ELSEVIER

Energy Policy 34 (2006) 212–222

ENERGY POLICY

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# Tradable certificates for renewable electricity and energy savings

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Available online 16 September 2004

**Abstract**

Tradable green certificates (TGCs) schemes have been developed and tested in several European countries to foster market-driven penetration of renewables. These certificates guarantee that a specific volume of electricity is generated from renewable-energy source (RES). More recently certificates (tradable white certificates (TWCs)) for the electricity saved by demand-side energy-efficiency measures (EEMs) have been introduced in some European countries. Recent advances in information and communication technology have opened up new possibilities for improving energy efficiency and increasing utilization of RESs. Use of technological resources such as the Internet and smart metering can permit real-time issuing and trading of TGCs. These technologies could also permit issuing of TWC. This paper reviews current renewable TGC and TWCs schemes in Europe and describes the possibilities for combining them in an Internet-based system. In the proposed combined tradable certificate scheme, both RESs and demand-side EEMs could bid in real time through the Internet to meet a specific obligation. The energy savings from the demand-side measures would be equivalent to the same amount of green electricity production. The paper describes the needed common targets and obligations, the certificate trading rules and the possible monitoring protocol. In particular, the paper focuses on the TWCs verification issues, including the assessment of the baseline, as these poses additional problems for TWCs compared to TGCs.


*Keywords:* Tradable green certificates; End-use energy-savings certificates; Verification protocols

## 1. Introduction: the policy context

Under the Kyoto protocol, the European Union (EU) has agreed to reduce by 8% greenhouse gas (GHG) emissions between 2008 and 2012 relative to 1990 levels. As a result of the Kyoto agreement, GHG issues are playing a central role in EU energy and environmental policies.

In addition, new priorities in the EU strategy for sustainable development, adopted by the Gothenburg European Council in June 2001, include the following regarding demand-side energy efficiency and development of renewable-energy sources (RESs):

- Realize the potential for energy-efficiency improvements as far as economically possible, and reduce energy consumption by 1%/year to achieve two-thirds of the potential savings (18% by 2010) and thereby reduce $CO_2$ emissions by about 40% of the EU's Kyoto commitment.
- Double the share of electricity production from combined heat and power so that it reaches 18% by 2010 and avoids an estimated additional 65 million metric tonnes of $CO_2$ emissions.
- Develop the potential of RES, improve the quality of renewable technologies available on the market, and create optimum conditions for speeding up

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0301-4215/$ - see front matter © 2004 Published by Elsevier Ltd.
doi:10.1016/j.enpol.2004.08.026

investment by increasing installed capacity for energy production from RES, which would avoid an estimated 330 million metric tonnes of $CO_2$ emissions.
- Introduce programs and legislative measures to increase the consumption of RES (electricity, heating, bio-fuels) from 6% to 12% of EU gross energy consumption by 2010.
- Increase the share of electricity produced from RES to 22.1% by 2010.

The other main EU energy policy drive is to restructure electricity and gas markets. The structure, ownership, and regulation of the electricity and gas businesses in the EU's member states are much more diverse than in the US. Historically, energy entities have been state owned in some EU member states (e.g., France, Italy, and Portugal), owned by a mix of private and public/municipal companies in others (e.g., Germany and Sweden) and municipal-only companies in still others (e.g., Denmark and the Netherlands). These diverse business structures have been difficult to integrate into an internal EU energy market, and the adoption of a common EU energy-efficiency policy has, understandably, been challenging in this context. A European Directive (96/92/EC) adopted in 1996 established rules for an Internal Electricity Market: EU member states were required to introduce wholesale and minimal retail competition (for customers who consume more than 40 GWh/year) by 1999 (or 2000 for Belgium and Greece). However, the Directive, the product of a long process of negotiation, gave a great deal of freedom to member states in reconfiguring their markets to be competitive, and the market restructuring implemented so far by member states is at least as varied as were the various countries' energy industries before restructuring. Devising an energy-efficiency policy against this backdrop will require the identification of common interests without overlooking individual countries' needs.

To accelerate electricity market restructuring, the European Commission proposed a new Directive in 2001 (COM(2001)125 final), which calls for member states to give all non-domestic (i.e., industrial and commercial) electricity customers freedom to choose their electricity suppliers by 1 January 2003, and this freedom to all customers (i.e., 100% market opening) by 1 January 2005. In June 2003, the new Directive on the market liberalization was published (Directive 2003/54/EC). The following timetable for market opening was agreed: the electricity and gas markets will be fully liberalized by July 2004 for non-household customers, while all customers (including households) will be able to choose their supplier by 1 July 2007 at the latest. This process will take account of a report assessing the impact of liberalization to be presented by the Commission in 2006.

