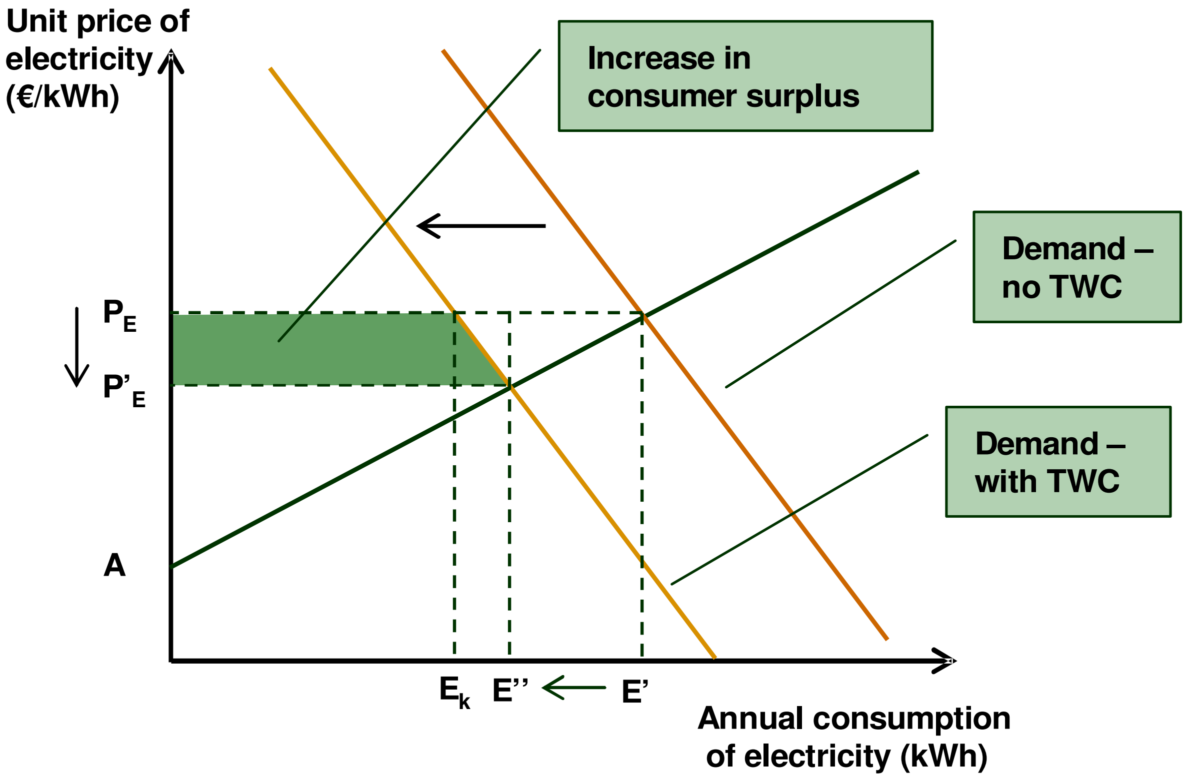
Figure 4.16
Direct benefits of TWC scheme to consumers - EEM market



The shaded area in Figure 4.17 shows the indirect benefits to consumers from the subsidised energy efficiency investment. As noted, the investment in energy efficiency shifts the demand curve for electricity to the left. But this, in itself, does not lead to any increase in consumer surplus since the shift results from consumers voluntarily acquiring value in the EEM market that at least offsets their loss in value in the electricity market (Braithwaite and Caves, 1994, p. 105). Summing the apparent change in consumer surplus in both markets would amount to double counting.

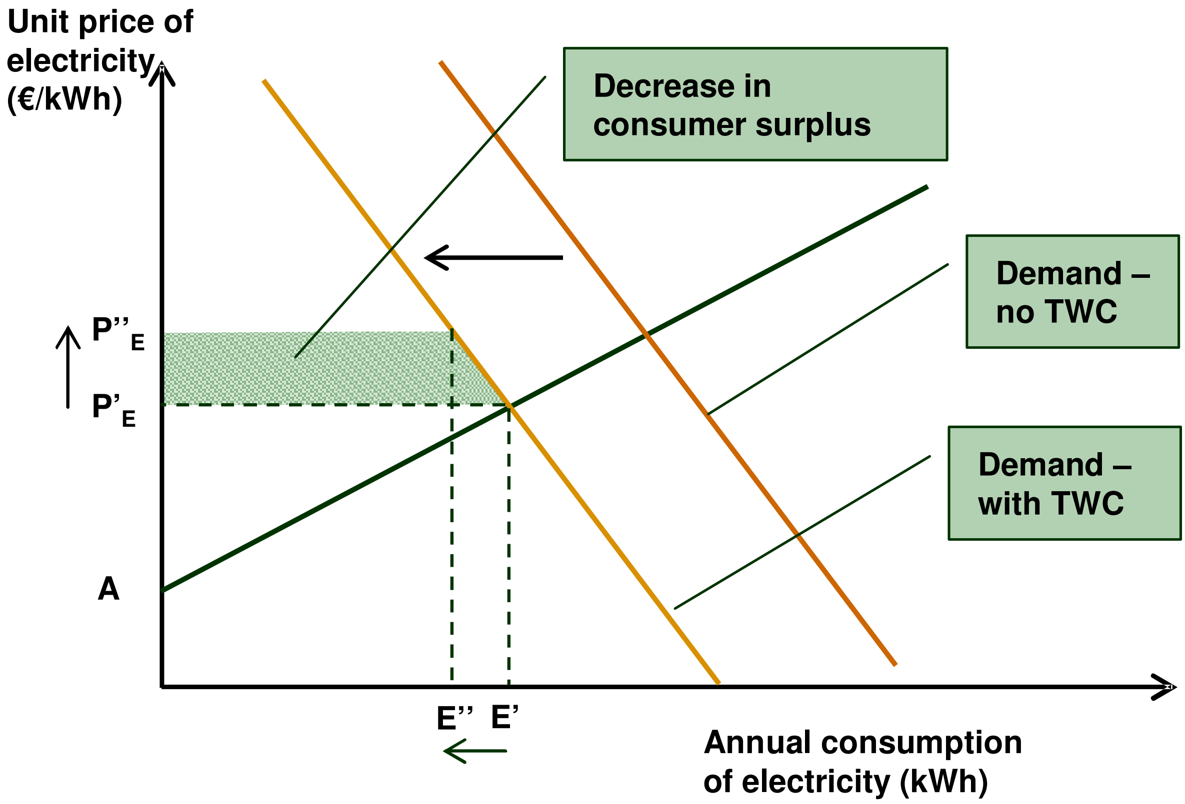
However, consumer surplus *does* increase as a result of the reduction in the electricity price from P_E to P'_E. This is because E' units of electricity are now being purchased at a lower price of P'_E. The area between the new demand curve and the new price line represents this increase, which may be considered an *indirect* benefit of the TWC scheme. This is additional to the *direct* consumer surplus, illustrated in Figure 4.16.

Figure 4.17
Indirect benefits of TWC scheme to consumers – electricity market



The shaded area in Figure 4.18 shows the <u>indirect</u> *costs* to consumers from the cost recovery for the TWC scheme. In contrast to the efficiency investment itself, cost recovery leads to a reduction in consumer surplus. This is because E" units of electricity are now being purchased at a higher price of $P"_E$ (since consumers are paying the levy) and (E"-E') fewer units of electricity are being bought (since electricity is more expensive).

Figure 4.18
Indirect costs of TWC scheme to consumers – electricity market



It should be clear that the indirect benefits to consumers represented by Figure 4.17 are largely offset by the costs to consumers represented by Figure 4.18. If the final electricity price (P''_E) is approximately equal to the original electricity price (P_E), then these two effects largely cancel out. The gains to consumers would then be positive and equal to the shaded area illustrated in Figure 4.16. If $P''_E<P_E$, these net benefits would be increased, while if $P''_E>P_E$, these net benefits would be reduced. At some level of P''_E, the net benefits would become negative.

This suggests that the sign of the overall net benefits is ambiguous, since the benefits to consumers (Figure 4.16 plus Figure 4.17) may or may not be sufficient to offset the costs (Figure 4.18). It depends upon the relative slope of the demand and supply curves in each market. Note, however, that the indirect benefits (Figure 4.17) depend on the price elasticity of electricity supply and would reduce to zero if the supply curve was effectively horizontal over the region of interest. In contrast, consumers must incur the bulk of the costs shown in Figure 4.18 since the electricity producers will impose a levy (l') on consumer prices to recover their direct costs (specifically, consumers must incur minimum cost equal to the area $(P''_E - P'_E)E''$). Hence, if the supply curve for electricity were relatively flat, it is likely that the TWC scheme would impose net costs upon consumers as a whole.

The costs and benefits of the scheme will not be distributed equally among consumers:

- the *direct* benefits of the scheme (Figure 4.16) will accrue solely to those consumers hosting the energy efficiency investments;
- the *indirect* benefits (Figure 4.17) will accrue to all consumers in proportion to their electricity consumption; and
- the costs (Figure 4.18) will be paid by all consumers in proportion to their electricity consumption.

Consumers may therefore be divided into *beneficiaries* of the TWC subsidies/efficiency investments and the *non-beneficiaries*. The first group should benefit from the TWC scheme, while the benefits for the second group are ambiguous.

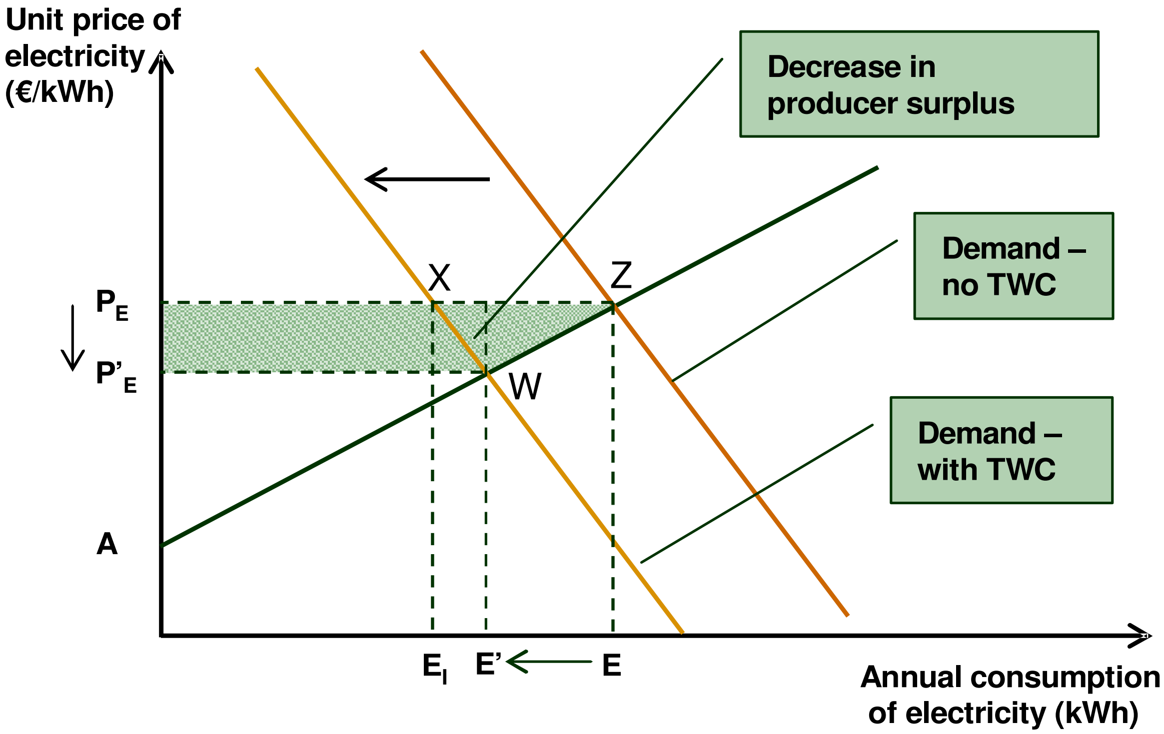
The non-beneficiaries benefit solely from the reduction in electricity prices following efficiency investment (Figure 4.17). If the supply curve is relatively flat over the region of interest this price reduction could be small. Furthermore, since the non-beneficiaries are likely to substantially outnumber the beneficiaries, they will bear the greater proportion of the direct costs (Figure 4.18). As a result, this group is likely to be net losers from the TWC scheme, which acts to transfer wealth from one consumer group to another.

The beneficiaries, in contrast, benefit both directly and indirectly from the scheme. Since the benefits they receive from the energy efficiency investments should be greater than their share of the indirect costs, this group should be net winners from the TWC scheme.

4.4.3 Effect on electricity producers

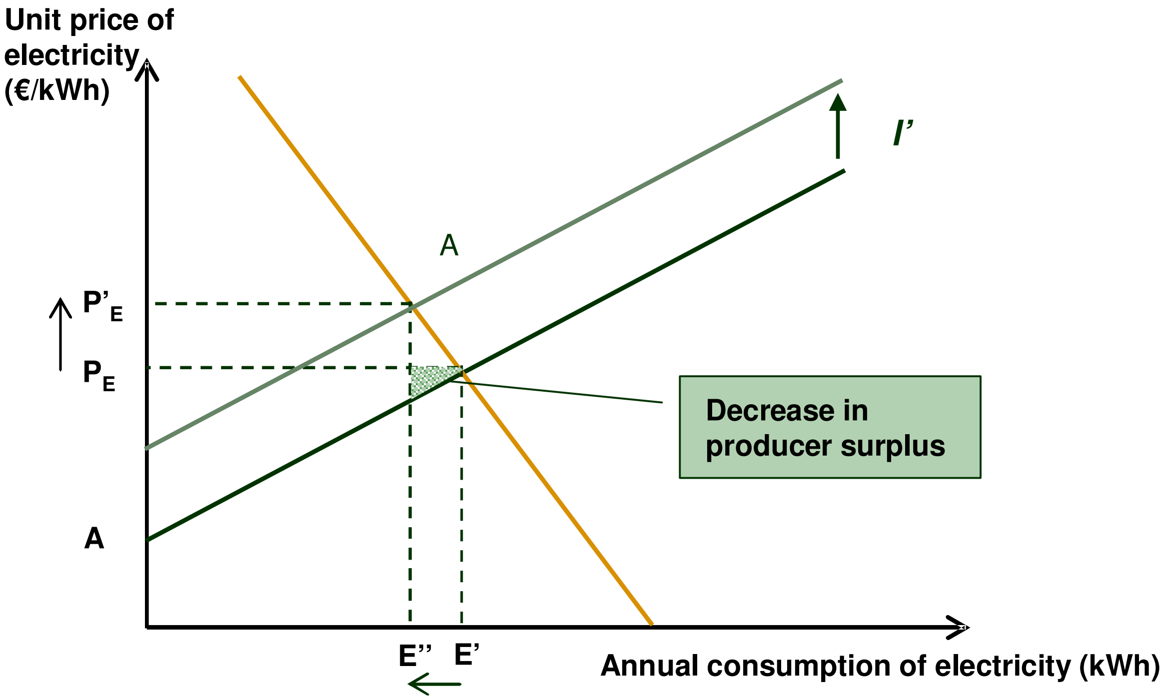
Electricity producers do not bear the direct costs of the scheme since they pass these on to electricity consumers. However, they may lose from the scheme in two-ways. First, they may lose producer surplus as a consequence of the reduction in electricity demand and hence electricity prices following the energy efficiency investment – as shown by the shaded area in Figure 4.19. This loss results from a combination of supplying less electricity and receiving a lower price for the electricity that is supplied.

Figure 4.19
Cost of TWC scheme to electricity producers – from demand reduction



Second, they may lose producer surplus a second time as a consequence of the additional reduction in electricity demand that results from increasing consumer prices to recover the direct costs - as shown by the shaded area in Figure 4.20. In this case, the loss results solely from supplying less electricity.

Figure 4.20
Additional cost of TWC scheme to electricity producers – from cost recovery



The magnitude of both of these effects will depend on the relative slope of the electricity demand and supply curves. If the electricity supply curve is relatively flat over the region of interest (e.g., if the reduction in demand from the efficiency investment is relatively small and has little impact on electricity prices), then the loss to the electricity producers is likely be small. In these circumstances, the overall cost of the TWC scheme will largely be borne by those consumers not benefiting from the energy efficiency investment (i.e., the scheme will simply transfer surplus from one group of consumers to another).

4.4.4 Summary

The distribution of the net benefits of the TWC scheme is summarised in Table 4.4.

Table 4.4
Summary of distributional effects of a TWC scheme in a national electricity market

Variable	Effect	Comments
Producer surplus – energy efficiency producers	Increased	Could be small or zero, since supply curve likely to be relatively flat (e.g., internationally traded technologies)
Producer surplus – electricity producers	Reduced	Less if supply curve is relatively flat
Producer surplus – overall	Ambiguous	Loss of electricity producers (national market) should outweigh gain of EEM producers (international market) Hence, likely to reduce.

Variable	Effect	Comments
Consumer surplus – beneficiaries	Increased	Direct benefits exceed indirect costs. Will increase less if supply curve is relatively flat
Consumer surplus – non-beneficiaries	Ambiguous	Likely to reduce. Will reduce more if supply curve is relatively flat
Consumer surplus – overall	Ambiguous	Likely to reduce if supply curves are flat. Transfer of wealth from non-beneficiaries to beneficiaries

4.4.5 Effects on producers and consumers in an international electricity market

This section briefly assesses how international trade in electricity affects the consumer and producer surplus effects of the TWC scheme.

As before there are four groups of interest: EEM producers; consumers benefiting from the efficiency investments; consumers not benefiting from these investments; and electricity producers. But it is necessary to distinguish between consumers and electricity producers in the host country and those abroad:

The effects in the host country are as follows:

§ EEM producers located in the host country benefit from the scheme in the same manner and to the same extent as before.

§ Domestic consumers hosting the efficiency investment benefit directly from the scheme as before. But, unlike the situation with no trade, there are no indirect benefits as consumer electricity prices unambiguously increase - and will be higher than in the case of no trade. Net benefits should still be positive, but may be lower.

§ Domestic consumers not hosting the efficiency investment will pay higher prices for their electricity consumption. Hence, they unambiguously lose from the scheme.

§ Domestic electricity producers face an unchanged demand and unchanged wholesale prices. Hence, they are unaffected by the scheme.

The effects in the exporting country or countries are as follows:

§ EEM producers located abroad benefit from the scheme in the same manner and to the same extent as before.

§ Consumers abroad pay the same price for the same level of electricity consumption. Hence, they are unaffected by the scheme.

§ Electricity producers abroad supply a lower demand, but wholesale prices are unchanged. Hence, there is no gain in producer surplus.

The results would be slightly different if changes in electricity demand in the host country were sufficiently large to reduce the international price for wholesale electricity by some small amount (i.e., the host country was not a price taker). In this case, consumers abroad would consume more electricity at a lower price and hence would obtain small benefits from the scheme. Consumers in the host country would largely pay for these benefits. Similarly, electricity producers abroad would sell less electricity at a lower price and hence would suffer a small loss.

The costs and benefits of the scheme in the idealised case of no change in wholesale prices are summarised in Table 4.5.

Table 4.5
Summary of distributional effects of a TWC scheme in an international electricity market

Variable	*Effect in host country if no electricity trade*	Effect in host (importing) country if electricity trade	Effect in exporting country/countries if electricity trade	Comments
Producer surplus – EEM producers	*Increased*	Increased	Increased	Could be small or zero, since supply curve likely to be relatively flat (e.g., internationally traded technologies)
Producer surplus – electricity producers	*Reduced*	Unchanged	Unchanged	If there is a small reduction in wholesale prices, producers abroad will lose while domestic producers will be unaffected.
Producer surplus – overall	*Ambiguous*	Increased	Increased	If there was a small reduction in wholesale prices, the effect would be ambiguous
Consumer surplus – beneficiaries	*Increased*	Increased	N/a	Benefits are less than in the case of no electricity trade, since there are no indirect benefits from the TWC scheme to offset the cost recovery.
Consumer surplus – non-beneficiaries	*Ambiguous*	Reduced	Unchanged	Loss is greater than in the case of no electricity trade, since there are no indirect benefits from the TWC scheme to offset the cost recovery. Transfer of wealth from non-beneficiaries to beneficiaries
Consumer surplus – overall	*Reduced*	Reduced	Unchanged	If there is a small reduction in wholesale prices, consumers abroad will gain. There will be a transfer of wealth from domestic consumers to consumers abroad

4.5 Summary

This section has provided a comprehensive introduction to the theory and practice of TWC schemes. By exploring the implications of a TWC scheme in isolation, it has provided a sound basis for studying the interactions between TWC schemes and the EU ETS. Specifically, this section has achieved the following:

§ Introduced the origins, basic elements and objectives of a TWC scheme

§ Discussed the basic design features of a TWC scheme, including the choice of target group, the denomination of the targets, the certification of energy efficiency activities and the procedures for monitoring and verification.

§ Assessed the current state of development of TWC schemes and described the design features of the two existing schemes (Italy, UK) and one proposed scheme (France).

§ Analysed the operation of an idealised TWC scheme that is confined to electricity retailers operating within an isolated, liberalised and perfectly competitive electricity market. This includes the effect of this scheme on a number of 'price and quantity' variables, including electricity demand and electricity prices.

§ Conducted a simplified analysis of the costs and benefits of this scheme for EEM producers, electricity producers and electricity consumers. This is not a complete analysis, as market failures and secondary effects are ignored.

§ Analysed the implications for the idealised TWC scheme of international trade in electricity, including the effect of this trade on various 'price and quantity' variables within the host country and abroad, as well the distributional changes for various groups.

The analysis has shown that the price of white certificates depends upon the stringency of the energy saving target and the relative slope of the demand and supply curves for energy efficiency measures. Specifically, certificate price will be greater if both the supply and demand for energy efficiency are sensitive to price. Under the assumption of linear supply demand curves, the certificate price required to achieve a particular energy-saving target should be independent of the marginal cost of energy efficiency investment required to meet that target. However, this conclusion is modified if the supply and/or demand curve are non-linear.

The analysis has also shown that wholesale electricity prices should be reduced by a TWC scheme, but the impact on retail electricity prices is ambiguous- it depends upon the relative slope of the demand and supply curves for electricity. Also, the size of the required levy on retail prices to recover the costs of the scheme should be proportional to the square of the energy-saving target.

Tables 4.2 and 4.4 summarise the impacts of the idealised TWC scheme in an isolated national market, while the Tables 4.3 and 4.5 do the same for a TWC scheme operating in an electricity market that is open to international trade – for the particular case when imports form the marginal supplier. Taken together, these tables summarise the effect of an idealised TWC scheme operating in <u>isolation</u> from other environmental policy instruments. In Chapter 6, this analysis is used as a basis to explore the nature of the interactions between a TWC scheme and the EU ETS.

5 Impact of Green and White Certificate Schemes on the EU ETS

This chapter will build on the discussion in previous chapters to analyse the interaction of the EU ETS with tradable green certificate schemes. The analysis has three parts, as described below.

First, we consider some general issues regarding the interaction between both green and white certificate schemes with the EU ETS. This includes, the impact of introducing certificate schemes on aggregate CO_2 emissions, as well as the effect on the green and white certificate markets.

Second, we build on the discussion in previous sections to analyse in more detail how a TGC scheme affects the operation of the EU ETS and its interaction with the electricity market.

Finally, we perform a similar analysis in the context of TWC schemes.

As before, the analysis uses idealised national TGC and TGC schemes confined to electricity suppliers operating within a liberalised and perfectly competitive electricity market. A comparison is made with the effects of each instrument operating in isolation. The analysis focuses on how this combination of instruments affects a number of key variables such as electricity prices and CO_2 emissions, and how the costs and benefits are distributed between different groups. This analysis is refined in subsequent chapters, where the impact of several ‘real-world’ design parameters and market characteristics is explored in more detail.

5.1 Generic Issues Concerning the Interaction between Emissions Trading and Certificate Schemes

In exploring their interactions with the EU ETS, there are number of issues that are common to both green and white certificates schemes. Indeed, several of these issues are common to the interaction of a CO_2 emissions trading scheme with *any* additional policy instrument that directly or indirectly effects CO_2 emissions (Sorrell et al. 2003). These issues have important consequences for the attainment of the objectives of each instrument. This section reviews these issues under the following headings:

§ types of policy interaction;

§ policy interaction under a cap;

§ policy interaction and allowance prices; and

§ fungibility of trading commodities and double counting.

The discussion is based in part on Sorrell and Sijm (2003) and Sorrell (2003).

5.1.1 Types of policy interaction

In exploring policy interaction, it is useful to distinguish between *directly* and *indirectly* affected target groups. The directly affected target group has obligations and incentives imposed upon it immediately by a policy, while the indirectly affected target group is influenced in some way by the behavioural changes that are made by a directly affected target group.

Of particular interest is the extent to which the additional costs imposed by a policy on the business sector are indirectly borne by consumers, suppliers and shareholders. For example, electricity generators participating in the EU ETS may either increase wholesale electricity prices (pass costs on to consumers), reduce the consumption or unit price paid for fuel inputs (pass costs on to suppliers) or reduce dividends and capital gains (pass costs on to shareholders) (Cramton and Kerr, 1997). In each case, the extent to which costs can be passed on will depend on the market situation of the firm and the demand and supply elasticities in each market. It will also depend on the timeframe under consideration and the extent to which companies have the opportunity to change behaviour and investment decisions.

Indirect effects permeate throughout the economy and ultimately require analysis within a general equilibrium framework. But for present purposes, the indirect impact of the EU ETS and other policy instruments on electricity consumers is of particular interest.

The distinction between directly and indirectly affected target groups leads naturally to a distinction between *direct* and *indirect* policy interaction. In addition, there is the additional possibility of *trading* interaction. These are introduced below:

§ *Direct interaction* is where the target groups directly affected by the two policies overlap in some way. For example, participants in the EU ETS may already be subject to a CO_2 tax on fuel use.

§ *Indirect interaction* occurs when a target group is indirectly affected by one policy and either directly or indirectly affected by a second. For example, there is indirect interaction between the EU ETS and a tax on electricity consumption, since electricity consumers are indirectly affected by the former and directly affected by the latter.57 Similarly, there is indirect interaction between the EU ETS and a TGC scheme, since non-green electricity generators are directly affected by the former and indirectly affected by the latter. Also, electricity consumers are indirectly affected by both.

§ *Trading interaction*, or *linking,* is where two policies influence one another by the exchange of an environmental trading commodity. For example, CO_2 allowances from a trading scheme in Japan may be exchangeable for allowances in the EU ETS. Such links need to be governed by transfer and exchange rules, which in combination define the *fungibility* of the commodities. Linking between the EU ETS and other tradable GHG currencies established under the Kyoto Protocol has attracted much attention and has been embodied in the Article 25 of the Emissions Trading Directive and in the Linking Directive.

The interactions between the EU ETS and certificate schemes may take each of these forms. But it is the indirect interactions and their effect on electricity consumers that is of particular interest.

57 Similarly, electricity generators are indirectly affected by the tax and directly affected by the EU ETS.

5.1.2 Policy interaction under a cap

5.1.2.1 General implications of a cap

A defining feature of a cap-and-trade scheme such as the EU ETS is that, assuming adequate enforcement and full compliance, there is certainty that total emissions will be less than or equal to the aggregate cap. A second feature is that, under a standard set of assumptions regarding the competitive operation of the allowance market, the scheme will allow the emissions target to be met at least cost. In equilibrium, marginal abatement costs will be equalised across sources and equal to the allowance price.

These idealised features of the EU ETS have important implications for its interaction with other policies. Coupled with comparable assumptions regarding the idealised operation of product markets, they imply that *policies affecting facilities participating in the EU ETS will have* <u>*no*</u> *immediate CO_2 reduction benefits*. Furthermore, such policies will increase the overall costs of meeting the emissions cap (Sorrell and Sijm, 2003).

This result applies to instruments that *directly* affect CO_2 emissions from EU ETS participants, such as a CO_2 tax on fuel use, as well as those that *indirectly* affect those emissions, such as a green or white certificate schemes. Such policies may either increase or reduce the abatement costs of individual EU ETS participants, but in all cases the aggregate costs of meeting the cap will be increased and participant emissions will continue to be less than or equal to the cap. Hence, these instruments will contribute nothing to the effectiveness of CO_2 abatement (i.e., meeting the overall cap) and may potentially undermine the efficiency of abatement (i.e., achieving that cap at least cost) (Sijm 2003).

To illustrate this, assume that the second instrument is a CO_2 tax on the energy use of a number of EU ETS participants. As a consequence of this tax, the affected participants are likely to reduce fuel use (and hence emissions) further than they would under the EU ETS alone, which means that they are likely to either sell more allowances or purchase fewer allowances. The consequent reduction in allowance prices will make it easier for other EU ETS participants that are not affected by the tax to comply with their EU ETS targets. Aggregate emissions will not have changed, since other participants will use any 'freed-up' allowances to cover increases in emissions (or reduced emissions abatement). But aggregate abatement costs will have increased, since the distribution of abatement actions across participants will have departed from the cost minimising optimum. Also, the participants subject to the tax will effectively be subsidising competitor participants that are not.[58]

This has some further potential implications:

§ If *all EU ETS participants* were subject to the same tax, the primary effect would be to increase overall abatement costs and lower the allowance price;

§ If *all of the EU electricity sector* were subject to the tax, costs to the electricity sector would increase but costs to non-electricity participants would decrease because of lower allowance prices. The overall cost would increase.

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[58] This only applies to those competitors which are buyers of allowances. If they are sellers, the value of their sales will be reduced.

§ If *the tax were sufficiently stringent*, aggregate emissions would be reduced below the cap, making the EU ETS redundant, and reducing the price of allowances to zero. The cost of achieving the emissions reductions would, however, be higher than in the case of using the trading scheme to accomplish the same reductions.

5.1.2.2 Implications of TGC/TWC schemes

Very similar conclusions apply to the effect of TGC and TWC schemes on CO_2 emissions. A TGC scheme indirectly affects non-green generators participating in the EU ETS by substituting renewable for non-green generation. A TWC scheme also indirectly affects the same participants by reducing overall electricity demand. In both cases, the measures stimulated by the certificate schemes will be adopted by generators in lieu of other (on average cheaper) abatement measures or the purchase of allowances. At the same time, the overall emissions from EU ETS participants will be unchanged. Both schemes would therefore raise the cost of meeting the EU ETS cap without delivering any additional emission reductions.

In the case of TGC schemes, an ambitious target for renewable generation could theoretically reduce non-green generation (and hence emissions) sufficiently that the EU ETS cap is no longer binding and allowance price falls to zero. Similarly, an ambitious target for energy saving in a TWC scheme could theoretically reduce electricity demand (and hence emissions) sufficiently that the cap is no longer binding. However, since existing schemes apply solely at the national level and affect only a portion of the sectors covered by the EU ETS, their impact on aggregate emissions may be limited in practice. Thus, in general, emissions from the sources participating in the EU ETS will be set solely by the aggregate cap. Instruments such as TGC schemes that target these emissions will therefore contribute nothing further to emission reductions at the EU (or global) level.

These effects are discussed in detail in the subsequent sections of this chapter.

5.1.2.3 Implications of measures affecting non-covered emissions

It is important to note that the same conclusion does not follow for policies that do not interact, either directly or indirectly, with the EU ETS. These will contribute emission reductions independently of and in addition to the EU ETS. For example, the EU ETS does not cover emissions from household fuel consumption, but it does (indirectly) cover those from household electricity consumption. Since policies that affect household fuel consumption *would not* interact with the EU ETS, they will contribute to additional reductions in CO_2 emissions. Conversely, policies that affect household electricity consumption *would* interact with the EU ETS and hence will not contribute to additional emission reductions.

TWC (but not TGC) schemes may affect emissions sources that are inside the EU ETS cap as well as those that lie outside. For example, the UK and Italian TWC schemes affect both household electricity consumption and household fuel consumption. This suggests that, in insofar as the aim of TWC schemes is to contribute additional reductions in CO_2 emissions, and in the presence of the EU ETS, they should focus on non-electricity energy carriers and on household rather than industrial sector energy efficiency.

5.1.2.4 Implications of tightening the cap

The above argument assumes that the ETS cap is fixed. In practice, it is likely that the cap will be tightened for Phase 2 and for subsequent compliance periods, as countries endeavour to meet their Kyoto targets. The effect of instruments such as TGC schemes on the process of negotiating and establishing these caps must then be considered.

In Phase 1, national allocation plans were based in part on emissions forecasts. In principle, these forecasts should have taken into account the emission reductions expected from instruments such as TGC schemes and renewables policies in general that were anticipated to be in operation during Phase 1. Therefore, the emission reductions expected from these schemes should have been reflected in a more stringent Phase 1 cap.

It is possible that the absence of such schemes would have led to a less stringent Phase 1 cap. If so, these schemes would have contributed to aggregate emission reductions during Phase 1 by helping to ensure a more stringent overall cap. Conversely, it is possible that the absence of these schemes would have made no difference to the stringency of the Phase 1 cap. If so, these schemes would not have contributed to any additional emission reductions.

