

THE INTERACTION BETWEEN ELECTRICITY, HEAT AND GAS IN A TRADABLE GREEN CERTIFICATE SYSTEM

Paper for the analysis phase of InTraCert

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Preface

This report presents the results of work carried out by ECN Policy Studies within the InTraCert project: 'The Role of an Integrated Tradable Green Certificate System in a Liberalising Market', funded by the European Commission in the Fifth Framework Programme (contract no. NNE5/1999/428). The overall project is co-ordinated by the Netherlands Energy Research Foundation (ECN). Other contractors are Zentrum für Europäische Wirtschaftsforschung (ZEW) in Germany, RISØ National Laboratory in Denmark, Universidad Autonoma de Madrid (UAM) in Spain and the Centre for Management under Regulation at the University of Warwick (CMUR) in the UK. A full overview of the project's analyses, results and conclusions, i.e. including the contributions of the all the project partners, will be published in a final report.

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Abstract

The InTraCert project aims to explore the possibility of integrating the existing and planned Tradable Green Certificate (TGC) schemes in the European Union and, therefore, creating a plausible unified market for TGCs. Particular attention was paid to the possibilities of integrating TGCs for green electricity, green heat and biogas. This report gives an account of this particular issue. An inventory and analysis of the specific issues at stake when taking green heat and biogas into account in a green certificate system has been made. The analysis shows that production-based issuing of certificates is preferred, although for practical reasons it is easier to start with grid-based (and 'electricity-only') certificates. Conversion between different certificates and units are of main concern when green heat and biogas are included in the system. The kWh seems to be a convenient unit to issue the certificates. It should be possible to exchange certificates for new certificates, i.e. 'redemption for conversion' (conversion of the certificates in parallel with the conversion of the physical energy flow), as opposed to the redemption of certificates to fulfil an obligation. Mandatory demand, or the obligation, should suitably be put on consumers and stated in general terms. The consumer may then decide on the preferred energy mix to fulfil his obligation. Countries may allow for the possibility to comply with the obligation using foreign certificates and restrict the import of TGCs that they judge 'unacceptable'. However, for substantial international trade to take place, some harmonisation, e.g. for issuing certificates, is required.

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1. INTRODUCTION

The discussion on tradable green certificates (TGCs) mainly focuses on this new instrument as a stimulus for the penetration of *electricity* produced from renewable sources. However, the White Paper on renewable energy of the European Commission (CEC, 1997) envisaged that in order to meet the target of 12% energy from renewable sources in 2010, it will be necessary to deploy renewable technologies based on *gas* and *heat* as well. Under these conditions, it would be sensible to expand the TGC system to all energy carriers in the energy mix, in particular green heat and biogas. A TGC system could be implemented to stimulate biogas (e.g. gas from biomass), ‘green heat’ (e.g. heat from solar boilers or heat from biomass plants) or bio-based motor fuels. For that matter, some governments are thinking about the introduction of green certificates for green electricity, biogas and/or green heat, although generally details are still unknown.

This chapter starts with an overview of renewable energy technologies. Then, the main issues concerning the integration of green certificates for electricity, heat and gas are identified. In subsequent chapters, the three main issues are analysed in more detail. Each issue is analysed in the light of *policy for renewable energy and for climate change*, the existing ‘*framework conditions*’ in Member States and the EU as a whole, and the *practicalities* of implementing the options considered. Additional viewpoints are considered when relevant for the specific case, that means, when they play an important role in deciding on the design of a TGC system. Cost-effectiveness and consumer’s gains are examples of economic and social consideration that matter. This approach suggests a thorough and a structural scientific analysis. However, the reader will find a rather philosophic analysis, giving some thoughts about the subject without necessarily being complete.

1.1 Renewable technologies, renewable sources and renewable outputs

Three groups of renewable energy sources can be distinguished:

- flow sources,
- biomass and waste sources,
- sources from ambient and geothermal heat.

For each group, a number of technologies can be identified. Table 1.1 gives an overview of these renewable energy production technologies. For each technology, it is shown whether it is generally used as a grid-connected (including heat and gas grids) or stand-alone system. Moreover, if it is grid-connected, it is also denoted if auto-use, i.e. behind the meter options, generally plays a significant role. If the technology is generally considered as a production unit, energy production is directly metered and monitored. If energy is produced behind the meter, i.e. immediately consumed, the technology is not easily monitored. The table also shows which type of green energy (output) is produced by each technology.

Table 1.1 *Overview of renewable energy production technologies*

Technology	Stand alone	Behind the meter	Grid connected	Output ^b	Input
Flow sources					
Hydro power			×	E	
Wind energy			×	E	
Tidal energy / waves			×	E	
Solar - PV	×	×	×	E	
Solar - Thermal					
solar boilers		×		H	(E)
other ^a		×		H	
Solar - Passive	×			H	
Ambient and geothermal heat					
Heat pumps		×		H	E
Heat / cold storage		×		E/H	E/H
Geothermal plant			×	E/H	
Bio energy					
Waste incineration		×	×	E/H	
Burning/gasifying					
wood ovens	×			H	
decentral power prod.		×	×	E/H	
co-firing, central pp		×	×	E/H	
Fermentation					
waste water				E/H or G	
sewage water				E/H or G	
manure				E/H	
compost				H/G	
landfill gas			×	E/H or G	

^a E.g. swimming pools and drying systems

^b E=electricity, H=heat, G=gas

Sources: Novem, 1999; CBS and Novem, 2000.

Flow sources are most easily labelled and their output typically is evident. This is not the case with biomass and waste sources as it may be problematic to label the different sources and to determine the output, which is often both electricity and heat. CHP is not explicitly mentioned in the table, but (de)central power production with co-firing could consist of CHP. While CHP is in most countries considered an energy efficiency option, when it is using a green fuel such as biogas, it might be considered as a renewables option. For the energy production from (municipal) waste, the distinction between the renewable and non-renewable part is important. Eurostat considers municipal waste as a separate energy carrier and uses the total energy content of waste to calculate the avoided primary energy consumption. Some countries just refuse to 'appreciate' any renewable part, and other countries find their way by deciding on some percentage (e.g. 50% in the Netherlands) because this would correspond to the organic part in municipal waste.

Some technologies, especially heat pumps and cold/heat storage, need some input of energy in order to function. The possible 'greenness' of the energy input is important here. A first consequence is that a correction, related to this input should be made. The other consequence is that there is an argument to consider the use of ambient and stored heat by heat pumps and heat/cold (seasonal) storage as energy savings options. In some countries, e.g. the Netherlands, these technologies are not considered as renewable energy options if they use waste heat produced with fossil fuels as input. Here again, the different national practices show more discrepancy than accordance.

1.2 Non-electricity options in current and near-future green certificate systems

The following example shows that it can make quite a difference if only produced green electricity is rewarded or if produced green heat is also rewarded with green certificates. Consider a central installation processing and burning municipal waste with an organic fraction of 50%, see Figure 1.1. At the moment, it is common practice to generate electricity with the produced heat, with an efficiency of about 40%. However, if the heat would have been valued as renewable and awarded with green certificates, the heat would perhaps have found a more efficient use, e.g. by transporting it to a nearby residential area for district heating. The reward for the waste incineration installation in terms of certificates would be higher for the heat.

