

# European Residual Mixes

## Results of the calculation of Residual Mixes for the calendar year 2022

Version 1.0, 2023-06-01

### 1 Introduction

The purpose of a Guarantee of Origin (GO) system is to enable consumers to decide how the electricity they purchase is generated by selecting a supplier and a power product. GOs (RED II, Directive 2018/2001, Art. 19) provide a way to reliably track the origin of energy from production to consumption within the context of the international and complex power markets.

GOs are used (cancelled) by electricity suppliers<sup>1</sup>, who must disclose the origin and environmental attributes of sold electricity (IEM Directive (EU) 2019/944, Annex 1 (5)). This process is called electricity disclosure.

A country's residual mix represents the shares of electricity generation attributes available for disclosure, after the use of explicit tracking systems, such as GO, have been accounted for.

#### Residual mix is a pre-requisite for reliable GOs

As long as not all consumption is tracked using GOs, a *residual mix* is needed to make the GO a reliable tracking instrument. The Residual Mix is the energy source mix excluding tracked energy generation attributes from the generation mix. A residual mix is a logical consequence of implementing energy attribute tracking as it ensures that the attributes represented by GOs are not double disclosed to other consumers through an implicit mix. In other words, without a residual mix, renewable electricity sold with GOs would be double counted because the same electricity would be disclosed to consumers buying "regular" electricity. The use of uncorrected generation statistics for purposes of disclosure should thus be avoided.

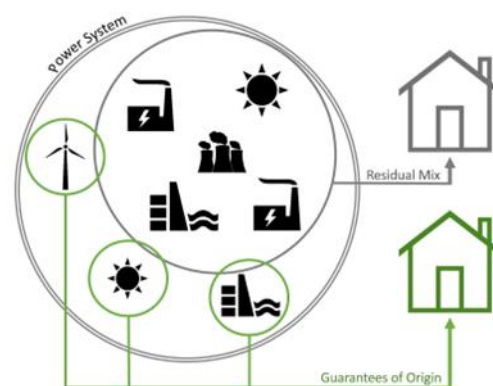
#### International harmonization of the residual mix calculation is needed

Due to the international nature of both the electricity markets and tracking systems, the volume of available generation attributes in the domestic residual mix differs from the volume of untracked consumption<sup>2</sup>. Thus, the calculation of residual mixes needs to be centrally coordinated and a common pool for balancing generation attributes must be used. This is achieved via the European Attribute Mix (EAM), which replaces the deficit of energy origin caused by exported GOs (and/or imported electricity). EAM acts as an "equalising reservoir" for generation attributes for national residual mixes. After the attribute balancing via the EAM the volume of available generation attributes in the residual mix is equal to the untracked consumption in every country. This is a precondition for the GO to be a credible tracking instrument in the context of international trading.

#### Residual mix is not needed in countries with "full consumption disclosure"

Residual mix is needed when consumption is only partially explicitly tracked. In so-called "full consumption disclosure domains" residual mix is not needed because all consumption is covered by cancelled GOs. Austria has had a full disclosure system in place since 2017 and hence the residual mix is zero. Also, Switzerland and Netherlands have full disclosure regulation but, due to implementation details and calculation rules, residual mixes can still be calculated and are included in the results.

#### AIB residual mixes are calculated with the issuance-based method



<sup>1</sup> In some cases and countries it might be done also directly by end-consumers (or service providers on their behalf) for own electricity use.

<sup>2</sup> Untracked consumption = Electricity consumption for which the energy source is not explicitly disclosed through tracking instruments such as Guarantees of Origin.

The AIB European Residual mixes are calculated using the so-called issuance-based method. For more information refer to methodology material on: <https://www.aib-net.org/facts/european-residual-mix>. AIB calculated national residual mixes are official when adopted by national disclosure authorities. A number of disclosure authorities calculate national residual mixes themselves. Most of those are calculated with the same issuing-based method utilizing EAM from this report, but some countries use different methodologies.