## 2. Tradable green certificate schemes for electricity from renewable sources

### 2.1. The renewable electricity Directive

The EU adopted a Directive in 2001 (2001/77/EC) to increase the share of green electricity from 14% to 22% of gross electricity consumption by 2010. This Directive will help double the share of energy met by RES from 6% to 12% of gross energy consumption in Europe by 2010 as indicated in the EU Renewable White Paper (COM (1997)599 b). Renewable energy still accounts for only a small fraction of the energy mix in the EU. However, as a result of technical progress and legislative and financial measures introduced by member states between 1989 and 1998, the wind-power sector has grown more than 2000% in 10 years. Nonetheless, renewable-energy production increased during the same period by only 32% for primary energy and 29% for electricity.

Directive 2001/77/EC establishes non-mandatory national targets for the portion of electricity consumption to be met by RES. These targets were negotiated among EU member states, the European Commission and the European Parliament. To achieve these targets, the Directive foresees continuation of national support schemes (mainly national feed-in tariffs, as in Germany and Spain) plus, if necessary, the creation of harmonized market-based support system compatible with the rules of the internal EU electricity market. The European Commission will monitor the progress of individual member states toward their national objective and will, if necessary, propose mandatory targets for member states that do not reach their goals. If all targets are met, renewable sources will cover 22% of the supply to gross inland electricity consumption by 2010.

The Directive requires a guarantee of the origin for green electricity; guarantee certificates must be reciprocally recognized by all EU member states. The guaranteed origin of green electricity could be included in mandatory labeling of electricity, which would disclose to the final user the generation mix for electricity supplied.

As a consequence of the Directive, the European Commission is to:

- assess national support schemes for electricity produced from RES,
- develop a market-based harmonized scheme, and
- establish tools for monitoring electricity produced from RES (and, if necessary, propose standard rules).

### 2.2. Tradable green certificates

One of the strategies that could help member states reach RES targets is the establishment of a market for tradable green certificates (TGCs). During the past few years, interest in tradable certificates has increased markedly in Europe and elsewhere, and markets have been established in a number of EU member states, including the UK, the Netherlands, Italy, Belgium (Flanders), Sweden, and Austria.

In principle, TGC schemes work as follows: a quantified obligation (quota) is imposed on one category of electricity system *operators* (generators, producers, wholesalers, retailers, or consumers) to supply or consume a certain percentage of electricity from renewable sources. On a settlement date, the operators must submit the required number of certificates to demonstrate compliance. Certificates can be obtained in three ways:

1. Operators can own their own renewable-energy generation, and each defined amount of energy (e.g., each 100 KWh) produced by these facilities would represent a certificate.
2. Operators can purchase electricity and associated certificates from eligible renewable electricity generators.
3. Operators can purchase certificates without purchasing the actual power from a generator or trader or via a broker, i.e. purchasing certificates that are traded independent from the power itself.[1]

Because of supply-side competition, a TGC system leads, under perfect market conditions (perfect price signals), to minimal generation costs for RESs (Technical University of Vienna, 2001) but only if there is surplus renewable generation beyond the demand for certificates.

The first voluntary TGC scheme was implemented in the Netherlands in 1998, although that system might have been more appropriately termed as a certified green electricity fiscal rebate system. Tradable renewable certificate systems are currently being proposed or implemented in Austria, Belgium, Italy, Sweden, the Netherlands (voluntary scheme) and the UK(ECN, 2001). The objective of a major EU research project, RECerT (ESD, 2001), was to ensure coordinated TGC market development and sharing of information and understanding among key EU stakeholders to minimize barriers to TGC trade among member states. By the conclusion of the RECerT project in July 2001, the idea of using market mechanisms to meet renewable-energy quotas or targets had moved into the mainstream of debate on renewable-energy policy. Now six EU member states are developing TGC schemes that conform to the same basic structure, which has three main elements:

- A tradable instrument representing the renewable-energy attribute of physical electricity and conferring property rights to the holder.
- The creation of demand for certificates through obligations, tax exemptions, etc.
- Institutional infrastructure and processes to support the schemes.

A voluntary harmonized pan-European scheme has been developed by RECS (www.recs.org). The scheme has been successfully tested during 2001–2003, during which 11.4 million MWh certificates have been issued, of which 3.5 million have already been used to guarantee to consumers the origin of the renewable energy they have purchased.

## 3. Tradable certificate schemes for energy savings

European experience with tradable energy-savings certificate (also known as tradable white certificates (TWCs)) schemes is limited. Policy debates have focused mainly on tradable permits for $CO_2$ emissions in response to the Kyoto Protocol. Many argue that emissions trading schemes (ETSs) should incorporate energy-efficiency measures (EEMs) because these measures reduce $CO_2$ emissions by reducing energy use. One difficulty in including EEMs in emissions trading is how to quantify the reduction in $CO_2$ emissions that results from an EEM, particularly for improvements in end-use efficiency.

