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Trading green or white certificates … for the sake of the environment or for the sake of traders?

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Abstract
In recent years promotion systems based on quotas and trading of (green or white) certificates for increasing electricity from renewable energy sources (RES) or for achieving demand-side energy conservation (DSC) have received attention to meet related EU policy goals. The objective of this paper is to summarize the major lessons learned from both of these markets and to look at their effectiveness and economic efficiency compared to other policy measures like feed-in-tariffs or targeted investment subsidies. We analyse the lessons learned with Green and White certificates in UK, Sweden, Italy, France and Belgium.

The method of approach is based on dynamic cost-resource curves for RES and DSC markets based on BAU developments without and with certificate trade.

A major result is that the following requirements have to be fulfilled in every trading system to be effective (bring about a significant change) and efficient (in a least-cost way): (i) avoid free riders and adverse selection, (ii) implement high penalties, (iii) ensure sufficiently large markets to avoid market power.

The major conclusions are:

- Trading systems do depend significantly on the potential – the cost curve – of the resource. E.g. Green certificates in Sweden were cheap because the available potential for RES is large and (rather) cheap;
- At present, Tradable Green Certificate (TGC) systems show a low effectiveness although comparably high profit margins are possible. Market mechanisms seem to fail in TGC-systems, mainly due to a risk premium in the expected revenues of the investors.
- The final major perception is that the following potential backlashes exist causing high costs for the public from certificate trading: (i) Free riders (customers who would have installed a RES-E system or a DSC measure also without a certificate); (ii) Non-liquid markets, which lead to a lack of competition, high rates-of-return and too short depreciation times; (iii) penalties for not meeting the quota are to low.

Introduction
The promotion of Renewable Energy Sources (RES) as well as the achievement of energy savings both have a high priority in the energy policy strategies of the EU. With respect to energy conservation the energy service directive strives for challenging reduction of a certain amount of energy consumption per year compared to a baseline trend.[1]

With respect to trading energy related certificates in recent years in EU countries the following different categories were introduced or discussed: Tradable Green Certificates (TGC) for electricity from renewable energy sources (RES), CO_2 emis-

1. In detail the energy conservation directive – EC(2003) – states: 1. national indicative energy savings target of 9 % for the ninth year of application of this Directive, to be reached by way of energy services and other energy efficiency improvement measures. Member States shall take cost-effective, practicable and reasonable measures designed to contribute towards achieving this target. (…) This methodology for measuring energy savings ensures that the total energy savings prescribed by this Directive are a fixed amount, and thus independent of future GDP growth and of any future increase in energy consumption.

sion certificates, and Tradable White Certificates (TWC) for demand-side energy conservation measures.

The objective of this paper is to derive lessons learned from TGC and TWC markets for their future prospects with respect to alleviating the environmental burden. This is especially important because trading systems are very often preached as "the solution for saving the world". However, to some extent it seems more kind of a religious approach blessing the instrument itself – the trading system – more than the purpose it should fulfill – in this case reducing CO_2-emissions.

In the literature the major recent papers are Bertoldi et al (2010), Eyre (2009) and Mundaca (2008).

How TGC and TWC work

The analyses in this paper are based on so-called static cost curves. A static cost curve provides for a point-of-time a relationship between (categories of) technical potentials (of e.g. wind energy, energy conservation …) and the corresponding (full) costs of utilisation of this potential at this point-of-time (note: no learning effects are included in static cost curves), see Figure 1 and Figure 2. Moreover, as Figure 1 depicts, these cost curves are associated with uncertainties. These uncertainties are higher the more right we move in the diagram.

TGCs as an instrument to meet quota obligations are generation-based, quantity-driven instruments. The government defines targets for RES-E deployment and obliges a particular party of the electricity supply-chain (e.g. generator, wholesaler, consumer) with their fulfilment. Once defined, a parallel market for renewable energy certificates is established and their price is set following demand and supply conditions (forced by the obligation). Hence, for RES-E producers, financial support may arise from selling certificates in addition to the revenues from selling electricity on the power market. With respect to technology-specific promotion in TGC systems this is also possible in principle. Yet it should be noted that a market separation for different technologies will lead to much smaller and less liquid markets. One solution could be to weight certificates from different technologies (e.g. biomass-cofiring=1. Wind=2, PV=8). However, the core dilemma is of course to find the correct or at least widely accepted weights[2]. Such a system with bands is in principle implemented since some years in the UK but it is too early to draw empirical lessons learned from that TGC-based quotas work as follows (see Figure 1): A quota (=certain percentage of electricity to be guaranteed from renewable energy sources) is set by a government. The generators (producers), wholesalers, retailers or consumers (depending who is obligated in the electricity supply chain) are obligated to supply/consume a certain percentage of electricity from renewable energy sources. At the date of settlement, they have to submit the required number of certificates to demonstrate compliance. Those obligated obtain certificates in three ways:

