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Published in:
Energy Policy

DOI:
[10.1016/j.enpol.2016.09.040](https://doi.org/10.1016/j.enpol.2016.09.040)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2016

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Mulder, M., & Zomer, S. P. E. (2016). Contribution of green labels in electricity retail markets to fostering renewable energy. *Energy Policy*, 99, 100-109. <https://doi.org/10.1016/j.enpol.2016.09.040>

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Contribution of green labels in electricity retail markets to fostering renewable energy

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HIGHLIGHTS

- In Europe, electricity retailers are obliged to disclose the energy source.
- In the Netherlands, most renewable energy is based on imported certificates.
- The certificates system does not result in more renewable energy.
- Restrictions on international trade may improve the effectiveness.

ARTICLE INFO

Article history:

Received 4 January 2016

Received in revised form

14 September 2016

Accepted 15 September 2016

Available online 29 September 2016

JEL codes:

L94

Q48

Q58

Keywords:

Electricity market

Environmental policy

Consumer behaviour

Electricity labels

Tradable green certificates

ABSTRACT

In European countries, retailers are obliged to disclose the energy source and the related environmental impacts of their portfolio over the preceding year. The electricity supplied in the Dutch retail market is presented as renewable energy for 34%, but this relatively high share is for 69% based on certificates (Guarantees of Origin) which are imported from in particular Norway. The certificates are used to sell green electricity to consumers. The premium for green electricity which is actually paid by Dutch consumers is no more than a few percentages of the retail price. The low level of this premium is related to the abundant supply of certificates at low marginal costs from Norway. This also means that the premium for green electricity is too low to give an incentive for investments in new capacity. Hence, the current labelling system for renewable electricity is mainly valuable, besides being an instrument for tracking and tracing of renewable energy, as a marketing instrument for electricity retailers. The effectiveness of Guarantees of Origin as a policy instrument to foster renewable electricity sources is weak. This effectiveness can be raised by implementing restrictions on the international trade or the issuance of new certificates.

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1. Introduction

Because of the liberalization of electricity retail markets, consumers are able to choose their preferred retailer and their preferred type of contract. The retailers as well as the contract types may differ in several aspects, such as the structure and the level of tariffs. Although electricity in itself is a homogeneous product, retailers may also offer electricity contracts which differ in the way the electricity is generated. As a result, consumers in some countries can choose between labels like ‘grey electricity’, ‘green electricity’ or ‘electricity produced by domestic wind turbines’. The existence of such type of contracts does not only result from the

innovation within electricity retail markets, but it is also related to the objectives of governments to stimulate renewable energy sources. In Europe, the objective is to realise a share of renewable energy of at least 20% in total energy consumption in 2020, besides the ambitions to realise a reduction of 20% in greenhouse gas emissions and an increase of 20% in energy efficiency. Recently, the target for renewable energy has been extended to 27% for 2030 (EC, 2015).

Because of these policy objectives for renewable energy, a number of policy measures have been implemented by the various Member States (CEC, 2008). Examples of such policy measures are feed-in-tariffs and contracts-for-differences. In this first subsidy scheme, producers of renewable energy receive a fixed amount per unit of electricity over the lifetime of the investment covering all costs, while in the second scheme the subsidy is also related to the actual price of electricity. These type of measures are

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implemented on a national basis. A policy measure which refers to all EU countries is the creation of a market for renewable certificates. EU Member States are obliged to issue certificates, called Guarantees of Origin (GO), for the generation of renewable electricity on request. This requirement is laid down in Directive 2001/77/EC which aims to promote electricity production from renewable sources (Van der Linden et al., 2004).¹ A GO serves as a proof that electricity is generated from renewable sources, such as wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogases. Producers of renewable energy receive a certificate for each MWh of electricity produced which they can transfer to retailers or other players in the electricity market. If a retailer acquires these certificates, it is allowed to sell electricity as being generated through a renewable technique. When the GOs are used, they are cancelled. Hence, cancellation of GOs means that a GO certificate is used to sell electricity under the label of green energy. Hence, the electricity in the retail market may be labelled as green. If a GO is not used within 1 year, it expires. The labelling system in the retail market to sell green electricity is thus based on a tracking system of the production of electricity (Lise et al., 2007).

A consequence of the existence of a separate market for certificates is that these certificates can be traded separately from actual electricity flows within the EU. This trade in the certificates is registered in the European Energy Certification System (EECS). Although the certificates are not necessarily linked to quota mechanisms (Van der Linden et al., 2004), Member States are allowed to include imported GOs from inside the EU to meet the national indicative target if the exporting Member State explicitly accepts that it will not count the renewable electricity for its own target.² Because of this option, countries are able to use imports of GOs to reach national targets for renewable energy instead of increase their own electricity production from renewable sources provided that they have an agreement with the GO exporting country that this country will not use this electricity for its target.

The certificates for renewable energy play an essential role in the electricity retail market as it enables retailers to acquire a green image and to explicitly sell green products. Selling green products can be profitable for retailers as several groups of consumers are prepared to pay extra for renewable energy (Yang et al., 2015). Offering new innovative products can also help retailers to retain old customers or to attract new ones (Yang, 2014). Up to now, however, little is known on the effectiveness in environmental terms of using labelling in the electricity retail markets. Hast et al. (2015) conclude that the impact of the green electricity labels in Finland, Germany and the United Kingdom on additional renewable-energy capacity is modest, while they also point at the risk of double counting of the impact on renewable energy. The latter risk is, however, minimized by the auditing policies of the Association of Issuing Bodies which are responsible for the issuing of GOs.³

In this paper, we analyse the environmental effectiveness of the labelling system used in the Dutch electricity retail market. This labelling system has been implemented on two levels: on the level of retailers and on the level of individual products. Both for the labels on retailer level and on product level, certificates for green electricity play a central role.