For tradable permit systems both so-called direct and indirect emissions approaches are possible. The direct approach means that it is based on the physical source (*the pipe*). In that case, the actual emitters are obliged to purchase sufficient emission permits (what *sufficient* exactly constitutes depends on the kind of quota allocation and trading system chosen). The cost of the permits will be one way or the other accounted for in the product price of the products the emitters sell. As a consequence products with a high carbon content will become significantly more expensive and buyers will

[1]In a TGC scheme, each certificate is unique and associated with a defined and identified amount of electricity produced from renewable sources (e.g., 1 MWh of wind energy produced on date and time *xy* by generator *zz*). The purchase of a certificate without the purchase of the associated power would in any case transfer the ownership of the *greenness* of the renewable electricity produced from the original power producer to the new market actor and therefore would prevent the original power producer from claiming that they have ownership of the amount of *green* energy that the certificate represents. The owner of the certificate can then dispose of it to meet its obligations or to get tax incentives that authorities may pay to power producers for development of additional RES generation capacity. Therefore, purchase of a certificate even without the associated power contributes to the development of RES capacity.

respond by consuming less or switching to an alternative with less price rise (which presumably, but not certainly, is also less carbon intensive). So, the direct approach only indirectly gives some incitement to energy savings as a means to consume less carbon intensive products without loosing the desired service level. Furthermore, cost differences between product alternatives are not only caused by carbon intensity.

The indirect approach on the other hand is based on the idea that the final users, who are causing the whole production chain, should see more precisely what the carbon intensity is. The price rise of the emitters' product (i.e., electricity) may not be not sufficiently accurate. In the indirect approach, the final users get allotted emission quota based on a baseline energy mix they would commonly purchase. In this case, the signal to use less fossil fuel gets through very precisely. Recently, the European Commission adopted a proposal for emissions trading (COM(2001)581 final) to reduce GHG emissions. The Directive (2003/87/EC) was adopted on 13 October 2003, allowing emission trading in some sectors to start in 2005. In the EU ETS, the indirect system is not chosen—among other things—because of its complications with respect to monitoring and inspection, especially at an international scale. However, it also means that the guidance of energy efficiency for companies inside the trading system is only indirect (even though there are references to BAT procedures in the Directive, coming from another Directive, the IPPC).

Sectors outside the emission trading system are influenced by the so-called initial division of reduction tasks between trading and non-trading sectors. If member states wish to favor the more export oriented companies inside the EU ETS, they end up with having to demand more efforts from other sectors in order to fulfill the overall target. Energy saving is a rather important option for those non-trading sectors, e.g. in the case of space heating. However, for electricity saving this is less the case since the benefit of less emissions remains with the power generation sector.

Under these circumstances policy makers may wish to seek for additional means to get more energy saving realized outside the sectors belonging to the EU ETS. Rather than imposing sector specific efficiency obligations policy makers could choose to introduce a tradable electricity saving permit in conjunction with electricity saving quota. The same logic applies here as in the emission permit trade. Instead of having to realize every bit of electricity saving in the own company or sector, one may look for sectors and companies where that can be achieved at lower unit cost. If the reduction in unit cost of saved MWh and overall amounts are sufficiently large compared to the—likely—extra transaction cost of the TWC system, the white certificate system is worth trying.

Renewable sources are not covered by the ETS because these sources do not emit $CO_2$. Therefore, the renewable-energy certificates are not integrated with the GHG allowances needed for compliance with the obligations of the draft Directive.

With the gradual opening of European electricity and gas markets to competition, new market-compatible tools are needed to promote energy efficiency in end-use. One possible market-based policy could be energy-savings quotas for some category of operators (distributors, consumers, etc.) coupled with a trading system for EEMs resulting in energy savings. The savings would be verified and certified by the *white* certificates. This scheme would also allow market participants (e.g., ESCOs or manufacturers), who are not covered by the quotas to invest in end-use energy-efficiency projects and sell the associated certificates (and energy savings) to the operators who must meet the quotas.

Recently, an innovative policy mix introduced in Italy combines command-and-control measures (i.e., energy-savings targets for electricity distributors), market instruments (tradable energy-efficiency certificates issued both to distributors and energy service companies), and tariff mechanisms (cost-recovery mechanisms through electricity rates) (Malaman and Pavan, 2002). The proposed Italian system is not currently integrated with the RES TGC scheme that is already in force in Italy. The Italian scheme will be operational in January 2004; however, the first check on the compliance with the obligations will be accrued in mid-2005.

The Australian TGC scheme for electricity from RES allows creation of certificates for solar water heaters based on the electricity consumption they displace; this is an example of integrating demand-side options (displacement of electricity) in TGC schemes (Andrews, 2001).

In the UK, the energy-efficiency commitment (EEC) program requires that all energy suppliers with 15,000 or more domestic customers must encourage or assist those customers to take EEMs in their home. Suppliers may trade either energy savings from approved measures or obligations to another supplier, with written agreement from the regulatory office (Costyn, 2002). In this scheme, it is also allowed that suppliers will be able to trade excess energy savings into the national ETS as carbon savings. The rules and mechanisms will be devised by the UK Department of Environment and OFGEM, when the emissions trading policy is finalized (Costyn, 2002).

