Electricity accounting in life cycle assessment: the challenge of double counting

Supplementary Material

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1. Overview on criticism on market-based energy accounting and EACs

The effect of Energy Attribute Certificates (EAC), such as Guarantees of Origin (GOs), and market-based (renewable) energy accounting on corporate emission reduction targets and the energy transition is critically discussed (Bjørn et al. 2022). In a performance analysis of the European GO system Hulshof et al. (2019) conclude that the GO market has a low market liquidity, as well as a high and in transparent price volatility. Additionally, they state that the GO market has been in a constant state of oversupply, leading to low GO prices.

Bogensperger and Zeiselmair (2020) state that market-based energy accounting does not provide incentives for the expansion of renewable energy sources (RES), due to the low GO prices and the low share of newly build RES among all GOs. Despite a slight price increase in recent years, GO prices still account for a very small part of the total revenues renewable power plant operators (Hauser et al. 2019). The GO related income therefore currently has more the status of a "take-home effect", which does not represent a decisive investment incentive. Additionally, the GO system is accompanied by technical challenges. The expansion of decentralized photovoltaics will lead to an increasing number of small RES based power plants with an annual power output below 1 MWh, which is the size of one GO (EU 2018; Weckmann et al. 2017). The inclusion of these small scale RES based power plants would require a general revision of the GO system design. Furthermore, the system does not generate a significant control effect for customer behavior, due to the low temporal resolution, and there is currently no integration of smart meters. Currently GOs can be issued and canceled within an annual time period (Kuronen et al. 2020). However, recently the introduction of GOs with a higher temporal granularity of one our is discussed (Kuronen 2021).

Furthermore, the possibility to account for 100% renewable energy might undermine the recognition of energy efficiency measures. This is due to the fact that money spend to purchase GOs from RES can lower scope 2 GHG emissions much more effectively than the same money spend in energy efficiency. Brander et al. (2018) question whether the market-based scope 2 accounting methodology is a useful for GHG emission reductions tool. They illustrate this statement using the following example.

Following the market-based GHG Protocol Scope 2 Guidance (WRI & WBCSD 2015), Company A purchases RES based GOs for all of its grid electricity consumption and reports electricity related scope 2 emissions of 0 t CO_2 eq, resulting a 30 % reduction in its total corporate emissions (Brander et al. 2018). In contrast, the otherwise identical Company B does not purchase contractual agreements for its grid electricity consumption, but invests the equivalent money in an energy efficiency program. These measures reduce its electricity consumption and scope 2 emissions by 10 %.

Consumers and investors use the GHG reports of the two companies to make their purchasing and investment decisions (Brander et al. 2018). They prefer Company A, since it seems to have a better environmental performance. However, Company A's consumption of grid electricity remains unchanged. Assuming that the purchase of RES based GOs does not sufficiently incentivise the construction of new RES based power plants, no physical emission reduction takes place. In contrast, Company B has reduced its demand for grid electricity, some of which is supplied by fossil fuel power plants. As a result, emissions are actually reduced.

In addition, to prevent that the exclusive claiming of grid electricity from specific energy sources leads to double counting, the market-based methodology requires the application of residual electricity mixes, in case no valid contractual agreements are acquired (WRI & WBCSD 2015). As this residual mix emission factor is higher than the average grid emission factor, Company B's performance is again represented worse (Brander et al. 2018).

2. Background – Guarantees of origin and residual mix calculation

This chapter elaborates the GO system, as the main European EAC system. Furthermore, it outlines the currently applied issuance based methodology for residual mix calculations.

GOs are regulated through the European Energy Certificate System (EECS), a standardized system developed and promoted by the Association of Issuing Bodies (AIB) (AIB 2021). The AIB is a non-profit international organization consisting of national issuing bodies for European EACs, such as GOs (AIB 2020). Its aim is to ensure a "the reliable operation of international energy certificate systems" (Klimscheffskij et al. 2015). Organizations representing national issuing bodies range from governmental institutions, such as the German Environment Agency (UBA), to private companies such as the Swiss Pronovo AG (AIB 2020). Outside of Europe, there are two main other EAC systems: the Renewable Energy Certificate (REC) system in North America and the international Renewable Energy Certificate (I-REC) system for global energy certification (Kuronen 2021).

The EECS with its GOs was initiated and obtained a legal mandate via the Directive 2001/77/EC, which specifies the promotion of electricity produced from renewable energy sources in the internal electricity market (EU 2001, 2018). The directives demand that member states shall ensure that GOs, with a standard size of 1 MWh, are issued in response to a request of a renewable energy producer. Such GOs, which are issued in accordance with the EU directive shall be mutually recognized among member states. Member states may decide not to issue GOs in case the energy generator receives financial support from a support scheme (i. e. German feed-in tariff). Member states may also decide to arrange the issuance of GOs for energy from non-renewable sources.