## 2 Description of the Document

The main results of this document are the **European Attribute Mix (EAM)** and the **residual mixes for all 34 countries** included in the calculation<sup>3</sup>. A wide variety of additional information and graphs is presented as supporting material. The EAM (Table 1) is the mix of energy sources and the corresponding CO<sub>2</sub> and radioactive waste that is collected from countries which have surpluses of energy attributes. The EAM is then used to fill up the national residual mixes in case of a deficit of disclosure attributes. The national surpluses and deficits to/from EAM are shown in Table 3 and Figure 3.

The **national residual mixes** for 34 European countries are shown in Figure 1 and Figure 2 as well as Table 2. Note that the official residual mixes for each country are published by the respective national authorities. Also note that for countries without recorded explicit tracking, untracked consumption equals the total electricity consumption, and thus the residual mix is applicable for the disclosure of the entire electricity consumption.<sup>4</sup>

Energy sources in the residual mixes are divided in three main categories: renewable, nuclear and fossil, of which renewable and fossil are further divided into subcategories (Table 8). Selected subcategories are based on relevance in terms of volume and perceived consumer importance. The used categorization is also identical to all residual mix calculations since the 2013.

Figure 4 shows the direct greenhouse gas emissions as **direct CO<sub>2</sub> emissions per kWh** of produced electricity. Figure 5 shows the content of **highly active radioactive waste as mgRW/kWh**. Both environmental indicators are calculated for the European Attribute Mix (EAM), the production mix (PM), the residual mix (RM) and the total supplier mix (TSM) of European countries.

**The total supplier mixes (TSMs)** are presented in Table 4, Figure 6 and Figure 7. The total supplier mix represents the total consumption mix of a country, i.e. it is the sum of attributes of 1) cancelled GOs as well as 2) the final residual mix. Thus, both explicitly tracked and available remaining electricity attributes are included in the TSM, which equals in physical volume with the country's total electricity consumption. For understanding, it might help to consider that without the international transferability of GOs and electricity, the TSM would equal the production mix of the country.

The production mixes of the countries are shown in Table 5. The evolution of attributes, on the European scale: how much renewables are in the Production mix, how much of those are left in the residual mix and lastly how much renewables are carried on to EAM is shown in the Figure 10 and Table 6.

The rest of the results are different kinds of comparisons between different mixes and different years, between the production and residual mixes as well as production and total supplier mixes of different countries. Finally Table 7 and Figure 15 show the difference between final residual mixes of 2020, 2021 and 2022.

Annex 1 presents the fuel categories of the calculation, Annex 2 sources of data by country and Annex 3 the input data for CO<sub>2</sub> factors.

**Note:** Any use of the data presented in this document should include a reference to AIB.

**Note:** The calculated country and energy source/technology emission factors forming the base for the National Residual Mix calculations may not be sold, distributed or processed as part of a derivative tool.

<sup>3</sup> Austria, Bosnia & Herzegovina, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, Greece, Hungary, Iceland, Ireland (All-Island), Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland

<sup>4</sup> Calculation of the Residual Mix obviously can only take the volumes of explicit tracking systems into account if the respective data is public or known by the authority and respectively being made available to the one who conducts the calculation. This means that explicit tracking systems, for which no statistical data is available to the competent authority and/or AIB, cannot be reflected in the residual mix and are therefore likely to lead to double counting.

**Disclaimer on data quality:**

Because of the 12 months lifetime of GOs, the residual mixes were calculated based on all recorded GO transactions during the assumed time period (1.4.2022 – 31.3.2023) for disclosure of 2022 consumption, irrespective of the underlying production year of these GOs. This ensures that over the years all GO transactions are considered in the calculation.

Volumes which have been explicitly tracked without the use of transparent tracking instruments, e.g. by so-called contract based tracking, self-declarations etc., cannot be taken into account at all, if they are not reported by the competent authority.

**Partners**



### 3 Data sources and references

The main data source for the calculation is information collected from the national competent authorities through an information request specifically for the purpose of residual mix calculation. Most notably this includes information on any possible national tracking systems (certificate or non-certificate based) and electricity generation.

Where not reported by the competent authority, the generation data is based on Eurostat (electricity generation by fuel as well as supply, transformation and consumption of electricity). Power import/export data from/to countries outside of the calculation area are collected from ENTSO-E Transparency platform.