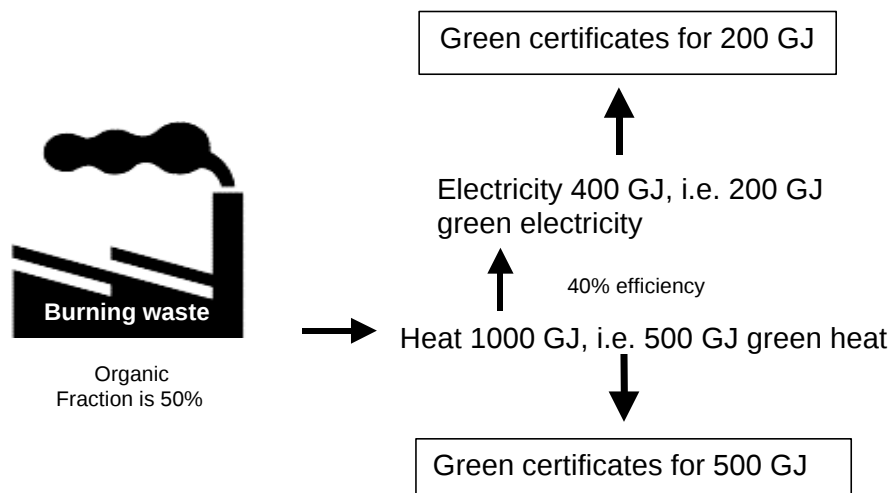


Figure 1.1 *Physical conversion, rewarding electricity or heat with certificates?*

Several countries or states that will implement green certificate systems have plans to include also non-electricity options in the certification scheme. The common feature of all these systems is that they are mainly designed for renewable electricity. The certificate unit is expressed in kWh. Non-electricity options are included by issuing kWh-equivalent certificates, based on an administrative conversion factor (which differs in each of the countries). In Australia, solar boilers will get certificates according to the quantity of electricity that would have been used for the same heat demand, assuming that electric boilers would have been used. In the Netherlands, green certificates (within the system of Green Labels until January 2001) have been issued in kWh-equivalents for green gas, based on the CO₂ content of a cubic meter of biogas, compared to the 'average' CO₂ content of kWh-production with the current electricity production mix in the country. In Texas, green gas receives certificates in kWh-equivalents, assuming that the gas would have been converted into electricity in an average gas-fired power plant in the state. The consequences of these differences in methods are illustrated in Table 1.2.

Table 1.2 *Example of administrative conversion, certificates issued in kWh*

	Netherlands	Texas
Landfill gas	1000 GJ	1000 GJ
Conversion based on	Emission factor of 56 kg CO ₂ per GJ primary energy	Average efficiency of gas-fired power plants, e.g. 60%
Result in tCO ₂	56 tCO ₂	
Further conversion based on	Average emission of power production, e.g. 70 kg CO ₂ per GJ primary energy	
Result in GJ	800 GJ	600 GJ
	Divide by 3.6	Divide by 3.6
Result in MWh	222 MWh	167 MWh

In all the cases mentioned above, the conversion of the green value of one energy carrier into another is made at the point of production. In the market, only renewable electricity certificates expressed in kWh-equivalents exist. Demand for these certificates comes from obligations or voluntary green demand for electricity. This might change however in the future. In the Dutch green certificate system, starting in July 2001, there are plans to issue green certificates for the production of green heat in the future. Heat pumps using green electricity will then be able to produce 100% green heat, and will, if this heat is delivered to a heat grid, be issued green certificates. In principle, these certificates could also be used to sell green electricity or green gas to consumers.

1.3 Setting the scene

It seems that the list of issues at stake, when designing a TGC system, is a very long one. In this report, however, the focus is on the aspects that would change because of integration of different green certificates into one system. For instance, verification procedures, i.e. to check whether the energy delivered is really 'green', is important but relevant for all green certificate systems. In this report, it is merely an issue if it significantly changes due to the proposed integration form. For now, under the assumption that the choice for an integrated TGC system is already made, the main apparent issues are about:

- certificates units, exchange and conversion,
- general certificates (one type of certificate for all energy sources) versus specific certificates (each energy carrier, i.e. electricity, heat and gas, has its own certificate),
- production-based versus grid-based issuing of certificates,
- general obligation versus specific obligations, and the related market volumes.

Administrative and physical conversion

Green certificates have generally been defined in terms of kWh. However, renewable energy targets in e.g. the Netherlands are stated in terms of 'avoided PJ', while the 12% EU target is based on the Eurostat method of primary energy input, i.e. 'primary PJ'. This illustrates the importance of the unit in which the certificates are defined and of the 'exchange rate' used to translate one unit into the other. This can be viewed as administrative conversion for which clear but achievable agreement on units and conversion factors has to be reached.

Physical energy flows are not always delivered directly to final consumers. Gas, for instance, might first be converted to electricity and heat in a CHP-plant, before being delivered as electricity and/or heat to the consumer. In a situation in which green certificates are issued for the production of all renewable energy carriers, the possibility of conversion of one form of green certificate (if they exist in different forms) into another should also be taken into account.

Stand-alone, behind the meter and double counting

If stand-alone and/or behind-the-meter production of renewable energy is included in the green certificate system, possibilities of ‘conversion’ of certificates will go far beyond the analogue physical conversion processes. For example, the green value (i.e. the certificate) of electricity produced by solar home systems in remote areas can, in theory, be used as input for a heat pump. Thus, the certificate can be used to ‘green’ the input of electricity necessary for operating the heat pump. Consequently this heat pump will produce 100% renewable heat, and may be eligible for receiving green certificates. Moreover, in many countries, wood used by households is a relevant issue. As the amount of heat produced or consumed is not measured in this case, other ways should be found if certificates are to be issued for these type of energy production/consumption. Obviously, off grid production is only eligible for green certificates if it is also consumed, i.e. conventional consumption is replaced.

Another focus of attention in certificate conversion processes is that certificates are not issued twice for the same amount, e.g. both for the production of biogas, and for the electricity and/or heat produced with this gas. By issuing certificates at the moment of production of biogas, the green value of this gas flow is immediately detached from the physical flow. This means that from that moment on, the physical biogas cannot be considered as renewable any longer, and cannot be used anymore to produce renewable electricity (or, in other terms, cannot be used anymore ‘to green’ conventional electricity production).

Obligations

While the concerns raised up to now have emerged at the supply side (mostly about issuing activities), there are also questions related with the demand side of a market for tradable green certificates. The demand for certificates can be organised in completely dissimilar ways. First of all, in case the government chooses to enact an obligation (to acquire a certain number of certificates within a certain period), which actors in the energy supply chain should be obliged? And how will each actor respond to the obligation? Second, the obligation may be put in general, aggregated terms of ‘energy’, or may be put into effect for each specific energy carrier, i.e. separate obligations for green electricity, green gas and green heat. These are two options that might have different impacts on the whole energy supply chain.

This section has depicted the scene and distinguished the different issues. In Chapter 2, the ‘currency’ unit (or unit of denomination) of the certificates and the conversion issues will be discussed. The analysis in Chapter 3 is focused on the issuing of certificates for grid-based production only or for all renewable production. In Chapter 4, the consequences of integrating (non-) electricity certificates for setting and complying with the obligations is discussed.

2. CERTIFICATE UNITS AND CONVERSION

When designing a TGC system, one may choose not to account for any conversion at all. This would be the special case when specific (i.e. for each energy carrier) certificates are being issued and when they are denominated in the same units as their respective physical carriers. The same applies to the situation when there is no need expressed (or no permission given) to exchange some types of certificates into each other. This particular ‘non-integration’ case has at least two limitations. First, the green certificates would then only be redeemed in their original unit, which means that there should also be specific obligations for each energy carrier. A comprehensive discussion of the main advantages and disadvantages of separate obligations with separate markets is reported in Chapter 4. Second, one common ‘currency exchange rate’ seems to be still necessary if the TGC system is to deal equally (in the political sense) with all producers of renewable energy. Given the example of the CHP plant above, where one would like to give credit to green gas and green heat, some exchange/conversion becomes indispensable. It means that, independently of the choice of having general or specific certificates, one has to choose one (or several) convenient unit(s) to work with, as well as a proper methodology to use them. These are the two issues at stake in Section 2.1 and Section 2.2 respectively.

2.1 Unit of the certificates issued

There are many possibilities to choose a unit for the certificates. In many cases, certificates are discussed in terms of kWh (or MWh), which is, of course, generally driven by the fact that only or mainly green electricity certificates are considered. However, when green gas and green heat are also involved, certificates may logically be stated in cubic meters or GJ. Moreover, renewable energy targets are often stated in terms of ‘avoided GJ’, while the 12% EU target is based on the Eurostat method of primary energy input, i.e. ‘primary GJ’. Finally, in order to reveal the link of renewable energy with greenhouse gas issues and the Kyoto protocol, avoided CO₂ or CO₂ equivalents might be used as a unit for green certificates. Some considerations when using a particular unit are given below.

2.1.1 kWh

Using kWh as a unit for all green certificates focuses on the electricity output of the RE production. For the technologies, producing electricity directly that is fed into the grid and easily monitored, it would make sense to issue certificates in terms of kWh produced. Typical examples of such technologies are hydro, wind, tidal/waves, PV and geothermal systems. It is already standard practice and the volume of green heat and green gas produced is and will be very small compared with the volume of green electricity. Moreover, the kWh is an internationally accepted and unambiguous unit for the production of electricity, while for example the energy content of a m³ for gas differs between countries, albeit that some countries also use kWh as the standard unit for natural gas.

