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Some challenges related to introducing tradable green certificates

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Abstract

Denmark is about to implement a tradable green certificate (TGC) system. This paper presents and discusses some of the obstacles related to using TGCs as a part of the energy policy. The most prominent obstacles are related to managing the coexistence of multiple types of RES-E suppliers with just one policy instrument. The first problem considered relates to the creation of incentives for new RES-E deployment. The second problem relates to unfortunate mixes of RES-E sources. The final problem discussed relates to the problem of production overflow.

JEL: H21; L94; Q28

Keywords: Tradable green certificates; Deployment of renewable energy; Energy policy

1. Introduction

The Danish energy policy regarding renewable energy has to cope with many structural challenges. This paper investigates some of these to see whether the TGCs address or enhance these problems.

Denmark is about to implement Tradable Green Certificates (TGCs) as a part of the energy policy (cf. Energistyrelsen, 1999b; Amundsen and Mortensen, 2001). The TGC system will put an obligation on electricity consumers to match a fraction of their consumption by purchase of TGCs. This system replaces the former fixed feed-in tariff system, under which the deployment of wind turbines has been very successful with regard to expanding generation capacity. In 2000 the electricity generated by renewable energy sources (RES-E) was 15% of domestic electricity supply, cf. Energistyrelsen (2001). The Danish target on RES-E derived from the Kyoto goals on CO_2 is 29% of consumption in 2010, see European Commission (2001). This target might very well be met much sooner than 2008 if the current rate of RES-E deployment continues. To see more Danish energy data in English language please confer Energistyrelsen (1999a).

Under the proposed (and delayed) Danish TGC scheme the income to new wind turbines erected will consist of the gains from selling their electricity on the electricity markets together with the income from the sales of TGCs. The implementation of this scheme has been somewhat delayed due to pending EU approval. The implementation of the TGC system has been stalled and some of the details are currently being reconsidered. Already some of the plans for giving offshore wind farms favourable conditions have been cancelled, leaving private investors to engage in offshore wind at market conditions.

2. The Danish RES-E legislation in brief

The Danish RES-E supply origins mostly from wind turbines and biomass. However, biomass is still scarcely deployed among power generators. Offshore wind turbines are expected soon to be large contributors of RES-E. The Danish legislation defines generators of TGCs to be wind power, biogas, biomass, solar and wave energy, and small-scale hydropower (<10 MW).

The Danish 1999 Act on Electricity Supply contained a number of important changes regarding renewable energy. The existing fixed feed-in tariff system (8 cEuro/kWh) will not apply to wind turbines erected from 2000 and onwards. All new turbines will obtain tradable green certificates according to their production. In addition, privately owned wind turbines entering in year 2000–2002 will be receive a power price equal to

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approximately 4 cEuro/kWh. Privately owned wind turbines entering after year 2002 must sell their power at the electricity markets with no price guarantees. Consumers will be obliged to purchase green certificates to match a fraction of their electricity consumption. The energy authorities will set this fraction on a 5 years rolling scheme. A green certificates market was planned to be initiated by the beginning of year 2000 and be fully operating in year 2003. The RES-E producers will be economically compensated until the market for green certificates is fully operational. Applying a fixed feed-in tariff of 1.33 cEuro/kWh to the certificates in the interim period does this.

Turbines erected offshore from year 2000 and onwards will receive a feed-in tariff of approximately 5 cEuro/kWh plus a green certificate, e.g. per kWh. If the turbines are financed by appropriations, the feed-in tariff will not apply. Hence these wind turbines will be treated as turbines on shore.

Due to a very flexible definition of the year 2000 deadline and strong incentives for replacement of existing wind turbines, the Danish RES-E feed-in tariff system will not be fully abandoned during the next 10 years. It is expected that less than half of the RES-E production would result in issuing green certificates in year 2003.

The payments to the existing biomass production comes from three sources: (1) A feed-in tariff of 4 cEuro/kWh, (2) a TGC, and (3) production subsidies depending on the amount of fuels incinerated. New biomass plants erected during 2000–2002 will have both a feed-in tariff of a little less than 7 cEuro/kWh and green certificates. Power plants using solid waste as one of their fuels will not receive certificates.

3. Modelling the RES-E supply in the short run

Under the TGC scheme the owner of a RES-E facility faces two sources of income. First, he receives revenue from feeding electricity into the national grid. This income depends on whether the producer is subject to feed-in tariffs (existing turbines and turbines subject to the interim scheme) or if he obtains the spot market price (turbines under the new scheme). Second, further to the direct income on sales, the turbines erected under the new or the interim scheme receive a number of tradable green certificates corresponding to their actual production. These certificates can be traded on a special TGC market, leading to extra income. The certificates need not to be traded instantly, but can be kept for later sales depending on the specific expiry conditions. To enhance efficiency in certificates markets, it might be necessary to assign infinite life to the certificates. Conversely, if the certificates have different expiry dates, then the market for TGCs becomes segmented with low volume markets with volatile prices.

