Energies **2009**, *2*, 477-489; doi:10.3390/en20300477

OPEN ACCESS

energies

ISSN 1996-1073

www.mdpi.com/journal/energies

Review

Calculation of Residual Electricity Mixes when Accounting for the EECS (European Electricity Certificate System) — the Need for a Harmonised System

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Received: 31 May 2009; in revised form: 22 June 2009 / Accepted: 26 June 2009 / Published: 1 July 2009

Abstract: According to the Electricity Directive, suppliers of electricity must disclose their electricity portfolio with regards to energy source and environmental impact. This paper gives some examples of disclosure systems and residual electricity mixes in Norway, Sweden and Finland, compared to an approach based on a common regional disclosure. Disclosures based on the E-TRACK standard are presented, as well as the variation in CO_2 emissions from different residual mixes. The results from this study clearly show that there is a need for a harmonised, transparent and reliable system for the accounting of electricity disclosure in Europe.

Keywords: renewable electricity certificates; electricity disclosure; residual mix; global warming potential; life cycle assessment

1. Introduction

According to the Electricity Directive (2003/54/EG, article 3) suppliers of electricity must disclose their electricity portfolio with regards to energy source and environmental impact. The information shall be reliable and based on data from the preceding year. This complies with the customers' right to information about purchased products whether the customer has made an active choice of product specific electricity or not. A tracking system for electricity generation attributes is required to disclose

the electricity generation attributes according to the Electricity Directive. Tracking is a procedure to allocate electricity generation attributes to individual customers or groups. Generation attributes mean any piece of information about the process of electricity generation, which might be of relevance for energy consumers, other market actors, governments or regulators. Such attributes might generally include information about the energy source and the technology used for electricity generation, in addition to the emissions and any nuclear waste associated with the generation process [1]. Since the flow of electrons follows physical laws, without any influence from the electricity trading market, the tracking of attributes must be regarded as a separate accounting mechanism for the generation of electricity over a certain period.

Tracking of electricity attributes is an important prerequisite for several EU policies and market processes in addition to the Electricity Directive: the RES Directive (2001/77/EC), the CHP Directive (2004/8/EC), as well as for the implementation of Guarantees of Origin (GO). Being able to track electricity is a crucial element in the supply of green power for voluntary demand. Different approaches to tracking are currently applied, including contract-based tracking, the use of certificate systems or the application of statistical default values [2].

Electricity disclosure represents a significant opportunity for suppliers to position themselves in the market to appeal to customers' environmental concerns. However, reliability, transparency and accuracy are all key elements to the success of disclosure [3].

The main purpose of this paper is to explore the need for a harmonised system for electricity disclosure in Europe. This is achieved by comparing the present disclosure systems in some Nordic countries. The paper focuses on the disclosure systems for residual electricity mixes and their importance for trading of the 'green' attributes of renewable energy, as well as the problems associated with current disharmonious practice. It also explores the effects of these differences on climate gas accounting for the end user of electricity.

The paper is organized as follows: In Section 2 we present the background and trading system for Renewable Electricity Certificate and Guarantees of Origin. Section 3 gives some examples of the present disclosure systems and residual electricity mixes in Norway, Sweden and Finland, compared to a proposed approach based on a common regional disclosure. Examples of electricity disclosures for the Nordic countries based on the E-TRACK standard are also presented, and the section finally illustrates the great variation in CO_2 emissions for end users of electricity from the different calculated residual electricity mixes. In Section 4 a short state of the implementation of electricity disclosure across Europe is given and Section 5 concludes and provides some final remarks.

2. Trading of Renewable Electricity Certificate and Guarantees of Origin

2.1. EU Directives, Certificate Systems and Associations

The RES Directive (2001/77/EC), sets national indicative targets for renewable energy production from individual member states. These objectives contribute toward achieving the overall indicative EU targets. In December 2008, a Commission proposal for a new RES Directive was discussed and agreed by the Member States and the Parliament. This is expected to be implemented in the Member States by October 2010 [4]. In addition the CHP Directive (2004/8/EC) aims at encouraging the generation of

heat and power. Both the RES Directive and the CHP Directive requires the Member States to implement Guarantees of Origin (GO) for electricity for renewable resources (RES-E GO) or from high-efficiency CHP plants. The Directives only specify rules for the issuing of GO. It is not clear how the GO can be used and when and how they will be taken out of existence [5].

