THE LIBERALIZED DUTCH GREEN ELECTRICITY MARKET: LESSONS FROM A POLICY EXPERIMENT[#]

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Revised Version
June 30, 2003

[#] Paper presented at the Conference "Competition and Market Power: Measurement, Theory and Implications", Groningen, December 12-13, 2002. The authors thank the organizers, Marco Haan and Bert Schoonbeek, the discussant Jan Kees Winters, and Michaela Krause for comments on an earlier version.
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Abstract

In order to meet the Kyoto targets, in the Netherlands in 2010 9% of electricity consumption should be generated from renewable resources. In this paper, we discuss and comment on the green energy policy that the Dutch government has adopted in 2001 and 2002 in order to reach this goal, and the new subsidy system that will be in place as of 2003. On the one hand, the policies from the past were successful since they led to 10% of electricity consumption being green in 2001, with a further increase to 13% in 2002. On the other hand, the government argued that the policy was too costly and inefficient. We analyze whether the arguments that the Dutch government used to get the new law accepted hold water and we show that mainly the Dutch supply companies benefited from the generous subsidies that the government provided.

Keywords
Green energy, market liberalization

Jelcodes: D43, H32, L94, Q48

1 INTRODUCTION

In order to protect the environment, also in the long run, the Kyoto agreement specifies targets for efficient and environmentally friendly production and consumption of energy. One may distinguish between efforts in four different domains. On the input side, there is the desire to move from fossil fuels to renewable energy sources; on the production side, one wants to stimulate efficient technologies; on the consumption side, one wants to induce consumers to save on energy use; finally, to prevent global warming, one wants to limit CO_2-emissions. This paper focuses on the first domain and on the electricity market in particular. EU directive 2001/77/EG (European Commission, 2001) has translated the Kyoto goals in certain target levels for EU-countries for green electricity consumption (i.e. consumption of electricity that is produced from renewable sources, such as wind, water and the solar system, as opposed to 'conventional' gray electricity). For the Netherlands, the target is that in 2010 9% of consumption is green. In this paper, we discuss and comment on the green energy policy that the Dutch government has adopted until the end of 2002 in order to reach this goal, and the proposed changes to this policy.

The Dutch experience is interesting since, during 2001 and 2002, the Dutch experimented with a policy mix that differed from that in the rest of the European Union. While most other European countries have relied on "command and control" systems, during 2001 and 2002 the Netherlands adopted a purely market based voluntary system. One may distinguish between supply-side and demand-side policies. Most European countries (Austria, Denmark, Finland, France, Germany, Greece, Italy, Portugal, Spain and Sweden) maintain fixed feed-in tariffs for green electricity: for any electricity produced from renewable sources that is fed into their network, network companies are forced to pay green generators relatively high prices that are determined by the government. These feed-in tariffs may differentiate according to the generating source, and various ways of distributing the costs of this obligation among the users of the network may be distinguished. Austria, Belgium, Denmark, Sweden and the UK adopt demand-side policies, in which an obligation is imposed that a certain fraction of demand be supplied from renewable sources. (See Krause (2002) for further details.)

The Dutch green electricity market was liberalized on July 1, 2001, when all consumers got the right to freely choose their green electricity supplier. For the first one and a half-years, policy mainly relied on demand-side subsidies: consumers did not have to pay the regulatory energy tax (REB), amounting to 6 €cents/kWh for small users, when they consumed green electricity. With a total energy price, including distribution charges and taxes amounting to some 20 €cents/kWh, these subsidies can be said to be quite generous. In addition to these consumer subsidies, there were also some direct producer subsidies. During 2001, green electricity produced abroad was not eligible for the demand side subsidies, but distribution companies lobbied for including imports, arguing that domestic production capacity was insufficient to meet demand. This lobby was successful, and, as of January 1, 2002 also imports of green energy became eligible for this subsidy. As a result of the demand-side subsidy, green electricity demand has soared, with the number of households that demand green energy reaching 1.4 million by the end of 2002. This is some 20% percent of all households, and compares to less than 1% green consumers in Germany and the US. For details see www.greenprices.com, where one can also compare prices of different supply companies. (The site reports that, in the first quarter of 2003, another 400,000 Dutch consumers have switched to green energy, so that, at present no less than 26% of Dutch households are consuming green energy.)

As a matter of fact, in a certain sense, the Dutch green electricity policy was too successful and, at the end of 2002, a new law was proposed to bring policy more in line with that in other European countries; see Tweede Kamer (2002-2003a). The intention was to have the new policy in place at the start of 2003, but, as the first Balkenende cabinet fell after having been in office for only a couple of months, plans were delayed. Recently, also the First Chamber of Parliament has approved the new law, and it will come into effect as of the 1st of July 2003. According to this new law, the consumption subsidies are reduced, and the producer subsidies are increased but are limited to domestic production. The main arguments given for this change in policy are that:

(i) Some forms of renewable electricity production have received higher subsidies than are needed to make them competitive with gray electricity,

(ii) A great part of Dutch electricity consumption has been produced abroad by already existing generating units that are competitive without receiving additional subsidies, hence, these units make handsome profits, at the expense of Dutch taxpayers,

(iii) The subsidies have not led to increased capacity for the production of renewable electricity abroad,

(iv) The competition from foreign green energy has eroded the incentives to invest in renewable electricity generation capacity within the Netherlands.

In the motivation for the change in policy (Tweede Kamer 2002-2003b), the Dutch government argues that the Netherlands can be sure to meet the 9% target for green electricity consumption in 2010 only if a substantial part of this 9% is produced domestically. The reason, so it is argued, is that also the other European countries have similar targets, hence, the generation capacity that is used now can no longer be relied on in the future. Of course, this argument cannot be accepted at face value: one can guarantee supply by concluding long-term contracts. Furthermore, even if there would be some truth in the argument, it does not justify restricting subsidies to domestic renewable production. If it would be cost efficient to produce renewable electricity abroad, one would want to subsidize dedicated production capacity abroad and ensure that that production can reach the Netherlands by guaranteeing access to European transport networks. Indeed, the EU Energy Directives aim at creating a single European electricity market by strengthening the European transport networks and by guaranteeing non-discriminatory access to these networks. In other words, the worries about “security of supply” should be addressed first and foremost at the European level, by insisting on market liberalization, rather than by adopting second best measures such as subsidizing domestic production. (This argument was also discussed in the First Chamber of Parliament; see Eerste Kamer (2002-2003, page 5.))

While one could, hence, criticize the proposals (Van Damme and Zwart, 2002), our emphasis in this paper will not be on the new law, but rather on the situation that prevailed in 2001 and 2002. Our aim is to describe and analyze the workings of that system, in order to see whether the arguments that the Dutch government used to get the new law accepted hold water. The Dutch cabinet argued that, in the existing system, a considerable part of Dutch environmental subsidies were leaking abroad, but it did not provide an estimate of the amounts involved. Our analysis will allow us to give a reasonable estimate: we will show that approximately one third of the total subsidy ended up abroad, the rest remaining in the Netherlands. As one may expect, those who lobbied to extend the subsidies to the foreign producers, i.e. the local distribution companies, were the main beneficiaries of the act.

The remainder of the paper is organized as follows. Section 2 gives background information on the relevant subsidy schemes and on the green certificate system. Section 3 gives prices of green certificates and interconnector capacity and shows that the latter do not reflect arbitrage between the German and the Dutch markets. Section 4 provides analysis, explains this “anomaly” and answers the question of who benefited from the Dutch environmental friendliness. Section 5 concludes.