The RES-E producers' short run decisions are depicted Fig. 1 below. In this figure it is assumed that the marginal producer generates dispatchable power, e.g. from biomass power plants, whereas the level part of the MC curve reflects that the wind turbines have very low marginal cost. It is worth noticing that had the generation technology consisted of wind turbines alone, the relevant supply curve would have a vertical segment, reflecting that wind turbines are expected to generate subject to wind conditions only. To compensate for the physical implications of fluctuations in the wind, the MC curve in Fig. 1 shifts to the left in calm years and visa versa. Some of these shifts will also be visible in the TGC supply curve. A low instantaneous production of TGCs implies that the sum of all TGCs available in the current period will be lower regardless of TGC banking accounts and visa versa.

Throughout the analysis it is assumed, that both the power and the TGC markets are competitive, such that production decision are made to equalise marginal cost with price (or rather the expected dual source revenue). In a TGC market with two distinct types of producers, wind power and biomass, the supply curve might not be as smooth as indicated since the MC on biomass plants is considerably higher than on wind turbines.

Fig. 1 reflects the assumption that wind turbine owners will act as price takers on the certificate market, whereas the biomass power plants are assumed to be dispatchers, i.e. that they will only choose to produce if the dual income stream covers their marginal cost. This implies, that in the case where expected revenues are high enough to encourage electricity production from biomass plants, the wind turbines also face a high revenue, unrelated to their own cost. Thus, the assumption on competitivity can be relaxed to apply to biomass plants only.

In the case with no production from biomass plants, there exists no focal point for the RES-E price and

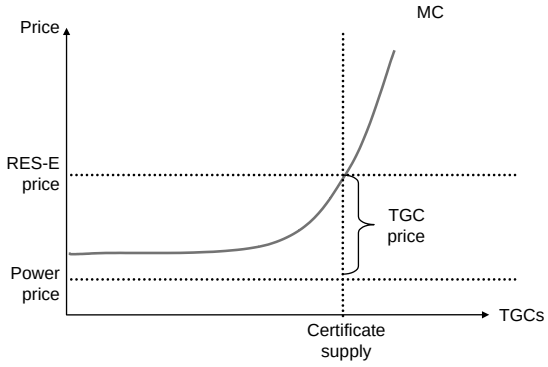

Fig. 1. *Supply based determination of the TGC price.* The expected value of a TGC must be sufficient to cover the difference between marginal cost and the power price at the marginal RES-E producer.

TGCs might be temporarily worthless due to the competition among wind turbines during that period. This is just a case of excess wind power capacity. Even though this excess is only temporary, due to strong winds or to little demand for TGCs, it will lead to a decoupling of short and long run prices.

As indicated above, in the RES-E scheme where the power generated from biomass is subject to the same tariff as the wind power, the mere existence of biomass will have a positive externality on wind power by raising the certificate price to a level consistent with the dispatchable supply.

The Danish biomass generators are subject to a feed-in tariff of 4 cEuro/kWh, which would almost always exceed the spot price of power, even in a low price scenario where the hydro power producers in the Nord Pool area set the price. To compensate for this fixed feed-in tariff in the set-up in Fig. 1, the biomass part (the rightmost part) of the supply curve should be lowered since the biomass plants will demand less income from the sales of electricity and certificates. However, the introduction of such a jump on the curve will not alter the analytical implications. It should though be noted that the impact of a high biomass feed-in tariff is that certificate prices will be lower. Still the biomass plants may very likely generate excess income to wind turbine owners.

The simplest way to illustrate the biomass externality on wind turbines is to consider the case where the biomass plants are the price setters on the certificate market. Following price relation will then be valid to both biomass plants and wind turbines:

$$\text{Price of TGC} = \text{Marginal biomass production cost} \quad \text{less the biomass feed-in tariff.}$$

The wind turbine capacity is a dynamic variable defined relative to installed stock and weather conditions. In case of periods with calm weather many wind turbines will cease to generate, hence the supply curve will move to the left. Following the line of arguments above, the TGC price should be higher during that period. In reality this will not be the case, since the certificates will not be instantly priced. In fact, they will almost surely not be instantly traded. And since the consumer obligation period is expected to be the calendar year, or even 15 overlapping months, the individual supply decision will not alter the TGC price. Consequently, the rational non-wind RES-E dispatchers ignore actual wind conditions, and base their production decision on the expected TGC price and the current spot price or fixed feed-in tariff only.