More recently some other EU Member States have announced their intention to introduce a TWC scheme; among these there is France and possibly Sweden. TWC schemes will attract more and more the interest of national policy makers, as the new proposal for a Directive on Energy End-Use Efficiency and Energy Services (COM(2003) 739 final), recently adopted by the

European Commissions, says in Article 4 "the Commission will examine whether it is appropriate to come forward with a proposal for a Directive to develop further the market approach in energy efficiency by means of 'white certificates'". The proposal gives also the following clear definition of White Certificate: "'*White certificates*': certificates issued by independent certifying bodies confirming the claims of market actors for savings of energy, as a consequence of energy end-use efficiency measures."

Common issues raised by energy-efficiency certificate schemes already under way are: setting the policy goal (electricity savings, primary energy savings, carbon savings, etc.); setting the obligations to create the demand for certificates; defining which market *actors* (e.g., electricity distributors, etc.) would be subject to the obligation; setting the rules for issuing of the energy-savings certificate; which are the annual energy-savings targets; who can certify the savings and issue the certificates; who can get certificates; who must hold the certificates at the end of the periods; who will redeem them; what technologies and projects are eligible, what the redemption period should be, how to arrange banking and borrowing, etc.; and finally defining a non-compliance regime (sanctions), and the trading rule (certificates exchange and/or bilateral contracts).

In general, it is important to separate the rules for the issue of the certificates from the rule of the trading of the certificates. The certificate is an instrument that may be useful for different energy policies, such as tax credits, incentives, obligations (e.g., an end-user has to have certificates to prove that he has saved 10% over the previous year), etc.

The basic principle for the certificate is that a certain amount of energy is saved compared to a reference scenario. The choice of the reference scenario offers some difficulties. At the moment, however, there are a lot of activities and research in this area as it has some common issues with other policy instrument, e.g. JIs and CDMs in climate change mitigation. The Executive Board of the Kyoto Protocol's Clean Development Mechanism has recently approved the first two baseline and monitoring methodologies, thus giving a major boost to the CDM. Baseline and monitoring methodologies play a key role in determining how well the CDM functions as they help ensure that emission reduction credits claimed by CDM projects are legitimate.

The same holds true for TWC schemes. The saved energy resulting from an EEM could be measured at the end of a predetermined period (e.g., after 1 year) or over the life time of the project (which has to be accurately assessed). The certificate can be equal to the energy saved over the period or the life time of the project or could be issued when a certain amount of energy savings has been achieved (e.g., 1 MWh). The latter option will make the system more simple and more comparable to the TGC scheme. When a 1 MWh certificate will be issued, the certificate will have a unique time and place of issue attached to it, to indicate the period over which the energy has been saved, by whom it has been saved (initial owner of the certificate) and the location of the savings. It is important that each certificate is unique, traceable, and at any time it has a single owner. No other certificate should be issued for the same energy-saving or energy-efficiency action. This very important notion is missing in some of the early energy-efficiency certificate schemes where the whole potential energy savings of an energy-efficiency action is assumed a priory and an equivalent certificate is issued.

The validity and the ownership transfer rules of the certificate will be decided by the trading rules. For example, the trading systems may allow for banking or borrowing, but this does not modify the value of the certificate, i.e. that a measured amount of energy has been saved, during a specific time, and in a specific location as results of an energy-efficiency action. As discussed later in the paper, it is important that a reference consumption and conditions are allocated to each participant in the scheme under obligation. This is the major difference with the RES scheme where effective electricity production can be measured without any reference, even if only additional generation capacity is allowed in the scheme for a limited amount of time, because at each additional supply it is possible to add a meter and check the electricity production after a certain period (or during a specified period).

If the electricity savings cannot be metered then more problems appear, as a certain estimation of the energy saving for specific measure must be carried out. For example, the saving resulting from the replacement of a refrigerator with one in class A+ is calculated on the difference to the installed average or the sales average (we have already a first approximation, one which could be underestimating the energy savings and one which may be overestimating the energy savings). The savings $XY$ kWh/year can be calculated and each time the basic unit of the certificate is reached the equivalent certificate will be issued. If after a certain period the appliance is changed or fails, the issuing of certificates linked to that appliance should stop.

Another important aspect that has to be discussed is whether to include in the certificate saving measures, which do not include energy-efficiency improvements but behavioral changes. For example, the user may decide to switch off equipment, decrease the set point (heating/cooling) or decrease the size of equipment (e.g., refrigerator). This, however, may conflict as described later with structural or temporal changes forced on the participants by other circumstances. For example, a contraction (e.g., an empty hotel) or a smaller production output will result in energy savings. At the same time it shall not penalize companies that are in a business expansion phase which will result in more consumption. The scheme may ex post adjust the certificates for climatic condition, e.g. a very hot summer or a cold winter, and/or production levels.

## 4. Verification methods

One of the main implementation issues for TWCs is choosing a verification system for energy-efficiency projects (using standard values for energy saved by particular measures vs. directly measuring savings) and setting baselines (*business-as-usual* scenarios) to measure the impact of projects.