Climate policies that interact with the EU ETS and which are introduced subsequent to the negotiation of the Phase 1 cap will not contribute to any additional emission reductions during Phase 1 for the reasons discussed above. But these policies may reduce *national* CO_2 emissions. If the national allocation plans in Phase 2 are again based on national emission forecasts, the existence of such policies may contribute to the negotiation of a more stringent Phase 2 cap (and possibly to more stringent caps in subsequent compliance periods). If so, these policies would have contributed to aggregate emission reductions during Phase 2 (and subsequently) by tightening the overall cap.

In summary, while policies that interact with the EU ETS will not contribute to additional international emission reductions during the current compliance period, they may contribute to the negotiation of more stringent emission caps in subsequent climate periods. By this process, such instruments may contribute to additional emission reductions in the longer term compared to a counterfactual scenario in which they are not introduced. In all cases, however, once a cap is established for a given period, that cap may be achieved most cost effectively through the use of the EU ETS alone, rather than in combination with other instruments.

5.1.3 Effect of interactions on the allowance market

5.1.3.1 Impact on the allowance market when the cap is fixed

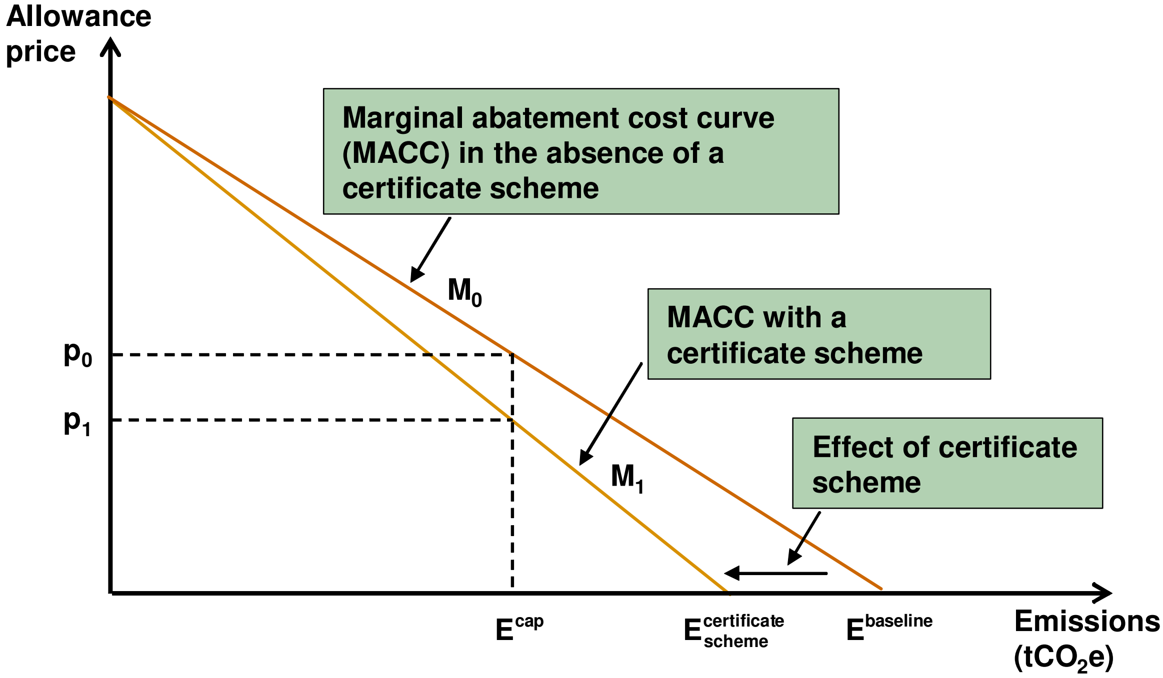
Policies such as certificate schemes that directly or indirectly interact with the EU ETS will necessarily *reduce* the EU ETS allowance price. This effect can be illustrated in general terms, without considering the details of individual policies.

The introduction of either a TGC scheme or a TWC scheme will reduce the volume of CO_2-emitting electricity generation. In the case of TGC schemes, the emission reduction results from the displacement of non-green electricity by green generation; while in the case of a TWC scheme it results from a reduction in aggregate electricity demand. Figure 5.1 shows BAU emissions as well as a marginal abatement cost curve for these sources. With a zero allowance price and no certificate scheme, emissions from EU ETS sources are equal to

$E^{baseline}$. When a white or green certificate scheme is introduced, these emissions fall to $E_{scheme}^{certificate}$. The difference between $E^{baseline}$ and $E_{scheme}^{certificate}$ represents the emissions from CO_2-emitting electricity generation that are avoided as a result of the certificate scheme.

The abatement options encouraged by the certificate scheme represent a portion of the abatement options that were contained in the original marginal abatement cost curve for EU ETS sources (M_0). With these options already implemented, the curve becomes steeper (M_1). In effect, the abatement opportunities available to EU ETS participants are reduced by the introduction of the certificate scheme.

Figure 5.1
Effect of certificate scheme on the EU ETS allowance market

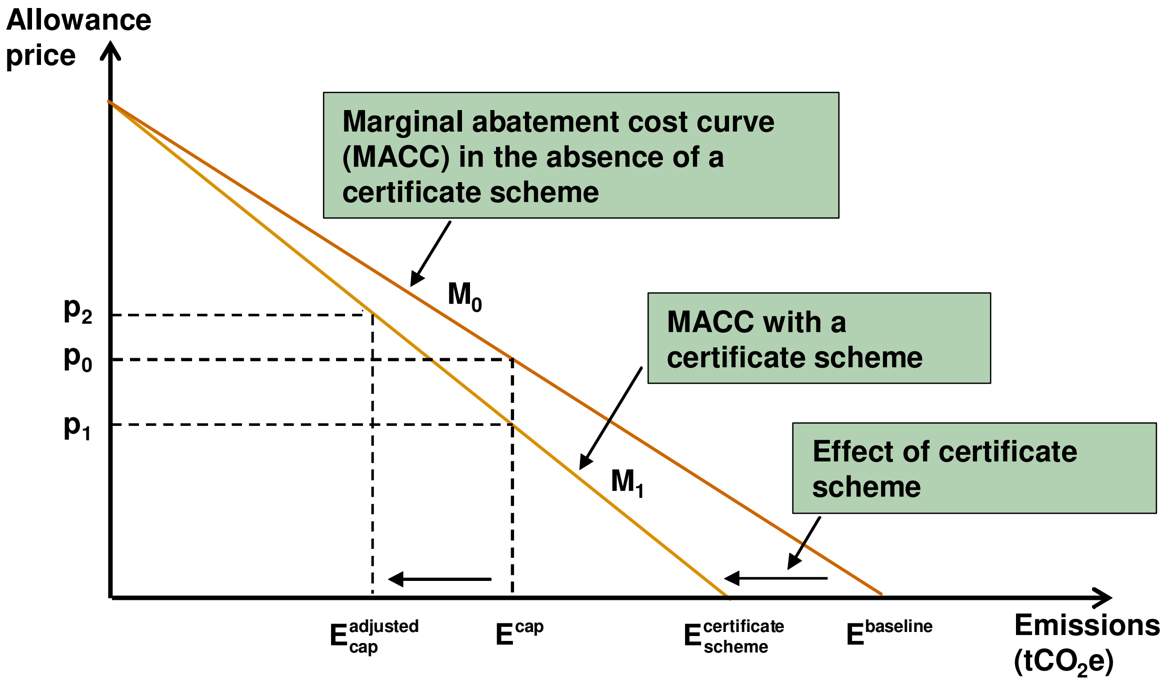


If the cap is kept constant, the introduction of the certificate scheme leads to a fall in the allowance price, from p_0 to p_1. This occurs because the overall scarcity of the EU ETS is relaxed: in effect, some abatement has already been 'paid for' through the certificate scheme. As a result, the cost of compliance for EU ETS participants is reduced and the cost of the EU ETS 'in isolation' is lower. However, the overall cost of achieving the EU ETS cap is increased. This is because the certificate scheme substitutes assumed high cost abatement options (e.g., renewable energy) for the low cost CO_2 abatement options that would have otherwise been chosen by the EU ETS participants (e.g., fuel switching). As discussed in previous chapters, the extra costs are divided between electricity consumers and producers in a complex way. Hence, while the impact *of the EU ETS* on electricity consumers will be lower with the certificate scheme, the overall price impact (i.e., from the EU ETS and certificate scheme combined) will be higher. Note that this accounting does not include the benefits from the green and white certificates that are unrelated to the abatement of CO_2 emissions.

5.1.3.2 Impact on the allowance market when the cap is tightened

The above discussion assumes that the certificate scheme is introduced after the negotiation of the EU ETS cap. However, if the certificate scheme was taken into account in the negotiation of the cap, the cap may be adjusted. This is illustrated in Figure 5.2, where it is assumed that the cap is reduced by an amount identical to the reduction in emissions represented by the certificate scheme, to the new adjusted cap $E_{cap}^{adjusted}$. The new allowance price is determined by the adjusted cap and the M_1 marginal abatement cost schedule. This price (p_2) is higher than the original price (p_0) as the marginal cost of abatement increases as the overall level of emissions decreases.

Figure 5.2
Effect of certificate scheme on allowance market with adjustment of the emissions cap



5.1.3.3 Magnitude of impact

In either of the above two cases, the certificate scheme will only have a noticeable effect on EU allowance prices if the emissions reduced by the scheme represent a significant portion of the total emissions covered by the EU ETS. This is unlikely to be the case for most green and white certificate schemes confined to individual Member States. In these cases, the allowance price is likely to stay at or very close to the level it would have been in the absence of the national certificate scheme. Similarly, adjustments of the cap to account for the certificate scheme are unlikely to have much consequence.

On the other hand, the simultaneous use of certificate schemes by a number of Member States could have a more noticeable impact. For example, the widespread use of national TGC schemes could displace a significant volume of CO_2-emitting electricity. Cumulatively, these schemes may reduce baseline emissions sufficiently to result in a lower allowance price. A similar result would obtain with a single EU-wide TGC scheme.

The price impact may be dampened if the EU ETS is closely linked to international CO_2 markets. Generally speaking, the linking of the EU ETS to such markets would limit the influence of intra-EU factors on the allowance price, as credits could be imported or exported to the EU at the international price. The effect of certificate schemes, or other EU-specific measures, would then be less noticeable. In practice, the situation is complicated, as the availability of CDM/JI credits is limited and its moderating impact on the EU allowance price might not be very large. Also, the EU is not a mere 'small' part of international CO_2 markets, but the chief source of demand, and an increase in EU demand is likely to influence international prices significantly.

5.1.3.4 Fungibility of trading commodities and double counting

The linking of trading schemes is a topical policy issue. The EU ETS has been linked to JI and CDM through the Linking Directive and it may subsequently be linked to CO_2 trading schemes in other countries. At present, however, there are no proposals for allowing trading between the EU ETS and TGC/TWC schemes. This may be feasible, however, and has been proposed by a number of authors. Since the certificates in these schemes represent avoided CO_2 emissions, they could potentially be converted to CO_2 allowances using a suitable conversion factor and traded into the EU ETS.

This type of linking is available in principle (although not in practice) within the UK emissions trading scheme (UK ETS). Here, electricity suppliers who over-comply with their targets in the UK TGC scheme (the Renewables Obligation) can convert their surplus certificates into CO_2 allowances and sell them into the UK ETS. Similar arrangements are available for the UK TWC scheme (the Energy Efficiency Commitment) (Sorrell, 2003). These arrangements may be described as 'one-way fungibility', since UK ETS allowances cannot be used for compliance with targets in the certificate schemes.

Linking arrangements are feasible in the UK because participants in the UK ETS are responsible for the CO_2 emissions associated with their electricity consumption. But in the EU ETS, electricity generators are responsible for these emissions. In these circumstances, linking the EU ETS to a TGC/TWC scheme could lead to problems of *double counting* of CO_2 emissions. There are two related concerns (Zapfel and Vainio, 2001).

- *double coverage:* where two separate CO_2 allowances are surrendered for a one-tonne increase in physical emissions;[59] and
- *double crediting:* where two separate CO_2 allowances are generated from a one-tonne decrease in physical emissions.

For example, CO_2 allowances created through over-compliance with TGC targets and sold into the EU ETS will lead to double crediting. First, the displaced fossil fuel generation will free up EU ETS allowances that will be used to cover emissions elsewhere. Second, an

[59] A cross-border example of double coverage would be the export of electricity from country A, which has an emissions trading scheme where electricity generators surrender allowances, to country B, which has an emissions trading scheme where electricity consumers surrender allowances. Both the seller of the electricity (generators) in country A and the purchaser of the electricity (consumers) in country B would need to surrender allowances to cover the emissions associated with this electricity, which means the emissions would be covered twice by two separate trading schemes. A primary motivation for introducing a harmonised ETS throughout the EU was to avoid such problems.

approximate equivalent volume of new allowances will enter the EU ETS via the conversion of green credits into EU ETS allowances. Since this double crediting will not be offset by double coverage, the prior cap in the EU ETS is exceeded.

In addition to double counting, linking raises some practical problems of CO_2 accounting. First, the use of a fixed emissions factor for conversion creates problems of *discrepancy* between the actual and claimed emissions reductions. The quantity of emissions displaced will depend on the time of day, week and year the energy is generated/saved and possibly on the location of the investment. A fixed factor based on the average fuel mix will become increasingly inaccurate over time, unless it is regularly updated. Second, the monitoring and verification of CO_2 savings through the certificate schemes may not meet the required standards of the EU ETS. In the case of TWC schemes, the savings are estimated rather than monitored and the accuracy of these estimates may be questionable.

One alternative that has been proposed would be to separate the CO_2 and non-CO_2 'values' of the green and white certificates and trade them independently in separate markets. The first could be eligible for trading in the EU ETS and international markets, while the second could be confined to the country hosting the certificate scheme. Suppliers would be required to purchase a certain quantity of both to meet their obligation. The difficulty with this proposition is that the CO_2 value of the certificates is already reflected in the EU ETS allowances 'freed up' by the displaced fossil fuel emissions. Creating a separate CO_2 value and trading this into the EU ETS would lead to two allowances being created for *all* the emissions displaced by the green and white certificate schemes, rather than just from over-compliance. Such a 'splitting' of white or green certificates may therefore not be advisable in the presence of the EU ETS.

In summary, linking certificate schemes to the EU ETS creates a range of practical difficulties and may potentially threaten the environmental integrity of the EU ETS through problems of double counting. Since the marginal cost of CO_2 abatement through these instruments is likely to greatly exceed EU ETS allowances prices, there seems little to be gained in attempting to develop such arrangements.

5.2 Effect of a Green Certificate Scheme on the EU ETS

This section explores the interactions between an idealised national TGC scheme and the EU ETS. As before, we examine a country with a liberalised and perfectly competitive electricity market that is isolated from international trade. We assume that the operation of the electricity market means that consumers pay for certificates.

In this analysis, it is assumed that the country is already participating in the EU ETS and that a national TGC scheme is introduced. This scenario is relevant to those Member States that are considering the introduction of TGC schemes, but is also relevant to the tightening of the quotas within existing TGC schemes. Section 7.2 conducts a comparable analysis of a scenario in which the instrument sequence is reversed.

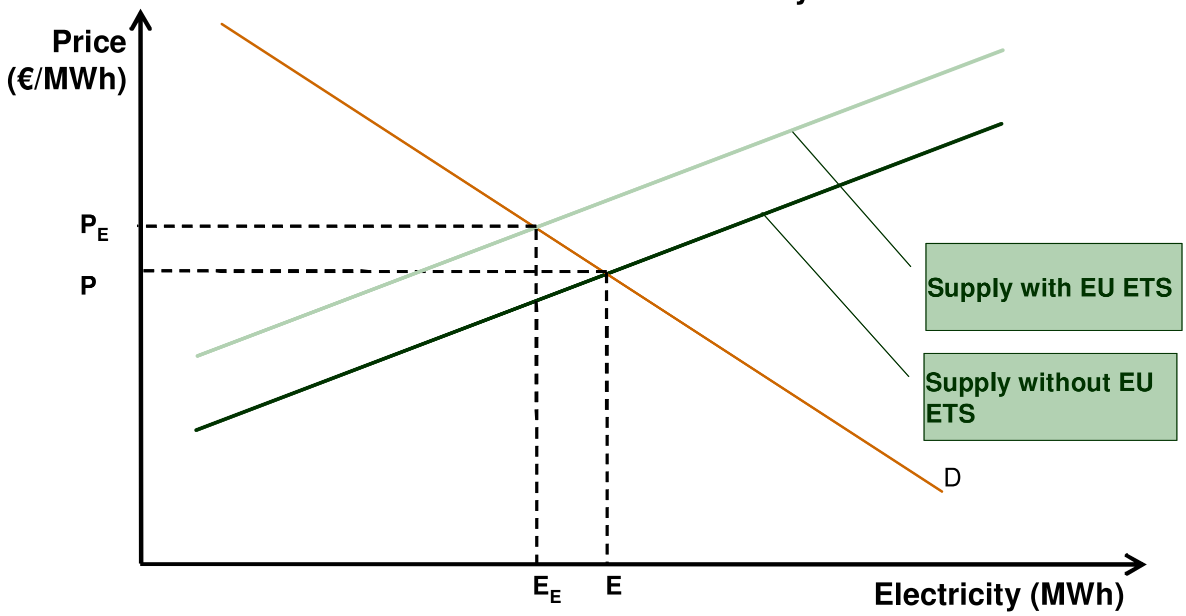
As before, the interactions are analysed in terms of the effects on a number of 'price and quantity' variables, together with the distribution of costs and benefits. The key question is how the addition of the TGC scheme alters the operation and impacts of the EU ETS. The results are summarised in tables.

Note that this discussion incorporates only the effect of a TGC scheme on the EU ETS. The effects of the EU ETS on the TGC scheme (including on certificate prices) are discussed in the next chapter. The analysis is therefore not a full analysis of all the simultaneous interactions, but intended to illustrate the mechanisms at work. As noted, a full analysis would require modelling of the simultaneous effects of all variables, preferably in a general equilibrium framework.

5.2.1 Effect on electricity demand and electricity prices

The effect of the EU ETS on an isolated national electricity market was discussed in detail in Chapter 2. The most important effect is to increase the wholesale price of electricity by an amount corresponding to the opportunity cost of CO_2 of the marginal producer in the national system. The magnitude of the price effect will depend on the CO_2 intensity of the marginal producer, which in turn will vary by time of day and time of year. As wholesale price increases result in higher retail prices, electricity demand decreases in the longer run. Figure 5.3 illustrates this effect in a stylised form. Wholesale/retail prices increase from P to P_E, while demand falls from E to E_E.

Figure 5.3
Effect of the EU ETS on the electricity market



The effect of an idealised TGC scheme on national electricity markets was discussed in Chapter 3. It was shown that the final equilibrium in the electricity supply market results from a combination of several factors:

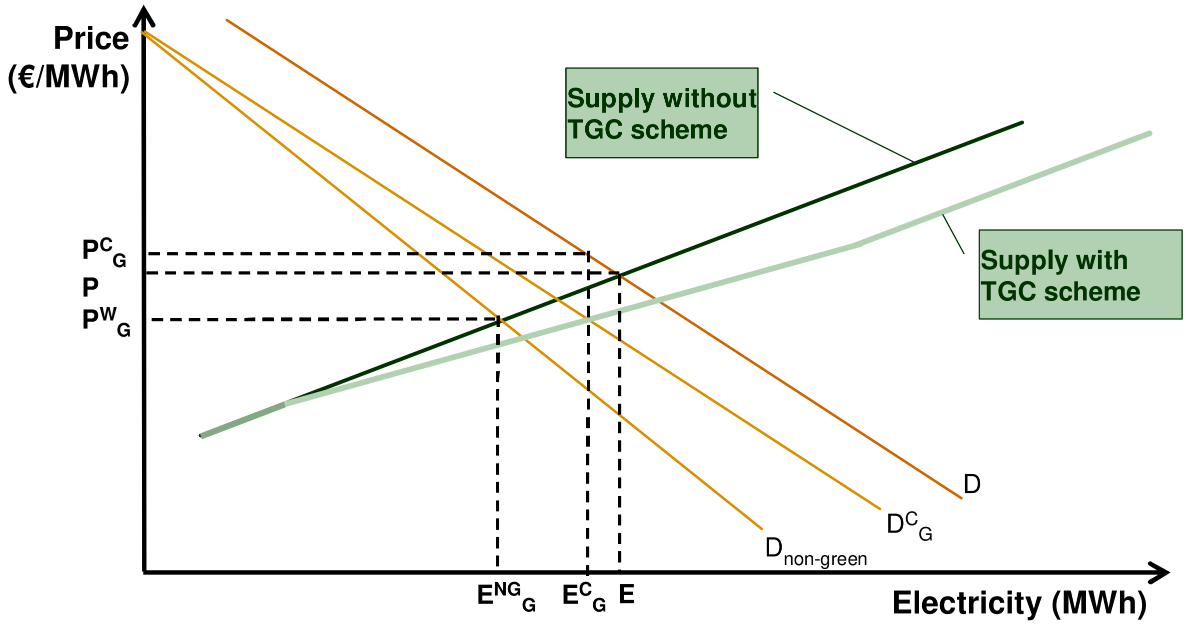
§ A combined flatter electricity supply schedule of combined non-green and (subsidised) green electricity;

§ Increased retail electricity prices, as consumers pay for green certificates; and

§ long-run reduction in overall electricity demand, in response to higher retail prices.

The net effect of the TGC scheme on the electricity market is illustrated in Figure 5.4. The inclusion of subsidised green electricity in total supply results in a flatter supply schedule. In the *retail* market, the extra cost of certificates to consumers is indicated by a downward shift in demand (schedule $D^C{}_G$). Prior to the introduction of the scheme, a quantity *E* of electricity is supplied at a price *P*. Following the introduction of the TWC scheme, a quantity E_G of electricity is supplied at a price $P^C{}_G$. In total, electricity demand has *decreased* from E to E_G and consumer electricity prices have *increased* from P to $P^C{}_G$. Meanwhile, in the *wholesale* market, the market is restricted, and the wholesale price $P^W{}_G$ ensues. The quantity $E^{NG}{}_G$ is that supplied by non-green producers.

Figure 5.4
Effect of a TGC scheme on the electricity market



As detailed in Chapter 3, the short-term impact of a TGC scheme on retail electricity prices is ambiguous. There are situations where in theory the fall in wholesale prices (due to lower volumes of non-green electricity supplied) could outbalance the increase due to certificate costs. This would cause overall retail prices to *decrease* rather than increase. The outcome depends upon the relative slope of the demand and supply curves, as well as the size of the green quota. Also, effects in the long-run may differ from those in the short-run. In particular, the long-run supply schedule likely *not* to be flatter as illustrated in the figure, as wholesale prices have to cover the cost of new entry. In this case, the outcome is an unambiguous increase in prices and decrease in total volumes supplied.

Figure 5.5 shows the effect on the *wholesale* market of introducing the EU ETS and then also a TGC scheme. This is the result of three distinct effects:

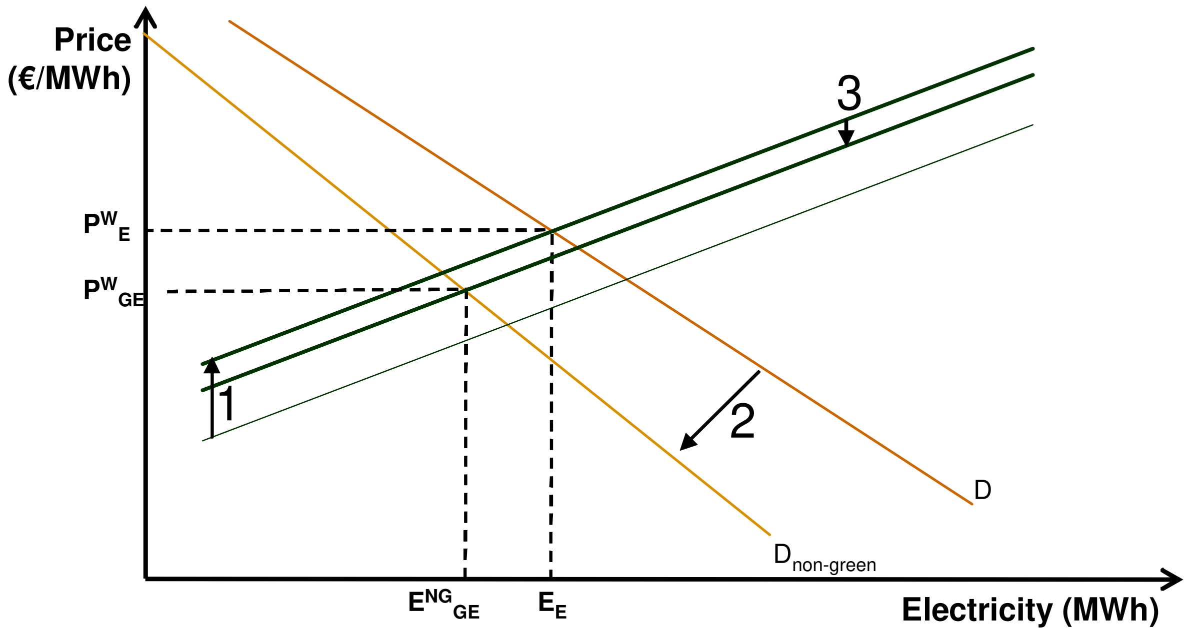
In considering the net effect, this therefore has to be taken into account.

§ First, the EU ETS raises wholesale prices. This is indicated by the arrow labelled ‘1’ in the figure.

§ Second, the TGC scheme results in lower demand for non-green electricity, and the arrow labelled '2' indicates both the downward shift ('tax effect') and swivel ('market share effect') of the demand schedule to $D_{non\text{-}green}$ that follow from a TGC scheme (this is discussed in detail in Chapter 3).

§ Third, the displacement of CO_2 emissions by a TGC scheme potentially has the effect of lowering allowance prices in the EU ETS (cf., Figure **5.1**). This reduced the impact of the EU ETS and therefore shifts down the non-green supply schedule. The effect is illustrated by the arrow labelled '3' in the figure.

Figure 5.5
Effect on the wholesale electricity market of introducing a TWC scheme alongside the EU ETS



The combination of the two instruments leads to an equilibrium where demand E_{EG} is supplied at retail price P^C_{EG}. Compared to the situation with the EU ETS alone (E_E, P^C_E), the following changes are apparent:

§ The total quantity non-green electricity supplied is smaller ($E^{NG}_{GE} < E_E$)

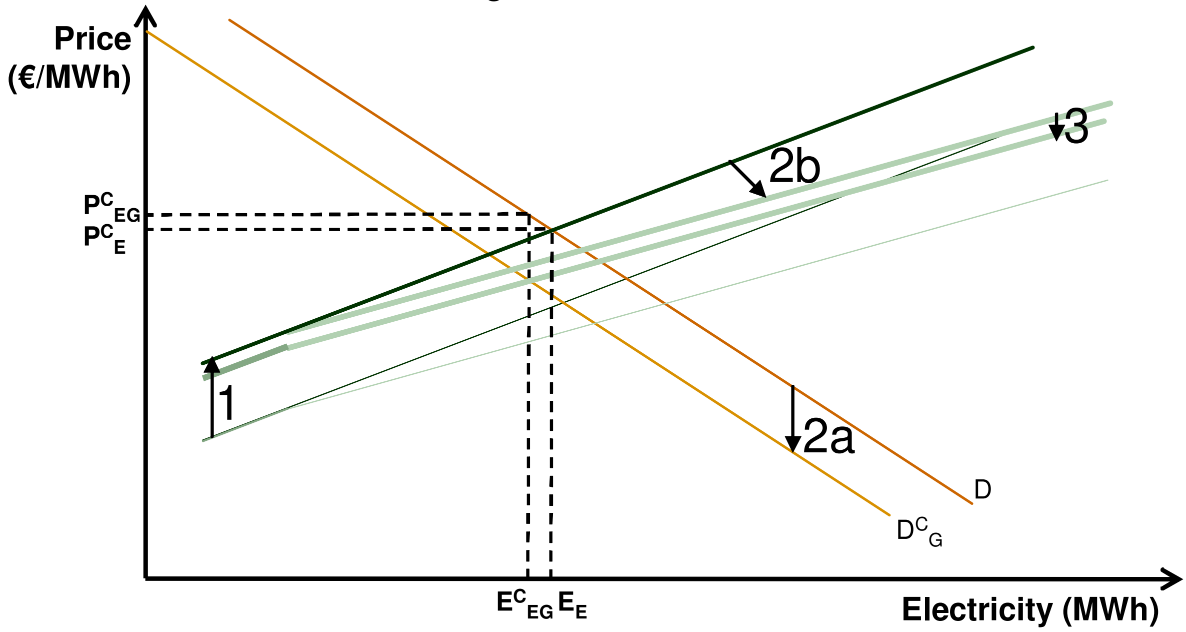
§ The wholesale electricity price is lower ($P^W_{GE} < P^W_E$)

Note that, in order to improve the clarity of representation, the third effect whereby the TGC scheme lowers allowance prices is indicated as very substantial in the figure. In reality, however, the effect of a single national TGC scheme on EU ETS allowance prices is unlikely to be significant. As mentioned, an EU wide TGC scheme could have a substantial impact.

Figure 5.6 details the effect on the retail electricity market. In this figure too, three steps are indicated:

- First, the EU ETS raises wholesale prices. This is indicated by the arrow labelled '1' in the figure.
- Second, the TGC scheme has two distinct effects:
  - Arrow '2a' indicates the downward shift of the demand schedule to DCG . is the result of the 'tax effect' of green certificates
  - Arrow '2b' indicates the swivel to a flatter supply schedule faced by consumers. As discussed, this is the effect of the combined non-green and (subsidised) green electricity.
- Third, lower allowance prices as a consequence of the TGC scheme shifts down the (already flattened) total upply schedule. The effect is illustrated by the arrow labelled '3' in the figure.

Figure 5.6
Effect on the <u>retail</u> electricity market of introducing a TGC scheme alongside the EU ETS



Compared to the EU ETS alone (E_E, $P^C{}_E$), the following changes are apparent:

- Electricity demand may either be higher or lower than with the EU ETS alone (E_{EG}<>E_E)
- The retail electricity price may either be higher or lower than with the EU ETS alone ($P^C{}_{EG}$<>P_E). While the increase in cost due to certificates raises the retail price, the lower wholesale prices resulting from the TGC scheme partly offset this. In addition, lower allowance prices may lead to a smaller impact of the EU ETS.

As mentioned, in the longer run, wholesale prices are not affected by the TGC scheme. In this case, wholesale are unaffected, retail prices increase, and demand is lower, as compared to the situation with the EU ETS alone.

Similarly, compared to the electricity market in the absence of *any* environment regulation (E, P), the following changes are apparent:

- Electricity demand is lower than with no regulation ($E_{ET}<E$)
- The retail electricity price can be either higher or lower than with no regulation ($P^{C}_{EG}<>P$). This depends on the extent to which the TGC scheme lowers wholesale prices, and how this is balanced against the cost of certificates and the price increase due to the EU ETS. In reality, it is very likely that retail prices will be higher, as the effect of the EU ETS is likely to outweigh any downward pressure on retail prices by a TGC scheme (which may in any case be smaller or non-existent).
- The wholesale price may either be higher or lower than with no regulation ($P^{W}_{EG}<>P$). This depends on the balance of the price increase due to the EU ETS and the price decrease due to the TGC scheme.

Again, in the longer run wholesale prices are not affected by the TGC scheme. In this case, wholesale are higher, retail prices higher, and demand lower, as compared to the situation with no regulation.

5.2.2 Effect on electricity generation and CO_2 emissions

The addition of the TGC scheme leads to a smaller amount of CO_2-emitting generation. This is due to the displacement of (CO_2-emitting) non-green electricity by (non/low CO_2-emitting) green electricity. The extent of this effect depends on the CO_2-intensity of the generation being displaced, i.e., the generation on the margin *with* the EU ETS. As noted in Chapter 2, the EU ETS may itself lead to a situation where low-emitting generation is on the margin. In this case, the impact of the TGC scheme may be to displace already comparatively 'clean' generation, and in any case to lead to lower CO_2 reductions than it would in the absence of the EU ETS (see next chapter for more discussion of this).

In addition, as depicted above the TGC scheme leads to a further demand reduction as consumers respond to the certificate cost (and this is not fully outweighed by the flatter supply schedule). This leads to further reductions in CO_2 emissions from the relevant generators. As discussed in detail above, however, with the EU ETS in place these reductions in CO_2 emissions simply result in surplus allowances that may be sold to other EU ETS participants either within the host country or abroad. If these allowances are used to cover emissions, there will be no reduction in CO_2 emissions within the EU as a whole - and hence no global environmental benefit. Similarly, if all of the allowances are purchased and used by national participants in the EU ETS, there will be no reduction in national CO_2 emissions. In practice a portion of the allowances are likely to be banked or sold to participants in other countries. Hence, the TGC scheme should lead to some reduction in national CO_2 emissions, but this may be less than the reduction from the national electricity generators.