2 BACKGROUND

As stated above, the Dutch policy goal with respect to green electricity is that, in 2010, 9% of electricity consumption is produced from renewable sources. Present consumption in the Netherlands is about 107 TWh per year,[1] which amounts to average demand of about 12,200 MWh per hour. On the production side, it is customary to distinguish between generation, transmission, distribution and supply of electricity.

Domestic installed generation capacity is about 21,000 MW, of which some 14,000 MW is owned by four large generating companies (Electrabel, E.On, Essent, and Reliant). These larger generating units are directly connected to the high voltage grid. System operator TenneT, a state owned company that is responsible for balancing the system, manages the electrical transmission system: at any time total electricity production should be matched with demand (i.e. electricity is not storable). Supply companies (such as Nuon, Essent and Eneco) are the intermediaries between producers and end consumers. Currently larger consumers are free to choose their supply company. The same is true for small end users consuming green electricity. Market opening for all consumers is planned to take place in July 2004. Until that

[1] 1 TWh = 10^{12} Wh = 10^9 kWh = 10^6 MWh = 10^3 GWh = 3.6 10^{15} J.

time, supply of gray power to the captive consumers remains a regulated (local) monopoly. Physical delivery requires use of the local, low-voltage, distribution grids, which are (and remain) regulated natural monopolies. Total end-user charges are composed out of the commodity price, grid charges, fees for supply companies and taxes.

TenneT's high voltage grid is connected to the grids of E.On-Netz and RWE-Netz in Germany and to that of Elia in Belgium. In total, the interconnectors with these neighboring countries have a capacity of 3,650 MW to import or export electricity. Use of this scarce capacity is allocated via auctions, organized by TSO-auction, a daughter of TenneT and the foreign grid owners. We will discuss these auctions in more detail later.

In both Germany and the Netherlands, wholesale (gray) energy is traded on exchanges, the EEX in Germany and the APX in the Netherlands. Prices for wholesale (gray) energy in Germany are typically lower than Dutch prices. In 2002 average German prices ranged around € 25/MWh, while prices for power in the Netherlands were somewhat over € 30/MWh on average[2]. The price difference is mainly due to differences in electricity production technologies (with low marginal cost nuclear and coal production in Germany, and gas-fired power plants in the Netherlands). As a consequence, demand for import capacity over the German-Dutch interconnection is high, and frequently congestion occurs on these lines, translating in non-zero auction prices for capacity. Congestion on the Belgian-Dutch border is much less frequent.

Statistics Netherlands has recently published data about renewable electricity production in the Netherlands; see CBS (2002) and CBS (2003), and see Table 1 for a summary. In 2002, total domestic production of green electricity was 3.627 TWh, up from 2.936 TWh in 2001. Most of this green electricity (2.576 TWh) was produced

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[2] These wholesale prices are only a small component of retail prices for end users: costs of distribution via the grid, costs of supply companies and taxes lead to a final electricity bill of over € 200/MWh, or € 0.20/kWh for household consumers. For one of the authors, in May 2003, the gray price is composed as follows: Network charges: € 5.08 per month and € 0.03264/kWh, supply: € 1 per month and € 0.046/kWh, REB: € 0.0639/kWh and VAT: 19% over the sum of the previous three items. For green electricity, the network charge and VAT are the same, supply is € 1 per month and € 0.0924/kWh and REB is correspondingly lower so that the end price is about the same.

from biomass, just as in 2001 (approximately 2 TWh). Windmills produced 0.910 TWh of electricity, 10% more than in 2001, when production was a bit less than in 2000, mainly as a result of the absence of wind. During 2001, the number of windmills increased by 34 to 1330, while in 2002 there was a further increase with 132 units. As a result of this additional investment, the total capacity of the Dutch windmill park increased by 40% in 2002. The small remainder of renewable production is mainly hydropower; the production of solar energy is marginal.

[Insert Table 1 about here]

Given that production of green energy is subsidized, it is natural to assume that domestic capacity is not much higher than domestic production, and it follows that current domestic capacity is insufficient to meet the Kyoto-target; hence, green imports seem needed. Statistics Netherlands reports that, in 2001, green electricity imports were with 7.6 TWh rather large and much higher than in 2000, when they were only 1.5 TWh. Interestingly, in 2002, green imports were even larger and had increased to 10.35 TWh. These estimates are based on firms' filings for ecotax reduction, hence they are reliable; see Ecofys (2002) and Kroon (2002) for more details on the data for 2001. Note that if we add domestic and foreign generation, we come to a total of 10.6 TWh of green electricity that was produced for the Dutch market in 2001, and to a total of 14 TWh in 2002. Consequently, since generation equals consumption, already in the year 2001, about 10% of Dutch electricity consumption was green, while in 2002 even 13% of consumption was green. In other words, the Netherlands already met the Kyoto target nine years before the deadline! It should be noted also that, in 2001, "official" green consumption was only 1.57 TWh, while in 2002, the estimate is about 3.5 TWh, and hence, most of the green energy is sold as being "gray".

The above makes one wonder about which instruments were responsible for this success. A distinction has to be made between supply-side subsidies, which were in place throughout 2001, and demand-side subsidies that were available as of the date when the Dutch market for green electricity was liberalized, July 1, 2001. Although we are mainly interested in the demand-side, we describe the supply-side subsidies first.

On the basis of article 36o of the "Wet Belastingen op Milieugrondslag" (law on environmental taxes, available as Schuurmans & Jordens, 2000) during 2001, generators of green electricity could get a subsidy of € 20/MWh for each MWh of green electricity that was produced and consumed in the Netherlands. Note that, compared to the average commodity price for electricity traded on the APX in 2001, of € 35/MWh, the size of the subsidy is considerable; of course, compared to the total end user retail prices for domestic consumers of over € 200/MWh, the impact seems smaller. This subsidy was available for domestic producers, but, under certain conditions, also for foreign producers. In essence, the latter had to provide sufficient proof that they did not receive other types of subsidies for their electricity and that they transported the electricity to the Netherlands, so that it was consumed there. As evidence, the exporters had to demonstrate their E-programs to the relevant Dutch tax authority, hence, one had to show the contract path for the electricity and one had to buy the transport capacity that was needed to carry out this E-program. We note that small-scale (< 15 MW) hydropower was eligible for this subsidy, but that larger hydropower production units were assumed to be competitive without subsidies and, hence, were excluded from the subsidies. Kroon (2002) notes that these subsidies are also very attractive for small-scale hydro installations and he estimates that in Europe some 2400 MW of capacity may be ready to export to the Netherlands.

The market for green energy was fully liberalized as of July 1, 2001, i.e. at that time all consumers got free choice of supply-company for their green energy. On that same day, the demand-side subsidies (under article 36i of the same law on environmental taxes) came into effect and the system of green certificates was introduced; see Staatscourant (2001a). A *domestic* generator of green electricity (i.e. a producer who produces electricity from wind, biomass, water or the sun), who is recognized as such by the relevant authority, and whose production is measured by the network company that connects him to the grid, receives a green certificate for each MWh of electricity that he produces. These green certificates state the source of production, but they can be traded between market participants independently of the electricity. A subsidiary of TenneT, Groencertificatenbeheer BV, (abbreviated GCB) facilitates the trading of these certificates, which are valid for a year. Eventually, the supply companies that supply electricity to end-users will buy these certificates.