Based on the Electricity Market Directive (2003/54/EC) of 26 June 2003, retailers are obliged to disclose the energy source (i.e.

the electricity fuel mix) and the related environmental impacts (CO₂ emissions and nuclear waste) of their portfolio over the preceding year. This regulation aims to provide consumers the ability to make informed decisions regarding their choice of retailers. From our analysis, it appears that the electricity supplied in the Dutch retail market which is labelled as renewable energy has a market share of 34%, but this relatively high share is for 69% based on GOs which are imported from in particular Norway. In addition, labels are used to define the characteristics of specific products supplied by retailers. These labels are in particular used to sell green electricity to consumers. From our analysis, it appears that the premium for green electricity which is actually paid by Dutch consumers amounts to a few percentages of the retail price. Hence, in the current design GOs appear to be more valuable as a marketing instrument, next to other instruments like offsetting carbon from electricity consumption, for electricity retailers than as policy instrument to increase the capacity of RES.

The structure of this paper is as follows. In Section 2, we first describe the European market for GOs. Afterwards, we discuss the method of determining the labels for retailers in the Dutch market as well as the method and data of determining the premium which is paid for renewable energy on product level. The results are presented in Section 3 and discussed in Section 4. In Section 5, we present the conclusions and policy implications.

2. Method and data

2.1. The market for Guarantees of Origin

The market for GOs has grown strongly over the past years. In 2014, it covers 362.5 TWh of electricity, which is about 10% of total EU consumption of electricity in that year (AIB, 2015). The Netherlands is a net importer of GOs: the net import is twice as large as domestic production of green electricity. Even Germany, which is the major producer of renewable energy in Europe, is a net importer of GOs. Norway is the largest net exporting country of GOs with a net export of 89.2 TWh (see Table 1). The other net

Table 1
Transactions of GOs per country in 2014 (in TWh).
Source: AIB, 2015.

Country	Issue	Export	Import	Net import	Expire	Cancel
Austria	11.9	14.6	18.9	4.3	—	15.7
Belgium	6.8	15.9	28.4	12.5	2.0	14.9
Croatia	—	—	—	—	—	—
Cyprus	—	—	—	—	—	—
Czech Republic	0.8	—	0.0	0.0	0.2	0.8
Denmark	16.5	7.2	2.4	−4.8	1.0	8.3
Estonia	0.2	—	—	—	0.0	0.1
Finland	20.9	25.8	16.6	−9.2	7.7	25.4
France	20.2	15.0	2.7	−12.2	0.9	7.9
Germany	18.4	4.8	67.6	62.8	4.1	80.5
Iceland	10.0	10.1	0.1	−10.0	0.0	0.1
Ireland	—	—	—	—	—	—
Italy	27.4	2.1	6.4	4.3	1.6	31.6
Luxembourg	0.0	0.2	3.5	3.3	0.3	3.3
Netherlands	11.6	7.9	32.5	24.5	1.0	37.9
Norway	130.5	116.9	27.7	−89.2	1.9	29.9
Portugal	0.2	—	0.2	0.2	—	0.2
Slovenia	—	—	—	—	—	—
Spain	0.8	0.2	0.0	−0.2	—	—
Sweden	22.6	26.9	26.9	0.0	0.4	20.9
Switzerland	63.4	7.2	11.8	4.6	50.4	54.3
UK	—	—	—	—	—	—
Total	362.5	254.8	245.6	−9.2	71.6	331.9

Note: Cancellation of a GO occurs when the certificate is realised, i.e. the certificate has been used.

¹ At least one independent body is assigned by each Member State with the task to issue GO within its own jurisdiction. In the Netherlands, CertiQ is responsible for the issuance of GO.

² Communication from the European Commission to the Council and the European Parliament (COM(2004) 366 final, May 2004).

³ See www.aib-net.org.

exporting countries in 2014 are France (12.2 TWh), Iceland (10.0 TWh), Finland (9.2 TWh), Denmark (4.8 TWh) and Spain (0.2 TWh). The large share of export of Norwegian GOs results in a low share of RES electricity in the national electricity report for consumer disclosure of Norway. This reported share is substantially lower than the actual production of RES electricity in Norway, since 98% of the generated electricity in Norway is produced using renewable sources (NVE, 2015). However, the export of GOs does not affect the Norwegian performance in terms of renewable-energy production, nor does it affect the importing countries in realising their renewable-energy targets. For inclusion of imported GOs in the EU energy targets, the exporting EU member state needs to officially withdraw from counting the RES electricity for its own target (EU Renewable Energy Directive (2009/28/EC)). Although Norway is not a member state of the EU, Norway has implemented the EU RES Directive (2009/28/EC), meaning that Norway acts legally on similar principles as EU Member States. However, Norway has not concluded an agreement on the use of GOs for the national RES target with most EU countries.⁴ Hence, GOs from Norway cannot be used for the RES targets in these EU member states. As a result, exporting the GOs to these EU countries does not have an opportunity costs for Norway making it attractive for this country to sell the GOs at any positive price. Though Norway is not obliged to comply with the EU energy targets, the country did submit an action plan in the context of the EU Renewable Energy Directive. Norway states a target for 2020 to achieve a RES energy share of 67.5% in the gross final consumption of energy. Norway bases, however, its calculation of the RES electricity share on its production (RES production over total electricity consumption). Hence, the GOs sold to EU member states (except Sweden) do not affect the realization of the target of Norway. Therefore we may conclude that GOs foremost purpose is to disclose the source of electricity towards consumers.