The European Energy Certification System (EECS) is a harmonised system for trading energy certificates, which provides standards for the operation of public and commercial certificate systems [6]. The EECS has been developed by the Association of Issuing Bodies (AIB), which is the leading enabler of international energy certificate schemes. The AIB promotes the use of a harmonised European system to ensure the reliable operation of international energy certificate systems. This system offers a set of agreed standards, known as the "Principles and Rules of Operation" (PRO) which ensure that the systems of its member organisations are compatible with each other.

EECS now support RES-E GOs (guarantees of origin under Directive 2001/77/EC), CHP-GOs (guarantees of origin for CHP, under Directive 2004/8/EC), RECS certificates and disclosure certificates for fossil and nuclear sources of electricity (these support the Internal Markets in Electricity Directive 2003/54/EC). Both Guarantees of Origin and RECS certificates fulfil the same function, and are of similar quality. Where they differ is that a Guarantee of Origin is required under the RES Directive (201/77/EC), which is obligatory on all Member States of the European Union; whereas RECS certificates are a voluntary initiative by energy companies [6]. Currently 17 European countries are registered as members in the EECS [7].

The EECS has been developed based on the Renewable Energy Certificate System (RECS), an association of market players trading in renewable energy certificates throughout Europe, which has been operating since a start up phase in 2000. RECS International has been fully operational since 2003, changing its status from foundation into association in 2004. RECS International had about 200 members from 24 European countries in 2007. The system advocates a standard certificate as evidence of the production of a standard renewable energy quantity and provides a methodology which enables renewable energy trade. This enables a market for renewable energy to be created, so promoting the development of new renewable energy capacity in Europe [8].

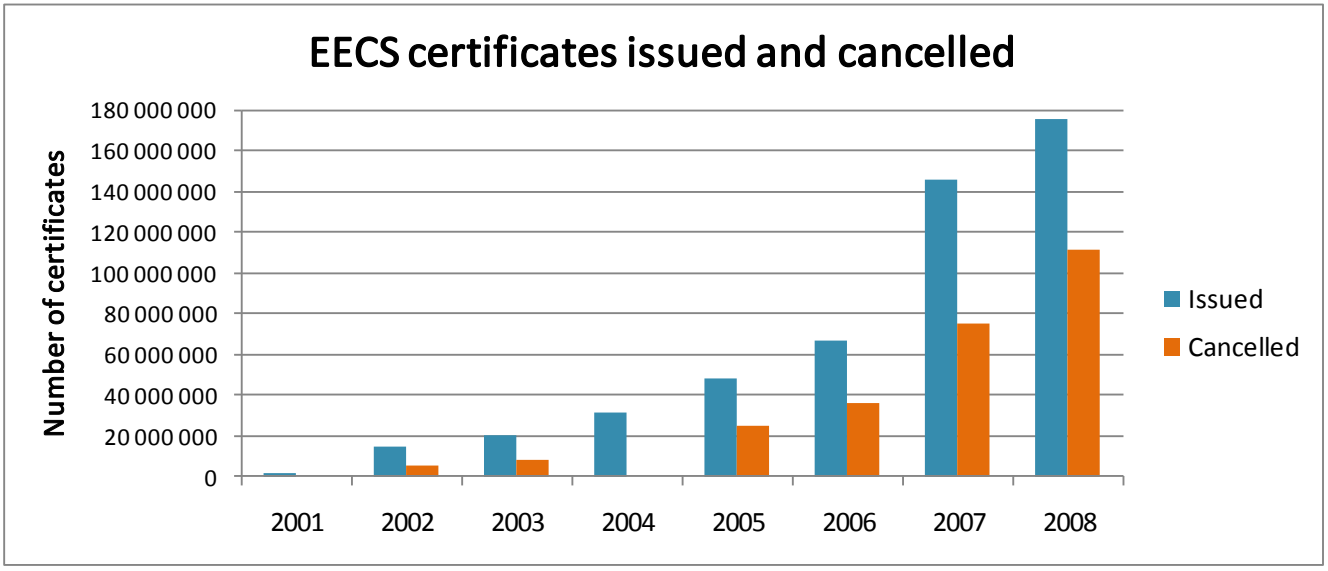
Electricity certificates (GO RES-E Certificate) go through three phases: issuance, transfer and cancellation [9]. The certificates are issued on registries for the energy output of Production Devices registered specifically for the purposes of GO RES-E. After issuing, the certificates may be transferred from the account of the producer to that of a trader, either within the country of origin or to other registries in the EECS network across Europe. Finally, the certificates are cancelled, which is a mechanism whereby the certificates are removed from circulation. The cancellation occurs at the point at which the value of the certificate is realised, for example when a consumer pays for the certificate, which means that certificate is used. Once a cancellation has been done, a GO RES-E Certificate cannot be moved to any other account. In order to maintain an open and orderly market, The Issuing Body in a Domain has a duty to publish activity reports on the number of GO RES-E Certificates which have been issued, have been transferred and have been cancelled. Since the tracking of the electricity generation attributes must be regarded as a separate accounting mechanism for the generation of electricity, these reports for GO RES-E Certificates play an important role for the calculation of electricity generation attributes for the residual electricity mix for a certain period and domain.