Lower demand and lower non-green electricity generation should lead to lower CO_2 emissions from national electricity generators. Since the transfer of EU ETS allowances after 2008 is linked to the transfer of assigned amount units ('AAUs') under the Kyoto Protocol, the TGC scheme will *not* help the host country in meeting its Kyoto obligations. This is an important conclusion, since the contribution to meeting CO_2 emission targets may form one of the objectives of such a scheme.

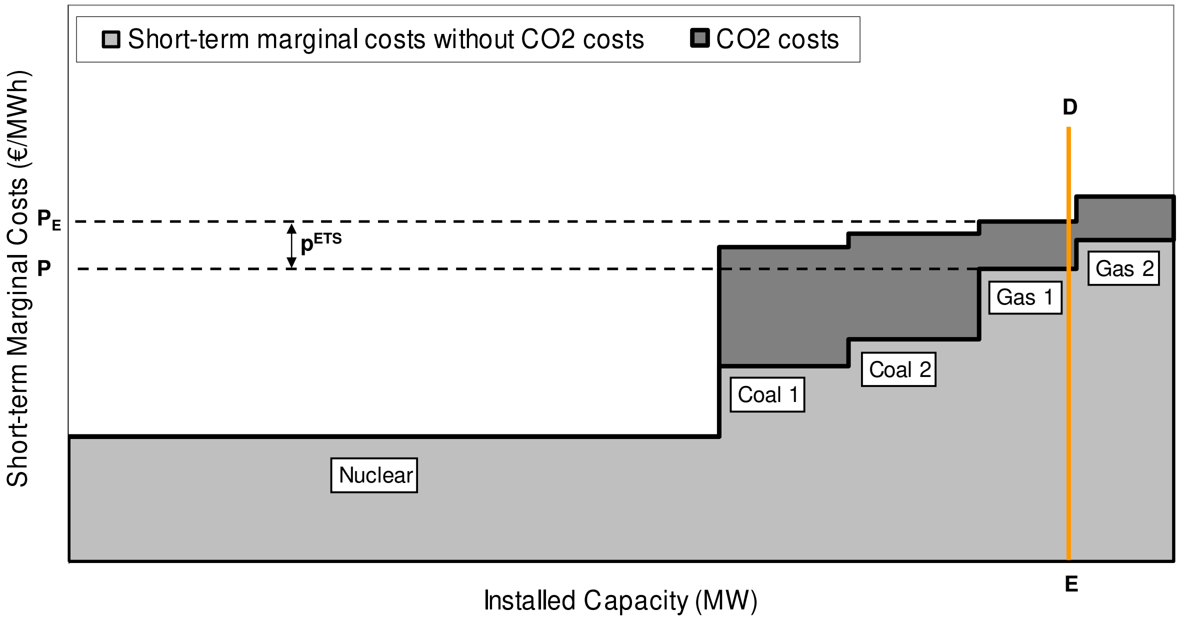
Finally, there is also an interaction with the objective of tradable white certificate schemes to increase energy efficiency. The impact on investment in energy efficiency depends on the net effect on the retail price. This cannot be determined *a priori*. As indicated above, retail prices are *lower,* with consequent *less* investment in energy efficiency with the TGC scheme, compared with the EU ETS alone. This is not, however, a general conclusion. It is equally possible that the TGC scheme does not substantially lower the allowance price, and that the cost of certificates outweighs the decrease in the wholesale price occasioned by the TGC scheme. In this case, retail prices will increase, with better incentives for energy efficiency investment. As mentioned, in the long run retail prices unambiguously increase *more* with the TGC scheme than with the EU ETS alone, again leading to more energy efficiency investment.

5.2.3 Effect on the merit order and fuel mix of generation

The above discussion indicates that the interactions are very complicated and depend on a range of specific factors. One illustration of this is the potentially impact of a TGC scheme in the short run, i.e., for a given merit order and fixed demand . Consideration of the effect on the marginal operator gives rise to additional complications.

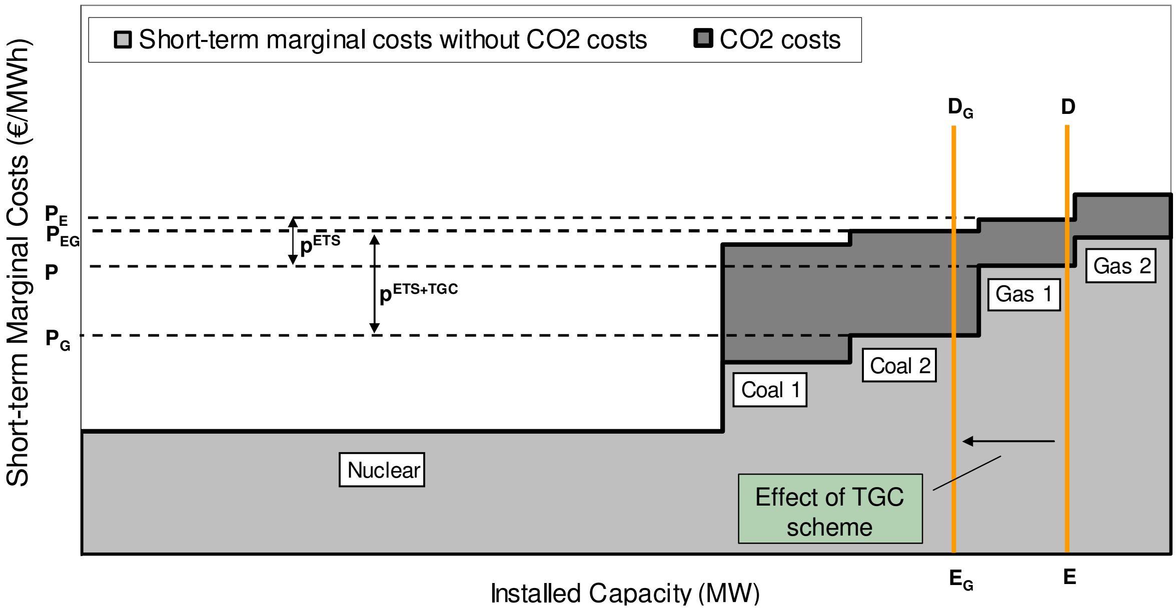
This situation is depicted in Figure 5.7 (similar to Figure 2.4, in Chapter 2), a representation of the wholesale market for non-green electricity. The y-axis shows the short-term marginal cost of generation, while the x-axis represents the available capacity of non-green generation. Prior to both the EU ETS and a TGC scheme, demand is indicated by schedule *D*, and is fixed at the amount *E*, with wholesale price *P*, corresponding to the short-term marginal cost of gas-fired generation. The introduction of the EU ETS does not change short-term demand, which is inelastic and therefore fixed at level *E*. However, the EU ETS does cause a rise in the wholesale electricity price from *P* to P_E, incorporating the marginal opportunity cost of gas-fired generation. The opportunity cost is indicated by p^{ETS} in the figure.

Figure 5.7
Effect of the EU ETS on short-term electricity prices (no TGC scheme)



The introduction of the TGC scheme displaces some non-green generation by mandating that a certain proportion of total electricity consumed must be from green producers. This is illustrated in Figure 5.8. The new demand for non-green electricity is E_G in the figure. In this example, green generation displaces all available gas-fired generation, and the new marginal technology is coal-fired generation. This means that the new wholesale electricity price is that corresponding to the marginal cost of coal generation, *including* the marginal opportunity cost of CO_2 emissions as determined in the allowance market. The new price is P_{EG}, while P_G is the price that would have obtained at demand E_G, i.e., with the TGC scheme but without the EU ETS. The TGC scheme thus changes the price impact of the EU ETS, and the net impact of the EU ETS with the TGC scheme is indicated by $p^{ETS+TGC}$ in the figure. (As represented, P_E is still higher than P, the original, pre-EU ETS wholesale electricity price.)

Figure 5.8
Effect of EU ETS when a TGC scheme changes the fuel mix of generation



With this particular configuration of green quota, merit order, and demand (described in Figure 5.8), the TGC scheme in effect increases the impact of the EU ETS on wholesale electricity prices, as $p^{ETS+TGC}$ is larger than p^{ETS}.

This example is clearly very simple, and also a special case. With a different merit order, or smaller green quota, there may be no change in the CO_2-intensity of the marginal producer. Also, green quotas are generally introduced over a period of time. To the extent that wholesale prices are reflected in retail prices, there therefore may be a further impact on electricity demand and total electricity consumed (this would amplify the effect described by occasioning a further shift to the left in the figure). In addition, adjustments will eventually be made to the electricity generation stock in response to the new conditions created by the TGC scheme. As outlined in Section 3.2.2.5, the exact long-term adjustments to generation plant resulting from the introduction of a TGC scheme depend on the extent to which a situation of excess capacity ensues, and the rate at which the closure of plants and eventual investment in new plant takes place.

Nonetheless, this example illustrates the generic point that a TGC scheme potentially has an impact on the electricity generation merit order, including the characteristics of the marginal technology. To the extent that this affects the CO_2 intensity of the marginal producer, it can also have an impact on the wholesale market price effects of the EU ETS.

5.2.4 Effect on the costs and benefits for different groups

The TGC scheme will impose costs on some groups and provide benefits to others. These will add to the costs and benefits already imposed by the EU ETS. The net effect of these changes may be assessed by combining the analysis of the EU ETS presented in Chapter 2 with that of an idealised TGC scheme presented in Chapter 3. For simplicity, as before, we assume that electricity generators pass-on the opportunity cost of CO_2 allowances.

There are three groups of interest: producers of non-green electricity, producers of green electricity, and electricity consumers. It is also useful to distinguish between 'high-CO_2' generators (e.g., coal) and 'low-CO_2' generators (e.g., nuclear). It is again important to stress that this is not a full assessment of the costs and benefits of a TGC scheme, since market failures (including environmental externalities) and secondary effects in other markets are ignored.

The effects on producer surplus of combining a TGC scheme with the EU ETS are as follows:

§ Producers non-green electricity:

- *Lose* from the reduction in the market available to them when the green quota is introduced, as well as the consequent decrease in the wholesale electricity price. This is similar to the situation without the EU ETS.
- *Gain/lose* from the lower allowance price caused by the TGC scheme if their generation has a higher/lower CO_2 intensity than the marginal generator *after* the effects of the TGC scheme.
- *Gain/lose* if (a) the TGC scheme causes a shift from a low/high to a high/low-emitting marginal producer, and (b) their emissions intensity is lower than that of this new marginal producer.

§ Producers of non-green electricity:

- Gain from the introduction of the green quota
- The impact of the lower allowance price and wholesale price is neutral as the certificate price adjusts to provide the support necessary.

§ Electricity consumers:

- May either gain or lose in the short run, depending on the net effect on retail prices (which is ambiguous)
- Lose in the long-run, as the TGC scheme causes retail prices to rise further, above the level of the EU ETS alone in the long run.
- Nonetheless, the interactions of the two schemes, with lower allowance prices, mean that the impact of the combination of instruments is lower than would be the sum of each one operating in isolation from the other.

The magnitude of these impacts will depend on a variety of factors, including: the elasticity of (green and non-green) supply and demand in the electricity market; the relative stringency of the EU ETS cap and the green quota; the extent to which the opportunity cost of EU ETS allowances and green certificates are passed through. The impact of the EU ETS is likely to be greater than that of existing TGC schemes, so the additional impacts of the latter on producers and consumers may be relatively small.

5.2.5 Summary

The most immediate impact of a TGC scheme on the EU ETS is mediated through its displacement of CO_2 emissions and consequent potential effect on the allowance price, as was discussed in detail above. However, there are also second-order effects that depend on the way that the TGC scheme affects the fuel mix and merit order of electricity generation. In the second case, the TGC scheme may affect the CO_2 emissions intensity of the marginal electricity producer. As this is a direct determinant of the effect of the EU ETS on the wholesale price, it changes the impact of the trading scheme. The effect may be to either increase or decrease the wholesale price impact of the EU ETS, depending on the precise characteristics of the merit order and fuel mix.

These effects mean that the effect of superimposing a TGC scheme on the EU ETS is more than just an addition of effects. The exact outcomes cannot be predicted *a priori*, but depend on the exact circumstances of the relevant electricity markets.

Table 5.1summarises the 'price and quantity' effects of introducing a TGC scheme (or increasing the quota of an existing TGC scheme) in a country that is already participating in the EU ETS. These highly stylised results relate to an idealised TGC scheme that is confined to electricity efficiency and to a national electricity market that is isolated from international trade. The columns represent:

§ the effect of the EU ETS alone, compared to no regulatory intervention;

§ the effect of the EU ETS and TGC scheme in combination, compared to no regulatory intervention; and

§ the additional effect of introducing a TGC scheme (i.e., the effect of the instrument combination compared to the EU ETS alone)

Table 5.2 summarises the distributional effects of introducing a TGC scheme in a country that is already participating in the EU ETS. The three columns have the same interpretation as in Table 5.1. Again, it should be emphasised that this is not a complete analysis of the costs and benefits of the instrument combination, since market failures and effects in secondary markets are ignored. If these were taken into account and quantified, the instruments could lead to positive benefits for society as a whole. Nevertheless, the analysis does illustrate which groups are likely to benefit directly from the instruments and which are likely to incur additional costs. These results should still broadly apply to real-world markets. While the magnitude of effects may vary widely, the *sign* of these effects is less likely to do so.

Table 5.1
Summary price and quantity effects of introducing a TGC scheme in a country participating in the EU ETS

Variable	EU ETS	EU ETS and TGC scheme	Additional impact of introducing the TGC scheme
Wholesale electricity price	Increased in short term	Likely increased in short term	Lower price than with EU ETS alone in the short-run, due to lower allowance price and smaller volume of (price-setting) non-green generation.
	Increased in long term	Increased in long term	Long-run prices unaffected by the TGC scheme. Price therefore increases due to EU ETS.
Retail electricity price	Increased	Likely increased	Retail price reduced lower by wholesale price, but increased by cost of certificates. Long-run impact is a net price increase.
Electricity demand	Reduced	Reduced	In the short-run demand can either be higher or lower than with EU ETS alone, as the TGC scheme contributes to lower wholesale electricity prices.
			In the long-run, wholesale prices are unaffected by the TGC scheme, and demand therefore lower than with the EU ETS alone (owing to higher retail prices).
National non-green generation	Reduced	Reduced	Lower generation than with EU ETS alone due to both restriction through the green quota and likely lower demand.
National green generation	Likely Increased	Increased	Existing renewables have low short run marginal cost and should take preference in merit order. They are therefore unlikely to be affected by reduced demand.
National CO_2 emissions	Reduced	Reduced	Emissions from national electricity generators decrease. National emissions decrease provided at least some of the thus ‘freed-up’ allowances are sold to operators in other countries.
EU CO_2 emissions	Reduced	Reduced	Unaffected by TGC scheme. With EU ETS in place, TGC scheme has no impact on EU CO_2 emissions within a given EU ETS phase.
Investment in end-use efficiency	Increased	Increased	Impact compared to the EU ETS alone depends on the effect on retail prices. These are likely to increase in the short run, and unambiguously increase in the long run.
Investment in new renewables	Increased	Increased	Increase to the level set by the green quota.
EU ETS allowance price	-	-	Lower, due to displacement of CO_2 emissions from non-green generation. Abatement paid for by electricity consumers and non-green producers through TGC scheme

Notes: Columns 2 and 3 compare the effects of the policies to a situation where there is no regulation. Column 4 outlines the incremental effect of adding the EU ETS —i.e., it compares the effects in column 3 to those in column 2.

Table 5.2
Summary distributional effects of introducing a TGC scheme in a country participating in the EU ETS

Variable	EU ETS	EU ETS and TGC scheme	Additional impact of introducing the TGC scheme
Producer surplus			
High-CO_2 green electricity generators	Reduced	Reduced	Surplus further reduced by TGC scheme restricting market share and reducing wholesale prices. This may be partly offset by lower allowance prices due to the TGC scheme, but the effect is likely to be small.
Low-CO_2 non-green electricity generators	Increased	Reduced	Surplus further reduced by TGC scheme restricting market share and reducing wholesale prices. Lower allowance prices causes further loss of surplus.
Green electricity generators	Increased	Increased	Further increase from TGC scheme.
Electricity generators overall	Increased	Ambiguous	EU ETS may give rise to 'windfall' gains from higher prices while the TGC scheme leads to gains by green generators due to TGC scheme. Against this, the TGC scheme and EU ETS both lead to lower demand, while the TGC scheme results in lower allowance prices, a market share restriction for non-green generators, and lower wholesale electricity prices. The net impact is therefore ambiguous, but likely lower surplus compared to the EU ETS alone.
Consumer surplus			
Consumers overall	Reduced	Reduced	Surplus likely to be lower than with EU ETS alone, due to lower volume of electricity consumed and higher retail prices. (In the short run, these effects do not unambiguously follow.)

Notes: Columns 2 and 3 compare the effects of the policies to a situation where there is no regulation. Column 4 outlines the incremental effect of adding the EU ETS —i.e., it compares the effects in column 3 to those in column 2.

5.3 Effect of a White Certificate Scheme on the EU ETS

This section performs the same analysis as the previous one, but studying the impact of a tradable white certificate scheme to promote energy savings rather than a tradable green certificate scheme to promote renewable and other 'green' electricity. As in Chapter 4, we assume that the participants in the TWC scheme are electricity retailers and that the scheme is confined to improving electricity efficiency. We also maintain the assumption of full pass-through of certificate costs to electricity consumers, as would be expected in a competitive market or if certificates as treated as 'allowable costs' in regulated market.

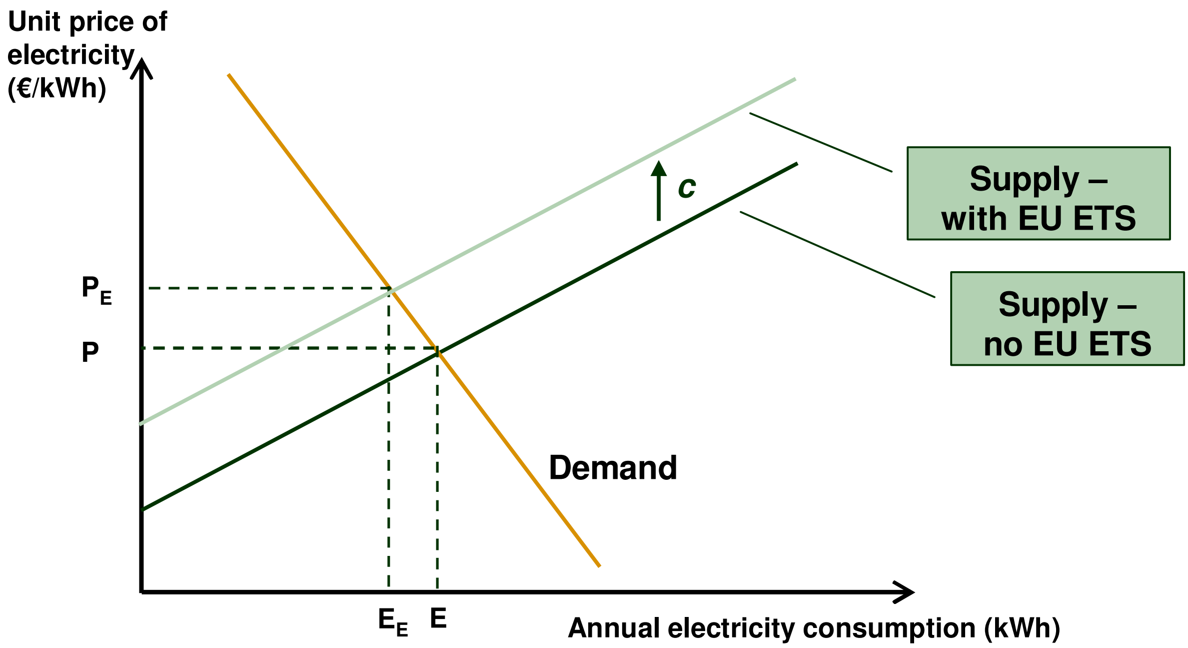
Many of the effects of TWC schemes are similar to those of TGC schemes, and in order to provide a full treatment some of the discussion repeats the analysis of the previous section.

The main points of difference from the case of a TGC scheme stem from the reduction in demand occasioned by energy savings, and the different specification of the white target as *additional* to the baseline and *absolute*, rather than in the *relative* form used in most TGC schemes. These issues are further discussed in Chapter 7.

5.3.1 Effect on electricity demand and electricity prices

Figure 5.9 illustrates the effect of the EU ETS on the electricity market, similar to Figure 5.3, above. Wholesale/retail prices increase from P to P_E, while demand falls from E to E_E, as the opportunity cost of CO_2 emissions is included in the wholesale and retail electricity price.

Figure 5.9
Effect of the EU ETS on the electricity market



The effect of an idealised TWC scheme on national electricity markets was discussed in Chapter 4. It was shown that the final equilibrium in the electricity supply market results from a combination of two factors: a) a reduction in electricity demand, with a corresponding reduction in electricity prices, following the subsidised investment in energy efficiency; and b) an increase in electricity prices, with a corresponding further reduction in electricity demand, following the recovery of the cost of the subsidy from electricity consumers.

The net effect of the TWC scheme on the electricity market is illustrated in Figure 5.10. Prior to the introduction of the scheme, a quantity E of electricity is supplied at a price P. Following the introduction of the TWC scheme, a quantity E_T of electricity is supplied at a price P^C_T. In total, electricity demand has *reduced* from E to E_T and consumer electricity prices have *increased* from P to P^C_T. But while a reduction in electricity demand is an unambiguous outcome of the TWC scheme, the final consumer price for electricity (P^C_T) may be greater or less than the original price (P). It all depends upon whether the reduction in price from the lower demand following the energy efficiency investment outweighs the increase in price from cost recovery. This in turn depends upon the relative slope of the demand and supply curves.

As discussed in chapter 4, electricity retailers are assumed to recover the costs of the TWC scheme through a per unit levy (*l*) on the consumer price of electricity. Since it is assumed that consumers pay the full cost of the subsidy, this cost recovery does not affect the *wholesale* price of electricity. However, wholesale prices may fall if the cost recovery leads to an additional reduction in electricity demand. If we assume that transmission and distribution costs are zero, the wholesale price of electricity may be given by the cost of supplying the final demand (E_T), *excluding* the per unit levy (*l*). This is represented by $P^W{}_T$ in Figure 5.10. In contrast to the final consumer price ($P^C{}_T$), the final wholesale price ($P^W{}_T$) is unambiguously reduced by the introduction of the TWC scheme ($P^W{}_T$<P).

Figure 5.10
Effect of a TWC scheme on the electricity market

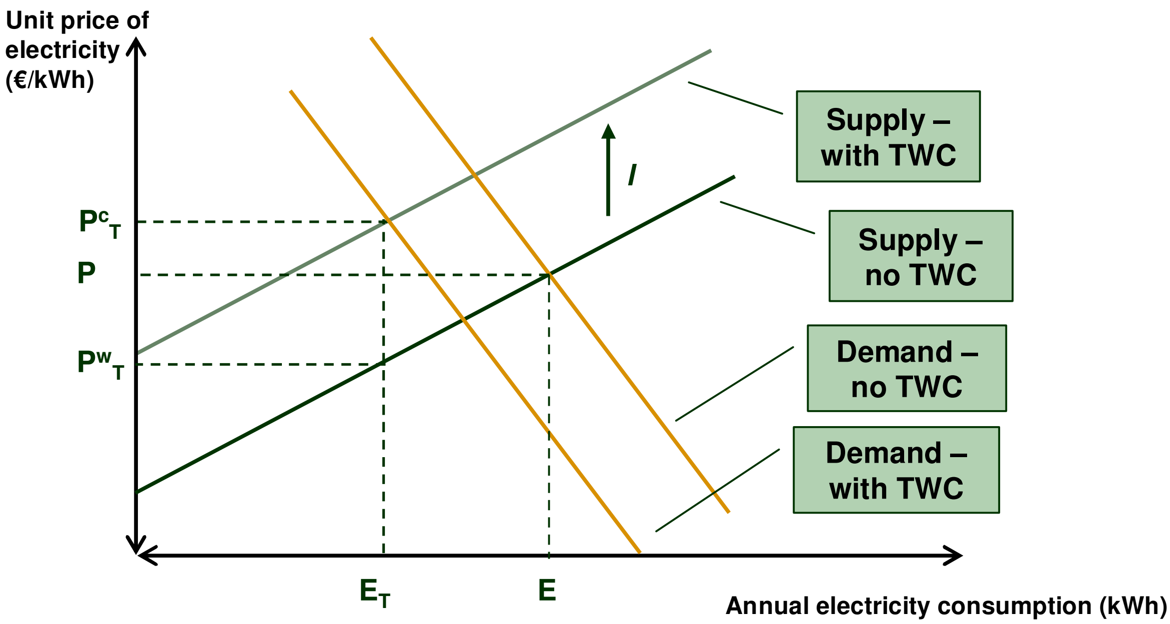


Figure 5.11 superimposes the effect of the TWC scheme (Figure 5.10) on the effect of the EU ETS (Figure 5.3). In contrast to the case of the TGC scheme above, it assumed that the effect of the TWC scheme is entirely *additional* to that of the EU ETS alone. There is therefore no effect on allowance prices, and no direct interaction. This is a reasonable assumption since the 'additionality' of energy savings from individual projects should be measured from a baseline that includes the effect of the EU ETS, which is already in place (see Chapter 4).[60]

The combination of the two instruments leads to an equilibrium where demand E_{ET} is supplied at retail price $P^C{}_{ET}$. This represents the net effect of: a) internalising the opportunity

60 As described in Chapter 7, this may not be the case if the instrument sequence is reversed; i.e., if a TWC scheme is in place and the EU ETS subsequently is introduced. However, as the EU ETS is already in place in the EU, this is largely a counterfactual scenario.

cost of EU ETS allowances in the electricity price; b) reductions in electricity demand as a result of subsidised energy efficiency improvements through the TWC scheme; and c) recovery of the costs of this subsidy through a levy (*l*) on all electricity consumers.

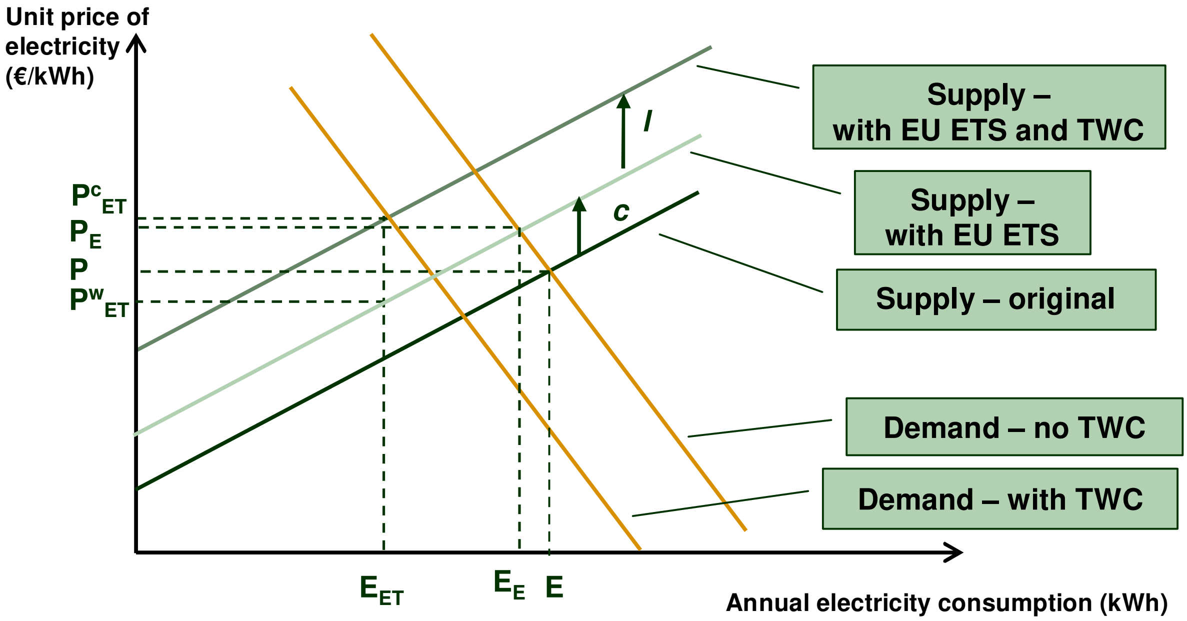
Compared to the EU ETS alone (E_E, P_E), the following changes are apparent:

- Electricity demand is lower than with the EU ETS alone ($E_{ET}<E_E$)
- The retail electricity price may either be higher or lower than with the EU ETS alone ($P^C_{ET}<>P_E$). While the reduction in demand following efficiency investment lowers the retail price, the recovery of costs increases the retail price. If the supply curve is relatively flat, the TWC scheme is likely to increase retail prices compared to the EU ETS alone.
- The wholesale price is lower than with the EU ETS alone ($P^W_{ET}<P_E$).

Similarly, compared to the electricity market in the absence of *any* environment regulation (E, P), the following changes are apparent:

- Electricity demand is lower than with no regulation ($E_{ET}<E$)
- The retail electricity price may either be higher or lower than with no regulation ($P^C_{ET}<>P$). While the reduction in demand following efficiency investment lowers the retail price, this is offset by an increase in retail price from both cost recovery and the EU ETS. In practice, the latter two factors are likely to outweigh the first, leading to an increase in retail prices.
- The wholesale price may either be higher or lower than with no regulation ($P^W_{ET}<>P$). In this case, the reduction in price as a consequence of demand reduction is offset by an increase in price from the EU ETS. But since cost recovery does not increase wholesale prices, these are more likely to fall than are retail prices. At the same time, if the supply curve is relatively flat, the price increase from the EU ETS is likely to dominate, leading to an increase in wholesale prices.

Figure 5.11
Effect on the electricity market of introducing a TWC scheme alongside the EU ETS



5.3.2 Effect on electricity generation and CO_2 emissions

As indicated above, the addition of the TWC scheme leads to lower electricity demand than with the EU ETS alone. This should reduce electricity generation from non-green (fossil fuel) plant, since these are likely to be the marginal plant on the national system. Whether there will be a corresponding reduction in renewable electricity generation will depend on the location of existing renewables in the merit order. Since existing renewables have low short-run marginal costs, they are likely to provide base-load supply and hence be unaffected by small changes in demand.

The TWC scheme may also *reduce* investment in new renewable capacity. In the absence of other policy mechanisms, the incentive to invest in new capacity derives primarily from the wholesale price of electricity. As indicated above, this is unambiguously reduced by the introduction of the TWC scheme. However, since new renewables are uncompetitive at current electricity prices, the additional effect of the TWC scheme could be minimal.

Subsidies from the TWC scheme will increase investment in energy efficiency. On the other hand, the retail electricity price may either increase or decrease as a result of the scheme, and in the case of the latter there will be a smaller price incentive for energy efficiency. However, the price reduction will be small at best and the most likely outcome is for retail electricity prices to increase. Overall, the effect of the TWC scheme should be to increase investment in energy efficiency.

Lower demand and lower non-green electricity generation should lead to lower CO_2 emissions from national electricity generators. As in the case of a TGC scheme, however, this will not lead to lower EU-wide CO_2 emissoins and also will not help EU Member States achieve their Kyoto targets.

5.3.3 Effect on the merit order and fuel mix of generation

The TWC scheme may also have some additional impacts on the merit order and fuel mix of generation that are not captured in the stylised analysis above. The mechanisms are similar to those of a TGC scheme, discussed above.

It is less likely that such changes occur in the case of a TWC scheme, as the amount of (non-green) electricity generation displaced is likely to be smaller. In the case of a TGC scheme, the quota for renewable generation may reduce the share of non-green plant in total electricity generation by a significant amount (e.g., by 10 or more by 2010 in some EU Member States). In the case of a TWC scheme, the reduction in demand for non-green generation results solely from the reduction in aggregate electricity demand. With weak targets for energy savings, low demand elasticity and underlying demand growth, the probability of a TWC scheme achieving a significant reduction in energy demand may be rather low. In these circumstances, there is unlikely to be any change in the plant merit order. (Naturally, it is theoretically possible that a TWC scheme has a very large quota as well)

5.3.4 Effect on costs and benefits for different groups

As in the case of TGC schemes, the TWC scheme will impose costs on some groups and provide benefits to others, adding to the effects of the EU ETS. There are three groups of interest: producers of energy efficiency equipment, electricity producers, and electricity consumers. As in the case of TGC schemes, it is useful to distinguish between 'high-CO_2' generators (e.g., coal) and 'low-CO_2' generators (e.g., nuclear). In addition, TWC shcmes make it necessary to distinguish between those consumers who benefit from the subsidised energy efficiency investments and those who do not.

Again, it is again important to stress that this is not a full assessment of the costs and benefits of a TWC scheme, since market failures are not included. The neglect of failures in the energy efficiency market is of particular importance, since these provide a primary rationale for the introduction of a TWC scheme.

The effects on producer surplus of combining a TWC scheme with the EU ETS are as follows:

§ Producers of energy efficiency equipment will benefit from the instrument combination The TWC scheme will encourage additional investment through the subsidy, while the EU ETS will encourage investment through higher electricity prices.

