February 2003 ECN-C--03-014

EUROPEAN COGENERATION CERTIFICATE TRADING - ECOCERT

Demand creation and scheme interactions

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Acknowledgement

As interest in market-based domestic mechanisms has increased in the EU, a tradable certificate scheme for CHP is an option. During the period January 2002 - April 2003, within the European Cogeneration Certificate Trading (ECoCerT) project, activities have been undertaken in a series of phases to analyse a CHP certificate scheme. The ECoCerT project was financially supported by the European Commission as part of the SAVE II programme and known as contract number 4.1031/Z/01-025/2001. The ECoCerT project team was coordinated by COGEN Europe and further included ESD Ltd (UK), ECN (Netherlands), Öko Institut (Germany), Campbell Carr (UK), Akzo Nobel (Netherlands), Fortum (Finland), M-co (UK), Vattenfall (Sweden) and NUON (Netherlands). Further information and all reports and results of the ECoCerT project can be found through COGEN Europe and on http://www.cogen.org/projects/ecocert.htm.

This report (ECN-C--03-014) is the result of ECN's contribution to the project and focuses on demand creation for CHP certificates and interaction between a CHP certificate scheme and other policy schemes. The authors of this report greatly acknowledge the input of and stimulating discussions with COGEN Europe and the other team members. The ECN project number of this project is 7.7433. With reference to the report number ECN-C--03-014 additional copies can be ordered (see the inside of the cover of this report).

The funding by the EU does by no means imply that this report contains EU statements. The responsibility for the text, including its inevitable flaws, remains with the authors.

Abstract

Once the definition of the CHP certificate is clear, demand for it can be organised in several ways. A well-designed system of *mandatory* demand, by means of an obligation to acquire a certain amount of CHP certificates each year, is effective to meet the policy target. The *voluntary* willingness to pay for CHP certificates is likely to be small, resulting in a very thin market. Finally, instead of creating a demand solely targeted at the CHP certificates, demand could also result from *interacting policy schemes* such as emissions trading.

Assuming that a CHP certificate scheme is going to be introduced, we would recommend to issue standard CHP certificates based on additional ('fuel-free') kWh output (substitution approach with standard certificates) and create demand by means of an incentive on electricity supply companies to purchase CHP certificates. The incentive could either be quantitative (an obligation) or a price incentive (fiscal or feed-in tariff). Policy goals with respect to CHP justify a support scheme that is specifically designed for CHP. Integration into other tradable schemes would underestimate the value of CHP. A standard CHP certificate scheme is also compatible with renewable certificates and does not interfere with a guarantee of origin. When introducing CHP certificates, international harmonisation is highly recommended in order to prevent undesirable and complex conversion issues.

CONTENTS

1. INTRODUCTION AND BACKGROUND

Combined Heat and Power production (CHP) is one of the most promising options to achieve massive reductions in greenhouse gas emissions in Europe in the medium term. Yet it is suffering in a climate of hard electricity price competition, and there is currently no consistent and strong EU-wide policy framework for the support of CHP. The European Commission presented a proposal for a CHP Directive in July 2002, which is currently being debated by the Council and the European Parliament. The proposal presents, for the first time, a European legal framework to promote CHP and it opens the way for future harmonisation of support mechanisms Europe-wide.

One of the proposed mechanisms is a certificate of origin for electricity from CHP installations. This could be the first step towards a tradable certificate scheme for CHP. As interest in market-based domestic mechanisms has increased in the EU and carbon (emissions) trading becomes ever more important, 'Tradable Green Certificate' schemes have been developed in several Member States, to stimulate increased investment in renewable energy.

During the period January 2002 - April 2003, within the European Cogeneration Certificate Trading (ECoCerT) project, activities have been undertaken in a series of phases, beginning with the establishment of a consultative group and research to establish possible voluntary demand and regulatory demand for CHP certificates (Phase 2). CHP types, quality criteria and outline accreditation framework have been defined (Phase 3), and a practical methodology for accreditation, verification and monitoring of CHP developed (Phase 4). The issue of demand, and how to create this, was explored, followed by an analysis of the policy aspects that relate to demand, and interactions between different schemes (Phase 5). The outline design of an EU-wide scheme represents the peak of the project's activity, and this is accompanied by recommendations for a programme to establish a certificate trading scheme and how to feed this into a CHP Directive development. Further information and all reports and results of the ECoCerT project can be found on http://www.cogen.org/projects/ecocert.htm.

The ECoCerT project team consists of:
- COGEN Europe, Brussels
- ESD Ltd, UK
- ECN, Netherlands
- Öko Institut, Germany
- Campbell Carr, UK
- Akzo Nobel, Netherlands
- Fortum, Finland
- M-co, UK
- Vattenfall, Sweden
- NUON, Netherlands.

This report addresses the research issues within Phase 5 of the project. The objectives are to study:
1. Demand creation for CHP certificates.
2. Interactions between a CHP certificate scheme and other policy instruments.
3. International interactions between national CHP certificate schemes.
4. Costs and benefits of introducing a CHP certificate scheme (see Appendix A and B).

The question of how to create a market for CHP certificates assumes that CHP certificates are a well defined commodity. The first issue to consider is therefore what the basis of issuing CHP certificates is, and consequently in what dimensions (heat, power, environmental value, etc) and units are CHP certificates defined. Defining the basis of issuing CHP certificates is a crucial step in designing a CHP certificate scheme as it defines the dimensions in which demand can be created, as well as the interactions with other policy instruments and markets. Consequently, the issue of eligible CHP and CHP quality criteria needs to be considered. In considering these design issues it is important to keep in mind the main policy drivers for developing a CHP support policy, which are energy efficiency, CO_2-emission reduction and reduced transmission losses.

CHP definition issues have been discussed within the ECoCerT project team and are mainly addressed in the earlier phases of the project. Therefore, they will only be briefly discussed in Chapter 2 in order to set the scene for the remainder of the report. Subsequently, Chapters 3 to 5 will be devoted to the analysis of the main subjects of this report, i.e., demand creation for CHP certificates, interactions between a CHP certificate scheme and other policy schemes, and international interactions. Conclusions and recommendations are given in Chapter 6.

2. CONCEPTS FOR CHP CERTIFICATION

2.1 Dimensions of CHP certification

A CHP plant has four main outputs; heat, electricity, energy losses (waste heat), and environmental externalities (e.g. CO_2-emissions[1]). The question is which output or combination of outputs should be chosen as the basis for issuing CHP certificates.

When choosing for heat, there is a potential risk of stimulating dimensioning the CHP plant on heat production and providing incentives for heat dumping. Issuing based on electricity incorporates the risk of stimulating dimensioning on electricity production while providing no incentive for good use of heat. Furthermore, the production of electricity from CHP may cause problems in electricity markets with a high degree of CHP penetration when incentives are not in line with the electricity market. Issuing of certificates based on a combination of heat and electricity output captures the total energy benefit from CHP and could be designed so as to not discriminate in favour of heat or electricity production. However, additional quality criteria would be needed to assure efficient operation of the plant.

Issuing of certificates based on a combination of heat and electricity output does not provide any incentive for the use of, or switch to, cleaner fuels, which may be desirable from a CO_2 perspective. Additional incentives may have to be applied to ensure that the CHP certificate scheme is in line with environmental goals.

CHP certificates can also be based on the environmental benefits (e.g. energy savings or avoided emissions) associated with CHP generation. The difficulty with taking energy savings as the basis for CHP certificates is to set a baseline against which to quantify the environmental benefits. Unless the baseline is standardised this approach will increase the transaction cost (see Appendix B) associated with the issuing of a CHP certificate. Moreover, the baselines will be different in different countries or regions. This would hinder trade between these regions or add transaction cost in converting the CHP certificates from one region to the equivalent in another region.

Quality criteria may be applied to the eligibility of CHP plants insofar as a CHP certificate scheme does not provide (sufficient) incentives to stimulate high quality standards in investment and operations. In this regard it should be noted that the basis of issuing certificates might in itself imply a quality criterion. For example, when a CHP certificate is issued based on avoided primary energy consumption, the formula for calculating the energy saving as well as the references used in the calculation will determine the amount of CHP certificates issued per unit of CHP production. Efficient plants will be issued many certificates, while less efficient plants will be issued fewer certificates. At a given certificate price the economic performance of the more efficient plants will thus be better. The CHP certificate scheme thus provides the right incentives for investment in energy efficient plants. Below, this is referred to as the substitution approach. In the current discussion, e.g., in the draft Directive on cogeneration, an *ex ante* approach towards certifying qualifying CHP technologies prevails. The three concepts for CHP certification discussed below also apply an *ex ante* approach, although the assorted certificates (in the dummy approach and the minimum efficiency approach) leave room for some *ex post* differentiation.