It should be mentioned that there are ongoing discussions about the value of the energy electricity certificate system, in general, as a mechanism for emission offset credits [10]. The debate is mostly about whether purchasing EECS certificates will lead to the generation of more renewable electricity instead of electricity from non-renewable energy sources. This subject is not the covered in this paper, but the issue is absolutely relevant for the overall discussion about EECS.

2.2. Trading of Certificates — EECS Statistics

By May 2009, more than 574 million 1 MWh certificates have been issued, which accounts for a volume of 574 TWh of electricity [11]. The number of certificates issued increases every year, with 184 million certificates being issued and 111 million cancelled ("cancelled" has replaced the term "redeemed") during 2008 alone. Figure 1 shows the annual amount of issued and cancelled EECS certificates from 2001 to 2008 [12].

Figure 1. The number of issued and cancelled EECS certificates per year from 2001 to 2008 (1 certificate equals 1 MWh) [12].



As shown in Figure 1, the numbers of both issued and cancelled certificates have increased significantly every year, with an average annual growth of over 100% at times. The total number of issued certificates in 2007 equals to 4.2% of the total gross electricity production in the corresponding European countries [13].

Norway, Sweden and Finland are the major issuing countries, accounting for 89% of all certificates issued in 2008, of which Norway alone issued 63% of the total volume. Approximately 60% of the gross electricity generation in Norway was certified according to the EESC system in 2007. The corresponding numbers for Sweden and Finland are 23% and 10%, respectively.

2.3. Influence on the Residual Electricity Mix

A customer who buys electricity without any specific requirements will receive electricity generated from several different energy sources. Purchasing renewable electricity using the EECS-system, gives the customers an opportunity to make an active choice regarding the generated attributes related to the purchased electricity. However, if some customers actively buy EECS certificates, the remaining electricity mix available for the customers who purchase electricity like a commodity without any specific attributes will change and should become more "grey". This means that the attributes for the amount of electricity that have been traded explicitly using the EECS systems, have to be excluded from the overall residual electricity mix calculation to avoid multiple counting of the attributes. Multiple counting of attributes is defined as a situation where the use of attributes from the same instance of generated electricity (1 MWh) is claimed more than once [5].