One of the frequently used protocols to verify energy savings is the International Performance Measurement and Verification Protocol (IPMVP, 2001) (www.ipmvp.org). IPMVP provides an overview of current best practice techniques available for verifying results of energy-efficiency projects in commercial and industrial facilities. It may also be used by facility operators to assess and improve facility performance. Energy conservation measures covered in the protocol include fuel saving measures, water efficiency measures, load shifting and energy reductions through installation or retrofit of equipment, and/or modification of operating procedures. In 2001, a revised addition of the IPMVP was issued. It builds on the excellent history and working knowledge gained from previous editions (Hansen, 2002). The general framework of the MVP builds around four M&V options. Those options are:

- *Option A: Partially measured retrofit isolation*. Savings are determined by partial field measurement (some, but not all, parameters may be stipulated) of the energy use of the system(s) to which an EEM is applied, separate from the energy use of the rest of the facility. Measurements may be either short term or continuous. This option involves the isolation of the energy use of the equipment/system affected by an EEM from the rest of the facility.
- *Option B: Retrofit isolation*. The savings determination techniques of Option B are identical to those of Option A except that no stipulations are allowed under B. Full measurement is required. Savings are determined by field measurement of the energy use of the systems to which the EEM is applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit.
- *Option C: Whole building*. Option C is often referred to as the *Whole Building* approach; however, this option can be used for part of a building. It determines the collective savings of all EEMs applied to that part of the facility monitored by a single meter. Short-term or continuous measurements are taken throughout the post-retrofit period. Option C usually relies on *continuous* measurement of whole-facility energy use and electric demand for a specific time before retrofit (base-year) and *continuous* measurement of the whole-facility energy use and demand, post-installation. Measurements may be taken on a periodic basis if acceptable to all parties involved.
- *Option D: Calibrated simulation*. Savings are determined through computer-based simulation of the energy use of components of the whole facility. Simulation routines must be calibrated so they predict an energy use and demand pattern that reasonably matches actual energy consumption. Caution is warranted, as this option typically requires considerable skill in calibrated simulation and considerable data input; so the process can be quite costly.

## 5. Recent technological developments

Demand-side strategies using the Internet and/or advanced metering have been developed mainly to buy and sell electricity (Douglas et al., 2000), to get real-time load curtailments (Bonneville Power Administration (BPA), 2001), and to optimize loads on the electricity network (BPA, 2001). In particular, the EnergyWeb concept developed by BPA foresees the "…integration of the utility electrical system, telecommunications system, and the energy market to optimize loads on the electrical network, reduce costs to consumers and utilities, facilitate the integration of renewable resources, increase electrical system reliability and reduce environmental impacts of load growth. Currently the commercialization of new technologies is converging with deregulation to transform a centrally planned utility hierarchy into an energy web. Examples of technology that will enable the EnergyWeb to be discussed include: emerging small-scale generation technologies, enabling technologies such as smart metering, energy storage systems and telecommunications, expanding range of renewables and environmental considerations, new energy efficiency technologies that are Internet enabled, evolutions in power grid control technologies ('chips talking to chips')…" (Hoffman, 2001).

In parallel with policy developments regarding energy-efficiency certificates, a new range of *intelligent* end-use equipment has been introduced to the market, including white goods with Internet connection/control (e.g., some commercially available appliances presented at the Lonworld Fair in October 2001, Frankfurt), Internet-based building control systems (Echelon), and smart metering (the largest Italian utility, ENEL, has started to install digital meters for its 22 million residential customers in 2003).

Another relevant development is the recent research and experimentation on dynamic pricing and demand response. Demand response refers to the capacity of electricity customers to reduce their consumption as prices rise on an hourly basis in wholesale markets or to reduce their consumption in response to emergency calls for curtailment or reduced load to forestall the need to implement rolling blackouts. These developments have taken place in the US, mainly in California following the year 2000 electricity crisis. Time of use tariffs, real-time pricing, and critical peak pricing have shown to help enhance system reliability, reduce power purchase and individual consumer costs, and to protect the environment (Herter et al., 2002).

## 6. Aim of the *Internet Trading* project

The aim of the European Commission Joint Research Centre (JRC) *Internet Trading*[2] research project is to design and test a reliable, universal, open, inexpensive system to trade certificates for both RES and demand-side options (including energy-efficiency improvements resulting in energy savings) through the Internet. The project is intended to assess the practical implementation of the system and to test the *rules of the game*.

The final system will support EU policy goals of:

- serving 22% of electricity consumption through RES (RES-E Directive goal),
- monitoring renewable electricity generation and efficiency measures, and
- facilitating energy-efficiency improvements in the electricity end-use sector.