Under the 2001 regime, consumers who bought green electricity did not have to pay the regulatory energy tax (REB). If a supply company supplied *X* MWh of electricity to a consumer who had a green contract, and the supply company had *X* green certificates, then the tax authority reimbursed the supply company the REB for this consumer. The REB rates that applied in 2002 are given in Table 2; in 2001, these rates were not much different.

[Insert Table 2 here]

As the REB is a regressive tax, it follows that buying green electricity is most attractive for small-scale consumers, hence, supply companies will first target those. An average household consumes about 3.2 MWh of electricity per year and there are about 7 million households in the Netherlands, hence total electricity demand of small-scale consumers is 22.4 TWh, a bit more than 20% of total electricity demand, and much above domestic green electricity production.

In the fall of 2001, following a lobby by the distribution companies, who argued that (potential) demand for green electricity outstripped domestic generation capacity, the “Regeling groencertificaten” was modified, and also imported electricity became eligible for the consumer subsidy; see Staatscourant (2001b). As with the producer subsidies, it had to be proved that the electricity was physically imported into the Netherlands, hence, at the interconnectors transport capacity had to be bought for that purpose. (The Regulation states this somewhat vaguely: one should have enough capacity to import, but one did not necessarily need to have the capacity at the point in time when the imports took place.) The other elements of the subsidy scheme remained in place, with the exception that hydropower was no longer eligible for REB-reduction. Most probably, this change was made mainly in order to exclude imported hydropower from these attractive subsidies. The amendment took effect as of January 1, 2002; hence, as of that moment GCB also issued certificates for green electricity produced abroad. In the remainder of this paper we will investigate the consequences of this policy change.

Of course, an immediate consequence of opening up the Dutch market for foreign producers was that the supply of green certificates increased, which one would expect to result in a price reduction. At the same time, however, supply companies stepped up their advertising campaigns, in order to attract additional demand for green energy. Indeed, one might expect there to be latent demand: as information on www.greenprices.com shows, the majority of Dutch consumers prefers to consume green energy if that has the same price as gray energy, while a considerable minority (45% in 2000) is even willing to pay a premium for green electricity.

A second consequence of the opening up of the certificate market was an increased demand for interconnector capacity. After all, a foreign producer could only get a Dutch green certificate if he also had bought interconnector capacity. Here, since the available capacity is scarce, one would expect an increase of its price. As we will see in the next section, the auction results indeed show an increase in auction prices.

3 PRICES OF GREEN CERTIFICATES AND INTERCONNECTOR CAPACITY

Green Certificates

At the site of GCB (www.groencertificatenbeheer.nl) one can see how many green certificates have been issued. We will concentrate on the totals for the year 2002, which are provided in Table 3. In the table, we distinguish between certificates from a Dutch source (labeled by ‘H’) and certificates originating abroad (labeled by ‘A’). Since there was a significant distinction between green imports in the first and second half of the year (imports increased during the year and stabilized from September onwards), we also provide the December 2002 data for reference.

[Insert Table 3 here]

Table 3 shows that, during 2002, certificates were issued for about 10.5 TWh of electricity. We also see that about 78% of green electricity consumption originates abroad and that the production of solar energy is, with 0.01% of the total, negligible. The most important source is biomass, with 54% of the total; hydropower comes next with almost 37% of the total. The production of wind energy (9%) is relatively modest.

Note that the data from Table 3 are not entirely consistent with those of Table 1. There are large discrepancies as far as domestic biomass is concerned, and for these we do not have a good explanation, except that, perhaps, the certificates for this power were issued only in 2003. In percentage terms, the discrepancy is also large for solar energy, but as the total quantity from that source is rather small, this does not bother us very much. In addition, on the basis of Table 3, one would estimate imports as 8.1 TWh, where according to CBS these were 10.35 TWh, composed as biomass 6.21 TWh and hydropower 4.14 TWh. Again there are large discrepancies and we can only explain the difference for hydropower. Recall that, as of 2002, hydropower is eligible for green certificates, but not for the demand side subsidies, hence, as the certificate is not necessary to get the subsidy, a producer of hydropower may not bother to claim a certificate. Nevertheless, at least two reasons can be mentioned for why certificates would be attractive also in this case. First of all, the certificates may be used for marketing purposes: some suppliers advertise that they deliver hydropower, which is perceived to be "greener" than biomass. Secondly, with a certificate one can claim the producer subsidy. Since having a certificate is not necessary for claiming the producer subsidy, however, one may expect that not all hydropower imports have been submitted to GCB and that the data from Table 2 underestimate the amount of hydropower that was imported. Consequently, one could explain the difference between the 3.7 from Table 3 and the 4.14 estimated by CBS by the fact that not all producers of hydropower will apply for certificates.

All power mentioned in Table 3 was eligible for the production subsidy of € 20/MWh, however, hydropower was not eligible for the demand-side subsidy. If we take hydropower out, we are left with 6.7 TWh of power that can profit from the demand-side subsidies. At the moment, about 1.4 million Dutch households have switched to green power. With an average consumption of 3.2 MWh per household per year, this gives an annual green demand of about 4.5 TWh resulting from households. To this has to be added the green demand from larger users about which no data are available. For a sufficiently low green certificate price, (lower than the marginal REB rate of € 20/MWh), it would be attractive for supply companies to also target medium sized businesses with annual consumption less than 50 MWh. If total demand from business consumers would remain below 2.2 TWh, however, we should expect the price of green certificates to be small, in fact, under competitive conditions, if green certificates were not storable, the theoretical price would be zero.

Unfortunately, the prices at which green certificates are traded are not public. Through a broker it was possible to get some information on prices for imported biomass certificates, which is reproduced in Table 4. This table gives the price for the stripped certificate, i.e. it does not include the producer subsidy. Note that the price has gone down, but that it has not yet reached the level of zero. Also note that the price since May is less than € 20/MWh. We understand that certificate prices for e.g. domestically produced wind electricity have been significantly higher, with prices around € 40-50/MWh. Since the bulk of green energy consists of imported biomass, however, the average green certificate price will be relatively low.

[Insert Table 4 here]

Interconnection

We now move on to discuss the interconnector auctions. A trader who has acquired power abroad and who wants to export it to the Netherlands, will have to acquire interconnector capacity at the border. In total, about 3650 MW of capacity is available, out of which 300 MW is reserved for system balancing by TenneT, while 900 MW is reserved in order to execute long-term import contracts that date back to the days of coordinated electricity planning. The remaining capacity, about 2450 MW, is auctioned. There are different auctions for different interconnectors and, at each interconnector, year, month and day auctions are distinguished. Capacity that is acquired in the year auction can be used throughout the year and capacity acquired in the auction for say May 2002 can be used during May 2002. The day auction actually consists of 24 hourly auctions, capacity acquired in the "March-17-2002; 2-3 am"-auction can be used during that hour of that specific day. The year auction takes place in November of the preceding year, the month auction takes place in the preceding month and the day auction is a day ahead auction. As it is not easy to buy electricity in Belgium, having capacity at the interconnectors with Belgium is not very valuable for market parties, with the exception of Electrabel, which has production capacity on both sides of the border. This is reflected in auction prices that are rather low.