[1] Note that CO_2 emission could be a positive externality, e.g. CO_2 fertilising in horticulture in greenhouses.

2.2 Approaches to certification

With respect to the mechanism of calculating and issuing the CHP certificates on the basis of energy output and energy efficiency the following approaches have been distinguished:

1. Dummy approach
2. Minimum efficiency approach
3. Substitution approach.

The CHP certificates could either be standard or assorted. In the case of standard certificates, the number of certificates received varies according to the efficiency of CHP production. Hence, certificates are homogeneous goods. Assorted certificates contain information about efficiency, power/heat ratio, fuel used, energy saved, etc., and therefore they are not homogenous.

2.2.1 Dummy approach

In the dummy approach a CHP certificate is issued for all CHP electricity[2] produced from a CHP plant, regardless of the efficiency of the plant. It is defined as the net heat production from a cogeneration process (total heat production minus heat produced in separate boilers) times the power to heat ratio, see option A in Table 2.1. This approach is roughly equivalent to issuing a guarantee of origin for CHP electricity production and is in line with the proposals at the EU and Member States level for disclosure of electricity sources. The main disadvantage of this approach is that it does not capture the environmental and energy savings benefits associated with CHP production, nor does it provide any incentives to maximise these benefits.

2.2.2 Minimum efficiency approach

In the minimum efficiency approach clear minimum efficiency standards are set for eligible installations and production. Certificates are issued for all CHP production only if the eligibility criteria are met. The minimum efficiency approach thereby introduces an efficiency threshold above which all CHP production is considered equivalent in terms of environmental and energy savings benefits, see option B in Table 2.1. To make distinctions in the level of benefits associated with CHP production, different classes of CHP certificates can be introduced reflecting the differences in efficiency of the installations. The minimum efficiency approach can be linked to a system of guarantees of origin and electricity disclosure.

With the minimum efficiency approach, certificates will be assorted since all qualifying CHP (above a certain threshold) is certified. This option is less sensitive to reference levels (i.e., to political games) and may be compatible with (other) guarantee of origin schemes that run in parallel. However, it gives no incentive to increase efficiency further. Moreover, the amount of information on the certificate can become confusing (and irrelevant to the consumer) and the spectrum of values makes it difficult to trade the certificate.

2.2.3 Substitution approach

In the substitution approach CHP certificates are issued in proportion of energy savings or avoided emissions, relative to a reference. The certificates themselves represent a standard amount of energy saved or emissions avoided. This approach has been adopted by the Dutch Ministry of Economic Affairs in the support regulations for CHP. Based on energy savings by CHP, 'CO_2 free' kWh are being determined (denoted as 'blue') for which a compensation is paid. There is no trade in these 'blue' certificates and this system operates in parallel to a system of guarantees of origin and disclosure.

[2] CHP electricity excludes electricity produced in non-cogeneration mode (condensing electricity).

The substitution approach can be applied to new plants. For existing plants quality criteria for eligibility may have to be applied because at the time of investment, no (market) incentives were in place equivalent to the demands placed on new investments under the CHP certificate scheme. In that case a minimum efficiency approach may be more appropriate.

In the substitution approach, the saved or 'emissions-free' electricity is the additional amount of electricity produced by a CHP plant with the same amount of fuel as separate production of heat and power (see option C in Table 2.1). The certificate can easily be denominated in kWh and trade will be easy with the standard certificate. The substitution approach rewards higher efficiency plants because more certificates are given to them. It somehow gives a 'green' attribute to the certificate, which allows fungibility with e.g. RECS certificates. However, there is a real danger of setting the reference efficiency too high, so that few plants would comply[3]. Since the number of kWh certified is lower than total CHP electricity production, perceptions to producers might be negative. Moreover, the substitution approach may not be compatible with (other) guarantee of origin schemes that run in parallel with the CHP certificate scheme.

Table 2.1 *Three concepts for CHP certification*

A:	Dummy approach (assorted certificates)	$E_{CHP} = Q_{net} * P/H$
B:	Minimum efficiency (assorted certificates)	If $E_{CHP}/(F_{CHP}-(Q_{net}/\eta_{ref,heat})) > min$ then $E_{CHP} = Q_{net} * P/H$ (same as A)
C:	Substitution approach (standard certificates)	$E_{add} = E_{CHP} - E_{ref} = E_{CHP} - [(F_{CHP} - (Q_{net}/\eta_{ref,heat})) * \eta_{ref,elec}]$

E = electricity, Q = heat, F = fuel, P/H = power to heat ratio, η=efficiency.

2.3 Unit of denomination

Related to the options for certification, CHP certificates can be denominated in several units e.g., Joule, kWh, grams of CO_2. It should be noted that defining CHP certificates in terms of electricity (kWh) or environmental externalities (CO_2) connects best to existing markets for electricity and emissions markets proposed or in development. Energy and environmental units can be converted into each other. Conversion of certificates may play a role in two cases:

- Cross-border trade of certificates with different references (see Chapter 5).
- Redemption of certificates for different policies, e.g. emissions trading, voluntary agreements on energy efficiency or a CHP target (see Chapter 4).

2.4 The ECoCerT approach

Within the ECoCerT project it was agreed that the unit in which certificates should be issued is kWh and that energy savings would preferably be the basis of issuing CHP certificates. We inclined away from using CO_2 because it does not refer to all the benefits of cogeneration (e.g., improved efficiency of primary, depletable fuel use) and it doubles up with the upcoming EU emissions trading scheme.

No final decision was reached on whether to take the minimum efficiency approach or the substitution approach as a mechanism of issuing CHP certificates. The project team inclines towards the concept of energy savings in combination with standard certificates, i.e., the substitution approach because it rewards higher efficiency plants. However, the minimum efficiency approach will also be analysed in this report.

[3] A reference, which is too low, also gives rise to problems, e.g., if the market for certificates extents beyond CHP and if separate generation of heat and power is more efficient than the reference.

3. CREATION OF DEMAND FOR CERTIFICATES

Each of the options for CHP certification already implicitly assumes a specified demand for CHP certificates. The dummy approach and the minimum efficiency approach assume a demand for qualified CHP electricity output (kWh produced), whereas in the substitution approach demand stems from energy savings or avoided emissions (relative to a reference).

The demand for tradable CHP certificates can be organised in different ways:
1. Mandatory demand (at EU or Member State level).
2. Voluntary demand (at EU or Member State level).
3. Combination of mandatory and voluntary demand.
4. Through other policies: e.g., renewable certificate or CO_2 markets and voluntary agreements on energy efficiency.

Based on the analysis below and research and discussion within the ECoCerT project team, demand for CHP certificates only becomes substantial when it is enforced by an obligation or by some fiscal (price) incentive. Voluntary demand will not generate a substantial market for CHP certificates but can be used in addition to mandatory demand.

3.1 Mandatory demand

The demand for tradable CHP certificates can be created by setting an obligation on an actor in the electricity chain, to acquire a certain number of certificates within a certain period. Such a quota system ensures a high level of certainty over the policy outcome. However, it is politically challenging to set up a mandatory CHP certificate demand scheme, especially because it requires a complex additional design of the associated regulatory system. Key design issues in a CHP certificate scheme with a demand obligation are defining the obliged actors and the obligation and creating a mechanism for compliance control. All these parameters will affect the certificate market and can create barriers to harmonisation.

3.1.1 Obliged actor

An obligation to acquire a certain number of certificates can be put on various actors in the electricity chain, see Figure 3.1, related to their production, supply or consumption. The question on who should bear the obligation seems independent from the concept of CHP certification. For example, it would probably not make any difference whether all qualifying CHP electricity is certified or only additional CHP electricity (relative to a reference), because the target would most likely be relative to the number of certificates - if all qualifying electricity is certified then the target will be higher to take than into account. As a result, it is likely that any greater number of certificates would be offset by a decrease in price, making it so that the obliged actor received the same amount of money regardless. More general considerations play a role here. Good policy analysis would say that, in theory, once the obligation is set, the point at which it is imposed should:

a. give the right incentives to the right parties,
b. minimise compliance and transaction costs,
c. prevent distortions in competition.