2.1.2 Avoided GJ

Using avoided GJ as a basis to issue green certificates focuses on the replacement of fossil fuels that ‘would otherwise be consumed’. This seems a fair measurement for counting RE production or consumption. However, the way to calculate how much is actually avoided becomes the important issue. Reference or baseline technologies, reference periods or years and reference geographical (e.g. national or European wide) levels are needed. Since each of these issues appears arguable, the whole method is converted into a complex issue on which preferably international agreement should be reached.

2.1.3 CO₂

If the reduction of GHG emissions is the main argument to stimulate RE production and consumption, it would be reasonable to establish green certificates in terms of CO₂ equivalents. Issuing green certificates in kilograms of CO₂ reduction, or rather CO₂ displacement, focuses also on replacement of fossil fuels. Therefore, regarding the calculation, the same reasoning applies as with avoided GJ. Note that this might reduce the TGC value to the CO₂ value only and it would simplify the integration of RE into a CO₂ permit trading scheme.

2.1.4 Primary GJ

The Eurostat method of counting primary energy input merely focuses on the energy input of RE production. A big advantage is that it may be the greatest certainty one has, which means that any needed (international) agreement would be more easily achieved. However, it does not account for efficiency losses during conversion of RE into useful electricity, heat and gas. Total primary or potential heat content of e.g. landfill gas is generally larger than the amount of energy from landfill gas that is applied effectively, because part of the extracted landfill gas is flared at the source. Thus, the use of primary GJ as a unit to issue certificates over-estimates the amount of RE produced / consumed, especially when bio energy sources are concerned. This drawback can be removed by accounting for the net production of RE or setting stricter obligations in order to achieve the same level of deployment. However, when flow sources such as wind power play an important role in a particular country, the primary GJ method may result in an under-estimation of RE production. After all, the metered kWh should be translated into a primary GJ measurement, for which again a baseline or reference is needed.

2.1.5 Practicalities

Currently, all green certificate systems that will be in place in 2001/2002 will use kWh as the currency unit. Any procedure to calculate currency unit equivalents should be transparent with respect to conversion of different certificates at the country border. Problems may arise, for instance, if in one country the amount of green certificates for one m³ of biogas is calculated by taking the average conversion efficiency of gas-fired power stations, while in another country, this is done by comparing the CO₂ content of biogas with the CO₂ content of an average kWh from the overall electricity mix.

If the conversion procedures are not the same, countries within a 'green bubble' could agree on exchange rates at the border for green certificates for which the conversion calculations differ. The issues will become more important if the size of the bubble increases. There is also the option of developing and adopting a 'green protocol' (like the http-protocol for the Internet) able to calculate the right 'exchange rates' at the different borders. Such a protocol could also be used for international trade with countries outside the bubble. Some way or another, harmonisation is (eventually) needed in a full international context.

The European Commission, for instance, may either try to harmonise the green certificate currency unit and/or the conversion factors. The currency unit of the overall EU-target is 12% of the gross energy consumption (in terms of primary GJ). But also renewable electricity targets are indicated (in terms of GWh). Apart from that there are of course the Kyoto-targets in terms of CO₂ reduction. A one-currency system would fit well with overall EU-targets for RE. If CO₂ reduction is favoured as the currency unit, also exchange with the US, Australia and other countries may be easier to establish.

Besides the choice for one or another unit to cope with all certificates, there is the possibility to use several units for several types of renewable energy simultaneously (e.g. kWh for electricity but cubic meters for gas) and to 'convert' them only if and when needed. In both cases, certification happens early in the supply chain, i.e. as soon as production of renewable energy is iden-

tified, and conversion happens as far downstream as possible. To be clear, in the first case, the administrative conversion of green energy into one agreed unit is done at once when the certificates are issued. This was also the case assumed in the section above, where the green electricity, green heat or green gas was administratively translated in a common unit immediately after production. In the second case, however, certificates will be issued in the particular unit of the type of green energy and conversion will only be an issue in some specific cases. Section 2.2 is devoted to the issues that will then arise.

2.2 Conversion methods

Independently of the choice of having general or specific certificates, one has to choose one (or several) convenient unit(s) to work with, as well as a proper methodology to use them. Therefore, two kinds of basic conversion methods are described which both imply a lot of (eventually, international) agreements to be achieved.

2.2.1 Administrative conversion

Green certificates that are defined in terms of kWh, avoided GJ, primary GJ or CO₂ reduction can be translated from one unit into the other. But this is not the whole story about administrative conversion. Since policy targets for RES are usually stated in terms of a percentage of (future) consumption and since national consumption is often measured in terms of GJ, the targets and obligations will primarily be stated in GJ (and policy targets for GHG emission reduction are usually stated in terms of CO₂).

For administrative conversion, many clear agreements have to be made. De facto, administrative conversion is already applied in some countries. The reference technologies that they often use play an important role, especially when the CO₂ content differs and emission factors are used as a reference. Which (average) content or emission per certificate unit to use? Those in the country where the energy (and the certificate) is produced, or those in the country where the certificate is consumed? The first option seems to be fair mainly from the point of view of the producer of renewable energy and it is not known beforehand where the certificate will be consumed. It seems too difficult to incorporate (and verify) all other countries' references at the moment when the certificates are issued. Administrative conversion of the production of green electricity (GWh), heat (GJ) and gas (m³) into any reference unit should not be too problematic. But the main issue is about the agreements that need to be achieved.

2.2.2 Physical conversion

The physical part of the conversion may, at first sight, bring most difficulties. Physical energy flows are not often delivered directly to final consumers: natural gas, for instance, might first be converted to electricity and heat in a CHP-plant, before being delivered as electricity and/or heat to the consumer. In the situation in which green certificates are issued for the production of all renewable energy carriers, possibilities of conversion of one form of green certificate to another will be numerous and should be taken into account in the TGC system.

Since physical conversion suffers the same problem of transparency about all referred conversion technologies as administrative conversion, the list of transparent (international) agreements will just be lengthened. That this list indeed is too long, becomes evident when one realises that even when the input is not green, one may wish to 'green' it, that means, to add some green value to this input. Consider, for instance, a CHP-plant that runs on natural gas (de facto, no renewable source). If the fuel input of this plant has been covered by the right (according to some agreements again) equivalent amount of green certificates, then this CHP-plant might be considered to run on 'renewable natural gas', i.e., natural gas with an added green value. The plant

then produces, apart from the physical electricity and physical heat, also green electricity certificates and/or green heat certificates.

Two assumptions made in the various examples are noteworthy; while the first is consequential, the second is imperative. First, in this example it is assumed that there will be different certificates for electricity, heat and gas. Of course this is not necessarily the case. Even in the case of 'general green certificates', one may wish to 'add green value' to an energy input (example: the electricity input of a heat pump) to produce green heat, which can again be separated in physical heat and general green certificates. The second assumption, and key in these processes of physical conversion, is that the input certificates are actually 'redeemed-for-conversion' instead of 'redeemed-for-obligation', before the new certificates related to the output are issued. Thus, 'redeemed-for-conversion' means that existing certificates are exchanged for new certificates and not handed over to fulfil an obligation. For the sake of clarity, to 'green the fuel input' means that the output is also 'greened' and will be eligible for receiving green certificates. Therefore, some certificates are 'eliminated' and some others can be 'created'. Note that in the case of heat pumps, it is possible that there are more green certificates created than eliminated. With efficiencies lower than 100%, part of the greenness will get 'lost', as is the case with the physical energy. Note also that some green certificates, like those issued to biogas, will be mainly 'stand by' or 'provisional' certificates in the sense of waiting for some 'redemption-for-conversion'. This is because biogas is not immediately 'consumed' but used in e.g. power plants or used for heating. Note finally that green certificates can also be issued for electricity produced by conventional power plants. This can happen if the fuel input is covered by the consumption of green certificates in terms of that fuel. Actors that deliver non-renewable energy to the grid and nevertheless wish to receive green certificates for that form of energy, have to prove that they consumed enough green certificates to cover their fuel input.

