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DISCUSSION PAPER

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Incentives to Invest in Electricity Production from Renewable Energy under Different Support Schemes

An evaluation of feed-in tariffs and renewable energy certificate trading schemes in the context of expansion targets for renewable energies in the EU

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Executive Summary

Promotion of renewable energy source plays a special role among the measures to reduce greenhouse gas (GHG) emissions. On January 23, 2008, the European Commission (EC) presented its energy and climate package containing specific proposals for the time until the year 2020. The pilot study "Renewable Energies" commissioned by the German Federal Ministry for the Environment assumes that a bare 80 per cent of the total power generation will be generated from renewable energies in 2050. The role of support schemes in the future, that are presently an uncontested necessity, is discussed about on a regular basis with regard to these climate protection objectives. The present study is a contribution to this discussion.

In line with the European Union's overall approach towards competition policy we assume perfect competition on the power market and analyse the incentives to invest in the respective installations. During the investment analysis one has to distinguish between the average annual electricity price and the price at the moment of electricity production. Several investigations during the last 18 months revealed that the electricity price at the power exchange heavily depends on the (fluctuating) electricity production from wind energy and photovoltaics. Whenever wind farms produce electricity, the spot price and thus the revenues from direct sales will decrease. The effect will be the stronger the larger the share of renewable energies in electricity production becomes. This systematic problem with revenues will decrease the incentive to invest in new, additional installations without public support massively. Public support schemes will still be necessary in 2050 if the share of renewable energies is to be increased further.

The introduction of a supplementary green certificates system would not solve the problem. The decreasing revenues from the electricity market will not be compensated by additional revenues from the sale of certificates. Operators of renewable energy installations will receive certificates at no costs ("on top") if and only if the corresponding electricity has been delivered to the grid. The marginal cost of producing certificates is therefore equal to zero for all producers. Consequently, in a competitive market the price at the exchange will be "randomly" anywhere between zero and a possible penalty for not meeting one's quotas. Under such conditions, risk premiums will increase capital costs for new installations substantially. The incentive to invest is likely to be very low. A significant market penetration cannot be expected under this regime.

Even in the year 2050 subsidy schemes like feed-in tariffs or tenders will be necessary - provided that the above mentioned expansion targets are to be met.

1. Introduction

On January 23, 2008, the EC has put its plans for an expansion of renewable energies in more concrete terms. The most important outcome was that energy from renewable sources shall make up 20% of the EU's overall energy consumption until 2020. This overall expansion target is divided into sub-ordinate national objectives which vary from member state to member state and that consists of separate objectives for the three fields of electricity, heating and transportation (COM 2008). There is a striving for an even larger expansion in the long run. The "Pilot Study 2007 – Renewable Energies Expansion Strategy" conducted on behalf of the German Federal Ministry of Environment states a share of a bare 80% of electricity from renewable sources in total power generation in the year 2050, whereas wind farms – with 68 Gigawatt (GW) of installed capacity – make up half of the total capacity from renewable sources (BMU 2007).

As the average total costs of production for power generation (in the following: TAC) from renewable energies for new installations are usually still higher than the wholesale electricity price, in liberalised electricity markets there is little incentive to invest in such installations. Therefore, already for a long time, different support schemes are in place.

In the recent past, the discussion about the "right" scheme has intensified significantly in Germany – but also in the EU. The German Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG), much-praised as a reference model, receives criticism of those who prefer a quota model based on a renewable energy certificate system.[1] They argue for a change of systems because of high costs, arbitrage effects taken by single plant operators and missing dynamic efficiency (ECN 2005). An EU-wide system would have the advantage of better reflecting the ideal of a single European market than merely national subsidy schemes. Some investors also see opportunities to introduce new products through directly marketing electricity at power exchanges (Köpcke 2007).[2] More and more voices call feed-in tariffs an interim solution because the TAC of new installations will constantly decline and that there would not be any promotion necessary in the future: "*I suppose that in the year 2020 the renewable energies will be so strong that we will no longer need a separate promotional system. We will then witness a harmonisation which will only leave emissions trading as a promotional system.*" [3]

The accuracy of the arguments apart, the line of reasoning holds some shortages. The renewable energies expansion objectives mentioned above can – especially in liberalised electricity markets – only be achieved if investors see sufficient incentives to invest in these installations. As we will show in the following, the effects of these incentives vary fundamen-

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1 See eg. article "German feed-in system no model for Europe", greenprices newsdesk, 25 April 2007, URL: http://www.greenprices.com.

2 Actually, those plans are often some kind of "cherry-picking"; in periods when prices at power exchanges are higher than the EEG remuneration, electricity is sold directly at the exchange; but in times of low prices the "safe harbour" of EEG remuneration is called at.

3 Matthias Ruete, EC Directorate General for Transport and Energy, in: Nikionok-Ehrlich, Angelika; Köpke, Ralf (2008): Der Kuchen wird aufgeteilt [The cake is being sliced], in: Energie & Management, 15 February 2008, p. 4. Translation by the authors.

tally under different subsidy schemes. The focus is on wind power plants as they make up the largest share in the expansion of renewable energies in Germany now and in the foreseeable future. The present study concentrates solely on the incentives to invest in these installations. Other aspects, as e.g. a possibly easier meeting of national targets within the EU by the use of certificates trading will not be assessed.[4] As we will show in detail later, wind power plants can represent all types of power plants with zero marginal costs of production.

2. Support schemes for renewable energies

Support schemes for power generation from renewable energies vary from country to country and also over time (see Table 1). While there have been direct subsidies e.g. in the beginning of the nineties in Germany, the support scheme type has been changed to a feed-in tariff with a fixed remuneration later. A more detailed description can be found e.g. in Wüstenhagen et al. 2006. For an international comparison see IEA 2004.