- they can own their own renewable energy generation, and each defined amount of energy (e.g. 10,000 kWh in the Dutch system) produced by these facilities would represent one certificate;
- they can purchase electricity and associated certificates from another renewable energy generator.
- they can purchase certificates without purchasing the actual power from a generator or broker, i.e. purchasing certificates that have been traded independently of the power itself.

Due to competition on the supply side, this system of tradable certificates leads, under the assumption of perfect market conditions (perfect price signal), to minimal generation costs from renewable energy sources. Of course, this happens only if there is a surplus of renewables generation above the demand for certificates.

The major arguments in favour of TGC are:

- High economic efficiency;
- A market for best-practice in the environment is created;
- No market distortion due to fixed subsidies;
- The market determines the magnitude of the subsidy.

Possible setbacks are:

- Uncertainty about actual investment requirements of stakeholders;
- Unpredictable (volatile and possible high) revenues
- Quota not fulfilled due to a too low penalty

TWC-based quotas work similarly (see Figure 2): A quota (=certain percentage of electricity to be saved from a baseline) is set by a government. Usually the electricity retailers or distribution companies are obliged to prove that a certain amount of electricity (kWh) has been saved by means of TWC. At the date of settlement, they have to submit the required number of certificates to demonstrate compliance. Those obligated may obtain certificates in three ways:

- they can implement their own energy conservation measures , and each defined amount of energy (e.g. 10,000 kWh) saved by these facilities would represent one certificate (see also definition of "programme savings" in next chapter;
- they can purchase certificates bilaterally from another company that implemented energy conservation measures ;
- they can purchase white certificates from a third party, e.g. a certificate exchange;

The specific costs of a conservation measure C_{con} (for every step in Figure 2) are calculated as follows:

$$C_{CON} = \frac{NPV - \sum_{t=1}^{n} \frac{\Delta E_t (1 - f_{reb}) p_t}{(1-z)^t}}{\Delta E_{tot}(1 - f_{reb})} \quad \text{(cent/kWh)}$$

NPV	Net present value of investment (EUR)
ΔE_t	Energy savings in year t (kWh/yr)
P_t	Electricity price (cent/kWh)
f_{reb}	Rebound factor
z	Discount rate
n	Depreciation time (yr)
ΔE_{Tot}	Total energy savings over the depreciation time (kWh)

2. And of course these weights have to be adapted over time.

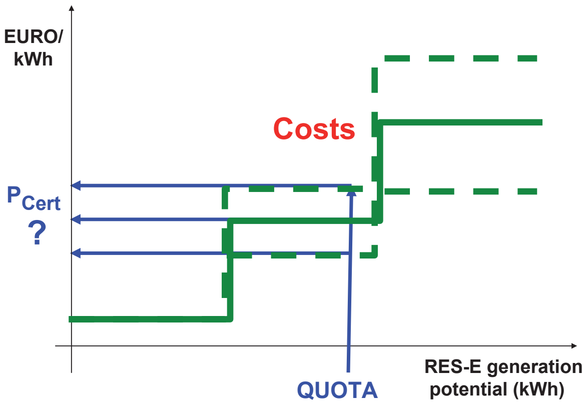

Figure 1. How a quota-based TGC system works.