We, hence, will focus here on the interconnectors with Germany. There are two such interconnectors, one connects the Dutch grid with that of E.On-Netz, the other connecting to RWE-Netz. In total, about 1600-1800 MW of capacity is available at these interconnectors, of which 572 MW is offered in the year auction, and 536 MW in the month auctions. Capacity at these interconnectors is valuable as there is a liquid power market, the EEX, in Germany, at which prices are on average lower (by € 6-10/MWh) than in the Netherlands. Here we will simply look at the aggregate capacity at these interconnectors and their average (capacity based) price. The latter is justified since the price differences in the year and month auctions are not very large.

The 1100 MW of capacity that is available, in the year and month auctions, for base load capacity is most attractive for traders that are interested to receive Dutch subsidies for renewable electricity that is produced abroad. Note that in order to import the 8.1 TWh of green electricity from Table 3 one needs to have 930 MW of capacity throughout the year, this is more than is available in the year auction only. Similarly, in order to import the 1.2 TWh of electricity during December 2002, one needs to have some 1350 MW of capacity during each hour of this month. Furthermore, taking the data from Table 1, we see that in order to import 10.35 TWh of power, one needs 1182 MW of hourly capacity on average throughout the year, which is again more than what is available in the year and month auctions. Consequently, yearly capacity is scarce and, in some months, capacity in the month auctions is scarce as well. One thus expects high prices in the year and month auctions.

At the website of TSO-auction BV (www.tso-auction.nl) price data are available. Relevant information for the annual auctions is provided in the table below. We see that in the year 2002, the price for capacity was much higher than in 2001, and also much higher than the price that was paid for capacity that will be available during 2003.

[Insert Table 5 here]

How to explain the rather large price difference? In a market that is working efficiently, one would expect the interconnector price to reflect arbitrage possibilities between the markets at the two sides of the interconnector. In the absence of green electricity, traders can buy gray electricity at the cheap (German) side at price p_G and sell it at the more expensive Dutch side (for a wholesale price of p_N); the profit made is the (wholesale) price difference

$$v_1 = p_N - p_G \tag{1}$$

between the two markets, and competition at the auction should drive the price up to this price difference. Of course, the actual price difference is somewhat uncertain, hence, one might expect a small risk premium: the auction price will be somewhat less than the expected price difference at the day of the auction. On the other hand, a trader is not forced to use the interconnector capacity; capacity bought in the year auction can be resold in the month or day auction. This implies that, if one holds capacity, one can import if the price difference is favorable and can resell capacity if the price difference is unfavorable, in other words, the arbitrage profit is equal to max $(0, p_N - p_G)$ and this would induce a trader to bid more aggressively in the auction. We note that, in 2001, the average (over all hours) of $p_N – p_G$ was € 9.5/MWh, whereas the average of $\max(0, p_N – p_G)$ was € 11.0/MWh, where p_N denotes the APX-price and p_G the EEX-price.

As an estimate of the expected price difference, at the time of auction, we may use the price difference for annual base load contracts, $p_N – p_G$, as reported by Platt’s in its European Power Daily (Platt’s, 2001-2002) on the day of the year auction, i.e. November 28 of the preceding year. On November 28, 2000, this price difference was € 11/MWh, one year later it was € 9/MWh and on November 28, 2002 it was € 7.35/MWh. One sees that auction prices in 2001 and 2003 are close to these values, but in 2002 they are way off.

We may make similar observations for the month auctions during 2002. The following graph gives for the year 2002 the price paid in the month auction (averaged over the two interconnectors) and the arbitrage price for monthly base load energy (based on Platt's quotes) on the day these auctions took place. We see that also in these auctions a substantial premium resulted, in particular at the end of the year.

[Insert Figure 1 here]

Figure 2 reports the same data as in Figure 1, but now for the year 2001. Note that, at the beginning of the year, the interconnector price was somewhat less than the price difference between the two markets, in line with arbitrage. From the middle of the year, however, the auction price was somewhat larger than the price difference, and this might indicate that hydro imports were starting to congest the interconnector. On the other hand, as the figure shows, the interconnector price did not reveal a significant mark-up on arbitrage values. (To import the 7.6 TWh of power from Table 1, one needs to have 868 MW of hourly capacity on average, hence, imports appear insufficient to congest the interconnector.)

[Insert Figure 2 here]

We next move on to an attempt to explain the observed prices in terms of an equilibrium model for green electricity, and will see that the Dutch subsidies may indeed provide an explanation for the seeming "anomaly" for the year 2002. Of course, our model is stylized, as all models are, and abstracts away from many issues such as marketing cost for green energy, maintenance cost for windmills, and switching costs of consumers, to name but a few. As a result of focusing, we get a clearer picture of the costs involved in the subsidy scheme and of who benefited from this scheme.

4. ANALYSIS: A MODEL OF GREEN CERTIFICATE AND INTERCONNECTION PRICES

The prices for green certificates and the mark-up on 'gray' arbitrage prices implicit in interconnection prices will depend on a balance between supply and demand for green electricity produced both abroad and in the Netherlands, in conjunction with the capacity constraints on imports of electricity. We will study this balance under the 2001-2002 subsidy regime. We will first focus on the supply side, next on the demand side, thereafter we will focus on the special role of small-scale hydro energy, and finally we will describe the equilibrium and compare it with observed price behavior.

Supply side

We first analyze the supply side of the problem. We will defer a discussion on small-scale hydro energy ('light green'), which only benefits from the producer subsidy, and first focus on green energy production that is eligible for the demand subsidy ('dark green').

We can divide potential suppliers of green certificates in four categories: existing domestic green generation, newly constructed domestic generation, and the same categories for foreign generation. All these producers will require a certain minimum green certificate benefit in order to produce for the Dutch green market.

The category of existing domestic green generation is simplest. These suppliers will mostly make up the lowest end of the supply curve. For wind and solar production, marginal production costs are near zero. Marginal costs for biomass plants depend on the type of fuel; in general their fuel costs can be expected to be somewhat higher than in the case of conventional generation. Given that all these generators will at least earn the price for gray electricity plus the € 20/MWh producer subsidy, we may expect the majority of these units to produce at low or zero green certificate prices.

For the longer-term equilibrium also newly constructed domestic units become relevant. These will for a large part make up the higher part of the supply curve, due to the large fixed cost component of many sources. (To induce entry of new units, revenues should exceed long run average costs, instead of short run marginal costs). Computations by KEMA/ECN (ECN 2002) lead to indicative required subsidies of some € 50-80/MWh to make investment in e.g. wind (on- and off-shore) and pure biomass fired plants profitable. Conventional plant adjustments to allow for biomass co-firing will be significantly lower, and can also be available on a much shorter time scale. The volume of potential newly constructed plants will be limited due to scarcity of available sites (wind), or available fuel (biomass).