Table 1: Overview on important support schemes for power generation from renewable energies (based on Meyer 2003, Bode 2005)

Name	**Core feature**
Feed-in tariff	Remuneration is paid for each kilowatt hour (kWh) fed into the grid. The amount is fixed for a longer period of time.
Quota model	Certain market participants (e.g. producers or consumers) are obliged to obtain a certain share of their total production or consumption from renewable energies. To support compliance with the quota requirements, regularly a RECS is installed. *)
Tender	A public body puts a certain amount of electricity from renewable energies to tender. The winning bidders get a guaranteed remuneration per kWh of electricity for the contracted period.
Direct subsidies	Capital costs are partially or fully funded by a public body.

**) It must be pointed out that the certificate trading system only allows for a cost-efficient achievement of the objective. The system does not support power generation from renewable energies itself. This is only achieved by establishing a target / quota.*

In recent past especially the so-called feed-in tariffs and so-called quota models based on certificates moved into the centre of discussion. The present study therefore concentrates on these two types of support schemes. The authors emphasize that especially on an interna-

[4] It should be mentioned that renewable energy certificates can be traded on both company as well as country level, meaning that the instruments discussed in the following can also co-exist on different levels, respectively.

tional level there has not yet evolved a formal or common-sense definition. That is why the following descriptions display the authors' understanding.

Feed-in tariffs

In case of a feed-in tariff in place, plant operators receive a fixed remuneration for each Kilowatt-hour (kWh) fed into the electricity grid. The remuneration may differ depending on type, age and location (and further factors) of the respective installations. With regard to the desired increase in market share the "Stromeinspeisungsgesetz" (law on feeding-in electricity into the grid; abbrev. StrEG), introduced in Germany in the year 1990 and today's German EEG proved to be effective models. The EEG has been adopted in numerous countries within the EU in a similar form, as e.g. in Spain, Austria, France, Greece, Ireland, Portugal and the Netherlands (REN21 2006). The actual designs and remunerations show a wide bandwidth. Tariffs are oriented towards the total average costs of power generation (TAC) and offer an incentive to potential plant operators to invest in installations that use renewable energies.

Critics argue against feed-in tariffs that the "right" remuneration is difficult to identify and therefore there is a risk of too much or too little support. Due to the wide variety of specific feed-in tariff modes – especially with regard to the respective technology – the promotion is not efficient in a strict economic sense, because the employed financial resources are not used to achieve a maximum in power generation from renewable energies. But it has to be pointed out that the variety of modes itself is lead by political, rather than purely economical objectives. This has to be considered in the following comparison of support schemes. Proponents of the EEG model emphasise that this is actually intended to promote such a wide variety of technologies and also to promote a broad distribution of plants with the aim of a decentralised energy supply.

Quota models based on certificates

With a quota model in place, certain market participants – e.g. producers or retailers – get bound to a quota, meaning they are obliged to obtain a certain share of the produced or sold amount of electricity from installations using renewable energies.

To comply with this given quota, it is possible to use so-called renewable energy certificates, too.[5] These are a proof for having produced a certain amount of electricity in a power plant using renewable energies – often certificates are issued to an amount of one MWh.[6] The RECs or GoOs are "generated" and sold by the plant operators, the electricity produced is directly fed-in to the electricity grid (Figure 1).

When further designing such schemes, there are a number of degrees of freedom. For example, it has to be defined, if a quota shall apply to production or consumption. This decision has consequences for the question whether or not foreign power generation can be credited against the national quota. Furthermore it has to be considered if certificates can be carried over into the next obligation period ("banking") or if it should be possible to issue bonds on future period certificates ("borrowing"). Both methods can help to absorb strong

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[5] With the European Energy Certificate System (EECS), a EU-wide system is already available.

[6] On this the EU draft directive defines the term "Guarantee of Origin (GoO)".