§ Electricity generators will lose from the TWC scheme: first, as a result of the reduction in demand following the subsidised energy efficiency investment; and second as a result of the additional reduction in demand following cost recovery. This loss will offset the benefits to generators from free allocation of allowances in the EU ETS. In principle, therefore, the net effect of the combined TWC scheme and EU ETS on electricity generators is ambiguous. It is likely, however, that the reduction in aggregate demand – and hence the loss in producer surplus - from the TWC scheme will be relatively small, while the gains from the free allocation of allowances will be larger. Hence, electricity generators should still benefit from the instrument combination.

- The impact of the TWC scheme on individual generators will depend on their position in the plant merit order. Base load generators should be largely unaffected, while those at the margin will lose. Similarly, the impact of the EU ETS on individual generators will depend on their emission intensity compared to that of the marginal producer. Lower-CO_2 generators should benefit from the EU ETS while high-CO_2 generators will lose. Base load, low-CO_2 generators such as nuclear should benefit overall from the instrument combination while marginal high-CO_2 generators such as coal should lose.

The effects on consumer surplus of combining a TWC scheme with the EU ETS are as follows:

- The effect of the TWC scheme on consumers is ambiguous, but (ignoring market failures) aggregate losses are more likely than aggregate gains. Moreover, even if the TWC scheme provides net benefits to consumers, these are likely to be smaller than the losses to consumers from the EU ETS. Hence, consumers overall are likely to lose from the instrument combination.
- Consumers hosting the efficiency investments should benefit from the TWC scheme. They receive direct benefits from the subsidised investments, but since consumer prices may go up or down as a result of the scheme, the sign of any indirect benefits is ambiguous. In practice however, the direct benefits should outweigh any indirect losses. Whether they are also sufficient to outweigh the losses from the EU ETS will depend on market circumstances.
- Consumers not hosting the efficiency investment are likely to lose from the TWC scheme. While they may benefit from any reduction in retail prices following the efficiency investment, this is likely to be outweighed by the higher prices from cost recovery (especially if the supply curve is flat). Hence, for this group (which represent the majority of consumers) the TWC scheme is likely to add to the losses from the EU ETS.

The magnitude of these impacts will depend on a variety of factors, including: the elasticity of supply and demand in the electricity market and energy efficiency market; the relative stringency of the targets in the two schemes; the extent to which the opportunity cost of allowances are passed through; and the degree to which market failures inhibit investment in energy efficiency, which would increase the net benefits from the TWC scheme. Overall, it may be that the (small) impacts of TWC schemes are outweighed by the (large) impacts of the EU ETS.

As well as changing the overall impact on producers and consumers, the interaction between the instruments changes the costs of meeting the EU ETS target. As discussed in above, the TWC scheme effectively lowers the ‘business as usual’ emissions from the installations covered by the EU ETS, thereby making the cap less stringent and lowering the EU ETS allowance price. Consumers pay for this additional abatement through the TWC scheme. But while the net cost to EU ETS participants of meeting the cap may be reduced, the total costs to society of reducing CO_2 emissions will be increased.

The same conclusion does not necessarily follow for the TWC scheme. Compared to a situation with no regulation, the EU ETS will increase retail electricity prices and increase the demand for energy savings. But since it is introduced prior to the TWC scheme, these higher prices should be taken into account when assessing the additionality of any energy-savings encouraged by the latter.

A higher baseline demand for energy savings implies that the TWC scheme must subsidise higher cost energy efficiency improvements to meet its energy saving target. But the price of white certificates should be determined by the *difference* between the marginal cost of energy saving before the introduction of the TWC scheme and the marginal cost required to meet the energy saving target. As discussed in Chapter 4, if the supply and demand curves for energy savings are linear over the region of interest, the price of white certificates and hence the aggregate cost of meeting the energy saving target should be independent of the underlying demand for energy efficiency. Hence, the total cost of the TWC scheme for producers and consumers should be unaffected by the pre-existence of the EU ETS. As discussed in Chapter 4, this conclusion would not apply if the supply and demand curves were non-linear over the region of interest.

5.3.5 Summary

Table 5.3 summarises the 'price and quantity' effects of introducing a TWC scheme (or tightening the target in a TWC scheme) in a country that is already participating in the EU ETS. These highly stylised results relate to an idealised TWC scheme that is confined to electricity efficiency and to a national electricity market that is isolated from international trade. The columns represent:

§ the effect of the EU ETS alone, compared to no regulatory intervention;

§ the effect of the EU ETS and TWC scheme in combination, compared to no regulatory intervention; and

§ the additional effect of introducing a TWC scheme (i.e., the effect of the instrument combination compared to the EU ETS alone)

Table 5.3 summarises the distributional effects of introducing a TWC scheme in a country that is already participating in the EU ETS. The three columns have the same interpretation as in Table 6.1. Again, it should be emphasised that this is not a complete analysis of the costs and benefits of the instrument combination, since market failures and effects in secondary markets are ignored. If these were taken into account and quantified, the instruments could lead to positive benefits for society as a whole. Nevertheless, the analysis does illustrate which groups are likely to benefit directly from the instruments and which are likely to incur additional costs. These results should still broadly apply to real-world markets. While the magnitude of effects may vary widely, the *sign* of these effects is less likely to do so.

Table 5.3
Summary price and quantity effects of introducing a TWC scheme in a country participating in the EU ETS

Variable	EU ETS	EU ETS and TWC scheme	Additional impact of introducing the TWC scheme
Wholesale electricity price	Increased	Likely increased	Lower price than with EU ETS alone
Retail electricity price	Increased	Likely increased	Retail price reduced by lower demand, but increased by cost recovery. Likely increased price if supply is insensitive to price.
Electricity demand	Reduced	Reduced	Lower demand than with EU ETS alone
National non-green generation	Reduced	Reduced	Lower generation than with EU ETS alone due to lower demand.
National green generation	Likely increased	Likely increased	Existing renewables have low short run marginal cost and should take preference in merit order. Generation therefore is unlikely to be affected by reduced demand.
National CO_2 emissions	Reduced	Reduced	Ambiguous. Lower emissions from national electricity generators. But whether national emissions are lower depends upon who purchases and uses the surplus EU ETS allowances.
EU CO_2 emissions	Reduced	Reduced	Unaffected by TWC scheme. With EU ETS in place, TWC scheme has n impact on EU CO_2 emissions within a given EU ETS Phase.
Investment in end-use efficiency	Increased	Increased	Increased investment due to TWC subsidies. Offset by ambiguous incentive from retail prices – but latter also likely to increase
Investment in renewable energy	Increased	Likely increased	Lower incentive to invest due to lower wholesale electricity prices
EU ETS allowance price	-	-	Lower, due to displacement of CO_2 emissions from generation. Abatement paid for by consumers through TWC scheme

Notes: Columns 2 and 3 compare the effects of the policies to a situation where there is no regulation. Column 4 outlines the incremental effect of adding a TGC scheme—i.e., it compares the effects in column 3 to those in column 2.

Table 5.4
Summary distributional effects of introducing a TWC scheme in a country participating in the EU ETS

Variable	EU ETS	EU ETS and TWC scheme	Additional impact of introducing the TWC scheme
Producer surplus			
Energy efficiency producers	Increased	Increased	Higher surplus than with EU ETS alone
High-CO_2 electricity generators	Reduced	Reduced	Lower surplus than with EU ETS alone
Low-CO_2 electricity generators	Increased	Ambiguous	Lower surplus than with EU ETS alone. But benefit from EU ETS likely to exceed loss from TWC
Electricity generators overall	Increased	Ambiguous	Lower surplus than with EU ETS alone. But benefit from EU ETS likely to exceed loss from TWC
Producers overall	Increased	Ambiguous	Ambiguous impact. But overall surplus likely to be positive
Consumer surplus			
Beneficiaries of TWC investment	Reduced	Ambiguous	Higher surplus than with EU ETS alone.
Non-beneficiaries of TWC investment	Reduced	Ambiguous	Surplus more likely to be lower than with EU ETS alone
Consumers overall	Reduced	Ambiguous	Surplus likely to be lower than with EU ETS alone.

Notes: Columns 2 and 3 compare the effects of the policies to a situation where there is no regulation. Column 4 outlines the incremental effect of adding a TGC scheme—i.e., it compares the effects in column 3 to those in column 2.

6 Impact of the EU ETS on Green Certificate Schemes

This section reverses the investigation conducted above, considering what implications the existence of the EU ETS has for TGC schemes. This includes how the EU ETS affects the certificate market as well as the impact of the EU ETS on the interaction of the TGC scheme and the electricity market. A key conclusion is that the EU ETS reduces certificate prices. In addition, there are complex interactions that determine how the costs and benefits of different groups in the electricity market are affected by the relative impacts of the TGC scheme and the EU ETS.

This structure of the analysis is clearly somewhat counterfactual (notably, the EU ETS is already in place, as are some TGC schemes). It is nonetheless relevant for comparing the situation faced a Member State considering to introduce a TGC scheme, as it highlights how the presence of the EU ETS may alter the situation compared to a 'textbook' TGC scheme. In addition, by structuring the analysis in this way, several individual effects can be identified that might otherwise not be very clear. The need for a simplified structure reflects of the fact that an analysis ideally would be carried out in a framework of general equilibrium, taking into account the simultaneous interactions and feedback that various markets and programmes exhibit. A general equilibrium analysis would require modelling that is well outside the scope of this study.

Finally, we also consider how different TGC scheme designs affect the various interactions.

6.1 Effects of the EU ETS on the Green Certificate Market

In this section we consider the opposite situation, in which a TGC scheme is in place and the EU ETS is 'overlaid'. As with the case of the EU ETS presented in Section 5.1.3, the principal effects are mediated through the market for the tradable instrument – in this case the green certificates. However, there are also issues arising from the way that the TGC scheme and EU ETS interact with the electricity market.

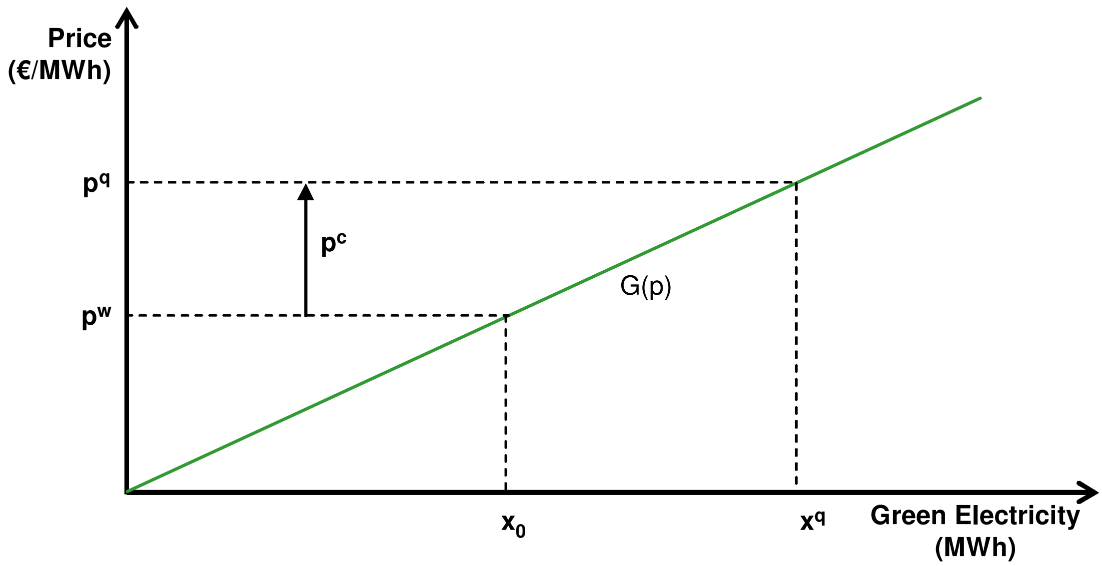
6.1.1 Short-term effects of the EU ETS on the TGC scheme and the green certificate market

As discussed in more detail in Section 3.2.2.1 the certificate price is determined by the difference between the revenue obtainable by green producers in the electricity market, and that needed to cover their cost of generation. More precisely, we would expect the certificate price to be equal to the amount necessary to fill the cost gap and make generation profitable for the *marginal* green producer, that is, the last green producer to meet demand and fill the quota. In a competitive certificate market the price is not expected to be larger than this, as green producers would then find it profitable to enter the market and offer lower certificate prices.

This relationship is illustrated in Figure 6.1 (similar to Figure 3.2, above). x^q is the amount of green electricity implied by the green quota under the TGC scheme for a given level of electricity demand. The wholesale price of electricity prior to the introduction of the EU ETS is represented by p^w, while p^q is the marginal cost of the marginal green producer, or, equivalently, the wholesale electricity price that would be required to make the amount x^q green generation viable. The resulting certificate price is p^c, the difference between these two.

The quota is directly determined by the policy maker, while p^q is determined by the green merit order and the amount of electricity supplied. p^q is therefore only constant for a given green quota, green merit order, and level of demand. Both the green merit order and the level of demand can be taken to be fixed in the short run, but may adjust in the longer run, as discussed below.

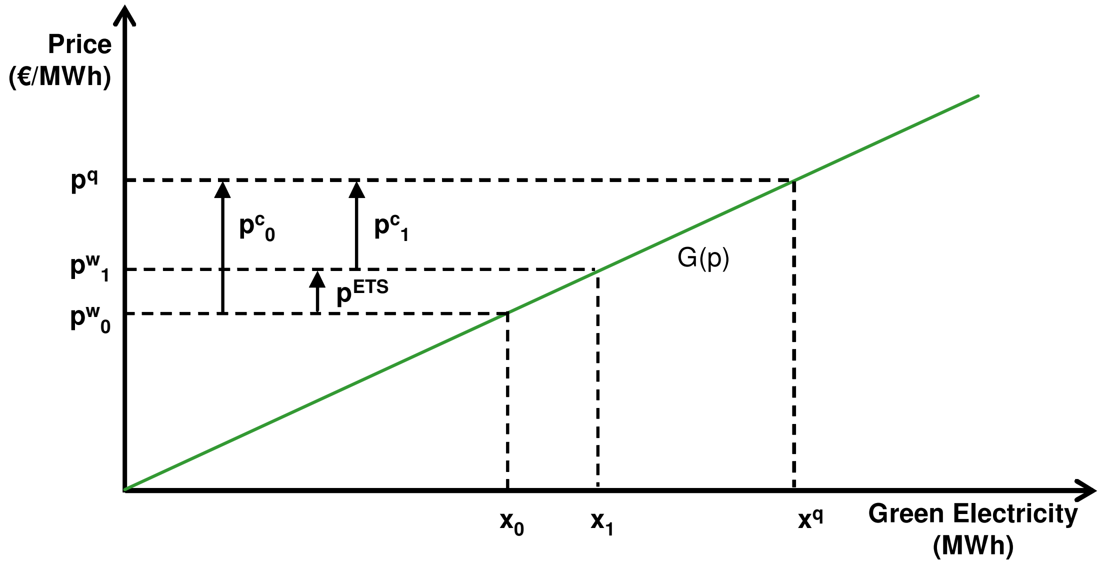
Figure 6.1
Green electricity supply schedule and the determination of the green certificate price



The short-term impact of the EU ETS on this market is illustrated in Figure 6.2 below. The wholesale price rise due to the EU ETS is p^{ETS}, corresponding to the increase from p^w_0 to p^w_1 in the figure. However, the EU ETS does not change the marginal cost of green generation is unaffected, as such generation does not result in CO_2 emissions (its emissions intensity is zero).[61] The merit order of green generation and price p^q therefore also remains unaffected. As a consequence, the difference between the wholesale electricity price and the marginal cost of green generation decreases, and certificate price therefore also decreases, from p^c_0 to p^c_1.

61 In fact, in the long run there are circumstances where the introduction of an emissions trading scheme *will* affect the costs of green generation. We return to this subject below.

Figure 6.2
Effect of EU ETS on green certificate market



This means that the immediate effect of the EU ETS on the TGC market depends on the extent to which the ETS causes the electricity price to increase (the magnitude of p^{ETS}). If the marginal producer were one with high emissions intensity (e.g., coal-fired generation) it would lead to a higher price rise (and hence lower certificate prices) than if it were one with low emissions intensity (e.g., gas-fired generation).[62]

A certain amount of green generation may be viable even in the absence of the TGC scheme. This is indicated by x_0 in the figure, which shows the amount of green electricity that is viable at wholesale price $p^w{}_0$. As the price increases to $p^w{}_1$, however, the amount of viable renewable generation increases to x_1. This shows that, in theory, a sufficiently high allowance price and corresponding increase in wholesale electricity prices could provide sufficient support for green electricity to meet the quota without the TGC scheme. This corresponds to the EU ETS causing a price rise from $p^w{}_0$ to the level p^q in the figure. At which point certificate prices would drop to zero. In reality, the allowance price required would be very high. With current allowance and TGC prices, allowance prices from €50-200 would be required, depending on the characteristics of the national merit order and fuel mix of the Member State.

6.1.2 Long-run effects of the EU ETS on the TGC scheme and the green certificate market

In the longer run, various additional adjustments may take place. There are three different aspects of the 'long run' in this context. First, there may be adjustments to the capital stock and available generation capacity, corresponding to the long-run in the wholesale market.

62 This effect is similar to other factors that affect the difference between the wholesale electricity price and the marginal cost of green generation. If, for example, gas prices were to increase and result in higher wholesale electricity prices, we would also expect certificate prices to drop. Similarly, if the efficiency of the marginal green generation improved and the marginal cost of green production dropped, we would expect certificate prices to adjust by decreasing as well.

Second, there may be a contraction in overall electricity demand as a consequence of the EU ETS, corresponding to the long-run in the retail market. Finally, there may be long-run effects of design elements of the EU ETS, mediated through the allowance allocation process. We briefly discuss each of these in turn.

6.1.2.1 Effects of the impact of the EU ETS on the electricity generation stock

As noted in Chapter 2, the long-run effects of the EU ETS may differ substantially from those observed in the short run. In particular, the long-run effect depends on the extent to which there is a change in the fuel mix of generation. For example, in a market where coal-fired generation is the marginal technology, the effect of the EU ETS on electricity prices is large in the short-run, reflecting the high emissions intensity of coal. This in turn improves the profitability of generation from fuels with lesser emissions intensities and could contribute to the incentive to construct additional low-emitting generation capacity (e.g., gas-fired generation). This in turn may lead to changes to changes in the fuel mix of generation and CO_2 emissions intensity of the marginal technology. If the long-term impact is a shift to more low-emitting generation as the marginal technology, the price effects of the EU ETS may be smaller in the long-run than they are in the short run.

This has two main consequences for a TGC scheme. First, certificate prices will be higher, as less support for green generation is offered through the EU ETS, and more consequently must be provided directly through the TGC scheme. Second, the amount of CO_2 displaced by the TGC scheme depends on what generation would have been in place had the TGC scheme note been in operation. For example, if the TGC scheme displaces coal-fired generation, then the amount of CO_2 emissions ‘avoided’ are larger than if gas-fired generation is displaced. If in the long-run the EU ETS leads to changes to the generation stock that mean that low-emitting generation increasingly is the marginal technology, then introducing TGC schemes would have less CO_2 reducing effects than otherwise.

6.1.2.2 Effects of the impact of the EU ETS on electricity demand

Electricity demand is likely to be elastic in the long run. To the extent the wholesale price increase of the EU ETS also results in retail price increases, this is likely also to result in a contraction in overall electricity demand. Indeed, increased energy efficiency or less use of production or services requiring electricity input may be among the cheapest CO_2 abatement options available for a given allowance price.

If the green quota is expressed in relative terms, a decrease in overall electricity consumption also results in a decrease in the absolute amount of green electricity supplied, and also in a lower marginal cost marginal green producer. This effect has three component parts. First, the extent of the contraction in overall demand depends on the retail price increase and the price-sensitivity of electricity demand. Second, the extent to which the overall decrease in demand translates into an absolute contraction in green electricity supply depends on the size of the green quota, with a larger contraction for a large quota. Finally, the extent of the decrease in the marginal cost of green electricity depends on the price-sensitivity of green electricity supply, with more of a decrease the less price sensitive is supply (‘the steeper is the supply schedule’).

As outlined in detail in Section 3.2.2.5.3, these demand adjustments mean that the certificate price decreases by an amount *greater* than the increase in the wholesale price. This reflects the lower cost of green generation at a lower absolute level of green electricity supply. Somewhat paradoxically, a stricter EU ETS cap and associated higher allowance and wholesale electricity prices can therefore lead to *less* support for green generation.[63] This may be counter-intuitive, but it is not an indication of a defect in the TGC scheme design. Instead, it follows from the self-adjusting properties of the certificate market that help minimise the cost required to meet a given (relative) quota. Put in simple terms, a lower level of green generation comes at a lower cost per unit of green electricity generated, and this is reflected in lower certificate prices.

6.1.2.3 Summary

In addition to the direct short-term interaction between allowance prices, electricity prices, and certificate prices, there are long-term electricity market adjustments due to the EU ETS that have a potential impact on the operation of a TGC scheme. These effects include:

§ Changes to the generation stock induced by the EU ETS may cause long-term electricity price increases to be smaller than short-term increases. This would lead to higher green certificate prices.

§ Changes to the CO2 intensity of the marginal producer occasioned by the EU ETS may mean that the amount of CO2 displaced by the TGC scheme is smaller than it would in the absence of the EU ETS.

§ A higher allowance price is likely to result in a greater contraction in electricity demand in the long run, and this has the effect of decreasing the effective subsidy available to green generators.

6.2 Effect of the EU ETS on a Green Certificate Scheme

6.2.1 Effects on electricity demand and electricity prices

The impact of a TGC scheme on the EU ETS and its implications for electricity demand and prices was discussed in Section 5.2.1., above. It was noted that the TGC scheme potentially leads to lower allowance prices, and that the combined effect of the two schemes on some variables therefore is smaller than would be the sum of each scheme taken individually.

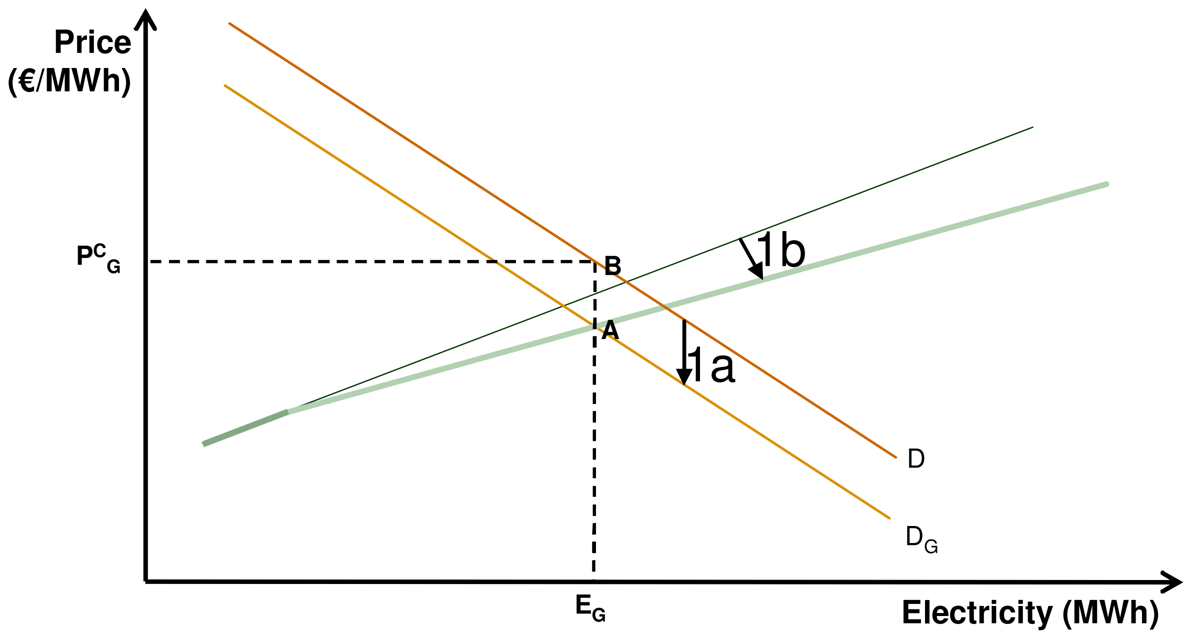
This section explores the opposite situation, where the EU ETS is superimposed on a TGC scheme. The results are analogous to those where a TGC scheme is superimposed on the E ETS, in that the introduction of the additional scheme (the EU ETS) leads to lower prices for the tradable instrument (green certificates). The EU ETS therefore lessens the impact *of the TGC scheme*, even as it introduces a large impact itself.

Figure 6.3, illustrates the impact of the TGC scheme alone on the retail electricity market. (The wholesale market effects are not considered as they present no interactions of interest to this discussion). The TGC scheme causes a lower level of demand (‘1a’) and a flatter total

63 See Amundsen and Nese (2005) for more discussion of this.

supply schedule ('1b'), as discussed in previous sections. The resulting quantity of electricity is E_G, while consumers pay P_{CG}. Note that the equilibrium is given by the intersection of total supply and the lower level of demand (D_G), indicated by *A* in the figure. Consumers, however, also pay the price of certificates, indicated by *B* in the figure.

Figure 6.3
Effect of a TGC scheme on the electricity market

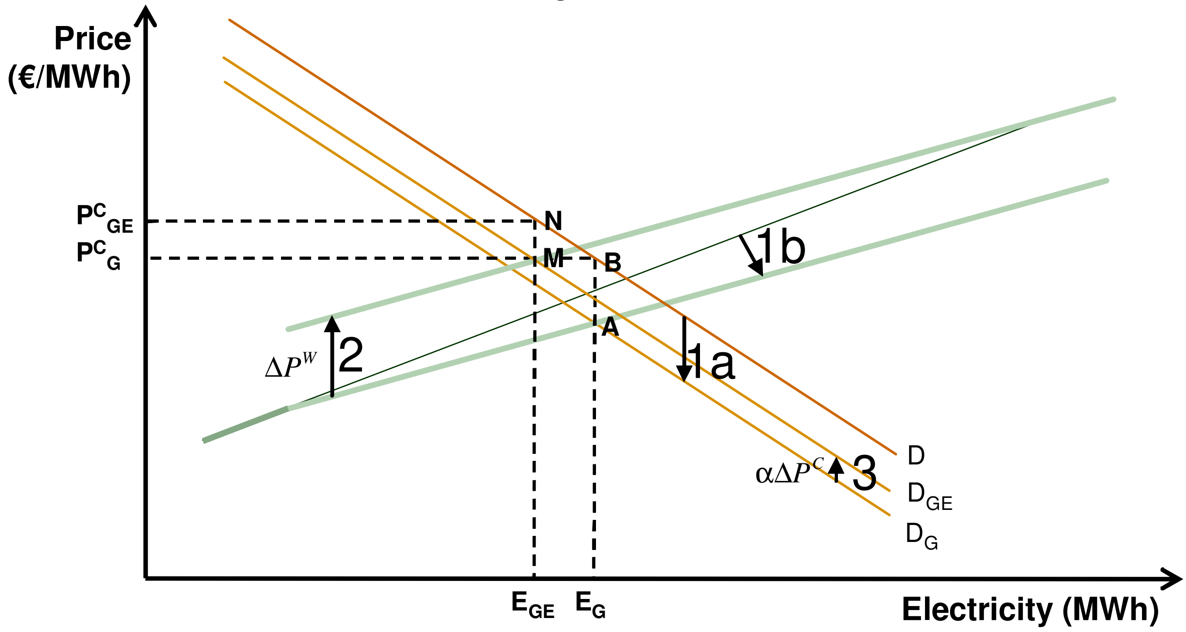


Introducing the EU ETS into this framework has two distinct effects, illustrated in Figure 6.4. First, the supply schedule shifts up, as the opportunity cost of allowances is included in wholesale and retail prices (indicated by arrow '2' in the figure). Second, the EU ETS has the effect of lowering the price of certificates, as discussed above. This causes the demand schedule to shift up from D_G to D_{GE}, as indicated by arrow '3'. This occurs because the lower level of demand is occasioned in the first place by the 'tax' represented by green certificates; with a lower certificate price, the effect is therefore smaller.

Note that the shift in the demand schedule is *smaller* than the shift in the supply schedule caused by the EU ETS. This may seem counterintuitive, as it was established above that a wholesale price increase due to the EU ETS will be more than offset by a decrease in the certificate price (i.e., certificate prices decrease more than wholesale prices increase). However, the increase in wholesale prices due to the EU ETS affects *all* of the electricity bought by consumers, while the certificate price decrease only affects a proportion α, where α is the green quota as described in Chapter 3. If the wholesale price increases by an amount ΔP^w, this results in a certificate price change ΔP^c of equal size (i.e., $\Delta P^w = \Delta P^c$). However, consumer demand shifts by $\alpha \Delta P^c$, as only a proportion α is subject to the green quota.

The net result is a shift to price $P^C{}_{GE}$ and quantity E_{GE}. The electricity market equilibrium is indicated by *M* in the figure, while the total cost to consumers also includes the cost of certificates, indicated by *N* in the figure. The difference between *M* and *N* corresponds to consumers' expenditure on certificates. As the EU ETS causes a decrease in the certificate price, the difference between *M* and *N* is smaller than the difference between *B* and *A*.

Figure 6.4
Effect on the retail electricity market of introducing the EU ETS alongside a TGC scheme



In sum, in the new equilibrium:

- The wholesale electricity price is higher than with a TGC scheme alone, as the EU ETS results in the opportunity cost of allowances being incorporated in the wholesale price.
- The certificate price is lower with the EU ETS than without, and hence the shift in the demand curve caused by the TGC scheme is smaller, i.e., *(B-A) > (N-M)*.
- The retail electricity price is higher with the EU ETS ($P^C_{GE} > P^C_G$). However, the price does not increase by the opportunity cost of allowances, as it is partially offset by lower certificate prices. The certificate price decrease caused by the EU ETS will has larger effect, i.e., retail prices will be *lower*, the *larger* is the green quota.
- Electricity demand is further reduced with the EU ETS ($E_{GE} < E_G$) as retail prices increase.

In sum, the EU ETS has the effect of lessening the impact of the TGC scheme on the retail electricity market. The combined effect of the two schemes is therefore *smaller* than would be the mere sum of the two schemes in isolation and absent any interactions. As noted in the previous chapter, there is also a potential effect of the TGC scheme on the EU ETS allowance price, and this effect also needs to be taken into account in a full assessment of the interactions.

6.2.2 Effect on the objectives of the respective schemes

The interactions between the two schemes also have implications for the stated objectives of encouraging investment in renewables and reducing CO_2 emissions.

National CO_2 emissions are likely to be smaller in the joint presence of a TGC scheme and the EU ETS than they would be under the EU ETS alone. The EU ETS can only provide incentives for such emissions abatement as can be effected at a marginal cost lower than or equal to the allowance price. With a TGC scheme, however, the extent to which green generation displaces non-green generation is determined by the quota, regardless of how the marginal cost of doing so relates to the allowance price. The result is a decrease in national baseline CO_2 emissions.

As detailed above, this does not mean that total emissions in the EU are affected. As discussed above, a cap-and-trade programme like the EU ETS provides assurance (conditional on full compliance) that the total emissions will not exceed the cap. When the cap is binding, however, emissions will not be reduced below this amount. National programmes, such as a national TGC scheme, will therefore not have a net impact on total EU emissions.

Conversely, the effect of the TGC scheme on CO_2 emissions is mediated through the displacement of non-green generation. However, for the purposes of the TGC scheme, generation technologies are classified either as green or 'non-green', and, unlike in a trading scheme, there is no distinction made between different non-green generation technologies. The effects of the TGC scheme on CO_2 emissions therefore depends heavily on the emissions characteristics of the non-green technology it displaces. For example, if efficient (low emissions intensity) natural gas generators tend to be on the margin and (high emissions-intensity) coal units serve as baseload producers, then the reduction in CO_2 emissions resulting from the TGC scheme will be less than if coal units were on the margin. Put differently, the TGC scheme has the potential to displace generation whose emission intensity is lower than the average emissions intensity. In the extreme case, if the TGC scheme were to displace generation that resulted in no CO_2 emissions but which was nonetheless classified as 'non-green' for the purposes of the TGC scheme (e.g., nuclear power, or certain waste fuels), there would be no CO_2 reductions achieved by the TGC scheme (this is unlikely to happen in practice, as the short-term marginal cost of nuclear power is very low, making it an unlikely marginal technology).

The incentives for the expansion of renewable electricity generation are also affected by the interaction of the two schemes. On its own, the EU ETS provides incentives for investment in generation from renewable energy sources (or other sources that do not result in CO_2 emissions) to the extent that the difference between the marginal cost of generation of such technology and the wholesale electricity price is no larger than the support provided by the allowance price.

With a binding TGC scheme, however, the green quota determines the amount of renewables generation. Assuming full compliance, the amount of green electricity produced will be neither larger nor smaller than this amount. The support offered by the EU ETS and TGC scheme is therefore complementary, and the EU ETS offers no additional support to that of the TGC scheme alone. Instead, as described above, the effect is to lower the certificate price to the point where the quota is just met.