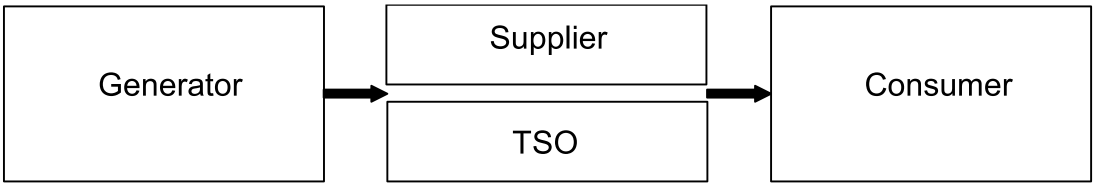

Figure 3.1 *The electricity supply chain*

If *generators* are required to have a certain part of their portfolio as cogeneration, the need to transfer certificates may be reduced to a minimum. This has a positive effect on transaction costs, but might have a negative effect on the liquidity and transparency of the CHP certificate market. However, problems may arise for producers with very efficient generation plant but no CHP and for small producers, e.g., with just one cogeneration plant operated in non-cogeneration mode during part of the season.

In the case that the *Transmission System Operator* or the *Distribution Companies* are the obliged actors, they have to buy a certain number of certificates in relation to the total load on the system or the total final electricity deliveries from the grid. However, in some jurisdictions, placing these obligations on the TSO or distribution company would either be contrary to their understood role (impartial, non-trading other than to balance) or would be difficult to administer (when the TSO does not act as an intermediary for the costs of losses and constraints, or does not spread them evenly across the demand side).

If the CHP obligation is put on domestic *suppliers*, they might be disadvantaged in competition with non-domestic suppliers that do not have an obligation. To avoid this, a condition to this option is that every actor that sells electricity, even if this is not its core business, should have a suppliers license for the specific Member State it is supplying in and/or to. Part of this license then is the obligation. Harmonised introduction of a CHP obligation also minimises distorted competition.

Obliging the most down-stream level in the energy supply chain, that is, the *final consumer*, imposes very significant transaction and compliance costs that would be much lower were the obligation imposed on suppliers. Although it is the least distortive option and not interfering with competition (see also Schaeffer et al, 2000), it is difficult to force consumers to justify the *quality* of their electricity consumption as long as this market is unclear. Moreover, requiring some CHP consumption should not interfere with consumption of 100% renewable electricity. Consumers might use the possibility, offered to them by suppliers, to pass on the obligation to their supplier. The incentive effects of putting the obligation on suppliers or consumers is pretty much the same because the price inelasticity of electricity demand suggests that the cost of the obligation will be passed on to consumers regardless, and competing electricity suppliers will seek to minimise costs and mirror consumer preferences.

In retrospect, when choosing for a mandatory demand for CHP certificates through an obligation, putting the obligation on licensed electricity suppliers seems the best choice.

3.1.2 The obligation

Obviously, the obligation on suppliers should match the concept chosen (see Chapter 2), e.g., in case of the dummy approach the obligation should be higher than in the minimum efficiency approach since the number of kWh certified will be higher as well. Inherent to the choice for the minimum efficiency approach or the substitution approach, the obligations should be formulated as an absolute amount of electricity (certificates denominated in kWh), which develops in time, in order to ensure a growing portion of cogeneration.

The obligation might grow with a fixed growth rate over time. By choosing this option a continued growth of the contribution of CHP is induced, without limiting this contribution in advance. The advantage of this approach is that the annual increase in the size of the market is more or less known in advance. A path of increasing obligations per compliance period can also be stipulated at the start of the scheme. This option forces the policy maker to explicitly state obligations for the (far) future. It requires strong policy commitment for the duration of the obligation, as the obligations will be fixed for the entire period. While this reduction in policy flexibility may be a disadvantage to policy makers it is a strong sign of commitment that provides certainty to investors, increasing the likelihood that the obligation will actually be reached. Theoretically, a fixed obligation with plant vintage restrictions can be defined. It means that plants are eligible long enough to recover their investments, and their CHP generation will continue to contribute to attaining the CHP policy targets after the first years of production. The total contribution of CHP can be maintained indefinitely at a predefined minimum by extending the target further into the future.

The duration of the obligation should be long enough to provide ample security to investors to recover their investments. This implies that when an obligation no longer grows, the obligation is maintained for several years in order to support the plants that started their operations under the obligation. This requires a very long-term policy commitment from governments and policy makers.

The obligation can be differentiated according to different classes of CHP technologies or different efficiency classes. The main disadvantage of differentiation of the obligation is that it reduces the size of the market. This reduces liquidity in each of the submarkets. Moreover, differentiation according to efficiency classes would release the link of the value of CHP certificates to the (minimum) environmental benefit. Nevertheless, differentiation may be granted from a technology development point of view.

An important issue to address is how to allocate the obligation over individual electricity suppliers. This question appears relevant in the discussion on greenhouse gas (GHG) emissions trading schemes, where a distinction is made between grandfathering and auctioning emission allowances. However, in case of a CHP obligation it seems irrational to compete for the allowance to produce CHP electricity in an auction. CHP production implies positive externalities whereas GHG emissions provide negative externalities.

3.1.3 Compliance control

Compliance process

The following steps can be distinguished in the process of compliance control with respect to the CHP obligation:

Step 1: Establishing the size of the obligation (in case of a percentage obligation).
Step 2: Accreditation of generators and the probity of their metering/measurement.
Step 3: Transfer of certificates to the control body before the date of proof.
Step 4: Verification of compliance by the control body.
Step 5: Depending on the amount of certificates transferred to the control body in relation to the obligation:
   a. The transferred certificates exactly match the obligation: nothing happens.
   b. Over-compliance: the obliged actor retains surplus certificates.
   c. Non-compliance: penalty or administration of the amount of certificates to be borrowed.

It could be decided that certificates issued in the period between the end of the compliance period and the date of proof could also be used for compliance of the compliance period that just passed.

Compliance period and timing
Usually we would think of a compliance period of one year, however a shorter or longer period could be set. Because of unforeseen circumstances (e.g. technical failure of CHP plants), a short compliance period bears the risk of not being able to comply with the obligation in time. A longer period allows more flexibility for the obliged actors. However, a long compliance period may allow parties to postpone investments towards the end of the period, possibly resulting in fluctuating CHP certificate prices within the compliance period.

The last day of the compliance period could also be used as the date of proof. However, in practice some time lag for administration purposes would need to be allowed. In these cases, spot market trade in certificates might develop towards the end of the compliance period (especially when the compliance period is long), resulting in less market liquidity and price transparency (Schaeffer and Sonnemans, 2000). Also, proofs could be required at several times during the compliance period. In that case, the compliance and transaction costs of the scheme could be high.

Control body
The body destined to control the CHP certificate scheme should be independent of any interests in the trade of the certificates. The control body could be an existing institution such as the Regulator or the Transmission System Operator (except where the TSO were permitted or required to trade in certificates). On the other hand, a separate purpose-made body could be formed. Monitoring and control might also be combined with certificate verification, trade registration and issuing.

Penalty
In a certificate system in which demand is driven by an obligation, penalties are key elements. The level of the penalty might have several consequences. It might function as a maximum price, thereby setting a cap on the total burden of the scheme on consumers (obliged suppliers will pass on costs to consumers). Similarly, the level of the penalty could be looked upon as a degree of political willingness to keep licensed electricity suppliers to the target. The level of the penalty (together with the level of ambition of an obligation) will influence market expectations of potential investors in CHP. Table 3.1 summarises the main market expectations in four penalty-obligation combinations.

Table 3.1 *Market expectations under different penalty-obligation combinations*

	Ample supply	Supply shortage
High penalty	The penalty has no effect on prices and provides a strong compliance incentive.	Prices will be bid up to the level of the penalty. Possible risk of volatility, as high prices may stimulate investment, which may consequently create oversupply and bring prices down sharply. However, investment is slow and lumpy, so this risk of volatility might be overstated.
Low penalty	The penalty may not provide enough incentive to comply with the obligation.	The obliged actors will pay the penalty rather than comply with the obligation.

Simulations on green certificate trading have pointed out that the most effective penalty-obligation combination is one that combines a realistic but demanding target with a penalty that is slightly above the marginal cost of the marginal CHP option to meet the target (Schaeffer and Sonnemans, 2000). This is in line with a standard Pigouvian welfare analysis given the desire to meet a cogeneration target that would otherwise be uneconomic.

The penalty can be set as a percentage or factor of the average market price of certificates (*ex post*). For example the proposed Swedish green certificate system stipulates a penalty of 150%

of the average market price of certificates in the previous year (the compliance period is one year). Alternately, the additional marginal coast could be estimated in advance and the penalty set accordingly. This would provide a level of certainty to investors as to what the maximum absolute premium above the wholesale electricity price would be, but could be subject to forecasting error.