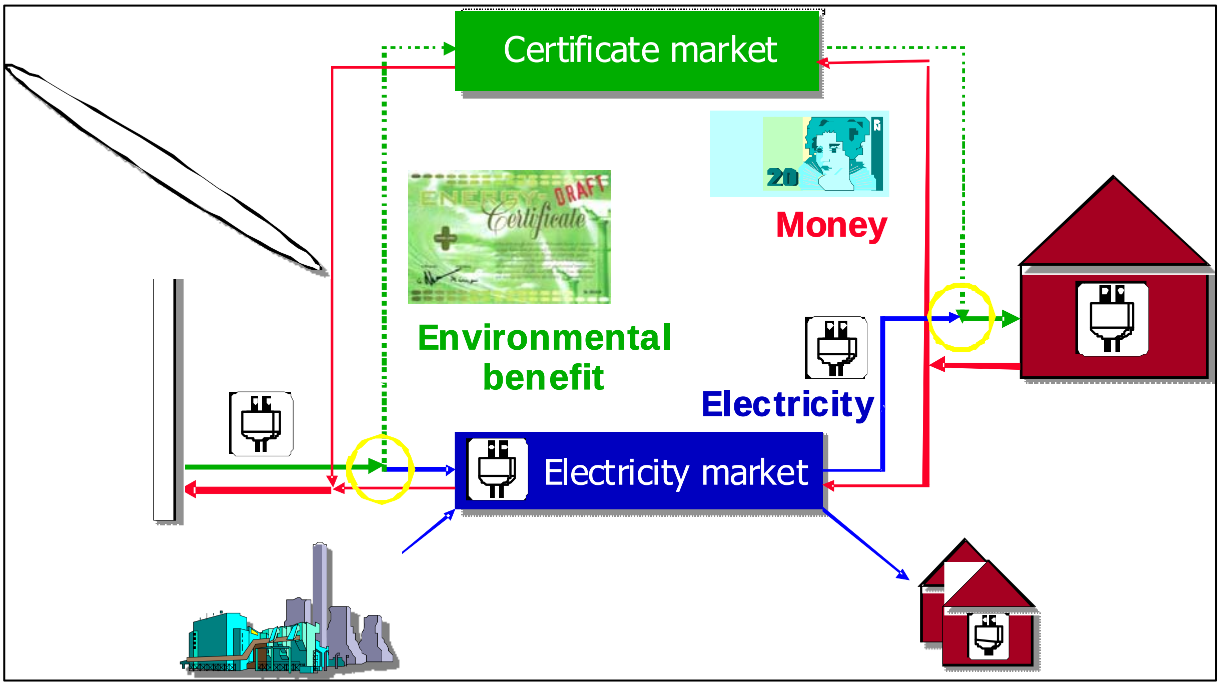

Figure 1: Functioning of Trading Green Certificates.

fluctuations of the certificates' price. Finally, it must be agreed on a sanction in case that a single market participant does not meet his obligations. This sanction can e.g. be a fine with or without the liability to deliver the missing certificates in addition.[7] The success of those systems cannot be definitely assessed up to now.[8]

The quota model – in contrast to the feed-in tariff – uses the method to fix an amount and leaves the formation of prices to the market. While in theory, both approaches can lead to the same result(s), proponents of the quota model argue that the legislator's task is the definition of ecological targets, i.e. to define the amount of electricity from renewable energies rather than the respective price. From a quota model they expect an intensified competition even among different types of renewable energies and a more efficient employment of the subsidies. Insofar, when comparing different instruments, different political objectives must be considered (see Table 2). In the EU, a certificate system may be supported due to the ideal of a European single market and a free movement of goods and especially because of the opportunities of a free cross-border trade.

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7 An in-depth description/illustration of the aspects to be regularised/regulated/refined can be found in e.g. in Drillisch (1999).

8 "The evaluation of international experiences with the obligation system gives rise to a mixed picture. […] the conclusion can be drawn that the obligation is a complex system, which will only function well if designed carefully." ECN (2005, p. 2)

Comparison of feed-in tariffs and quota models

When comparing both instruments, it has to be considered which political objectives are pursued with regard to single technologies. Table 2 points out the respective design characteristics of every instrument against the respective objectives.

Table 2: Design of support schemes with different objectives towards specific technologies

	Objective	
	Support of green power as such (independent of source)	**Support of green power from installations using certain technologies**
Pricing instrument (feed-in tariff)	Single remuneration tariff per fed-in MWh of green power	Different remuneration tariffs specific to a certain technology type (e.g. PV, wind or hydro power)
Quantity instrument (quota model with certificate trading)	Single quota (e.g. 25 % of green power of total consumption or generation)	Different quotas (e.g. 10 % wind power, 15 % PV of total consumption or generation)

There is another fundamental difference between „feed-in" and „quota" schemes apart from the difference in steering via either determining price or defining amount: The composition of income streams (Bode 2006). While under the EEG a facility operator gets a fixed, all-in remuneration for electricity and the environmental benefit (the "greenness") of the electricity produced by his installation,[9] under a quota model an operator gains income streams of two products: Firstly the revenues from direct sale of electricity and secondly those from the sale of RECs / GoOs (cf. Figure 1). Looking at this characteristic, the other instruments mentioned in Table 1 can also be assigned to certain categories or be identified as hybrids respectively (see Table 3).

If now the wholesale electricity price at the power exchange decreases e.g. for system-inherent reasons – which will be discussed in more detail in the following – the incentives to invest in additional facilities using renewable energies could disappear. Then it has to be assessed if revenues from a sale of the certificates can create equivalent incentives. In the following chapters these questions will be pursued. Firstly the formation of prices on the electricity market will be described. Secondly the formation of prices will be analysed for a theoretical, but possible stand-alone certificate market. Yet, as electricity and REC markets are in fact joint products, they are discussed together in another chapter.

[9] It should be noted that plant operators – under the EEG – are explicitly not allowed to double-market the environmental benefit. § 18 (2) of the EEG reads as follows: "Plant operators that call upon the remuneration according to §§ 5 to 12 are not allowed to pass on certificates for electricity from renewable energies and from firedamp. If an operator passes on certificates for electricity from renewable energies or from firedamp, he is not allowed to call upon a remuneration from §§ 5 to 12 [authors' translation].

Table 3: Support schemes discussed by means of income stream types)*

Remuneration for:	Power	Green power character	Power	Green power character	Power	Green power character
	variable	variable	variable	fixed	fixed	
Scheme type	Quota + certificate trade		investment grant		Feed-in tariff	
			Quota with fixed price for certificate		Tender	

*) The combination of fixed remuneration for power and variable remuneration for green power character is also possible, but has not been brought forward up to now in political debate.

3. Competition and formation of prices on the electricity market

Both support schemes have the same approach. By promoting the respective technologies' market entry economies of scale shall be initiated which finally leads to a situation with electricity from renewable energies becoming fully competitive in the electricity market This approach is – as we will demonstrate in the following – problematic in two respects: Total average costs of production for power generation from renewable energies are compared with the average market price of a given year. Yet, investment decisions are based upon the question for the effectively gained revenues for electricity from renewable energies. The actual revenues equal the price on the electricity market at the time of sale – and hence at the time of production – and not just the average wholesale prices of a year.

In order to assess if a direct marketing of electricity from renewable energies on the electricity market is possible without withdrawing the incentive to invest in the respective installations, the formation of prices on the electricity market has to be discussed first. From the perspective of competition policy it is out of question that this market has to follow the ideal of perfect competition. The proposals to separate the operations of electricity grid and power generation presented only recently by the European Commission aim exactly at this direction. The call for perfect competition[10] should go along with acceptance for the paradigm of marginal analysis and general equilibrium theories prevailing in economics. According to those, prices form on the supply side based on the marginal costs of production. Having this in mind, in the following paragraphs the formation of prices on the electricity market and on a green certificate market are assessed.