EECS GO statistics are collected centrally from the AIB statistics. The volume of ex-domain cancellations<sup>5</sup> (including the target domains of these cancellations) is collected as part of data collection from competent authorities.

The base data for the direct CO<sub>2</sub>-emissions is based on nationally reported information (where available) or the Ecoinvent database. The data for the radioactive waste has been compiled based on BDEW (2014), DECC (2014), the Platts World Database and IAEA PRIS. These indicators reflect the differences in waste rates produced by the types of nuclear power reactors used in the respective countries per kWh of electricity. Due to a lack of detailed data per reactor, the waste rates have been based on estimates of typical data for five major types of reactors used in Europe. However, where available, factors as reported by national authorities are used instead.

#### References

National Issuing Bodies and Disclosure Competent Bodies: Updates through the annual data collection

Generation data: Eurostat: [Product - Products Datasets - Eurostat \(europa.eu\)](#) and

[Product - Products Datasets - Eurostat \(europa.eu\)](#)

EECS Guarantee of Origin Statistics: Association of Issuing Bodies, [Statistics | AIB \(aib-net.org\)](#)

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<sup>5</sup> A cancellation of a certificate for disclosure of electricity consumption in another country. Under AIB rules, ex-domain cancellations are not allowed between two countries connected to the AIB Hub.

Sources for emission factors and radioactive waste:

Ecoinvent (2023): Ecoinvent database and bilaterally provided data. (See Annex 3)

BDEW (2014). Leitfaden "Stromkennzeichnung", Berlin, Oktober 2014

DECC (2014), Fuel Mix Disclosure Data Table, 2014

IAEA PRIS. The IAEA Power Reactor Information System (PRIS), 2015, <https://www.iaea.org/pris/>

Platts: The Platts World Database, 2014

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## 4 Main result tables

The need for a methodology to determine a cross-border central residual mix emerges when a country exports more GOs than physical energy, thus creating a deficit of generation attributes. In principle the deficit/surplus of attributes is always the net effect of import/export of electricity and export/import of GOs respectively (for details, please refer to the residual mix [methodology document](#)). Such a deficit of attributes in the disclosure of energy supplied without being backed by GO cancellation needs to be complemented with an excess of attributes from countries that are net importers of GOs.

The European Attribute Mix (Table 1) contains all surplus generation attributes from countries with an excess of attributes. It is used to fill the gap in the residual mix in countries with a deficit of attributes in their residual mix. The exchange with the European Attribute Mix is graphically presented in Figure 3.

Table 1: European Attribute Mix (EAM) 2022: Energy source distribution and environmental indicators

	RE Total	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO Total	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
<b>EAM</b>	9.22%	0.00%	1.21%	4.18%	0.00%	1.54%	2.28%	17.02%	73.76%	3.50%	38.04%	0.10%	1.63%	30.49%	531.21	0.63

**EAM** = European Attribute Mix is used for balancing surpluses and deficits in national residual mixes caused by international trading of electricity and guarantees of origin.

The introduction of a GO system provides a way to supply energy with specified attributes, but also impacts the remaining attributes of energy supplied without a GO. According to preamble 13 of 2018/2001/EC: 'residual energy mix' means the total annual energy mix for a Member State, excluding the share covered by cancelled guarantees of origin. If uncorrected generation statistics were used for the purpose of disclosure of untracked electricity consumption, then the renewable energy origin represented by GOs would be double counted. Table 2 and Figure 2 present the residual mixes of 2022 for 34 European countries as calculated by AIB. Note that the official residual mixes for each country are in principle published by the respective national authorities.