Summing up in the very short-term perspective we find that wind turbine owners are production dummies in the sense that they do not react on market signals. Furthermore, the income stream to wind turbine owners is determined by the supply condition for the other RES-E types through the TGC price. The dispatchers among the non-wind RES-E suppliers will make their decisions independently of the cost of operating wind turbines, but will of course react to the estimated value of the TGCs.

4. Long run considerations

The analysis behind Fig. 1 ignores the importance of the long run considerations. Even in a competitive set-up, having just their short term marginal costs reimbursed will not satisfy rational investors. They need an additional premium to cover capital cost and risk exposure. Fig. 2 below brings the marginal and the average cost considerations together in one picture.

The long run marginal cost (LRMC) is really not a marginal cost but an average cost since the long run equilibrium price must cover all cost. The analysis will show that it is problematic to manage both the incumbent RES-E producers with sunk costs and the producers to be, demanding full coverage of cost.

The two vertical lines in Fig. 2 represent two instances of TGC quotas, a high level and a low. This way of representing the consumer obligation on TGC is not fully correct. First, the Danish TGC quota is a target relative to total electricity consumption. But since total consumption is highly predictable, an absolute target could approximate the relative target (see Jensen and Skytte, 2002, for further discussions on the target). Second, banking will be allowed, dismantling the link between RES-E supply and TGC supply. The perceived demand curve would thus not be a vertical relation, but a sloped curve. The approximation will of course distort the determination of equilibrium in both quantities and price, but it will not blur the line of argumentation.

At the low quota level, the marginal cost and thus the marginal revenue are below average cost. Producers at the margin will not earn enough to fulfil investment obligations. If this situation pertains marginal producers

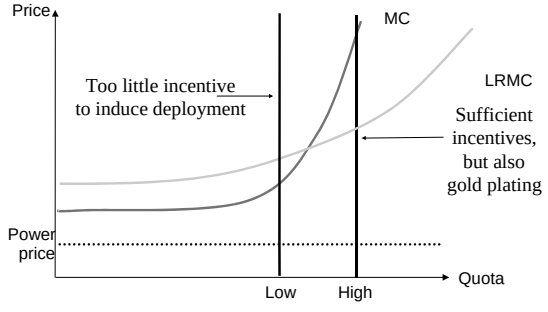

Fig. 2. *Inducing deployment.* If the TGCs are priced sufficiently high to cover average production cost on the marginal plant, this will induce deployment of new plants.

might go bankrupt. And no new generators will enter the scene.

At the high quota the price is way above cost, giving strong incentives to enter. Meanwhile, incumbents—although competitive—will earn a rent related to the high quota. It should be noted that this unintended rent could also be induced by a calm year. In this case prices would be high, but income to wind turbines could be low due to the reduced quantity. Rational investors should not mistake the high prices in a calm year as an invitation to enter. In calm years the marginal producers will benefit because they are dispatchers choosing their quantity. This would compensate for the poor income in the years when they are compensated either below or on average cost.

5. Energy policy

It is obvious from the previous section that the quota must be set close to expected RES-E generation to achieve a stimulation of deployment without generating excessive profits to incumbent RES-E plants. Fig. 3 below depicts a quota management in a multiple period set-up with a well-adjusted incentive to new investments in RES-E plants. Unfortunately, this optimal incentives set-up is very likely to induce unintended gains. These gains might occurs, if the power price remains unchanged implying that the price on TGCs will go up, in which case extra income will be generated to all incumbent generators. One way to overcome the threat of this kind of gold plating could be to give investment subsidies, hence lowering the long run curve. But such a scheme is exactly what the TGCs are supposed to replace. The gold plating problem still needs to be solved. Some help might be found in technological progress, bringing the average production cost down, hence reducing the pressure on the TGC price.

The Danish TGC scheme contains a maximum price on certificates. In a multiple period scenario this price

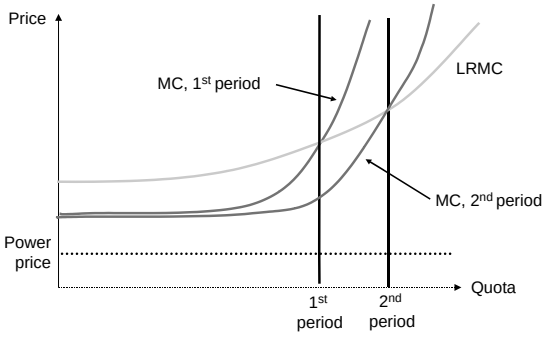

Fig. 3. *Multiple period quota management.* The continuation of providing incentives to enter the RES-E generator pool will make the existing generators face an ever-growing stream of income. These windfall gains will not be politically sound.