2.2. Labels on the level of a retailer

2.2.1. Calculation method

Because of European regulations, retailers are obliged to show to their customers the fuel mix of the electricity which was supplied by them in the preceding year (Electricity Directive 2003/54/EC). In addition, they need also to give information on the related environmental impacts in terms of CO₂ emissions and nuclear waste. Here we present how this energy label can be calculated on the level of retailers. This method enables us also to determine the contribution of GOs to making portfolios of retailers greener.⁵

In order to derive the energy label of the portfolio of a retailer over the past year, a number of fuel mixes and the corresponding emission factors need to be calculated. The fuel mixes that need to be calculated are the import mix, the national production mix, and the national trade mix (Fig. 1). The national production mix and import mix are calculated under the assumption that they only consist of grey electricity. This is done to prevent double counting of green electricity when calculating the label in the end when the GOs are used to determine the share of renewable energy.

The national trade mix is determined by the weighted sum of the national production mix and the import mix based on electricity flows:

$$T_i = \left[\frac{TNP}{TNP + TNI} \right] * NP_i + \left[\frac{TNI}{TNP + TNI} \right] * NI_i \quad (1)$$

⁴ Norway and Sweden are the first and so far only example of two countries implementing a "Joint Support Scheme" as defined under the RES Directive related to RES cooperation. (Ecofys, 2014).

⁵ This method is based on CE Delft (2014). The results for the average Dutch retailer can be used by individual retailers to determine their individual energy labels over the past year.

where T_i stands for the share of electricity in the national trade mix (production plus import) which is produced using technique i , TNP for the total net production, TNI for the total net import, NP_i for the share of electricity in the total net production which is produced using technique i , and NI_i for the share of electricity in the total net imported electricity (TNI) which is produced using technique i . TNP and TNI are measured in GWh, while T_i , NP_i and NI_i are percentages.

The national production mix equals the weighted sum of the centralized net production mix and decentralized net production mix based on electricity flows, where net production is equal to the production minus the producer's own consumption of the produced electricity. This is done using the following formula:

$$NP_i = \left[\frac{TCNP}{TNP} \right] * (CNP_i / TCNP) + \left[\frac{TDNP}{TNP} \right] * (DNP_i / TDNP) \quad (2)$$

where $TCNP$ stands for the total centralized net production, TNP for the total net production, CNP_i for the centralized net production using technique i , $TDNP$ for the total decentralized net production, and DNP_i for the decentralized net production using technique i . All values are measured in GWh except for NP_i which is a percentage. This is calculated for each technique for generating grey electricity. All shares or percentages together represent the national production mix.

The import mix is calculated as the weighted sum of the production mixes of countries from which electricity is imported, based on the total net import (import minus export) proportional to the import per country:

$$NI_i = \left(\sum_{k=1}^K NI_k * (P_{ik} / TP_k) \right) / TNI \quad (3)$$

where NI_i stands for the share of electricity in the total net imported electricity (TNI) which is produced using technique i , NI_k for the net imported electricity from country k , P_{ik} for the production of electricity of country k using technique i , and TP_k for the total produced grey electricity in country k . All values are measured in GWh, except for NI_i which is a percentage. This is calculated for each techniques used to generate grey electricity. All shares or percentages together represent the import mix.

Finally, the national supply mix is derived from the weighted sum of the national trade mix and the amount of cancelled GOs, the latter indicating the share of green electricity in the total electricity supplied:

$$S_i = \left[\frac{(TS - TG)}{TS} \right] * T_i + \left[\frac{TG}{TS} \right] * (G_i / TG) \quad (4)$$

where S_i stands for the share of generation technique i in the national supply mix, TS stands for the total supplied electricity, which equals the total net production plus the total net import, TG for the total amount of supplied green electricity, which is the total production of green electricity plus the total net imported green electricity, T_i for the share of electricity in the national trade mix (production plus import) which is produced using generation technique i , while G_i stands for the green electricity (production plus import) which is produced using technique i . The green electricity is measured in terms of GO. All values are measured in GWh, except for T_i and S_i which are percentages.

The supply mix on retail level is calculated in the same way, except that the national trade mix is scaled on the electricity production or purchase of the individual supplier or dealer and that this value is combined with the individual cancellation of GOs:

$$IS_i = \left[\frac{(PDE + PIE - CG)}{(PDE + PIE)} \right] * \left[\frac{(PDE * NP_i) + (PIE * NI_i)}{(PDE + PIE)} \right] \quad (5)$$

where IS_i stands for the share of electricity in the individual supply

Fig. 1. Components behind the determination of the environmental label of the average retailer.
Source: Afman and Wielders (2014).

mix which is produced using fuel i , PDE for the purchase of Dutch electricity, PIE for the purchase of imported electricity, CG for the cancelled GOs, NP_i for the share of electricity in the total net production which is produced using technique i , and NI_i for the share of electricity in the total net imported electricity (TNI) which is produced using technique i . The above formula is only relevant when the individual retailer does not purchase electricity under fuel specific contracts. In case of fuel specific contracts, the fuel mix percentages can be calculated according to the specific contract. Fig. 1 presents a visual overview of the different fuel mixes.