The third category consists of foreign existing green units (subject to a reciprocity clause limiting eligible countries). Insofar as these units may benefit from local feed-in tariffs, their required green certificate price to induce them to deliver to the Dutch market instead will be relatively high in general: for example, German wind energy could, in 2002, benefit from a minimum feed-in tariff of € 62/MWh, while small-scale biomass (<20 MW) was rewarded at least € 87/MWh (i.e. given that German EEX–prices were approximately € 25/MWh, these producers could receive a subsidy of the order of € 35 to 65/MWh in Germany). For units that are excluded from these generous schemes, such as larger biomass units, the situation is different. A good example may be larger German coal or lignite plants that can co-fire biomass fuel. Their marginal opportunity costs c_G for delivering in Germany would be the maximum of their marginal production costs and the German (gray) electricity price p_G, or

$$c_G = p_G + e \tag{2}$$

with $e \geq 0$ the excess marginal production cost. Michaela Krause informed us that there may be another way for producers to green their electricity. Rather than adjusting technical production, one may buy a RECS-certificate. RECS is a European system of tradable certificates that are recognized in various countries. By combining gray energy with a RECS certificate, the energy becomes green; hence, one may buy a RECS-certificate where it is cheap and trade it for a GCB-certificate in the Netherlands. We have been told that, in 2002, it was possible to buy a RECS-certificate for around €4/MWh, hence, this would imply $e = 4$ in (2).

Supplying to the Dutch green market instead entails an additional cost, the interconnector charge. The benefits are composed out of the Dutch gray price p_N, the € 20/MWh producer subsidy and the price of green certificates, g. Splitting the interconnection price into the (gray) arbitrage price p_N - p_G and a possible interconnector mark-up s we arrive at the requirement

$$g \geq s + e - 20 \qquad (3)$$

for it to be worthwhile to supply to the Netherlands.

Finally, the analysis for newly constructed foreign capacity is a straightforward extension of the above.

Adding things up we can construct a qualitative picture of the (medium term) green supply $q(g,s)$ as a function of green certificate price g and interconnector mark-up s,

$$q(g,s) = q_{ed}(g) + q_{nd}(g) + q_{ef}(g,s) + q_{nf}(g,s) \qquad (4)$$

where the subscript e (resp.n) refers to existing (new) capacity, where d (resp. f) refers to domestic (resp. foreign), and where the last two terms explicitly depend on s.

At fixed s the picture following from the above analysis looks like Figure 3. For clarity we have assumed s, the interconnector mark-up, large (>20): in this case we can identify separately the contributions from low marginal cost domestic production (at $g = 0$), and low marginal cost foreign production, the plateau at $g = s - 20$. For lower s (as appears to be the case in reality, judging from Figure 1) both contributions merge. In the graph, in region I we find the domestic installed capacity, which will contribute, even at very low certificate price. In region II it becomes profitable for foreign existing capacity to deliver in the Netherlands. Available volume at $g = s - 20$ is set by low marginal cost production (with e=0), the upward sloping part consists of production which is slightly more costly than marginal gray prices, i.e. $e > 0$. Region III is composed of new capacity (as well as high marginal cost installed capacity).

[Insert Figure 3 here]

Demand side

The total demand for green certificates will also depend, to some extent, on the price. There is presumably a large and inelastic demand at any $g < 60$ consisting of supply companies delivering to small consumers who need neither price incentive nor large scale advertising to switch to green energy. At decreasing g, green consumers will become more and more valuable for retailers, who pocket the difference $60 - g$, minus a possible discount they may pass on to customers, and, in this case, one may expect larger advertising and larger demand for certificates. Since green certificates stay valid for one year, expectations of potential growth of green consumption may induce a demand for certificates that exceeds consumption at that time. At low g (<20) demand in the category of small and medium sized businesses will be encouraged, as their marginal REB tariff equals € 20/MWh.

Hydro energy

Hydro power is not eligible for the consumer subsidy and therefore does not affect the green certificate price directly. For foreign hydro energy there is an indirect effect, however. Since hydro energy (from smaller units) does receive the € 20/MWh producer subsidy, it will be attractive to import this to the Netherlands as long as the interconnector mark-up s is smaller than 20 (since marginal costs for hydro power are near zero, opportunity costs are precisely the German price, or $e = 0$ for hydro energy). For small enough s, interconnector capacity will be used up partly by hydro energy, displacing some other green energy and thus limiting foreign certificate supply.

Equilibrium

The values for g and s will be determined by two equilibrium conditions. In the first place, total supply and total demand for non-hydro green energy, $d(g)$, will be equal for positive green certificate price (assuming of course that there is sufficient available supply in principle):

$$g \cdot \left[d(g) - \left(q_{\mathrm{d}}(g) + q_{\mathrm{f}}(g,s) \right) \right] = 0$$
$$g \geq 0; \quad d(g) - \left(q_{\mathrm{d}}(g) + q_{\mathrm{f}}(g,s) \right) \leq 0 \tag{5}$$

where we have aggregated contributions from existing and new capacity.

Second, the interconnector mark-up will depend on whether total foreign green production (hydro and other) is lower than available interconnector capacity, K, or equals it. In the former case, some interconnector capacity is still used by gray electricity, which implies that $s = 0$ (s can never be negative, since in this case gray imports would completely displace green imports, setting s again to its arbitrage value of zero). In the latter case, green imports will set the interconnector price. We can here distinguish two cases: if the mark-up s is less than 20, part of the capacity will be for the small-scale hydro power which does not benefit from g, while if s is larger than 20, it will only be profitable for non-hydro green energy to be imported. Denoting the total available foreign small-scale hydropower by H (assuming that $H < K$) we arrive at

$$\begin{aligned} s &= g + 20 - e(K\text{-}H); \qquad 0 < s \leq 20 \\ s &= g + 20 - e(K); \qquad s > 20 \\ s &= 0; \qquad q_{\mathrm{f}}(g,0) < K - H \end{aligned} \tag{6}$$

Here $e(K)$ respectively $e(K\text{-}H)$ are the excess marginal production costs e (as defined above), for the marginal foreign green plant at volume K, or $K\text{-}H$ (this is a fixed quantity, independent of s or g). The explanation for this equation is that, if import capacity is fully used by green electricity, generators will drive up the interconnection price until profits for the marginal generator are reduced to zero.

The equilibrium is found by solving both equations simultaneously. To illustrate the solution, as an example let us make the assumption that demand is completely inelastic, $d(g) = d$. We plot a qualitative picture of g and s as a function of d in Figure 3. For very small d ($d << K$), we may assume that there is sufficient green supply willing to produce for only the € 20/MWh producer subsidy, i.e. $g = 0$. Only low marginal cost domestic and foreign production will supply in this case. As $q_{\mathrm{f}}(0,0)$ will be smaller than $K – H$, the interconnector will not be congested with green energy and $s = 0$; the price for interconnection capacity is therefore equal to the gray price difference p_N - p_G. Total imports will consist of H hydro power, $q_f(0,0)$ green non-hydro energy and the rest (up to K) gray electricity.

As d increases beyond $q_f(0,0)$, first g will increase to attract the more costly (non-hydro) green supply, again both from domestic and foreign producers. Since foreign production at zero g is insufficient to congest interconnection capacity with green power ($H<K$, by assumption, and also born out by evidence from the 2001 situation), s will remain zero. This continues up to the point that $q_f(g,0) = K\text{-}H$, when the interconnector gets congested with green energy and the interconnector price mark-up s becomes positive. In the next phase both g and s continue growing, subject to $q_f(g,s)$ remaining constant at $K\text{-}H$, or $s = g + 20 - e(K\text{-}H)$, and $q_d(g)$ equaling $d - K - H$. This phase ends when s hits 20 and hydro energy is getting more and more displaced by green energy at increasing g, until g reaches the value where $q_f(g,20) = K$ and all hydro energy is displaced. From then on we are in the final phase where g and s again keep increasing subject to $q_f(g,s) = K$, or $s = g + 20 - e(K)$ and $q_d(g) = d - K$. The sequence of events is summarized in Table 6.