To prevent double counting electricity from specific energy sources it is important to exclude cancelled EACs from market-based residual electricity mixes (Klimscheffskij et al. 2015). In the following, the main steps of the European residual mix calculation are outlined based on the currently applied issuance based calculation methodology published by (Kuronen et al. 2020). The calculation procedure is illustrated in Figure 1.

EACs can be traded among all member states of the AIB. These member states also constitute the residual mix area. The starting points for the residual mix calculations are the physical electricity production data of each member state. For countries having electricity trade with countries outside of the residual mix area, the production data is corrected by physical electricity imports and exports. In order to calculate the domestic residual mix, issued

EACs are subtracted from the corrected production data. Any EACs that have been issued but not cancelled in the calculation period are seen as expired, and are hence added to the domestic residual mix.

Since EACs can be traded freely between members of the residual mix area, the volume of a countries domestic residual mix is likely to be unequal to the proportion of its electricity consumption that is not tracked via the cancellation of EACs. To match the volumes of countries untracked consumption with the volumes of the residual mixes, the European Attribute Mix (hereafter referred to as “attribute mix”) is calculated and applied. In case the volume of a countries domestic residual mix is greater than a countries untracked consumption, the country is defined as a “Surplus Country”. For “Surplus Countries” the volume of the domestic residual mix that is greater than the untracked consumption is added to the attribute mix. The remaining proportion of the domestic residual mix is the final residual mix. Both final residual mix and the contribution to the attribute mix have the same shares of energy sources. Consequently, the attribute mix is a mix of the domestic residual mixes of all surplus countries.

In case a countrie’s untracked consumption is greater than the volume of its domestic residual mix, the country is defined as a “Deficit Country”. The deficit between untracked consumption and domestic residual mix is filled by the with the attribute mix, in order to obtain the final residual mix. All “Deficit Countries”receive the same electricity mix from the attribute mix. In an optimal scenario, without any accounting imprecisions, the volume of the attribute mix exactly matches the cumulated deficits of all deficit countries. By adding the cancelled EACs of a country to its final residual mix, the countries total supplier mix is calculated. The total supplier mix resembles the total volume of attributes disclosed in a country, both explicitly tracked by EACs and implicitly disclosed via the final residual mix.