Formation of prices on the electricity market: theoretical assessment

When talking about the „electricity price", it is necessary to define, which price is actually referred to. It is important to distinguish

[10] Also see BMWI (2007), URL: <http://www.bmwi.de/BMWi/Navigation/Wirtschaft/Wirtschaftspolitik/wettbewerbspolitik.html>.

- the wholesale or power exchange price[11] as well as
- the price in bilateral business agreements which usually is oriented by the power exchange price, and further
- the power procurement costs (retail price) for business and private customers, which consist of the wholesale electricity price plus further cost elements like e.g. taxes and dues.

Additionally it is important to distinguish the wholesale price, which consequently determines the consumers' power procurement costs, from the total costs of production (TCP) of individual power plants. In a nearly entirely state-controlled energy system as it predominated until the end of the nineties, there was a simple connection between both of these values: The wholesale prices were substantially a mean value of the different power plants' total average costs of production plus an additional profit margin. In a liberalised electricity market the formation of prices works different, namely – as mentioned at the beginning – by supply and demand (e.g. BMU 2006, p. 21). Due to the focus of the support schemes, in the following we will only address the supply side.[12]

For the operation analysis of an existing power plant, capital costs are not relevant as they are fixed costs, i.e. they accrue independently of the power plant's actual operation. When operating, the focus of a plant operator is on maximising profits. In the short run, an operator therefore will always try to run his power plant when the revenues from the electricity sale are greater than the costs he has to pay to operate the plant. As a first approximation, in the past this was given if the quotient of fuel costs and efficiency factor (i.e. the marginal costs of production) was less than the electricity price realised (see Figure 2).

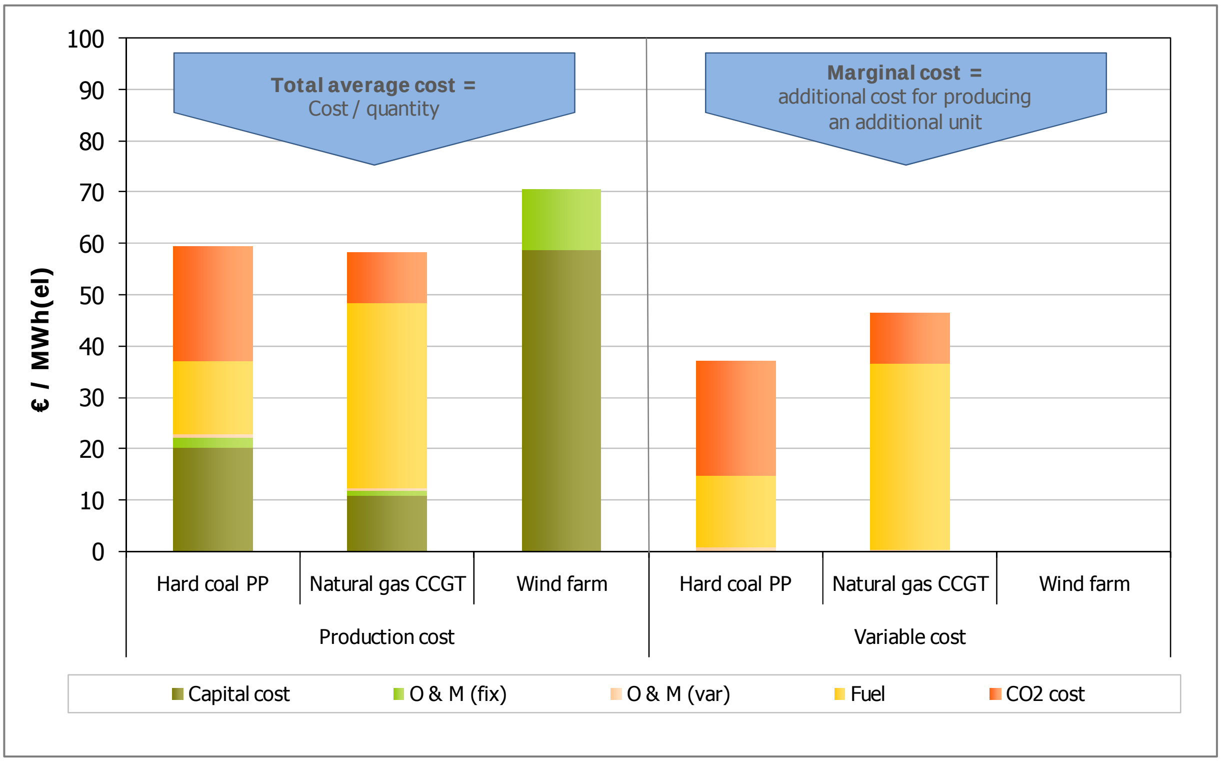

Figure 2: Variable costs of existing hard coal (HCPP) and combined-cycle gas turbine (CCGT) power plants with efficiency factors of 42 to 50 % at CO_2 prices of 0 and 25 €/t, respectively.

[11] Both terms will be used synonymously in the following.

[12] Demand can be explained similarly by the customers' willingness to pay.