The residual mix is defined as a set of attributes for use in electricity disclosure, which has been determined based on the attributes of all electricity generation in one or several disclosure domains and corrected by all attributes which have been used for explicit tracking or by ERTS (External Reliable Trading Systems), and also for exports and imports of attributes and physical energy. Each residual mix stands for a certain volume of attributes and should not be used for the disclosure of a larger volume of electricity consumption than this volume [5]. The residual mix has to be calculated for a certain region/domain by subtracting attributes being tracked explicitly (like cancelled certificates or feed-in systems with particular allocation mechanisms), and by correction for exports and imports from the overall production mix for the particular region [2]. This calculated residual mix (applied for a specific region/domain) is what the customers who buy electricity without any specific requirements will receive, and should be the specified disclosure of the electricity from the electricity suppliers according Electricity Directive.

The E-TRACK project [14], funded by the European Commission's Intelligent Energy programme aimed to outline a comprehensive approach for all tracking requirements which are imposed by European and national legislation. The project provides a detailed insight into the tracking of electricity, the requirements for the design and operation of tracking systems and offers a European-wide standard for these tracking systems. The term "standard" is used in an informal way, as it does not mean a formal standard, e.g. under CEN, but denotes a set of rules which can be applied in European countries in order to implement a tracking system. The project finished in June 2007, and has continued with a Phase II which will refine the proposed tracking standard, by integrating the new Guarantees of Origin for cogeneration (CHP-E GO). However, the E-TRACK standard has not yet been implemented as a common standard for the European countries.

As a result of the lack of an implemented common standard, applications of different and uncoordinated approaches are applied for electricity disclosure. For example, some countries do not subtract the volumes of electricity being tracked explicitly from their statistical default information — which is used additionally — resulting in double counting of these attributes [2]. At present, attributes are double counted at Swedish as well as at Nordic level with respect to the information reported to the customers [15].

The next chapter gives some examples on different ways of calculating the residual electricity mix in three of the Nordic countries, as a result of the lack of a coordinated, harmonised disclosure system.

3. Calculation of Residual Electricity Mixes — Examples from the Nordic Countries

3.1. Present Residual Mix Calculations

At present, the residual electricity mix calculation in Norway, Sweden and Finland are calculated in three different ways. A short introduction of the different calculation systems are given in the following, based in a report from Swedish Elforsk [15].

The Norwegian residual mix calculation:

- Uses the Norwegian national electricity statistics as the basis for the disclosure
- Adjusted for:
    - Physical import
    - Cancelled disclosure certificates (EECS GO/RECS) in Norway
    - Compensation for the difference between physical export and net export of disclosure certificates (EECS GO/RECS), tracked as "unknown".

The Swedish residual mix calculation:

- Uses the total Nordic power mix statistics as the basis for the disclosure
- Adjusted for:
    - Net physical import/export
    - Export and import of disclosure certificates (EECS GO/RECS)
    - Cancelled disclosure certificates (EECS GO/RECS) in the Nordic region
    - No compensation for the exported EECS GO/RECS
    - Bilateral exchange within Sweden (not within the total Nordic region) is excluded

The Finnish residual mix calculation:

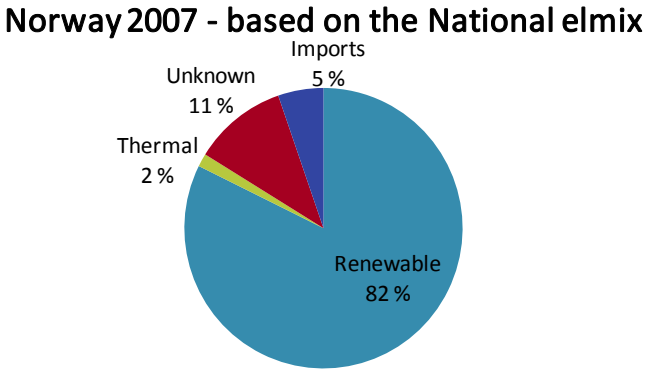
- Uses the total Nordic power mix
- Adjusted for
    - Physical import and export
    - Net export and import of disclosure certificates (EECS GO/RECS)
    - Cancelled disclosure certificates (EECS GO/RECS) in the Nordic region
    - Compensation for the exported GO, tracked as production mixes and volumes equal to the countries and volumes that the EECS GO/RECS are exported to.