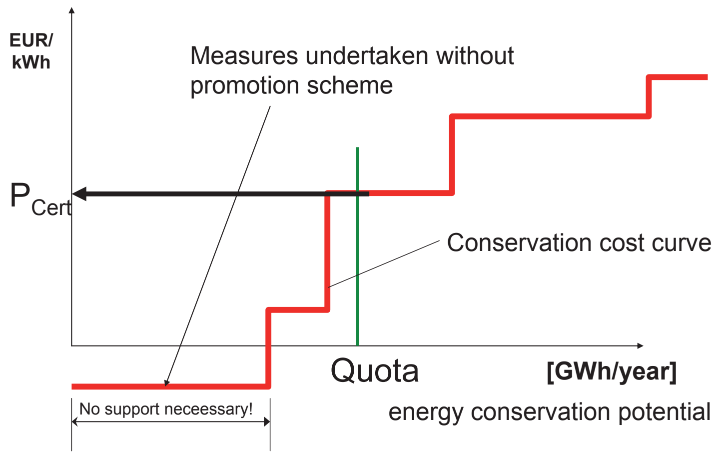

Figure 2. How a quota-based TWC system works.

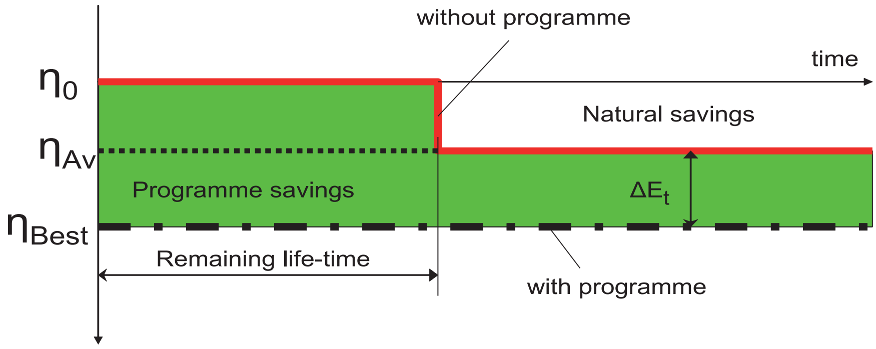

Figure 3. Natural and programme savings due to TWC in a dynamic context (η_0, η_{av} and η_{Best} refer to initial efficiency, efficiency of average new appliances and best new appliances).

Figure 3 depicts the natural and programme savings due to TWC in a dynamic context without programme after the remaining life-time of the technology and with programme that leads to implementation of the best available technology. In this context the following definition is important:

Programme energy savings
= Total energy savings - Natural enery savings

DIFFERENCES BETWEEN TGC AND TWC

While at first glance there are many similarities between TGC and TWC there are at least the following major differences:

- Quantities of RES-E generated can be monitored, quantities for energy conservation due to TWC can mostly only be calculated in detail because measured consumption has to be compared with a baseline, representing the situation without measures;
- It is more likely that (large) parts of the savings due to TWC would have been achieved without programme than RES-E would have been installed without a programme;
- The free rider problem and corresponding "Windfall profits"[3] is much more difficult to tackle in a TWC market.

3. "Windfall profits" are revenues for a market player that occur with own action e.g. due to changes in market rules

Lessons learned from TGC markets

Quota-based systems are now in place in the UK, Sweden, Italy, Belgium, and Poland. Table 1 summarises the most important features of the trading systems in EU countries. In the following we present some of the lessons learned from specific countries with respect to effectiveness and efficiency. In the countries with quota-based TGC systems, the lessons learned are as follows:

In the UK, the major problem – aside from high certificate prices – is that so far the quota has never been fulfilled. In 2004, only 2.2 % of electricity was generated from "new" RES while the quota was 3.3 %. One main reason for this failure is the low penalty and respectively the fact that this penalty is in a specific way returned to the RES-E generators. Moreover, because banking – save the certificate for a later point-of-time – is not allowed, RES-E generators fear that the certificate price will drop the closer they come to the quota.

There is a similar situation in Italy. Certificate prices here are high (see Figure 4) and quota fulfilment is moderate (about 80 % of the quota was fulfilled in 2008) (see Figure 5). One major reason for the high certificate price is the short validity of the certificates of eight years. Non-fulfilment of the quota can be explained by the low penalty level.

In Belgium there are two parallel TGC systems in Flanders and Walloon. The TGC prices in Flanders are among the highest in Europe and the system is very inefficient.

Table 1. Survey on TGC-systems in EU countries.