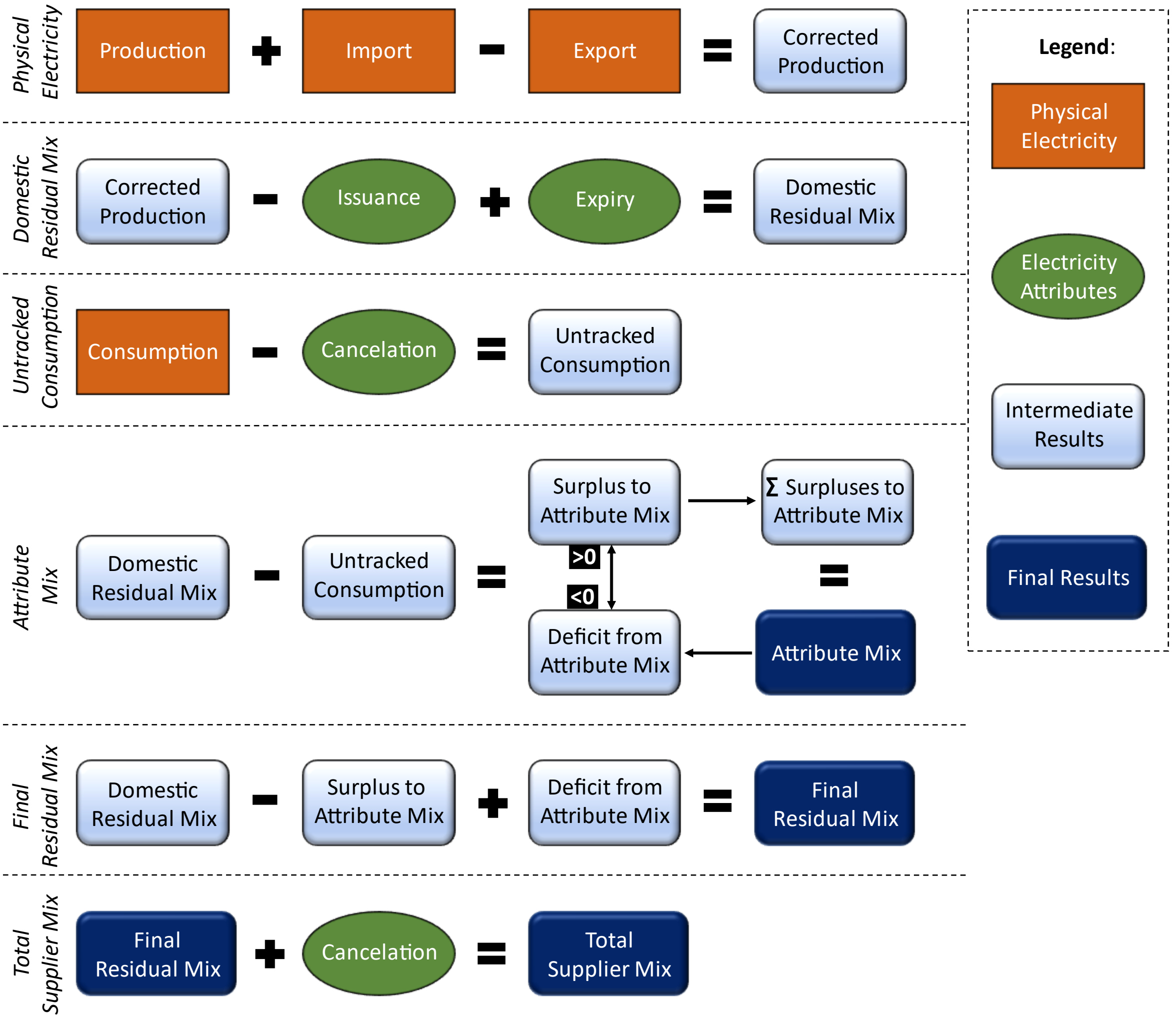

Figure 1: Illustration of the issuance based residual mix calculation methodology based on (Kuronen et al. 2020).

3. Illustration of issuance based residual mix calculation

The following Figure 2 illustrates the calculation of market-based residual and total supplier mixes for the "Fossil Country" and "Nuclear Country", as well as the attribute mix calculation.