Table 2: Residual Mixes 2022

	RE Total	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO Total	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	Untracked %	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
AT	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00	0.00
BA	34.04%	0.01%	0.00%	0.56%	0.00%	2.68%	30.79%	0.00%	65.96%	0.00%	65.96%	0.00%	0.00%	0.00%	100.00%	843.93	0.00
BE	11.68%	0.01%	2.14%	8.53%	0.00%	0.80%	0.20%	55.90%	32.42%	1.16%	2.74%	0.00%	0.02%	28.51%	71.23%	144.27	1.51
BG	13.99%	0.01%	4.26%	3.44%	0.00%	2.98%	3.29%	36.65%	49.36%	0.00%	44.30%	0.00%	0.85%	4.21%	98.17%	517.05	1.28
CH	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00	0.00
CY	17.73%	0.12%	0.77%	11.57%	0.00%	5.27%	0.00%	0.00%	82.27%	0.00%	0.00%	0.00%	82.27%	0.00%	100.00%	607.40	0.00
CZ	5.46%	0.01%	3.34%	1.47%	0.00%	0.01%	0.63%	40.95%	53.60%	0.13%	47.50%	0.00%	0.11%	5.86%	91.24%	697.21	1.43
DE	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.36%	88.64%	5.38%	57.62%	0.00%	1.51%	24.14%	27.24%	684.03	0.31
DK	16.27%	0.00%	0.67%	3.80%	0.00%	9.32%	2.48%	9.44%	74.29%	5.69%	44.45%	0.05%	1.84%	22.26%	59.52%	557.40	0.35
EE	7.22%	0.00%	0.71%	4.07%	0.00%	1.08%	1.35%	9.67%	83.11%	42.71%	21.61%	0.18%	0.93%	17.69%	84.10%	715.18	0.36
ES	3.06%	0.00%	0.00%	1.42%	0.00%	1.64%	0.00%	34.80%	62.14%	0.00%	4.83%	0.00%	1.88%	55.43%	62.15%	275.11	0.94
FI	11.69%	0.00%	4.42%	3.35%	0.00%	0.97%	2.96%	18.19%	70.11%	4.26%	38.92%	0.06%	1.39%	25.48%	50.69%	520.77	0.64



	RE Total	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO Total	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	Untracked %	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
FR	5.58%	0.00%	1.15%	2.66%	0.02%	1.44%	0.32%	72.86%	21.56%	0.44%	5.40%	0.01%	0.76%	14.94%	85.83%	124.96	1.99
GB	3.87%	0.00%	0.68%	2.80%	0.00%	0.39%	0.00%	23.02%	73.11%	4.15%	2.71%	0.00%	1.01%	65.24%	51.44%	365.15	1.84
GR	18.72%	0.00%	0.71%	9.63%	0.22%	4.93%	3.24%	1.08%	80.21%	0.81%	5.57%	14.13%	10.25%	49.45%	72.10%	531.38	0.04
HR	14.56%	0.13%	2.37%	2.45%	0.22%	5.35%	4.03%	8.63%	76.81%	1.78%	31.06%	0.05%	1.51%	42.42%	74.32%	515.06	0.32
HU	10.88%	0.00%	4.16%	5.25%	0.00%	0.63%	0.85%	43.74%	45.38%	3.48%	8.19%	6.50%	0.46%	26.75%	91.62%	319.96	1.55
IE	17.17%	0.00%	1.74%	0.04%	0.00%	15.38%	0.00%	0.00%	82.83%	1.57%	20.94%	1.75%	2.58%	55.98%	0.00%	474.84	0.00
IS	9.22%	0.00%	1.21%	4.18%	0.00%	1.54%	2.28%	17.02%	73.77%	3.50%	38.03%	0.10%	1.65%	30.49%	81.35%	531.29	0.63
IT	9.04%	0.00%	1.68%	5.97%	0.00%	0.84%	0.54%	2.62%	88.34%	2.73%	12.20%	0.02%	4.47%	68.92%	72.48%	457.15	0.10
LT	22.35%	0.37%	0.59%	2.31%	0.00%	15.93%	3.14%	8.86%	68.80%	3.19%	10.94%	0.02%	5.59%	49.05%	51.89%	466.36	0.33
LU	30.60%	2.74%	2.20%	9.21%	0.16%	7.19%	9.11%	11.42%	57.98%	9.39%	25.51%	0.07%	1.10%	21.92%	15.15%	419.68	0.43
LV	14.31%	0.00%	3.26%	3.84%	0.00%	2.67%	4.53%	16.24%	69.45%	2.89%	32.74%	0.08%	1.31%	32.43%	90.84%	510.71	0.60
ME	53.47%	0.45%	0.00%	0.21%	0.00%	7.57%	45.23%	0.00%	46.53%	0.00%	46.53%	0.00%	0.00%	0.00%	100.00%	538.59	0.00
MT	9.28%	0.00%	0.27%	8.20%	0.00%	0.33%	0.48%	3.60%	87.12%	0.74%	8.04%	0.02%	2.47%	75.85%	97.67%	404.94	0.13
NL	30.25%	0.00%	3.38%	25.27%	0.00%	1.49%	0.11%	0.05%	69.70%	0.00%	30.36%	0.00%	3.08%	36.26%	8.05%	438.97	0.00
NO	13.82%	0.00%	1.28%	3.89%	0.00%	1.96%	6.68%	15.78%	70.40%	5.25%	35.27%	0.09%	1.52%	28.27%	81.35%	502.31	0.59
PL	9.28%	0.02%	1.69%	4.43%	0.00%	2.67%	0.47%	0.49%	90.23%	0.42%	81.78%	0.00%	0.00%	8.02%	88.06%	858.12	0.02
PT	10.72%	0.00%	0.69%	2.37%	0.00%	0.88%	6.78%	9.66%	79.62%	6.93%	21.58%	0.06%	0.93%	50.13%	74.72%	445.55	0.36