Based on the above description of the different calculation system for the residual electricity mix disclosure, the compositions of the residual mix disclosures are shown in Figure 2 below. The figure shows that the present residual mixes for 2007 for the three countries differ from each other both in the shared types of energy sources and the size of the different shared energy sources.

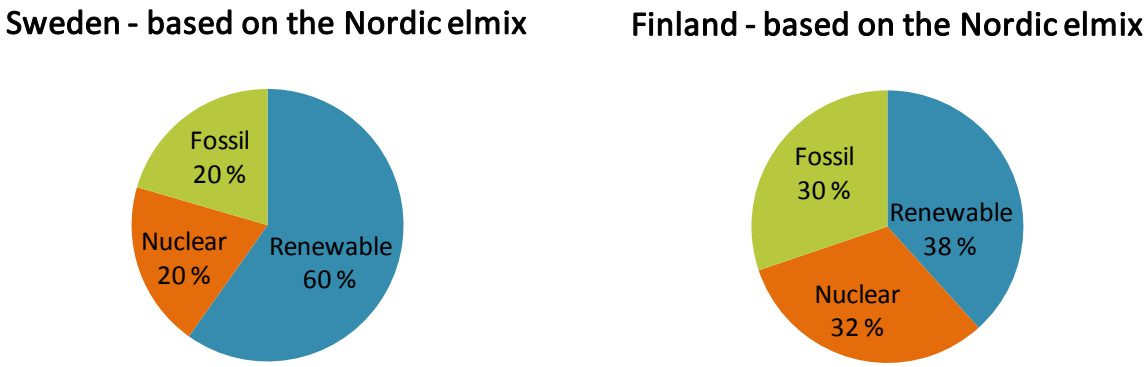
The Norwegian electricity disclosure is divided into the terms "Renewable", "Thermal", "Imports" and "Unknown". Only "Renewable" can be considered an energy source, whereas "Thermal" is an energy carrier while "Imports" and "Unknown" are titles that say nothing about the energy source. The information declared in the Norwegian electricity disclosure does not fulfil the requirements of the Electricity Directive. Firstly it does not give a complete picture of the contribution of each energy source to the overall fuel mix, and secondly, it is not possible to calculate the environmental impact (at least emissions of CO_2 and the radioactive waste) resulting from the electricity produced by the overall fuel mix when the energy sources are unknown.

Figure 2. Present residual electricity mixes in Norway, Sweden and Finland (2007) [15]. (a) Residual electricity mix in Norway (2007). (b) Residual electricity mixes in Sweden and Finland (2007).

(a) Residual electricity mix in Norway, 2007.



(b) Residual electricity mixes in Sweden and Finland, 2007.



The calculated Swedish and Finnish residual mixes do fulfil the requirements of the Electricity Directive by dividing the residual electricity mixes into energy sources. An interesting aspect is that those calculations should, theoretically, result in equal mixes, as both of them are calculated on a Nordic basis (using the NORDEL region as the domain for the residual mix calculation). This is not the case, as shown in Figure 2. The main reasons for this are different adjustments and compensation of EESC GO/RECS etc. (mentioned above), which leads to double counting of attributes.

According to the E-TRACK project [5], choosing a regional approach in defining the default values for disclosure makes sense for the Nordic countries because this region has such an integrated electricity market. However, if a regional approach is chosen, it is important that all the countries in the region agree on this joint approach. This is not the case in the Nordic region, as shown above, and the present situation results in multiple counting of the generation attributes in the countries.

A common Nordic residual mix based on the present disclosures has been calculated and compared to a proposal for a common Nordic residual mix, based on a more correct approach [15]. These are shown in Figure 3, together with the Nordic production mix for 2007 [16] which has no adjustment for certificate cancellations.

Figure 3. Comparison of a common Nordic residual mix for 2007, based on the present disclosures and an approach proposed by Swedish Elforsk [15], as well as the Nordic production mix for 2007 [16].