	UK	Belgium (Flemish region)	Belgium (Wallon region)	Italy	Poland	Sweden
Period	Start 2002	Start 2002	Start 2002	Start 2001	Start 2005	Start 2003
Obligation	3% in 2003, 10.4 % in 2010	1.2% (2003), 2% (2004) increasing up to 6% in 2010	3% in 2003 increasing up to 12% in 2010 From September 2010 onward, the quota will be multiplied by 1.01	2% in 2002 and increased annually by 0.35% between 2004 and 2008	7.5% in 2010	7.4% in 2003, 16.9% in 2010
obligation on	Supplier	Supplier	Supplier	Producers and importers	Supplier	End-user
technology bands within overall quota	No	No	No	No	No	No
involved technologies	small hydro****, wind, biomass, solar -, geo-thermal energy, no waste	all renewables, no solid municipal waste	all renewables and high quality CHP	all new renewables (incl. large hydro, MSW, CHP),	Small and large hydro, wind, biomass	small hydro (<1,5 MW), large hydro (only some cases), wind, biomass, geothermal, wave
Existing plants eligible	No	Yes	Yes	No (for certificate trade), Yes (for quota fulfilment)	No	Yes (small hydro)
international trade allowed	No.	No	No	Yes, but only in exchange with physical electricity and with reciprocity countries	No	Trading scheme with Norway planned
Floor price	not planned.	at federal level: Since 1st of July 2003 the grid operator is obliged to buy TGC issued anywhere in Belgium for the minimum prices per 1MWh of: offshore wind 90 €, on-shore wind 50€, hydro: 50€, solar: 150€, biomass: 20€ Within the Wallon-region, RES-E producers may exchange their TGC for a subsidy of 65 €.		Not planned	No	only in the introductory phase.
Penalty	Buy-out price £30,51/MWh (for 2003/2004) (~45 €/MWh)	75 €/MWh (in 2003; 100 €/MWh in 2004; and 125 €/MWh since 2005	From 1st of April 2003 onward: 100 €/MWh (100€ per missing TGC in size of 1MWh)	No. the grid operator sells certificates at a fixed price 12,528 €/MWh (2006)	The buy-out price is 125 €/MWh	150% of the market price with a maximum of about 19 €/MWh in 2004, 26 €/MWh in 2005

In Sweden, certificate prices are low – see Figure 4 – but the quantities of new RES-E installed are also very low. One reason is that some old capacity is also allowed in the Swedish quota system. This results in many more certificates being produced than redeemed.

Finally, it is of interest to analyse whether the dynamics fit. That is to say, it has to be analysed whether the financial support – in our case the price of the certificate – decreases over time. Figure 4 shows the support level in the selected countries over time. As can be seen the requirement of a noticeable dynamic decrease in the promotion costs is not met for TGCs.

For Poland and Romania it has to be stated that the experiences so far do not yet allow an appraisal of the success of the implemented policies.

Summary of results from trading white certificates

In the EU, Italy and France are the only countries where fully tradable white certificates are part of the policy portfolio to meet energy savings obligations, see Bertoldi et al (2010). The Table 2 summarizes the key design features of the currently im-

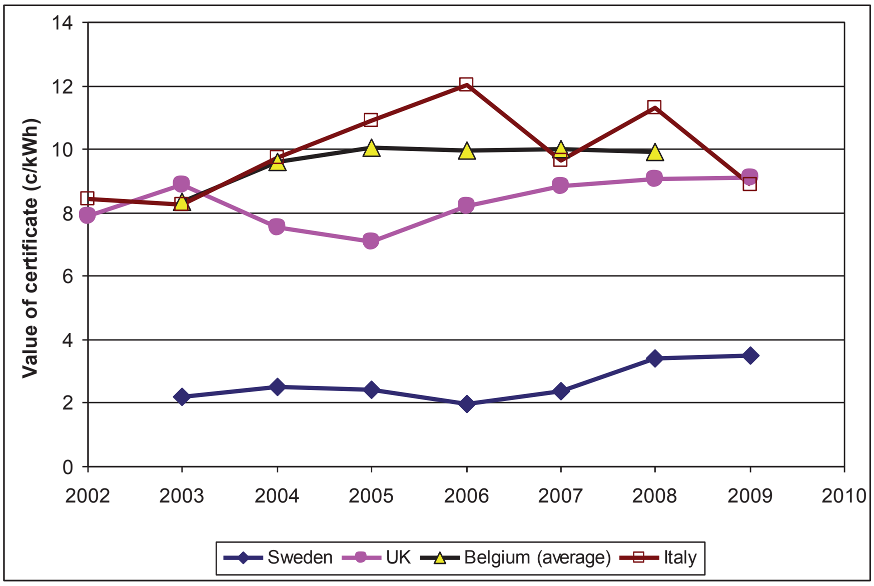

Figure 4. Value of certificate in different European TGC markets.