	RE Total	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO Total	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	Untracked %	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
RO	43.62%	0.06%	0.74%	3.43%	0.00%	13.16%	26.23%	21.09%	35.29%	0.87%	17.09%	0.00%	0.11%	17.21%	98.77%	275.75	3.50
RS	11.87%	0.00%	0.26%	0.92%	0.00%	0.33%	10.35%	3.69%	84.44%	0.76%	8.25%	64.54%	0.35%	10.53%	90.32%	954.21	0.14
SE	19.89%	0.00%	8.13%	6.29%	0.00%	1.65%	3.82%	73.03%	7.08%	4.77%	0.05%	0.09%	1.47%	0.71%	15.39%	38.95	1.97
SI	10.45%	0.00%	1.33%	6.00%	0.00%	1.26%	1.86%	28.48%	61.08%	2.85%	31.88%	0.08%	1.35%	24.91%	61.19%	370.80	0.96
SK	9.29%	0.43%	3.80%	2.99%	0.00%	0.03%	2.03%	69.06%	21.65%	2.27%	3.30%	3.76%	1.91%	10.40%	79.01%	186.50	2.42

**Untracked Consumption** = Electricity consumption not explicitly disclosed through tracking instruments such as Guarantees of Origin.

**Note:** CO<sub>2</sub> and radioactive waste figures reported are destined for purposes of electricity disclosure only (rf. page 2).