Banking and borrowing

In order to provide more flexibility in trading CHP certificates and meeting the obligations at lower economic cost, banking and borrowing of certificates can be introduced. Banking provides the option to carry over certificates issued in the current or a past compliance period to future compliance periods. Borrowing allows the obliged actor to compensate a shortfall in the current compliance period with certificates to be issued in a future compliance period. Effectively borrowing carries over part of the current obligation to future compliance periods. While both banking and borrowing add to the flexibility of the trading scheme, to enhanced price stability, and to a lower overall economic cost of meeting a target, some believe that borrowing increases the risk that obligated parties will fail to acquire enough certificates in time and then fail to comply with the obligation. Restrictions on borrowing would allow the regulator to identify issues of mass non-compliance and, if possible address them, in a timely manner.

Restrictions may be applied to both banking and borrowing, for instance through a percentage limit of the obligation in any compliance period may be banked or borrowed. Alternatively, interest rates may be applied to borrowing in order to provide incentives not to keep postponing the purchase of certificates. Also, borrowing carries the risk that the obliged actor goes bankrupt before the borrowed amount is fulfilled, in which case there is a greater risk that the mandatory production target will not be met.

Penalty revenues

The penalty revenues can be used for several purposes:

1. State finances
2. Financing of the compliance body
3. CHP technology support fund
4. Recycling to compliant actors.

A CHP technology support fund can be used to support R&D projects that help to bring innovative CHP technologies closer to commercialisation. An obligation with certificate trading mechanism may not provide sufficient support for these innovative technologies to enter the market. A fund can then help to enhance the diffusion of innovation into the trading scheme in the longer run.

Recycling of penalty revenues to compliant actors provides a strong incentive for compliance as is witnessed under the UK Renewables Obligation. Not only does not observing the obligation lead to a penalty payment it also results in extra revenues to the competitor. Under the UK Renewables Obligation the extra revenues even seem to be factored into the bidding prices for Renewable Obligation Certificates and thus provide an extra stimulus for investment in renewable generation. In this case, however, linkages between the certificates market and competition in the wholesale and retail electricity markets need to be monitored from a competition policy point of view, since recycling of penalties is equivalent to subsidising.

3.2 Voluntary demand

Voluntary demand here is interpreted as demand arising from the willingness to pay a premium for CHP electricity above the normal electricity price. Voluntary demand may be stimulated through additional incentives, such as fiscal measures (although then it is not strictly voluntary). The electricity deliveries to final customers have to be matched with CHP certificates to the degree specified in the supply contract between the customer and the supplier. The advantages are the simplicity and the alleged opportunity for harmonisation of the system. However, only relying on voluntary demand conflicts with the polluter-pays principle. A major disadvantage of voluntary demand and fiscal incentives is that it is difficult to control the uptake of CHP.

In principle, policy makers do not necessarily have to set rules for voluntary demand. If a customer wants to buy a certain certificate and if a supplier can offer a certificate and both agree on the price, no interference of the government is needed. However, policy makers might want to stimulate voluntary demand of CHP through fiscal measures. In the Netherlands the ecotax exemption has been a very strong incentive for consumers to switch to renewable electricity. However, it can be questioned whether CHP electricity will have a similar appeal to retail customers. Market research in Phase 2 of the ECoCerT project reveals that voluntary demand for CHP certificates is unlikely to be large. Voluntary demand for standard certificates based on additional or emissions-free CHP production (the substitution approach) is likely to be greater than for certificates based on the dummy or minimum efficiency approach. Voluntary demand for CHP certificates could develop if they are fungible with the carbon market. To allow fungibility, it is important to provide information on emissions savings on the CHP certificate. Again, the substitution approach seems to fit well with fungibility.

3.3 Mixed mandatory and voluntary demand

In the case of the combination of voluntary demand for CHP certificates with a CHP obligation (at the level of suppliers), there are two options:

- Voluntary demand is part of the obligation. If the obligation is put on suppliers, in principle it is up to them to find a way to comply with the obligation. They might do that by looking for customers that are willing to pay a premium for clean energy.
- Voluntary demand comes on top of the obligation. The obligation (on suppliers) then falls under the polluter-pays-principle (since the costs of meeting the obligation will be passed on to consumers), whereas those consumers that want to do more than the minimum can buy extra. In this case voluntary demand can still be stimulated through fiscal measures. In addition, the certificates that are used for the fulfilment of the obligation could also be supported through fiscal measures.

3.4 Demand from other policy instruments

Demand for CHP certificates may also be provided by policy instruments that are used to pursue other policy targets than the promotion of CHP per se. Examples of policies that may create a demand for CHP certificates are emissions trading and voluntary agreements with industry on energy efficiency and emissions reduction. The extent to which demand can arise from such policy instruments depends on:

1. Whether a CHP certificate can be converted into the units in which the other policy mechanism works.
2. Whether there are interactions between a CHP certificate scheme and the other policy instrument that would reduce the effectiveness of either instrument, such that a CHP certificate scheme should remain separate from the other policy instrument (and such that double counting is prevented).

These issues will be addressed in the next chapter.

4. INTERACTIONS OF CHP CERTIFICATE SCHEMES WITH OTHER POLICIES

In general interactions of policy instruments may arise from an overlap in objectives, target groups, and from the design and implementation of the system. Within ECoCerT the possible interactions of a CHP certificate scheme (designed in an EU framework) is researched with the following policy instruments:

1. Greenhouse gas emissions trading (analysis based on the proposed Directive on Emissions Trading, European Commission, 2001b).[4]
2. Renewable energy support mechanisms, in particular green certificates (biomass).
3. System of guarantees of origin and electricity disclosure.

4.1 Greenhouse gas emissions trading

4.1.1 The position of CHP in the proposed emissions trading scheme

One justification for action with respect to CHP at the European level is to address climate change. A proposal for a Directive on greenhouse gas Emissions Trading (ET) has been adopted by the Commission (European Commission, 2001b). A cap-and-trade scheme will be implemented at the level of individual installations, covering major energy users including the electricity generating sector. However, only larger combustion plants (> 20 MWth) are covered[5]. As a result, large and small CHP installations are treated differently under the ET Directive[6]. Each installation should obtain a GHG emission permit allowing them continued operation subject to the requirements set in the ET regime. Each installation/site would then be given a certain amount of emission 'allowances' for a specified period. The allocation method will be determined in national allocation plans and can, for example, be based on historical emission records and free of charge, i.e., grandfathering.[7] For each tonne of CO_2 emitted from a site, the operator would need to surrender an allowance. If the site emits less CO_2 than allowances held, then these may be banked from one year to the next, or they may be sold to another site that does not meet its CO_2 target and therefore needs additional allowances. With an EU scheme, the price of allowances would be similar wherever the plant is located. On the basis of this common price, plant managers can decide whether or not to reduce emissions themselves, or buy additional allowances from others who can reduce their emissions at lower costs. Quantitative (absolute) target setting for GHG reduction is left to individual Member States.

What are the incentives for CHP under a CO_2 cap-and-trade programme? Allocation of allowances based on outputs encourages clean and efficient plants and helps levelling the playing field for CHP generation. "Under an output-based system, plants receive the same allocation of allowances for the same level of production. However, the more efficient CHP plants will surrender fewer allowances with relatively lower emissions, resulting in an end-of-the-year revenue bonus" (Monis Shipley, et al, 2001). Thus, in general the prospects of CHP under an emissions allowance scheme are positive.

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4 Interactions with SO_2 and NO_x emissions trading is disregarded here because there are no plans for such schemes European wide, although especially NO_x is relevant for CHP.

5 The ET Directive includes some sites *not* covered by IPPC, e.g., combustion plants of 20-50 MWth.

6 However, any CHP installation, regardless of its capacity, on an industrial site subject to mandatory participation in the ET scheme, is covered by the emissions trading Directive.

7 The initial phase will run from 2005 to the end of 2007 in order to gain experience and be prepared for the commencement of international trade in the first commitment period (2008-2012) of the Kyoto Protocol. Some provisions of the ET Directive differ between periods, e.g., Member States can include additional sectors and gases (opt-in), and auction up to 10% of allowances from 2008, the penalty for non-compliance is lower in the initial period and companies may pool their emission allocations until 2012.

However, the proposed ET Directive may involve disincentives for some CHP plants (see also Cogen Europe, 2002). For example, district heating CHP schemes larger then 20 MW may have to compete on the heat market with small boilers, which are not covered by the ET Directive. If the ET scheme increases the price of production of district heating, it could imply a competitive disadvantage for large CHP, or several smaller CHP plants would be used for a district heating system.