3. SUPPLY SIDE OF INTEGRATED CERTIFICATES SYSTEMS

3.1 A supply side based classification of integrated certificates systems

As noticed in the previous chapters, a choice has to be made concerning the point in the supply chain when green certificates should be issued. The issuing activity itself can be done immediately after production or at the point where renewable energy is delivered to a grid. The TGC system will therefore be either ‘production-based’ or ‘grid-based’. The former approach is announced in some of the national TGC systems that will start in the near future; the latter approach is however considered more frequently, e.g. in the Dutch green certificate system. Two main differences between these approaches, on which the analysis focuses, are the impact on the volume of the market and the ability to administrate the system.

When designing the supply side of the market, it had to be decided whether to issue certificates only in one particular unit or whether every energy carrier will receive specific certificates. The discussion in Chapter 2 provides the basis for this choice.

The distinction between general and specific certificates, together with the options of production and grid-based issuing, leads to the categorisation in Figure 3.1.

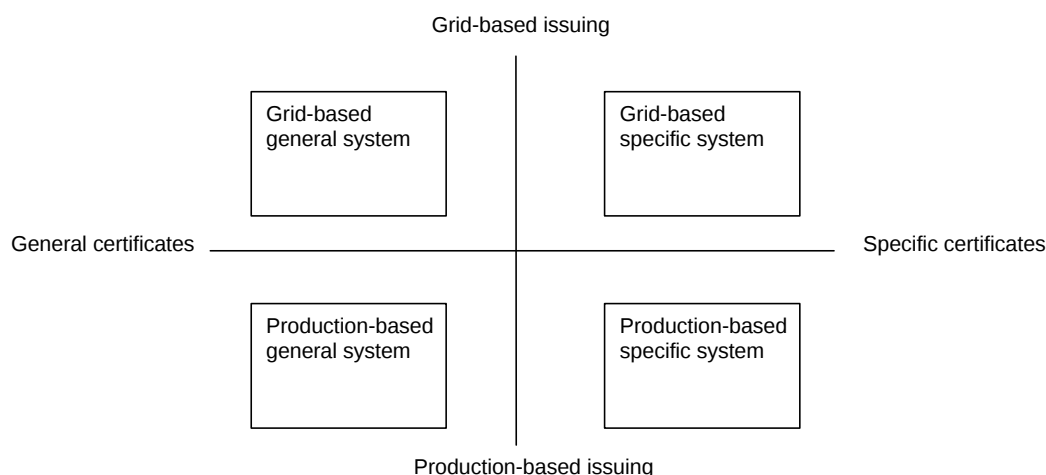


Figure 3.1 *Categorisation of integrated green energy certificate systems*

The four categories are defined as follows:

- Grid-based means that certificates are given to the entity that delivers renewable energy to a public energy network (grid). This can be an electricity grid, gas pipeline network or steam/heat distribution system.
- Production-based systems mean that certificates are given to the producer of renewable energy, regardless whether the energy is delivered to a grid or used on the spot (stand-alone or behind-the-meter).
- General certification means that green certificates for all sources and carriers are always issued in the same ‘currency’. The unit can be (equivalents of) kWh, primary GJ, avoided GJ, ton oil, m³ or any other unit in which energy flows are expressed, but also in ton CO₂ reduction (equivalents).

- Specific green certificates are awarded in the ‘currency’ in which their physical flow is measured (gas in m³, electricity in kWh, heat in GJ, gasoline in litres). Remember that some conversion of one form of specific certificates into another can take place, e.g. through ‘redemption-for-conversion’. By ‘covering’ the fuel input (e.g. gas) of a conversion plant (e.g. a CHP plant), some specific green certificates are ‘eliminated’. The output therefore becomes green and is eligible for receiving specific green certificates.

3.2 Evaluation of alternative options

The aforementioned four categories are evaluated against a set of criteria and in the context of national and international trade. Three criteria will be applied to evaluate each option. The first is the set of ‘practicalities’ where one can find most technical possibilities and impossibilities too. The second is the more economically oriented set of ‘framework conditions’ focusing mainly on switch costs and administrative burden. The third is the politically oriented set of observations about the fitness of the proposed TGC system to relevant policy (mainly through targets and obligations).

3.2.1 Grid-based systems with general certification

Practicalities

The advantage of the grid-based approach is that it avoids potential problems of double counting when one or more physical conversion processes occur. If green gas is delivered to the gas grid, it gets green certificates, but if it is directly fed into a power plant, it does not get green certificates. Instead the electricity, which is fed into the grid, gets green certificates. The amount of certificates for green electricity will be smaller as the efficiency is usually smaller than 100%. This is a clear system (because tacitly accounting for implied efficiencies) that is also relatively easy to measure. The issues about calculations to administratively convert the green value of a specific energy carrier into a one-currency certificate remain as exposed in Chapter 2. Moreover, if there is a clear way of administrative conversion of the green value of different renewable energy flows into one ‘currency’ unit, this conversion can easily be handled in software, and is clear and transparent.

Framework conditions

Grid-based systems fit relatively easily in existing institutional frameworks. The system operator or distribution companies measure input of physical energy anyway. They will either pass on this information to the Issuing Body (IB), or if they are IB themselves, they carry out the necessary calculations to convert the green value of the renewable energy flow into the general green certificate currency unit. Framework conditions in an international context do not differ from the national level.

Policy for RE and CC

A potential advantage of general certification is that the currency unit can be made the same as the unit in which the (inter)national targets are stated. The difference between the policy target and the renewable energy consumption can be easily established. Also, the target can be easily translated into an obligation (in terms of the appropriate energy unit) to create a market of the ‘right’ size, i.e. in concordance with the policy target. The disadvantage of a grid-based system is that not all renewable energy production and consumption is accounted for. The green value of behind-the-meter options, like auto-consumption from CHP-plants or heat pumps, is not valued in this approach. It means that the certificate system cannot be used as an accounting system for renewable energy and consequently the administrative burden increases. Moreover, the market might be thin when only grid-based production is awarded with certificates. The importance of this problem, i.e. the (potential) share of non-grid options in renewable energy, might differ per country.

3.2.2 Grid-based systems with specific certification

Practicalities

With regard to issuing the same advantages apply as in the case of the general grid-based system, in terms of avoiding double counting and transparency of the system. However, an additional issue with practical implications is that green certificates can also be issued for electricity produced by conventional power plants, as long as the fuel input is covered by the consumption of green certificates in terms of that fuel. This means that an additional accounting and verification procedure is necessary. Actors that deliver non-renewable energy to the grid and still want to receive green certificates for that form of energy, have to prove that they consumed ('redeemed-for-conversion') enough green certificates that cover their fuel input. In principle this should not be too difficult to verify. International trading is pretty straightforward in such a system. The only difficulty might be that the energy content of e.g. natural gas is not the same in all countries. If the energy content is indicated on the certificate, the 'administrative conversion' is easily calculated.

Framework conditions

Conversion can be expected to take place more often, and so the need for verification of conversion. This means more communication between the green certificate Central Monitoring Office, the Issuing Body and the organisation that measures the input flow into the grid (the system operator).

Policy for RE and CC

The different certificates consumed in a year can easily be calculated in terms of the units in which government targets are stated (e.g. avoided GJ, or CO₂ reduction equivalents). To get a nice match between a specific green certificate system and national targets (that are usually set in general terms), these targets could be sub-divided into targets for green gas, green heat and green electricity, and different obligations can be set. Just as for the former option, the disadvantage of a grid-based system is that not all renewable energy production and consumption is accounted for.

3.2.3 Production-based systems with general certification

Practicalities

The production-based approach is a lot more complex than the grid-based approach at the practical level because it means that all stand-alone and behind-the-meter options have to be examined. The production from stand-alone systems and behind-the-meter systems should be measured, and this should be done in a certified way. For renewable electricity, some meters are already on the market (e.g. because people like to know how much PV-electricity has been produced for their home), but they need to be officially acknowledged by the Issuing Body (and certified as such by an established certification organisation). For renewable heat, which appears in a large variety of forms, this is much more difficult as these varied forms are usually not easily measurable. An alternative solution for the metering problem is to define 'proxies' for certain technologies in certain situations. For instance, if a heat pump is officially certified as having a seasonal performance factor (SPF) of 3, then the gas/electricity input in the heat pump can be measured, and the output of green heat can be calculated according to this factor. For solar boilers, the expected average amount of energy delivered at a certain location (depending on the tilting angle and the shade factor) can be taken as the basis for the number of certificates to be issued. With regard to stand-alone renewable heat from biomass, at least the furnace should comply with certain emission standards. Then, the energy content of the fuel could be determined in a standardised/certified way.

