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TRADABLE GREEN CERTIFICATES

A new market-based incentive scheme for renewable energy: Introduction and analysis

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Preface

In early 1999 the issue of green certificates was the focus of several activities that took place in a number of different projects at ECN-Policy Studies. This included activities in the framework of Energie Verslag Nederland 1998 (Energy Report of The Netherlands 1998, ECN-project number 77207), activities in Working Group III of the EU-DGXII-project Renewable Electricity And Liberalising Markets (REALM, project (contract No. JOR3CT-98-0290)), activities in the framework of the EU-DGXVII project in the Altener program 'The Implications of Tradable Green Certificates for the Deployment of Renewable Electricity' (Contract number XVII/4.1030/Z/98-037) and an internal ECN-project (ECN project number 7.7191). This led to the formation of an internal Task Force in order to combine the various insights that had been developed within these projects. This report is the fist result of this Task Force. The contribution that has been provided by discussions with team members of the two European projects and especially with Peter Niermeijer from the Dutch Association of Energy Utilities EnergieNed is greatly acknowledged. The responsibility for the contents of this report, including the flaws, will, of course, remain with the authors of this report.

Abstract

In the coming decades the trend of liberalising energy markets will have to be combined with ambitious environmental goals within the European Union. Currently prevailing incentive schemes for renewable energy might not be in line with liberalisation of international energy markets. A new policy scheme that has been developed recently is the system of green certificates. In such a system producers of green electricity receive a certificate for each pre-defined unit of electricity produced. These certificates can be traded at a certificate market and adds to the revenue that the producer can get for the electricity itself. This report studies the way such a system could work. Issues are the sources of demand for green certificates, the functions that have to be performed in a certificate market, supply and demand conditions to ensure a stable system, the first experiences with such a system in the Netherlands and the influence of a green certificate market on the way renewable electricity targets can be distributed over Member State countries.

CONTENTS

INTRODUCTION

In the first decade of the 21st century, global energy markets will be confronted with two issues that have increasingly dominated the international energy agenda during the last decades of the 20th century. These two issues are the liberalisation of energy markets on the one hand and the fulfilment of environmental targets put forward in the international policy arena on the other hand. The best known example of the latter is the Kyoto-agreement on the reduction of CO_2 and other greenhouse gas emissions. Another example, which will be the focus of this report, is the indicative target that has been put forward in the White Paper on Renewable Energy of the Commission of the European Union. The White Paper states that 12% of the gross energy consumption in the European Union should come from renewable energy sources in 2010. In the White Paper it is assumed that about two-thirds of this target will be realised in the electricity sector. Since the consumption of electricity contributes to about 40% of the gross energy consumption within the European Union, this implies a 20% renewable energy target for the electricity sector in 2010.

To realise environmental targets in a liberalising market the design and implementation of policy measures and incentive schemes have to be in accordance with free market principles. Current incentive schemes, most of which have been established in the pre-liberalisation situation, might not be able to fulfil this requirement. This underlines the need for new policy measures which are more in coherence with the new market.

The focus of this report will be the discussion of a new market-conform incentive scheme which is known as the 'green certificate system'. The major characteristic of a green certificate system is that electricity produced by renewable sources is certified. These certificates have two purposes. First, they can serve either as an accounting mechanism in the case obligations set by the government have to be met, or as a proof to customers of green electricity that a certain amount of renewable electricity has been produced. Second, green certificates facilitate the creation of a green certificate market that functions independently from the market of electricity as a commodity.

This report will introduce the reader to the basic idea behind a green certificate system and discuss the results of the first analyses that have been made at ECN-Policy Studies on how such a market could work and what the possible consequences of such a system might be at a European level. Our analyses will show that there are many ways a green certificate system can be designed. It is not the aim of this report to show what the optimal design of such a system should be. Rather, we present and discuss general features of green certificate systems, their possible pitfalls as well as possible solutions. We do not claim that our analysis is complete and covers all issues related to a green certificate system. We restricted our analysis to some of them, including what we see as the most basic ones. An important part of the insights presented in this report draw upon the first experiences with a green certificate system in the Netherlands, which was created by the Dutch electricity sector[1].

Although the focus of this report is on green certificates for electricity, there is no reason why, in the longer term, such a system could not be applied to other energy carriers as well.

1 Apart from a publication in Dutch (Van der Tak, 1998) we did not come across any literature on green certificates yet. Just before publishing this report we became aware of the existence of a publication on the green certificate system in the United States (Clemmer, Nogee and Brower, 1999). That report has played no role in our publications. However, we were glad to find out that most of the findings of US-publication are either in line or complementary to ours.

The structure of this publication is as follows: As a background, in Chapter 1 we will describe and discuss shortly the main incentive schemes for renewables as they currently exist in European countries. In Chapter 2 the theoretical background and general functions of a green certificate system will be discussed. Besides, the experiences with the Dutch system will be described. In Chapter 3 conditions for a stable system will be explored and discussed. Since the value of green certificates in a country depends on the country's target and its possibilities to deploy renewable energy sources, target setting is a major issue, especially in an international context. Chapter 4 will describe an approach that can deal with the question how national targets within the European Union compare to each other by taking into account the possibilities of each country to produce renewable electricity. The report will finish with a summary and conclusions in Chapter 5.

1. SHORT DISCUSSION OF CURRENT POLICY SCHEMES

The most widespread instrument to stimulate renewable energy sources has been subsidies. In general, they can be divided into subsidies on renewable energy capacity and subsidies on renewable energy output. Subsidies on installed capacity only stimulate supply but not the demand for renewable electricity. Moreover, subsidies on installed capacity might be unfairly distributed if the total amount of subsidy is limited, and they have to be abolished if the technology that is stimulated becomes too widespread. Subsidies on output (e.g. the StromEinspeisungsGesetz or Electricity Feed-In Law in Germany where utilities are forced to accept renewable electricity produced in their area for which they must pay a premium tariff) have proved to be very successful in promoting the deployment of renewable energy sources. However in a market situation such a system will disadvantage those utilities that happen to be in areas with a large potential of renewable energy sources. These utilities will have to pay more premium tariffs because in their area more renewable electricity will be offered than in the areas of the competitors. To avoid this a EU-wide compensation mechanism should be designed. Another disadvantage is that there will be no strong incentive for investors to drive down cost by improvement of operation and efficiency. Furthermore, in the future subsidies might be considered as an unlawful regulation according to the trade agreements within the European Union.

One way to give all players an equal opportunity that includes a mechanism to drive down cost is to provide a limited subsidy on output that is awarded to only a limited number of investors. These investors will have to compete for the subsidy through a bidding system. For each bidding round only the most cost-effective offers will be selected to get the subsidy. This system currently prevails in the United Kingdom and Ireland (The Non-Fossil Fuel Obligation or NFFO). It has been proven to be very successful in driving down cost, but it has encountered other problems. Potential investors in a bidding system are faced with several uncertainties. First the chance of winning a bid is relatively low. Second, although every winning investor gets a period of 5 years to implement the project this has not been enough in many cases because of planning problems and local resistance against construction of the renewable electricity plants (e.g. wind). Third, for every NFFO-round (which happens each 2 years) it is unclear which part of the money available will be available for which renewable technology. Preferences among the deciding experts can change easily according to the latest fashion. Due to all these uncertainties, no long term-planning has been possible. For a further discussion of the renewables NFFO in England/Wales (Mitchell, 1995).

A policy that is most in line with laisser-faire principles is no stimulation of renewable energy at all. In such a situation utilities can still offer customers ‘green energy’. Green energy in the form of green electricity has been offered as a product to customers since 1995, first in the Netherlands[2] and later on also in other European countries. Customers that buy green electricity pay a premium on their electricity tariff. Their utility guarantees that the same amount of electricity for which they pay a premium price has been produced at a renewable basis. This is monitored by an independent organisation, often NGOs such as the World Wildlife Fund. Although such a system is completely in line with liberalisation of energy markets, it does not guarantee that policy goals will be reached. Most experts believe that the number of people that is willing to pay a higher price for green electricity on a voluntary basis will be limited to a few percent. Then, there is the problem of political acceptability. If policy makers merely rely on

[2] The existence of green tariffs in the Netherlands does not mean that the government in this country does not stimulate renewables. On the contrary, their is a wide range of incentive schemes for renewables in the Netherlands varying from direct subsidies to a various fiscal measures.

voluntary green energy as a means to reach the policy goals the public might consider this as unfair (not following the polluter-pays principle) and loose interest in the product.

Yet another policy measure that is in line with free market principles is the internalisation of external cost of non-renewable energy sources. This can be done for instance by taxing emissions of CO_2, SO_2 or $NO_{x,}$ or by taxing energy from which renewables are exempted. Such a tax exemption measure is specifically aimed at renewables, whereas taxing emissions also give an advantage non-renewable options like energy conservation measures and end-of-pipe solutions. To a certain extent, green tax systems exist in several countries of the European Union. In these countries the gap between renewable energy cost and cost of non-renewable energy has decreased. Because of considerations of international competition these taxes have never been put at such a level that they contribute substantially to the deployment of renewable energy sources. For that reason, such a green tax scheme should be introduced synchronically in all EU Member States. Until now attempts to introduce an EU-wide CO_2 tax have failed because of the different interests and industrial structures of the different Member States and because of international competition considerations with regard to the United States and Japan.

2. TRADABLE GREEN CERTIFICATES

2.1 General features of a green certificate system

The main objective of a system of tradable green certificates is to stimulate the penetration of green electricity into the electricity market. In a green certificate system, certification serves two purposes. It functions as an accounting system to verify whether the obligations have been met. Besides, it facilitates trade in electricity from renewable energy sources. Thus, through the establishment of a green certificate system (GC) a separate market for renewable electricity will originate besides the market for conventionally produced electricity.

2.1.1 Creation of green certificates

Green certificates are created by the producers of electricity. Producers receive a certificate for each pre-defined unit of electricity produced from renewable energy sources that is put on the grid. Consumers of electricity are allotted with targets for the consumption or sale of electricity from renewable sources[3]. In order to show that they meet their targets, these consumers have to hand over certificates at a given point in time. Penalties are set if they are not able to fulfil their obligations. Therefore, consumers have an incentive to buy certificates from the producers and the certificates become valuable. It is expected that competition between producers and increasing supply of green certificates will lead to a decline in the price of electricity from renewable sources. In this respect, the green certificate system is considered as a cost effective way to meet the renewable energy target.

2.1.2 Green certificate market

Consumers will pay a price for the certificates in order to meet their target. The price will depend on the market, i.e. on demand (that is fixed by the target) and supply. With low supply of green certificates, price will be high, which will be an incentive for new producers to provide renewable electricity. Moreover, in theory renewable energy will be provided in an efficient way because those producers who can provide renewable electricity at the lowest price will be able to sell their labels. Figure 2.1 shows how the market for certificates will work. MC renewables is the marginal production cost curve of electricity from renewable energy sources. The target is set at Q, with corresponding marginal cost mc*. Given a market price (including general taxes) for electricity of PE, the labels will be sold for PC = mc* - PE. Given the market price for electricity as drawn here, PE, part of the renewable energy (up to A) would be produced even without a green certificate system, because it is already profitable. For these producers, the green certificate system will create extra profit (the difference between mc* and PE. Total profit for renewable producers from the sale of electricity and the green certificates is equal to the area between the mc* line and the marginal cost curve, MC renewables.