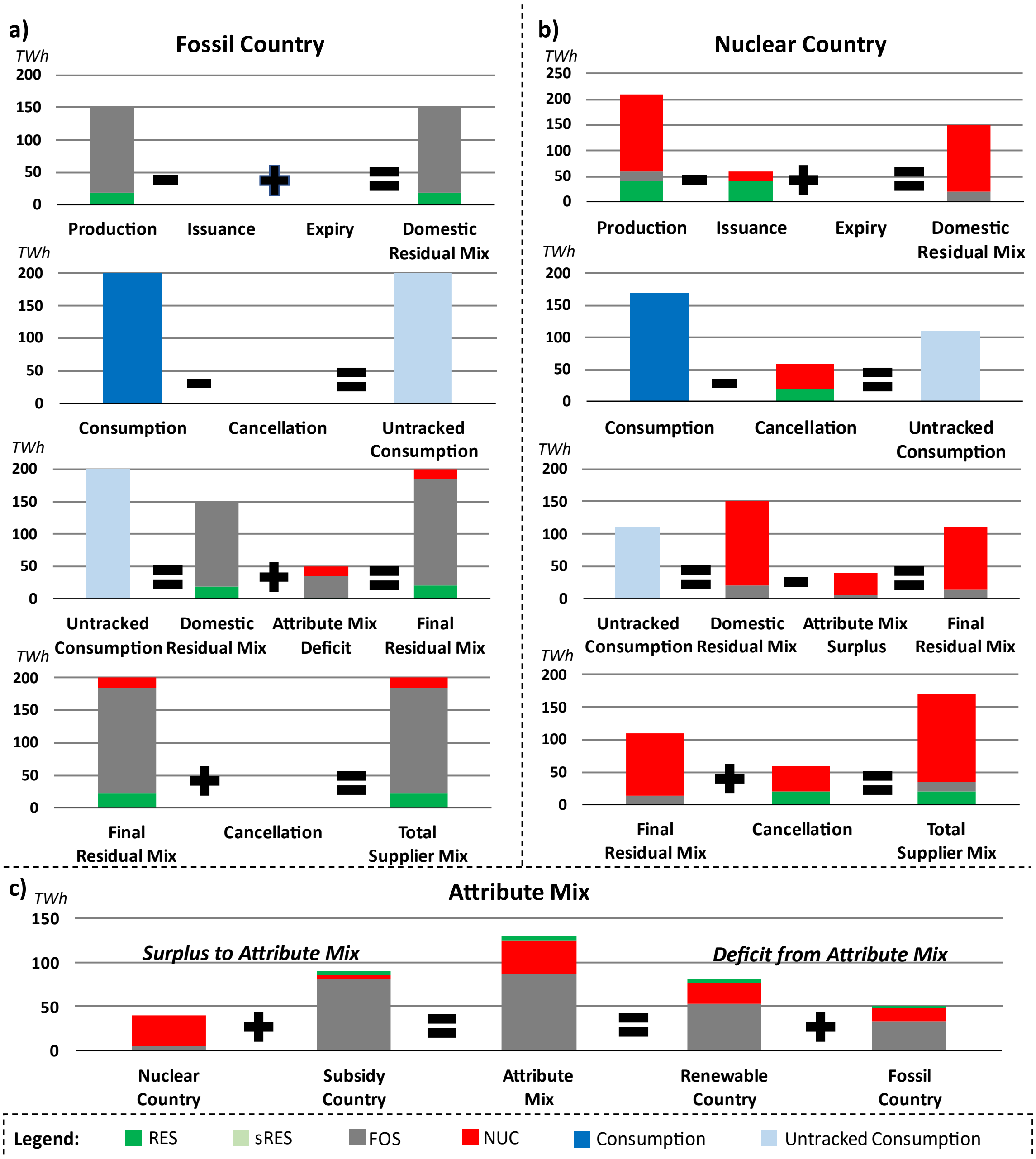

Figure 2: Illustration of market-based electricity mix calculation for the "Fossil Country" (a) and the "Nuclear Country" (b), as well as the attribute mix calculation (c).

In the "Fossil Country" no electricity producer issues any EACs. Thus, the domestic residual mix equals to the country's production mix. Furthermore, no EACs are canceled in the "Fossil Country", resulting in the equality of the country's total electricity consumption and its untracked consumption. The country's electricity consumption is 50 TWh higher than its production. Thus, 50 TWh of electricity have to be taken from the attribute mix, in order to obtain the final residual electricity mix. Since no EACs are canceled in the “Fossil Country”, the total supplier mix equals to the final residual mix.

In total, the “Nuclear Country” produces 210 TWh of electricity. The country issues EACs for all its RES based electricity production of 40 TWh. Additionally, the country issues EACs for 20 TWh for NUC based electricity production. This leads to a domestic residual mix with a volume of 150 TWh, which does not contain any RES based electricity. The “Nuclear Country” has a total electricity consumption of 170 TWh and EACs for 20 TWh of electricity from RES and 40 TWh of electricity from NUC are canceled. This leads to an untracked consumption of 110 TWh. Since the country’s domestic residual mix is 40 TWh higher than its untracked consumption, the “Nuclear Country” adds a surplus of 40 TWh to the attribute mix. The electricity mix shares of the final residual mix equal to the domestic residual mix shares. Adding the 60 TWh of canceled EACs for electricity from RES to the final residual mix results in the country’s total supplier mix.

Figure 2c shows the surpluses to the attribute mix and the deficits taken from the attribute mix by the individual countries. The “Nuclear Country” and the “Subsidy Country” are both “Surplus Countries” and thus contribute to the attribute mix, which has a total volume of 130 TWh and consists of 5% RES, 86% FOS and 39% NUC. The attribute mix is used by the “Renewable Country” and the “Fossil Country”, which are “Deficit Countries” to fill the deficits between domestic residual mix and untracked consumption.

Figure 3 illustrates the market-based electricity mix calculation for the “Full tracking Country”. The country issues EACs for all its 190 TWh of produced electricity. Thus, the country does not have a domestic residual mix. Since, EACs are canceled for all of the country’s 200 TWh of electricity consumption, it also does not have an untracked consumption. As all electricity consumption is tracked via the cancellation of EACs the “Full tracking Country’s” total supplier mix is solely based on its EAC cancellation.