The related issue is to establish the ownership of the certificates. This means, to find out to who certificates will be issued e.g. in the case of renewable heat from biomass in wood stoves. Ideally, one would like to measure the heat output from such a wood stove, and issue certificates

for that amount to the user of this stove. Two problems remain with this option. First, the heat output of a wood stove normally is just not measured (special measurement devices should be developed for this, which is not very easy). This is an issue in countries where households use wood. Second, final consumers will not be expected to take part in green certificate trade, but as voluntary purchasers of certificates. It is difficult to imagine how then they might be able to get the rewards from the green credits. It might be easier to issue the certificates more upward in the supply chain (e.g. to wood 'producers'), so that the final consumer will just only notice a cost advantage.

A central issue is double counting. In the case that stand-alone and/or behind-the-meter production of renewable energy is included in the green certificate system, possibilities of physical conversion of certificates will go far beyond that of the case of only grid-based production. For example, the green value of electricity produced by a solar home system in remote areas can be used as input for a heat pump. Alternatively, 'greened input' (once more, in the sense of having purchased up to 100% covering with green certificates) can be used together with the needed input electricity. Consequently, this heat pump will produce up to 100% renewable heat, and becomes eligible for receiving up to 100% green certificates. While many different, often sequential, conversion processes may happen, much attention should be paid that certificates are not credited twice, e.g. both for the production of biogas, and for the electricity and/or heat produced with this gas. Electricity produced by biogas can only be issued green certificates if the biogas used in the power plant has not yet received green certificates.

To demonstrate the way to avoid double counting and to deal with other difficulties, it is as well to remember how the proposed system will perform physical conversion. By issuing certificates at the moment of production of biogas, the green value of this gas flow is immediately 'detached' from the physical flow. This means that, from that moment on, the physical biogas cannot be considered as renewable any longer, and cannot be used anymore to produce renewable electricity. Note that the electricity producer still can choose to purchase these green certificates together with the physical gas, and to 'redeem them for conversion' in order to produce e.g. renewable electricity. Therefore, even if the issue becomes more complex in the case of production-based systems, double counting can be avoided in several ways. One provision is that the certificates that are used 'to green' the input should be immediately taken out of the market (but not redeemed-for-obligation) before new certificates for the energy output are being issued.

Like the grid-based option with general certification, here again, the issues about calculations to administratively convert the green value of a specific energy carrier into a one-currency certificate remain as exposed in Chapter 2. However, as it is not expected that there will be a clear way of administrative conversion of the green value of different renewable energy flows into one 'currency' unit, this conversion will be less easily handled.

Framework conditions

Because measuring is not always done by existing institutions (as is the case in grid-based systems where transmission operators do this job), communication forms and protocols between the auto-producers and the Issuing Body have to be established, and appropriate verification procedures have to be designed. This would help a better monitoring of the total renewable energy production, which is not achievable with a grid-based system.

Policy for RE and CC

Production-based systems cover a larger part of the total renewable energy production than grid-based systems. These systems will not only monitor a larger part of the renewable potential but will also stimulate this larger part. If the TGC system indeed has the expected impact on the deployment of new renewable energy, then this impact may even be increased in the wider production-based system. Moreover, general green certificates fit again better with existing, general renewable energy targets (or climate change targets) than specific certificates. The certificate system may also be used as an accounting system for renewable energy, and the administrative

burden may decrease. All renewable energy production, like auto-consumption from CHP-plants or heat pumps, can be accounted for (at least, if the producer of the renewable energy wants to obtain such certified appreciation). Production-based general green certificate systems seem to be the best choice with regard to reaching RE and CC policy targets.

3.2.4 Production-based systems with specific certification

Practicalities

It goes without saying that most topics as examined for the former option will remain important since, here again, every renewable production source should be identified and measured. ‘Metering’ and the identification of ownership still may appear big issues for some particular sources. The mapped problems to avoid double counting appear somewhat less obscure than for the option with general certification; with specific certification, it is easier to track all renewable energy flows as this is done for each carrier. However, as demonstrated in the former paragraph, the method of ‘redemption-for-conversion’ remains here also.

Framework conditions

Here again, because measuring is not always done by existing institutions (as is the case in grid-based systems where transmission operators do this job), communication forms and protocols between the auto-producers and the Issuing Body have to be established, and appropriate verification procedures have to be designed. However, this problem becomes larger, as the option includes all kinds of renewable production in all situations. Still the argument that this would anyway help a better monitoring of the total renewable energy production is valid.

Policy for RE and CC

Here again, production-based systems cover a larger part of the total renewable energy production than grid-based systems. These systems will not only monitor a larger part of the renewable potential but will also stimulate this larger part (since they prize all the renewables sources). An additional advantage is that the certificate system may also be used as an accounting system for renewable energy, and the administrative burden may decrease. Another advantage is that the volume of certificates traded is large. However, specific green certificates do not fit exactly with general renewable energy targets (or climate change targets), at least not in the form most of them are currently established.

3.3 Inferences on supply side considerations

From a practical point of view, grid-based systems are to be preferred. Production-based systems bring a lot of practical issues and more uncertainties as to issuing and monitoring the certificates. From a political point of view, general certificates systems are to be preferred, mainly because of the targets which are given in general terms. Because of existing framework conditions, the recommendation is to start relatively simple and to extend the TGC system later on. It seems most easy to start with a national grid-based system with specific certification or, as it happens right now often, to start with an electricity-only system. Gradually, some non-electricity options (possibly all calculated in kWh-equivalents in the first stage) can be added. Later on, non-grid options can be included. This may happen either before or after some internationalisation has occurred. It might be the case that specific certification enhances the process of harmonisation, as the number of agreements is reduced. Finally, after intensive discussions on harmonisation, the step to an international, production-based, system with general certification might be implemented, if this appears a clear improvement of the TGC system.

We feel that the more complicated production-based system with general certificates is more in line with general RE and climate change policy. Then, it might be reasonable to start relatively simple, for practical reasons, and to include the more complex issues gradually, to fit the green certificate system better with RE and CC policy. However, it might also be the alternative case

that RE and CC policy grow toward more practically designed targets. Thus, existing policy agendas should not receive more emphasis just because of historically grown policy patterns.

In fact, all considerations will have to be ‘weighted’ against each other. Economical and political considerations should also be taken into account. Trade-offs between these considerations will be a main subject in Chapter 4. What is important to know at the present stage is that it is not possible to determine which TGC system should be chosen, mainly because not all the determinants have been taken into account.

4. DEMAND SIDE OF INTEGRATED CERTIFICATES SYSTEMS

4.1 A demand side based classification of integrated certificates systems

The key feature of a green certificate system is the separation of the supply of ‘physical electricity’ from the ‘greenness’ that is produced along with the physical electricity by renewable electricity generation equipment. Both markets may function separately, and both will need their own demand. While the demand for the physical electricity does not differ much from customary goods, the demand for tradable green certificates may originate from several sources and may be organised in noteworthy ways. Options to create or reinforce the demand for TGCs can be either a tendering process aiming at buying the TGCs (certificates can be taken out of the market by a tendering procedure initiated by the government), or a voluntary demand (for instance, by green pricing or tax exemption that affects this ‘voluntary’ demand). But the relevant option in the framework of this study is an obligation, introduced by the government, to acquire a certain number of certificates within a certain period. The next sections deal only with this case of enforcing demand for green certificates through an obligation.

A choice has to be made concerning the point in the supply chain where the obligation should be put. In the Italian TGC system (InTraCert Group, 2000) the producer and importer of electricity will face an obligation. In some other national TGC systems the obligation is put on the consumer or supplier. Two main differences are the possibility to administrate the system and the impact on the competitive position of the obliged actor. Another question when designing the demand side of the market, is whether to oblige the actor to ‘redeem-for-obligation’ general certificates (any green certificates would be convenient) or specific certificates for every energy carrier (each specific obligation would need its own certificates). This question, for which the technical aspects have already been examined in Chapter 2, will mainly be analysed here as to the economic impact of the market.