[Insert Figure 4 here]

[Insert Table 6 here]

Connection to observations

In 2001, we effectively had $g = 0$ for foreign production: green certificates were only awarded to foreign production as of 2002. As Figure 2 shows, in the first half of the year, the interconnector prices were below arbitrage values, while, in the second half of the year, these prices were higher, but they still did not reveal a significant mark-up on arbitrage values. Total green imports (7.6 TWh in total or, on average 868 MWh/h) were insufficient to congest the interconnector. On the other hand, in the second half of 2002 the interconnector was congested, at a mark-up s of somewhat over € 10/MWh. Green certificate prices at the same time were around € 10/MWh. We can conclude that, at that time, we were in the regime of congestion by both hydro and non-hydro green energy, as is borne out by the statistics of Groencertificatenbeheer. Under the assumption of inelastic demand, we can estimate from (6) the marginal excess production costs $e(K\text{-}H)$ at circa € 20/MWh. Note that, according to Table 3, total green imports in 2002 were 8.15 TWh or 930 MWh/h, hence, in effect not much larger than the imports that CBS reported for 2001. As explained above, and as borne out by the CBS data for 2002 that became available very recently, in 2002, green certificate data understate the imported hydro energy and total green imports considerably; as a result the interconnectors were more congested than indicated by Table 3.

Who benefited from the green policy?

We next turn to an estimate of the cost of the Dutch green electricity subsidy scheme during 2002 and study what players have benefited from this scheme.

Recall that at the end of 2002, 1.4 million Dutch households had signed up for green electricity and that the average household consumes 3.2 MWh of electricity per year. If we estimate annual demand of green energy at 4.5 TWh (which coincides with the estimate provided in CBS (2003) and which more or less coincides with the number of redeemed green certificates as of January 2003), and value all consumer subsidies at € 60/MWh, the value for delivery to small consumers, we can conclude that € 270 million was spent on the demand side subsidies (€ 60/MWh times total consumption of 4.5 TWh). From Table 1, we can conclude that the supply side subsidies amounted to slightly more, € 280 million (€ 20/MWh times total production of 14 TWh), hence, the total subsidy is € 550 million. Where does this money end up?

The producers can claim the producer subsidies. Domestic producers can claim this subsidy in full; after all they do not need the cooperation of another party. Table 1 allows us to conclude that this amount is approximately € 72.5 million. In order to access the subsidies, green electricity producers from abroad have to pay increased prices for interconnector capacity. A rough estimate is that the interconnector price is € 10/MWh higher than it otherwise would be. At total imports of 10.35 TWh, this amounts to increased auction revenue of € 103.5 million, which (by the rules governing the auction) is shared equally between TenneT and the auction organizers (RWE-Netz and Eon-Netz) on the German side. With total production subsidies for foreign production of € 207 million, this leaves € 103.5 million for the foreign producers, which we assume they can keep in full (hence, we assume that they do not have to share with Dutch supply companies; in other words, the € 103.5 million is an upper bound for the amount received by foreign producers).

The consumer subsidies are divided between consumers, producers and suppliers. During 2002, consumers benefited only a little, since, despite the huge subsidies, the price for green electricity was only slightly less than the price for gray electricity. Retail price information from www.greenprices.com demonstrates that, at the moment, some new entrants do provide large discounts on green energy of € 10 to 40/MWh, however, prices of market leaders tend to be close to gray energy prices, and in 2002, new entrants only had a small market share. As we have seen, also producers benefit only marginally, as the price of a green certificate is rather small: between € 10/MWh and € 20/MWh. Hence, the major beneficiaries of the scheme are the intermediary supply companies. Given that supply companies receive the remaining € 40-50/MWh a sensible estimate is that of the € 270 million that is at stake, circa € 200 million ends up with supply companies, while the remainder, € 70 million, goes to producers. From the data that are publicly available, it is not possible to determine exactly how this latter amount is split between foreign and domestic producers. On the one hand, there is more supply from abroad, but on the other hand, for marketing purposes, there may be a preference for green electricity that is produced within the Netherlands. As a rough estimate, we assume an equal split between Dutch and foreign producers, hence € 35 million each. Domestic producers therefore receive, on aggregate, € 72.5 million producer subsidies and € 35 million from green certificates, leading to a total of € 107.5 million. For foreign producers, the resulting figure is € 138.5 million. All in all, the balance is as in Table 7.

[Insert Table 7 here]

One may wonder why, given that green electricity consumers have free choice of supply company, there is not more competition between these companies and why consumers do not benefit from lower prices. Allegedly this is because the Ministry of Economic Affairs has put pressure on these companies not to lower their prices for green energy; see Financieel Dagblad (2001). From a public finance perspective, this would be understandable, after all each household that switches to green electricity costs the Dutch taxpayer € 192 per year, but from a purely economic point of view, inducing cartel behavior to resolve a mistake in a policy design seems hardly satisfactory.

5 CONCLUSION: POLICY CHANGES

During 2001 and 2002, the Netherlands experimented with a liberal, mainly consumer-oriented policy to stimulate the greening of electricity. As the number of households switching to green energy rose from a very small base at the beginning of 2001 to approximately 1.4 million at the end of 2002, this policy can be considered a major success. Remarkably, as of 2002, the policy also did not make a distinction between domestic production and electricity generation abroad: a certain type of electricity generation was eligible for a certain type of subsidy, irrespective of the location where that electricity was generated. The darker side of the coin is that the policy was rather expensive; indeed to reach the goal of 9% of Dutch electricity consumption to be green, the 2002 policy mix would result in annual costs of approximately € 770 million (9.63 TWh of consumption, subsidized at € 80/MWh).

A second shortcoming of the system is related to its effect on interconnection prices. As we have seen, in 2002, the policy induced a permanent green congestion of interconnectors between Dutch and German grids. The first consequence of this is that a substantial part of the subsidies for green energy (19%) ended up in the hands of interconnector owners, while the use of more efficient foreign production was limited to the amount of interconnection capacity. A second and important effect of the congestion is that it distorts the (much larger) market for gray electricity, since price responsive gray imports, which play a role in reducing market power of domestic generators, are displaced by inflexible green imports. In effect, the Dutch green subsidies make it unattractive to import gray electricity from abroad, thus increasing the price of gray electricity in the Netherlands; see the Report by the Dutch Market Surveillance Committee (DTe, 2002). This is a second channel through which the Dutch producers have benefited from the green subsidy, a channel that has not been taken into account in Table 7. (As distribution companies own generating facilities, we note that this again benefited these distribution companies.)

In reaction to these problems, the Dutch government has chosen to adopt a completely different policy as of July 2003. The essence of the new policy is to reduce the demand side subsidies and to increase the supply side subsidies, but to limit the latter to newly or recently installed domestic production. Generators of green electricity located within the Netherlands will, for a period of 10 years, receive a subsidy related to the difference in cost of their technology and the cost of producing gray electricity, where technologies that are not much more costly will be compensated in full. Specifically, biomass will receive a subsidy of € 29/MWh, wind-power on land will receive a subsidy of € 49/MWh, and other forms of green power, including wind at sea, will receive the maximal subsidy of € 68/MWh. In addition, the demand side subsidies for small scale consumers will be reduced to € 29/MWh (from the € 60/MWh that it was in 2002). Note, therefore, that the maximal subsidy that will be available from July 2003 will be € 97/MWh, which is 20% above the maximal subsidy that was available in 2002.