4.1.2 Concurrent emissions trading and CHP certificate trading schemes

When CHP generation has supposed advantages other than avoiding CO_2 emissions (e.g. energy savings, supply security, etc.), or when the goal is to ensure that part of the emission reduction should come from increase energy efficiency in the energy sector, a separate support mechanism like certificates would be justified for CHP. Thus, an emissions trading scheme and a CHP certificate (trading) scheme may co-exist side by side.

Given the proposed emissions trading scheme of the ET Directive, what are the consequences for (the design of) a CHP certificate scheme? First, we will address if the CHP certificate should somehow capture the CO_2 benefit of CHP production. In general, CHP has a carbon benefit if it displaces more polluting types of electricity generation. This is only the case if there is overcapacity in the generation market and if the displaced power generation takes part in emissions trading. For those CHP plants not covered by the ET Directive, the (avoided) emissions of the CHP generation have no direct value. Thus, there is no need to refer to CO_2 in the certificate. For the CHP plants that *are* covered by the ET Directive, the situation in the power generation market is important. In case of an overcapacity in generation, less efficient generation is displaced. The emissions trading scheme provides the right incentives and the CHP certificate does not have to capture the CO_2 benefit. If, however, the CHP plant represents the marginal power generating option in the market, direct emissions rise, which should be covered by emission allowances. It depends on the Member States allocation plans how this CHP will be treated (e.g. CHP regarded as ‘new entrant’ getting allowances free of charge).

In any case, capturing the CO_2 benefit on the CHP certificate is not necessary, i.e. integration of the two trading schemes is not an option. Adding to this conclusion is the problem of denominating the carbon value on the CHP certificate. Emission savings or avoided emissions due to CHP generation can only be determined by a comparison to a reference technology (Emission Reduction Units - ERUs). The allowances in the emissions trading scheme, however, are based on absolute emission reductions compared to a reference period (Assigned Amounts). Thus, ERUs are not part of the ET scheme, but they are at the basis of the project based mechanisms of the Kyoto Protocol (Joint Implementation and Clean Development Mechanism).

It should be noted that, even without a direct link between CHP certificates and emissions trading, the two coexisting schemes (indirectly) affect each other. This is illustrated in Figure 4.1, where a certain price level that triggers CHP investments is assumed (which could be interpreted as the long-run marginal cost of CHP). With well functioning markets for electricity and CO_2, the costs induced by an emissions trading scheme covering the power industry will be reflected in the electricity price, i.e., the electricity price will increase. The average price levels for these commodities could be as illustrated in the left-hand side of the figure[8]. In this case, investments in CHP will be made anyhow because the implicit electricity price is high enough to induce CHP investments. In case that the CO_2 price is lower (right-hand side of Figure 4.1), the total price that CHP can get from the electricity and the CO_2 market is not enough to induce in-

[8] Note that this CO_2 price is not necessarily identified as such. In the long run, costs of an emissions trading scheme will always be reflected in the electricity price, thus only the total (spot plus CO_2) price is revealed. This also depends on the design and organisation of the schemes.

vestments. Therefore, CHP needs additional support, for example by tradable CHP certificates. The necessary price is indicated by the shaded area in Figure 4.1.

Whether or not the CHP certificates scheme and the emissions trading scheme are directly linked, any emissions trading scheme affects the long-run electricity price and therefore also the CHP certificates price.

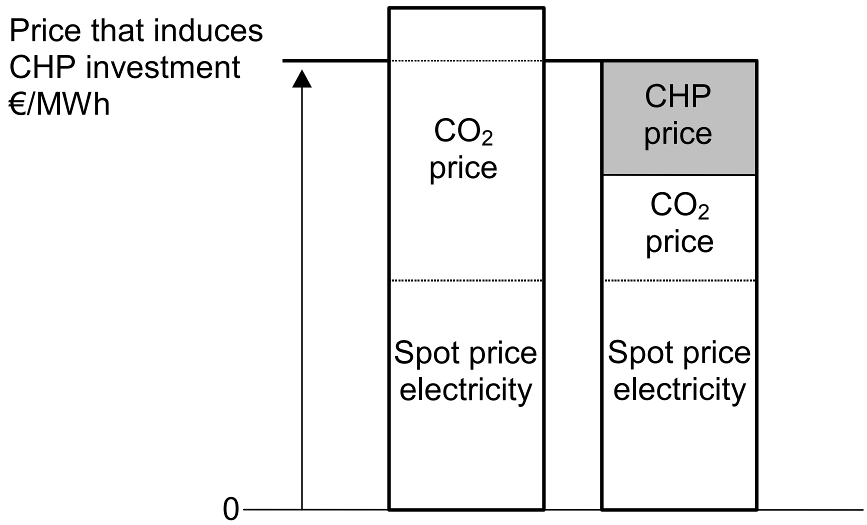

Figure 4.1 *Effects of emissions trading (in the power industry) on the CHP certificate price*

In the future, the CHP certificate scheme may become redundant when emissions trading is well on its way. The following quotation suggests that specific CHP promotion, for example by CHP certificates, will no longer be required once a CO_2 trading scheme is in full operation.

> "When such a market [for emissions] is in full operation, a price on CO_2 emissions will in effect be disclosed whereby an important step towards internalisation of external costs will have been taken. However, as long as a well-functioning market reflecting the price of CO_2 emissions is not in operation, cogeneration is particular vulnerable to competition from less clean energy producers and will therefore often need specific promotion" (European Commission, 2002).

4.1.3 Conclusions

The analysis in this section showed that emissions trading is not sufficient to stimulate cogeneration. ET only covers some plants and there are a number of barriers to CHP in the proposed European ET scheme. A CHP certificates trading scheme can coexist with an emissions trading scheme, assuming each is designed for its specific policy goals. With coexisting trading schemes for emissions and CHP certificates, capturing the CO_2 benefit on the CHP certificate is not necessary, and may even cause confusion. Integration of the two trading schemes is therefore not an option. However, even without a direct linked between both schemes, they both affect the long-run electricity price and therefore also each others (certificate or allowance) price.

4.2 Renewable certificate systems

Renewable certificates are issued to producers of renewable electricity for the amount measured and delivered to the electricity grid. Certificates can be sold, e.g. to electricity supply companies. An obligation or tax incentives ensure there is an incentive for e.g. supply companies to buy renewable certificates. Essentially, renewable certificates and CHP certificates may co-exist separately because each scheme has its own objective. Generally, CHP production is not regarded as renewable electricity production, although in Wallonie they are brought under one certificate scheme.

However, the issue becomes more complicated when the CHP installation is (partly) fired with renewable energy sources, such as biomass. In that case, the producer may have to choose whether the CHP output is rewarded with CHP certificates or with renewable certificates. Of course his choice will be based on market information, i.e. he will choose the certificates for which he gets a better price.

However, since both certificate schemes serve separate goals, production of renewable energy fired CHP electricity can also be endowed with both renewable and CHP certificates. Assorted CHP certificates then are not complementary with renewable certificates, since it could lead to double counting. This is because the value of the CHP assorted certificate will be based on the plant characteristics. Part of the value will be the fuel choice (biomass). The renewable certificate rewards the same part. Standard CHP certificates reward the efficiency gain of the CHP production in comparison with reference energy systems. For example, it will encourage CHP biomass production as opposed to straight power generation from biomass, or for that matter, as opposed to CHP production based on fossil fuels.

In sum, renewable energy and CHP targets can well be reached by coexisting schemes of renewable certificates and standard CHP certificates. When institutionalising these schemes, synergies can be used in order to minimise transaction costs, e.g. one Registrar keeping account of both type of certificates.

4.3 Guarantees of origin and disclosure

Chapter 2 already briefly indicated the relationship between the different CHP certification approaches and guarantees of origin. In order to further examine this relationship we first need to identify what guarantees of origin and disclosure are.

Guarantees of origin
A guarantee of origin is a type of certificate that authenticates the ‘origin’ of electricity. It may contain information regarding the fuel or renewable energy source, the generating technology and the geographical localisation. Guarantees of origin are just contractual documents stating that generation of a certain type has occurred somewhere. It does not mean that the electricity being received by the consumer is actually that same ‘electricity’ generated by the recipient of the guarantee of origin[9].