After calculation of the national supply mix and the supply mix on retail level, the shares of the fuels in the mix can be multiplied by the corresponding emission factors. The sum of these multiplications equals the overall emission factor of the supply mix.

$$EF_{supplymix} = \sum_{i=1}^I S_i * EF_i \quad (6)$$

where $EF_{supplymix}$ stands for the overall emission factor of the supply mix, S_i for the share of electricity in the national supply mix which is produced using generation technique i , and EF_i for the CO_2 -emission factor of the fuel belonging to generation technique i measured as kg CO_2 per kWh.

The CO_2 -emission factors are calculated by dividing the CO_2 -factor of the fuel type by its efficiency measure. The efficiency measure is defined as the ratio of the electricity and possible heat production (in case of a combined heat and power plant) to the fuel input:

$$EM_i = \frac{EP_i + HP_i}{F_i} \quad (7)$$

where EM_i stands for the efficiency measure for fuel i ; EP_i and HP_i for respectively the electricity and heat production of fuel i in terms of TJ; and F_i for the input of fuel i also in terms of TJ. The CO_2 -emission factors can then be calculated as follows:

$$EF_i = \frac{\left(\frac{F_i}{(1/3.6) * 1,000} \right)}{EM_i} \quad (8)$$

where EF_i stands for the CO_2 -emission factor of the fuel belonging to generation technique i measured as kg CO_2 per kWh, F_i for the CO_2 -factor of fuel i measured as ton CO_2 per TJ, and EM_i for the efficiency measure for fuel i .

2.2.2. Data

The data about the centralized net production is based on the information provided to the regulator of the Dutch energy market (ACM). This data refers to the largest electricity producers in the Netherlands in 2014. In this data, a distinction is made between the types of generation technique which are used. Furthermore, the decentralized net production, also split up to generation

technique, is derived from data published by Statistics Netherlands (CBS StatLine, 2014a, 2015). The fuel mix is derived from the table 'Electricity; production and means of production' (CBS StatLine, 2014a); the most recent data was on the year 2013. This fuel mix is weighted against the electricity production in the period November 2013 – October 2014, which was the most recent data available and derived from the table 'Electricity balance sheet; supply and consumption' (CBS StatLine, 2015). With respect to the import mix, data on the monthly electricity exchange over the period November 2013 – October 2014 came from Entso-e (2015). The production mixes of the countries from which is imported is based on data over the year 2012 of IEA Statistics (2014).

The amount of cancelled GOs, the production over the period January 2014 – November 2014, and net import of green electricity measured in terms of Guarantees of Origin over the year 2014 are based on the 'Annual statistical overview 2014' of CertiQ (2015a). The green electricity production of December 2014 was derived from the difference in the 'total certified production of renewable electricity in the Netherlands from 01 to 07-2001' of the statistical overview of December 2014 and November 2014 (CertiQ, 2014, 2015b).

For the calculation of the CO_2 emission factors, the CO_2 factors of the different fuel types are derived from Vreuls and Zijlema (2012). The CO_2 factor of waste is corrected for the non-fossil part. This is done by dividing the factor by the caloric value of the fossil part and multiply the result with the emission of the fossil part. Furthermore, the calculation of the efficiency measure of coal and petroleum for the Dutch production is based on data of Statistics Netherlands (CBS StatLine, 2014b). The input for the calculation of the efficiency measures of the other fuel types for the Netherlands and for the countries from which the Netherlands imported electricity, came from IEA Statistics (2014).

2.3. Labels on product level

2.3.1. Calculation method

While the previous analysis is directed at determining the environmental label of the total portfolio of a retailer, another component of the labelling system is to determine the environmental label of a specific contract. The existence of a market for certificates enables retailers to differentiate their products by using different labels. In order to assess the importance of green certificates in the retail market we analyse the price premium which consumers pay for these products.

Since GOs are traded on a bilateral market, price data is not publicly available. In order to obtain information on the prices of GOs, we implicitly derive the maximum of the prices of GOs by comparing grey electricity consumer prices with green electricity prices in the retail market. Assuming that cost of GOs will be passed on to the buyers of electricity, these costs can be assumed not to be higher than the price difference between green and grey electricity per supplier. Note that the price difference between

grey and green contracts in the retail market may not only differ due to the cost of GOs, because it may also be related to other costs of the retailers (ACM, 2015). Anyway, the price difference can be seen as the maximum of the costs of GOs.

We compare the prices of green and grey electricity products per retailer which are offered to the market on the same day. The fact that we look at the price difference per retailer for the two types of contracts implies that the prices of retailers who only offer green electricity are not evaluated here. The price differences of green and grey electricity are expressed as percentages of the grey-prices:

$$PD_t = \frac{P_{green,t} - P_{grey,t}}{P_{grey,t}} * 100\% \quad (9)$$

where PD stands for the price difference, P_{green} for the price of the green-electricity product, P_{grey} for the price of the grey-electricity product and t stands for time (i.e. days when the contracts are offered to the market). Some suppliers offer, next to grey electricity, two green electricity products which differ with respect to the sources used for generating the electricity. This enables us to compare the prices for different types of green electricity with the price of grey electricity.