Given the above analysis, it does make sense to reduce the demand-side subsidies, as is planned. Furthermore, given that the intention is to increase production capacity, it does make sense to limit the subsidies to new or recently installed capacity. However, the other parts of the plan, to limit the production subsidies to domestic generation and to differentiate these subsidies according to how inefficient these generating technologies are, are economically less efficient. No matter where electricity is produced from renewable resources and no matter which technology is used to produce it, the benefit to the environment is the same, hence, the subsidy should be the smallest amount that is necessary to reach the goal.

Actually, one would perhaps expect that EU-regulations would prevent a country from adopting policies that discriminate in favor of domestic firms. Quite interestingly, when the environment is concerned, this is not the case as the judgement of the European Court of Justice in the Preussen Elektra case shows. This case concerns the high feed-in tariffs that German distribution companies have to pay to windmill parks that are connected to their network. Preussen Elektra objected to having to pay at least 80% of the average sale price and started proceedings at the Landgericht Kiel, Germany. The Landgericht referred two important questions to the Court of Justice for a preliminary ruling:

(i) Does these rules constitute State Aid, i.e. are the rules in conflict with Article 92 of the EC Treaty?

(ii) Can these rules be interpreted as a quantitative restriction on imports, i.e. do they conflict with Article 30 of the EC Treaty?

In both cases, surprisingly, the Court came to the conclusion that the answer was negative; see the paragraphs 54 ff. of the Court Decision for the arguments.

The main argument that the Dutch government used to argue that subsidies should be limited to domestic generation was that considerable tax money was leaking abroad. The calculations that we have done in this paper show the extent of this subsidy flow to foreign parties: approximately one third of subsidies ended up abroad. However, the allocation of subsidies between domestic and foreign parties is not necessarily relevant. If the least costly way is to subsidize foreign renewable electricity production, then only foreign producers should be subsidized. The argument that the Netherlands cannot exclusively rely on imports and that we have to be self-supporting to a certain extent also is not convincing: the Dutch could sign long-term contracts with foreign producers, or they could construct dedicated capacity abroad. To a certain extent, such foreign production is actually desirable: it seems to be most efficient to construct windmills in those areas where there is (a) most wind and (b) few people; in that case, one also solves the NIMBY-problems: few people want to have large, modern windmill in their direct neighborhood. The policy that will be in place as of 2003 does not allow subsidies to be given for green capacity located abroad that is newly built and dedicated to the Dutch market, and as such the new policy is inefficient.

It is true, on the other hand, that apparently a large part of the foreign green energy imports is obtained from sources that need hardly any subsidy to be profitable, and that are currently excluded from subsidy regimes abroad (mainly from large units co-firing biomass). By limiting the subsidies to newly installed capacity, however, also this problem would be eliminated, hence, this is not good argument for banning foreign production from the subsidies.

More efficient solutions to the problems with the 2002 green policy regime would anyhow take advantage of the efficiency gains of employing the complete internal market. Obviously the ideal solution would be a joint green certificate market for the Community, as this would succeed in allocating generation to those places where it is most efficient. Total tax credits for redeemed certificates could be adjusted over time as prices are revealed in certificate trade.

In the meantime, a temporary solution that does resolve problems of the 2002 regime while employing the benefits of imported green power might consist of:

a) reducing the amount of subsidy;

b) possibly limiting the types of eligible generation types to the recently installed ones, or to coincide with foreign subsidy policies;

c) eliminating the need for physical imports, to take away the inefficiencies of green congestion.

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Source	2001	2002
Biomass	1,980,600	2,576,000
Hydro	117,280	124,000
Solar	13,060	16,700
Wind	825,420	910,000
Imports	7,645,000	10,350,000
Total	10,581,360	13,976,700

Table 1: Domestic green energy production and imports (in MWh) in the Netherlands in 2001 and 2002. Source: CBS (2002, 2003). We note that CBS remarks that of the imports in 2002, 60% was biomass and 40% hydropower.

Consumption (MWh)	Marginal Rate (€/MWh)
0-10	60.10
10-50	20.00
50-10,000	6.10
> 10,000	0

Table 2. Regulatory energy tax (REB) in 2002.

Source	H-Dec	A-Dec	T-Dec	H-02	A-02	T-02
Biomass	267,240	731,320	998,560	1,312,995	4,382,289	5,695,284
Hydro	9,597	502,207	511,804	117,199	3,731,150	3,848,349
Solar	796	-	796	2,411	-	2,411
Wind	87,458	4,326	91,784	924,642	35,735	960,377
Total	365,091	1,237,853	1,602,944	2,357,247	8,149,174	10,506,421

Table 3: green certificates issued in 2002 in MWh, split in Home, Abroad and Total.

Month	Price (€/MWh)
Jan 02	25
Feb 02	24
March 02	22
April 02	20.5
May 02	15
June 02	12
July 02	10.75
Aug 02	10.75
Sep 02	10
Oct 02	10
Nov 02	9
Dec 02	9

Table 4. Prices for green certificate for Nordic biomass energy.

Year	RWE	E.On
2001	10.90	10.50
2002	17.75	18.35
2003	6.75	6.90

Table 5. Prices (€/MWh) for capacity bought in the year auction for the interconnections with the two German grids, RWE and E.On.

g and *s*	**What happens**
g=0, s=0	Low marginal cost foreign and domestic producers
g>0, *s*=0	Also producers with costs higher than gray price start producing
g>0, *s*>0	Foreign supply is sufficient to congest interconnection, only new domestic supply can be attracted
g>0, *s*=20	Non-hydro foreign supplies start displacing hydro imports
g>0, *s*>20	Only non-hydro imports are profitable

Table 6: sequence of events as demand *d* increases.

Destination	Market player	Amount (million €)
Home	Producers	107.5
	Supply Companies	200
	Network Company	52
Abroad	Producers	138.5
	Network Companies	52
Total	Dutch government	-550

Table 7: who profited from Dutch environmental friendliness?