Finally, both schemes have the potential to have an impact on the incentives for energy efficiency measures. This is directly linked to the net impact of the two programmes on retail electricity prices, and will be discussed in more detailed in the next chapter.

6.2.3 Effect on costs and benefits for different groups

As outlined above, the total support offered for green generation is fixed when a TGC scheme is in place. A stricter EU ETS and cap and consequent increase in allowance prices does not offer additional support, but that fact that more support is offered outside of the TGC scheme means that lower certificate prices are required to meet a given green quota. In effect, the strictness of the EU ETS cap determines how much of the support required for a given green quota is 'paid for' through the EU ETS, leaving the remainder to be 'paid for' through the TGC scheme.

Meanwhile, the discussion in Chapters 2 and 3 clarified that the costs and benefits of different operators in the electricity market may differ in the two types of schemes. These differences are briefly summarised in Table 6.1. As stressed before, this only refers to the effects in the electricity market and does not account for other costs and benefits to the various groups.

Table 6.1
Overview of distributional effects of the EU ETS and TGC schemes on electricity market participants

Electricity market party	Effect of EU ETS	Effect of TGC scheme
Non-green electricity producers	Gain/lose if emissions intensity is lower/higher than that of the marginal producer in the wholesale market.	Lose, as wholesale price decreases and market share is restricted by green quota.
Green electricity producers	Gain, as operating margin increases with higher wholesale prices but no increase in generation costs.	Gain from green certificate subsidy and increased generation.
Electricity consumers	Lose because of retail prices increase and lower electricity consumption (in the longer run)	Short-run: may either gain or lose, depending on the net impact of the TGC scheme on retail prices (which in turn depends on the extent to which certificate costs are offset by decreases in the wholesale price). Long-run: Lose as retail prices unambiguously increase.

As indicated in the table, the different forms of scheme have different impacts on different groups. The most obvious difference is that non-green electricity producers may gain from the EU ETS, while they always lose from TGC schemes, and that electricity consumers always lose from the EU ETS, while they may gain from a TGC scheme, at least in the short term (see Section 2.4.1 and Section 3.4.2 for more detailed discussions of these effects)

The implication is that the costs to consumers and producers of achieving a green quota differ depending on the strictness of the EU ETS cap. In the short run, consumers are better off from a TGC scheme than they are from the EU ETS, and they would therefore benefit the more of the support for green generation is paid for through the TGC scheme (i.e., the lower is the allowance price). Conversely, non-green but low-emitting electricity producers are better of the more support is offered through the EU ETS, as they derive no benefit from the TGC scheme but may stand to gain from the EU ETS. As a consequence, the total cost to non-green generators as a group may be lower with a higher allowance price than with a higher certificate price.

These distributional effects of the different schemes may have implications for the type of instrument chosen to achieve the green quota. However, in the long-run (once the generation capital stock adjusts through the building of new capacity), the (relative) benefit to consumers of TGC schemes is likely to be eroded.

One of the attractive features of a TGC scheme is that, in a competitive certificate market, the price is self-adjusting, ensuring that the support paid by those with a certificate obligation is no higher than is necessary to meet the quota. The lower certificate price resulting from the co-existence with the EU ETS means that the total cost of the TGC scheme is lower in the presence of the EU ETS than it would be in its absence. (Note that this does not mean that the *total* cost of the two schemes is lower, as some costs are shifted from one policy instrument to the other.)

§ *green electricity producers* are unaffected by the addition of the EU ETS (as compared to the TGC scheme alone) as they benefit from the increase in wholesale prices, but the certificate price adjusts to offset this (and their costs are unaffected by the EU ETS);

§ *non-green electricity producers* may gain from the EU ETS (as compared to the TGC scheme alone) if their CO_2 intensity is lower than that of the marginal producer (and they are allocated free allowances), and may stand to lose if their CO_2 intensity is higher than that of the marginal producer;

§ *end-users of electricity* pay more with the EU ETS (as compared to the TGC scheme alone), as the wholesale price increases one-to-one for all electricity consumed, while the certificate price drop only affects the proportion covered by the quota.

6.2.4 Summary of Effects

Table 6.2 summarise the ‘price and quantity’ effects of introducing the EU ETS (or, tightening the EU ETS cap) in a country that already has a functioning TGC scheme. The columns represent:

§ the effect of the TGC scheme alone, compared to no regulatory intervention;

§ the effect of the TGC scheme and EU ETS in combination, compared to no regulatory intervention; and

§ the additional effect of introducing the EU ETS (i.e., the effect of the instrument combination compared to the TGC scheme alone).

Table 6.3 summarises the distributional effects of introducing the EU ETS (or, tightening the EU ETS cap) in a country that already has a TGC scheme. The interpretation of the columns is the same as in Table 6.3. As before, this is not a complete analysis of the costs and benefits of the instrument combination, since market failures and effects in secondary markets are not included in the analysis.

Table 6.2
Summary price and quantity effects of introducing the EU ETS in a country with a functioning TGC scheme

Variable	TGC scheme	TGC scheme and EU ETS	Additional impact of introducing the EU ETS
Wholesale electricity price	Reduced in short term	Varies in short term	Higher wholesale prices due to the EU ETS counteract the price decrease due to the TGC scheme. The net short-term effect cannot be determined *a priori*.
	Unaffected in long term	Increase in long term	Long-term prices are determined by the cost of new entry, and hence will increase as a result of the EU ETS.
Retail electricity price	Varies in short term	Likely increased in short term	Higher price than with TGC scheme alone, as wholesale price increase translates into retail price increase. However, the increase from the EU ETS is *smaller than the full opportunity cost of allowances*, as it is partly offset by lower certificate prices.
	Increased in long term	Increased in long term	
Electricity demand	Varies in short term	Likely reduced in short term	The EU ETS further lowers demand by increasing retail prices.
	Reduced in long term	Reduced in long term	
National non-green generation	Reduced	Reduced	EU ETS is likely to cause a further reduction in the amount of national non-green generation, as overall demand is likely to contract.
National green generation	Increased	Increased	EU ETS contributes *no additional support for green generation* as the amount is fixed by the green quota and the certificate price adjusts.
			In the long term, lower levels of demand may mean that the total absolute amount of green generation as well as certificate prices decrease.
National CO_2 emissions	Reduced	Reduced	Emissions reduced further by decrease in total electricity production.
EU CO_2 emissions	Reduced	Reduced	Lower emissions than with TGC scheme alone
Investment in end-use efficiency	Varies in short-term	Likely increased	Higher retail prices with the EU ETS than with TGC scheme alone means that incentives for investment in end-user energy efficiency are strengthened.
	Increased in long-term	Increased in long-term	
Investment in green energy	Increased	Increased	No additional investment with the EU ETS, as investment is determined by the green quota.
Green certificate	-	Reduced	The EU ETS causes the certificate price to

Variable	TGC scheme	TGC scheme and EU ETS	Additional impact of introducing the EU ETS
price			decrease.

Notes: Columns 2 and 3 compare the effects of the policies to a situation where there is no regulation. Column 4 outlines the incremental effect of adding the EU ETS —i.e., it compares the effects in column 3 to those in column 2.

Table 6.3
Summary distributional effects of introducing the EU ETS in a country with a functioning TGC scheme

Variable	TGC scheme	TGC scheme and EU ETS	Additional impact of introducing the EU ETS
Producer surplus			
High-CO_2 green electricity generators	Reduced	Reduced	Surplus is further reduced by the effects of the EU ETS
Low-CO_2 non-green electricity generators	Reduced	Ambiguous	Higher surplus than with TGC scheme alone, and benefit from EU ETS may exceed loss from TGC scheme.
Green electricity generators	Increased	Increased	No further increase in surplus in the short-run, and potential decrease in surplus in the long-run, as overall demand (and hence absolute amount of green generation) contracts.
Electricity generators overall	Decreased	Ambiguous	Higher surplus than with TGC scheme alone. Benefit from EU ETS likely to exceed loss from TGC.
Producers overall	Decreased	Ambiguous	Ambiguous impact. Overall surplus likely to be positive.
Consumer surplus			
Consumers overall	Ambiguous (short-term) Decreased (long-term)	Decreased (likely) Decreased	EU ETS reduces consumer surplus further as increase in wholesale and retail prices only partially offset by the decrease in green certificate prices.

Notes: Columns 2 and 3 compare the effects of the policies to a situation where there is no regulation. Column 4 outlines the incremental effect of adding the EU ETS —i.e., it compares the effects in column 3 to those in column 2.

6.3 Effect of Market and Design Features on the Interactions

The results of the above discussion of effects in an idealised electricity market and particular scheme design may be modified by design features of certificate schemes, as well as the features of electricity and certificate markets. Similar conclusions apply to the interaction with the EU ETS, and this section therefore discusses a number of potential deviations from the above baseline results.

There is also a brief discussion of the effects of EU ETS design parameters affecting interactions, and on the implications of less than full pass-through of CO_2 opportunity costs to electricity prices.

6.3.1 TGC scheme design parameters affecting interactions

As outlined in Section 3.2.3, certain design features of TGC scheme may result in different outcomes in the interaction of a TGC scheme and the electricity market. In this section we discuss how some of these also may affect the interactions between the EU ETS and TGC schemes. Specifically, we discuss the role of:

- the size of green quota;
- the extent of fungibility of green certificates;
- provisions for intertemporal flexibility ('banking' and 'borrowing' of certificates);
- restrictions on the eligibility of certain forms of green generation;
- regulation of certificate prices through price floors or price ceilings; and
- defining and allocating the green quota.

6.3.1.1 Size of the green quota

The size of the green quota determines how much non-green electricity is displaced by the TGC scheme. It is therefore the key parameter that influences the amount of CO_2 emissions reductions that the scheme displaces, and consequently the magnitude of the influence on the EU ETS cap and allowance market. A stricter quota, provided the scheme is sufficiently large to have an impact, leads to a lower allowance price.

In an EU-wide scheme, the quota would also determine to what extent emissions abatement is undertaken in the electricity sector. The allowances 'freed up' by emissions abatement through green generation mandated by the TGC scheme would be available to operators outside the electricity sector, who therefore benefit from lower allowance prices and less need to undertaken own abatement.

6.3.1.2 Extent of fungibility of green certificates

At present, green certificates are generally not fungible between Member States. No international TGC scheme is in operation, and although there is some cross-border trade in certificates linked to green power sources, internationally traded certificates are not generally valid for compliance under TGC quotas. It is nonetheless illustrative to consider the case where an EU-wide scheme, or one encompassing several EU countries, is in operation. We discuss two aspects of this: first, the implications for the competitiveness of green installations in different electricity markets, and second the effect on the CO_2 constraints faced by the electricity and non-electricity sectors in the EU ETS.

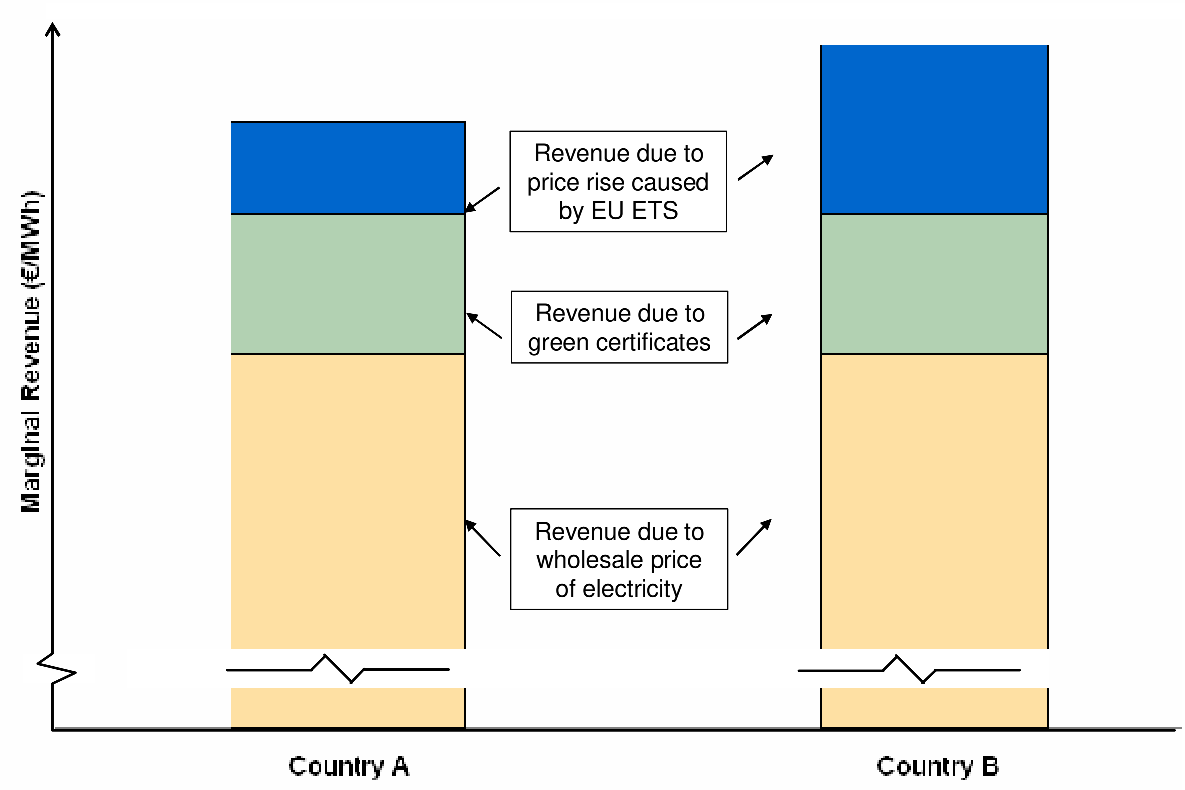
6.3.1.2.1 Competitiveness of green installations in different electricity markets

With such a scheme, there would be a single green certificate market, and therefore a single green certificate price. Other things being equal, the merit order of green generation would depend on the characteristics of the respective green technologies, and two installations with similar characteristics would show similar competitiveness (as the same level of support is offered).

However, this is altered by the fact that electricity markets are still segmented across Europe, including the way that the EU ETS interacts with these markets (which may span one or more Member States). The allowance price, and therefore the opportunity cost of CO_2, is the same in the entire EU. However, the CO_2 intensity of the marginal technology may differ between electricity markets, resulting in different electricity price increases in different countries (assuming there is no interconnection).

The result of this is that otherwise identical green generation technologies may look more attractive in one country than in another, even with the same EU ETS and same EU TGC scheme operating in both, and even assuming the same prevailing average power prices. This is illustrated in Figure 6.5, where the marginal revenue of green generators in Countries A and B differs because the price rise caused by the EU ETS is not equal in the two countries.

Figure 6.5
Marginal revenue for green generators in different countries



Put differently, the position of technologies in the *pan-EU* green technology merit order may depend on how the EU ETS interacts with their *national* electricity market. A similar situation could occur in a segmented national market where transmission bottlenecks mean that there are different regional marginal technologies, with different CO_2 intensities.

6.3.1.3 Provisions for intertemporal flexibility

As outlined in Section 3.1.3, the provisions for intertemporal flexibility within existing TGC schemes are often limited. The EU ETS allows for banking within Phases (2005-2007, and five-yearly thereafter) and therefore provides greater scope for banking than do most TGC schemes currently in operation. To some extent, investors in green generation may therefore benefit from the provision for intertemporal flexibility in the EU ETS. The potential benefit is indirect and arises from greater price stability (green electricity producers generally are not covered by the EU ETS).

Similarly, if the certificate market displays high volatility (perhaps because it is ‘thin’, or because it is dominated by a single technology that is subject to weather or other fluctuations), certificate prices are likely to incorporate an *ex ante* price premium to reflect this risk to investors. However, if some of the support for green generation is offered through the EU ETS investors will be less exposed to TGC market volatility and the volatility price premium therefore also likely to be lower (provided volatility in the EU ETS allowance market is uncorrelated with that in the TGC market).

Both these effects will be greater the more of the support for green generation is provided through the EU ETS. This corresponds to a higher allowance price, with correspondingly lower levels of support through the TGC market. With both the EU ETS and a TGC scheme in place, more intertemporal flexibility is therefore implicitly available to green generators the higher is the allowance price, and the certificate price risk may be smaller. However, both these effects are likely to be limited in practice, and subsidiary to other effects, notably the level of the certificate price.

6.3.1.4 Restrictions on the eligibility of certain forms of generation

It is possible to include CO_2 emitting generation among eligible ‘green’ technologies. For example, fossil fuel-fired combined heat and power (CHP) facilities are included in some TGC programmes. Their inclusion has the potential to change the merit order of green generation, in particular if CHP is anyway near profitable and could ‘crowd out’ other green generation from grid-connected renewables. Also, when CHP is in the green merit order, the EU ETS has the effect of rendering CHP (or other CO_2-emitting green generation) relatively less profitable and therefore potentially altering the green merit order. This is because CHP and other CO_2-emitting generation sources faces increased marginal costs (corresponding to their CO_2 emissions intensity) with the EU ETS whereas non-CO_2 emitting green technologies do not. When CO_2 emitting sources are eligible under the TGC scheme, the EU ETS may therefore lead to a different composition of green supply for a given quota. (In the case of CHP, there is also overlap with the objectives of TWC schemes, as special support for CHP normally is justified on grounds of energy efficiency.)

In addition, many TGC schemes exclude some portion of generation from renewable energy sources, including pre-existing/old and large-scale installations anyway deemed to be profitable. These installations do not get any support from the certificate market, but they do benefit from higher wholesale electricity prices under the EU ETS, whereas renewables covered by the TGC scheme do not because the certificate price adjusts, as discussed.

6.3.1.5 Regulation of certificate prices

It was outlined above that the support offered to green generators by the EU ETS is non-additional in the presence of a TGC scheme, as the certificate price is falls to the minimum required to meet the green quota requirement, taking into account any support implicitly offered by the EU ETS. This may change if certificate prices are regulated, and we discuss the case of a price ceilings and price floors below.

This may not be true if there is a binding ceiling on the certificate price, i.e., if certificate prices are constrained so that they combined wholesale electricity and certificate price is less than the green cost gap. In this situation, additional increases in the wholesale price due to the EU ETS may not reduce the certificate price, as the price is anyway lower than it naturally would be. In the presence of a binding price ceiling, the support offered by the two respective programmes therefore may be complementary. This ceases to be the case when the price ceiling is no longer binding, i.e., up to the point where the combined support corresponds to the cost gap associated with the green quota.

Conversely, a green certificate price floor could lead to a situation where the EU ETS provides support for green generation that is additional to that offered by the TGC scheme. A higher EU ETS allowance price rises and associated increased electricity wholesale prices would cause a decrease in the certificate price. If this fall is sufficiently larger, the price floor may become binding. In this case, green operators obtain higher revenue than they otherwise would, and additional increases in the electricity price would also be additional support (as the certificate price cannot fall further to offset this).

In reality, price ceilings or floors are likely to be binding only during shorter periods, as prolonged binding ceilings / floors would cause the certificate price to fail to reach / exceed the level necessary to meet the quota. In the case of price ceilings this could jeopardise scheme compliance, whereas price floors may imperil the cost-effectiveness of the scheme. The likely effect of a price cap on future revenue would optimally be anticipated *ex ante* by (prospective) green operators, who will require a certificate price premium to compensate for any periods when certificate prices are constrained (consistent with balancing the support offered by the scheme with long-run marginal cost). The existence of support through the EU ETS may decrease this price premium as it offers additional support in those periods where the certificate price ceiling is binding.

6.3.1.6 Defining and allocating targets

Many of the key features of the interactions between TGC schemes and the EU ETS stem from the 'self-adjusting' properties of the green certificate price. This in turn is a property of the specification of TGC scheme targets in *relative* rather than absolute terms. By contrast, if the quota were absolute (e.g., a certain number of MWh of green generation over a time period) *and* a requirement that generation be 'additional' to the baseline scenario, then other effects would obtain, and there would be many fewer interactions. These issues are discussed in detail below in Section 7.1.2.1, as these features commonly are found in tradable *white* certificate schemes.

6.3.2 EU ETS design parameters affecting interactions

It was outlined above that the EU ETS does not directly influence the cost of green generation as such generation normally does not result in CO_2 emissions. There are, however, some aspects of EU ETS design that may affect long-term costs through allowance allocation. Specifically, if the allowance allocation mechanism under the emissions trading scheme provides for allocations to new entrants, *and* if green generators are eligible for such allocations, the new entrant reserve provides an effective subsidy to green new entrants that will reduce the overall costs of the green generation asset. This scenario is not as unlikely as it may sound. In fact, in a number of EU Member States, thermal combustion units burning exclusively biofuels could be eligible to receive allowances. This would reduce their long-run marginal costs, and therefore also the long-run certificate price required to meet a given quota.

The precise outcome depends on the exact properties of the allowance allocation methodology. Notably, it may be likely that only thermal installations would receive allocations while other green technology (notably, wind and hydro power) would not. In this case, the effective allowance subsidy would not be available to some green generating sources, and the relative long-term marginal cost of different forms of green generation would change. This would in turn distort the choice between green technologies, potentially compromising the cost-effectiveness of a TGC scheme.[64]

6.3.3 Electricity market features affecting interactions

The above discussion also clarified that the interaction depends on the pass-through of the *opportunity cost* of allowances to wholesale electricity prices. As discussed in Section 2.2.3, this is the optimal behaviour for profit-maximising generators in a competitive electricity market and subject to the provisions of the EU ETS. However, it may not be an appropriate assumption for all situations, and in some markets cost pass-through may be more similar to average total cost recovery (i.e., to recuperate the 'shortfall' in allowances relative to 'need') instead of optimal marginal opportunity cost recovery. One reason for such a pattern of cost pass-through may be explicit regulation of prices or other regulatory action (e.g., through transmission charges), as is taking place in some Member States during Phase 1. More generally, imperfect competition may cause generators to pass through a smaller amount than the full opportunity cost.

Generally speaking, the impact on the EU ETS on a TGC scheme would be muted if opportunity costs are not passed through. The EU ETS offers increased support for green generation by increasing the electricity price to reflect the cost of CO_2 emissions without increasing their costs. With less than full pass-through of CO_2 costs the support offered for green generation is therefore lower than it is in the full cost pass-through scenario. With a TGC scheme, however, the support offered is unchanged, as the certificate price would adjust to the higher amount required to meet the green quota. With less than full pass-through of CO_2 costs in the electricity markets, TGC prices will be higher, and the total cost of the TGC scheme therefore also higher.

Also, with elements of average total cost recovery the impact on the electricity price depends not only on the CO_2 intensity but also on the shortfall of allowances of the marginal producer. The impact on the electricity market therefore depends on the allocation methodology used and in particular any under-allocation to the relevant generators. In this setting, some of the interactions described above may no longer be relevant all; for example, the CO_2 intensity of

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64 Because they can lead to broader distortions within emissions trading schemes, set-asides for new entrants are often dismissed as an undesirable design feature where they are considered. For better or for worse, such set-asides are part of the emissions trading policy landscape within the EU.

the marginal electricity producer no longer matters if generators receive the same allocation proportional to need and follow a strategy of average total cost recovery. In this situation, it no longer matters for electricity prices whether decrease in demand of the TGC scheme results in a change to the marginal technology of generation.

6.4 Summary

The interactions between the EU ETS and a TGC scheme are complex and mediated through all three markets relevant to the two instruments: the markets for emissions allowances, green certificates, and through the electricity market. In general terms, either instrument causes the implementation of the other scheme ‘in isolation’ to cost less. This is a reflection of overlapping policy objectives, which causes each scheme to help implement some measures that relax the constraints associated with the other scheme’s aims. By shifting some emissions abatement to be implemented through the TGC scheme, meeting the EU ETS cap becomes less onerous; conversely, by offering some support for renewables through the EU ETS, green electricity generation requires less encouragement through the TGC scheme.

There are a number of complications to this general conclusion, including the observation that the distribution of costs and benefits of the scheme may change in unexpected ways even as the overall stringency of the two programmes does not change. Also, long-term effects may be different from those in the short-term, reflecting the possibility of adjusting the electricity generation capital stock and the level of electricity demand. The geographic scope of either scheme may matter for the level of support offered for similar installations or the costs to consumers in different locations.

A number of design parameters may change these interactions. Notably, the formulation of the green target is of key importance, as interactions differ significantly depending on whether the target is set in relative terms (a quota) or absolute terms (a given amount of green electricity). Other design aspects such as certificate price regulation or the fungibility of green certificates across electricity markets can also change the results.

Many of these interactions are ‘general equilibrium’ effects that depend on several simultaneous feedback mechanisms, and an analysis of interactions would benefit from a more comprehensive modelling of market interactions.

7 Impact of the EU ETS on White Certificate Schemes

This chapter builds on the discussion in previous chapters to analyse the potential impact of the EU ETS on a TWC scheme. Again, this can be taken either as discussion of how a 'textbook' TWC scheme may compare with one where the EU ETS is in operation, or as an analysis of the effects of a TWC scheme or tightening the EU ETS cap. The analysis is in four parts:

First, we consider how a white certificate scheme differs from a green certificate scheme with regard to the specification and attainment of targets. This has important consequences regarding the response of the scheme to changes in electricity prices and consequently to the nature of its interactions with the EU ETS. The response of white certificate prices to changes in electricity prices is then clarified.

Second, we analyse the theoretical interactions between an idealised national TWC scheme and the EU ETS. As before, we assume a perfectly competitive electricity market, isolated from international trade. The scenario explored is hat of the introduction of the EU ETS, or the tightening of the target in the EU ETS, in a country that already has a functioning TWC scheme. As in previous sections, we examine how this combination of instruments affects a number of key variables, such as electricity prices and CO_2 emissions, and how the costs and benefits are distributed between different groups. A comparison is made with the effects of each instrument operating in isolation, and the results summarised in tables.

Third, we analyse how these results are modified in a situation where the host country is a net importer of electricity and where imports act as the marginal producer. Here, the discussion is confined to a scenario where a TWC scheme is introduced in a country that is already participating in the EU ETS.

Finally, we consider how a number of 'real-world' market and design features may change the results identified. We focus on the most important of these features, paying particular attention to design variables for the TWC scheme. For example, 'real-world' TWC schemes are not confined to electricity markets, but also include natural gas and other energy carriers. Their impact will therefore extend beyond electricity markets alone.

7.1 Effects of the EU ETS on the white certificate market

The interaction between a TWC scheme and the EU ETS may not follow the same pattern as that between a TGC scheme and the EU ETS. In particular, while an increase in electricity prices will reduce the price of green certificates, it will not necessarily reduce the price of white certificates. This is because of the differing specification of the targets for each scheme and the differing importance of regulatory decision-making in assessing compliance with these targets. It is useful to clarify these differences before exploring the interactions in more detail.

7.1.1 Green certificates and electricity prices

Typically, a TGC scheme requires a specified *proportion* (%) of total electricity generation to be supplied from qualifying renewable sources in each target period (the 'green quota').

Since the quantity of non-green and renewable electricity generation can be directly and accurately measured, compliance with this target is relatively easy to enforce.

The supply of green electricity and the incentive to invest in new renewable capacity is determined by the sum of the wholesale electricity price and the green certificate price. Taken together, these give the total revenue per unit of green electricity generated. As described in Chapter 3, if the wholesale electricity price goes up the green certificate price goes down (and vice versa). The relationship is not one-to-one, however, since it depends upon the size of the green quota and on the price elasticity of non-green electricity supply, green electricity supply and electricity demand. generally, an increase or decrease in wholesale prices will lead to a greater change in certificate prices, but in the opposite direction. This implies that, if wholesale electricity prices increase, the supply of green electricity (in kWh) will *decrease*, along with the remuneration to green generators and the incentive to invest in new renewable capacity. But compliance with the (proportional) target for renewable generation should *not* be affected since (in the absence of a ceiling on certificate prices) this is secured by the green quota.

This feedback mechanism between electricity and green certificate prices is determined by market forces and hence is relatively automatic. It implies that an increase in wholesale electricity prices will decrease the price of green certificates and decrease the supply of renewable energy. However, it will not make any additional contribution to meeting the (proportional) target for renewable electricity in the TGC scheme

7.1.2 White certificates and electricity prices

In contrast to a TGC scheme, a TWC scheme typically requires a specified *quantity* (kWh) of 'energy-saving' to be achieved through qualifying energy efficiency measures in each target period. Since energy-saving cannot be directly measured, but must be estimated with respect to a counterfactual in which the TWC scheme is absent, compliance with this target is difficult to enforce.

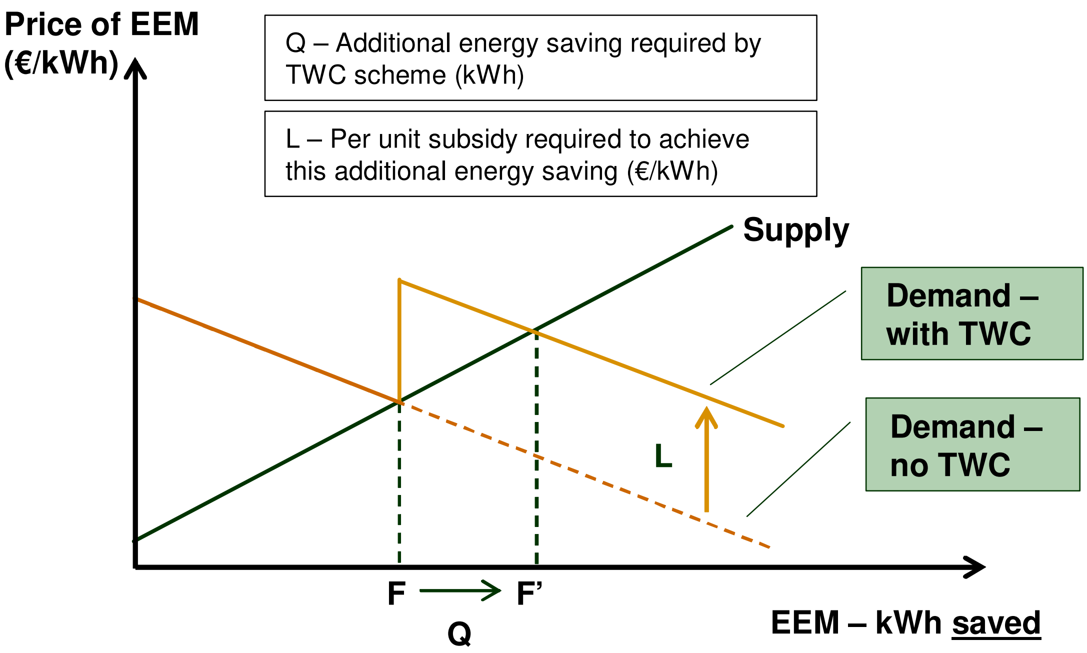
The supply of 'energy-savings' and the incentive to invest in energy efficiency measures is determined by the sum of the retail electricity price and the white certificate price. Taken together, these give the total revenue per unit of electricity saved. As described in Chapter 4, the white certificate price must be sufficiently large to induce *additional* investment in energy efficiency, above that which would have occurred in the absence of the TWC scheme. But if the retail electricity price goes up, the white certificate price may *not* necessarily go down. While higher retail electricity prices will encourage greater investment in energy efficiency, the resulting energy savings may not contribute towards meeting the TWC target because these savings would also occur in a counterfactual scenario in which the TWC scheme was absent. Hence, the relationship between electricity prices and white certificate prices depends upon how the requirement for additionality is interpreted and implemented by the regulator.

7.1.2.1 Additionality and white certificate prices

The effect of changes in retail electricity prices on the price of white certificates may be explored further with the help of the stylised model of the energy efficiency market developed in Chapter 4. This is illustrated in Figure 7.1. Here, the demand for energy efficiency measures ('EEM') in the absence of the TWC scheme is given by F, while the energy-saving target for the scheme given by Q. Assuming the regulator can observe the 'true' counterfactual level of EEM demand (F), the required demand for EEM with the TWC scheme in place is given by F+Q=F'. It is assumed that the energy-saving target is achieved by the provision of a per-unit subsidy (L) to consumers to encourage them to invest in energy efficiency. The size of the required subsidy determines the price of white certificates.

If participants can eliminate free-riders when administering the subsidy scheme, the subsidy will only be available for investment in energy efficiency beyond the 'business as usual' level, represented by F. This gives the 'kinked' demand curve shown in Figure 7.1. In these circumstances, the total cost of the subsidy scheme should be proportional to L*Q. This, rather than the price of white certificates, will determine the size of the levy imposed upon electricity consumers (*l*).