[3] Here, consumers are those economic agents subject to the green certificate obligations. In section 2.2 will be discussed which economic agents should be subject to the obligation.

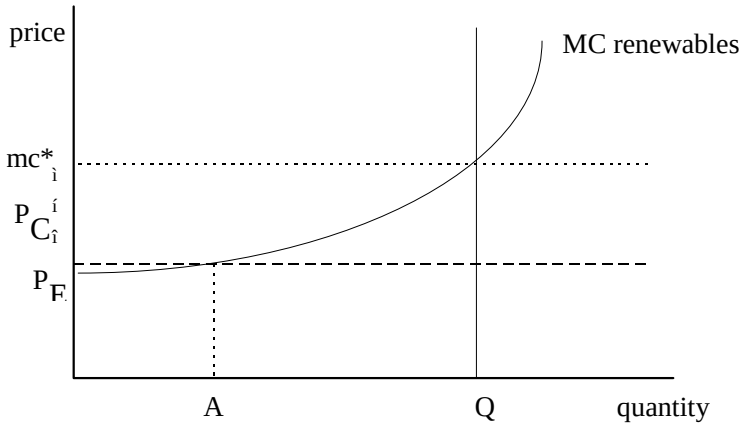

Figure 2.1 *Marginal production cost curve of electricity from renewable energy sources [MC]*

It is expected that both a spot market and a forward market will develop for green certificates. On the spot market, consumers or distribution companies will trade green certificates that have been issued in the past. This market will be used to buy certificates to fulfil their obligation. On the forward market consumers or distribution companies can negotiate about long-term contracts i.e. they trade in green certificates that will be issued in the future. The forward market will be used to hedge for price risks, therefore securing investments into renewable electricity projects.

2.1.3 Functions and issues in implementing green certificates

We can identify six different functions in the institutionalisation of a green certificates system:

1. Issuing certificates
2. Verification of the issuing process
3. Registration of certificates and trade
4. Exchange market
5. Banking of the certificates
6. Withdrawing of certificates from circulation.

Green certificates are issued at the moment that actual green electricity is registered at the kWh-meter. Each certificate should be unique and separately identifiable. It can be represented by a paper certificate. Certificates may get a unique number, representing codes to identify the type of renewable energy source, the date of production, the owner of the green certificate, etc. The certificates are withdrawn from circulation at the moment that a customer accounts for his obligation by presenting the certificates to the registration authority of the government. Certificates are also withdrawn if their period of validity expires. Between issuing and withdrawing green certificates, the certificates are accounted and can be traded. Accounting and trading of green certificates could be done by the owner of the certificates, but also by a 'bank', for example an energy utility or an association of producers. The organisation of the green certificate exchange could be coupled to e.g. the electricity exchange. All these activities require proper registration and verification.

Apart from these institutional functions, there are many other issues that have to be addressed in order to make a system of tradable green certificates work properly. Here we discuss four of them: The definition of renewables used, the time aspects of the obligation, the penalty for not reaching the target and the place of an obligation.

First, there should be an agreement on which energy sources are regarded as renewable, i.e. for which renewables green certificates are valid. For example, in the proposed EU directive it is assumed that electricity generated by large hydro plants is, in general, competitive and is therefore excluded from the scope of the directive[4]. Clearly, the definition in the EU directive is based on cost and not on the principle of hydro being a renewable source. Furthermore, there is large controversy about the renewable value of waste. In this respect, it should also be clear what the renewable value of imported electricity is. Hence, the accreditation, verification and auditing of electricity generated from renewable sources is an important issue.

Second, the targets, the point in time when the obligations will have to be met and the time validity of the certificates should be determined. These two aspects largely influence the stability of the system. In section 3.3 a further discussion on appropriate setting of targets and time validity of certificates is given.

Third, if there is no penalty for failing to meet the target, a green certificate system will not work. The penalty should be higher than the market price of green certificates. There are different possibilities to set up a sanctioning system. For example, the penalties for actors with a deficit could be paid to the fiscal administrator or to a fund that stimulates projects in the field of renewable electricity. In the Netherlands, actors with a deficit will be forced to buy green certificates from actors with a surplus. Van der Tak (1998) describes the problems that may arise in such a system.

Finally, it should be clear for which actors targets are set. The obligations regarding the minimum share of electricity from renewable energy sources could be put either on the distributors or on the consumers of electricity. The next section will deal with this question. In this respect the dimension of a green certificate is also important; if the obligation is put on the household level, the size of a green certificate should be smaller. Besides, consumers might voluntarily buy green certificates to stimulate renewable energy. In that case, the issue remains whether this part of renewable electricity generation should be additional to the obligations or whether it may contribute to reach the obligation.

2.2 Different models of a green certificate system

We may distinguish between different models of a green certificates system, according to the level at which the obligations are put and who pays the higher price for green electricity.

Quota model
In the quota model, the distribution companies or utilities face an obligation for electricity generated from renewable energy sources. Thus at the date of settlement, the utilities have to show the proper amount of green labels. The price of green labels could be passed on to the consumers of electricity in the form of a general price increase.

Green pricing
In the model of green pricing demand from utilities originates either from a voluntary business target, or from an obligation from the government, as is the case in the quota model. However, the price of green labels is only passed on to those consumers who have agreed to support renewable electricity, and therefore to pay a higher price. This system, however, does not seem to be sustainable, once consumers have found out that they are paying for something a utility is obliged to do anyway.

[4] The proposed EU-directive is published at the Internet-site of the German Wind Energy Association: www.wind- energie.de/englisch/eu_directive.html

Renewable electricity obligation
In this model, the obligation for renewable electricity is put on the consumers of electricity. At the date of settlement, consumers have to show the proper amount of labels, which they have to buy from the utilities. Here, the price for electricity and the price of green labels (green electricity) are strictly separated.

In order to structure the analysis of 'who to obligate', four different links in the electricity supply chain are considered: generation, wholesale, retail and consumers (Figure 2.2).

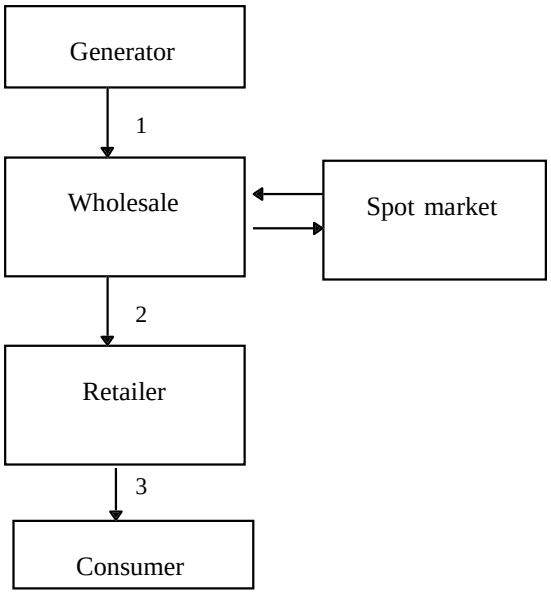

Figure 2.2 *Electricity supply chain (Hunt and Shuttleworth, 1996)*

In the choice of 'who to obligate' in a green certificate system there are some problems to be taken into account. For ease of reference, the level of wholesale and retail will be combined as supply, since there is no distinction in the analysis between the two.

When the obligation is put on the distribution companies (wholesale or retail) or the generators, a green certificate system would lead to unfair competition for these distribution companies vis-a-vis their foreign competitors that do not face a green certificate obligation. Under the current EU legislation, national Governments cannot enforce an obligation with respect to production methods on foreign companies entering the national market.

In a liberalised electricity market, customers are free to choose their supplier. When the obligation is put on distribution companies, their supply cost increase. This will give (large) customers an incentive to by-pass the distribution company and buy their electricity directly from the spot market or from independent generators and thus avoid the green certificate obligation. When a green certificates system is introduced EU-wide, the different stages of market liberalisation in the different EU countries is also of importance. Utilities in a more protected market would have an advantage above utilities in an open market, since they can pass the extra cost to their captive customers.

Generator
If a green certificate system is implemented nationally, the first two problems can be avoided by putting a target on each generator. The threat of unfair international competition does not seem to be relevant if the green certificate system is introduced at the European level, since the European electricity market can be considered as a closed system. At the same time, the problem of consumers by-passing the obligated distribution companies does not seem to be relevant,

since generators are at the top of the supply chain. However, the problem of different protection measures existing within the different countries could create unfair competition among generators.

Supply
Obligating suppliers in a European context seems the least attractive option, since it would create unfair competition and also the problem that consumers can by-pass the suppliers would still prevail.

Consumers
Putting the obligation on consumers dissolves the problems of international disadvantages of the electricity sector and by-passing by consumers. Unfair competition from countries with a high level of protection would still be possible, as in the case of generators. However, since consumers have the obligation for green certificates and supply or generation companies are not obliged directly, the disadvantage of this system seems to be minor in this situation.

From these arguments it can be concluded that the obligation for renewable electricity in a green certificate system should be put at the level of the end-consumers of electricity because it is the least distortive option. Table 2.1 summarises the considerations, where numbers 1, 2 and 3 represent the problems as described above. Of course, consumers may pass on the obligation to the supplier of electricity, who, in turn, transfers the extra cost to the consumer.

Table 2.1 *Market distortion problems per level of obligation*

Level of obligation	Green Certificate-system introduced at national level only	Green Certificate-system introduced Europe-wide with varying degrees of liberalisation
Generator	International competitive disadvantages because other countries not having a target obligation.	International comparative disadvantage because of varying degrees of liberalisation.
Supply	Possibility of consumers by-passing the obligated level. International competitive disadvantages because other countries not having a target obligation.	Possibility of consumers by-passing the obligated level. International comparative disadvantage because of varying degrees of liberalisation.
Consumer		(International comparative disadvantage because of varying degrees of liberalisation).

2.3 Dutch system

2.3.1 Background

In the Third Energy Paper, the Dutch Government has set a target of providing 10% of energy supplies from renewable sources by the year 2020 (in 1997 the share of renewables was only about 1%). It is expected that the biggest contribution in realising this target must come from renewable electricity. However, the cost of generating electricity from renewable sources is expected to be considerably higher than the production cost of power generation from conventional fuels (Third Energy Paper, 1995).

Following the Environmental Action Plan 2000, published in 1997 by the Dutch energy distribution companies, renewable energy sources will be stimulated by a system of tradable green certificates. Thus, the energy distribution companies voluntarily submit themselves to a renewable electricity target and a green certificates system. In the new Dutch Electricity Act of 1998, the possibility for the Government to implement a system of green certificates is also incorporated. The Electricity Act gives the Minister of Economic Affairs the possibility to set a minimum share of the renewable energy for all electricity transmitted through the grids. This mandated share of renewable energy applies to final delivery (the above mentioned RE obligation model). The Minister will announce the minimum share for a five-year period. However, until the year 2000, the voluntary system of the utilities will be applied (Ministry of Economic Affairs, 1997).