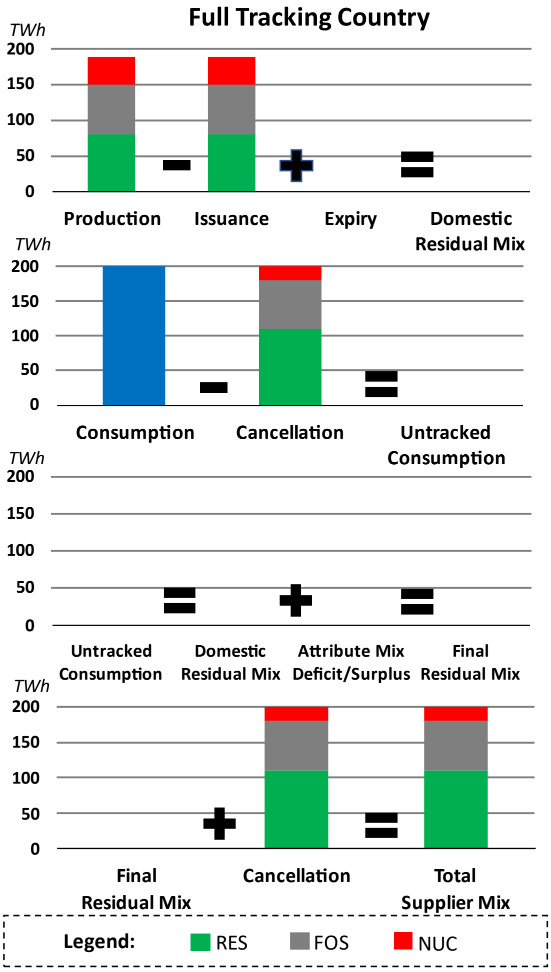

Figure 3: Illustration of market-based electricity mix calculation for the "Full tracking Country"

4. Non-certificate based reliable tracking systems in the residual mix calculation Example of the German Renewable Energy Sources Act (EEG)

One of the most prominent examples for electricity that is tracked by a non-certificate based reliable tracking system (RTS) is electricity that has received subsidies under the German Renewable Energy Sources Act (EEG). The EEG surcharge is generally payed by all electricity consumers (EEG 2021), with complete or partial exceptions for electricity intensive businesses. The right to claim the subsidized electricity is distributed among all electricity customers, who pay the EEG surcharge. For German EEG surcharge paying electricity consumers, the share of EEG supported electricity from RES is explicitly labelled on their electricity bill. In case of a partial exemption from the EEG surcharge, the EEG subsidized electricity is labelled according to the relative EEG surcharge payment.

Accounting for EEG subsidized electricity constitutes the last step of the electricity disclosure procedure (Hauser et al. 2019). Hence, if a full payment of the EEG surcharge entitles an entity to claim that 50% of its electricity is subsidised electricity from RES, the entity may substitute 50% of its original market-based electricity consumption with the subsidised electricity from RES. Consequently, a full subsidy surcharge paying entity, that does not acquire contractual agreements to claim the usage of electricity from specific sources, has to calculate the emissions related to 50% its electricity consumption according to the residual mix emission factor. The other 50% are calculated according to the emission factor of the subsidized electricity from RES.

Since the EEG electricity subsidizes all energy sources within the market-based electricity mix equally, claiming 100% electricity from RES still requires the reporting entity to purchase RES based contractual agreements for all its grid electricity consumption. It is not possible for full subsidy paying electricity consumers to acquire contractual agreements claiming the use of electricity from a specific energy source for 50% of their electricity consumption and thereby substitute the residual 50% with electricity generated under the subsidy scheme. In the case that RES based contractual agreements are acquired for only 50% of the initial market-based electricity mix, the total RES share would be little above 75%. The electricity consuming entity´s market-based electricity mix would consist of 50% subsidized electricity from RES, 25% electricity from RES according to the acquired contractual agreements and 25% according to the residual mix.

As elaborated in the paper, we suggest to include all electricity that is tracked by a non-certificate based RTS to be included in the residual mix calculations according to the procedure of labelling electricity that has received subsidies under the EEG. However, besides the option that is proposed in the paper, several other options exist for including subsidized electricity, which is tracked by a non-certificate based RTS, in the consistent market-based accounting of electricity related emissions. A selection of these options is outlined below:

(i) Allow the transfer of GOs to all operators of RES based power plants, even if they have received subsidies. This option is a political decision and is not upon the LCA and GHG accounting community to decide.

(ii) Include subsidized electricity, which is tracked by a non-certificate based RTS, in the residual mix calculations. However, with this option other countries than the subsidy issuing countries might receive a proportion of the subsidized electricity via the attribute mix.

(iii) Add all subsidized electricity, which is tracked by a non-certificate based RTS, to the countries final residual mix. With this option only electricity consumers in the country, which renders the subsidies, benefit from the subsidized electricity from RES. This option leads to an even balance of all produced and consumed electricity. However, electricity consumers who actively purchase GOs but still pay the EEG surcharge would still contribute to the residual mix, which would consequently have an overly high amount of subsidized electricity from RES. Furthermore, some regulations, like the German “Regionalnachweise” allow the partial utilization of subsidized electricity in exclusive green electricity products (Hauser et al. 2019), leading to double counting in this option.

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