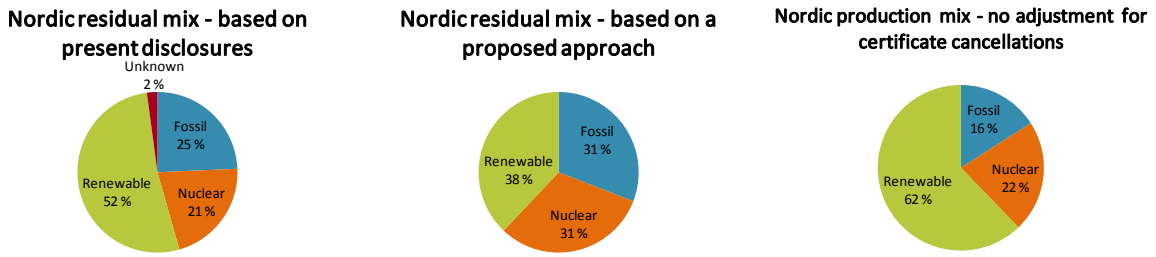


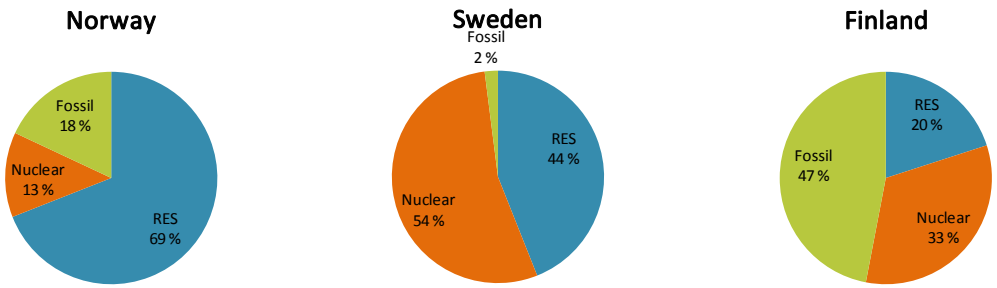
Figure 3 shows clearly that the present disclosure calculation results in multiple counting of attributes as the share of renewable is 52% in the mix based on present disclosure compared to 38% in the proposed mix based on a more correct approach. The Nordic production mix has, not unexpectedly, the highest share of renewable electricity as this mix is not adjusted for any certificate cancellations.

3.2. An Approach for Residual Mix Calculation Based on the E-TRACK Standard

The E-TRACK project provides a standard for the residual mix calculation including the use of a "Superior European Attribute Mix" as an adjustment of the surplus or deficit of attributes from several calculated domestic residual mixes. Since the standard is not implemented, this "Superior European Attribute Mix" has not yet been calculated. The standard proposes that this mix should be calculated annually by a European Clearing Body, based on input from all residual mix regions about the size of their surplus or deficit and the attributes of their preliminary calculated residual mixes [17].

However, at the REXchange conference in Copenhagen (April 23, 2009), RECS International presented a first step towards a reliable disclosure system for Europe. A presentation of the results from a project which has calculated the residual mixes in European countries based on the concept provided in the E-TRACK standard was given [18]. The residual mixes for each country are first calculated on a national level, then balanced on a regional level by delivering surplus/deficit to/from a regional pot, and at last balanced on an EU-level. The presentation outlined some problems that have to be solved, e.g. that the electricity production statistics are normally published late, making the system dependent on preliminary and/or old statistics. Some national tracking solutions are not based on EECS GO or the EECS GO is not fully implemented, cancellations of EECS GO are handled differently in different countries and, lastly, the closing dates for trading differ from country to country. Figure 4 presents the residual mixes for Norway, Sweden and Finland for 2008 based on the E-TRACK approach. It should be noted that these residual mix calculations do not fully implement the E-TRACK standard because the physical imports and exports are not taken into account, certificate cancellation is not considered and finally because the E-TRACK standard proposes only one European pool instead of regional pools. It should be noted that the residual mixes shown in Figure 4 are based upon data from 2008 and are therefore not directly comparable to those shown in Figures 2 and 3, which are based on 2007 data.