Figure 7.1
Effect of TWC scheme on the market for energy efficiency

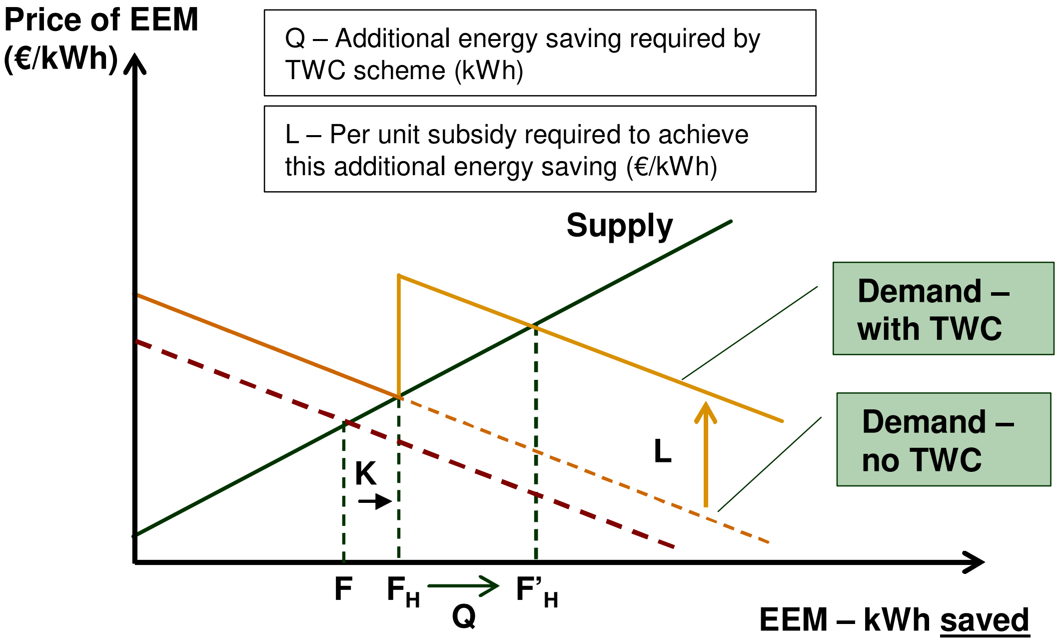


An increase in retail electricity prices will increase the cost effectiveness of energy efficiency measures. This should shift the demand curve for EEM to the right, as shown in Figure 7.2. In the absence of the TWC scheme, the demand for EEM will increase from F to F_H and the quantity of energy saving will increase by $K=F_H-F$.

Whether this price-induced energy saving will count towards the energy-saving target in the TWC scheme (Q) will depend on how the requirement for additionality is interpreted. If *dynamic* baselines are used to estimate energy savings, the price induced energy saving (K) should *not* count towards the target, since it would have occurred in the absence of the TWC scheme. The estimated energy savings from individual projects should be adjusted downwards to reflect the change in retail prices and participants in the TWC scheme will need to find additional energy savings to meet their obligations. In Figure 7.2, the revised energy-saving target (Q) will now be measured from F_H rather than F, such that the required demand is equal to $F'_H=F_H+Q$. It can be seen that, under the assumption of linear demand

and supply curves over the region of interest, the price of white certificates (L) is *unchanged* compared to a scenario of low electricity prices. Hence, in these circumstances a change in retail electricity prices should have *no* effect on the price of white certificates.

Figure 7.2
Effect of TWC scheme on the market for energy efficiency when electricity prices increase and dynamic baselines are employed

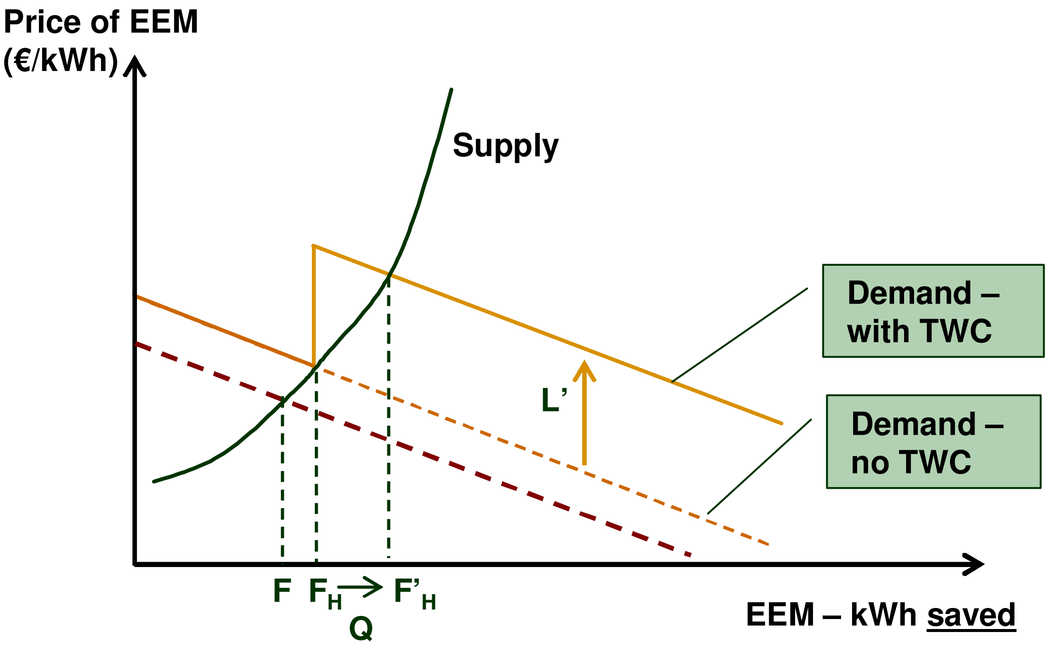


This conclusion will be modified, however, under two circumstances:

- Either the supply or the demand curve for energy efficiency is non-linear over the region of interest.
- The regulator uses static rather than dynamic baselines when assessing compliance with the energy-saving target (Q).

The first possibility is illustrated in Figure 7.3. Here the supply curve for energy efficiency is inelastic (i.e., energy efficiency alternatives increase only modestly for a given increase in price). In this case, the per-unit subsidy required for achieving the TWC target will increase as retail prices increase (i.e., L'>L) and thereby the price of white certificates. Conversely, if the supply-curve for energy efficiency was relatively elastic (i.e., the energy efficiency alternatives increase substantially for a given increase in price), the required subsidy and hence the price of white certificates could decrease as retail prices increases.

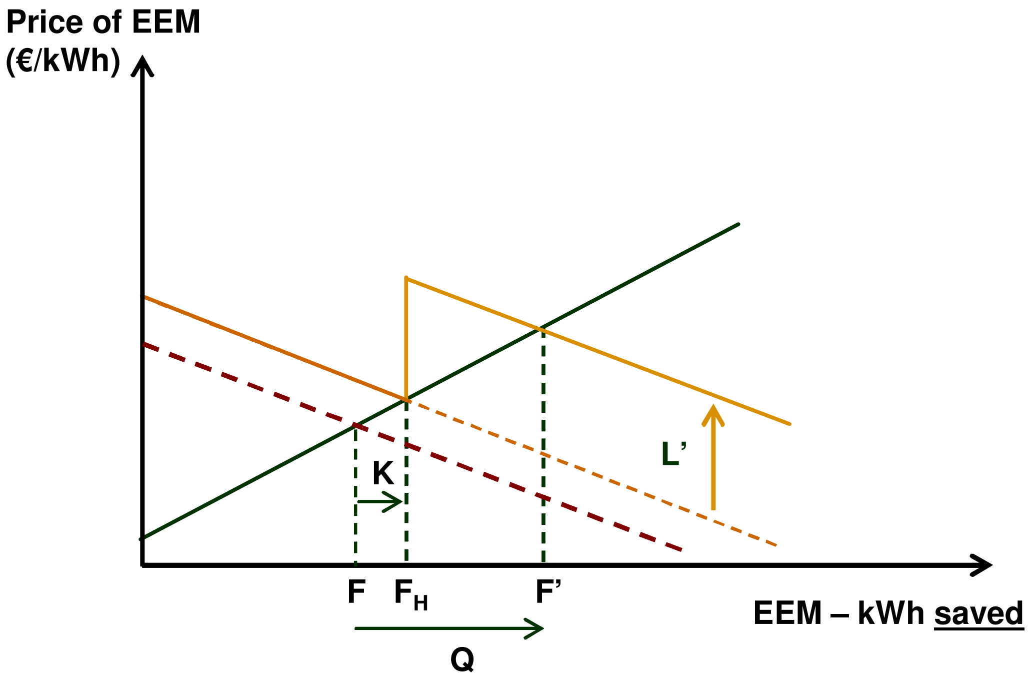
Figure 7.3
Effect of TWC scheme on the market for energy efficiency when electricity prices increase and the supply of energy efficiency is inelastic



The second and more important possibility is illustrated in Figure 7.4. As before, the increase in retail electricity prices leads to a counterfactual level of demand for energy efficiency equal to F_H. But it is assumed that the regulator does not take this into account when assessing compliance with the energy-saving target (Q). Instead, the required level of energy saving is measured from the previous level of demand (F), such that the required demand is equal to F'=F+Q. This is likely to be the case if *static* baselines are used to estimate energy savings, since a change in energy prices that occurs after a project is certified will not be taken into account when estimating the energy savings from that project

In these circumstances, the estimated energy savings from individual projects will *not* be adjusted downwards to reflect the change in retail prices and participants in the TWC scheme will not need to find additional energy savings to meet their obligations. Since the energy-saving target under the TWC scheme can now been met with a smaller per-unit subsidy (L'<L), the price of white certificates should be reduced.

Figure 7.4
Effect of TWC scheme on the market for energy efficiency when electricity prices increase and static baselines are employed



In summary, a TWC scheme does not provide an automatic feedback between retail electricity prices and certificate prices. An increase in retail prices should increase the demand for 'energy-saving', but whether this leads to a corresponding reduction in the price of white certificates will depend on how the requirement for additionality is interpreted.

§ If *dynamic* baselines are used, the additional price induced energy saving will not count towards the energy-saving target, since it would have occurred in the absence of the TWC scheme. In these circumstances, higher retail electricity prices should not make it easier for participants to meet the target and the price of white certificates should be unchanged.

§ If *static* baselines are used, the additional price induced energy saving will count towards the energy-saving target, despite the fact that it would have occurred in the absence of the TWC scheme. In these circumstances, higher retail electricity prices should make it easier for participants to meet the target and the price of white certificates should decrease.

In principle, similar conclusions should apply to the response of white certificate prices to a decrease in retail prices.

7.1.2.2 Free-riders and total costs

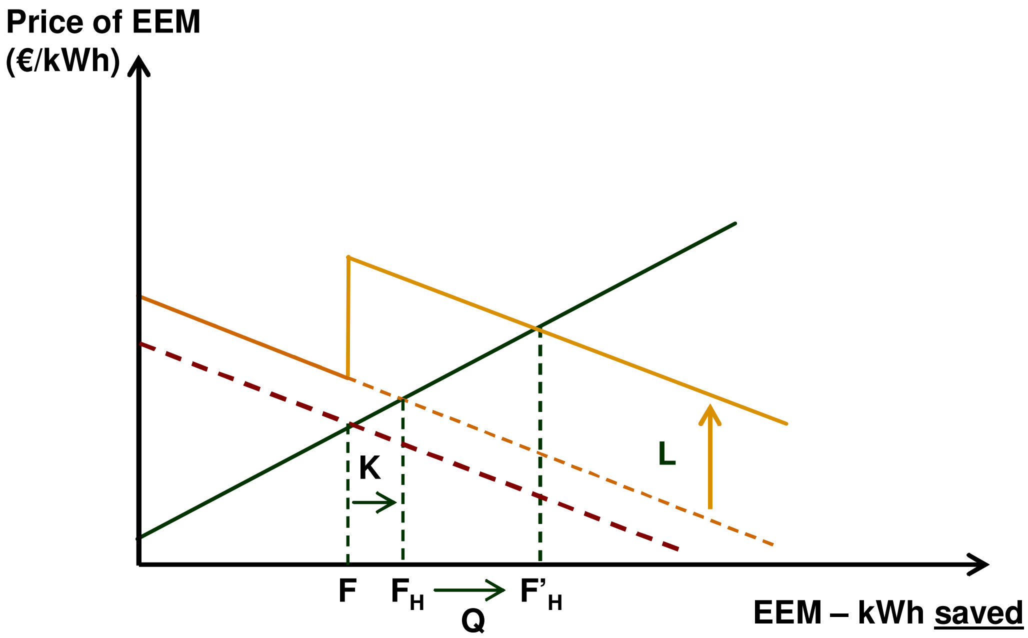
As described in Chapter 4, the price of white certificates should be independent of the ability of participants to eliminate free-riders from their subsidy schemes. But this will affect the *total* cost of compliance with the TWC scheme and hence the size of the levy (l) on electricity consumers. Since interaction with the EU ETS is mediated through the electricity market, the number of free-riders may also affect those interactions.

In both Figure 7.2 (dynamic baselines) and Figure 7.3 (static baselines) it is assumed that free-riders are eliminated and the energy saving represented by K is not subsidised. In Figure 6.2, the total cost of the scheme remains unchanged at L*Q, while in Figure 7.3 (static baselines), it reduces to L'*(F'-F_H).

Figure 7.5 represents a situation where free-riders are not eliminated and the energy saving represented by K is subsidised. It is assumed that dynamic baselines are used so that the energy-saving target is measured from the new counterfactual level of demand represented by F_H. As before, the price of white certificates is unchanged at L. But the total cost of compliance with the TWC scheme is increased to L*(F'$_H$-F) or L*(Q+ (F_H-F)).

This implies that the total cost of the scheme will depend on *both* the interpretation of additionality by the regulator *and* the ability of the participants to eliminate free-riders from their subsidy schemes. While these two variables are independent in principle, they may be linked in practice. For example, regulators may decide that energy savings subsidised by a participant should qualify as additional.

Figure 7.5
Effect of TWC scheme on the market for energy efficiency when electricity prices increase and static baselines are employed, but free-riders are not eliminated



In summary the feedback mechanism between electricity and white certificate prices is not automatic, but instead is influenced by regulatory decision-making on the additionality of energy savings from individual projects. This introduces an element of uncertainty into the behaviour of the white certificate market. In principle, if dynamic baselines were employed and perfectly enforced for all energy-saving projects, an increase in retail electricity prices would increase the overall demand for energy saving but not affect the price of white certificates. However, if static baselines were employed for all projects, an increase in retail electricity prices would not affect the overall demand for energy saving but reduce the price of white certificates. In both cases, however, the increase in retail prices should not make any additional contribution to meeting the (absolute) target for energy savings in the TWC scheme (Q), since this is measured relative to a counterfactual level of demand.

In practice, a mixture of static and dynamic baselines is likely to be employed. Generally, the greater the use of static baselines (i.e., the simpler the monitoring and verification procedures) the greater should be the response of white certificate prices to changes in electricity prices. Any change in these prices should also affect the total cost of compliance with the TWC scheme and hence the size of the levy imposed upon electricity consumer. But this may also be influenced by the ability of participants to eliminate free-riders from their subsidy schemes.

7.1.3 Comparison of green and white certificates

The above demonstrates that a change in electricity prices should contribute *nothing* to the attainment of the relevant targets in either the TGC scheme or the TWC scheme. This is because the (%) target in a TGC scheme is measured relative to current electricity generation, while the (kWh) target in a TWC scheme is measured relative to the counterfactual demand for energy savings given by the regulator's interpretation of additionality. But the change in electricity prices could change the *total* supply of renewable electricity and the *total* demand for energy savings, as well as the cost of attaining the respective targets. In the case of the TGC scheme, the response is determined solely through the operation of the certificate market and is relatively automatic, but in the case of the TWC scheme the response is determined partly by regulatory decision-making and is more uncertain.

The feedback between electricity prices and green certificate prices suggests that a sufficiently high electricity price could induce sufficient supply of renewable electricity to achieve the target for renewable generation in the TGC scheme, without the need for green certificates. In these circumstances, the green certificate price would fall to zero. The same conclusion would only follow for the energy saving target in a TWC scheme if static baselines were used and the requirement for additionality was not effectively enforced. A higher electricity price should increase demand for energy savings compared to a counterfactual scenario of low electricity prices. But since these savings would have occurred in the absence of the TWC scheme they should not really be classified as additional and should not really count towards the TWC target. In practice, however, they may well do since dynamic baselines are very difficult to specify and enforce. Hence, high electricity prices *may* achieve the TWC target on their own and force the white certificate price to zero, but only by violating the requirement for additionality.

In principle, therefore, a TWC scheme may respond differently to changes in electricity prices than a TGC scheme. We should therefore expect the interactions between a TWC scheme and the EU ETS to differ from those between a TGC scheme and the EU ETS. These differences should become clearer as the interactions are explored in more detail below.

7.2 Effect of the EU ETS on a White Certificate Scheme

In this section we reverse the instrument sequence and examine the effect of the EU ETS *on* a white certificate scheme. That is, we assume that a country already has an established TWC scheme and explore the implications of introducing the EU ETS. This may seem a bit artificial since the EU ETS is already in place. However, this scenario is equally applicable to the tightening of the EU ETS cap at the beginning of Phase 2. As before, we examine a country with a liberalised and perfectly competitive electricity market that is isolated from international trade and assume that the participants in the TWC scheme are electricity retailers.

This scenario is explored in an identical way to that in the previous section, by overlaying an equilibrium analysis of a TWC scheme with that of the EU ETS. However, since the TWC scheme *precedes* the introduction of the EU ETS, the additionality of investments encouraged by the TWC scheme becomes an issue.

7.2.1 Effect on electricity demand and electricity prices

The EU ETS will increase wholesale and retail electricity prices and increase the demand for energy savings. As described in Section 7.1, if *dynamic* baselines are used in the TWC scheme, the additional price induced energy-savings that result should *not* count towards the energy-saving target in the TWC scheme, since these would have occurred in the absence of the scheme. In these circumstances, the estimated energy savings from individual projects should be adjusted downwards to reflect the change in retail prices and participants in the TWC scheme would need to find additional energy savings to meet their obligations. The scheme should achieve the same *additional* energy saving (Q) as it would in the absence of the EU ETS, but since this measured from a different baseline the *overall* energy savings should be higher.

Under the assumption of linear supply and demand curves for energy savings, the price of white certificates (L) should be unchanged by the introduction of the EU ETS. Under the additional assumption that free-riders can be eliminated in the administration of any subsidy scheme (Chapter 4), the per-unit levy (l) to recover the costs from electricity consumers should also be unchanged. Hence, if dynamic baselines are assumed, the net effect of the two instruments in the electricity market can be examined by simply summing the individual effects of the two schemes.

However, if *static* baselines are used in the TWC scheme, the outcome may be different. In these circumstances, the additional energy savings induced by the EU ETS *will* count towards the energy-saving target in the TWC scheme, despite the fact that these would have occurred in the absence of the scheme. The estimated energy savings from individual projects will *not* be adjusted downwards to reflect the change in retail prices and participants in the TWC scheme will find it easier to meet their obligations. Measured from the pre-EU ETS baseline the TWC scheme should achieve the same absolute quantity of energy saving (Q), but measured from the post EU ETS baseline the overall energy savings will be less (Q'<Q). Hence, the *additional* energy savings achieved by the TWC scheme will be less than the target (and less than if dynamic baselines had been used) and the overall energy savings should be lower.

Under the assumption of linear supply and demand curves for energy savings, the price of white certificates (*L*) should be reduced in these circumstances. Under the additional assumption that free-riders can be eliminated in the administration of any subsidy scheme, the per-unit levy (*l*) to recover the costs from electricity consumers should also be reduced. Hence, if static baselines are assumed, the net effect in the electricity market *cannot* be examined by simply summing the individual effects of the two schemes. Instead, the impact of the instrument combination on the electricity market will be *less* than if the instrument sequence were reversed (or if dynamic baselines were used in the TWC scheme).

It follows that the impact of the EU ETS and TWC scheme in combination may depend on the sequence in which the instruments are introduced (note that this applies to both the introduction of each instrument and to any tightening of their respective targets). In principle, the only instance where the impact will be identical should be where dynamic baselines are used in the TWC scheme and where they are perfectly enforced. However, since static baselines are likely to be more common in practice, the impact of the instrument combination is likely to be less when the EU ETS is introduced *after* the TWC scheme than when it is introduced before. Compared to the situation when the EU ETS was in place *before* the TWc scheme (Figure 5.11 in Chapter 5), both the leftwards shift of the demand curve induced by the subsidised energy efficiency investment and the upward shift of the supply curve induced by the cost recovery mechanism (*l*) should be less.

Note that this result assumes that the prior existence of one instrument does not alter the choice of targets for the second, which may not be the case in practice. The result is also derived from a static and highly stylised analysis that employs a number of simplifying assumptions.

With these caveats in mind, Figure 7.6 shows the effect on the electricity market of introducing the EU ETS alongside an existing TWC scheme. The scale of the impacts is similar to that illustrated in Figure 5.11, which implies the use of dynamic baselines. With greater use of static baselines, the net effect of the two instruments should be reduced.

Compared to the electricity market in the absence of *any* environment regulation, the results are similar to those analysed in Chapter 5, namely:

§ Electricity demand is lower than with no regulation ($E_{ET}<E$).

§ The retail electricity price may either be higher or lower than with no regulation ($P^{C}_{ET}<>P$).

§ The wholesale price may either be higher or lower than with no regulation ($P^{W}_{ET}<>P$).

However, the size of these changes should be smaller (larger) if static (dynamic) baselines dominate.

Compared to the TWC scheme alone (E_T, P_T), the following changes are apparent:

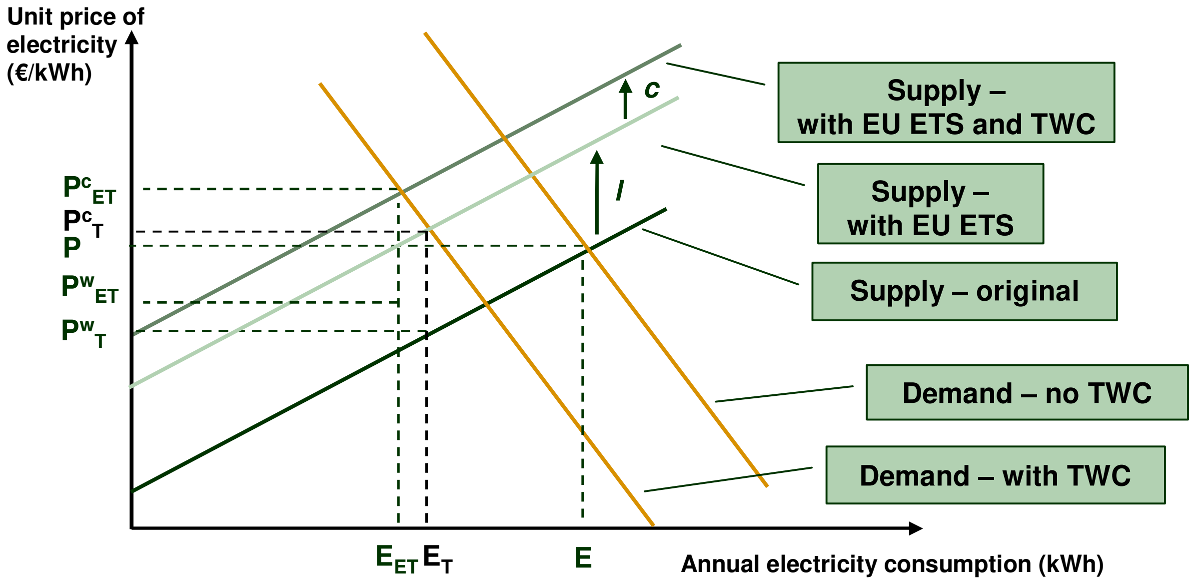
§ Electricity demand is lower than with the TWC scheme alone ($E_{ET}<E_T$)

§ The retail electricity price is higher than with the TWC scheme alone ($P^{C}_{ET}>P^{C}_{T}$).

§ The wholesale price is higher than with the TWC scheme alone ($P^{W}_{ET}>P^{W}_{T}$).

Again, these differences should be smaller (larger) if static (dynamic) baselines dominate.

Figure 7.6
Effect on the electricity market of introducing the EU ETS alongside a TWC scheme



7.2.2 Effect on the objectives of the respective schemes

Compared to a TWC scheme alone, the effect of the EU ETS on key variables is as follows:

- Non-green electricity generation is reduced, due to lower electricity demand.
- The effect on the volume of renewable electricity generation is ambiguous. Although lower electricity demand may reduce total generation, the output from renewables may increase, since they become more competitive once CO_2 is priced. Since most existing renewables have low SRMC, their output is likely to be unaffected by both instruments.
- The price incentive for investment in new renewable capacity is increased. However, EU ETS allowance prices are unlikely to be sufficient to encourage much new investment.
- The price incentive for investment in end-use efficiency is increased. This adds to the increased incentive provided by the TWC subsidies.
- Both national and EU CO_2 emissions are reduced.

Again, these differences should be smaller (larger) if static (dynamic) baselines dominate.

7.2.3 Effect on costs and benefits for different groups

The aggregate costs and benefits of the instrument combination are identical to those outlined in the analysis of the introduction of a TGC scheme in addition to the EU ETS in Chapter 5. It is simply that the basis for comparison is now the TWC scheme alone, rather than the EU ETS alone. In brief, the results are:

- Producers of energy efficiency equipment will benefit more from the additional demand created by the EU ETS.
- Electricity generators will gain from the EU ETS and these gains should offset any losses from the TWC scheme. Low-CO_2 producers should benefit, while high-CO_2 producers will lose.
- Consumers will lose in aggregate from the EU ETS, and this will add to the likely losses from the TWC scheme. The losses to the beneficiaries of TWC subsidies may be greater or less than the direct benefits from the TWC scheme. In contrast, non- beneficiaries are very likely to lose overall.

As discussed above, the extent to which the EU ETS contributes to the achievement of the energy saving target in the TWC scheme will depend on the interpretation of additionality by the regulator. If static baselines are used, the EU ETS should make the TWC targets easier to achieve and the costs to TWC participants should be reduced. But participants in the EU ETS will pay for this cost reduction and the overall cost to society of meeting the energy efficiency target will be increased. In contrast, if dynamic baselines are used the EU ETS should not affect the costs and benefits of the TWC scheme (provided the supply and demand curves for energy efficiency are linear over the region of interest).

7.2.4 Summary of effects

Table 7.1 summarises the ‘price and quantity’ effects of introducing the EU ETS (or tightening the EU ETS cap) in a country that already has a functioning TWC scheme. The columns represent:

- the effect of the TWC scheme alone, compared to no regulatory intervention;
- the effect of the TWC scheme and EU ETS in combination, compared to no regulatory intervention; and
- the additional effect of introducing the EU ETS (i.e., the effect of the instrument combination compared to the TWC scheme alone).

Table 7.2 summarises the distributional effects of introducing the EU ETS in a country that already has a TWC scheme. The interpretation of the columns is the same as in Table 7.1. As before, this is not a complete analysis of the costs and benefits of the instrument combination, since market failures and effects in secondary markets are ignored.

Table 7.1
Summary price and quantity effects of introducing the EU ETS in a country with a functioning TWC scheme

Variable	**TWC scheme**	**TWC scheme and EU ETS**	**Additional impact of introducing the EU ETS**
Wholesale electricity price	Reduced in short term	Likely increased in short term	Higher price than with TWC scheme alone.
	Unaffected in long term	Increased in long-term	
Retail electricity price	Likely increased	Likely increased	Higher price than with TWC scheme alone
Electricity demand	Reduced	Reduced	Lower demand than with TWC scheme alone.
National non-green generation	Reduced	Reduced	Lower generation than with TWC scheme alone
National green generation	Likely Unchanged	Likely Unchanged	Existing renewables have low short run marginal cost and are likely to take preference in merit order. Generation therefore is unlikely to be affected by reduced demand.
National CO_2 emissions	Reduced	Reduced	Lower emissions than with TWC scheme alone
EU CO_2 emissions	Reduced	Reduced	Lower emissions than with TWC scheme alone
Investment in end-use efficiency	Increased	Increased	Higher than with TWC scheme alone, owing to higher retail prices
Investment in new renewables	Reduced	Varies	Higher than with TWC scheme alone, due to higher wholesale prices but unchanged costs to renewables.
White certificate price		-	Either reduced or unchanged, depending upon interpretation of 'additionality'.

Notes: Columns 2 and 3 compare the effects of the policies to a situation where there is no regulation. Column 4 outlines the incremental effect of adding the EU ETS —i.e., it compares the effects in column 3 to those in column 2.

Table 7.2
Summary distributional effects of introducing the EU ETS in a country with a functioning TWC scheme

Variable	TWC scheme	TWC scheme and EU ETS	Additional impact of introducing the EU ETS
Producer surplus			
Energy efficiency producers	Increased	Increased	Higher surplus than with TWC scheme alone
High-CO_2 electricity generators	Reduced	Reduced	Lower surplus than with TWC scheme alone
Low-CO_2 electricity generators	Increased	Ambiguous	Higher surplus than with TWC scheme alone. But benefit from EU ETS likely to exceed loss from TWC
Electricity generators overall	Increased	Ambiguous	Higher surplus than with TWC scheme alone. Benefit from EU ETS likely to exceed loss from TWC
Producers overall	Increased	Ambiguous	Ambiguous impact. But overall surplus likely to be positive
Consumer surplus			
Beneficiaries of TWC investment	Reduced	Ambiguous	Lower surplus than with TWC scheme alone
Non-beneficiaries of TWC investment	Reduced	Ambiguous	Lower surplus than with TWC: Loss from EU ETS likely to exceed benefit from TWC.
Consumers overall	Reduced	Ambiguous	Lower surplus than with TWC scheme alone.

Notes: Columns 2 and 3 compare the effects of the policies to a situation where there is no regulation. Column 4 outlines the incremental effect of adding the EU ETS —i.e., it compares the effects in column 3 to those in column 2.

7.3 Effect of International Trade in Electricity on the Interactions

This section explores the interactions between the idealised national TWC scheme and the EU ETS in a country that is a net importer of electricity. The additional assumptions are that:

§ imports provide the marginal supply on the system and continue to do so after the introduction of both the EU ETS and a national TWC scheme;

§ the host country is sufficiently small to be a price taker in the international electricity market.

For simplicity, only a single scenario is explored, namely that in which a TWC scheme is introduced in a country that is already participating in the EU ETS. As before, the impact of the interactions on a number of key variables is explored, together with the distribution of costs and benefits.

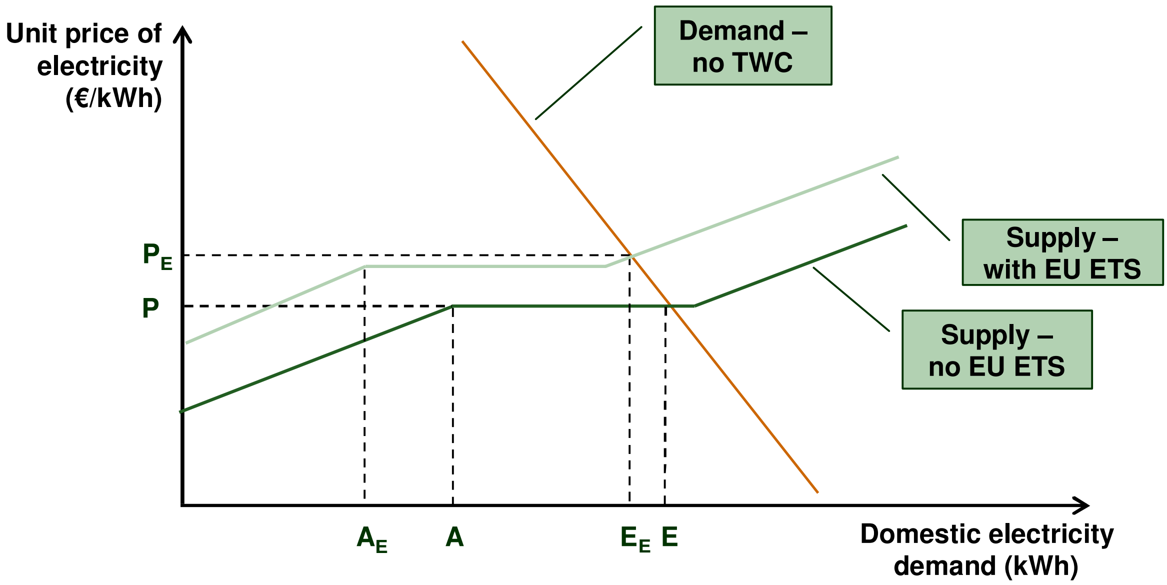
7.3.1 Effect on electricity demand and electricity prices

The implications of international trade in electricity for the EU ETS were explored in detail in Chapter 4. As with an isolated national market, the EU ETS increases the international wholesale price by an amount corresponding to the opportunity cost of CO_2 of the marginal producer on the international system. But the marginal producer on the national system may be more or less CO_2 intensive than the marginal producer on the international system, after allowing for changes in demand. Hence, the EU ETS may change the relative cost effectiveness of imports.

In Figure 7.7, it is assumed that the EU ETS has a smaller impact on the price of imported electricity than on the price of nationally generated electricity (i.e., the marginal producer on the national system is more CO_2 intensive). But it is equally possible that the opposite is the case or that the size of the impact is relatively similar. Following the introduction of the EU ETS, demand of a national market falls from E to E_E and the wholesale price increases from P to P_E (the wholesale price of electricity in the international market). The supply of electricity from domestic generators decreases from A to A_E, while the volume of imports changes from (E-A) to (E_E-A_E).