For the supply of electricity (both from conventional and renewable sources) in the Netherlands, producers receive feedback payments. The feedback tariff is based on the cost of conventionally produced electricity (currently about 0.036 C/kWh). Production cost of renewable electricity are usually higher. Until the introduction of Green Labels, as the certificates are called in the Netherlands, fiscal rebates and subsidies from the distributors made up the difference. Subsidies were based on the exploitation cost of the project and funded by a small supplement on the electricity price (so called MAP-supplement). The Green Labels system replaced the existing subsidy on feedback tariffs that producers of electricity from renewable sources received from distributors.

Dutch electricity distributors are liable for paying a regulating energy tax (REB) on total electricity consumed to the fiscal administration, but renewable energy is exempted[5]. Note, that the REB is an instrument to encourage energy savings, but not primarily to encourage the use of energy from renewable sources.

[5] The Dutch Ecotax (REB) for electricity was 2.95 cent/kWh (1.34 Cct/kWh) until December 1998 and is 4.95 cent/kWh (2.25 Cct/kWh) for small customers (consumption level up till 10,000 kWh/y) and 3.23 cent/kWh (1.47 Cct/kWh) for customers consuming between 10,000 and 50,000 kWh/y since 1 January 1999. The level of exemption for renewables used to be equal to the REB for small customers, but since 1 Jamuary 1999 it has been set equal to the 10,000-50,000 kWh/y group (3,23 cent/kWh or 1.47 Cct/kWh).

2.3.2 The Dutch Green Certificate System: Green Labels

In January 1998, the Dutch energy distribution companies, united in EnergieNed, have voluntarily introduced the Green Label system which establishes a market for renewable electricity. The certificate system should achieve a target of 1.7 TWh electricity produced by renewable energy sources by the end of the year 2000. The first binding target is set for that year. Until then the distributors have the chance to get acquainted with the Green Label system. It is expected that trading will really develop in the year 2000 when distribution companies have to meet their individual targets.

Each energy distribution company is allotted a minimum target (quota) for electricity from renewable sources to be accomplished by the end of the year 2000. The company-specific targets are based on their sales volumes in 1995. In order to meet its quota, a distributor has to hand over so-called Green Labels at 1 January 2001. These Green Labels are created by producers of renewable electricity and issued by EnergieNed. A producer receives one Green Label for every 10,000 kWh electricity produced from renewable sources and delivered to the grid.

Distributors and customers generating their own electricity from renewable sources can also receive Green Labels. If their renewable autogeneration exceeds their obligatory targets, they can capitalise the difference by selling their Labels. This will encourage further introduction of autogeneration of renewable electricity by private individuals, offices and firms (Ministry of Economic Affairs, 1997).

Renewables in the Dutch system are those renewables that receive a rebate from the regulating energy tax (REB), which are (small) hydro, wind, solar, biomass and gas from landfills. A difficulty here is the identification of renewable-based electricity imported from other countries. Until now, it was agreed that the import of electricity from Norway (produced with large hydro power plants) was not included in the Green Label system. Furthermore, at present, Green Labels are valid only in the year in which they have been created. At the end of 1998 and 1999, Labels are artificially settled between distributors. However, the settlement system does not yet involve monetary payments, emphasising the experimental phase of the system. The limited validity of the Green Labels might hinder the development of the Green Label market; when labels retain their value they can more easily be traded, and investing in renewable energy is less hazardous (Chapter 3).

With the introduction of Green Labels, separation between the physically supplied electricity and the renewable part is established. Green Labels can be traded nation-wide. Energy distribution companies no longer depend on the possibilities of producing renewable electricity in their own region.

Producers of renewable electricity receive Green Labels only when they also receive a rebate of the REB, which is looked after by the Dutch fiscal administration. This will help to assure that a Green Label does indeed represent 10,000 kWh of green electricity. Those distributors who fail to meet their targets are obliged to buy Green Labels from distributors with an excess of Green Labels. The price will be fixed by an independent third party (possibly 50% above the market price). This type of sanction system stimulates strategic behaviour on the side of excess suppliers. For an analysis of the consequences of this system, see Van der Tak (1998).

2.3.3 Green Labels and Green Tariffs

In addition to the Green Label system, Dutch distributors are also selling green electricity to their customers according to the above mentioned green pricing model (distributors use different names for this phenomenon). Consumers voluntarily pay a higher price (0.005 to 0.018 €/kWh more) for green electricity and therefore stimulate the production from renewable sources. The extra revenues are used to invest in renewable energy projects. At the end of 1997, about 35,000 consumers bought green electricity (BTG, 1998 p.29). The World Wildlife Fund audits the production and sale of green electricity in the Netherlands.

There is no specific agreement on whether or not this green electricity can also be counted in the target of 1.7 TWh. In practice, some distributors use the Green Labels acquired in the production of the green electricity they sell, to meet their target, while other distributors do not include these labels (which therefore increases demand for Green Labels). For example, the utility PNEM/Mega uses green electricity to meet its target, whereas NUON/ENW distinguishes between 'free' Green Labels (which they are willing to trade and use to meet their obligation) and 'bound' Green Labels (i.e. green pricing).

2.4 Experiences with the Dutch system so far

The Green Label system was launched in January 1998. The first binding target is set for the year 2000. The first two years are trial years in which the Green Label market can be developed. For these two years it is recorded how many Green Labels are created and how many Labels are owned by distribution companies which, combined with their targets, give an idea about supply and demand. Every month, a nation-wide registration office registers the new producers of renewable electricity that have entered the market, their actual production and production capacity, which Green Labels have been created by whom (including their serial number) and which Green Labels have been bought, including the duration of the contract. This information is partly available at the Green Label website which has been set-up by the association of Dutch utilities EnergieNed (*www.groenlabelned.nl*, in Dutch). Labels can also be bought and sold on this website.

Starting problems

According to the information on this website the utilities are currently not on track to reach the target of 170,000 Green Labels at the end of the year 2000. It is reported that about 44,000 Green Labels have been produced by now, but in August 1998 the production of only about 19,000 Green Labels was reported. The renewable energy production figures of 1997 however show that total renewable energy production from wind, water and solar energy was about 560 GWh in that year (Energie Verslag Nederland 1997, 1998), equalling 56,000 Green Labels. Information from EnergieNed indicates that the shortage of Green Labels is due to starting problems of registration in the first year that the system operates. In 1998 the net growth of wind energy capacity has been about 35 MW. This indicates that production of electricity out of wind, water and solar energy will be a slightly over 600 GWh (60,000 Green Labels).

Local barriers and internationalisation

The difference between current renewable electricity production levels and the target for the end of the year 2000 means that still a substantial amount of over 100,000 Green Labels has to be created in 1999 and 2000. The current growth of renewable electricity production capacity is far too slow to reach this level. The main barriers for investment in renewable electricity in the Netherlands at the moment are due to slow local planning procedures and issuance of permits for construction of wind turbines.

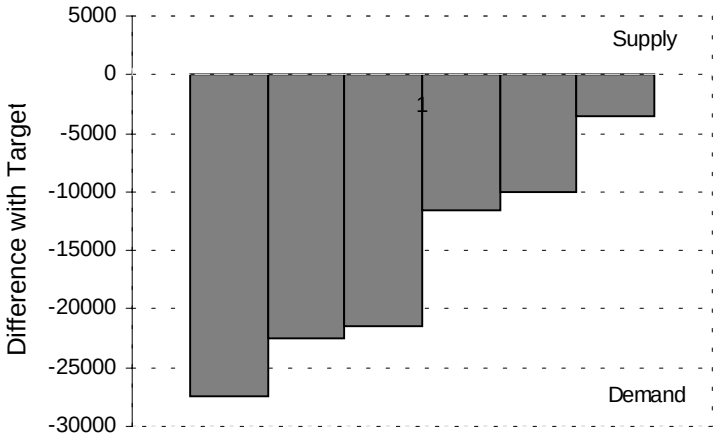

Figure 2.2 *Supply and demand Green Labels per utility (Source: www.groenlabelned.nl)*

Figure 2.2 shows for six of the major utilities the difference between the Green Labels acquired in August 1998 and the amount of Green Labels needed to satisfy the target in the year 2000. As can be seen from this graph the demand for Green Labels is high. The utilities still have to acquire a significant number of Labels in 1999 and 2000. That is the main reason that one of them (ENW) has started to acquire Green Labels in other countries. In early 1999 ENW bought Green Labels from National Wind Power in the UK. Although the question whether these Green Labels can be used for ENW's target for 2000 is still debated, this transaction means the first step to an internationalisation of the Green Label system. Since late 1998 discussions with utilities in the UK, Germany and Denmark have been started to involve them in the Green Label system.

Trade characteristics

Figure 2.3 shows that Green Labels are mainly bought on the basis of long-run contracts. In that case, utilities oblige themselves to buy Green Labels that still have to be created (i.e. renewable electricity produced) in the future. On the spot market, there is not much trade of Green Labels (only a few percent). Distribution companies probably delay trading on the spot market until 2000, when the obligations for renewable electricity become restrictive.

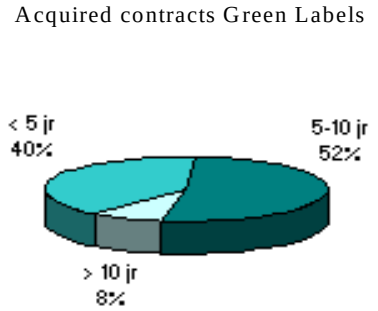

Figure 2.3 *Remaining contract period Green Labels (Source: www.groenlabelned.nl)*

Reactions from private wind turbine owners

In January 1999 the Dutch organisation of private wind turbine owners (PAWEX) stated (Anonymous, 1999): 'The trade in Green Labels has resulted in a better negotiation position for the private operator. This means that the operator gets a better price for his wind electricity. Although not all conditions of PAWEX have yet been met, the intermediate evaluation is positive.' Since the introduction of the Green Label system the private wind turbine owners have seen their prices gone up from an average of 14.3 cents/kWh (6.5 Cct/kWh) to an average of 16 cents/kWh (7.3 Cct/kWh).

The conditions PAWEX refers to include:

- The wish that the price for the non-green part (the electricity) of renewable electricity must be fixed by law. In the new Electricity Law of 1998 this is the case for projects smaller than 8 MW (8.1 cents/kWh = 3.7 Cct/kWh), but for larger projects private owners will have to negotiate.
- The demand that a shortage of Green Labels in 2000 will indeed lead to (very) high prices, according to market principles and not to 'reasonable prices' as the distribution companies indicate.
- The setting of a high penalty on distribution companies for not reaching the target. This target is now described as '1.5 times the market price', but this description is too vague to convince the PAWEX.
- The obligation for system operator utilities to connect everyone who wants to put renewable electricity on the grid. This has been regulated in the new Electricity Law.

3. CONDITIONS FOR A STABLE GREEN CERTIFICATE SYSTEM

As the Dutch example of the green certificate market shows, a number of market imperfections still exist with respect to the implementation of the green certificate system. In this chapter the conditions required for a properly functioning green certificate system are analysed.