**Data Sources:** Information reported by national Competent Bodies; Association of Issuing Bodies (AIB); Eurostat

## 5 Graphs with detailed calculations results

### 5.1 Residual mixes and the European Attribute Mix

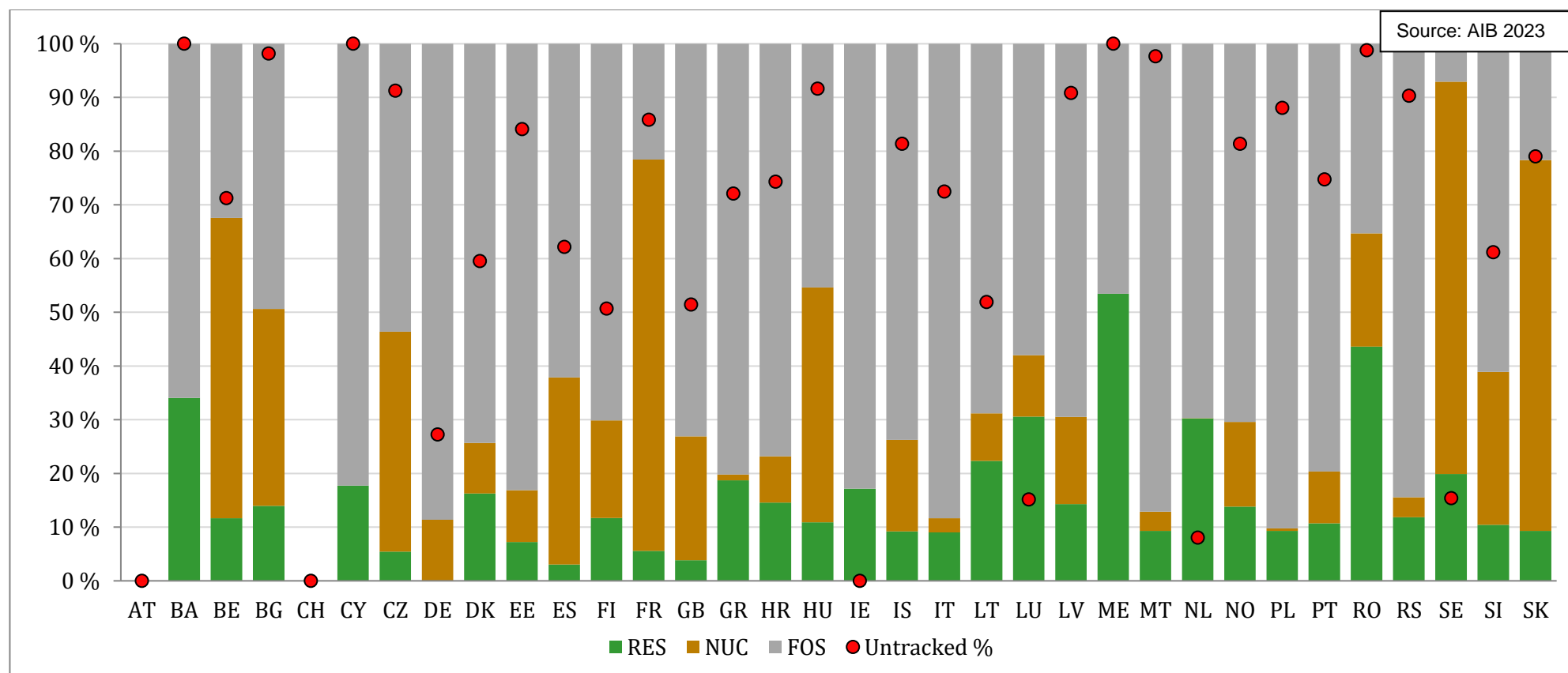


Figure 1: Residual Mixes 2022

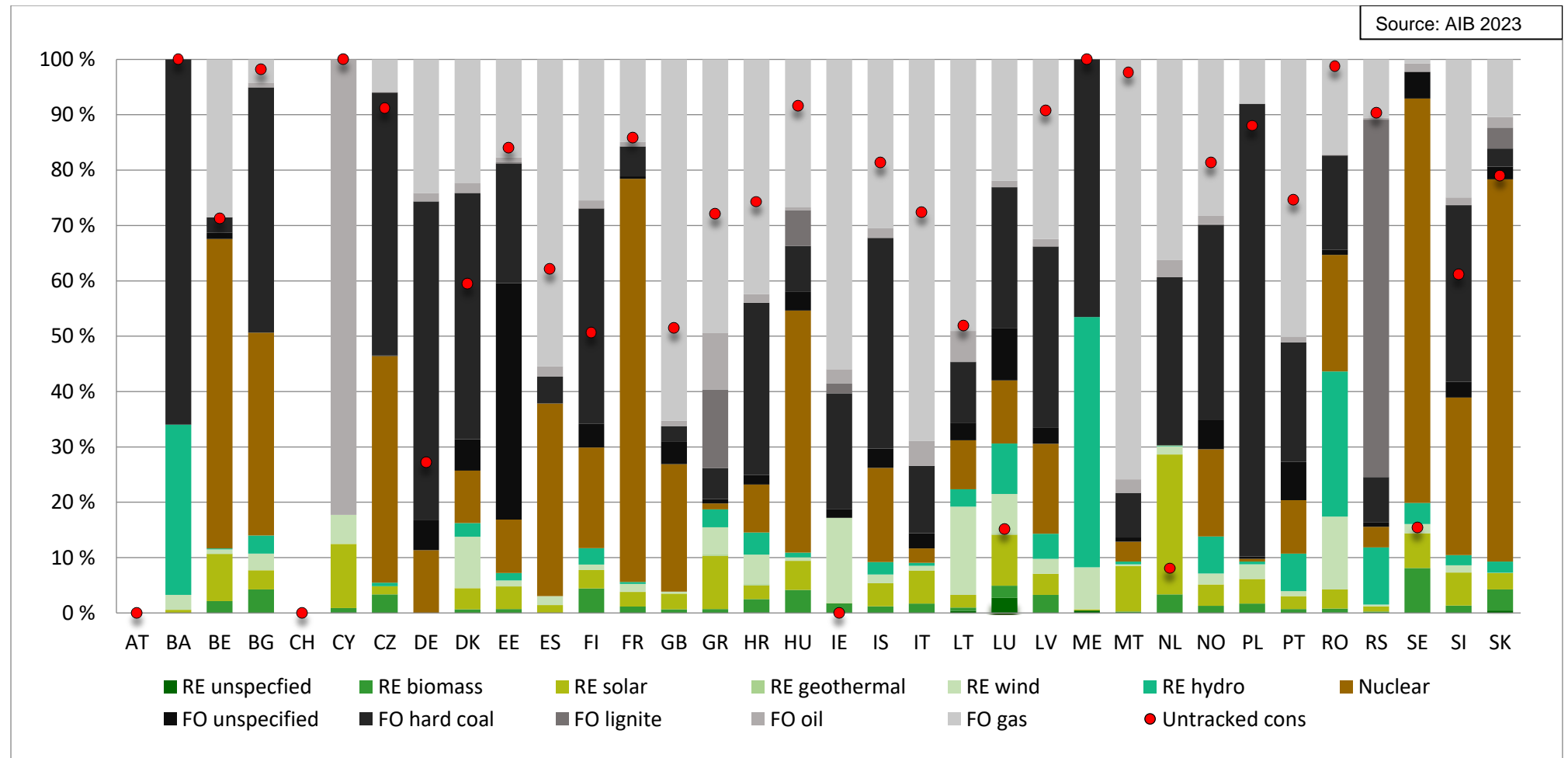


Figure 2: Residual Mixes 2022 (detailed fuel categories)