Since the introduction of EU emissions trading however there is another component adding to this: costs for CO_2 emissions (see Figure 2). For an existing power plant it is irrelevant, if the emission allowances are issued free of charge or if they are sold (e.g. by auctioning). In case the power plant is not operated, the emission allowances issued free of charge can be sold on the CO_2 market. In case the plant is running, these potential revenues cannot be realised and have to be considered as so-called opportunity costs (see Figure 2).[13]

Table 4 gives an overview of the marginal costs and the respective influencing variables as function of different factors

Table 4: Marginal costs in dependence of installation type

Installation type / fuel	Marginal costs / influencing factors
Nuclear power	
Lignite	Fuel costs
Hard coal	Efficiency factor
Natural gas	CO_2 costs (fossil-fuelled power plants)
Biomass	
Hydro power	
Wind power	none
Photovoltaic	

Due to the variety and diversity of power plants bearing different characteristics as capacity, type of fuel, age etc., a schematic supply curve can be developed as shown in Figure 3a). If now a governmentally organised support scheme instigates the expansion of wind power bearing marginal costs of (nearly) zero, the supply curve is shifted as shown in Figure 3b) and the wholesale prices decreases (Bode/Groscurth 2006).

If, and to which extent this leads to a net relief of electricity consumers, cannot be universally answered and shall not be discussed further here[14] due to the focus being on the incentives to invest – which are calculated based on the revenues and consequently from the power exchange prices.

According to theory the growing feeding-in of wind power plants results in a further decrease of prices. In an extreme case, prices fall to zero (see Figure 4). Especially remarkable is the fact that the power exchange price is extraordinarily low in those times when large bulks of electricity from wind power plants are offered. Hence, especially revenues for wind turbines fall the deeper the more electricity from those sources is offered. This context is especially relevant with regard to the expansion objectives mentioned above.

[13] On this and the consequences with a modified set of power plants see Bode (2008).

[14] On this, see e.g. Bode (2006), Bode (2007) and Wissen et al. (2008).

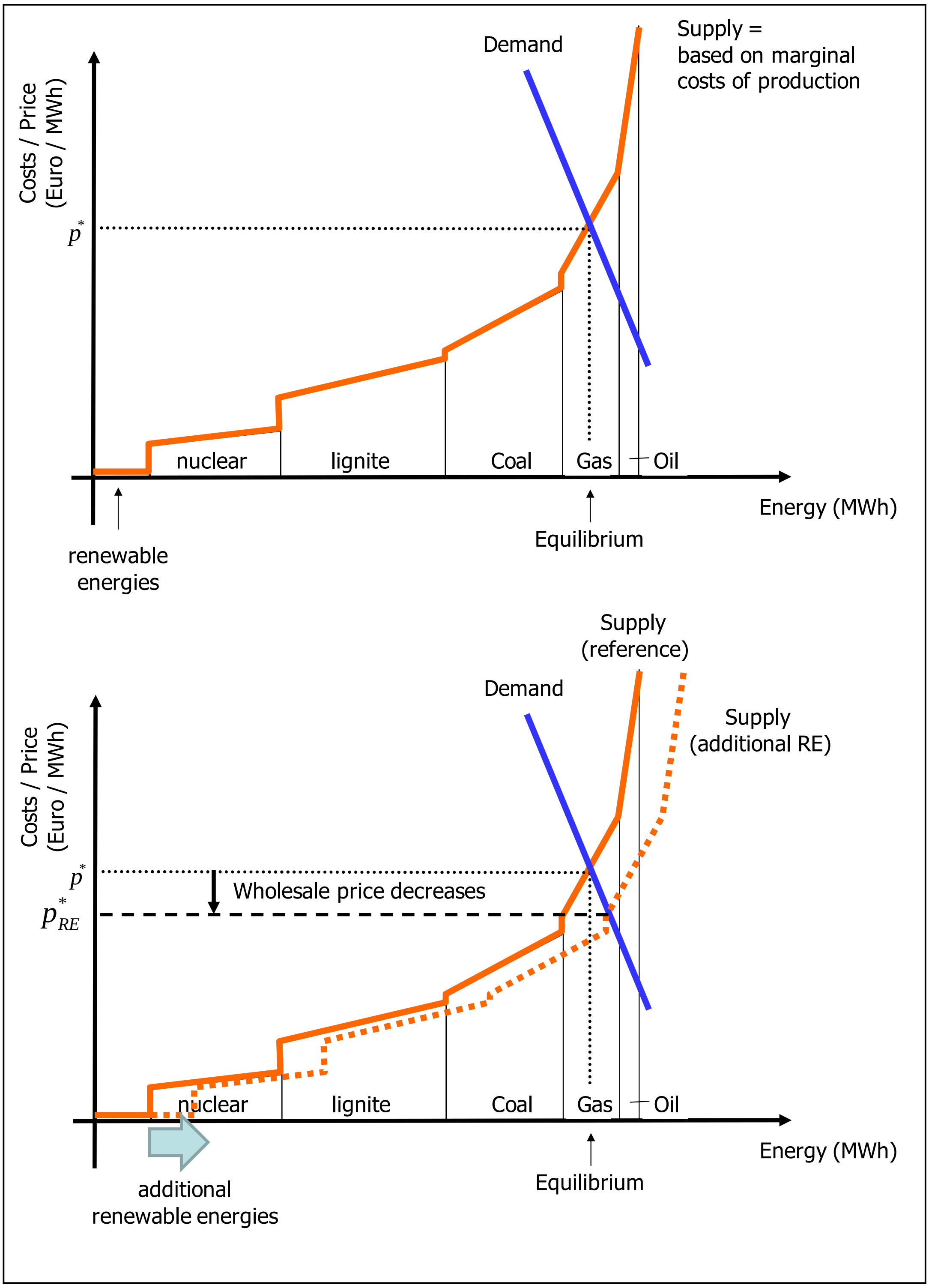

Figure 3: Formation of prices on the electricity market and effect of additional feeding-in of wind power