### 6.1. Certification

The first aim of the Internet Trading project is to certify RES electricity so consumers can have confidence that when they purchase green electricity (in most cases for a price premium), they will get what they pay for. The aim is to create an open, universal, reliable, and cheap system to provide customers with the Guarantee of Origin certificate as required by the RES-E Directive. In a scheme for the Guarantee of Origin, the consumer gets and *holds* the green energy certificate for the amount equal to the RES electricity s/he has purchased and consumed, as proof of his purchase; a central system records the transaction and it may also allocate the green energy premium paid by the consumer to the power producer. At the same time, the system can also be used for checking renewable generation obligations on power producers (with or without trading). The last and more innovative use of the scheme would be to use it also to certify end-use energy-savings measure and EEM and their results (as metered or assessed using monitoring and verification procedures based on crediting standard savings amounts for particular measures).

### 6.2. Creation of a certificate market

The second and more innovative aim of the Internet Trading project is to create a real market for certificates, which may also allow for the creation of derivative products (such as *sell* and *buy* options, futures, banking, borrowing, etc.). Since the market can be created only if there is demand, demand must be created by imposing quotas or obligations for green electricity consumption and/or energy savings. Quotas for using RES electricity are already in force in the TGC schemes in some countries mentioned earlier in this paper, and energy-savings quotas/obligations have been introduced in the UK and Italy. An obligation that covers both RES electricity and energy efficiency requires careful consideration and it has not yet introduced in any country. In Europe, there are as yet no schemes that allow for the trading of both types of certificates in a single market under a single obligation or set of obligations.

## 7. The rules of the game

The rules of the game must be designed to stimulate new, additional investments in end-use energy efficiency and RES. A key concern is rules for issuing certificates for demand-side options. Energy produced from RES can easily be metered, but there are many complications in quantifying the savings represented by EEMs.

### 7.1. Verification of energy savings

Verification of the savings to be achieved is a key challenge in white certificate schemes. Possible approaches for example are:

- *The metering approach*: Metering real electricity consumption and calculating savings (which could be adjusted for climate and weather conditions) based on consumption before and after the energy-efficiency improvement is carried out.
- *The standard savings factors approach*: Using standard savings factors for EEMs (e.g., a given number of CFLs installed is equivalent to a given number of kWh of energy saved). This approach is allowed in the current Italian scheme.

Although the metering approach would be a more accurate guarantee of energy saved than could be provided by the standard factors approach (which could

[2]The *Internet Trading* project is a small project with a limited budget.

not verify such details as where CFLs are installed, what their operating hours are, etc.), a number of issues must be clarified for the metering approach, including how to address situations in which:

1. a consumer purchases a larger high-efficiency device rather than the standard, commonly installed model, resulting in an increase in consumption but a gain in efficiency;
2. a company cuts production during a slow period or an individual goes on vacation, resulting in a sharp decrease in energy use but no long-term efficiency gain.

One solution to concerns such as these would be to use the metering approaches and to take into account the conditions prevailing in the facility, which would affect the energy-efficiency project. Before being granted a certificate, operators could be required to describe the EEMs they are implementing and provide metered data before and after the implementation of the measures as well as any *standard* information and conditions (whether, activity, etc.) needed to evaluate the measures (e.g., their load profile).

For instance:

1. If the work force increases or decreases by 10% and everybody uses computers then any HVAC-related measure must account for the increased/decreased cooling load resulting from the higher/lower number of people and computers.
2. If the temperature or humidity set point is changed before and after the retrofit, it will also have a bearing on the total energy consumption and the resulting energy savings.

Regarding the issue of efficiency vs. use, it really depends on what the operating hours are for the piece of equipment or appliance. The appliance or equipment should not be penalized for people's behavior.

Moreover, if, e.g., an end-user installs a more efficient commercial refrigerator, which is larger than the one being replaced, it should be possible to calculate the electricity consumption of a non-energy-efficient refrigerator of the same dimensions as the new one. This is a matter of setting the right baseline and using it for energy-savings determination purposes. To this end the IPMVP offers a good solution to verify the savings.

In order to reduce the volatility (and thereby the average reliability) of *certified savings* it would be better if a certificate represents a package of measures and refer to longer time periods (several years) in order to smooth out hardly controllable variations, such as caused by weather. In that case, there is more leeway for internal compensation between more and less successful elements.

The Internet Trading project will test this approach and aims to demonstrate the feasibility of the metered verification approach using Internet connections, and then calculate for changing in size, usage patterns, and set points.

### 7.2. Obligations

As discussed above, the right obligations or quotas are essential to create a demand for certificates and as a consequence the trading in certificate schemes for green electricity and EEMs.[3] The obligations imposed on operators must cover electricity produced from RES as well as energy-efficiency improvements. Operators would have to demonstrate that a certain portion of electricity consumption is served by RES (this obligation can be imposed either on users or on distributors) or that an equivalent amount is saved through efficiency improvements.

In such a scheme, the operator would have the following options:

1. to produce electricity from RES (for its own use and/ or to sell);
2. to buy electricity produced from RES and the associated certificates;
3. to reduce electricity consumption through an EEM (e.g., by installing efficient equipment, controlling, and shedding load), either on its own premises (for consumers) or on the premises of clients (for distributors);
4. to implement a combination of the above;
5. to buy certificates only, without the associated energy (from another operator who must also meet the quotas, a trader, or an energy service company).