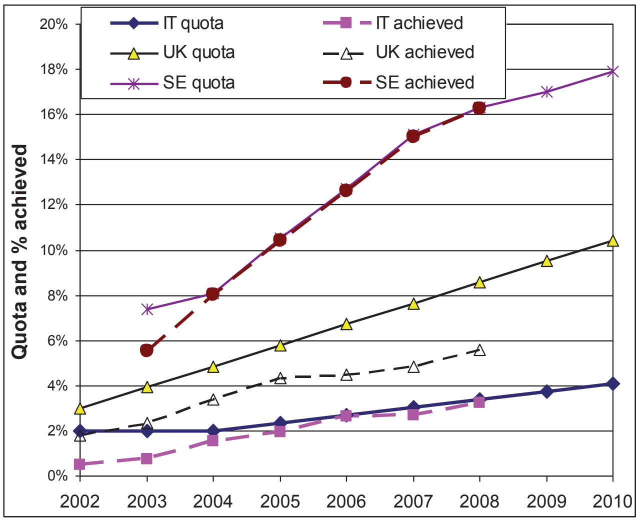

Figure 5. Fullfillment of quotas in the largest European TGC markets.

plemented systems in UK, Italy, and France based on Bertoldi (2010) and Eyre (2009).

Table 2 summarizes the major features of these programmes. We can see a wide diversity in performances as well as applications. From these descriptions the rather sobering perception is that there are some savings achieved but there are no convincing arguments for distributing this system wider.

Requirements to successful trading strategies

In recent years a wide variety of energy policy strategies have been implemented in various OECD countries. In the following the major objectives of and the requirements for replication of strategies of other countries are described. These perceptions are also derived from other analyses see e.g. Haas et al (2011) and Haas et al (2008).

The major objective of/requirement for a deployment strategy for RES-E is of course to increase the capacity installed and the amount of electricity generated from RES-E to profit from the corresponding environmental benefits.

The major objective of/requirement for an energy conservation programme is to achieve significant demand reductions.

This leads straightforward to the following core requirements for TGC or TWC systems:

- effectiveness with respect to deploying a substantial amount of RES-E capacities or energy conservation quantities;
- economic efficiency: the quantities achieved should be provided at prices which correspond to prices in a competitive market;
- minimised costs for the public and
- enhanced social acceptance.

Derived from these fundamental aspects *related strategies' targets* are:

- to increase public awareness with respect to renewable energy and energy conservation;
- to reduce costs per kWh generated/saved;
- to improve technical reliability, technical performance and standardization;
- to remove obstacles with respect to grid-connection for RES-E;
- to strive for low administration costs, low transaction costs and to minimise public financial support to reach a certain amount of RES-E capacity installed or energy conservation measures achieved;
- to exhaust customers voluntary Willingness-to-pay;
- to ensure sustainable growth of the RES-E or energy efficiency industry.

Table 2. Survey on TWC-systems in UK, Italy, and France Bertoldi (2010) and Eyre (2009).

	UK	Italy	France
Current target	185 MtCO2 lifetime in 2012	22.4 Mtoe primary energy to be saved by 2012	54 TWh final energy lifetime discounted
Current phase	2008-2012	2005-2012 (annual targets)	2006-2009
Annual end use energy savings (TWh)	3.5	1.3	4.5
Annual end use energy savings (%)	0.69%	0.15%	N.A.
Annual Carbon savings (MtCO2)	0.7	0.2	1.5
Cent/kWh_ele	2.03	1.00	0.27
Trading opportunities	Energy savings can be traded only between obliged parties	Fully trading of certificates on spot markets as well as over the-counter (OTC) trading	over the-counter (OTC) trading
Eligible parties for savings accreditation	Electricity and gas suppliers only	ESCO's, non-obliged gas and electricity distributors, private and public enterprises	Any economic actor but restriction on non-obliged parties
Sectoral coverage	Residential consumers only	All consumers	All except emission-trading-system (ETS) qualifying resources
Penalty for not meeting the obligation	Maximum of 10% of suppliers turnover	Fixed by the regulator depending on various parameters	0.02 EUR/kWh for not met obligation