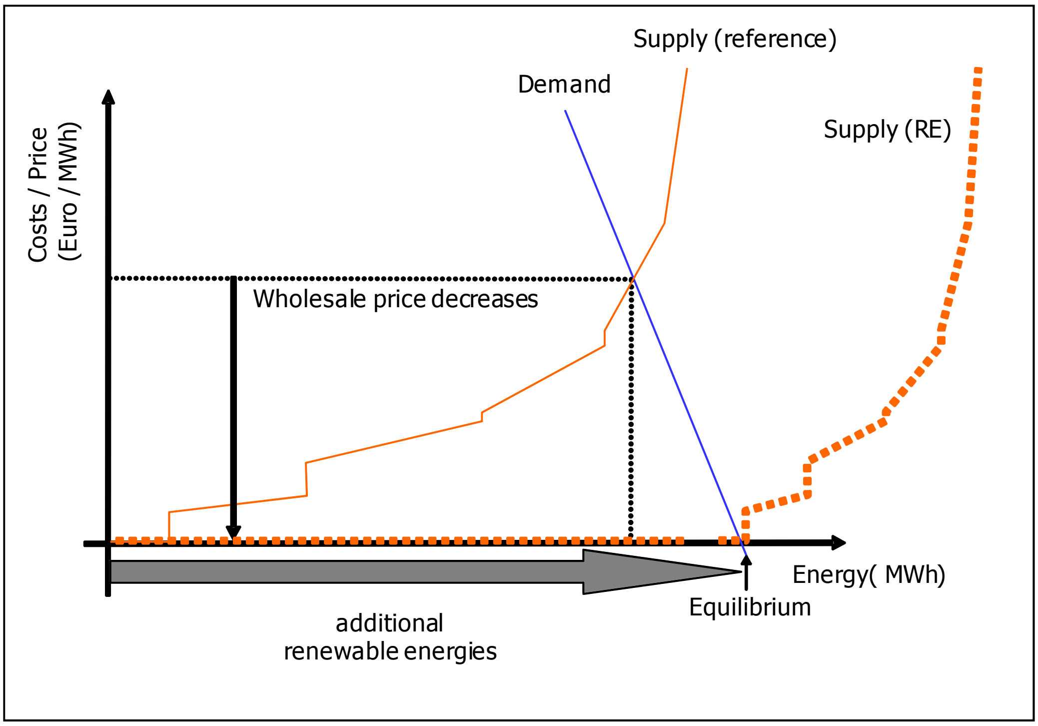

Figure 4: Decrease in prices (extreme case) at a high volume of additionally fed-in wind power

Quantitative assessment

In recent time, effects of support schemes for renewable energies were not only assessed qualitatively but also quantitatively – whereas different approaches were followed. Neubarth et al. (2006) assessed the electricity prices at Leipzig power exchange dependent on the feeding-in of wind power and saw a price decreasing effect of about 1.9 Euro per 1000 MWh of fed-in electricity. The linear regression carried out may be interfered by other factors such as CO_2 prices, fuel costs (oil, gas, coal), power plant blackouts as well as import and export effects.

Sensfuss/Ragwitz (2007) analysed the price decreasing effect in Germany using an agent-based simulation model for different years. For the year 2006, they determined an average reduction by 7.8 Euro/MWh. Morthorst (2007) reviewed the effects of wind power fed into the electricity grid in (Western) Denmark and illustrated how – in times of high-volume feed-ins – prices decrease or even fall to zero. As a result, we can establish that the theoretically expected merit-order principle can be observed in real electricity markets, too.[15]

[15] Wissen et al. (2008) critically discuss if and how the merit-order effect can be applied to assess the net burden imposed by support schemes towards electricity consumers. The fundamental mechanism, however, was also confirmed in this assessment.

Formation of prices for green certificates in a stand-alone market

In this section, the formation of prices on a stand-alone market for green electricity certificates – i.e. without co-existence of an electricity market – is discussed theoretically. It has to be emphasised that such a stand-alone market does not exist as electricity and green certificate markets in reality are closely connected (see next section). Within this theoretical analysis, the competition policy's ideal of a market with perfect competition is applied. Furthermore, in such a certificate market the supply function would be based on the marginal costs of production. The marginal costs of production of a renewable energy certificate would be equivalent to the marginal costs of power production (cf. Table 4).

If we at first suppose a stand-alone market for green certificates with a constant demand for electricity and a certain share of consumption that must be satisfied by electricity from renewable energies, the result is a demand curve in the form of a vertical line. As photovoltaic, wind and hydro power bear marginal costs of zero, the "price-setting" installations (with regard to the merit-order principle) will be biomass plants (see Table 4 and Figure 5). Even though the meeting of objectives in certificate markets is usually determined and controlled at the end of a given year, the price forms in the course of a year based on expected supply and demand values. The market for CO_2 emission allowances under the EU Emission Trading Scheme (ETS) may serve as an example.[16] The market for certificates with a given installed capacity will react similarly to exogenous influences. If, for instance, there is a significantly higher production from wind power than was expected the prices for certificates will decrease.[17] If in this given year there is a (further) expansion of installations taking place, the effect also depends on the question, if the quota is heightened equivalently.[18]

The analysis of a stand-alone green certificate market also shows that the introduction of different specific quotas for individual types of power generation that have marginal costs of zero (i.e. photovoltaic, wind and hydro) perhaps is not interesting from an investor's perspective. With a lack of certificates on such a sub-market, the plant operators obliged to certificate trading will pay an amount as high as the fine at most. The amount of the fine payable could be specific to certain technologies. If the supply of certificates is greater than or equals demand, the equilibrium price is zero (see). In this case the plant operators would not be able to realise revenues. The incentives to invest in more expensive types of power generation like photovoltaic would tend to zero. In case the supply is less than the demand, there is no clear equilibrium and the price would form randomly between zero and the amount of the fine. The formation of a clear equilibrium would be far more likely in a market with an overall quota that is not sensitive to the respective technology type.