2.3.2. Data

The statistics on the GO market per EECs member come from AIB (2015). To calculate the price differences between grey and green electricity per supplier, price data of electricity of Dutch electricity suppliers, who both offer green and grey electricity to consumers and small businesses, in 2014 are used. This data is provided by the regulator of the energy market in the Netherlands (ACM).

3. Results

3.1. Environmental label of the average Dutch retailer

More than half of the electricity which is produced in the Netherlands in 2014 is generated by using natural gas, either by combined heat and power (CHP) plants or non-CHP plants (see Fig. 2). The second largest domestic source of electricity are coal-fired power plants, while Blast Furnace Gas plants form the third largest category (measured in the group 'other' in Fig. 2).

The Netherlands only import electricity from Belgium (10.7%), Germany (74.8%), Great Britain (0.1%), and Norway (14.4%) in 2014 (see Fig. 2). Compared to the national production mix, the import mix consists of relatively more electricity generated using coal and nuclear sources, and relatively less electricity from natural gas from CHP plants. Using the production mix and the import mix, we are able to determine the so-called national trade mix as the weighted average of both.

Lastly, in order to determine the national supply mix we also need to take into account the amount of cancelled GOs. In this mix, the green electricity component makes up for 34% of the total electricity supplied in the Dutch market (see Fig. 2). This high share of renewable energy in the Dutch market is mostly due to net import (69%): only 31% of the GOs come from Dutch producers. GOs are mostly imported from Norwegian (34%), French (15%), and Swedish (12%) producers (see Fig. 3). In Norway and Sweden, green electricity is mostly produced by using hydro power (resp. 99% and 92%), in France also a large part come from this source (76%) (IEA Statistics, 2014). This explains why a large part of the green electricity in the supply mix is generated by hydro power (57%) (Fig. 4). Green electricity in the Netherlands is mostly produced by wind power (50.5%) and biomass (48.2%).

Weighing the fuel mixes with the emission factors per fuel type (see Appendix A) gives an overall emission factor per fuel mix (see Table 2). From this table it can be seen that the Dutch production

Fig. 2. Fuel mixes of the Netherlands in 2014. Note: The different fuel mixes are calculated using formulas (1)–(5). The data sources used for the calculations are described in Section 2.2.2 and include ACM data and data from Statistics Netherlands (CBS StatLine, 2014a, 2015), Entso-e (2015), IEA Statistics (2014), and CertiQ (2014, 2015a, 2015b).

Fig. 3. Dutch import of Guarantees of Origin (GOs) per country in 2014. (*The import from the Netherlands refers to GOs that are first exported and later on imported again.). Note: This figure is based on data from AIB (2015).

pollutes less and results in less nuclear waste than the weighted average of net imported electricity of the four countries from which the Netherlands imported electricity in 2014 (i.e. Belgium, Germany, Great Britain, and Norway). The average emission factor and nuclear waste of electricity supplied in the Netherlands equal 0.316 kg/kWh and 0.0001 g/kWh respectively.

3.2. Value of green labels in retail electricity market

In order to determine the value of green labels in the retail electricity market, we analyse the differences in prices between green and grey electricity for consumers and small businesses in the Netherlands over 2014. Column A of Table 3 shows the price differences when we only regard the cheapest available green electricity products in case a retailer offers different types of green-electricity contracts. This table shows that, on average, the price of green electricity is only slightly higher than the price of grey electricity. The highest mean price difference is with respect to E1B per kWh low⁶: the mean green price is 1.7% higher than the

⁶ 'E1B per kWh low' refers to the variable off-peak price in case consumers have a off-peak/peak metering system.

Fig. 4. The green electricity in the national supply mix by source in 2014. Note: This figure is based on own calculations using data from [CertiQ \(2014, 2015a, 2015b\)](#).

Table 2
Emission factors for each fuel mix.
Source: see [Appendix A](#).

Fuel mix	Includes:	CO ₂ -emission (kg/kWh)	Nuclear waste (g/kWh)
National production mix	Grey electricity	0.469	0.0001
Import mix	Grey electricity	0.531	0.0006
National trade mix	Grey electricity	0.477	0.0002
National supply mix	Grey and green electricity	0.316	0.0001

mean grey price. With respect to the fixed prices, there is almost no difference between green and grey electricity. Although the standard deviation around these means are low, in some cases the price for green electricity is significantly (more than 50%) above

Table 3
Differences in prices between green and grey electricity for consumers and small businesses in the Netherlands in 2014 (in % of the price for grey electricity).
Source: Own calculations based on ACM data.

Product	A. Price grey versus price of cheapest green product per retailer					B. Price grey versus most expensive green product per retailer (if retailer offers more than two different green products)				
	Obs.	Mean	St. dev.	Min.	Max.	Obs.	Mean	St. dev.	Min.	Max.
E1A fixed	411	0.2%	2.9%	0%	53.3%	81	0%	0%	0%	0%
E1A per kWh	411	1.5%	1.6%	0%	18.7%	81	13.6%	0.3%	12.6%	14.1%
E1B fixed	411	0.2%	2.9%	0%	53.3%	81	0%	0%	0%	0%
E1B per kWh low	411	1.7%	2.1%	–16.0%	21.7%	81	16.0%	0.4%	15.0%	17.0%
E1B per kWh high	411	1.4%	2.0%	0%	23.2%	81	12.3%	0.4%	11.2%	12.8%

Notes: The two most common connections are shown: E1A and E1B. For E1A there is only one variable rate; for E1B two variable rates exist (low and high), which depends on the time of day of the electricity usage.