Figure 4. Residual electricity mixes in Norway, Sweden and Finland calculated based on the E-TRACK approach (2008) [18].



3.3. Global Warming Potential from Different Residual Electricity Mixes

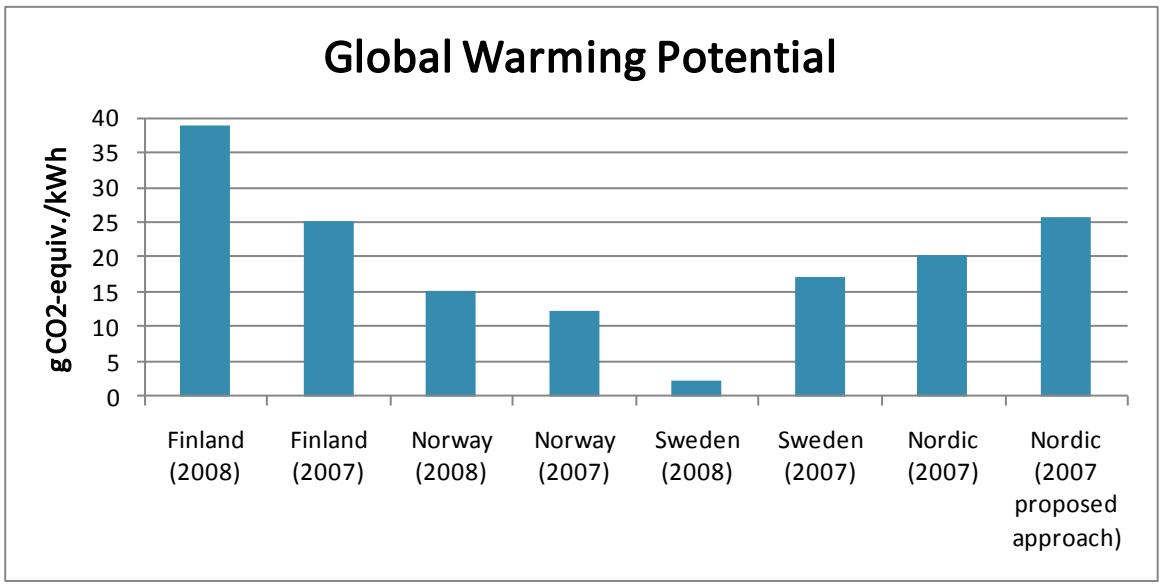
According to the Electricity Directive the electricity suppliers are required to specify at least emissions of CO_2 and the radioactive waste resulting from the electricity produced by the overall fuel mix of the supplier over the preceding year. These environmental impact indicators, of course depend a lot on the energy sources included in the electricity mix. To illustrate how the CO_2 emissions differ for the different electricity mixes, a calculation of the Global Warming Potential (GWP), shown as emissions of CO_2-equivalents, has been done for the electricity mixes presented above (see Figure 5 below). The calculation of GWP is based on a time horizon of 100 years using the IPCC 2001 characterisation factors. The impact calculation has been based on the Life Cycle Assessment approach [19,20] using the following assumptions for simplification:

- Electricity from fossil energy resources is assumed to be produced from a coal-fuelled combined heat and power plant using data from Vattenfall's EPD of electricity and heat from the Danish coal-fuelled combined heat and power plants [21].
- Electricity from nuclear energy resources is assumed to be produced from a nuclear power plant using data from Vattenfall's EPD of electricity from Forsmark nuclear power plant in Sweden [22].
- Electricity from renewable energy resources is assumed to be produced from a hydro power plant using data from Vattenfall's EPD of electricity from Nordic hydropower [23].