4.1.1 Deciding on the different obliged actors

Which group of actors will be subject to the obligation? All obligation cases are assumed to work on the basis of a percentage of the conventional energy production supplied or consumed in the reference period. The obliged actor can be one of the following positions in the supply chain: the producer, the supplier, or the consumer, see Figure 4.1.

Producers

In the Italian TGC system, which started in 2001, producers and importers of electricity face the obligation. In most other national TGC systems the obligation is put on the consumers or suppliers. A valuable consequence of putting the obligation on the producer is that the need to transfer certificates to other actors is reduced to a minimum, since certificates are awarded to producers. One should bear in mind that an obligation on producers must always be supported by additional actions, for instance an obligation on suppliers to purchase the production from RE schemes or a priority dispatch for RE. It should be noted that there often exists an obligation to the transport or distribution grid to integrate the production of small renewable energy suppliers. Regional or federal authorities establish the price at which they have to purchase. A disadvantage of this option is that if producers in one country meet such an obligation, they will have a competitive (price) disadvantage with regard to other producers in neighbouring countries that do not have such an obligation.

Suppliers

Suppliers seem to be the suitable actors to undergo the obligation mainly because they are used to measure energy flows. This case is most applied or discussed currently. It should be mentioned at this stage that the analysis will be continued without the cases based on the suppliers, because it has been found that the results do not differ significantly from results obtained with obligations based on the consumers.

Consumers

Obliging the final consumers is, at least in theory, the best choice. There would be no international, competitive disadvantage compared to an obligation at a higher level in the supply chain (see for instance Schaeffer et al. 1999 and 2000). Final consumers might fulfil their obligation themselves, which implies large bureaucracy and difficult controlling procedures. They might also use the possibility, offered to them by suppliers, to pass on the implementation of the obligation to their suppliers. Policy makers might point out this possibility explicitly to the industry and remove legal and regulatory barriers for this when they exist. Having the consumers subject to the obligation fits well with the ‘polluter pays’ principle.

4.1.2 Deciding on the aggregation of the obligation

Should the obligation be differentiated for energy carriers (i.e., classes of energy form electricity, gas and heat) or aggregated for all energy carriers? The issue is indirectly related to the practicalities discussed in Chapter 2 and 3. For example, the choice for a general obligation does not necessarily mean that general unit certificates have to be issued. But then, it would imply that administrative exchange is well organised between the specific certificates, since the obliged actor would be free to fulfil a general obligation with a mix of green energy certificates. Accordingly, the choice for specific carrier obligations would imply the issuing of specific certificates. While generality of the obligation is usually implied in the economic analysis, as well as in the official targets, specificity corresponds more with the developed practice up to now.

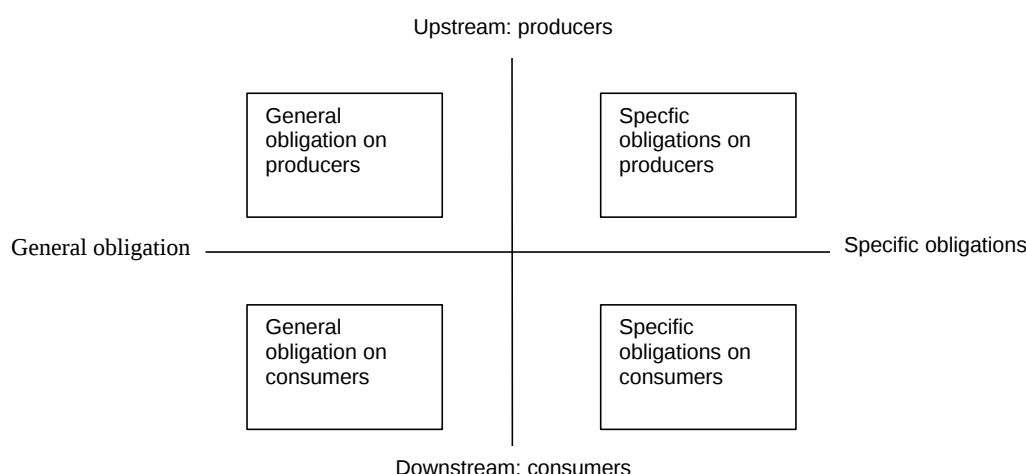


Figure 4.1 *Categorisation of obligations in an integrated green energy certificate system*

4.2 Economical and political trade-offs

This section will examine the trade-offs between many potential economic benefits and practical benefits as they appear due to the implementation of an obligation. But of course, it will mainly focus on these aspects that may significantly change under the assumption of one or other form of integration for the TGC system.

4.2.1 Cost-effectiveness as an economic consideration

The particular relation between the aggregation of the obligation and cost-effectiveness is quite obvious. Suppose that every obliged actor of a specific energy carrier was asked to show a certain percentage of green production, distribution or consumption. This would lead, depending among other things on who the obliged actor is, to an increase in the costs of compliance.

Assuming that the producer is the obliged actor, one accredited way to decrease the costs of green energy generation is to allow the producers to buy certificates somewhere else where production and thus certificates are cheaper. This requires a minimum degree of 'liquidity' and of 'transparency', in order to capitalise on cost differences between different producers of the same energy carrier.

One obvious way to increase the degrees (one for each specific TGC market) of liquidity is to allow exchange between the specific carriers obligations. This, in essence, means that the TGC system (with e.g. three TGC markets) is 'reduced' again to a general system. Due to the broader exchange, one can then capitalise on an ever-greater variety of natural cost differences. Renewable electricity developers and generators will have access to a wider market for TGCs. This helps to give confidence to financial institutions and technology developers who rely on a long-term view in the market to reduce risk and therefore improve access to finance. Investment capital flows then to new renewables development in the most cost-effective locations out of a range of three energy carriers. To open the TGC market to all energy carriers should, theoretically, balance out the prices of the different carrier certificates, and subsequently balance out, to some extent, the prices of the different technologies. This is, in turn, expected to affect the investments. However, with or without achievement of a level playing field, this will improve cost-effectiveness of compliance and encourage investments.

For actors further down the supply chain, like the suppliers or the consumers, outcomes are expected to be rather similar even if they may appear with some lag. And this is in turn only the case if improved competitiveness at the downstream level affects competitiveness at the upstream level in the energy chain. As there is no certainty about the (pace of this) process, there is an inclination to select the producers as obliged actors.

4.2.2 Consumers' gain as a social consideration

Cost-effectiveness is also expected to increase acceptance by the obliged actors to fulfil their obligations. A transparent and liquid TGC market is capable of bringing much greater choice to obliged actors, especially to obliged consumers and at the same time to voluntary green energy consumers. This fits also the purpose of European energy market liberalisation, which is to bring greater choice and freedom and lower prices to European energy consumers.

This consumers' gain is not merely an enumeration of costs for compliance to the obligation. Consumers might also call for more influence on the variety of renewable technologies. An obligation that is articulated in a collection of specific obligations would fail to empower the TGC consumers. However, an unconditionally aggregated obligation might reduce consumers' empowerment in the case they would not have all information about the renewable energy source. Thus, the obligation may be general, but the certificates should still indicate the source of the renewable energy.

While this examination seems to only point to the consumers' gain, (increase in) empowering of the consumers will in turn impact other actors in the supply chain. Energy suppliers or distributors would have to offer a variety of renewable energy sources and tariffs to customers. Subsequently, the possibility to observe which specific type of energy consumers really prefer, would enable more accurate market segmentation and, in turn, a more effective selection of new investments. This would increase the volume of the market for green power products because vol-

untary demand increases. Such consumer empowerment is likely to be an important factor in the development of renewable energy markets in the coming years.

4.2.3 Potential 'lock-in' effects due to time-specific demand and free supply

The aim of any obligation in a TGC system is to stimulate or enforce the demand for green certificates by the obliged actor. While the obligation is set to enforce demand, there is no guarantee that demand and supply will match perfectly in the daily certificates market. Indeed, the demand obligation does not in itself impose a time restriction on the supply of green certificates. Thus, if green certificate suppliers are not forced to sell their certificates within a certain time limit, the demand obligation combined with a strategic supply could force the TGC price to a very high level. In a TGC system that would merely interfere at the demand side of the market, demand 'lock-in' may occur. This delivers arguments for penalties and price caps on TGC (and penalties to 'opt out' of the system) and/or legislation that prevent co-ordinated supply. There is an additional risk for lock-in at the demand side if consumers are asked to cope with three instead of one obligation. In theory, specific obligation can lead to excessive trade in the 'other' carriers. The long-term argument that the three markets will adapt up to the point different certificates reached a common price, can not easily be hold. The necessary switch mechanisms (by which consumers would substitute their carriers to reduce their (certificate) costs and/or by which producers move to carriers with a higher price) would be drastic.