E1 is the code for households with a connection to the distribution grid of 3 × 25 Ampère. The code A refers to connections with a single metering scheme, while B refers to a peak/off peak metering scheme (i.e. low and high tariff). "Fixed" refers to a capacity charge independent of actual usage. The formula for calculating the price difference is as follows:

$$PD_t = \frac{P_{\text{green},t} - P_{\text{grey},t}}{P_{\text{grey},t}} \cdot 100\%$$

where PD stands for the price difference, P_{green} for the price of the green-electricity product, and P_{grey} for the price of the grey-electricity product and t stands for time (i.e. days when the contracts are offered to the market).

Fig. 5. Issuance, net import, and cancellation of GOs in the Netherlands Note: This figure is based on data from [CertiQ \(2015c\)](#).

the price of grey electricity. The small price difference between grey and green contracts is related to the low price of GOs. Apparently, retailers can buy these GOs for a really small price. Hence, the price of green electricity is not related to the costs of green electricity. This results from the fact that subsidies for renewable energy are not paid from the GOs prices, but from separate subsidy schemes, like feed-in-premiums.

Some electricity suppliers offer a second more expensive green product (see Column B in [Table 3](#)). It appears that the fixed element of the price does not differ between these green products and the grey electricity. The variable component, however, shows relatively large differences. The highest mean price difference is seen with respect to E1B per kWh low, where the green product is 16% more expensive than the grey version.

4. Discussion

The target of the European Union (EU) to ensure that 20% of the energy consumption (thus not only electricity) is produced by using renewable sources by 2020, requires that 35–40% of the electricity is generated using RES ([Wilsher, 2009](#)). Taking the contribution of GOs into account, the Netherlands seems to have become quite close to this value (see [Fig. 5](#)). In 2014, 34% of the total electricity supplied in the Netherlands came from renewable sources. However, about 10% of the total electricity supplied is

actually produced using RES in the Netherlands. The Dutch green-electricity production has increased slowly over the past decade, while the net import of GOs shows an increasing trend, in particular since 2010 (see also [EI&I, 2011](#)). Because of European legislation, the import of GOs from other EU member states can only be included in the national renewable-energy production if a bilateral agreement between the member states has been concluded in order to prevent double counting. As a consequence, the Dutch retailers are (on average) allowed to position itself as a relatively green (based on the share of 34% of green electricity in the total portfolio), but this green image is mainly based on administrative rules regarding the trade in GOs, while it also does not correspond with the national performance in realising the renewable-energy target.

In order to have an impact on investments in renewable energy, the GOs need to have a price which is sufficiently high to trigger investors to invest in this type of energy. Information on the price for these certificates is acquired by looking at the differences in retail prices for green and grey electricity. We have found that these price differences are modest. Assuming that the costs of GOs are passed on to the customers, we are able to conclude that the prices of GOs are relatively low as well. These low prices are likely related to the abundant supply of GOs compared to the level of demand. An indication for this oversupply can be seen in the number of GOs that expires without being used (see [Table 1](#)), implying that there may be an excess supply of GOs driving the price of GOs downwards. The price of GOs moves to the marginal cost of the marginal supplier, which is the supply from Norway as this country has an abundant resource of GOs. The marginal (opportunity) costs of the Norwegian supply is almost zero as the GOs don't have a value in the domestic Norwegian market. The larger price differences seen in the second more expensive product will most likely be due to a price premium for the specific power source used. All second more expensive products are generated using wind power, whereas the most important power source for the cheap green products is hydropower (58%), followed by wind power (19%) and biomass (17%).

The magnitude of these price differences correspond to the willingness to pay (WTP) for renewable electricity of Dutch consumers as derived by the [OECD \(2014\)](#). The OECD study reports a mean WTP of around 7.5% in 2011, which is the lowest WTP seen in the sample of 11 OECD countries. When only considering positive WTP values, the mean WTP of Dutch consumers is 13.5%, which is comparable to the price differences in column B of [Table 3](#). This means that the retailers seem fairly well successful in skimming the value of consumer for renewable energy. For most consumers this value is low, as according to [OECD \(2014\)](#) a large group (40%) of Dutch electricity consumers appear not to be prepared to pay anything extra for renewable energy.

5. Conclusions and policy implications

According to the electricity label for the average Dutch retailer, about one-third of the electricity supplied came from renewable sources. A large part of this is due to the net import of Guarantees of Origin, which has shown an increasing trend since 2009, while the Dutch green electricity production has been rather stable around 10% of the electricity supplied. This means that Dutch retailers strongly depend on imports of GOs in order to present themselves as green retailers.

Furthermore, this study has shown indirectly that the price of GOs is fairly low, because of the modest price differences between grey and green electricity in the Dutch retail market. These differences are in line with WTP studies, indicating that over 40% of

the Dutch consumers are not willing to pay anything extra for green electricity compared to grey electricity and the consumers, who do have a positive WTP, are willing to pay no more than 13.5%.