Within the EU, pursuant the Directive on renewable electricity (European Commission, 2001a), Member States are required to implement a system of guarantees of origin for renewable electricity by October 2003. A system of guarantees of origin can be implemented exactly the same as a system of tradable renewable certificates. Guarantees of origin need to be distinguished from tradable renewable certificates in that they are not necessarily tradable. However, in the case that guarantees of origin are not tradable, the information content can provide the basis for issuing tradable certificates. Guarantees of origin are an important tool in providing transparency and standardisation to the European renewable electricity market. The interactions between renewable electricity guarantees of origin and CHP certificates are analogous to the interactions between tradable renewable certificates and CHP certificates as discussed in Section 4.2. There-

[9] In the case of tradable certificates, it is usually the case that they certify generation that has occurred. Guarantees of origin may, however, be issued in advance of generation actually occurring. In this case there is no guarantee that the generator in question will actually be dispatched by the system operator and to meet commitments relating to the guarantee of origin the generating company may have to express the guarantee as an aspired average generation type over a period of time.

fore the focus here is more on the interactions with disclosure, i.e. the interaction between guarantees of origin of CHP production and CHP certificates.

Disclosure

Disclosure reveals a set of attributes associated with the origin and mix of electricity that is delivered to a customer. By providing objective and standardised information about these attributes, disclosure increases the transparency of the market and allows customers to make an informed choice on their power purchases (Timpe and Bürger, 2002). Similar to guarantees of origin above, the power being supplied to customers cannot be guaranteed to be the same as that disclosed to them because of the physics of the electric system.

Disclosure requires tracking methods to link a power product delivered to a final electricity consumer to the source(s) of generation. The options for such a tracking method are:

1. Contract-based: the sources and attributes of electricity used in a physical electricity transaction are specified in the contract between the parties in the transaction.
2. Certificate-based: the information about the attributes and sources of electricity are captured in a certificate that can be traded separately from the physical electricity. This approach is effectively the same as a tradable renewable certificate system.

With regard to renewable electricity, guarantees of origin can provide information for disclosure based on both the contract and certificate approach.

Interactions

While guarantees of origin and disclosure certify and track all the electricity that is produced by a CHP plant a CHP certificate only captures that part of production that meets specific criteria. This is also reflected by the information that is used in each of these systems. As discussed before, standard CHP certificates capture the energy savings benefit associated with CHP production. Neither renewable certificates, nor renewable electricity guarantees of origin contain any information on the energy savings. Thus there need not be any non-desirable interactions between CHP certificates and guarantees of origin or disclosure. It is only when the information on a CHP certificate is also part of a guarantee of origin or subject to the tracking method employed for disclosure, and when this information has a value outside the CHP certificate scheme that undesirable interactions may occur. For example, suppose an industrial electricity customer buys CHP certificates to meet an energy savings target. In addition, suppose that disclosure is based on a certificate approach. Then, if the disclosure certificates associated with the electricity for which the CHP certificates were issued are not transferred to the buyer of the CHP certificates, the CHP quality of the electricity can be sold again on the market for disclosure certificates. Thereby the uniqueness of the attributes embodied by both the CHP certificate and the disclosure certificate is damaged. To avoid such interactions, the relationship between the use of CHP certificates and disclosure needs to be clearly defined. Most importantly, CHP certificates and the associated disclosure certificates need to be redeemed at the same time by the same consumer in a way that can prevent double-counting.

5. INTERNATIONAL INTERACTIONS OF NATIONAL CHP CERTIFICATE SCHEMES

The options for shaping demand and issuing CHP certificates presented in this report and other EcoCerT reports allow a broad range of overall CHP certificate scheme designs. If different schemes are introduced in different countries, these schemes may interact with each other and influence each other's effectiveness. Such interactions pertain to the differences in value of CHP certificates between countries and to the fungibility of different support schemes linked to a CHP certificate scheme. The insights on policy interactions through certificate schemes are primarily based on the experiences with international trade of renewable certificates.

The main conditions for international trade in CHP certificates is that CHP certificates are mutually recognized between countries and that the attributes and value that the certificates represent are unique to the certificate. If these conditions are not met international trade in CHP certificates is not credible.

5.1 Levels of harmonisation

The above requirements can be met by establishing a common unit of trade that is captured in CHP certificates in the trading countries and by mutually recognizing the certificates for policy purposes. Thus international trade assumes at least a minimum of harmonisation with regard to what is traded and the recognition of a certificate.

In Chapter 2 three different options for certifying CHP electricity were discussed; the dummy, minimum efficiency and substitution approach. If different countries adopt different certification approaches, conversion of certificates is necessary in order to make the schemes in the different countries fungible. The same is true for the fungibility of different policy schemes that allow the use of CHP certificates within a single country. However, international circulation of different types of CHP certificates that can be converted into each other would diminish the transparency of the market. This may reduce the potential benefits of international trade. Thus in order to capture the benefits of international trade in CHP certificates a common unit of trade is desirable.

There are two ways of creating a common unit of trade. The first is to adopt a common approach to issuing CHP certificates, i.e. according to the dummy, minimum efficiency or substitution approach. The second is to convert different types of CHP certificates into a common type of certificate with common reference efficiencies. Thus a pool of internationally tradable CHP certificates is created. These internationally tradable certificates in turn can be converted into any other type of certificate for the purpose of consumption. The latter option, however, seems complicated compared to the first option. Therefore, we recommend that a common approach to issuing CHP certificates is adopted in all countries participating in international trade and that certificates may be converted into another type of certificate at the point of consumption, abroad or in the country of origin[10]. This provides most transparency on the supply and trading side of the market, while allowing maximum flexibility on the demand side to use CHP certificates for different (policy) purposes.

A common unit of trade does not necessarily imply common references or efficiency standards in the case of a minimum efficiency or substitution approach, as certificates with different references in principle can be converted into each other. Thus there is scope for subsidiarity in set-

[10] This has implications for the information content of CHP certificates in order to make them easily convertible.

ting different efficiency standards. However, in the interest of transparency of the market it is commendable to set common efficiency standards for issuing certificates. If a country wishes to set higher standards within its domestic policies it can do so, because at the point of consumption the certificates can be converted into certificates with higher reference efficiencies.

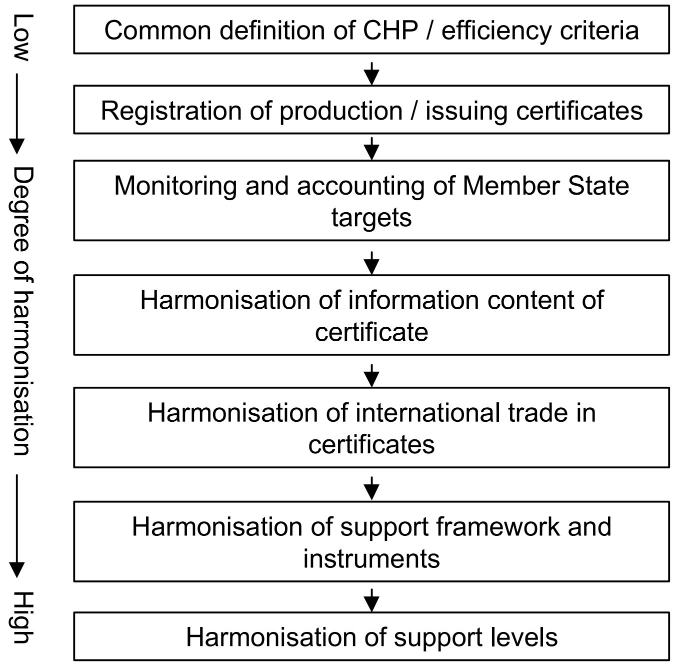

Figure 5.1 *Levels of harmonisation (adapted from Van Sambeek, 2002)*

Once a common framework for trade of CHP certificates is implemented, policy schemes in different countries that are based on CHP certificates are linked, and their efficiency and effectiveness are affected by each other. The most important source of interaction arises from differences in the value of certificates in different countries. For example, arbitrage between these countries may cause the policy instruments in the low value country to be ineffective and in the high value country to be too costly. Thus, once the conditions for international trade are created, some level of co-ordination of policies between countries is necessary in order to avoid such adverse effects. This co-ordination may result in full harmonisation of the CHP certificate market. Figure 5.1 explains the different levels of harmonisation that can be distinguished with respect to the CHP electricity market and policies.

6. CONCLUSIONS

The main objective to introduce a system of tradable CHP certificates is to support CHP production in a way that is compatible with the liberalised market. Certificates can be traded separately from the electricity and heat produced, thus creating an unrestricted market, which is potentially bigger and more flexible than the market for the physical CHP kWh output. Given the policy target for CHP, in theory, trade in CHP certificates is beneficial for the actors involved; the policy objective will be reached at the lowest possible costs.