The intention of a green certificate system is to meet a renewable energy target in a cost effective way using competitive market forces. The introduction of market forces will stimulate generators to incorporate cost into their decisions and operate in an efficient manner. As is known from general economic literature, for markets to work competitively, a number of conditions have to be fulfilled, such as:

- Sufficient suppliers and demanders to ensure that a single participant cannot influence the price and to ensure market liquidity.
- Market transparency and equal access to relevant information for all participants.
- No entry barriers and negligible transaction cost.

These general requirements will not be further discussed in this chapter. Instead, the focus will be on those conditions unique to a government created market, like the green certificate market. The first focal point of the analysis (in 3.1) is price determination on a green certificate market as described in Chapter 2. The next focal point (3.2) is to see how the specific nature of renewable energy systems will influence the supply of green certificates. The choices for the government in setting up a green certificate system are the subject in section 3.3.

3.1 Price volatility due to inflexible capacity adjustment in the short run

In this section an attempt is made to analyse market behaviour in a green certificate system as described in section 3.1. In such a system the government tries to meet its renewable electricity target by obliging utilities (or consumers for that matter) to purchase a certain amount of green certificates. Figure 4.1 provides the same marginal cost curve for renewables (MC renewables) as in Fig. 3.1, and the demand curve for renewables represented by the aggregate target set for the utilities (Q_T). The x-axis shows the quantity of electricity generated through renewable energy, the y-axis shows the price of the green certificate per kWh.

It is assumed that targets have to be met in a certain period (for instance one year) with green certificates generated in that period. The obligations can not be passed on to the next time period, implying that in case a consumer does not meet its target, a fine (p_f) has to be paid. Green certificates produced beyond the aggregate target amount Q_T cannot be used to meet the target for the next period and their market price will decrease to zero.

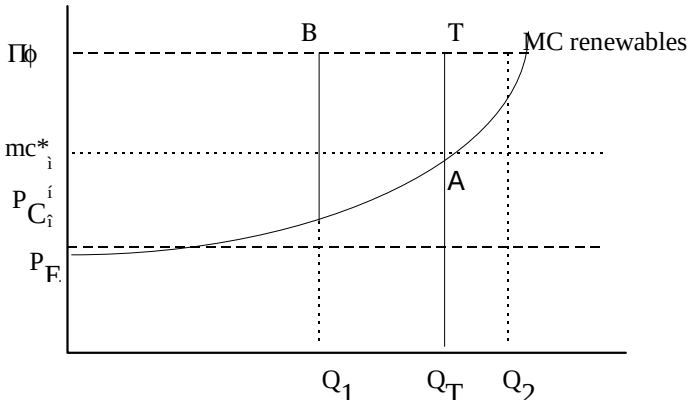

Figure 3.1 *Market Equilibrium in a Green certificate Market*

The supply of green certificates is determined by the installed capacity of renewable energy. The cost structure of renewable energy systems is in general characterised by high fixed cost and low variable cost. Hence, once a renewable energy system is installed, the generator will produce power, unless the price is close to zero. Finally, it is difficult to expand installed capacity on short notice, therefore capacity is fixed for the given period, even though changing market conditions favour additional capacity.

Depending on the capacity installed in this period, three possible equilibrium prices can be found:

1 *Installed capacity equals the target*

When the installed capacity generates the exact amount of the target (QT in Figure 3.1) suppliers will compete on the basis of their marginal cost. The market equilibrium is represented by A in Figure 3.1 and the green certificate price is Pc (mc* minus Pe).

2 *Installed capacity is lower than the target*

In case of under capacity, the amount of green certificates supplied is Q_1 and the supply curve becomes inelastic at Q_1. The new market equilibrium is point B and the green certificate price is Pf minus Pe.

3 *Installed capacity is higher than the target*

In case of over capacity, the supply of green certificates is higher than demand and competition among suppliers will lead to a strong downward pressure on the price of green certificates to almost zero.

The conclusion is that due to the inflexible demand and supply in the short run, the price of green certificates can vary from the level of the penalty in one period (case 2) to zero in another period (case 3). Hence, this green certificate market is characterised by a high price volatility[6].

A number of options is available to prevent this price volatility. They can be divided into two categories:

- Improve the ability of renewable energy generators to keep installed capacity around Q_T. If supply has sufficient flexibility to do so, then even under these strict rules price stability is possible.
- Improve flexibility on the demand side by changing the rules of the game.

These two options will be discussed in sections 3.2 and 3.3.

[6] In this sense the price determination of green certificates (i.e. the high price volatility) resembles those of products which cannot be stored.

3.2 Supply side conditions for stability

In this section, a number of conditions affecting the flexibility of suppliers is analysed. These conditions are relevant to ensure flexible supply in a market as described in 4.1, but will remain relevant even if different rules are applied.

The capability of renewable energy suppliers to reach the target depends on:
1. the transparency of the green certificate market,
2. the stochastic climate patterns which influence renewable energy technologies,
3. external factors such as granting of licenses and access to finance which may hinder the flexibility of suppliers to react on changing market conditions.

3.2.1 Transparency

In a competitive environment, the choice to expand installed capacity will depend on market participants' expectations on the future price of green certificates. The previous analysis showed that a good price can be expected for green certificates until total capacity reaches point the target. If the market is not transparent, it may be difficult for investors to decide whether it is appropriate to increase installed capacity or not.

The spot market price of green certificates may not reflect all relevant information due to the time lag of investing and supplying. The consequence is that in case of a good price for the green certificates, too many investors may be induced to increase renewable energy capacity resulting in an over capacity in the next period, with a subsequent low price.

Measures to improve transparency could include the systematic reporting of total installed renewable energy generation capacity. The creation of a forward market will also contribute to increased transparency on future price expectations of green certificates.

3.2.2 Stochastic climate factors

Another cause for uncertain supply of green certificates is the role of climate factors. Variations in climate[7] can lead to lower or higher quantities of supplied green certificates for a given capacity and result in price volatility, as described above. Three policy options to deal with the stochastic climate factors will be discussed here (Van der Tak, 1998):

- *No climate correction*
  This system has the disadvantages of high price volatility as described above. It is the most likely option in a European context, since not every country has kept a water or wind index, or different definitions have been applied. Note that climate factors play a role in case of limited validity of green certificates. If green certificates are valid over a longer term, the chances are higher that wind supply in that period averages the wind-index. Another solution in this context is therefore to extend the period for which a green certificate is valid (see 3.3.1).
- *Issuance of climate-corrected green certificates*
  In this option the green certificates are corrected according to the relevant index at the moment the renewable electricity is generated. The disadvantage of this system is the time-lag of producing the green certificate and measuring the index. For instance, the wind-index is measured monthly, so only at the end of the month a green certificate will know its value.

[7] Climate factors that can play a role are water, wind, solar irradiation, tidal movements.

- *Adjustment of the target per period*
  The adjustment of the target to the share of climate dependent generating sources decreases the price volatility in the green certificate market caused by climate factors. Climate dependent generators, however, still run the risk of uncertain sales. Also purchasers of wind energy on long term contracts face higher risk because from period to period they may have shortage or abundance in green certificates and are dependent on the spot market to meet their target.

3.2.3 Barriers for Renewable Energy Development

External factors can cause the inability to expand capacity of renewable energy. Such inability could be based on the limitation in potential (biomass, onshore wind), or on financial and institutional barriers. In the Netherlands for instance, the expansion of onshore wind power is barred by the unwillingness of local governments to grant licenses for developing wind energy.

A specific market barrier well known in renewable energy development is the access to finance. The renewables NFFO in the United Kingdom is the first example in Europe to support renewable energy in a competitive environment. With regard to obtaining finance, the NFFO experience has learned that market-based renewable energy development meets some difficulties. These problems are due to the newness but also to specific characteristics of renewable energy technologies, which do not match the requirements of the private sector financial system (Mitchell, 1995).

One of these aspects is the relative high proportion of initial investment required for renewable energy technologies. To reduce risk for investors and facilitate the access to credit, contracts are demanded to ascertain purchase of electricity[8]. See Hunt and Shuttleworth (1996), for further reference on contractual relations to cover producer risk). Thus, the challenge for a renewable energy developer will be to find a market party who is willing to purchase all green certificates produced by the generator. The forward market with long term contracts could play a role in a green certificate system.

Another instrument is the use of financial options. For instance, through the issuance of put options with a guaranteed price for which generators may, but do not have to, sell their electricity (Van der Tak, 1998). Crucial for these instruments is that counterparts can be found who are willing to take up the risk of a long term green certificate obligation. Future expectations of the green certificate price are crucial in this regard.

3.3 Demand-side flexibility: the rules of the game

Most of the demand for green certificates will be enforced through the obligation of the government. The rules of the green certificate system include various aspects such as setting the fine, the validity period of the green certificates and the level of the target. In the case the target is described as a percentage of total electricity consumption, the absolute level of obligation is also uncertain. Apart from making up the rules, the government can affect the outcomes of the system by directly intervening in the green certificate market through trading or changing the target, etc.

In this section, especially the validity of certificates will be discussed as an option to enhance the stability of the green certificate system. As a final point, the desirability of government intervention is discussed.

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[8] Commercial banks have a general requirement for renewable energy projects of 10 years (Van der Tak, 1998).

3.3.1 Validity of certificates

The validity of green certificates is an important factor to increase the demand flexibility of green certificates and decrease the price volatility. This aspect has been touched upon in section 3.1. In the case described in that section the inflexibility of demand is caused by the absolute date of settlement of the green certificate obligation. A green certificate produced in certain period is therefore worthless after settlement of obligations has taken place. A number of alternatives can be thought of to address this inflexibility (Van der Tak, 1998).

Alternative 1: Validity is limited until x year after issuance (x > 1)

Through this system the owner of the green certificate can use the green certificate to meet a target for more than one year. If x equals 2, overproduction in year 1 will not result in a price that goes down to zero, but the green certificate will receive the price which is expected for the next year, which is determined on the forward market. (Van der Tak, 1998).

Extending the validity to more than one year will stimulate the stability, because short term price determination will follow the long term green certificate market expectations, and hence is based on real (long term marginal) cost. The disadvantage is that the green certificate becomes more heterogeneous. In every year old and new green certificates exist, which might lead to price differentiation and thus to a lower liquidity of the markets (Van der Tak, 1998).

Alternative 2: Validity is limited until x year after issuance and FIFO (first in first out) is used on date of settlement

In order to reduce the problem of heterogeneous green certificates on the market, an option is to apply a first-in-first-out (FIFO) rule at every date of obligation settlement.

Alternative 3: Eternal validity - The golden-crested green certificate

The above mentioned alternatives point into one direction: Make the green certificate eternally valid. The owner can choose the appropriate moment to use the green certificate for settlement of his agreement. Thus the problems indicated in alternatives 1 to 4 are eliminated and administrative procedures are minimised. An eternal valid green certificate resembles the precious metals and the subsequent future markets, since precious metals are not subject to decay either. That is the reason why it can be called ‘the golden-crested green certificate’.

Alternative 4: Using future green certificates to meet current obligation

Another option besides extending the validity of certificates to subsequent years, is to extent the validity of green certificates to meet targets before actual production of the green certificate has taken place. This means that the expected green certificates to be generated in the next period (which can be purchased through forward contracts) can be used to meet today’s obligations. This can be referred to as ‘borrowing’ of green certificates.