It should be noted that the GWP is based on simplified assumptions as the electricity production from the three different classified energy resources (fossil, nuclear and renewable) is calculated using specific data from EPDs for some Danish coal-fired CHP-plants, one nuclear power plant and several hydropower plants. The GWP from electricity production varies to a large extent, within the classified energy recourses dependent on both the energy resource (e.g. fossil: coal, oil and gas; renewable: hydro, wind and bio) and also the type and size of the power plant [24].

Note also that the Norwegian electricity mix is roughly recalculated to include the energy sources "Fossil", "Nuclear" and "Renewable" instead of the existing "Renewable", "Thermal", "Imports" and "Unknown" as shown in Figure 2 [15].

Figure 5. Calculated Global Warming Potential (GWP) per kWh electricity for different residual electricity mixes using the Life Cycle Assessment approach.



The variation shown in Figure 5 is large, from approximately 2–39 g CO_2-equivalents/kWh. In order to illustrate why this is important, the global warming potential for a company is calculated for the case where they use a large proportion of electricity for their production processes. The calculation is based on a large company that has an annual consumption of electricity of 530 GWh/year. If they buy GOs for Norwegian Hydropower (approx. 1 g/kWh [25]) instead of using the Nordic residual mix (shown as the proposed approach in Figure 4, approx. 26 g/kWh), this gives a reduction in climate gas emissions of 13,000 tonnes CO_2-equivalents per year. If one alternatively considers the two most extreme residual mixes shown in Figure 5, this would result in results ranging from just under 900 to over 20,000 tonnes CO_2-equivalents per year. This means that companies that want to document the environmental profiles of their products will struggle to do this correctly and consistently if the systems are not harmonised.

4. State of the Implementation of Electricity Disclosure across Europe

The status for implementation of electricity disclosure and Guarantees of Origin has been analysed in depth for 29 European countries [26]. The overall conclusion from this study is that 12 (plus Flanders and Wallonia) of these 29 countries have fully operational or even advanced disclosure systems in place when compared to the requirement of the Electricity Directive, while 16 countries (plus Brussels-Capital region) do not have a disclosure system implemented. It should be noted that none of the defined fully operational systems are evaluated as fully accurate and reliable as some of them still have some weaknesses (e.g. the disclosure is not based on GO and GO import and exports are not tracked or reflected in the residual mix calculation).

To summarise; disclosure systems are still not implemented according to harmonised standards in European countries, which can represent a risk for distrust in disclosure, due to double counting of generation attributes.

5. Conclusions

From the examples of different calculations of electricity residual mixes presented in this study, and the effects on calculation of the associated climate gas emissions, it should be clear that there is a need for implementation of a fully coordinated, harmonised, and reliable system for the accounting of residual mixes in European countries.

End-users of electricity should be provided with accurate attributes information for the electricity that they buy. The voluntary GOs and RECS markets will not have a fair incentive to flourish if the "green" value of renewables is also sold to customers not paying for this. There is thus a huge risk for distrust in disclosure due to double counting. Companies wishing to document the environmental performance of their products made using electricity need to be able to do this in a consistent fashion.

To implement the E-TRACK standard at a European level, it is suggested that a European Clearing Body (European governance organisation) is founded with areas of responsibility like operation of a central hub for communication between the certificate registries and determining the attributes and the volume of the Superior European Attribute Mix based on information from all the residual mix domains [5,14]. The success of implementation of the E-TRACK standard will certainly depend on the relationship between a European Clearing, The EU Commission, national governments, regulators and industry trade associations.

It is important that the work being done in Europe on this issue continues and a broad consensus is formed. Projects like E-TRACK Phase II, Elforsk's work in Sweden and the Norwegian project the authors are involved in (Energy Trade and Environment 2020, financed by the Research Council of Norway and industry) can make an important contribution to this.

Acknowledgements

The authors would like to thank the Research Council of Norway for their financial support through the RENERGI programme. We would also like to thank representatives from the companies and R&D organizations in the project group in the Energy Trading and Environment 2020 project for valuable discussions and input to the paper. We are also grateful for the possibility to use the results from the preliminary report from Swedish Elforsk.

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