The main question addressed in this report - how best to create demand for CHP certificates - does not have an unambiguous answer. There are several possibilities for which advantages and disadvantages depend, among other things, on the exact design of the certificate scheme and on the existence and design of related policies, such as GHG emissions trading, renewable certificates, fiscal measures, electricity disclosure, etc.

First of all, a CHP certificate should be well defined, preferably as a homogeneous commodity, for a credible and liquid certificates market to develop. Standard certificates would therefore be preferred. We take output-based certification in terms of kWh produced as a starting point. Either total CHP kWh production (possibly only from plants meeting certain minimum efficiency standards), or additional ('fuel-free') production could be made eligible for issuing certificates. The latter option gives incentives to increase efficiency, but it is sensitive to reference levels. With the former option, the amount of information on the certificate can become confusing (and irrelevant to the buyer of certificates) and the spectrum of values makes it difficult to trade the certificate.

Once the definition of the commodity, i.e. the CHP certificate, is clear, demand for it can be organised in several ways. A well-designed system of mandatory demand, by means of an obligation to acquire a certain amount of CHP certificates each year, is effective to meet the policy target. However, it requires a complex system design. Issues to be addressed are defining the obliged actors, the allocation of the obligation over the actors, the responsible authorities for e.g. issuing the certificates, facilitating trade in certificates and monitoring and controlling the compliance, enforcing compliance e.g. by means of setting a penalty on non-compliance, etc. Thus institutional transaction costs are likely to be substantial, particularly when initiating the certificate scheme.

The voluntary willingness to pay for CHP certificates is likely to be small, resulting in a very thin market. However, demand could be supported by additional measures such as fiscal incentives or feed-in tariffs. This fits in well with existing policy structures (low institutional transaction costs), however, it is not certain that CHP policy targets will then be reached.

Finally, instead of creating a demand solely targeted at the CHP certificates, demand could also result from interacting policy schemes such as GHG emissions trading. Additional transaction costs are low because of the synergy between the trading schemes. However, then CHP production is only valued for its CO_2 mitigation benefits, while additional benefits of CHP production are disregarded.

Given the existing CHP policy objectives, a separate market for CHP certificates (i.e. with its own demand) is therefore justified. A CHP certificates trading scheme can coexist with an emissions trading scheme, assuming each is designed for its specific policy goals. With coexisting trading schemes for emissions and CHP certificates, capturing the CO_2 benefit on the CHP certificate is not necessary, and may even cause confusion. Integration of the two trading schemes is therefore not an option. However, even without a direct linked between both schemes, they both affect the long-run electricity price and therefore also each others (certificate or allowance) price.

Standard CHP certificates based on energy saving can be made fungible with the renewable certificate market and may therefore induce voluntary demand. Since standard certificates reward the efficiency gain of CHP production that uses renewable energy sources as fuel input, this type of CHP certificates is also compatible with renewable certificates. It is unlikely that undesirable interaction between standard CHP certificates and guarantees of origin, or the tracking method employed for disclosure, will occur. Standard CHP certificates based on energy savings prevent any possible interference with guarantees of origin and disclosure.

Based on the analyses in this report we would recommend to issue standard CHP certificates based on additional kWh output (substitution approach with standard certificates) and create demand by means of an incentive on electricity supply companies to purchase CHP certificates. The incentive could either be quantitative (an obligation) or a price incentive (fiscal or feed-in tariff). Policy goals with respect to CHP justify a support scheme that is specifically designed for CHP. Integration into other tradable schemes would underestimate the value of CHP. A standard CHP certificate scheme is also compatible with renewable certificates and does not interfere with a guarantee of origin. When introducing CHP certificates, international harmonisation is highly recommended in order to prevent undesirable and complex conversion issues.

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APPENDIX A BENEFITS OF TRADE IN CHP CERTIFICATES

The economic effects of issuing tradable CHP certificates can be illustrated by means of Figure A.1. This figure presents the marginal cost curves for two firms, i.e. MCI and MCII, with the amounts of CHP certificates reflected on the X-axis and the corresponding marginal production costs on the Y-axis. The marginal cost curve for firm I (MCI) originates from the left corner of Figure A.1, whereas MCII starts from the right corner. The area or integral below the marginal cost curve represents the total costs of producing/supplying CHP certificates of the firm concerned.

The overall policy objective (obligation) for the two firms is indicated by the amount 0Q on the X-axis, with each point on this axis representing the allocation of this objective between the two firms involved. At point Q', for instance, firm I is obliged to produce the amount 0Q' and firm II the amount QQ'. This point Q' corresponds to a specific, initial allocation of the CHP obligation among firms I and II. In principle, each point on the X-axis - and the corresponding allocation - can be chosen by policy makers as the overall policy objective (i.e. producing CHP electricity by the amount 0Q) will be achieved in any case.

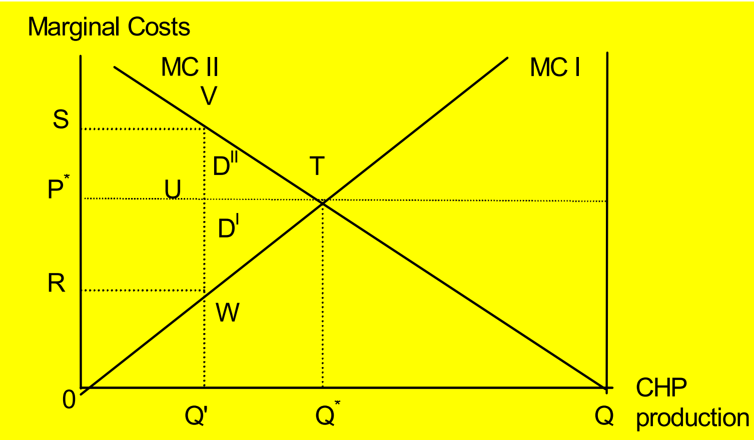

Figure A.1 *CHP certificate trading*

At the firm level, however, the economic effects of a system of tradable CHP certificates will differ depending on the initial allocation of the obligation among the firms involved. These effects can be illustrated by distinguishing two cases, i.e. Case 1 in which no trade in CHP certificates among firms is allowed, and Case 2 in which such trading is permitted.

In Case 1, assuming an initial allocation corresponding to point Q' of Figure A.1, the marginal costs of firm I are significantly lower than in firm II (indicated by points R and S, respectively). These differences in marginal costs provide a major incentive for certificate trading, as both firms will benefit from such trading. In Case 2, assuming a similar allocation of the obligation, certificates trading will continue until the marginal costs are equalised between the firms involved, resulting in the most efficient allocation of CHP production over firms in order to achieve the overall target of 0Q. In Figure A.1, this situation is reflected by the intersection of the two cost curves MCI and MCII (i.e. point T). At this point, the marginal production costs of firms I and II are equal to the equilibrium price (P*) of the certificates traded between these firms (based on the assumption of a well functioning market with no trade restrictions and no transaction costs).

At price level P*, firm I will produce an amount 0Q* of CHP electricity, receiving the corresponding amount of certificates and sell its surplus of certificates (Q* - Q'), whereas firm II will produce QQ* and buy the resulting deficit of certificates (Q* - Q'). As a result, a so-called 'capital transfer' will take place from firm I to II, equal to P*(Q* - Q'), i.e. area Q'Q*TU in Figure A.1. Both the size, the direction and the number of these capital transfers depend on several factors, including (i) the firm's CHP production in the baseline scenario which is used to allocate the obligation initially, (ii) the overall CHP production objective, (iii) the initial allocation of the obligation among firms, and (iv) the differences in marginal costs between firms.

Capital transfers resulting from the introduction of tradable CHP certificates should be distinguished from a related economic effect of such a system called 'trade benefits'. Whereas capital transfers are paid by the one firm that buys certificates and received by the other selling certificates, trade benefits accrue to both sectors participating in such a system. In Figure A.1, firm I receives a capital transfer equal to area Q'Q*TU by selling a surplus amount of CHP certificates Q'Q*, but in order to generate this surplus it has to incur additional production costs equal to area Q'Q*TW, resulting in a net trade profit of area TUW (equal to D^{I}). On the other hand, although firm II has to pay the capital transfer Q'Q*TU for buying the amount of certificates Q'Q*, it also benefits from this transaction as it lowers its production costs by area Q'Q*TV, leading to net cost savings equal to area TUV (or D^{II}).