Specific success criteria for TGC

Most important with respect to the correct design of quota-based TGCs for promoting RES-E are the following features:

- A quota-based TGC system has *to focus mainly on new and currently not yet cost-effective RES-E capacity*. If a large share of the required capacity to meet a quota already exists, TGCs lead to windfall profits for the owners of existing plants, see Figure 6. Hence, it is counter-productive to include old depreciated facilities into a trading system especially if the marginal cost of new capacity is high; If existing capacity is low, it is less relevant to exclude existing plants from a (national) Quota/TGC system;
- *High penalty for not purchasing a certificate:* It has to be guaranteed more or less by fundamental/reasonable-law that the penalty for not purchasing a certificate is significantly higher than the expected market price for TGCs. Otherwise there is no incentive to fulfil the quota! This means that if different countries participate, the lowest penalty must exceed the expected marginal generation costs (minus market price for electricity) within the system. This fact is depicted in Figure 6. The case on the left-hand-side is characterised by no 'wrong' penalties. The penalties for all countries A, B, and C are higher than the additional marginal costs and hence the market price for TGCs is higher. Under this assumption the quota for all countries A, B, and C will be reached. The impact of a 'wrong' penalty setting is depicted on the right-hand-side of Figure 6. As the penalty in country C is lower than the additional marginal costs for providing TGCs, total demand will be less than obligated. In this case only country A and B have an incentive to reach their quota. For actors in country C it is rational to pay the penalty C rather than fulfil the quota at the given market price p_{TGC}. In this case the quota Q_{A+B+C} will not be reached.
- Another important issue is a long-term planning horizon with planning certainty. It has to be guaranteed by highly credible authorities that a TGC system will exist for a specified and sufficient planning horizon. This is also important for the validity of certificates. Otherwise the uncertainty for potential investors is to high and it is likely that no investments at all take place.
- Ensure a competitive market: To avoid market power of some players – and the corresponding high certificate prices – it is of utmost relevance that the market for TGC is sufficiently large. If TGC´s are traded on a small short term spot market this system will not work in the sense that new capacities are not constructed: Short term competition works only for existing capacities. Hence, quotas based on TGC´s work better from society's point-of-view, if the owners are allowed to sign long-term contracts because then the risk premium is lower.
- Of core relevance is the focus on providing public money only for the difference between the BAU scenario and the certificate trade scenario.
- *The role of the cost curve:* If the expected cost curve is flat, by far less problems arise than if it is too high. For further details on this see Haas et al 2011.