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16 In the EU ETS, achievement of objectives is controlled annually. For every year there are expectations concerning supply and demand values. If – already at the beginning of the year – expectations are not met e.g. due to a mild (hard) winter, the emission allowances' price reacts to the shifted expectations and decreases (rises).

17 As far as the authors know to date there are no quantitative studies examining the merit-order effect on a green certificate market.

18 On this, also see Drillisch (1999).

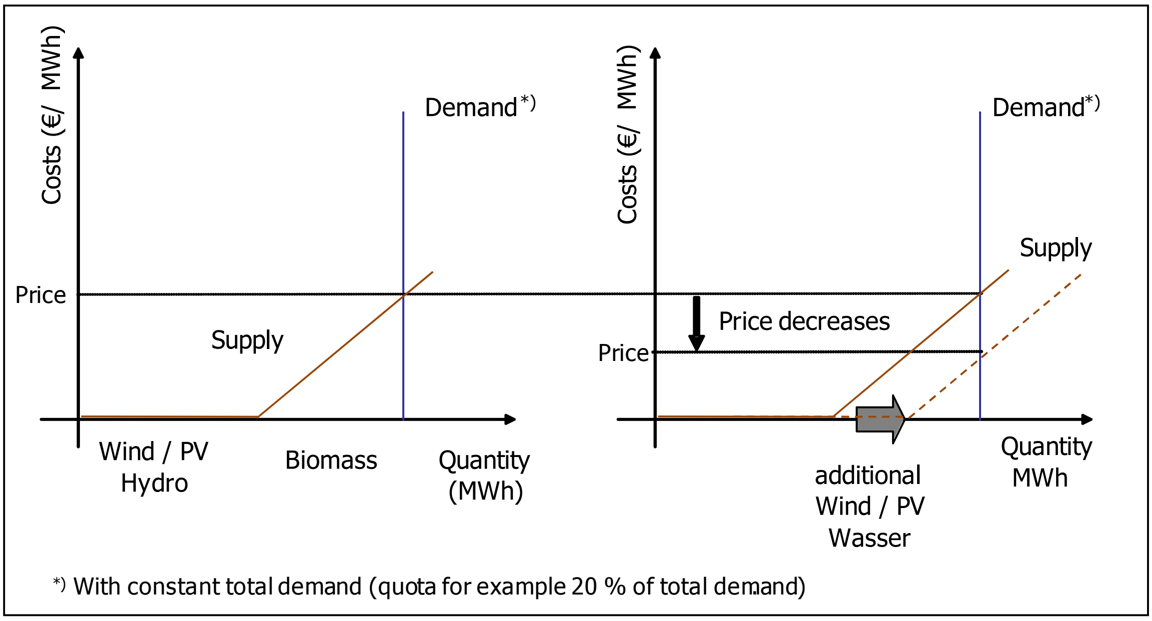

Figure 5: Effect of increased supply of wind power on the price for renewable energy certificates at a constant quota.

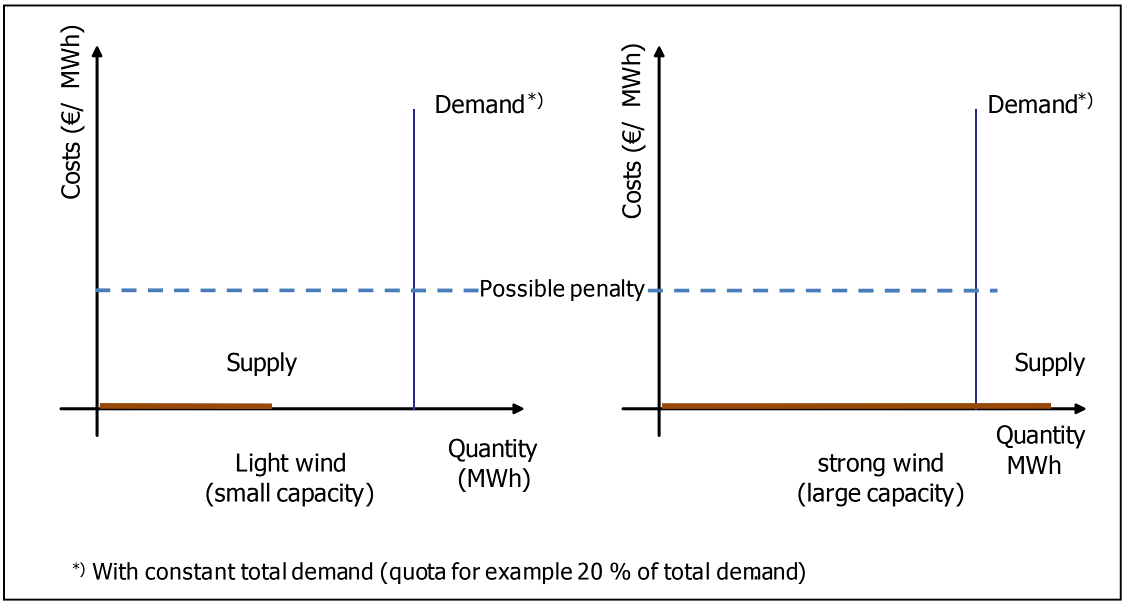

Figure 6: Price formation on a green certificate sub-market with marginal cost of zero.

Combination of electricity and green certificate market

In the previous section both "products", electricity and certificate were assessed as if existing on isolated markets. In fact they are closely connected. Both of the products can only be generated jointly. For each megawatt hour of electricity a certificate is generated that is denominated exactly to the same quantity of electricity (see Figure 7).