This measure would also enhance supply side flexibility on the green certificate market in a number of ways. First, in case of shortage, the price will not reach the fine rate, but instead market participants will purchase forward contracts to meet their obligations. Second, correction for stochastic climate factors will automatically take place. In case of a year with little wind, future green certificates can be used. Over the time span of the wind turbine, the produced green certificates will match with the targets for which its electricity was sold. Third, the extra demand for forward contracts results from this set-up, will help renewable energy developers to secure finance from finance institutes (see 4.2.3).

Following the analysis above, it can be concluded that the last two alternatives are better than the first two.

3.3.2 Target Setting

Implementing a green certificate system will help the government to meet its long term renewable energy objectives. These long term renewable energy objectives have to be translated into clear long term green certificate targets which will not change during the course of the years (due to the election of a different government, new priorities, etc.). This is an important condition to convince market participants that they will be able to earn back their investments through the green certificate market. If market participants have the perception that the government might change the rules, they will try to anticipate such changes in their decisions (Van der Tak, 1998), leading to market distortions.

Clear consistent government policy is therefore an important condition for a stable green certificate system. One way to achieve this is to agree on a time frame in which the government stipulates the rules and required targets and will not further intervene in the green certificate system. The Government of the Netherlands has acknowledged this principal and has announced that in case a green certificate system will be implemented the green certificate target will be announced for five succeeding years (Tweede Kamer, 1998).

Having a long term time frame would in principle make a green certificate market work. Consumers can bank their purchased certificates until the withdrawing of certificates at the time of the obligation settlement. However, to keep markets liquid, it seems appropriate to bridge the time from the long term targets, by translating them into intermediate targets set every year, or even every half year.

4. GREEN CERTIFICATES AND NATIONAL TARGETS IN A EUROPEAN CONTEXT

4.1 Introduction

The European renewable energy target of 12% in 2010 translates to a renewable electricity target of 20% in that same year. This ambitious target asks for cost effective solutions. When technology is involved with an expected cost decrease through technological development, especially ecotax and tradable permits (or certificates for this matter) are the most cost-effective national policy measures to stimulate clean technologies as opposed to regulatory measures (Wiersma, 1989). One of the things that will be done in this chapter is to explore qualitatively the cost effectiveness of tradable green certificates introduced on a European scale compared to a system of stimulating green electricity on a European scale with no possibility of trade to meet the national targets.

The potential of achieving cost effectiveness on a European scale is introduced through the possibility of trading. The advantage of trading green certificates instead of green electricity is that no physical barriers exist to this trading. Trading opportunities exist because of different values of green certificates in each country. In each country this value depends on the possibilities within a country to produce green electricity (the supply curve) and its target (the demand curve). This means that national target setting is a crucial aspect for international trading of green certificates. The combination of national targets and the respective supply curves also determines the total cost burden in each country. This raises the question how cost can be equally shared among the Member States of the European Union and what an approach of equal burden sharing would mean for national target setting.

In this chapter a conceptual approach will be put forward that deals with the question of equal burden sharing and the consequences of such an approach for national target setting[9]. The approach assumes that cost is the main consideration for decisions with regard to the deployment of renewable electricity in each country. Another assumption is that renewable electricity potentials and their cost can be known in a comparable way per country. The approach only takes direct cost into account. It will be illustrated by assuming an *imaginary community of three nations*, each with their own characteristics in terms of population, Gross Domestic Product, total electricity demand and renewable electricity supply curves. The consequences on burden sharing and target setting of four different burden sharing rules will be shown. These burden sharing rules are:

1. equal relative targets (in % of total electricity consumption),
2. equal marginal cost,
3. equal cost per capita,
4. equal cost per unit GDP.

The consequences of these four burden sharing rules will first be elaborated for a situation without trade between the countries. Next the effects of free trade will be discussed. Finally for the last two burden sharing rules, ‘equal’ national targets will be determined by taking into account the effects of trade.

[9] The approach that will be described in the remainder of this chapter has recently been implemented in an ECN-spreadsheet model called REBUS (REnewable BUrden Sharing).

In Section 4.2 the characteristics of the imaginary community of three countries will be explained. In Section 4.3 the difference of taking minimal total cost for the consumer or minimal total production cost as a starting point for a burden sharing analysis will be discussed. In the Sections 4.4 and 4.5 burden sharing with and without the possibility of trade will be treated. Section 4.6 will give the conclusions of this chapter.

4.2 Characteristics of the countries

The imaginary community consists of three countries. They can be characterised as follows (see Table 4.1). Country A is a rich country with a relatively small population that consumes 100 TWh electricity per year. Its renewable potential is low, and its renewable electricity production possibilities are relatively expensive (Figure 4.1). Country B is an average country with respect to size of population and GDP. Its renewable potential is large and the possibilities it has are relatively inexpensive (Figure 4.2). Country C can be characterised as relatively large and poor, whereas its renewable energy potential is medium (Figure 4.3).

Table 4.1 *Characteristics of the countries*

Country	Size of population	Gross Domestic Product		Total
		total	per cap.	
	[million]	[bC]	[kC]	[TWh/year]
A	10	200	20	100
B	20	150	7.5	180
C	30	100	3.33	120
Total	60	450	7.5	400

Figures 4.1 to 4.4 show the supply curves of renewable electricity of each for the three countries and for the community as a whole. Each curve only covers 25% of the total electricity consumption and the vertical axes are assumed to be the same scale. The vertical axis represents the reference price for electricity. In this case it is assumed that even the cheapest options are more expensive than this reference price.

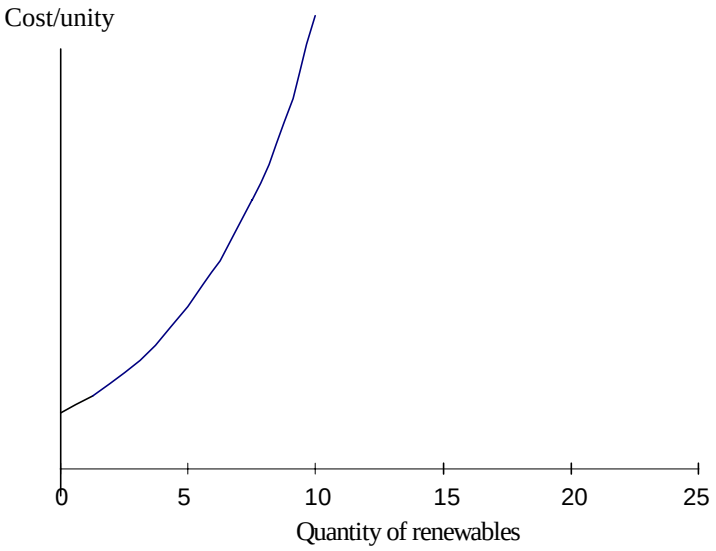

Figure 4.1 *The renewable electricity supply curve of Country A*

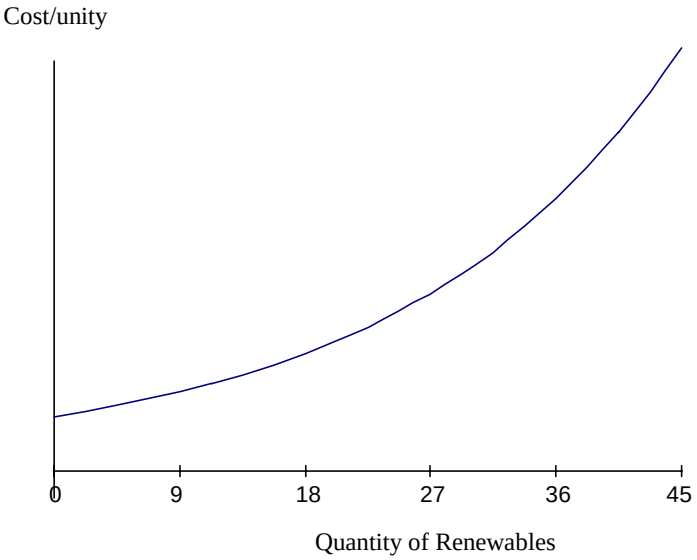

Figure 4.2 *The renewable electricity supply curve of Country B*

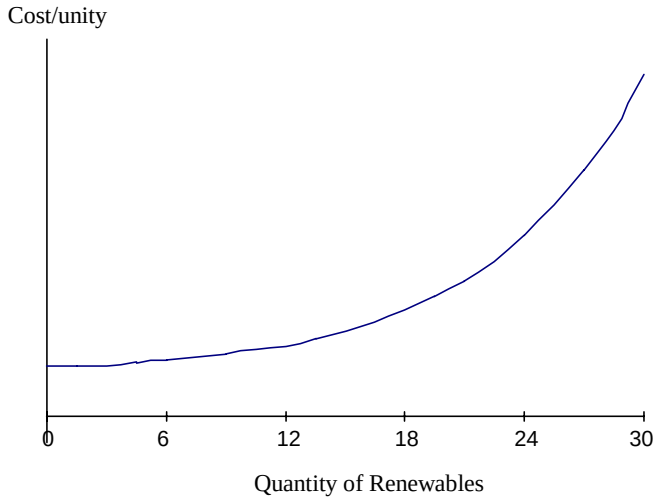

Figure 4.3 *The renewable electricity supply curve of Country C*

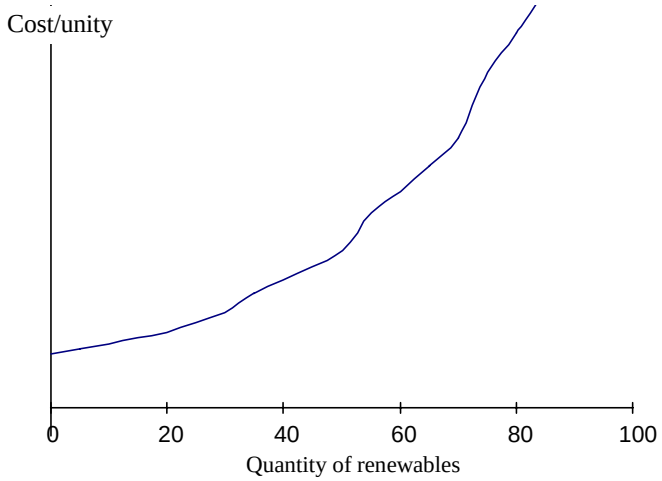

Figure 4.4 *The renewable electricity supply curve of the whole Community*

4.3 Minimal Total Cost

The community as a whole consumes 400 TWh of electricity per year. Suppose a target is set to produce 50 TWh (=12.5% of total electricity consumption) by renewable sources in a certain year in the future. If the countries collaborate well (e.g. by introducing a system of tradable certificates), they will develop the most inexpensive options in the community which will result in minimal total cost as indicated in Figure 4.5.