4.2.4 Adaptation of the existing framework conditions

Any chosen TGC system will have to be implemented within an already existing situation. It is easy to show that this implies new trade-offs between the implementation costs and the expected advantages compared to the old situation. There is a necessity to switch from the existing framework to that of the TGC system with a general obligation, or to that of the TGC system with a specific obligation. Some of the existing situations may look, at first sight, quite distinct from the TGC system, such as that of a feed-in tariffs system. Since most of the feed-in tariff systems recognise actual differences in costs between the different technologies, tariffs vary accordingly. Adaptation to a TGC system means also adaptation to a different appreciation structure. Investment in any renewable technology will receive another amount, which is the price of the green certificates on the market.

The character of the obligation will affect the character of the demand on the market. Note once more that it is not the same as a demand for different specific technologies. In the case of generality of the obligation, the effect on the energy structure due to the implementation of the TGC system is the greatest because of the inherent equal appreciation of all renewable investments. This tends to lower the earnings from the more expensive technologies; therefore, their specific markets will tend to shrink. In the case of specificity of the obligation, energy structures will be less affected because the eventuality of three specific demands for three specific carriers reduces the potential uniformity of the appreciation of the renewable investments. Note, however, that the inclination toward uniformity remains at least within each carrier: this is a group where all technologies, and thus all associated investments, receive the same earnings, which is the price of the specific TGC on that part of the market.

In a large international TGC market, there are at least two opportunities for each renewable technology/carrier to improve its earnings. The first one is linked to cost-effectiveness due to the greater choice for a (better) location of the new investments. The second one is indirectly linked to consumers' gain due to the greater differentiation in the (obliged and voluntary) demand for green certificates. However, to extend a TGC system to an international system, i.e. to allow cross-border trade in TGCs is more complex. Certificate units and conversions between units are relatively easy issues to decide upon in a national context. But internationalisation re-

quires the policy makers in each country to go through a lengthy process of agreements, which often means a process of concessions too.

When a TGC system is already implemented, adaptation of the current, national system will imply some reaction of the renewable energy market and some reworking of the industry structure. For instance, current TGC systems that are electricity-only, work de facto with an electricity obligation. In this case, both the certification and the obligation are specific. To extend the system to biogas and green heat as well then affects the whole energy system. The extent will depend on whether it is either a general obligation/demand system or a specific one. In turn, extending the system across borders might lessen the disadvantages of specificity of the obligation, mainly due to the larger size of the three specific markets.

4.2.5 Conformity with the policy targets

An important issue for the policy makers who establish renewable policy targets is to know whether new renewable production really will be added, conform to the targets. Then, the first issue is to chart the difference, if any, between short- and long-term cost-effectiveness. Obviously, governments essentially need the confidence of investors willing to start new generation of renewable energy. Evidently, investors look at the risk of generating green certificates that would not be sold on the TGC market. Therefore, two related questions are whether the behaviour of the investors changes with the position of the obliged actor in the supply chain and whether it changes with the degree of aggregation of the obligation.

In the short run, those producers who can provide TGCs at the lowest price will be able to sell. As the revenues from sales determine the 'returns to investments' for the producers, they also determine which mix of investments will be carried out. With (too) low supply in the TGC market, the price of the TGCs may be high, which may be an incentive for producers to provide various renewable sources instead of only the cheapest technology. However, in a competitive TGC market, prices are low and governments have no guarantee about the mix of technologies. This can be an issue for some governments with well-defined preferences. This issue relates to the long-term costs of compliance, which typically should concern governments and the EU. There is expectedly a trade-off between the short-term cost-effectiveness (when the cheapest solutions are chosen) and the long-term cost-effectiveness (when, in a dynamic way, some other solution may appear preferable).

A loss of 'control' on the mix of energy carriers by policy makers is expected in the case of a general obligation system. However, as they nonetheless have influence on the mix of technologies to bring specified energy outputs, the situation is not really altered. Furthermore, even when it is worth noting how the mix of technologies is various, it is impossible to state that a narrow range would be farther from long-term cost-effectiveness than a broader range. Indeed, there is no knowledge here about which (mix of) technologies happen to come close to the best situation in the future.

4.3 Inferences on demand side considerations

Strictly economical considerations (cost-effectiveness) have appeared a plea for the implementation of a general obligation. This may happen in principle at any level of the supply chain, but with less confidence at the level of the producers in the supply chain, as they may fail to incorporate the preference of the consumers of green energy. Moreover, the obliged actor may nicely co-operate when he feels free to fulfil his obligation with the mix of energy carriers he prefers. Therefore, the obligation may be general, but the certificates should still indicate the source of the renewable energy. Consumers' empowerment may be an important goal to aim at when designing the TGC system.

Cost-effectiveness can be achieved mostly through size and liquidity in the TGC market. Whenever one of both is lacking, the other may compensate. For example, the need for additional flexibility to achieve the economical benefits of a TGC market, is more pronounced in the case of a specific obligation due to the reduced size of the market. This insufficiency may be removed by incorporating counteracting instruments that compensate for part of the shortage of cost-effectiveness. Flexibility measures such as banking and borrowing may indeed increase cost-effectiveness of a TGC system. Banking causes the specific obligation to become more general, at least with regard to 'timing'. Furthermore, allowing 'borrowing' will endow the obliged actor with flexibility. Banking and borrowing, which are expected to reduce the price of the certificates and to help stabilise the TGC market, seem more compulsory when the obligation is specific. This is mainly because the probability of friction between supply and demand is bigger in each specific TGC market, compared to a system with a general obligation. However, simplicity is reduced by the introduction of additional instruments. If the TGC market becomes too complex, then one TGC system with a general obligation should be preferred.

Liquidity and transparency of a TGC market are also expected to improve the acceptance of the obliged actors to fulfil their obligations. Governments need upright co-operation from the part of the obliged actors. Therefore, governments will have to make up what the actors really prize: flexibility, simplicity, etc. Different actors may also define these features differently. If the assumption holds for a particular group of actors that they cherish most flexibility and low prices, acceptance will be greater with a general than a specific obligation system. An important understanding is that integrating specific obligations (green electricity, green gas and green heat) in one obligation (or alternatively, allowing exchange of separate certificates) will increase the flexibility of reaching the obligation, and possibly the co-operation of the obliged actors. This holds also the other way around. Enlargement in cost-effectiveness and consumers' gain signifies that the burden that the renewable energy target should depict, may be reconsidered. For example, increased cost-effectiveness may, other things being equal, carry on a more severe obligation (possibly in the form of a higher percentage). Just as well, increased consumers' gain may signify that a higher obligation can be thought of.

As an all-embracing trade-off should not merely be considered for its social-economic dimension as above, the required adaptations of the existing systems should also be considered. While generality of the obligation is considered more often in the economic analysis, as well as in the official targets, specificity corresponds more often with the developed practice up to now. And this has much to do with some practicalities. Unlike the case of a general obligation, when policy makers have no control on the preferred mix of green electricity, green gas and green heat, specific obligations for each energy carrier empowers the government that would want a particular distribution. This can even be realised when at the EU level, for instance, a general obligation is put, but the Member States still wish to deviate from this general obligation and, instead, choose for another subdivision of the general target. This would fit the European principle of subsidiarity. Central rules for certificates trade should be kept to a minimum set of criteria and principles, in order to respect subsidiarity and give maximum independence to Member States.

5. RECOMMENDATIONS AND CONCLUSION

This report analysed one of the themes of the InTraCert project. The central question is how green certificates for renewable (or green) heat and biogas could be in accordance with the more common notion of certificates for renewable electricity. The focus is on the aspects that would change because of integration of different green certificates into one system. It is assumed that the choice for integrating green heat and biogas in the TGC system is already made. The main apparent issues identified are:

- certificates units, exchange and conversion,
- general certificates (one type of certificate for all energy carriers) versus specific certificates (each energy carrier has its own certificate),
- production-based versus grid-based issuing of certificates,
- general obligation versus specific obligations, and the related market volumes.