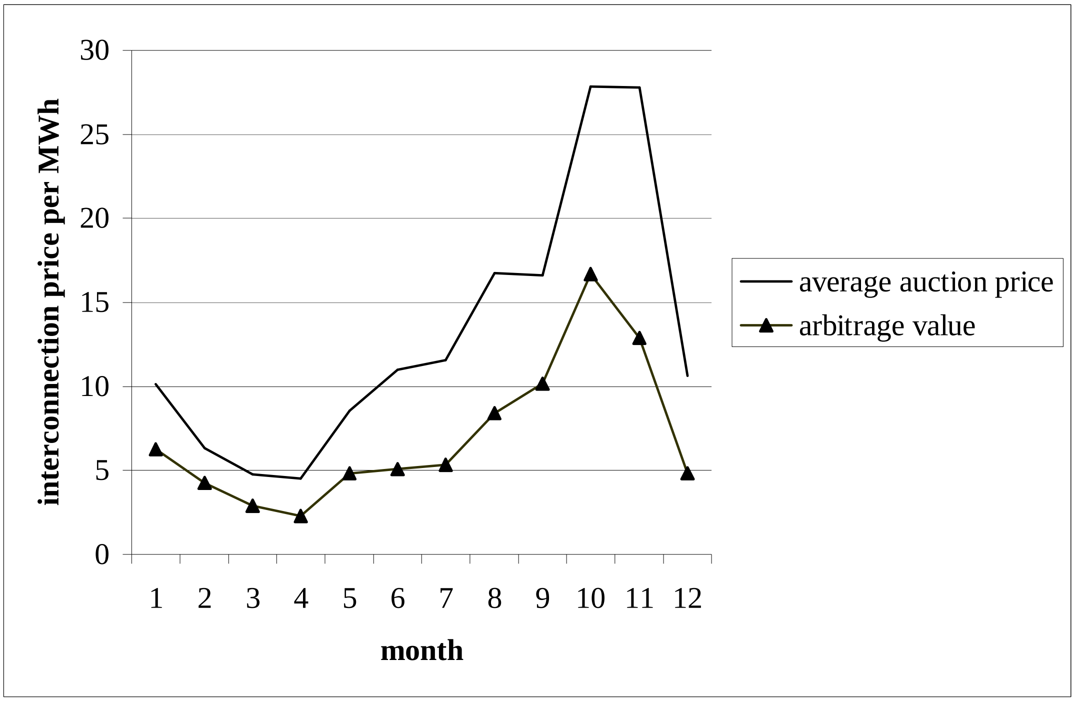

Figure 1: Interconnector prices in month auctions for 2002 in relation to the price difference p_N - p_G between the Dutch (APX) and German (EEX) market.

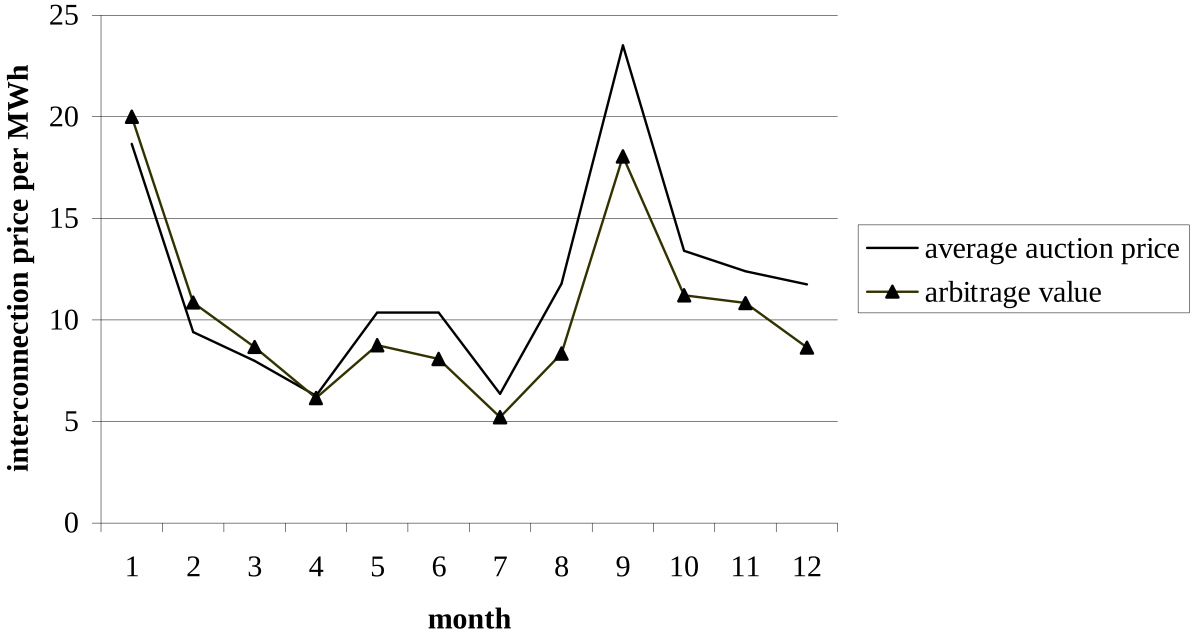

Figure 2: Interconnector prices in month auctions for 2001 in relation to the price difference p_N - p_G between the Dutch (APX) and German (EEX) market.

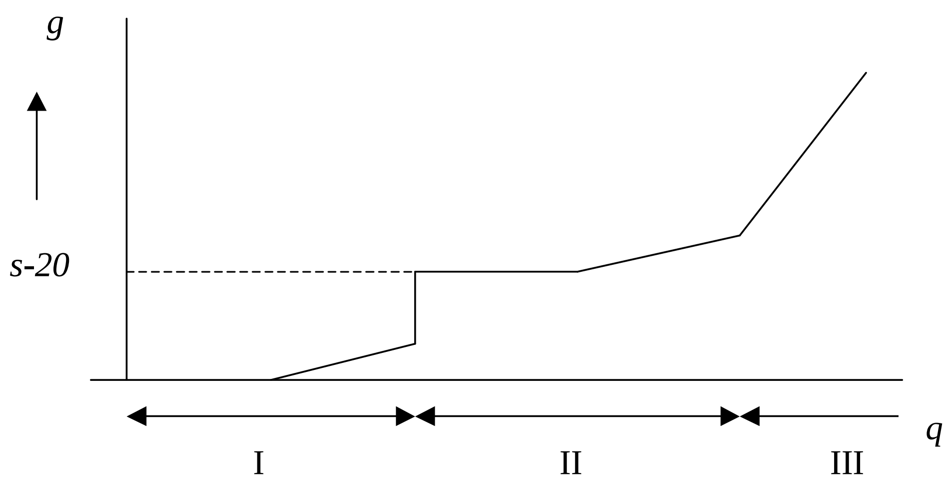

Figure 3: qualitative picture of green electricity supply q depending on green certificate price g .

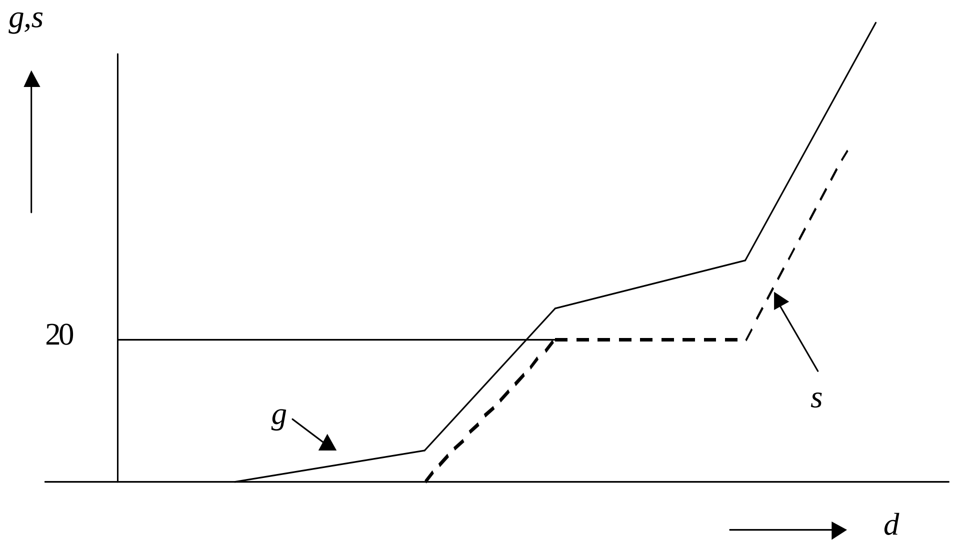

Figure 4: qualitative behavior of green certificate price and interconnection mark-up as a function of green demand.