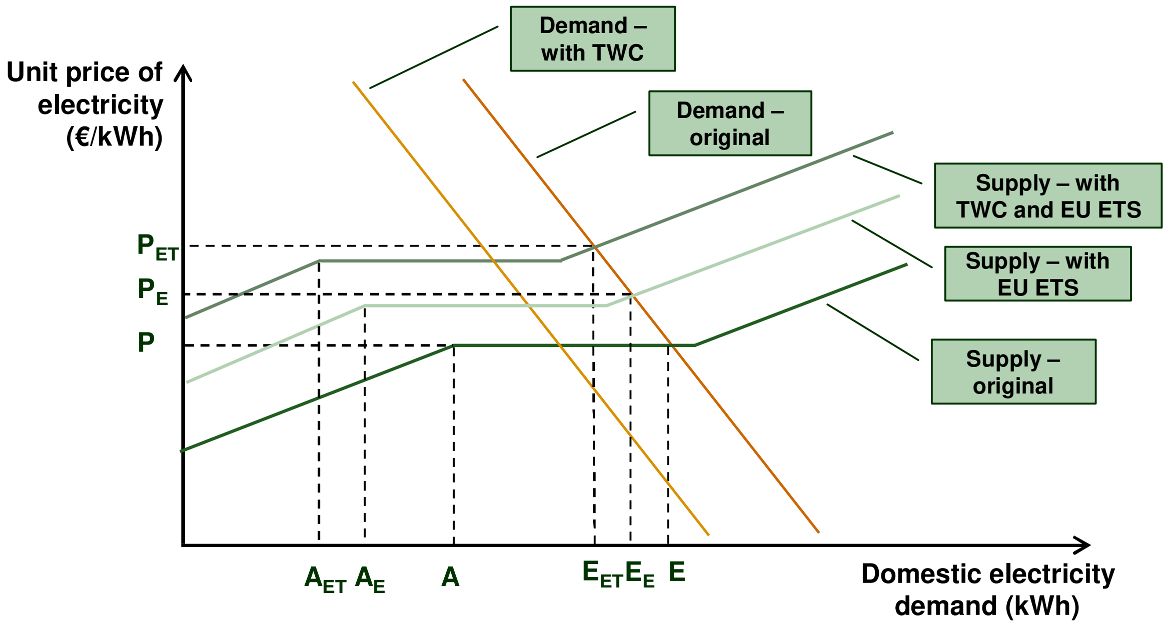
Reductions in demand will reduce the required imports (by E-E_E), with the size of the change being determined by the elasticity of demand. At the same time, the quantity of imports could increase if the marginal producer on the domestic system is more CO_2 intensive than that on the international system, and decrease if it is less. The net effect is therefore ambiguous: both the absolute quantity of imports and the share of imports in total demand may either increase or decrease as a consequence of introducing the EU ETS.

Figure 7.7
Effect of the EU ETS on the electricity market when the country is a net importer



We now assume that a TWC scheme is introduced in the national level. The additional effect of the scheme on the electricity market is illustrated in Figure 7.8. First, the subsidised investment in energy efficiency shifts the demand curve to the left. Second, cost recovery increases retail prices by an amount *l*. This leads to a lower demand E_{ET}, and a higher retail price $P_{ET.}$ However, the international wholesale price of electricity is unaffected by the TWC scheme and remains at P_E.

Figure 7.8
Effect on the electricity market of introducing a TWC scheme alongside the EU ETS when the country is a net importer



Compared to the EU ETS alone (E_E, P_E), the following changes are apparent:

§ Electricity demand is lower than with the EU ETS alone (E_{ET}<E_E)

§ The retail electricity price is higher than with the EU ETS alone (P_{ET}>P_E).

§ The wholesale price is unchanged and remains at the international price (P_E).

Similarly, compared to the electricity market in the absence of *any* environment regulation (E, P), the following changes are apparent:

§ Electricity demand is lower than with no regulation (E_{ET}<E), with both instruments contributing to reductions in demand.

§ The retail electricity price is higher than with no regulation (P_{ET}>P), with both instruments contributing to price increases.

§ The wholesale price is higher than with no regulation (P_E>P), solely as a consequence of the EU ETS.

7.3.2 Effect on electricity generation and CO_2 emissions

The effects of the EU ETS in isolation are:

§ To reduce domestic electricity generation from A to A_E.

§ To increase wholesale electricity prices from P to P_E.

§ To change the volume of imports from (E-A) to (E_E-A_E). Whether this change is positive or negative will depend on the CO_2 intensity of the marginal producer in the national system compared to that on the international system, together with the elasticity of domestic demand.

§ To change domestic electricity generation from A to A_E. As with imports, the sign of this change is ambiguous.

§ To change electricity generation in the exporting countries from (E-A) to (E_E-A_E). The sign of this change is also ambiguous, but must be equal and opposite to the change in domestic electricity generation.

§ To reduce CO_2 emissions overall. CO_2 emissions may increase in the importing (exporting) country, but this must be offset by a greater decrease in emissions from the exporting (importing) country.

The additional effects of introducing the TWC scheme are as follows:

§ To reduce imports from (E_E-A) to (E_{ET}-A).

§ To increase retail electricity prices from P_E to P_{ET}.

§ To reduce electricity generation in the exporting countries by (E_E-E_{ET}). Domestic electricity generation is unchanged.

§ To reduce CO_2 emissions from the electricity generating sector in the exporting country. Emissions from the generating sector in the importing country are unchanged.

As in the case of no EU ETS, while retail prices are increased by the TWC scheme, wholesale prices are unaffected and remain at the level of the international price (P_E) (assuming again that the host country is small relative to the international market). In contrast to a situation without electricity imports, the volume of domestic electricity generation is unaffected and remains at A_E.

Importantly, CO_2 emissions will *not* be reduced overall by the TWC scheme because the ‘freed-up’ allowances will either be banked (emissions shifted in time) or sold to other EU ETS participants (emissions shifted in space). As a result, emissions in the exporting country could either be unchanged (all purchasers are located in that country) or reduced (only a portion of purchasers located in that country).

It was shown in Chapter 4 that a TWC scheme would not reduce national CO_2 emissions when imports are the marginal supplier. When the EU ETS is in place, CO_2 emissions in the importing country could actually increase as a result of the TWC scheme, since some of the purchasers of the exporting country’s ‘spare allowances’ could be located in the importing country. This would not affect compliance with the Kyoto Protocol, since a transfer of AAUs will accompany the imported allowances. But it does mean that the TWC scheme would not contribute to the realisation of targets for *domestic* CO_2 emissions.

7.4 Effect of Market and Design Features on the Interactions

This section briefly assesses how some 'real-world' features of white certificate schemes may change the results identified above. This draws on the detailed discussion of design features presented in Chapter 4. These features will affect the size, location and costs of energy savings and thereby the impact of the TWC scheme on electricity markets. This in turn will affect those interactions with the EU ETS that are mediated through electricity markets and which are discussed in stylised form above. In addition, TWC schemes may sometimes affect emissions from participants in the EU ETS that are not electricity generators. Both of these issues are explored below.

7.4.1 Sources of demand for certificates

The theoretical analysis has assumed that the TWC scheme is confined to the electricity market, with the obligation being imposed upon electricity retailers. In practice, this may not be the case. First, suppliers of other energy carriers (e.g. coal, oil, gas) may also be given obligations to improve energy efficiency (indeed, if they were not given such obligations, the scheme could distort competition for those end-uses where different fuels compete). Second, these obligations may be imposed at different points in the supply chain, such as electricity generation and distribution.

In principle, the inclusion of other energy carriers should have a greater impact on the operation of the scheme than the location of the obligation within the supply chain. The latter is likely to change the administrative costs of the scheme and could change the compliance costs if individual participants either have market power or are subject to economic regulation (see below). But otherwise, the outcome is likely to be the same. In contrast, the inclusion of other energy carriers should significantly change the overall scope of the scheme, the number of participants, the liquidity of the white certificate market, the overall compliance costs, and the effect of the scheme on electricity and fuel markets. In particular, the TWC scheme may have a smaller impact on electricity demand, electricity prices and hence on the EU ETS (see below).

A distinction needs to be made between the selection of participants in the TWC scheme and the selection of energy saving activities that qualify for white certificates. It is entirely possible, for example, to allow improvements in the efficiency of gas or oil use to qualify for white certificates even when the TWC scheme is confined to electricity retailers.[65] In this case, the choice of qualifying activities matters more than the choice of obligated parties, since it is this that determines overall compliance costs and the effect of the scheme on electricity and fuel markets. In contrast, the choice of obligated parties largely affects the number of participants in the scheme and the liquidity of the certificate market.

[65] For example, the UK TWC scheme is confined to gas and electricity retailers, but improvements in the efficiency of oil use also qualify for compliance.

The location of participants within the supply chain could be important if these participants have natural monopoly elements and hence are subject to economic regulation. This is the case in the Italian scheme, for example, where obligations are imposed upon electricity distribution companies and the cost recovery mechanism is subject to regulatory control. In practice, the regulator will not allow the *actual* cost of implementation to be passed through to consumers, but only the *standard allowed cost*. This is calculated with reference to the average avoided cost of a unit of energy saved, and is updated on a regular basis. In this respect, the Italian scheme is analogous to more traditional forms of DSM.

With this approach, there is an incentive for distributors to keep actual costs below allowed costs, but the resulting cost savings will not be immediately passed through to consumers. With sufficient market liquidity, the price of white certificates (L) and hence the costs borne by distribution companies (L*Q) may be comparable to those in a more liberalised market. But the increase in electricity retail prices (*l*) will be determined by the standard allowed costs, rather than the actual costs. Consumers will only benefit from the cost savings achieved by the TWC scheme if and when the standard allowed cost is reduced at the next periodic review. Furthermore, information asymmetry between the regulator and the distribution companies makes it possible that consumers will not receive the full benefit of any cost reductions. This means that the impact of the TWC scheme on electricity market, and hence on the EU ETS, will be mediated by regulatory decision-making and could be either increased or reduced.

A second factor affecting the cost efficiency of a white certificates scheme is market power in the electricity market. If one or a small number of companies dominate the electricity retail market, the incentive for these companies to minimise costs will be reduced. While the energy saving target should still be achieved, individual market participants may have control over the price of electricity. As a result, retailers with market power might react to higher costs by price increases that are either larger or smaller than if the market were competitive.

Similar issues of market power may arise within the white certificate market. This may be a greater issue for TWC schemes than the EU ETS, since the former are national rather than EU-wide and may be confined to one or more sectors (e.g. electricity) that are highly concentrated. Large participants may be able to use their dominant market position to either modify certificate prices to their advantage[66] or deny certificates to competitors. The potential for such behaviour depends upon a number of conditions, including the size of the dominant participant and the proportion of the certificate market that it can command. Widening the scope of the scheme to include suppliers of other energy carriers should help to mitigate such problems.

7.4.2 Defining and allocating targets

The denomination of targets in the TWC scheme may influence energy savings, compliance costs and the resulting impact on electricity markets.

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66 A monopsony buyer could hold back purchases to reduce the certificate price while a monopoly seller could hold back sales to drive up the certificate price

A first choice is between targets denominated in primary energy consumption as opposed to secondary energy consumption. With the former, a 1 kWh saving in electricity consumption by end-users is comparable to a 3 kWh saving in gas or oil consumption. Hence, a TWC scheme targeted on primary energy consumption will bias investment towards electricity savings, even if energy savings from other energy carriers qualify. Denominating targets in primary energy consumption would therefore lead to a greater impact on electricity markets.

A second choice is between cumulative versus lifetime savings. If the latter is chosen, the impact on electricity markets may be less in the short-term, but greater in the long-term. As an example, suppose that participants have a choice between two energy efficient technologies of equal marginal cost. The first reduces consumption by 20 kWh per year and has a lifetime of five years, while the second reduces consumption by 10 kWh per year and has lifetime of 40 years. Participants are likely to choose the first option in a TWC scheme with a cumulative savings target, and the latter in a comparable scheme with a lifetime savings target. The choice may be modified if lifetime savings are subject to a discount rate.

The choice between cumulative versus lifetime savings is linked to a choice between single versus periodic targets. Lifetime savings are most likely to be combined with a single target specified for the end of the TWC scheme. With this arrangement, the volume of trading activity during the course of the scheme is likely to be much less than where periodic (e.g. annual) targets are employed. This may partly explain the limited trading activity in the UK TWC (lifetime savings, single target) compared to the Italian scheme (cumulative savings, periodic targets).

The choice of target denomination will depend on the objectives of the scheme. While compliance costs will be minimised when participants are allowed to utilise the most cost-effective energy saving options, this may conflict with some of the broader objectives of the scheme. For example, the UK TWC scheme requires all energy savings (strictly, ‘energy benefits’) to be found within the household sector, and 50% of these to be found within low-income households. Such restrictions increase the overall cost of the scheme and thereby increase the impact of the cost recovery mechanism on retail electricity prices (*l*). At the same time, a focus on low-income households may reduce the energy savings from individual investments, since the cost savings from improved efficiency may be largely taken up in increased consumption of the relevant energy services (the rebound effect). This has the countervailing effect of decreasing the impact of the scheme on aggregate energy demand. In the UK, such rebound effects do not undermine compliance with the aggregate targets in the TWC scheme, since these are denominated in terms of ‘energy benefits’ rather than energy savings (Chapter 4).

In practice, the rebound effect takes three forms.

§ *Direct effect*: A decrease in the price of supplying an energy service due to an increase in technical efficiency should lead to an increased consumption of that service. For example, a more efficient heating system may allow higher levels of thermal comfort to be enjoyed. This increase in consumption will partly offset the energy savings that are achieved.

§ *Indirect effect*: Insofar as this increase is limited by satiation or other factors, consumers will enjoy an increase in their disposable income that may be spent on other goods and services. To the extent that these other goods and services involve consumption of energy, this will further offset the energy savings achieved.

§ *Economy-wide rebounds*: Entirely analogous direct and indirect effects are applicable to improvements in energy efficiency by manufacturers. Furthermore, a fall in the real price of energy services will reduce the price of products throughout the economy and lead to series of adjustments, with energy-intensive goods and sectors gaining at the expense of less energy-intensive ones. Energy efficiency improvements should also increase economic growth, which should itself increase energy consumption by some second-order fraction.

The direct effect may be expected to vary widely between different sectors, consumer groups and end-users. For example, rebound tends to be higher for space heating than for lighting. Hence, if the TWC scheme encourages investments in areas where the direct effect is large, it will have a smaller impact on aggregate consumption. This is particularly relevant to the UK scheme, where the bias towards low-income households leads to substantial rebound effects from improvements in household heating (efficiency improvements are taken up in improved comfort).

Where the direct effect is smaller, the indirect effect will be larger. But the impact of this upon individual energy markets will depend on how the extra income is spent. For example, if it is spent on overseas holidays, the impact on electricity markets will be minimal. Conversely, if it is spent on more electrical appliances, the energy savings from improved electricity efficiency will be undermined.

Generally, the direct and income effects in combination lead to a greater rebound than the direct effect alone, while the economy wide effect will add a further increment. But while the direct effect will be confined to the energy carrier that is the focus of the TWC scheme, the rebound than results from the other effects will not. Hence, the aggregate impact of a TWC scheme on the consumption of a particular energy carrier will depend on both the size of these individual rebound effects and the extent to which they affect the relevant energy carrier. This may, in turn, be expected to vary over the short and long-term.

7.4.3 Defining and certifying energy efficiency activities

If energy savings from more than one energy carrier are allowed, savings will be biased towards those carriers where efficiency improvements have the lowest marginal cost. Frequently, this will be fuel efficiency rather than electrical efficiency, thereby dampening effect of the TWC scheme on the electricity market (and hence on the EU ETS). In the UK TWC scheme, for example, up to two thirds of the achieved savings have been through improvements in thermal insulation and gas heating, rather than lighting or electrical appliances. This reflects both the relatively low cost of heating improvements and the denomination of the target in terms of lifetime savings (thermal insulation lasts longer than appliances). As a result, the scheme has had a much greater impact on gas markets than on electricity markets.

There may also be restrictions on the sectors and consumer groups in which investment can take place, as well as on the types of technology that can be used. These restrictions will increase the cost of the scheme and with it the price of white certificates.

Savings in electricity consumption will always affect the EU ETS by reducing the allowance price. Whether savings in fuel consumption will do the same depends upon whether the emissions from that consumption are covered by the EU ETS. For example, improvements in fuel efficiency at industrial sites participating in the EU ETS will reduce emissions and hence affect the allowance market, while improvements in household fuel efficiency will not. The UK TWC scheme is confined to households, so it only influences the EU ETS via the electricity market. Conversely, the Italian scheme provides no restriction on the choice of end-user, so it could in principle encourage energy-saving projects at EU ETS installations. In practice, however, the scheme appears to be biased towards small-scale projects located within households and SMEs. At present, therefore, the influence of TWC schemes on the EU ETS appears largely confined to the electricity market. This could change as new TWC schemes are introduced and as the scope of the EU ETS is widened in Phase 2.

7.4.4 Monitoring and verification

The projects encouraged by the TWC scheme require estimation of baseline energy consumption and monitoring and verification (or estimation) of actual energy consumption. Since both may involve considerable administrative costs, regulators will seek methods of simplifying them. In practice, the accuracy of monitoring and verification may be expected to vary with the size and nature of individual projects.

As discussed earlier, the establishment of the baseline is the most important element in assessing the additionality of individual energy savings. Dynamic baselines provide greater assurance of additionality since they can be adjusted to accommodate exogenous changes such as increases in electricity prices. Static baselines do not provide this assurance, but are much simpler to use and lower the risk to project developers. Importantly, static baselines provide feedback between electricity prices and the price of white certificates, while dynamic baselines do not. By extension, static baselines provide feedback between EU ETS allowance prices and the price of white certificates, while dynamic baselines do not.

In practice, static baselines are likely to be dominant on the grounds of minimising investment risk and simplifying administrative procedures. This means that energy savings from the TWC scheme and the EU ETS combined may be less than if dynamic baselines were used. Put another way, the price incentive for greater energy efficiency following the tightening of the EU ETS cap in Phase 2 could be offset by an effective weakening of the energy saving target in existing TWC schemes.

The relationship between electricity/allowance prices and white certificates prices will therefore be mediated by regulatory decision-making on additionality. This is an important contrast to green certificate schemes, where the price response is relatively automatic. The approach to baselines and monitoring and verification will therefore have significant consequences for the total costs of TWC schemes and the energy savings achieved.

7.4.5 Compliance procedures and enforcement

A compliance penalty within the TWC scheme will establish a ceiling on white certificate prices and hence on the total cost of the scheme. This should only be important if the penalty is close to the anticipated cost of energy efficiency investments and hence to the market price of certificates - otherwise, most participants may be expected to comply.

If compliance penalties are binding, the impact of a TWC scheme on electricity prices will be less than some maximum value.

7.5 Summary

This chapter has achieved the following:

- Investigated the response of white certificate prices to changes in electricity prices and emphasised how this differs from the case of green certificates.
- Analysed the interactions between an idealised national TWC scheme and the EU ETS and analysed the effect on various ‘price and quantity’ variables and the distribution of costs and benefits. The interactions were explored in terms of the introduction of the EU ETS, or the tightening of the EU ETS cap, in a country that already has a functioning TWC scheme.
- Examined how these results are modified in a situation where the host country is a net importer of electricity and where imports act as the marginal producer. This situation is also relevant to countries that are net exporters of electricity and to countries that import or export electricity at some times.
- Considered how a number of ‘real-world’ market and design features may change the results identified.

A key result is that the interaction between TWC schemes and the electricity market (and hence the EU ETS) should be mediated by the interpretation of additionality by the regulator. This means that the feedback between electricity and certificate prices will not be as automatic as it is for TGC schemes. But since static baselines are likely to dominate in practice, certificate prices are likely to fall as electricity prices increase.

Once the EU ETS is in place, a TWC scheme that is confined to the electricity market will *not* contribute any additional reductions in CO_2 emissions. This is important, as the contribution to national emission targets may be one of the primary objectives of such a scheme. Furthermore, if there is international trade in electricity, CO_2 emissions in the importing country could actually *increase* as a result of the TWC scheme. This is because EU ETS participants located in the host country may purchase the ‘spare allowances’ that have been displaced from electricity generation in neighbouring countries as a result of the TWC scheme. In contrast to TGC schemes, however, TWC schemes are likely to extend *beyond* the electricity market to include energy savings from fuel consumption. In these circumstances, the TWC scheme can provide additional emission reductions, provided the relevant fuel consumption is not also covered by the EU ETS.

Chapter 4 demonstrated how the implications of a TWC scheme in isolation are not straightforward. This complexity increases when the instrument is combined with the EU ETS. While the analysis in this chapter is highly simplified, it does demonstrate the complicated and sometimes counterintuitive effects that result. In the ‘real-world’ these interactions will be mediated by host of market and design features that are specific to individual countries. Nevertheless, the basic effects identified in this chapter should still hold. A fuller investigation would require quantitative modelling, preferably within a general equilibrium framework.

8 Conclusions

8.1 General Conclusions

The following are general implications of the interactions between the national Green and White Certificate programmes and the EU ETS.

§ National TGC and TWC programmes generally would *not* affect EU-wide CO_2 emissions from EU ETS participating facilities, although the programmes would affect other facets of the EU ETS.

- The CO_2 allowance price would be reduced.
- Overall costs of meeting the CO_2 cap would be increased (but this comparison does not take into account the non-CO_2 benefits and any 'technology-forcing' benefits of the two programmes).
- Changes in the location of CO_2 allowance purchases/sales due to the programmes could affect national CO_2 emissions.
- EU-wide CO_2 emissions from participating facilities could in theory be reduced below the overall cap if the Green and/or White Certificate programmes were sufficiently stringent; in this case, the EU ETS would not be binding and the CO_2 allowance price would be zero. (Of course, the cap could also be reduced if the presence of the Green/White Certificate programmes led policy makers to reduce overall allowances to the participating facilities.)
- Moreover, CO_2 emissions outside EU ETS participating facilities could be reduced due to White Certificate programmes if non-electric efficiency projects were included (e.g., insulation programs that reduce household/commercial fuel use and thus CO_2 from oil/natural gas sources not covered by EU ETS).
- TGC and TWC programmes would reduce the effects of the EU ETS on wholesale electricity costs (because they reduce CO_2 compliance costs and the CO_2 allowance price); but this result does not imply that the combined electricity cost/rate increases of the EU ETS and the TGC and TWC programmes would be smaller than the effects of the EU ETS on its own.

§ Providing CO_2 credits for TGCs or TWCs would not be desirable.

- Providing such credits would represent double counting, which would have the effect of undermining the EU ETS CO_2 cap.
- Providing credits based upon average CO_2 rates for Green or White Certificates would introduce inefficiencies since the average rates would not reflect the actual CO_2 emissions 'reduced' as a result of increased green generation or reduced generation.

8.2 Detailed Conclusions

The following are implications of the interactions between green and white certificate programmes and the EU ETS that take into account various complications. Specifically, these implications relate to the following complications:

- Regulatory treatment of the electricity sector;
- Relative geographic scope of the various programmes; and
- Alternative design parameters for the various programmes.

The report provides additional information on the details of these programmes and their interactions.

8.2.1 Implications of Different Regulatory Treatment of the Electricity Sector

The following are implications of regulatory treatment, specifically whether wholesale or retail electricity markets are subject to price regulation rather than being liberalised (as anticipated eventually throughout the EU). Wholesale electricity markets are now deregulated in the UK, but retail regulation is still in place in a number of EU Member States. In addition, there are likely to be instances where newly deregulated markets do not conform to the assumptions of 'perfect competition' made in most of the analysis in the report.

Electricity regulation may prevent the opportunity costs of CO_2 emissions from being reflected in electricity prices, which would increase the cost of meeting the CO_2 target but would not affect achievement of the CO_2 target.

  - The EU ETS programme costs would increase under regulation if opportunity costs were not included in electricity prices because electricity demand would be greater and thus it would be necessary to adopt more costly methods of reducing CO_2 emissions (e.g., substitution to more costly low-CO_2 fuels).

- Electricity price regulation would not directly affect the green and white certificate programmes because the additional costs due to the certificate requirements would be direct payments–rather than 'opportunity costs'—and thus would likely be accounted for in both 'cost-of-service' and 'price cap' regulation as well as in a liberalised electricity market.
- Electricity regulation would, however, have indirect effects on the certificate programmes through the electricity price effects of the EU ETS programme.
  - If green and white certificate targets are set as a percentage of electricity sales, the greater sales (due to lower prices from not including the opportunity costs of CO_2 emissions) would lead to a requirement for more green and white certificates, which in turn should result in higher certificate prices.
  - This result assumes that the percentage targets are not adjusted.
- If the number of buyers or sellers of green or white certificates were small—perhaps because of regulatory requirements—certificate markets may not operate in a competitive manner and prices could therefore be affected. If there were a single purchaser (e.g., the regulated utility), the certificate price would be lower and thus there would be less support for green generation or energy savings. Conversely, a small number of sellers could lead to market power and higher certificate prices, which might undermine programme cost effectiveness.

8.2.2 Geographic Scope of Programmes

The following are implications of the relative geographic scope of the EU ETS and green and white certificate programmes.

§ The effects of the EU ETS—which is an EU-wide system—will differ in different geographic electricity markets.

- Electricity markets with different fuels on the margin—and thus different CO_2-intensity—will have different CO_2 electricity price effects, which in turn will mean different effects on green and white certificate programmes.
- Greater integration of European electricity markets (e.g., further development of EU-wide markets) will lessen these differences.

§ The effects of green and white certificate programmes will differ depending on their geographic scope.

- If certificates from different Member States are not fungible, certificate prices are likely to differ, and therefore to offer varying levels of support for investment in green generation or energy savings.
- If green certificates are fungible across Member States, certificate prices will equalise and investment incentives will be greatest wherever wholesale electricity prices are highest and eligible technologies can be built at the lowest cost. In general, the location and type of investment in green generation will differ from the case of purely national certificate markets. Similar conclusions apply to white certificate programmes.
- If electricity markets are also fragmented, this will introduce further potential for variation in certificate prices. Connected electricity markets may still offer different levels of support through different certificate prices, however.
- Similarly, different electricity prices in national or regional electricity markets could result in different incentives for renewables or energy saving even where green and white certificates were fungible across Member States.

The effects of individual green and white certificate programmes on the EU ETS are likely to be limited.

- If limited to programmes in individual Member States, green and white certificate markets are likely to have small effects relative to the size of the EU ETS market. The cumulative effect of on the EU ETS will of course depend on the stringency of the programmes (as noted below).
- Certificate schemes are likely to reduce demand for non-green electricity, and thus its wholesale price, but this price effect could be muted in an international electricity market. In this case, wholesale prices would not decline as much in response to a certificate programme, so retail electricity prices would be greater than in the absence of international trade in electricity.
- Relative to the case of segmented electricity markets, international trade in electricity therefore could mean a greater reduction in electricity demand, and therefore a greater

reduction in baseline CO_2 emissions—and thus potentially somewhat reduce the price of EU ETS allowances. (Like other effects on the wholesale price, this effect would be transitory, as long-term electricity prices would reflect the cost of new entry, regardless of certificate markets.)

§ International trade in certificates may affect CO_2 emissions in individual Member States, as imported certificates lead to lower CO_2 emissions in the originating but not in the importing country. However, this will not have an impact on EU-wide CO_2 emissions as long as certificates are traded only within the EU.

8.2.3 Design Parameters of Programmes

Various design parameters of the programmes influence the interactions of the EU ETS with the green and white certificate programmes.

§ Greater stringency will accentuate the effects of the programmes on one another.

- A stricter CO_2 target will raise electricity prices and provide more support for green generation and energy savings, with less support required from the certificate programmes themselves and consequent lower certificate prices for a given target.
- Similarly, a higher percentage 'green' electricity required or large amount of energy savings would result in more CO_2 reductions, with a smaller difference between EU ETS baseline emissions and the EU ETS cap, and correspondingly lower allowance price.

§ Certificate price constraints may alter some interactions between certificate programmes and the EU ETS.

- With a binding certificate price floor or ceiling (e.g., a maximum green certificate price) the certificate price would not be free to adjust to reflect the level of support needed to meet the green quota. In this situation, the EU ETS may offer additional support for investment in green generation.
- A high allowance price makes it less (more) likely that the certificate price ceiling (floor) will be binding in a particular period.

§ Factors that mute the effect of the EU ETS on electricity prices also mean that green and white certificate prices will be higher for a given target, as less support for green generation and energy savings would come from the EU ETS.

- Allocations to new entrants would lower the cost of adding generating capacity, and therefore also long-term wholesale electricity prices. More generally, 'updating' allocation approaches lead to a lower effective CO_2 opportunity cost for generators, with lower resulting wholesale electricity prices.
- Electricity prices would also be lower if pass-through constraints (on either the wholesale or the retail level) are imposed by regulators seeking to limit the impact of the EU ETS on power prices.
- Efforts to reduce the electricity price impact of the EU ETS may be less effective in the presence of certificate price scheme, as certificate prices and therefore retail electricity prices would increase, partly offsetting any pass-through constraints on the

EU ETS. The magnitude of this effect increases with the size of the TGC quota / TWC target.

- The interactions depend on how the certificate targets are formulated, and whether the effects of the EU ETS are included in the baseline against which the target is set.
  - The EU ETS may lead to lower electricity demand, and therefore to less green generation or energy savings if targets were relative (as in most green certificate schemes). This effect would not occur if targets were absolute (as in most white certificate schemes).
  - If the effects of the EU ETS were not taken into account in setting targets, certificate prices would be lower as the EU ETS offers more support for green generation and energy savings.
  - By contrast, if the energy savings or green generation targets were to take account of expected EU ETS allowance prices, the certificate prices will not be lower. Indeed, achieving a given amount of additional energy savings / green generation may become more expensive as low-cost opportunities are exhausted, leading to higher certificate prices.
  - In practice, defining 'additionality' may be very difficult, particularly for determining energy saving targets.
- Depending on their eligibility for certificates, pre-existing or 'economically viable' generation technologies may be more affected by the EU ETS than would be other renewable energy sources.
  - Many green certificate schemes exclude pre-existing or otherwise economically viable renewable generation sources and thus these sources would not receive the subsidy provided by green certificates. However, these sources do benefit from the price effects of the EU ETS.
  - If generation from some CO_2-emitting technologies were eligible for certificates (e.g., fossil fuel-fired combined heat and power installations), the green merit order may be altered as the EU ETS would make such generation relatively more expensive than that from non-CO_2 emitting 'green' sources. Like all changes to the merit order this effect has the potential to alter the price of certificates as well as the composition of green electricity supply.
- Support for energy saving or green generation offered by the EU ETS may decrease the risk related to the varying price of green/white certificates.
  - The EU ETS has more flexible borrowing and banking rules than do many existing certificate schemes. The EU ETS allowance prices may provide greater ability than the certificate programmes have to offer certainty for investors in green generation / energy savings projects.
  - More generally, the volatility of certificate prices may be moderated by support offered through the EU ETS, and vice versa (assuming certificate and allowance prices are uncorrelated).
  - Conversely, some certificate schemes have a longer time horizon than does the EU ETS, so they actually may offer greater certainty.

§ If the EU ETS allows extensive use of Joint Implementation and Clean Development Mechanism projects, the effects of the EU ETS on the certificate programmes (and vice versa) could be substantially diminished.

- The EU ETS affects the certificate programmes through effects on electricity markets, which would be reduced if JI/CDM credits reduced CO_2 allowance prices.
- Similarly, the certificate programmes affect the cost of the EU ETS programme in part through effects on the price of CO_2 allowances; if the price of CO_2 allowances is set by the cost of JI/CDM credits, these price effects would be smaller.

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Appendix A. Review of Existing and Proposed Tradable Green and White Certificate Schemes[67]

A.1. National TGC schemes in the European Union

The Belgian Federal structure devolves responsibility for the promotion of renewable energy to the following regions: Flanders, Wallonia, and Brussels. Among these three regions, only Flanders and Wallonia have instituted TGC schemes supporting green electricity. These regions also constitute the only two regional schemes presently in operation in the European Union. In addition, there are provisions on a federal level for large customers connected directly to the national grid and for electricity generated outside any of the regions, e.g., from offshore wind turbines.

The Flanders scheme became operational on 1 January 2002 while the Walloon scheme began trading in 2003. The schemes differ in several respects, including the eligible generation, penalties, and price regulation.

In the Flanders scheme, certificates are issued by Vlaamse Reguleringsinstantie voor de Elektriciteits- en Gasmarkt (the Flemish electricity and gas regulator, 'VREG') for each 1,000 kWh of eligible electricity generated. The definition of eligible green electricity sources excludes all fossil fuel fired generation and also large-scale hydro power. In contrast, the Wallonia certificates are not denominated in electricity but in the amount of CO_2 emissions calculated to have been avoided relative to a counterfactual amount of electricity generated from traditional energy sources. Each certificate corresponds to 456 kg of CO_2 emissions. This is equivalent to the amount of CO_2 calculated to be emitted from producing 1 MWh of electricity in a combined-cycle gas turbine power station with an efficiency rating of 55 percent. Renewable energy sources eligible are those listed in EC Directive 2001/77/EC, but the scheme also has provisions for efficient co-generation as well as CO_2 emissions reductions contributed by efficient combined heat and power (CHP) installations. The Walloon scheme thereby incorporates an energy efficiency element into the green certificate scheme. In contrast, a separate CHP certificate scheme is planned in the Flanders region.