It is doubtful whether GO trading in its current practice provides an incentive to increase green electricity production. Because of the abundant supply in the market, the price for GOs is too low to give incentives to producers or prosumers to extent the capacity of RES. GOs are popular, though, as it enables retailers to charge (slightly) higher prices and, hence, realise extra profits or to increase their market shares. It appears that the impact of GOs on the profits of retailers exceeds the impact on the production of RES. Hence, in the current design of the GO, it is more valuable as a marketing instrument for electricity retailers than a policy instrument to increase the capacity of RES.

On top of this modest effect of GOs on the capacity of RES, the impact of GOs on the emissions of carbon dioxide is even more doubtful because of the interaction with the European Union Emission Trading Scheme (EU ETS) (see also [Ragwitz et al., 2007](#)). Any increase in the supply of RES has a downward effect on the price of carbon permits, which raises the emissions by other participants in the EU ETS. As a result, the net effect on emissions of such a policy is zero ([Böhringer, 2014](#)). This means that the benefits of an increase in RES capacity must be found on other dimensions, such as a reduced dependency on imports of fossil fuels ([Lehman et al., 2013](#)).

In order to make the system of GOs more effective in raising the RES capacity, several options can be chosen. One option is to restrict the international trade in GOs, for instance by limiting it only to EU countries. The consequence would be that the abundant supply of GOs from Norway would not be available anymore for the EU market, which would have an upward effect on the price for these certificates. This option is, however, not really feasible because of the fact that Norway has implemented the EU RES directive into action. Another option would be to only issue GOs to new production facilities generating renewable electricity. In this situation it will be avoided that existing non-RES producers can profit from GO trading with higher consumer prices as a consequence, without stimulating the renewable electricity production. Another benefit of making GOs in this way more effective in stimulating the RES capacity is that less subsidies are needed to finance investments in that capacity.

Acknowledgements

The authors are grateful to colleagues at the ACM for their comments. The authors are, however, fully responsible for any remaining shortcomings. The contents of this paper do not constitute any obligation on the ACM.

Appendix A. Emission factors

see: [Tables A.1–A.5](#).

Notes:

1. The values for the efficiency measures and the emission factors are calculated using formula (7) and (8) respectively, see [Section 2.2.1](#);
2. The values for the import per country (in [Tables A.2–A.5](#)) are calculated by scaling the total net import over all countries on the import per country. The import per country is then multiplied by the percentage of electricity that is produced using fuel *i* of that particular country. The following formula is applied:

Table A.1

Emission factors for Dutch electricity production over 2014.

Source: see text in notes.

		Natural gas	Natural gas (CHP plant)	Coal	Petro-leum	Waste (fossil part)	Other
A	CO ₂ -factor (ton CO ₂ /TJ)	56.5	56.5	94.7	77.4	106.1	56.5
B	Fuel input (TJ)	117,517	331,541	220,710	773	71,060	
C	Electricity production (TJ)	56,462	144,202	88,609	288	14,368	
D	Heat production (TJ)	–	94,975	2686	–	13,643	
E	Efficiency measure	0.48	0.72	0.41	0.37	0.39	0.40
F	Emission factor (kg CO ₂ /kWh)	0.423	0.282	0.824	0.748	0.763	0.509

Table A.2

Emission factors for electricity produced by gas-fired power plants of the import countries over 2014.

Source: see text in notes.

		Natural gas	Belgium	Germany	United Kingdom	Norway	Weighted average
A	CO ₂ -factor (ton CO ₂ /TJ)		56.5	56.5	56.5	56.5	
No heat production (no CHP plant)							
B	Fuel input (TJ)		80,946	179,956	638,613	17,741	
C	Electricity production (GWh)		11,057	23,359	82,167	2630	
D	Efficiency measure		0.49	0.47	0.46	0.53	
E	Import (GWh/year)		271	582	4	2026	
F	Emission factor (kg CO ₂ /kWh)		0.414	0.435	0.439	0.381	0.395
With heat production (CHP plant)							
G	Fuel input (TJ)		101,210	512,307	132,311	–	
H	Electricity production (GWh)		12,489	54,243	17,907	–	
I	Heat production (TJ)		28,718	146,151	–	–	
J	Efficiency measure		0.73	0.67	–	–	
K	Import (GWh/year)		306	1352	1	–	
L	Emission factor (kg CO ₂ /kWh)		0.279	0.305	0.439	0.381	0.301

Table A.3

Emission factors for electricity produced by coal-fired power plants, per import country over 2014.

Source: see text in notes.

		BEL	GER (coal)	GER (brown coal)	UK	NOR	W.A.
A	CO ₂ -factor (ton CO ₂ /TJ)	94.7	94.7	101.2	94.7	94.7	
No heat production (no CHP plant)							
B	Fuel input (TJ)	31,961	910,165	1,449,580	1,315,447	–	
C	Electricity production (GWh)	3340	101,508	154,347	142,453	–	
D	Efficiency measure	0.38	0.40	0.38	0.39	–	
E	Emission factor (kg CO ₂ /kWh)	0.906	0.849	0.950	0.874	–	
With heat production (CHP plant)							
F	Fuel input (TJ)	1104	199,528	81,130	5920	645	
G	Electricity production (GWh)	48	14,881	6392	728	39	
H	Heat production (TJ)	–	104,237	37,555	–	246	
I	Efficiency measure	0.16	0.79	0.75	0.44	0.60	
J	Emission factor (kg CO ₂ /kWh)	0.906	0.431	0.488	0.874	0.569	
K	Import (GWh/year)	83		6907	8	30	
L	Emission factor average CHP / non-CHP (kg CO ₂ /kWh)	0.906		0.875	0.874	0.569	0.874

$$NI_c = \left[(I_c/I_{all}) * NI_{all} \right] * NP_{ci} \quad (10)$$

where NI_c stands for the net import per country c that is scaled on the amount of import; I_c and I_{all} for the import of from respectively country c or all countries (all); NI_{all} for the net import from all countries together; and NP_{ci} for the share of electricity in the total net production of country c which is produced using fuel i .

