Design of a New Scheme for Tradable Certificates for Renewable Electricity and Energy Efficiency

Paolo Bertoldi and Thomas Huld
European Commission – DG Joint Research Centre
Institute for Environment and Sustainability
T.P. 450, I-21020 Ispra (VA)
E-mail: paolo.bertoldi@cec.eu.int

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Abstract

Recent advances in information and communications technology have opened up new possibilities for improving energy efficiency and increasing utilization of renewable energy sources (RES). Use of technological resources such as the internet and smart metering can permit real-time trading of "green" energy certificates, which guarantee that a specific percentage of power is generated from RES, and could also permit simultaneous trading in green energy certificates and certificates for the amounts of electricity saved by demand-side energy-efficiency measures.

Tradable green certificate (TGC) schemes have been developed and tested in several European countries to foster market-driven penetration of renewables. This paper reviews current renewable TGC schemes in Europe, describes the possibilities for combining them with demand-side management strategies in an internet-based system, and assesses the potential for new policy measures in restructured European electricity markets. In the proposed combined tradable certificate scheme, both renewable energy sources and demand-side energy-efficiency measures could be bid in real time through the internet to meet a defined level of power demand. The savings from the demand-side measures would count in place of a percentage of green electricity production. Trading rules and a monitoring protocol have been developed to ensure that the market achieves a specified percentage of green electricity production. A demonstration project to prove the feasibility of this tradable renewable energy/demand-side energy-efficiency scheme is currently being carried out by the European Commission Joint Research Centre (JRC).

Introduction: the policy context

Under the Kyoto protocol, the European Union (EU) has agreed to reduce by 8 percent 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:

- Realize the potential for energy-efficiency improvements as far as economically possible, and reduce energy consumption by 1 percent per year to achieve two-thirds of the potential savings (18 percent by 2010) and thereby reduce CO_2 emissions by about 40 percent of the EU's Kyoto commitment;
- Double the share of electricity production from combined heat and power so that it reaches 18 percent 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 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 percent of EU gross energy consumption by 2010;
- Increase the share of electricity produced from RES to 22.1 percent 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 U.S. 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 January 1, 2003, and this freedom to all customers (i.e. 100% market opening) by January 1, 2005. In November 2002 a political agreement was reached in Council. 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.

Tradable Green Certificate Schemes for Electricity from Renewable Sources

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 percent of gross electricity consumption by 2010. This directive will help double the share of electricity demand met by RES from 6 to 12 percent of gross energy consumption in Europe by 2010. 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 2,000 percent in 10 years. Nonetheless, renewable energy production increased during the same period by only 32 percent for primary energy and 29 percent 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, electricity consumption from renewable sources will rise to 22 percent of gross 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 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).

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, Austria, and Denmark.

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 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 renewable energy sources (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. Tradable renewable certificate systems are currently being proposed or implemented in Austria, Belgium, Denmark, Italy, Sweden, and the UK. 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.

Tradable Certificate Schemes for Energy Efficiency

European experience with tradable energy efficiency-certificate schemes is limited. Policy debates have focused mainly on tradable permits for CO_2 emissions in response to the Kyoto Protocol. However, many argue that emissions trading should incorporate energy-efficiency measures because these measures reduce CO_2 emissions by reducing energy use. One difficulty in including energy-efficiency measures in emissions trading is how to quantify the reduction in CO_2 emissions that results from an energy-efficiency measure, particularly for improvements in end-use efficiency.

Recently, the European Commission adopted a proposal for emissions trading (COM(2001)581 final) to reduce GHG emissions. The political agreement on the proposal was reached on 9 December 2002, allowing emission trading in some sectors to start in 2005. The proposal also addresses energy efficiency but only for large industrial and power-production installations for which emissions allowances are allocated. Since the proposed emissions-trading scheme covers only direct emissions, it excludes end-use energy-efficiency options. Renewable sources are not covered by the emissions trading scheme 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-efficiency quotas for some category of operators (distributors, consumers, etc.) coupled with a trading system for energy-efficiency measure certificates. This scheme would allow market participants who are not covered by the quotas to invest in end-use energy efficiency and sell the associated certificates 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 2002). The proposed Italian system is not currently integrated with the RES TGC scheme that is

[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). Therefore, the purchase of a certificate without the purchase of the associated power would remove that certificate from the market and therefore prevent any other operators from claiming that they have used the amount of green energy that the certificate represents. In addition, the price of the certificate is often the source of the premium that authorities 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.

already in force in Italy. The Italian scheme is operational since January 2002, however the first check on the compliance with the obligations will be accrued in mid-2004.