If the green electricity/energy-savings obligation applies for a defined period (e.g., 1 year), then the RES certificate price may be very high during that period, and the incentives to self-produce (e.g., through co-generation or photovoltaic (PV) technology), shed load, or invest in energy efficiency could be very strong. This is one of the main attractions of the system; the demand-side/energy-efficiency option could compete fairly with clean electricity generation from RES. From the point of view of economic efficiency, integration of the supply and demand options should result in the lowest cost for consumers and society.

Several demand-side possibilities are currently under evaluation. One, already tested by BPA, is to give load-

[3] Of course the policy goal is to achieve the overall goals, by assuring that the obligations are met. The trading is desirable (and a certain liquidity in the market) as this would lead to the lowest-cost options been implemented first, and therefore the overall objective is reached at lower costs for the society (provided the transaction costs are low and comparable to the one of the other policy instruments).

shedding options to the electricity consumer: by freeing capacity, the consumer becomes as a *virtual* generator. This scheme will be further evaluated to ensure that it can address both power savings (which consumers can achieve without undertaking specific efficiency improvements—and to be sold in the electricity spot market) and energy savings through efficiency improvements (which may result in a load increase, e.g. in a company, which increases production after making an efficiency improvement—to be sold in the certificate market). This strategy would mirror most RES TGC schemes where the *greenness* of the electricity is separate from the electricity itself: for the demand side the power savings would be separated from the energy savings. Moreover, as RES TGC schemes in which only *additional* RES generation capacity is eligible for certificates, valid for a certain number of years, as a means of stimulating investment in additional RES generation capacity, the same could be done for WTCs schemes.

The system would allow for trading of demand-side options (e.g., load-shedding and/or energy-efficiency investments) and sale of the unused power (also often called *negawatt*; this would be sold on the power market) and/or of the energy savings certified by the associated certificate, or a combination, according the power and certificate spot price. A market would be created (on the Internet) that allows price comparisons between electricity from RES and demand-side options on the separate markets, the power and the certificates. This should drive investments toward the cheapest option.

The issuing of certificates for energy efficiency is one of the most difficult issues in the development of a demand-side scheme, given the very large number of possible electricity efficiency improvements and the difficulty of evaluating them (as explained above, metering alone cannot address all situations).

## 8. Overview of the project

The Internet Trading project will set up a simple, Internet-connected system that can be attached to electricity production and consumption units to communicate information to a server about energy produced/consumed and energy *saved*. Information—i.e., *certificates*—can also be traded between the electricity-consuming and electricity-producing subsystems. Certificate flow must be separated from the physical electricity flow, so two parallel, separate markets must be established.

The central server must be able to store information about transactions so that it can *dispense* certificates and provide aggregated data about transactions involving specific producers or consumers (for physical electricity flow and certificate trade).

The characteristics of the combined system can be divided according to the functions of the subsystems:

- the system connected to electricity producer,
- the central server, and
- the system connected to electricity consumer.

The central server must accept incoming connections from energy producers and consumers and must be able to provide information about transactions to interested parties (the system administrator, owners of energy-producing and energy-consuming subsystems, owners of certificates, traders, etc.). The distributed and asynchronous nature of the system suggests the need for a relational database to store information about outstanding and used certificates and transactions.

The various registered *customers* of the system should be able to get relevant information, including energy produced and consumed, weather data, changes in production and consumption, load profiles, etc. This information should be available for registered participants via a web interface.

The tasks of the electricity producer subsystem are to:

- Get information from the energy production unit about the amount of energy produced.
- When a certain amount of energy has been produced (e.g., 10 kWh), send information to the central server.
- If a connection cannot be established, take emergency action to avoid losing data, such as saving data locally and trying to send the data later. The hardware must at least be able to communicate with the sensor (e.g., a pulse meter) that registers the power produced and to connect to the Internet via modem, DSL or wireless technology.

Most of the specifications for the energy production subsystem are also valid for the electricity consumer subsystem. Energy consumers will typically be small scale, so the system necessary for *buying* certificates and detecting that they are being used should be even simpler than the energy production subsystem.

## 9. Test experimental setup

The systems will be tested using several PV panels installed at the European Commission JRC. Each PV module will be allocated to a *virtual generator*; the electricity consumers will be individual offices in a single building at JRC, and lighting and office equipment energy consumption will be monitored in these offices. The main demand options available are shedding load by switching off lighting and office equipment or utilizing power management features of office equipment. Investments can also be made to improve lighting system energy efficiency (e.g., to increase daylighting, install occupancy sensors and efficient luminaries, etc.).

The system will be tested by imposing monthly quotas on consumers for using PV-generated electricity or reducing consumption (available PV power varies according to weather conditions and is not sufficient to serve all lighting energy consumption in the offices). Each participant will receive a virtual budget to use in choosing efficiency and renewable-energy (PV) options. The budget can be used to buy additional PV power not yet in the system but available on site or to invest in energy-efficiency options.