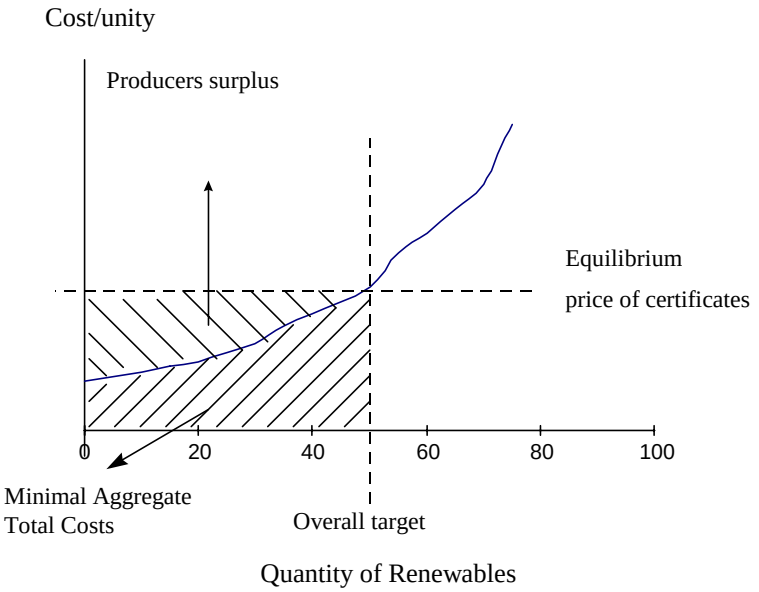

Figure 4.5 *Minimal total cost and size of the green electricity market in the whole community*

The equilibrium price for trade of certificates will be determined by the point at which the target and the supply curve cross. The shaded area under the supply curve until the target value represents the *minimal total production cost* of reaching the target. If in all countries the market of certificates is created by an obligation on the part of the consumers, and the consumers have no possibility of producing the certificates themselves, then the potential profit on the certificate market for producers of green certificates can be indicated by the area above the supply curve and below the equilibrium price line (*the producers surplus*). Both areas together, equalling the target amount times the equilibrium price, then represents *the minimal total cost for the consumer* of reaching the target.

4.3.1 Burden sharing: total cost for the consumer

If in each country the obligation will be put on the consumers, and the countries want to distribute the burden equally among their inhabitants, then an equal relative target of 12.5% of the consumers' electricity consumption seems fair, at least at first sight. Those who consume more electricity will pay more and those who consume less, will pay less. However, Countries B and C will probably not agree, because of the large income differences with Country A. Persons in Country A are, on the average, 6 times as rich as persons in Country C and 2.7 times as rich as people in Country B. One could argue that this would mean that the target for people in Country A should be 6 times as high as the target for people in Country C and 2.7 times as high as for people in Country B.

This assumption results in the following set of equations:

$$TREC_A/TEC_A = (GDPcap_A/GDPcap_C)*TREC_C/TEC_C$$
$$TREC_A/TEC_A = (GDPcap_A/GDPcap_B)*TREC_B/TEC_B$$
$$TREC_A + TREC_B + TREC_C = TREC_{TOTAL}$$

where

$TREC_X$ = Targeted Renewable Electricity Consumption of Country X
TEC_X = Total Electricity Consumption of Country X
$GDPcap_X$ = Gross Domestic Product per capita of Country X
$TREC_{TOTAL}$ = Targeted Renewable Electricity Consumption of the Community

Solving this set of equations for the three countries, using the figures of Table 4.1, results in a renewable electricity target for Country A of 26,7 GWh (26,7%), a target for Country B of 18 GWh (10%) and for Country C of 5,3 GWh (4.3%).

4.3.2 Burden sharing: Total cost of production

The assumption that in every country the obligation will be put on the consumer might not hold. In our imaginary Community we assume the principle of subsidiarity applies. This principle implies that the Community only provides general policy frameworks, whereas within this general framework the individual countries keep their freedom to make their own choices. Some of the countries for instance might not want to put the obligation on the consumers, but rather on the producers or suppliers of electricity. Such a choice would have the disadvantages mentioned in Chapter 2, but it has some advantages as well. Since producers and suppliers are able to make 'make-or-buy-decisions', they will choose to produce their own renewable electricity as long as the cost of doing this will be lower than the cost of buying green certificates on the international green certificate market, i.e. as long as their own marginal cost will remain below the equilibrium price. In that case total cost in a country will be limited to the total production cost (see Figure 4.5) plus possibly an amount that is imported from other countries (if trade is allowed). Another consequence of this subsidiarity principle is that countries might decide not to reach their target by a direct obligation but by other policy measures, such as premium feed-in tariffs, bidding systems, or capital subsidies. In such a case it will be difficult to assess what the burden per country will be, and how it will be distributed. What remains is the knowledge about the minimal production cost that could be achieved. In the third place, even if the obligation is on the consumers in all three countries, the possibility exists that a substantial part of the consumers will be able to make 'make-or-buy'-decisions, e.g. by participating in wind power corporations, by exploiting small-scale hydropower plants, or by putting solar panels on their roofs. In such a case much of the consumers will provide, as self-producers, in their own certificates, and the total cost for consumers will get close to the total production cost. Also it can be imagined that one of the countries decides not to implement an obligation, but to leave reaching the target to the market in the belief that there will be enough customers, be it individual consumers or enterprises, that will be willing to buy 'green electricity'. In such a case suppliers might want to maximise their sales by a product differentiation strategy. Low-cost green electricity, e.g. hydropower or (organic) waste incineration, might be offered against lower prices to specific customers than higher-cost green electricity, e.g. offshore wind to other customers. This means again that the cost for the consumer will get closer to the total production cost.

For all these reasons it is not evident that the 'total minimal burden' to be distributed will either be given by the sum of the shaded areas of Figure 4.5 (total cost for the consumer) or by the shaded area below the supply curve (total production cost). The consequences of taking the former as a starting point have been elaborated in the foregoing section. In the remainder of this chapter the latter will be taken as a starting point.

4.4 Burden Sharing Without Trade

In this section we will start with a situation without any trade of green electricity or green certificates. This will serve as a point of reference and comparison for the analyses in later sections that take the possibility of trade into account.

4.4.1 Equal target rates

Suppose it is decided that each of the three countries will have to produce an equal percentage of their electricity consumption by renewable energy sources. Figure 4.6 shows the consequences for each country. The intersection of the supply curves with the target is the point that represents the marginal cost for each country, which differ substantially from each other. For Country A it is even not possible to reach the target. Moreover the shaded areas, which represent the total cost per country, differ substantially as well. Since there is no trade, options will be developed that would not have been developed if the Community had been regarded as one country. This means that the total cost for the Community as a whole are not minimised.

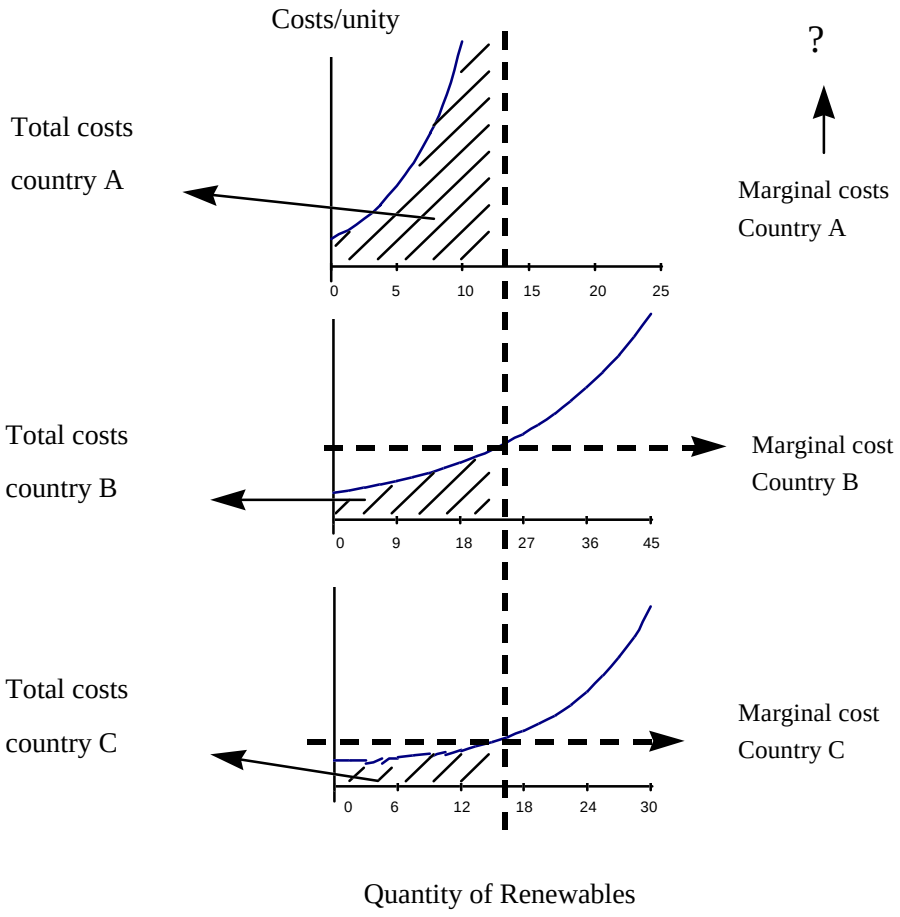

Figure 4.6 *Equal targets per country*

4.4.2 Equal marginal cost

The only way in a situation without trade to get rid of the disadvantage of not having minimal total cost for the Community as a whole is to divide the targets in such a way that marginal cost are equal (Figure 4.7). The marginal cost for each country will then equal the equilibrium price level as given in Figure 4.5. As Figure 4.7 shows the cost for each country will be distributed very unequally.

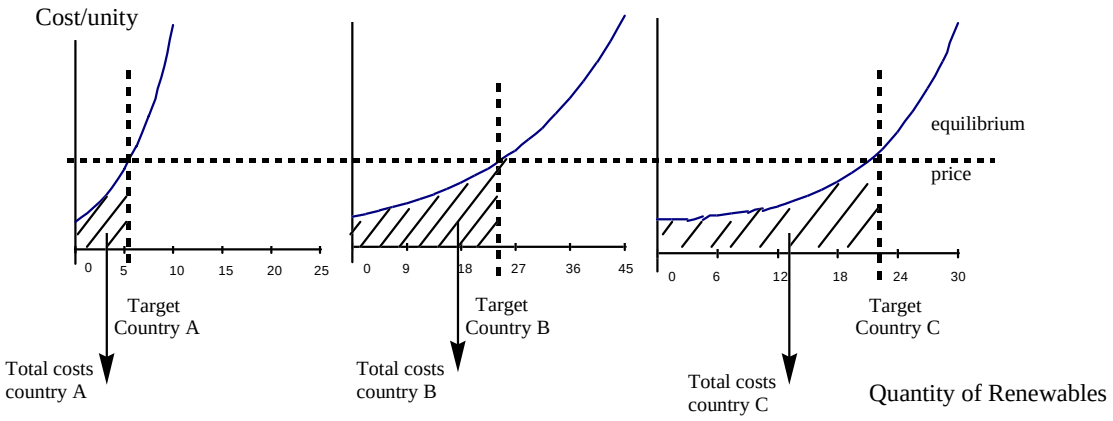

Figure 4.7 *Equal marginal cost*

4.4.3 Equal total cost

One way to remove an unequal distribution of cost over the three countries is to take equal burden sharing as a starting point and subsequently calculate the resulting targets and marginal cost in each country. As we have seen in 4.2.1 different equity criteria exist. This implies that a 'fair' distribution of the burden can be made in different ways (i.e. the decision on which equity criterion to apply will be a political one). In Figures 4.8 and 4.9 two examples are given. In Figure 4.8 the size of population of the different countries is taken as a base for burden sharing. In Figure 4.9 the Gross Domestic Product is taken as a base for burden sharing. Comparing the area for the two cases makes clear that different concepts of 'equity' can make a very substantial difference.