– The weighted averages of the emission factors of all countries (row F and L) in Table A.2 are calculated using the following formula:

$$EF_{WA,allcountries} = \sum_{c=1}^C (I_c/I_{all}) * EF_c \quad (11)$$

where $EF_{WA,allcountries}$ stands for the weighted averaged emission factor over all countries; I_c for the import from country c ; I_{all} for the import of all countries together; and EF_c for the emission factor of country c .

1. The values if the weighted average of the emission factors of the non-CHP plant and the CHP plant of the individual countries (see row L) in Tables A.3–A.5 are calculated using the following

Table A.4

Emission factors for electricity produced by petroleum-fired power plants of the import countries over 2014.

Source: see text in notes.

Petroleum		Belgium	Germany	United Kingdom	Norway	Weighted average
A	CO ₂ -factor (ton CO ₂ /TJ)	77.4	77.4	77.4	77.4	
No heat production (no CHP plant)						
B	Fuel input (TJ)	646	42,187	16,054	185	
C	Electricity production (GWh)	66	4703	1163	42	
D	Efficiency measure	0.37	0.40	0.26	0.82	
E	Emission factor (kg CO ₂ /kWh)	0.758	0.694	1.068	0.341	
With heat production (CHP plant)						
F	Fuel input (TJ)	2919	20,979	14,726	–	
G	Electricity production (GWh)	255	2924	1901	–	
H	Heat production (TJ)	1216	1599	–	–	
I	Efficiency measure	0.73	0.58	–	–	
J	Emission factor (kg CO ₂ /kWh)	0.381	0.482	1.068	0.341	
K	Import (GWh/year)	8	190	0	32	
L	Emission factor average CHP / non-CHP (kg CO ₂ /kWh)	0.459	0.613	1.068	0.341	0.570

Table A.5

Emission factors for electricity produced by waste-fired power plants of the import countries over 2014.

Source: see text in notes.

Waste (fossil part)		Belgium	Germany	United Kingdom	Norway	Weighted average
A	CO ₂ -factor (ton CO ₂ /TJ)	83.5	83.5	83.5	83.5	83.5
No heat production (no CHP plant)						
B	Fuel input (TJ)	27,568	85,132	39,221	295	
C	Electricity production (GWh)	1511	7022	3021	28	
D	Efficiency measure	0.20	0.30	0.28	0.34	
E	Emission factor (kg CO ₂ /kWh)	1.524	1.013	1.084	0.880	
With heat production (CHP plant)						
F	Fuel input (TJ)	11,099	97,224	18,894	9500	
G	Electricity production (GWh)	653	4482	1137	186	
H	Heat production (TJ)	1800	37,237	–	7852	
I	Efficiency measure	0.37	0.55	–	0.90	
J	Emission factor (kg CO ₂ /kWh)	0.804	0.548	1.084	0.335	
K	Import (GWh/year)	53	287	0	165	
L	Emission factor average CHP/non-CHP (kg CO ₂ /kWh)	1.307	0.832	1.084	0.406	0.743

formula:

$$EF_{average} = \left[\left(\frac{EP_{non-CHP}}{EP_{non-CHP} + EP_{CHP}} \right) * EF_{non-CHP} \right] + \left[\left(\frac{EP_{CHP}}{EP_{non-CHP} + EP_{CHP}} \right) * EF_{CHP} \right], \quad (12)$$

where $EF_{average}$ stands for the average emission factor of the CHP plants and non-CHP plants; $EP_{non-CHP}$ for the electricity production of the non-CHP plants; EP_{CHP} for the electricity production of the CHP plants; $EF_{non-CHP}$ for the emission factor of the non-CHP plants; and EF_{CHP} for the emission factor of the CHP plants. The last value in row L, the weighted average of all countries, is calculated using the following formula:

$$EF_{WA,all\ countries} = \sum_{c=1}^C (I_c / I_{all}) * EF_{average,c}, \quad (13)$$

where $EF_{WA,all\ countries}$ stands for the weighted averaged emission factor over all countries; I_c for the import from country c ; I_{all} for the import of all countries together; and $EF_{average,c}$ for the weighted averaged emission factor over the non-CHP and CHP plants of country c .

Sources:

- The CO₂-factors in the tables come from Vreuls and Zijlema (2012);
- The values for the fuel input, electricity production, and heat

production for natural gas, natural gas (CHP plant), and waste (fossil part) for the Dutch electricity production over 2014 (Table A.1) come from IEA Statistics (2014); as well did the values for the fuel input, electricity production, and heat production in Tables A.2–A.5 on the electricity production of the import countries over 2014;

- The values for the fuel input, electricity production, and heat production for coal and petroleum for the Dutch electricity production over 2014 (Table A.1) come from CBS (2014b);
- The (net) import flows between the countries are retrieved from Entso-e (2015) and the fuel mixes per countries are retrieved from IEA Statistics (2014), which were needed to calculate the import values of Tables A.2–A.5.

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