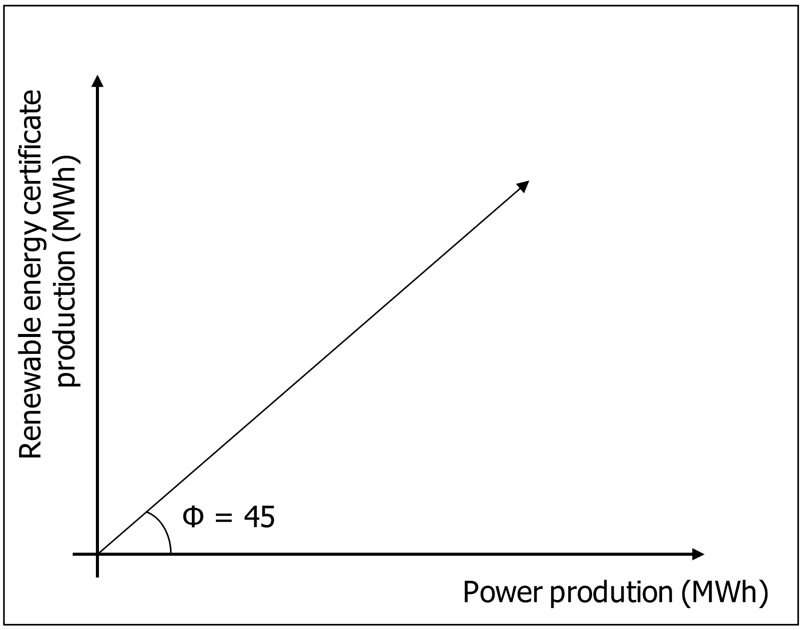

Figure 7: The combination of electricity and green electricity certificates bear a firm relation.

Proponents of a quota model argue that the quota facilitates a stable demand for green certificates. Implicitly it is supposed that their price would form in such a way that the respective plant operators gain revenues which – together with the revenues from the electricity sale – make the investment profitable. For instance, Drillisch (1999) states:

"A supplier of electricity from renewable sources that fall under the quota regulation, just then breaks even with regard to total average costs when the total revenues from electricity and certificate sale equals the total average costs He will only build up power generation capacity based on renewable sources if the expected revenue from the certificates' sale equals or exceeds that part of his expected total costs of production which cannot be covered by the expected revenues from electricity sales. If one divides the portion of the total average costs of production that is not covered by the revenues from electricity sale by the total sum of certificates received, one gets the supply price of a potential green power producer on the certificate market." [19]

The conclusive the first part of this quotation is, the inconclusive is the last sentence. As shown at the beginning, supply in markets with perfect competition is not based on "any"

[19] Drillisch (1999), p. 267. For instance, Bräuer et al. (2001) argue in the same direction. Translation by the authors.

expected or desired minimum revenues but rather on the marginal costs of production. These have already been analysed for a theoretical stand-alone certificate market in the previous section. As electricity and certificates can only be generated jointly, the assessment now has to be extended to the combination of power and green electricity certificates.

With regard to the costs-quantity relation in a short-term analysis of joint products von Stackelberg (1948) proposes to define both products as a new "product package" and to apply the laws for a single product. However, he does not make a statement concerning the decision, at which price both products should be offered on their respective markets.

The distinctive factor concerning electricity and green certificate respectively is, that they are indeed a 'joint product' with a constant generation ratio, but electricity has the dominant role in this combination as a certificate is produced if and only if the supplier's bid is accepted on the electricity market, i.e. if his marginal costs are lower than the equilibrium price. Insofar this joint product differs from others like e.g. combined heat and power (CHP) generation insofar that other joint products can – within the bounds of technical possibilities – generally be sold on either market.

The operator of an installation using renewable energies will consequently offer at the rate of the marginal costs of production on the power market and – if his bid is accepted – will get a green certificate "on top". The marginal costs of production of green certificates hence are zero – without regard to the generation technology. As all providers place their offers with marginal costs of zero, there is not necessarily a clear equilibrium. In case that supply is greater than demand the price is always zero. If the supply is less than the demand, the price can form randomly between zero and an amount equalling the fine for not non-compliance.[20]

Conclusion

The assessment of revenues under a quota model implies that further investments in power plants using renewable energies can only be expected to a limited amount due to the quota model's inherent logic. Investments could be expected if

- the total average costs of production are lower than the expected electricity price, i.e. the investor would not depend on the revenues from the sale of green certificates, or if
- the investor is willing to take high risks and accepts a possibly random formation of prices on the certificate market and consequently revenues that are difficult to estimate. [21]
  One should note that investors regularly ask for a risk premium, which leads to higher costs for capital. In this context IEA (2007) writes: „*Renewable energy policy effectiveness is more affected by the perceived investment risks on renewable project than on their potential profits and / or costs.*" [22]

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[20] Cf. comments on the different quotas specific to a certain technology type in the previous section.

[21] On the sensitivity of investors see e.g. Anonymous (2007) Ein verlorenes Jahr für die österreichische Ökoenergie [A lost year for Austrian eco-energy], in: Windenergie, No. 45, June 2007.

[22] From the investors point of view it is important to note that there is little upside in this investment as the maximum revenue from the sale of certificates is most likely to be smaller or equal to the penalty.

The meeting of the objectives outlined in the beginning seems to be unlikely in case an appropriate support scheme is missing – even if the total average costs of power production from renewable energies drops below those of conventional power plants. The EEG model offers generally sufficient incentives for green power investments. To counteract the frequently feared over-supporting effects tenders might hold advantages over feed-in tariffs as the incentive to only choose the most profitable locations is considerably greater here. An appropriate design of the support scheme is of crucial importance. [23]

[23] For tenders applied in the context off wind energy see the example of Denmark (http://ens.dk/sw63828.asp), for a more theoretical conclusion on tenders see ECN (2005, p. 61).

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