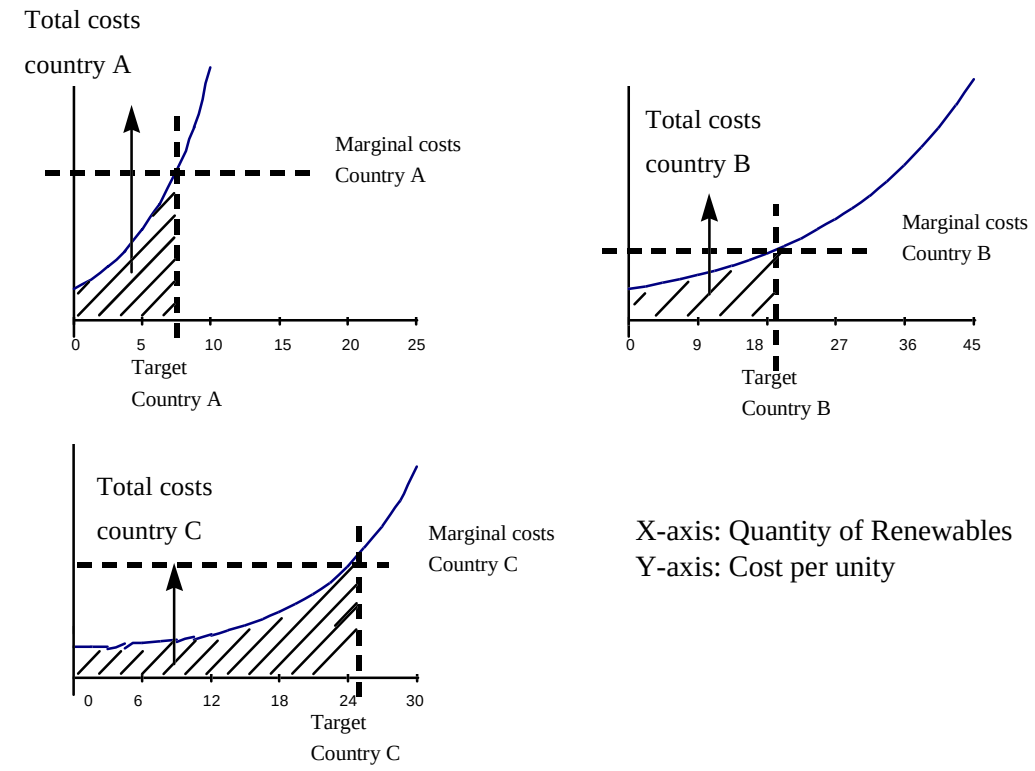

Figure 4.8 *Equal cost per capita*

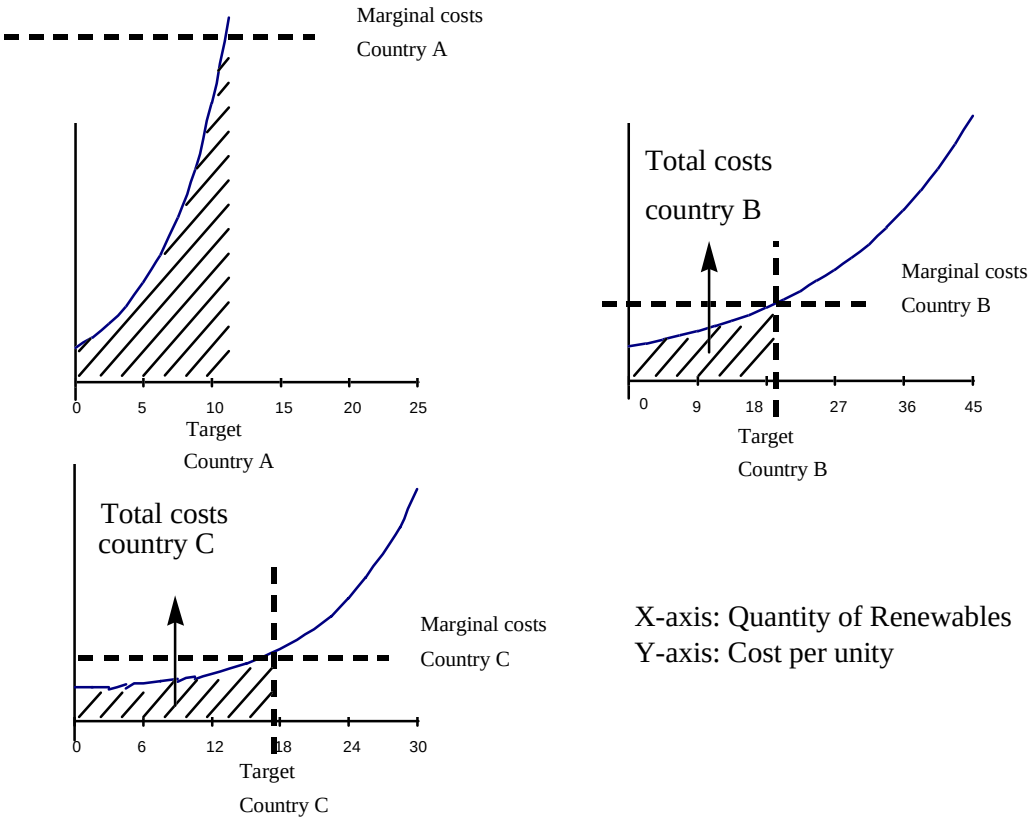

Figure 4.9 *Equal cost per unit GDP*

4.5 Burden sharing with trade

In both cases of the foregoing section equal burden sharing is ensured since it is taken as the starting point (of course depending how one sees ‘equity’). In neither of the cases, however, minimal cost for the community are attained because options will be developed that would not have been developed if the Community had been regarded as one country. This disadvantage can be dealt with by allowing trade. Trade will have beneficial consequences for all three participating countries, as can be seen in Figure 4.10.

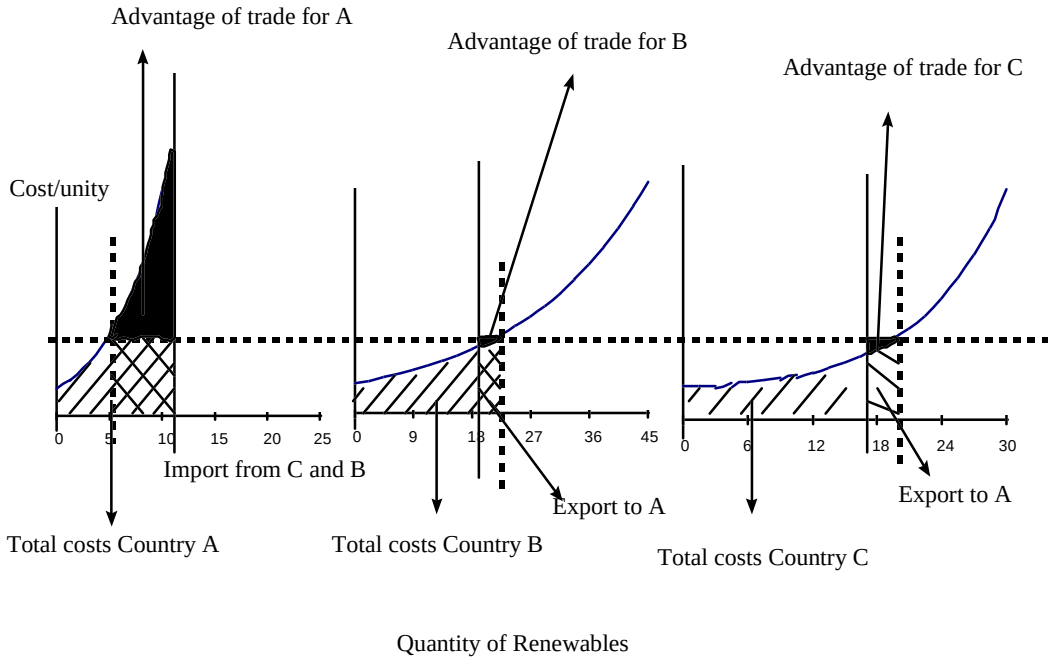

Figure 4.10 *The effects of trade in the case of ‘equal cost per unit GDP’*

In Figure 4.10 the targets are equal to those resulting from an ‘equal cost per unit GDP’-approach without trade (see Figure 4.9). The black shaded areas in Figure 4.10 represent the advantages of trade for each country. In the case of Country A this represents cost savings. The options within country A that are below the equilibrium price have been developed, but for the remainder of its target Country A is importing certificates from Country B and C. These two countries develop more options than required for reaching their target, but they are able to sell the extra certificates to Country A against the equilibrium price. Since their production cost are lower then the equilibrium price, they make a (small) profit on these sales (represented by the black shaded areas).

Figure 4.10 shows that the effects of trade might be more beneficial for one country than for the other. Country A is profiting more from the possibility of trade than the other two countries. The result is that in Figure 4.10 the total cost per unit GDP in each country is not equal anymore. To get an equal burden sharing the targets of each country could be readapted in such a way that the total cost for each country, per unit GDP (or per capita, depending on the equity criterion chosen), is equal. This is illustrated in Figure 4.11.

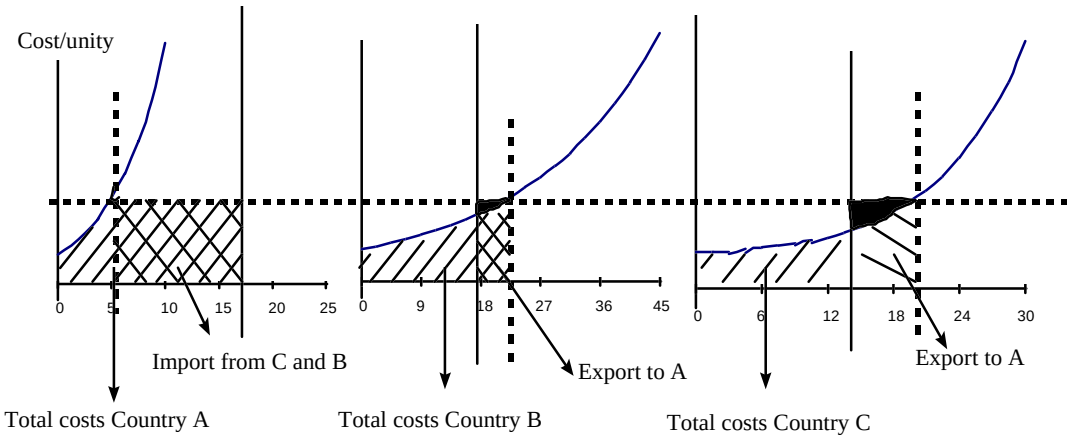

Figure 4.11 *Distribution of targets after having taken the effects of trade into account ('equal cost per unit GDP')*

The net total cost of each country are equal to the production cost of the options developed in each country plus cost from import minus the revenue from exports. In Figure 4.11 these cost are supposed to be equal on a per capita basis for each country. With regard to Figure 4.10 the target of Country A has been enlarged, whereas the target of Country B remains the same and the target of Country C has been reduced.