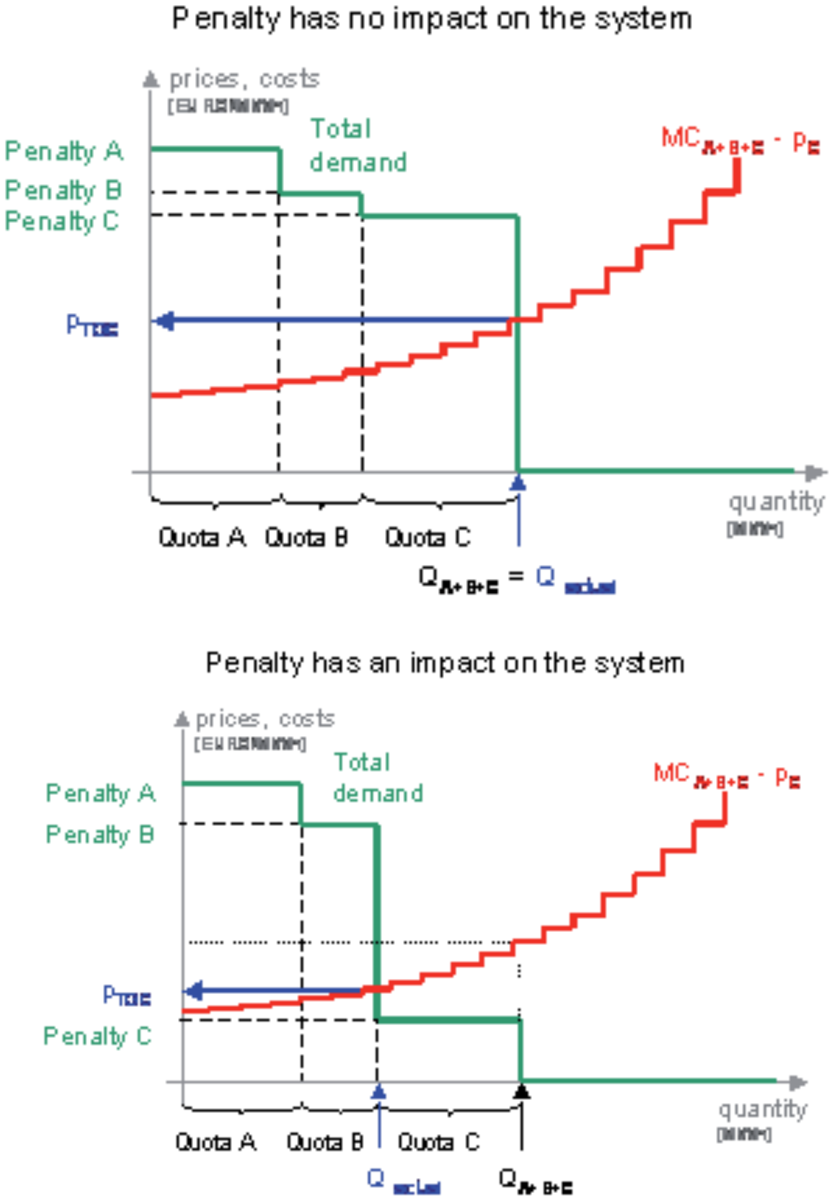

Figure 6. Influence of the penalty on the electricity generation: sufficiently high penalty (left) and to low penalty (right).

Finally, it has to be stated that with respect to a TGC-based quota for RES-E the situation is ambiguous. Despite experiences from other fields being promising, e.g. pollution abatement, as yet there has been no successful example in electricity supply.

Success criteria for TWC

TWC systems introduced in recent years have been described comprehensively e.g. in Vine (2007) or Mundaca et al (2008). Derived from the conditions for the correct design of a quota-based TGC system for promoting RES-E the recommendations for the design of TWCs are:

- *High penalty for not purchasing a certificate:* It has to be guaranteed more or less by fundamental/reasonable-law that the penalty for not purchasing a certificate is significantly higher than the expected market price for TWCs. Otherwise there is no incentive to fulfil the quota! This means that if different countries participate, the lowest penalty must exceed the expected electricity saving costs within the system.
- *Avoid free-riding:* Ensure that no already conducted DSC measures and no measures which are likely to be implemented without the programme qualify for certificates.
- *Ensure best available technology:* It is very important that qualifying measures only implement the best technology available and no measures qualify that implement average technology.
- *Ensure a competitive market:* To avoid market power of some players – and the corresponding high certificate prices – it is of utmost relevance that the market for TWC is sufficiently large and really liquid which means that no single player in the market can exert so-called "market power".

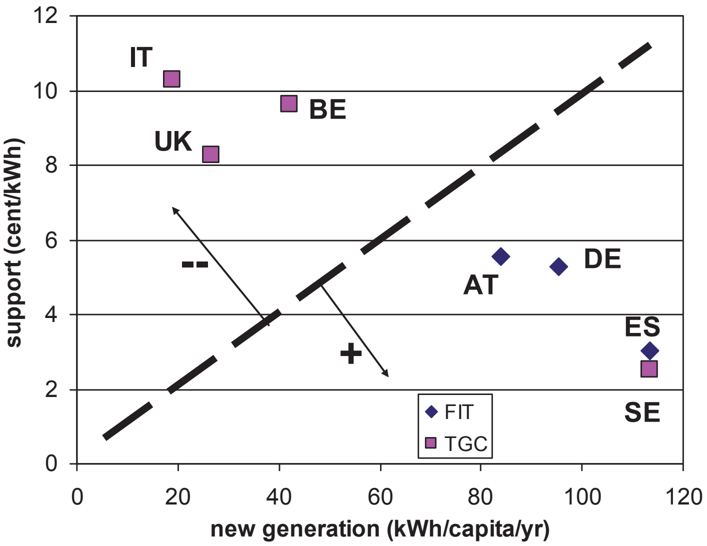

Figure 7. Comparison of the performance of FIT vs quota-based-TGC systems in selected EU-countries 2007–2009. Note that for all countries Photovoltaics support is excluded from the cost figures because it is in no country subject to certificate trade.