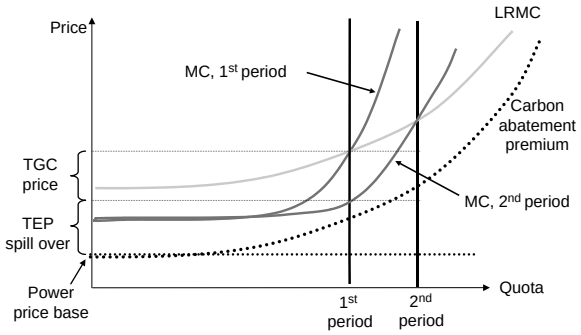

Fig. 4. *Counteracting the price cap on TGCs.* By forcing carbon abatement cost on non RES-E the power price will rise reducing the gap between RES-E cost and the power price.

could very well be binding, disabling the energy authorities to induce sufficient incentives to enter at a sufficiently high rate. Fig. 4 below indicates a solution to the cap on the TGC price.

If the scarcity of tradable emission permits (TEP) is strong enough, the cost of producing thermal power will go up due to the growing cost of attaining TEPs. The income gap to be filled by the TGCs will then grow at a slower rate or even diminish. In a fossil fuel set-up with an ever growing RES-E and priority dispatch capacity the gap reduction will likely be the case for Denmark in the near future, making the TGC system obsolete.

This picture will though be distorted if hydro or nuclear power is predominant, since the cost of these producers will be independent of the TEP price. Also, if the energy conservation programs will be successful, high cost thermal power plants will be abandoned and the competition among the surviving thermal producers would be expected to become fiercer. This implies both a lower spot market price on power and a lower price on TEPs. In this case, a strong reduction of the number of TEPs is needed to make the TGC system obsolete. This topic is further discussed in Jensen and Skytte (2002).

6. TGCs and production overflow

Recently, the promotion of RES-E has been accused of aggravating the Danish generation overflow problem. The Danish power sector in organised such that a priority dispatch system covers a large fraction of the generation. Priority dispatchers are local CHP, biomass (very little for the time being) and wind turbines. On very cold and windy nights these sources together produce power in excess of domestic demand enabling Denmark to export carbon abatement. With a growing capacity of wind turbines this could be a new export trade in Denmark. Unfortunately, this positive externality to the neighbouring countries remains unpriced as of today. The derived excess regulation cost and high

wind power tariffs will eventually be borne by the domestic consumers. This has certainly not made the RES-E more politically acceptable, and has been made a strong argument against the TGC system.

A short detour on the problem would be to notice that the Danish effort to save energy and to improve energy efficiency is in fact accentuating the overflow problem, since it could be easily overcome by stimulating more domestic power consumption. Consumption growth might be a solution if the consumption was politically correct. Introducing more electrical vehicles could be acceptable, but would probably call for an excessive subsidy scheme.

Returning to the problem again, the right question to be asked here might not be: "Could production overflow be avoided by an appropriate design of the TGC system", but rather "Should RES-E be more dispatchable".

Taking the first question first, it is important to emphasise that the wind turbine marginal generation cost are very low, and will when installed almost always be cheaper than all other power sources. Once installed, wind turbines are competitive independent of the subsidy scheme used. Hence, any system renewables through price subsidies will generate the same problems. But leaving wind turbines to pure market conditions will soon prove that wind turbines are not a mature technology.

The second solution, to make the RES-E more dispatchable, is not the right way to address the problem. The wind turbines can never avoid their inhering indispatchability, but they could be closely integrated with other technologies. Several such approaches have been discussed, including formal procedures for power banking at hydro power plants and to install electrical heaters in the district heating plants. The problem is not such much the indispatchability, but rather that the Danish energy policy has not been properly adjusted to the tremendous growth in the share of the priority dispatchers relative to the total generation.

7. Concluding remarks

The Kyoto agreement calls for a large reduction of the Danish emission of CO_2. The RES-E is still not capable to exist on market conditions. A subsidy scheme for RES-E is clearly needed, and since the Commission calls for market based systems, the TGC system seems appropriate. The Danish TGC system is not implemented yet which leaves time to reconsider the details in the system design. As pointed out in the paper, technological progress together with a strict emission policy could reduce the need for subsidies in the long run.

Whilst running the TGC scheme energy authorities should be very much focused on keeping the RES-E on the right track, that is to provide incentives for new deployment without gold plating existing generators. This might be impossible. This is a severe drawback on the intention to improve the economic efficiency of stimulating deployment. Proper internalisation of emissions will improve the manoeuvrability and the quality of the TGC system.

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