4.6 Conclusion

Different ways exist to derive national targets from an overall target. Depending on the equity criterion applied, the effects of trade taken into account and if total cost of consumption or production are to be considered, results in different reduction targets per country. Table 4.2 summarises the characteristics of the burden sharing rules that have been discussed in this chapter.

Table 4.2 *Characteristics of different burden sharing rules*

Burden definition and possibility of trade	Burden sharing rule	Equal burden sharing	Equity base	Minimal cost
	equal relative targets	yes	kWh consumed	yes
Consumption cost/trade	equal cost per GDPcap	yes	GDP/cap	yes
	equal relative targets	no		no
	equal marginal cost	no		yes
Production cost/no trade	Equal cost per capita	yes	size of population	no
	equal cost per unit GDP		GDP	no
	equal relative targets	no		yes
Production cost/effects of trade	equal marginal cost	no		yes
	Equal cost per capita	no		yes
	equal cost per unit GDP	no		yes
Production cost/trade into account	equal cost per capita	yes	size of population	yes
	equal cost per unit GDP	yes	GDP	yes

The combination of equal burden sharing and minimal total cost is reached only in the first two and in the last two cases. Whether these cases are perceived as equal, depends on the equity criterion one prefers, and as such will remain a political decision. Another issue to be decided on is whether total cost for the consumer or total cost of production should be taken as a basis for burden sharing. Although the former seems more simple and straightforward, the latter might be preferred in situations in which Member States adhere to the subsidiarity principle and prefer to reach their target in their own way. For both approaches the consequences for each country in the European Union can be calculated for different burden sharing rules, given that appropriate renewable electricity supply curves for each country are available.

5. SUMMARY AND CONCLUSIONS

5.1 Summary

Support of renewable energy in a liberalised energy market requires policy incentive schemes that are conform market principles. One of the possible market-conform schemes that could be implemented is the green certificate system. In such a system, energy production from renewable sources is certified. The certificates can be used for accounting (to proof that certain targets or agreements are met) and could be traded among customers or utilities.

Several models of green certificate systems could be defined, depending on the level at which the obligations to buy green certificates are put and who should pay the price for these certificates. Analysis shows that putting the obligation for renewable electricity on the level of the end-consumers distorts the market to the least extent. In addition to an obligatory green certificate system, distribution companies could opt for a green tariff system in which customers voluntarily pay a higher price for green electricity. Experiences in the Netherlands and other Western European countries show that there is a (small) market for this additional system, despite the fact some people rightfully consider this as unfair with regard to the polluter-pays principle.

In the Netherlands, a green certificate system was introduced in January 1998. In this so-called Green Label system the Dutch distribution companies have voluntarily made a commitment to a renewable electricity target and a green certificates system. A target is set for the end of the year 2000, but no restrictive intermediate targets are set. Since the validity of the Green Labels is limited to one year, the distribution companies have not been very active yet in trading their labels. Probably the market will be more active when the obligations become restrictive, i.e. in the year 2000. First experiences with the system are positive. The shortage for domestic production due to problems in local planning and permitting procedures has led to a drive to internationalise the system. The first international transaction of Green Labels has been made.

The price and price volatility of green certificates will depend on a number of aspects:

- Demand and supply of green certificates.
- The stringency of targets: more stringent targets induce higher prices for green certificates.
- The frequency of targets: intermediate targets decrease the price volatility.
- The time-frame of targets: clear long-term targets reduce uncertainty for potential investors, leading to lower prices and less price volatility.
- Market price for electricity, including (environmental) taxes and subsidies: the market equilibrium price of green certificates is equal to the difference between the marginal cost of the most expensive renewable electricity option required to meet the target and the reference price, minus tax exemptions and/or subsidies.
- The price-effects of other incentive schemes influencing the green certificates market.
- The validity of certificates: extending the validity and using future green certificates to meet current obligations could significantly decrease the price volatility.
- Which actors are obliged to buy green certificates: when the obligation is not put on end-consumers, but for instance on distribution companies, some consumers could buy their electricity elsewhere and thus avoid their obligation.
- The scope of the system: internationalisation of the system would reduce the number of opportunities to by-pass obligations, but attention should be paid to different stages of market liberalisation in different Member States as distribution companies in more protected markets could surpass their additional cost to captive customers, whereas their competitors in open markets could not.

In order to make a tradable green certificate system work properly, a number of additional requirements should be fulfilled, such as a clear and consistent government policy that induces a stable investment climate. Furthermore, accreditation, verification and auditing of renewable electricity generation should be organised properly. This is also the case for registration of issuance, trade and redemption of the certificates.

In reference to the EU renewable energy target formulated for the year 2010, an important political issue is the division of cost among Member States. When the European renewable energy market would be regarded as completely open and transparent, the introduction of a tradable certificates system would result in minimal total cost for the EU as a whole. However, translation of the overall EU targets into equal targets for all EU countries would result in an unequal distribution of cost, resulting from, amongst others, differences in geographical advantages, population and national welfare. For an equal burden sharing among the Member States, an equity criterion could be determined, such as equal cost per GDP or per capita. A political discussion will arise on what would be considered a 'fair' criterion. The resulting cost for individual Member States could differ largely between different equity criteria. Again it should be realised that also in case of burden sharing, minimal total cost for the EU as a whole would only be reached when trade is allowed.

5.2 Conclusions and recommendations

Based on the summary the following conclusions and recommendations can be made:

1. First experiences with a green certificate system in the Netherlands are evaluated as positive.
2. To reduce uncertainty of the potential investors, minimise cost and volatility of prices *clear long-term renewable electricity targets* should be set by the government.
3. To reduce price-volatility *appropriate intermediate targets* (e.g. in each year) should be set by the government.
4. The *validity of green certificates should be unlimited* and the possibility of using future certificates to account for targets should be considered.
5. The *most appropriate level* for an obligation in a *fully liberalised market* are the *final consumers*.
6. *Internationalisation* of the system should be pursued to enhance the stability of the system.
7. It is possible to determine 'fair' targets for each participating country given an overall target, the supply curves for each country of renewable electricity in the target year and an equity criterion.

5.3 Remaining issues

The issue of green certificates is as interesting as complicated. This report forms just an introduction and a first analysis. Several issues remain to be studied[10], some of which are listed below.

Definition of renewables

Member States of the European Union as well as State governments in the USA use very different definitions of what counts as renewable under a green certificate system. The green certificate system in the State of Arizona only includes solar energy, whereas in the State of Connecticut also natural-gas fuel cells are counted as renewable energy sources. In Europe as well as in the United States the two technologies most debated are large hydro-power and waste incineration.

[10] The study of these issues is part of the two EU-projects mentioned in the Preface.

Main arguments against including large hydro-power are that

- it does not need support since it is already deployed and competitive,
- it is a technology with a limited potential of further improvement and,
- it is a technology of which most of the potential has already been used,
- it would dominate the green certificate market so much that alternatives ('new renewables') would not get a chance,
- cheap large hydro-power would get enormous wind-fall profits.

The first argument is not always true. Existing large hydro-power in Austria for instance is substantially more expensive than gas-fired combined cycles (REALM Research Group, 1999). The second argument might be true, although on the level of environmental compatibility there is still much to be learned, Furthermore it is the question whether the green certificate system is meant to be an incentive scheme to stimulate renewable technology development or renewable technology deployment. The third argument is true in relative terms. But because of the size of large hydro potential, even a small increase of the theoretical potential used will contribute substantially to the total production of renewable electricity. The fourth argument is true if targets are set too low. If targets are set higher, there will be possibilities for new renewables to be deployed and developed. The last argument is true for any low-cost renewable option.

Arguments against inclusion of waste incineration are similar to those of large hydro, including the argument that part of the waste is not of organic nature, so it is difficult to see this fraction as renewable. This argument gets to the point of renewable accreditation, i.e. what conditions should be fulfilled to count something as renewable (or sustainable). If there are objections against the renewable character of a source (including environmentally hazardous consequences) the question arises whether such a source should be seen as renewable/sustainable or not. This is an important issue and it regards most of the renewable technologies.

Stringency of the targets

The stringency of the targets influences what technologies will profit from the incentive scheme. A combination of low targets and a less restricted definition of renewables (including waste incineration and large hydro-power for instance) will not give a chance to new renewables. Targets that are too high will result in high certificate prices and a large cost burden for the actors with an obligation. Studying the effects of given targets is an important issue.

Transition phase

If the EU-Member States decide to implement a green certificate system, transition regulations are necessary for those renewable plants that have benefited from other incentive schemes. The complexity of this is illustrated in Denmark. This country is the first country were a green certificate system will be implemented by the government. Most of the debate and the largest part of the text of agreement between the political parties are about transition regulations. The same issue will play for other countries if they decide to implement a green certificate system.

Accession countries

The 12% renewable target for 2010 has been set for the current 15 countries of the EU. Based on this overall target, 'fair' targets can be determined for each of the countries, according to their geographical possibilities, and their population size or level of welfare. If a green certificate system is implemented at an EU-level the question is what target the accession countries should have and how such a target relates to the overall EU-target.

International extension

Suppose a green certificate system is implemented in a few countries. How can such a system be expanded gradually to other EU-countries. And what if countries outside the EU (e.g. the US, China) want to participate?

Interaction with other incentive schemes
The interaction with an environmental tax exemption regulation has shortly been discussed in this report. How does a green certificate system interact with other incentive schemes, such as feed-in systems of tendering systems (see Chapter 2)? What are the consequences in an international system. Will these extra incentive schemes function as a kind of export subsidy or will they finance other countries targets?

Extension to other energy carriers
Apart from green electricity a certificate system could also be implemented to stimulate 'green gas' (e.g. gas from biomass or from natural gas in combination with the storage of CO_2) or 'green heat' (e.g. solar boilers or heat from biomass plants). In fact, such an extension will be necessary if we want to treat all green energy forms equally. If only a green electricity certificate system is applied, heat from biomass CHP-plants will not be given an equal credit as the electricity produced by this plant.

Link with CO_2 policy
The deployment of renewable energy sources reduces CO_2 emissions, but there are many other measures, often less expensive than renewables, that do the same. If a CO_2 reduction certificate system comes into existence, will renewable energy producers get both a green certificate and CO_2 reduction certificate? Should the producers make a choice for one of these certificates. Will they be allowed to transform the one into the another? How will the CO_2 certificate market influence the green electricity market, or the other way around?

Implications for technology development
Another major issue is the effect of a Green Certificate System on technology development. With regard to almost competitive options (wind energy, landfill gas, hydropower) a large market for renewables will be realised. This means a large stimulation of technological development for these options by mechanisms of learning-by-doing and learning-by-interaction. Other options however (such as photovoltaics), which are still far from market competitiveness, might become victim of such a system. How should a green certificate be designed to stimulate the development of currently expensive options? Should these options be supported by other policy measures and be left out of the green certificate system?

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