Alternative approaches

In the following, some approaches as an alternative or a completion to TGCs and TWC are discussed. The most important alternative to TGCs for promoting RES-E are Feed-in tariffs[4] (FITs, see e.g. Haas et al 2008). Figure 7 depicts that in a comparison of the performance of FIT vs. quota-based-TGC systems in EU-countries, FITs show clearly the better performance.

This leads to the question whether other more regulated approaches than trading could lead to wider conservation success faster and more effectively. In the following, we shortly elaborate on the advantages / disadvantages of the major alternative approaches.

Firstly, a *dynamic best available technology standard* is discussed. The major advantage of this approach is that it can provide significant savings on the long run, because only the best available technologies will be allowed to enter the market. Moreover, the problem of free riders is ruled out. The major disadvantage is that short-term savings are low and for bad technologies with a long life-time they will succeed only in the very long run. However, in any case a *dynamic best available technology standard* should accompany all regulatory and trading-based financial incentive programmes.

Another alternative are *direct investment or loan programmes* (e.g. for building insulation or comprehensive industrial retrofit). Advantage: It kicks the currently worst technologies out of the market at costs without risk premium (as likely with TWC). Disadvantage: In this case free riders could be a severe problem and (calculated) natural savings have to be considered. This type of programme should, similarly to TWC, mainly focus on units of technologies which are highly inefficient and are not expected to be replaced without incentives over about the next decade. However, it is very difficult to determine which specific units of equipment should be replaced.

Likewise the incentive could be set by kWh saved (a *feed-out tariff*). Advantages and disadvantages are the same as for direct investment/loan programmes. A major additional advantage is that due to the fact that the incentive is provided on really physical monitored[5] programme savings.

Conclusions

The major conclusions regarding the design of trading systems are:

- The replication effectiveness of TGCs towards other countries depends significantly on the credibility of the system for potential investors. It must be guaranteed that the strategy persists for a specified planning horizon. Otherwise the uncertainty for potential investors is too high and it is likely that no investments will take place at all.
- At present, quota-based TGC systems show a low effectiveness although comparably high profit margins are possible. Market mechanisms seem to fail in TGC-systems, mainly due to a risk premium in the expected revenues of the investors.
- An important perception is that there are the following potential backlashes regarding high costs for the public arising from certificate trade for meeting the quota: (i) Free riders (customers who would have installed a RES-E system or a DSC measure also without a certificate); (ii) Non-liquid markets, which lead to a lack of competition, high rates-of-return and to short depreciation times; (iii) the penalties for not meeting the quota are too low.
- The major conclusions are that the following requirements have to be fulfilled in every trading system: (i) avoid free riders and adverse selection, (ii) implement high penalties, (iii) ensure sufficiently large markets.
- The major general conclusions are:
- In recent years not much progress with respect to the success of trading systems can be reported. TGC systems has not improved their performance. In Sweden – for some years the role model of a functioning trading system – it has even become continuously worse. In other countries like UK and Italy the system has gradually been changed towards a mix with Feed-in-tariffs, drifting away from exhausting the free market powers.
- With respect to trading white certificates the situation is almost unchanged compared to what we knew three years ago. No new systems have been implemented and no new thrilling activities has been launched in EU-countries.

4. Under a feed-in-tariffs (FITs) scheme the price is set by a regulatory authority and the quantity finally generated is decided by the market. Generators receive a fixed amount per kWh generated regardless of the costs of generation. Technology-specific FITs are – in 2011 – by far the overwhelming support scheme in EU-27 countries. For further details see Haas et al (2008) or Haas et al (2011)

5. However the distortion with respect to neglecting the adjustment for a baseline trend remains

- Hence, we can conclude that trading systems has contributed more to fostering trading activities than to really saving the environment and we cannot consider them to be really promising for alleviating the ecological burdens in the next years.

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