## 10. Conclusions

The experiment is more a test of the instrument, and hence its actual effectiveness can be more accurately judged after a year or more of experience. The test aims at providing some answers for the many question raised in this paper.

As a result of the advent of widespread Internet use, advanced meters, and the possibility of connecting/controlling end-use equipment by means of the Internet, a market-based instrument has been proposed to simultaneously promote use of electricity generated from RES and demand-side end-use efficiency measures resulting in energy savings. An Internet system linked to real metering has been described as the most viable solutions if the scheme would have a large number of operators. The technology is already available, but of course not yet installed in large quantities. This would simplify verification issue and reduce transaction costs.

TGC schemes for electricity from RES have been employed in a number of EU member states and other countries; however, the first trading schemes for demand-side efficiency measures or TWCs are just being introduced in Italy, and therefore there is still a debate whether this policy instrument will deliver savings and will be cost-effective.

Despite their common impact on electricity generation and GHG emissions, the TWC schemes are not integrated with RES TGC schemes, this requires careful consideration and setting of common obligations.

Both TWC and RES TGC schemes could be also linked to the Emission Trading scheme,[4] as both schemes may result in $CO_2$ emissions reduction, and these can be calculated. The carbon value to each certificate could be calculated and included in the certificate (even in a more sophisticated way then national or EU averages). Both the electricity (or energy) savings and the carbon savings may be verified and used to proof compliance with some obligations. The possible advantage of a combined schemes is that once one of the two values is redeemed (the energy or the carbon) the certificate would be declared not anymore valid and therefore expired, this would avoid double counting. What is important is the traceably of each certificate (date and place of issue, and current ownership).

The same certificate could be used also for other policy instruments such as incentives, special tariff, taxation, etc., also in this case the double counting could be avoided through the use of the database and the principle of redemption.

As described in the paper, energy-savings certificate schemes are more complicated than RES TGC schemes, so integrating the two entails additional challenges and difficulties, some of which could be addressed by combining Internet and smart-metering capabilities. The key design issues for an Internet-based system, which include verification methods and quotas for participants, will be tested in a small-scale project supported by the European Commission. The experiment is designed to prove the feasibility of the system and to test both the technical components (hardware and software) and the *rules of the game* that will stimulate the most economically efficient investments in sustainable energy solutions. In parallel, the further development and testing of TWCs schemes are needed to prove the effectiveness and cost-effectiveness of this instrument.

[4]This is not possible in the EU ETS, which allocates the emission allowance only to some industrial sector and to power producers. However, when an end-user reduces its electricity consumption, he will reduce the $CO_2$ emissions of the power producer which is supplying him electricity. The end-use certificate scheme could be used to transfer part of the benefits that the power producers receive by lowering its $CO_2$ emission to the actor who has actually implemented the measure and saved energy.

## References

Andrews, G., 2001. Market based instruments: Australia experience with trading renewable energy certificates. Proceedings of the UNFCCC Workshop on Good Practices in Policies and Measures, Copenhagen, Denmark, October 2001.

Costyn, J., 2002. Certificate trading for UK's energy efficiency commitment. Paper presented at IEA/CESI Workshop on Energy Efficiency Certificate Trading, Milan, Italy, April 2002.

Douglas, P., et al., 2000. Bidenergy.com—Internet based energy analysis and procurement. Proceedings of the ACEEE 2000 Summer Study on Energy Efficiency in Buildings. Washington, DC: American Council for an Energy-Efficient Economy.

ECN, the Netherlands, 2001. InTraCert: the role of an integrated tradable green certificate system in a liberalising market. Study for the European Commission, Final Report, Brussels, Belgium.

ESD, the UK, 2001. RECerT: the European renewable electricity certificate trading project. Study for the European Commission, Final Report, Brussels, Belgium.

Hansen, S., 2002. Manual for Intelligent Energy Systems. The Fairmont Press, Lilburn, Georgia, US.

Herter, K, et al., 2002. Rates and technologies for mass-market demand response. Proceedings of the ACEEE 2002 Summer Study on Energy Efficiency in Buildings. Washington, DC: American Council for an Energy-Efficient Economy.

Hoffman, M., 2001. EnergyWeb. Poster at the ECEEE 2001 Summer Study on Energy Efficiency, Mandelieu, France, June 2001.

IPMVP, 2001. The International Performance Measurement and Verification Protocol. Available also at: http://www.ipmvp.org.

Malaman, R., Pavan, M., 2002. Market-based policy approaches for end-use energy efficiency promotion. Proceedings of the IEECB '02 Conference on Energy Efficiency in Commercial Buildings, Nice, France, May 2002.

Technical University of Vienna, Austria, 2001. ELGREEN: organising a joint European Electricity Market. Study for the European Commission, Final Report, Brussels, Belgium.