In both regions, the quota is applied to suppliers of electricity, who must surrender certificates corresponding to a certain share of the electricity they supply. This is conducted on a yearly basis in the Flanders scheme, while compliance is monitored on a quarterly basis in the Walloon scheme. The quota obligations are also different for these regions. However, both schemes have long-term and rising quota obligations (detailed in Table A.1 below). The long-term target for Flanders and Wallonia (within the framework of EC Directive 01/77/CE) is 6 and 8 percent, respectively.

[67] This draws on IEA (2004).

Table A.1
Green electricity quota obligations in Belgium

Year	Flanders Quota (percent)	Wallonia Quota (percent)
2002	1.41	N/A
2003	2.05	3
2004	3	4
2005	N/A	5
2006	N/A	6
2007	N/A	7
2008	N/A	N/A
2009	N/A	N/A
2010	6	8

Source: CWaPE (2005), VREG (2005a).

CWaPE, which operates the Walloon scheme, offers to purchase certificates at a fixed price, effectively providing a fixed minimum price for the certificates. Certificates sold directly to CWaPE are withdrawn from the market, providing a feedback mechanism designed to help boost the certificate price should it drop to the minimum price level. Neither system has a formal price ceiling, although a *de facto* maximum price is defined in both systems by a penalty for non-compliance. This is set in absolute terms, currently at €100/MWh, rising to €125/MWh under the Flanders scheme. The Walloon scheme also includes a system for recycling revenues from non-compliance penalties into a regional renewable energy fund. Collected revenues are used to finance new renewable installations.

The certificates are valid for five years under both systems, and banking (but not borrowing) is provided for. In the first year of the Walloon scheme, 20 percent of the certificates were banked.

A.1.1.Italian TGC scheme[68]

The Italian TGC scheme was created in 1999 and became operational in 2002. It imposes a quota on electricity producers to ensure that certificates corresponding to 2 percent of generation are surrendered each year. No long-term quotas have been set, but there are provisions in the relevant legislation for the government to increase the quota amount as necessary.

In addition to many non-fossil fuel generation sources, efficient combined heat and power installations are eligible for certificates. The scheme also restricts eligibility with a view to encourage the construction of new green generation capacity. Only generation capacity added after 1 April 1999 is eligible, and there is also a time-limit to eligibility, as installations only receive certificates for the first eight years of operation. While this helps provide an incentive for new construction, the implied life-time subsidy accruing to investments in renewable energy is decreased.

The Gestore della Rete di Trasmissione Nazionale SpA (the Italian Independent Transmission System Operator, 'GRTN') is responsible for issuing, verifying and monitoring compliance. Its affiliate company, Gestore del Mercado Elettrico ('GME') is responsible for running the

68 The following section draws heavily from Lorenzoni (2003).

market for the certificates, although these certificates can also be freely traded in outside agreements. Each certificate corresponds to 100 MWh of green energy, an unusually large unit of measurement. Compliance has to be demonstrated on a yearly basis and certificates are only valid for the year in which they were generated. There is thus no provision for banking of borrowing. Currently, no details of penalties have been published.

The introduction of this scheme has complicated the transition from previous subsidy schemes. In particular, the so-called CIP6 programme, in operation until 1999, offered a subsidy in the form of higher prices for generation. The two schemes have now effectively merged and operators of CIP6 projects can either opt to receive certificates or to keep their previous higher-than-market price contracts. In the latter case, GRTN pays the subsidy (which was previously paid by consumers through their electricity bills), but is allowed to issue certificates to be sold at a regulated price designed to meet the costs associated with the subsidy. The effect of this arrangement makes GRTN a very dominant supplier of certificates. Concerns associated with market concentration, including the prospect of market power, may therefore be relevant. Another likely effect is that the GRTN offer price forms an effective price ceiling, albeit one that is uncertain.

An unusual feature of the Italian scheme is it allows for the import of certificates from countries with similar adequate certification of renewables. Unlike domestically generated certificates, the imported electricity and certificates have to be traded together. This effectively limits importing from neighbouring countries.

A.1.2. Dutch TGC schemes

Two TGC schemes have been operational in the Netherlands in recent years: the 1998-2001 *groen label* ('green label') scheme and the 2001-2005 green certificate scheme, which superseded the *groen label* scheme. These were the first TGC schemes in Europe, but neither is now in operation. Nonetheless, reviewing the Dutch experience with these schemes is instructive.

A.1.2.1. The 1998-2001 *groen* label scheme

The *groen label* scheme was launched as a voluntary agreement between the power sector and the government to achieve reductions in CO_2 emissions and was the first TGC scheme operational in Europe. In the 1997 Environmental Action Plan, a total of 1,700 GWh of renewable electricity supply was apportioned to industry, with quotas in proportion to companies' 1995 supply levels. The introduction of tradable 'labels' (essentially, certificates) was at the behest of industry, which saw this as a cost-efficient alternative to quotas.

Labels were valid for only one year and the penalty (fee) for non-compliance was set at 150 percent of the average label price. Most trading was done bilaterally, often through long-term contracts. In total, the renewables generation during the scheme's lifetime amounted to about 1,500 GWh, although there is disagreement about the extent to which this was attributable to the scheme.

The scheme existed alongside other support mechanisms, including a scheme for the voluntary purchase of green electricity by consumers. The existence of multiple support mechanisms added to the administrative burden of the scheme because of efforts to avoid the double crediting of green generation.

The scheme ended in 2001, partly because a new voluntary agreement was not forthcoming. In addition, the concurrent deregulation of the Dutch electricity market complicated the definition of obligations and quotas. Agreements made under the old, monopolistic approach were difficult to reconcile with the new situation of increased competition in the electricity market. The *groen label* scheme therefore lapsed in 2001 and was replaced by another scheme design.

A.1.2.2. The 2001-2005 green certificate scheme

In 2001, a new scheme was launched. The national grid operator, TenneT, administered the scheme, including certificate issuance and compliance monitoring. Initially, only domestically produced green electricity was eligible for certificates, but this was subsequently changed to include some provisions for the import of certificates through the Renewable Energy Certificate System ('RECS').

The Dutch scheme differed from other TGC schemes in that it was based on voluntary participation. Instead of mandating a quota for participants in the electricity market, demand was driven by offering end-users of green electricity exemption from energy taxes, set at a level intended to ensure that green electricity was on an equal footing with non-green energy sources. TenneT monitored the amount of green electricity sold and also issued and retired certificates accordingly.

Certificates were valid for five years. The voluntary nature of the scheme meant that no maximum price or compliance penalties were relevant. In addition, there was no minimum price. Although the TGC scheme was introduced within the context of the Netherlands's obligations under the EU renewables directive (Directive 2001/77/EC), the system did not contain any provisions for the specific target level of green generation to be achieved.

The scheme had difficulties establishing a functioning certificate market. In particular, demand did not pick up as expected. Part of the reason might have been a widespread perception among consumers that green electricity was more expensive than other electricity, quite contrary to the scheme's provisions. The link to the energy tax regime also meant that demand depended on parameters that were politically contentious, making long-term support uncertain and ill-defined. As a result of these and other factors, prices were very low by early 2003, offering little support for renewables investment. The Dutch parliament voted in November 2004 to end the scheme, switching instead to feed-in tariffs to support renewables generation.

A.1.3. Swedish TGC scheme[69]

The Swedish TGC scheme was launched on 1 May 2003. The scheme is jointly administered by the energy regulator, Statens Energimyndighet (Swedish Energy Authority, STEM), and

69 This section draws on Wang (2005), STEM (2003) and STEM (2004).

the grid operator, Svenska Kraftnät. STEM has overall responsibility for the monitoring of compliance, which has to be demonstrated on a yearly basis.

The scope of the scheme is designed to be compatible with the Renewable Energy Certificate System, an international system of green certification which includes only non-fossil fuel generation. There are also mechanisms in place to ensure that generation are not awarded two separate certificates under multiple countries' certificate programmes (no double-counting). There has been some concern about the definitions of qualifying energy sources. In particular, while the specifications for qualifying hydropower are very detailed and aim to exclude most of the pre-existing and economically viable hydropower, there has been some criticism of windfall profits accruing to incumbent installations. Another controversial issue has been the inclusion of peat among fuels eligible to receive certificates.

The quota obligation is placed on end-users, though energy used for certain energy-intensive and wood processing industrial processes is exempted from any obligation under the scheme. End-users can compile their own compliance reports, but in practice all but large end-users have opted to delegate the administration of compliance reporting to their suppliers. In a recent review by the Swedish Energy Authority, it was suggested that the obligation should be shifted from end-users to suppliers.

Certificates are valid indefinitely and allows for banking. In the scheme's first year of operation, a certificate had to be surrendered for seven percent of electricity consumed, rising to almost 17 percent in 2010 (see Table A.2). The quotas are designed to contribute to the addition of 10 TWh of annual production from qualifying sources by 2010, relative to 2002 levels.

Table A.2
Quota obligation in the Swedish TGC scheme, 2003-2010

Year	Quota obligation (percent)
2003	7.4
2004	8.1
2005	10.4
2006	12.6
2007	14.1
2008	15.3
2009	16.0
2010	16.9

Source: STEM (2003).

Non-compliance is punished through a fine corresponding to 150 percent of the average certificate price during the relevant compliance year. For the first two years, the fine was subject to an upper ceiling (both in relative and absolute terms), scheduled to be abolished during the 2005/06 compliance year. There is also a price floor, since STEM guarantees to purchase certificates at the regulated price. The price floor will be gradually phased out and is expected to disappear entirely by 2007/08.

The market has been reasonably liquid with stable prices. In 2004, Nerd Pool, the Nordic energy exchange, started listing the Swedish TGC certificates. According to STEM, 2.4 percent of the cost of electricity for a representative household is attributed to the cost of green certificates. However, STEM also calculates that because of administrative complexities, only half of the total expenditure on certificates actually went to generators of qualifying electricity. One-sixth was collected by suppliers as administrative fees and the rest was retained by the government as fees and taxes.

STEM recently evaluated the scheme and suggested a number of modifications. The most important recommendation was the transition from a temporary scheme that is renewed every two years to a permanent scheme with a long-term political commitment. Parliament is expected to vote on this issue in 2005.

Another suggested modification was the transition from a consumer obligation to one placed on suppliers, making it part of the overall electricity price. In practice, consumers are unable to handle their own compliance reports. However, suppliers that charge for the administrative costs of the scheme are not subject to proper competition.

A.1.4. UK TGC scheme

The UK TGC scheme is termed the Renewables Obligation and the associated certificates are known as Renewable Obligation Certificates ('ROCs'). A quota obligation is placed not on electricity generators but on suppliers and certificate issuance and compliance monitoring is vested with the Office of Gas and Electricity Markets ('Ofgem').

Qualifying renewables include most renewable energy sources. Restrictions are placed on the eligibility of hydropower above a certain threshold size, which only qualify if classified as new additions to capacity. Co-firing of biomass is eligible subject to a number of contingent conditions, including a minimum proportion of biomass to fossil fuel, and a limit to the number of ROCs derived from co-firing that can be used for compliance. ROCs are valid for two years and thus bankable one year into the future.

The scheme initially required that three percent of total electricity supplied to customers in 2002/2003 be derived from renewable sources. Targets have been set for each year till 2010/2011 which is set at 10.4 percent (see Table A.3). The policy emphasised the need to provide long-term support for investment and to that end the Obligation will remain in place at least until 2027. In addition, the UK has been emphasising the long-term nature of the scheme and there are legal provisions for the scheme to remain in place until at least 2027. The energy minister has also announced the intention to maintain a rising target beyond 2011, with an overall aim of 15.4 percent in 2015.

Table A.3
Target obligation in the UK TGC scheme, 2003-2011

Year	Target (percent)
2003	3.0
2004	4.3
2005	4.9
2006	5.5
2007	6.7
2008	7.9
2009	9.1
2010	9.7
2011	10.4

Source: UK Renewables Obligation Order (2002)

An unusual feature of the UK scheme is the ‘smearback’ mechanism used to recycle revenue from non-compliant suppliers to ROCs holders. A supplier who fails to register sufficient ROCs within a compliance year must buy its shortfall from Ofgem at the ‘buy-back’ price. This price is set each year by Ofgem and rises each year in line with the retail price index (the 2005 price has been announced at £32.33 (€46.80) per MWh.) The money raised by the buy-back mechanism is redistributed to complying suppliers in proportion to the ROCs they hold. Suppliers holding ROCs for actual renewables generation therefore derive benefit not only by avoiding the buy-back charge, but also by receiving a rebate from Ofgem.

The combination of the buy-out price and the smearback mechanism is designed to help alleviate price fluctuations by providing an effective ‘safety-valve’ mechanism, while also providing increasing incentives to renewables producers the greater the shortfall in actual renewable generation. However, it also injects some uncertainty into the valuation of ROCs, especially for future vintages. It has been argued that this uncertainty has reduced the usefulness of the system for long-term finance, as banks and other financiers are reluctant to accept the ‘smearback’ component of future ROCs as a security for finance. Investor skittishness was compounded during the first year of the scheme, when UK supplier TXU went into administration in November 2002, leaving unfulfilled its obligation to pay into the buy-out fund. TXU’s failure to meet its Renewables Obligation in the 2002/03 compliance year reduced the size of the fund, reducing the value of each ROC currently in the market by an estimated £4 (€5.80) in one stroke.[70]

Apart from the TXU episode, the ROC market has generally been stable. A review will be conducted in 2005-2006 and is scheduled to include a wide range of issues.

In addition to ROCs, there is also the so-called Levy Exemption Certificates (LECs) operating in the UK market. Renewable generation is exempt from the Climate Change Levy, a form of energy tax which all other generators are required to pay.[71] The LEC is a certificate of exemption that can be sold to any other party. Unlike in other schemes, the value of the LEC is determined not primarily by the supply of renewables but by the cost of the associated energy taxes.

A.2. Green Certificate Schemes outside the European Union

A.2.1. Australia

Tradable credit programmes to promote renewable energy and energy efficiency are not limited only to Europe. Australia began a programme similar to the Tradable Green Certificate scheme in April 2001. The Mandatory Renewable Energy Target (‘MRET’) was adopted by the Australian Parliament to increase the amount of electricity supplied by renewable sources. Eligible energy sources and technologies include hydro power, wind power, solar power, and various methods of capturing energy from waste. However, energy

70 Such criticisms of the potential for price fluctuation must of course apply to any market-based certificate scheme. Investors in search of guaranteed prices would do better favouring other support mechanisms.

71 Some combined heat and power (CHP) facilities are also exempt from the levy.

derived from fossil fuels, even fossil fuel waste, is ineligible. Through this programme, Australia plans to have 9,500 GWh of extra electricity from renewable sources per year after 2010. To put it in perspective, 9,500 GWh represents roughly five percent of the annual electricity generated in Australia. To ensure that there is adequate long-term incentive for building new renewable energy facilities and for researching cleaner technology, regulators have specified that the renewable obligations will be enforced through at least 2020.

Every MWh of electricity generated by renewable energy is worth one certificate, which is registered in an online database managed by government regulators. Similar to the European TGC schemes, electricity wholesalers and large-scale buyers as a group are obligated to hold the necessary number of certificates in order to meet the national quota. Allocation of liability to these wholesalers and buyers is based on the percentage of electricity bought. For example, a wholesaler that buys five percent of the electricity generated nationally in one year is responsible for five percent of the year's quota for electricity from renewable sources. The penalty for non-compliance is A$40 (€24) per MWh.

Electricity retailers can either buy electricity directly from renewable sources (and thus acquire the certificates corresponding to the amount of renewable electricity bought) or purchase sufficient credits to meet their obligations. Electricity retailers weigh the costs of electricity from renewable sources against the cost of certificates available in the national market. As in other trading certificate schemes, MRET enables Australia to increase its generation of electricity from renewable sources without creating severe inefficiencies in the electricity market.

A.2.2 State and Regional Programmes in the United States

Eighteen US States have adopted renewable source generation requirements and many states permit credit trading. Similar to the EU, these standards mandate that a minimum percentage of the power supply come from renewable sources. To ensure compliance, the renewable portfolio standards require that each power supplier in the area meet the minimum percentage—by either producing renewable energy or purchasing renewable energy credits ('RECs'), which are the equivalent of green certificates. Tradable RECs are crucial to the success of renewable portfolio standards because they allow the standards to place the burden of compliance on all power suppliers. Individual states have developed unique RPS plans based on the general REC trading approach.

Some States have set up REC tiers—based on ages or types of renewable energy sources. By 2009, Massachusetts will require that four percent of all electricity sales be accompanied by RECs for new renewable sources (sources that came on line after 1998). Rhode Island requires that two percent of all electricity sales be accompanied by RECs for pre-1998 renewable sources, and will require (by 2019) that 14 percent of all electricity sales be accompanied by RECs for newer sources. These schemes promote the development and use of new renewable source technologies and create separate markets for RECs from existing sources and RECs from renewable sources.

Connecticut's standards stipulate that 1.5 percent (seven percent by 2010) of its electricity sales come with RECs for Class I resources (which include wind power, landfill gas power, fuel cells, solar power, ocean thermal power, wave/tidal power, some hydropower, and some biomass power), and that an additional three percent of sales come with RECs for either Class

I resources or Class II resources (which include municipal waste power, additional hydropower, and additional biomass power). This scheme promotes the use of specific types of renewable sources and creates separate markets for different types of renewable sources.[72]

Many of the states that allow REC trading receive substantial amounts of power from out-of-state sources. Thus, states must consider the complications that arise from REC distribution to out-of-state suppliers. Maine, Connecticut, and Massachusetts allow all renewable sources within New England[73] (or along the border of New England, if they supply New England directly) to apply for credits. However, the three states have different criteria for the eligibility of renewable sources. Some renewable sources in New England are eligible to generate RECs for any of the three states, while others might only be able to generate RECs for a single state. Additionally, RECs for Massachusetts, Connecticut, and Rhode Island are separated into tiers. The New England Power Pool ('NEPOOL') tracks RECs throughout New England and the surrounding area. NEPOOL categorises every generated REC according to its usability (i.e., the states and tiers to which it applies). Most RECs are valid in multiple states, but no REC can be used more than once. Thus, the NEPOOL system is set up to prevent double-counting (wherein, for example, a wind plant in Vermont might sell separate RECs for the same generated power in both Massachusetts and Connecticut). The NEPOOL system allows individual states in New England to successfully expand REC trading beyond the confines of their state boundaries while maintaining state-specific RPS plans.[74]

By the end of 2005, a similar system in Western North America, the Western Renewable Energy Generation Information System ('WREGIS'), will allow eleven states and two Canadian provinces to coordinate trading of RECs across state boundaries. WREGIS will also include the capability of importing RECs from beyond the WREGIS coverage area, so that states can opt to trade with entities outside the immediate area.[75] Like the NEPOOL system, WREGIS unites state-specific standards for RECs and prevents double-counting.

A.3. National TWC Schemes in the European Union

A.3.1. Italian TWC scheme[76]

A.3.1.1. Background, objectives and status

The Italian scheme was proposed by two Decrees from the Ministry of Industry (one for the electricity sector and one for the gas sector) issued in April 2001 but have taken until January 2005 for it to enter into force. The scheme requires distribution companies to achieve a specified quantity of primary energy savings over a five-year period. The Regulatory Authority for Electricity and Gas (AEEG) administers the scheme and the main objective is to contribute to Italy's greenhouse gas objectives under the Kyoto Protocol.

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72 Evolution Markets

73 New England includes the following states: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and New York.

74 Evolution Markets

75 Western Governors' Association

76 This summary is based on Pavan (2002), Pagliano et al. (2003) and Pavan (2005).

A.3.1.2. Sources of demand for certificates

Participants in the scheme are gas and electricity distribution companies with more than 100,000 customers (there are 8 electricity distributors and 22 gas distributors above this threshold). This includes both major national companies such as ENEL, which is responsible for 85% of the electricity market and several much smaller municipal companies - a split that could potentially lead to market power. Since distribution companies are regulated monopolies, the scheme includes appropriate provisions for cost recovery.

A.3.1.3. Defining and allocating targets

The scheme imposes *annual* targets for *cumulative* savings in *primary* energy use. These increase each year to a total of 2.9Mtoe by the end of 2009. Electricity distributors have to achieve at least half of their obligations via savings in electricity consumption (converted to primary energy use using an appropriate conversion factor), while gas distributors have to achieve at least half of their obligations via savings in gas consumption. This is referred to as the '50% constraint'. The remainder of the targets may be achieved through a reduction in consumption of any form of primary energy. Certificates have the same denomination as the targets - tonnes of oil equivalent (toe).

A.3.1.4. Defining and certifying energy efficiency activities

Individual energy-saving projects may be implemented by the distributors themselves or subcontracted to energy service companies. Qualifying projects are those that reduce energy consumption by end-users - supply-side activities do not qualify. Beyond this, there is no restriction on the location or type of projects. An illustrative list of 14 classes and 32 sub-classes of eligible projects is provided, but companies are free to propose additional projects provided that they conform to the guidelines established by AEEG.

A.3.1.5. Monitoring and verification

Projects are not subject to approval before implementation, although developers may request an eligibility check. Instead, AEEG makes an ex-post evaluation and certification of the savings achieved by each project and issues an appropriate quantity of certificates. The method of monitoring and verification takes one of three forms depending upon the type and complexity of the project, namely: a) a 'deemed savings' approach, where energy savings from particular technologies are estimated using standard parameters; b) an engineering approach, where energy savings are determined by an equation that depends upon one or more parameters that needs to be monitored at the site; and c) a comprehensive approach, where a site-specific baseline and monitoring of energy consumption is required. AEEG has spent much time consulting on the deemed saving approach, which represents the dominant methodology for projects in the household sector. The engineering approach may be more applicable to projects in industry or public and commercial buildings, while the comprehensive approach is only suitable for large-scale projects.

A.3.1.6. Compliance procedures and enforcement

Penalties are provided for non-compliance with the overall target and for non-compliance with the '50% constraint'. These are defined as the maximum of a fixed value (in €/toe) and the market price of the certificates.

A.3.1.7. Market characteristics and operation

To implement the 50 percent constraint, three types of certificates are required – electricity, gas and other fossil fuels. These have the same denomination as the targets and are only partially fungible. Certificates have a maximum lifetime of five years. Banking is allowed, but subject to a maximum percentage of a given year's target.

A.3.1.8. Experience and prospects

The scheme has only been in operation for four months and at present there is no English language commentary on the early experience.

A.4. Proposed French TWC scheme [77]

A.4.1. Background, objectives and status

French proposals for a TWC scheme are contained in the draft Energy Law, which is at the final stages of negotiation. This contains proposals to improve national energy intensity by 2 percent per year until 2015 and reduce CO_2 emissions by 2.5 percent per year until 2013. The TWC scheme aims to contribute to both these objectives, focusing on sectors that are outside the EU ETS. The scheme will be administered by the Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME) and will run for an initial period of three years, beginning in January 2006. The following outlines the current (April 2005) proposals, but these are subject to change.

A.4.2. Sources of demand for certificates

Participants in the French Scheme are suppliers of electricity, gas and fuel oil, as well as heat from district heating schemes. Minimum size threshold for participation are currently under discussion and are likely to vary between different types of energy carrier. Most of the suppliers are regulated monopolies and cost recovery is allowed to a maximum of a 0.5 percent increase in unit tariffs.

A.4.3. Defining and allocating targets

The aggregate target is denominated in terms of the *lifetime* energy savings in *primary* energy consumption achieved from the certified energy efficiency investments. Energy savings in future years are discounted at a rate of 6 percent per year. The target for the end of the 3-year period is 54 TWh discounted lifetime savings, with separate targets for each energy carrier. The aggregate target is distributed between suppliers on the basis of their market share (measured in turnover, rather than energy sales) in the household, public and commercial sectors combined (i.e., excluding industry). There are no targets for intermediate years.

A.4.4. Defining and certifying energy efficiency activities

Individual energy-saving projects may be implemented by the suppliers themselves, or subcontracted to a wide range of other actors. Projects may take place in any sector, including

[77] This summary is based on Moisan (2005).

transport, provided that the site is not participating directly in the EU ETS. Projects may also focus on any energy carrier, including electricity, even though the generators are participating in the EU ETS.[78]

ADEME has developed a list of 'standard actions' (e.g., loft insulation, double glazing, low energy lighting) for which standardised methodologies for calculating energy savings have been developed (resembling those for the UK and Italian schemes). At present, approximately 30 standard actions have been developed for the household/commercial sectors, ten for industry and five for transport. There is also provision for 'non-standard actions' that may be proposed by the project developer and approved by ADEME and which (unlike the standard actions) may require on-site monitoring of project performance. Energy savings for the standard measures vary with factors such as the type and age of the building, and also with the region in which the building is located - to allow for variations in climate.

Each action must meet an 'additionality' criteria, which may vary according to whether the action is standard or non-standard and whether the action is undertaken directly by an obligated supplier or indirectly by a third party. These criteria are still under negotiation.[79]

A.4.4 Monitoring and verification

ADEME is responsible for monitoring and verification, using procedures that are similar to those in the UK scheme. Suppliers are required to report their energy efficiency programmes to ADEME, who calculates the resulting energy savings, award certificates and audits a selection of individual schemes. At present, it is expected that all projects will be of the 'deemed savings' type, with no supplier showing interest in projects that would require ex-post monitoring.

A.4.5 Compliance procedures and enforcement

Suppliers are not required to comply with targets each year, but only at the end of the three-year period. The proposed penalty for non-compliance is 20€/MWh, which is expected to be higher than the cost of compliance.

A.4.6 Market characteristics and operation

Certificates are dominated in kWh of final energy use, are fully fungible and have a validity of ten years. Certificates accumulate over the three-year period and are used to assess compliance at the end of the period. Decisions have yet been made on banking the certificates beyond the three-year period and these depend on the continuation of the scheme after that time.

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78 The dominance of nuclear power in French electricity generation means that the carbon savings from improved electricity efficiency will be small.

79 For example, it is proposed that investments by ESCOs that increase its turnover will not be considered additional – a criterion that would appear to rule out effective participation by third parties!

A.4.7 Experience and prospects

The Energy Law should be passed by summer 2005, at which time the final shape of the scheme will be known.

A.5. UK TWC scheme[80]

A.5.1. Background, objectives and status

The UK Energy Efficiency Commitment (EEC) scheme was introduced in 2002, following on from an earlier DSM scheme (the Energy Efficiency Standards and Performance scheme). The first phase of the EEC ran from 2002 to 2005 and a second more ambitious phase will run from 2005 to 2008. The government has proposed a third phase from 2008 to 2011 but targets for this have yet to be established.

The scheme requires electricity and gas supply companies to achieve a specified quantity of *'fuel standardised, lifetime discounted energy benefits'* by the end of each period, through improving household energy efficiency (other sectors are excluded). While the EEC will contribute to the UK's greenhouse gas targets under the Kyoto Protocol (saving around 1.4MtCO_2/year by 2005 and a further 2.5MtCO_2/year by 2008), there is also a strong social component, with half of the investment being targeted at low-income households. The energy regulator, the Office of Gas and Electricity Markets ('Ofgem'), administers the scheme.

A.5.2 Sources of demand for certificates

Participants in the EEC are gas and electricity supply companies with more than 50,000 customers. 'Dual-fuel' suppliers have separate obligations for each energy carrier. Since the gas and electricity supply markets are liberalised, there are no requirements on cost recovery. Suppliers may cover the costs of the scheme through any means they choose and typically share the costs of each investment with either consumers themselves or third parties such as housing associations.

A.5.3 Defining and allocating targets

Targets are denominated in terms of *energy benefits*, which may represent either reduced energy use for the same level of energy service or improved levels of energy service for the same level of energy use. The targets are denominated in terms of *lifetime* energy benefits, whereby the savings attributed to each energy efficiency investment are those that accrue over its full lifetime. To complicate things further, these energy benefits are 'fuel standardised' and 'discounted'.

Each investment in energy efficiency that is made/encouraged by suppliers is assigned a particular value of these 'fuel standardised, lifetime discounted energy benefits'. This is calculated as follows: a) the total kWh energy benefits over the lifetime of the measure are estimated using assumptions about equipment lifetime, efficiency improvements and rebound effects; b) these benefits are discounted over the lifetime of the measure at an annual rate of six percent during phase 1 and 3.5 percent during phase 2; and c) the figures are adjusted

[80] This summary is based on DETR (2000) and DEFRA (2005).

according to both their contribution to primary energy savings and the CO_2 content of the relevant energy carrier.

During phase 1 of the EEC, suppliers were required to invest in measures that delivered a total of 64 TWh of these benefits by the end of 2005. The corresponding target for phase 2 is 130 TWh by the end of 2008. Although the EEC applies only to gas and electricity suppliers, the energy benefits may be achieved through investments affecting any types of energy carrier. However, 50 percent of the energy benefits must be obtained through investments in a ‘priority group’ of low-income households. The calculation of benefits is adjusted to allow for free-riders (‘deadweight’). The aggregate target is then distributed between suppliers on the basis of household customer numbers, with progressively more stringent targets for larger companies.

A.5.4 Defining and certifying energy efficiency activities

Individual energy-saving projects may be implemented by the suppliers themselves, or subcontracted to energy service companies or other actors. Qualifying projects are those that reduce energy consumption by households. While there is flexibility in the type of projects used, these are subject to regulatory approval. The regulatory guidance details the allowed projects and the corresponding energy benefits in different applications. Certain types of projects - for example CHP and energy service offerings – are incentivised through the energy benefits formulae.

A.5.5 Monitoring and verification

Since the EEC is confined to small-scale projects within households, there is no monitoring of individual projects. Instead, the ‘deemed savings’ approach is used to estimate the energy benefits from different types of energy efficiency measure in different situations. Each supplier submits proposals to Ofgem detailing the measures they are planning to undertake and who will benefit from them.[81] Ofgem determines whether the measures qualify and uses formulae to calculate the discounted energy benefits to be attributed to them. These are assigned to the suppliers on an ex-ante basis. Ofgem monitors the overall progress of each supplier towards its target and audits a selection of individual schemes over the course of the programme.

A.5.6 Compliance procedures and enforcement

Suppliers are not required to comply with targets each year, but only at the end of each four-year period. Penalties for non-compliance with the targets are not explicitly defined. Instead, the legislation makes general reference to the qualifications for electricity and gas supply licences – with the implication that these could be removed. Suppliers need to comply both with their overall targets and with the proportion of energy benefits that are obtained by low-income households.

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[81] Suppliers have established a range of programmes, including partnerships with retailers to promote energy efficient appliances; collaboration with social housing providers to insulate the properties of low-income consumers; and tie-ins with local authorities to encourage private households to improve the thermal insulation of their properties by offering reductions in council tax bills.

A.5.7 Market characteristics and operation

The EEC does *not* include tradable certificates. The energy efficiency programmes of individual suppliers are monitored and approved by Ofgem, but no certificates are issued. However, the EEC scheme does incorporate trading in two ways. First, suppliers can trade their *targets* (obligations) under the scheme, such that one supplier takes responsibility for a portion of another supplier's obligation in exchange for payment. Second, suppliers can trade their *performance* under the scheme such that one supplier sells kWh of achieved energy benefits to another supplier, who uses this towards their own EEC target. Trading of targets can take place at any time, while trading of performance can only take place ex-post, after the compliance of the seller with its target has been verified. In most cases, this will be at the end of the four-year period. Both forms of trade require approval by Ofgem.[82]

Suppliers who over-comply with their targets in phase 1 are allowed to count this surplus towards their targets in phase 2 (2005-2008). There are no constraints on banking and measures taken in non-priority group households in phase 1 may contribute to the target for priority group households in phase 2.

A.5.8 Experience and prospects

Phase 1 of the scheme has proved to be a success, with suppliers delivering 47 TWh of energy benefits by the end of 2004, more than three quarters of the 2005 target. The benefits from the EEC are confined to the (10 million) households receiving some form of incentive or support, but the total benefits averaged over all households estimated by Ofgem is €13.90/year per household by 2005 (DEFRA 2001).[83] The trading mechanisms have attracted little interest however, with the great majority of suppliers meeting their obligations through in-house initiatives.

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82 Phase 1 of the scheme also included rudimentary proposals for interfacing EEC trading with the UK emissions trading scheme (Sorrell 2003). But these provisions have not been used.

83 Energy benefits will continue over the lifetime of the investment, giving an estimated present value of lifetime benefits of around €3.9 billion (six percent discount rate) (EST 2001). Lifetime carbon savings are estimated at 9.5 Mtonnes which, discounted at a private sector rate of 12 percent, gives an average abatement cost for the EEC scheme of ~€50/tCO_2.

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