Depending on the slopes of the marginal cost curve, the net cost savings of those firms buying certificates may even be larger than the net profits for those firms selling certificates. Moreover, depending on the equilibrium price of the certificate, these trade benefits may even be more significant than the capital transfers among firms resulting from the initial allocation of the obligation.

Note, that the above gives a stylised version of a CHP trading scheme. In practice, the obligation (if demand is mandatory) will probably be set on electricity supply companies, while CHP producers are issued with certificates. Thus, producers will sell certificates to supply companies (and not to other producers). Note also that this analysis is also valid when considering trade between different countries.

APPENDIX B TRANSACTION COSTS[11]

Transaction costs are defined as the costs that arise from initiating and completing transactions, like finding partners, negotiating, consulting with lawyers and other experts, monitoring agreements, etc., or opportunity costs, like lost time and resources. The most obvious impact of transaction costs is that they raise the costs for the participants of the transaction and thereby decrease the net economic and commercial benefit of trading; lower the trading volume or even discourage some transactions from occurring. Transaction costs that fall under this definition can take many forms. Different authors have used different subcategories. They, for example, divide the so-called investor or *market transaction costs* in:

- Search costs: costs of finding interested partners to the transaction as well as the costs of identifying one's own position and optimal strategy.
- Negotiation costs: the costs for coming to an agreement. Negotiating terms may for example take time, visits to the site of a project, and hiring lawyers to draft contracts.
- Approval costs arise when the negotiated exchange must be approved by a government agency. Modifications could be imposed on the deal.
- Monitoring costs are the efforts the participants must make to observe the transaction as it occurs, and to verify adherence to the terms of the transaction.
- Enforcement costs: the expenses to insist on compliance once discrepancies are discovered.
- Adjustment costs: costs of changing strategies, due to a change in regulations or new scientific discoveries.

These costs can occur with every transaction that is carried out; they are also called periodic transaction costs.

Another category of transaction costs arises in designing and implementing public policies. The so-called set up or *institutional transaction costs* are considered relevant for market based instruments such as renewable or CHP certificate systems, and tradable environmental policy instruments in general, by many experts, market actors, and politicians. They include:

- Developing the instrument in question.
- Enacting it by legislature.
- Establishing of an administrative infrastructure.
- Implementing and enforcing the policy by administrative agencies and the courts.
- Fighting political opposition against the instrument; campaigning for social acceptance.

Note that the market transaction costs concerns the individual investor while the institutional transaction costs concerns society at large.

In discussions about trading systems, the high institutional transaction costs of enacting, implementing and monitoring such a scheme are often cited as a main disadvantage. Yet, hardly anybody has so far made a comprehensive attempt to list the affecting parameters and to quantify them. Furthermore, usually it is not mentioned that other support schemes, e.g. tax exemption policies, also cause institutional transaction costs; nor are thorough qualitative or quantitative analyses made. A comprehensive (quantitative) analysis and comparison of the transaction costs of CHP certificate systems is not possible within the scope of this report.

Costs for identifying a suitable trading partner are expected to be relatively low for firms who are in the same industry and who may even be accustomed to doing business with each other. This aspect displays one of the differences between regional and international trading schemes. Regarding emissions-trading, Foster and Hahn (1995) point out two types of trade that are ex-

[11] This section heavily draws on Bräuer and Kühn (2001) and Hoffmann et al. (2002).

pected to have relatively high transaction costs: exchanges of thinly traded commodities or services, due to the fact that it will be harder to find suitable trading partners (this may for example apply to the trading of non-CO_2 greenhouse gases in a second step of the EU emissions trading system) and exchanges involving very small volumes of allowances or certificates, due to bureaucratic approval process and as well to the difficulty of finding suitable trading partners.

In general, the number of potential trading partners will be an important factor for the magnitude of transaction costs. Stavins (1995) suggests that transaction costs will decline as the number of potential traders and the number of transactions per source increases. However, where existing trading patterns and relationships exist (as is the case in the electricity market), a smaller number of participants may not necessarily cause higher transaction costs - indeed, it may well cause them to decrease.

Transaction costs are expected to be higher in initial stages of a trading program and decline with the acceleration of experience and information. This trend could be perceived in the US emissions-trading schemes. It was also the result of the studies by Gangadharan (2000) and Aidt and Dutta (2001). In their study on the choice of environmental policy instruments, Aidt and Dutta (2001) suggest, that it is the learning-by-doing effects that help to explain why the later U.S. emissions-trading programs were more successful than initial ones. They conclude, that international spill-over effects of this learning process will support the transition from pollution taxes to tradable permits in Europe.

Gangadharan (2000) provides an empirical study on transaction costs connected to the trade in pollution permits within the framework of the Regional Clean Air Incentives Market (RECLAIM). This program was launched in Los Angeles in 1994 and used emissions trading to reduce smog creating pollutants, mainly nitrous oxides (NO_X) and sulphur oxides (SO_X). Gangadharan investigates the dependence of the decision of firms to participate in the market on such transaction cost variables as the presence of brokers, search costs of finding a trading partner and negotiation costs of entering the market. The analysis shows, that efficiency losses due to transaction costs were substantial, particularly in the first years of the program, and that the inclusion of transaction costs explains why a large number of firms do not participate in the market. He concludes, that in the later years of the program without transaction costs the probability of trading increases by 12%. This is in line with the results from Kerr and Mare (1995), who estimate that the transaction costs for lead permit trading result in an efficiency loss of 10%, and with Montero (1997), who claims transaction costs of the US SO_2 emissions trading scheme to be 8% of total transaction value (Woerdman, 2000).

In the PwC report to the Danish Energy Agency (PwC, 1999) and the KPMG report for the Dutch Ministry for Economic Affairs (KPMG, 1999), transaction costs of green certificate systems got some attention, but the thoughts and estimates remain rather general. On the basis of discussions with the system operators and possible candidates for operating the market place, the expenses of establishing and operating the Danish system are assessed at € 1.6 million a year plus/minus € 0.4 million. The specific costs for establishing and operating (from issuing to quota fulfilment) a green certificate system in Denmark are estimated to amount to 10-17% of the maximum certificate price of 4 €ct/kWh (0.27 DKK) in 2000 and to drop to 0.9-1.4% of this maximum price in 2003 (Energistyrelsen 1999, Annex 3). These estimates of course depend on the assumed market and trade volumes and design of the scheme. Market and trade volumes are not expected to become very high under the Danish system for the years to come, mainly due to generous transition periods from the feed-in to the green certificate system. For comparison, in the financial and asset markets, costs of going public are usually between 6 and 12% of the emission volume, depending on the size of the company (Blättchen and Jasper, 1999). The consumer-level obligation nature of the Danish system would have made it very complex and expensive to administer because the TSO would have had to estimate consumption information for all individual consumers. Quite often, such disaggregated information is not readily available to

TSOs or other bodies charged with enforcement and even if it were it would be almost impossible to enforce on a consumer-by-consumer basis.

There are several categories of institutional transaction costs where the difference between support systems seems to be negligible. For example, CHP plants are subject to an approval procedure prior to connection to the electricity grid, and checks are conducted and reported to the system operator regarding electricity production from CHP plants. Moreover, procedures to identify qualifying CHP plants, which can gain from specified support policies, are likely to be similar. For delivery to the grid, information collection needs to take place. Institutional set up is concerned with auditing and measuring the amount of produced. Also, all CHP kWh produced have to be recorded, the accounts of the grid and supply companies have to be managed and balanced. Overall electricity sales and consumption data need to be obtained. Thus, the necessary functions for running CHP support schemes are in fact more similar than discussions propose. The possibilities for the institutional set-up are plenty, however. Searching for efficient institutional arrangements that reduce transaction costs and share the risks are keys to the potential success of policy instruments.

Transaction cost should be taken into account in iteratively designing implementation scenarios for a CHP certificate scheme. In this regard it may also be useful to document the design history as this may provide valuable insights in the design process for policy makers. To maximise certificate-trading volumes, transaction costs will need to be as low as possible. The less liquid and less transparent the market, the higher the transactions cost per contract will be. If transaction costs would be too high, trading might not get under way properly. Especially during the first stage of a certificate system, transaction costs may be an essential cost factor. However, they decline with the accumulated amount of trades. A cross-border or EU-wide trading scheme gives quite an advantage in this respect. Finally, tradable instruments in Europe are rather new instruments in practice - not in theory. The different market players, administration and society as a whole have not come too far on the learning curve, yet. Therefore, it may take longer to solve issues, and to come to agreements. Resistance may be higher, as well as the investments in the distribution of information.