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 energy-efficiency measures in their home. Suppliers may trade either energy savings from approved measures or obligations to another supplier, with written agreement from the regulatory office (Ofgem). It is expected that suppliers will be able to trade excess energy savings into the national emissions trading scheme 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).

Common issues raised by green energy certificate schemes already under way are: defining rules for energy-efficiency certificate trading (who can issue certificates, who must redeem them, what technologies are eligible, what the redemption period should be, how to arrange banking and borrowing, etc.) and defining a non-compliance regime (sanctions).

Verification methods

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

One of the most used protocol to verify energy savings is the International Performance Measurement and Verification Protocol (MVP) (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). 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 energy efficiency measure (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.

Recent developments

Demand-side strategies using the internet and/or advanced metering have been developed mainly to buy and sell electricity (eBidenergy.com), to get real-time load curtailments [Bonneville Power Administration (BPA)], and to optimize loads on the electricity network (BPA). 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., Samsung and Merloni Elettrodomestici 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).

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) 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 percent 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.

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 a open, universal, reliable and cheap system to provide customers with the Guarantee of Origin certificate as required by the RES-E directive. In principle, the consumer buys and destroys the green energy certificate for the amount equal to the RES electricity s/he has purchased and consumed; a central system records the transaction and allocates the green energy premium to the producer. At the same time, the system can also certify end-use energy savings and energy-efficiency measures and their results (as metered or assessed using monitoring and verification procedures based on crediting standard savings amounts for particular measures).

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 countries mentioned earlier in this paper, and energy-efficiency quotas/obligations have been introduced in the UK and Italy. An obligation that covers both RES electricity and energy efficiency requires careful consideration. 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.

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 energy-efficiency measures.

[2] The "Internet trading" project is a small project with a limited budget.

Verification of energy savings

The first problem to solve related to certificates for energy-efficiency measures is verification of the savings from these measures. Possible approaches include:

- 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, or
- The Standard Savings Factors Approach – using standard savings factors for energy-efficiency measures (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 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 high-efficiency device rather than the standard, commonly installed model, resulting in an increase in load 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 energy-efficiency measures they are implementing and provide metered data before and after the implementation of the measures as well as any “standard” information 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 no. of people and computers.
2. if the temperature or humidity set point is changed before and after the retrofit, it'll 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 is for the piece of equipment or appliance. The appliance or equipment should not be penalized for people's behavior.

Moreover, if a end-user installs for example, a more efficient commercial refrigerator that is also 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 offer a good solution to verify the savings.

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.

Obligations

As discussed above, obligations or quotas are crucial to create viable tradable certificate schemes for green electricity and energy-efficiency measures. The obligations imposed on operators must cover electricity produced from RES as well as energy-efficiency improvements. Operators would have to verify that a certain portion of electricity consumption is served by RES (this obligation can be imposed on users or 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 (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-efficiency obligation applies for a defined period (e.g., one year), then the RES certificate price may be very high during that period, and the incentives to self-produce (e.g., through cogeneration or photovoltaic 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.

The system would allow for trading of demand-side options (e.g., load shedding or energy-efficiency investments) and sale of the unused power and of the energy saving associated certificate, or a combination, according the electricity spot price. A market would be created (on the internet) that allows price comparisons between electricity from RES and demand-side options, which should drive investments towards the cheapest option.

Several demand-side possibilities are currently under evaluation. One, already tested by BPA, is to give load-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 energy savings (which consumers can achieve without undertaking specific efficiency improvements) and efficiency improvements (which may result in a load increase, for example in a company, which increases production after making an efficiency improvement). This strategy would mirror most 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 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).

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.

Test Experimental Setup

The systems will be tested using several photovoltaic (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.

One key issue to be addressed is scalability of the system. If certificates for demand-side measures become a reality, the number of certificates traded could be enormous. Based on the number of households in Europe, even one certificate per day for 10 percent of homes would translate to a continuous flow of approximately one transaction every 10ms.

Summary

As a result of the advent of widespread internet use, advanced meters, and the possibility of connecting/controlling end-use equipment with the internet, a market-based instrument has been proposed to simultaneously promote use of electricity generated from RES and demand-side end-use efficiency options. Although TGC schemes for electricity from RES have been employed in a number of EU member states and other countries, the first trading schemes for demand-side efficiency measures are just being introduced. Despite their common impact on GHG emissions, these demand-side programs are not integrated with RES TGC schemes. In general, energy-efficiency certificate trading schemes are more complicated than RES TGC schemes, so integrating the two entails challenges, 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.

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