A well working Tradable Green Certificates system should facilitate trade in certificates because it is trade in the ‘added environmental value’ of renewable energy generation, which is also in harmony with a liberalising energy sector. The topic ‘integration’ in relation to the TGC instrument may be divided in two main aspirations: integration of various green certificates in one system, and integration of various national systems.

As to the first aspiration, a good TGC system should enable as much as possible all forms of renewable energy generation to participate in the TGC system. It should also improve acceptability by simplifying the way a TGC market can offer certificates tailored to the needs of different market actors. Once this is established, then one can work out some mainly practical recommendations, and this will be done in the form a list of issues that have to be tackled when designing the TGC system. The next sections give the recommendations regarding the integration of various renewable energy forms into a certificate system that follow from our analysis. As to the second aspiration, note that few countries have anticipated the internationalisation of TGCs in the design of their national systems, and even the information content of the certificate differs from one country to another. The final section will give some reflection on this issue.

5.1 Include all renewable energies into the certificate system

The discussion on tradable green certificates (TGCs) mainly focuses on this new instrument as a stimulus for the penetration of electricity produced from renewable sources. However, the White Paper on renewable energy of the European Commission (CEC, 1997) envisaged that in order to meet the target of 12% energy from renewable sources in 2010, it will also be necessary to deploy renewable technologies based on gas and heat. The proposal for the renewable electricity Directive envisages a future Directive on biofuels. Under these conditions, arguably, it would be sensible to expand the TGC system to all energy carriers in the energy mix, in particular green heat and biogas. In fact, governments of some EU Member States are about to introduce green certificates for green electricity, biogas and/or green heat (although details of these are still unavailable).

5.2 Use kWh as the certificate unit

The use of kWh seems to be already international standard practice. The use of other units such as ‘avoided GJ’ or CO₂ bring tricky issues of ‘assumed displacements’ and ‘baselines’. The kWh is an unambiguous unit for the production of electricity and in some countries also for gas, while the volume of green heat and green gas will be very small compared with the volume of green electricity. Therefore m³ or GJ seem less appropriate. Primary GJ, another candidate unit,

may overestimate or underestimate the production of RE as it does not account for efficiency losses during conversion of RE into useful electricity, heat or gas. No matter the outcome of these reflections, they can be viewed as ‘administrative conversion’ for which clear but achievable agreements have to be made.

5.3 Use both ‘redemption-for-conversion’ and ‘redemption-for-obligation’

Theoretically, delivered green certificates may contain all kinds of determined (even, predetermined) physical conversion factors so that it would be known (even beforehand) how much heat is represented by, for example, the original PV production (e.g. in kWh). There is, however, a practical problem to map all relevant information with the certificate. It seems not sensible to aim at recording all possible conversions.

‘Redemption-for-conversion’ means that existing certificates are exchanged for new certificates and not handed over to fulfil an obligation. Therefore, some certificates are ‘eliminated’, e.g. when used as an input in an energy conversion process, and some others can be ‘created’, e.g. when the output of the energy conversion is certified. Note that only in the case of heat pumps, there are more green certificates created than eliminated. With efficiencies lower than 100%, part of the greenness will get ‘lost’, exactly as is the case with the physical energy. Thus, the most important benefit of using the early physical conversion (‘redemption-for-conversion’) method is that any particular efficiency of a plant used to convert energy is automatically accounted for.

5.4 Aim for production-based and general certification

When implementing a TGC system, it seems most easy (practical) to start with a national grid-based system with specific certification for the different energy carriers or, as it often happens now, to start with an electricity-only system. Gradually, some non-electricity options (possibly all calculated in kWh-equivalents in the first stage) can be added. Later on, non-grid options can be included. This may happen either before or after some internationalisation has occurred. It might be that specific certification enhances the process of harmonisation, as the number of agreements (on the conversion factors and units) is reduced. Finally, the step to a harmonised international, production-based system with general certification might be implemented, if this appears a clear improvement of the TGC system.

The more complicated option of a production-based system with general certificates is more in line with general renewable energy and climate change policy. For practical reasons it might be reasonable to start relatively simple, e.g. RE targets given in general energy terms, and to include the more complex issues gradually. However, it might also be the alternative case that RE and climate change policy grow toward more practically designed targets.

5.5 Put the obligation on the consumer and work on endorsement

The cost price effects of an obligation can be passed on to actors in the lower levels of the supply chain. However, consumers cannot do this, even not when they contract with suppliers to fulfil their obligation for them. The consumers will have to pay anyway for the greening of their consumption, which is in line with the ‘polluter pays’ principle. The alternative is to put the obligation on the producers. The producers may fail to incorporate the preference of the consumers of green energy for one or another energy carrier and/or technology. For long-term effectiveness of the TGC system, it is important to maximise its endorsement. This is achieved when the obliged actor is free to fulfil his obligation with the mix of energy carriers (and renewable technologies) he prefers. Note that, even in a system where the obligation is general, the certificates should still indicate the source of the renewable energy. Potential buyers of certificates can de-

cide, based on the information attached to the certificate and depending on the type of obligation they have (the obligation should specify which certificates are acceptable), which certificates to buy.

5.6 Prevent 'lock-in' in the demand for green certificates by putting obligations in general energy terms

When enforced by an obligation, the demand for green certificates is always time specific (even when some banking or borrowing is allowed). However, this demand does not in itself impose a time restriction on the supply of green certificates. In general, if green certificate suppliers are not forced to sell their certificates within a certain time limit, the demand obligation combined with a co-ordinated supply could force the TGC price to a very high level. If the demand is related to a carrier-specific obligation, the discrepancy will even expand. Two obvious ways to prevent 'lock-in' at the demand side is to make the obligation less rigid, for example general instead of specific, and to limit the tradability of TGCs in time.

5.7 Some considerations in an international context

The application of the listed recommendations will largely depend on the inclination for a country to work in an international TGC system. Some countries may prefer to start without waiting until difficult, time demanding processes to achieve European harmonisation are finished. Moreover, in the case a country just starts with its domestic system, it may indicate whether it is willing to grow towards a harmonised system. From a domestic point of view, it does not make sense to indicate whether the electricity that is represented by the certificate has received other kinds of support, like tax rebates or investment subsidies, since this is equal for all the renewable production installations. However, from an international perspective this kind of information can be essential. Either domestic certificates may only be accepted, or all certificates, wherever they are produced, may be valid. If only domestically produced certificates are valid, international trade in TGCs is prevented. If foreign certificates are valid too, the possibility to use foreign certificates to comply with a domestic obligation is depending on their availability on the market. The design of a fully harmonised system seems more complex due to the need to take into account national supply system characteristics and differing levels and modes of support for RE (which are sometimes indirect such as guaranteed grid access, favourable planning conditions).

However, it may be the case that no full harmonisation of the institutional framework is needed to start a TGC system even at the level of EU-15. In this scenario, countries do not necessarily have to agree on what is traded. Countries may limit the import of TGCs that they judge 'unacceptable', for instance excluding waste or large hydro, and allow other trade. It is however questionable if this is allowed in an EU context. Moreover, countries always may reduce the risks of importing TGCs that they would judge not suitable by increasing (if they have any) the quota that has to be performed within their national borders. Countries may also put some restrictions on, for instance, the kind of support like tax rebates or investment subsidies, but still participate in certificate trade to some extent. These restrictions would then appear through the detailed demand for green certificates, instead of generic demand. The TGC market would react (quickly if the detailed demand is large) to the disclosure of (new, foreign) preferences. These mixed situations of course would imply a decrease of the economic efficiency. However, it may be helpful to get experience with international trading and make progress in TGC trade anyhow. It means that countries may choose for themselves to acknowledge each other's certificates and their relative value. It is clear that for international trade to take place in the renewable energy sector, some internationally agreed procedures for issuing certificates must be put in place in order to 'certify' what is really produced. In a sense, this should merely be seen as a first step toward full integration and harmonisation, toward a future in which all incentive measures, and

many other things, have been harmonised, in a bubble or at the EU-15 level. The main warning is that a national system should be designed together with its own transition period and methodology developed for harmonising the national system with the proposed EU-15 system when it comes that far.

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