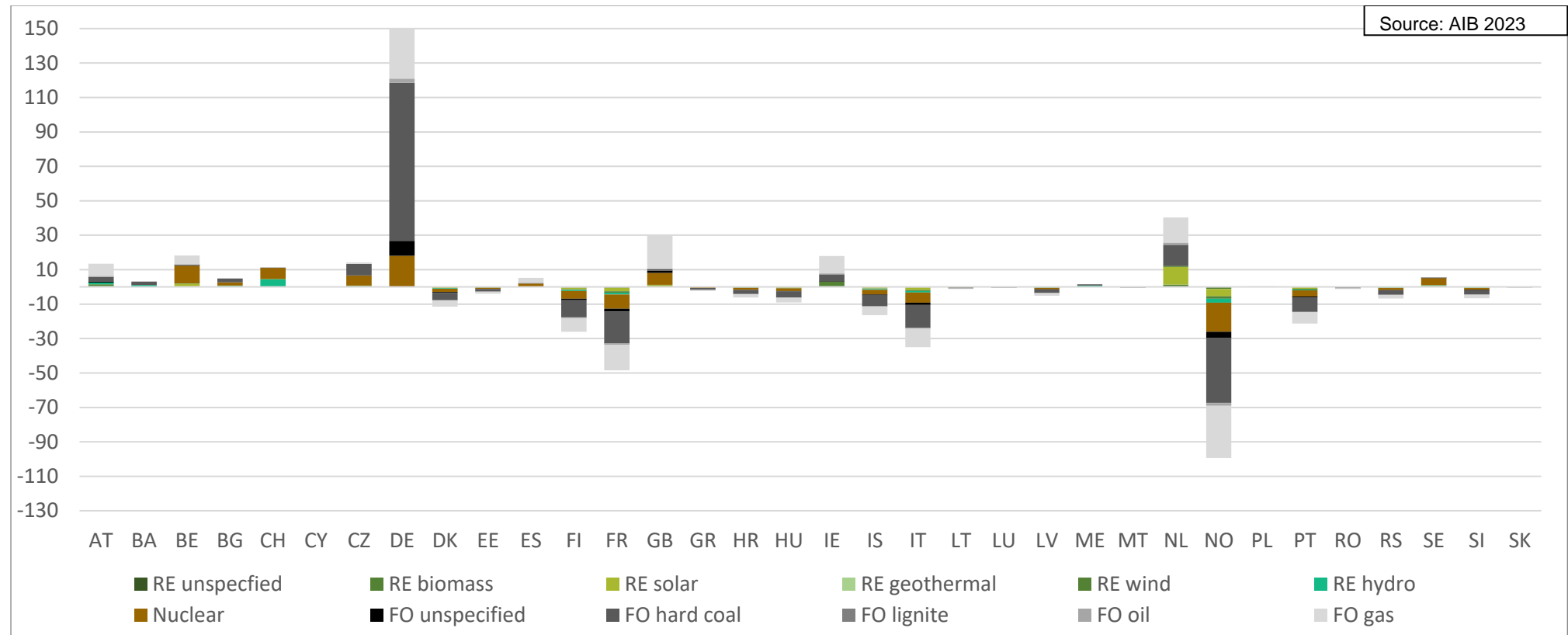


Figure 3: Attributes [TWh] to(positive)/from(negative) the European Attribute Mix 2022<sup>6</sup>

<sup>6</sup> In this figure, the renewable energy added to the EAM does not equal the renewable energy taken out of it, which may seem peculiar. There are two reasons for it: 1) temporal attribute deficit caused by issuing volumes being higher than cancellation volumes, and 2) some countries have negative renewable energy balance in domestic residual mixes (caused by variation in disclosure periods and GO lifetimes overlapping two disclosure periods). This negativity is transferred into the EAM before considering the domestic residual mix attribute surpluses and deficits.

Table 3: Attributes [TWh] to/from the European Attribute Mix 2022<sup>7</sup>

	RE unspeci- fied	RE biomass	RE solar	RE geother- mal	RE wind	RE hydro	Nuclear	FO unspeci- fied	FO hard coal	FO lignite	FO oil	FO gas
AT	0.00	0.55	0.00	0.00	0.89	1.07	0.00	0.65	2.63	0.00	0.65	7.08
BA	0.00	0.00	0.02	0.00	0.08	0.94	0.00	0.00	2.02	0.00	0.00	0.00
BE	0.00	0.39	1.56	0.00	0.15	0.04	10.22	0.21	0.50	0.00	0.00	5.21
BG	0.00	0.22	0.18	0.00	0.15	0.17	1.87	0.00	2.26	0.00	0.04	0.22
CH	0.00	0.00	0.24	0.00	0.00	4.21	6.59	0.16	0.00	0.00	0.00	0.16
CY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
CZ	0.00	0.48	0.21	0.00	0.00	0.09	5.83	0.02	6.76	0.00	0.02	0.83
DE	0.00	0.00	0.00	0.00	0.00	0.00	18.11	8.57	91.88	0.00	2.41	38.49
DK	0.00	-0.14	-0.48	0.00	-0.18	-0.26	-1.95	-0.40	-4.35	-0.01	-0.19	-3.49
EE	0.00	-0.05	-0.17	0.00	-0.06	-0.09	-0.69	-0.14	-1.54	0.00	-0.07	-1.23
ES	0.00	0.00	0.07	0.00	0.09	0.00	1.80	0.00	0.25	0.00	0.10	2.87
FI	0.00	-0.32	-1.09	0.00	-0.40	-0.59	-4.43	-0.91	-9.90	-0.03	-0.43	-7.93
FR	0.00	-0.59	-2.02	0.00	-0.75	-1.10	-8.24	-1.69	-18.41	-0.05	-0.79	-14.76
GB	0.00	0.21	0.85	0.00	0.12	0.00	7.00	1.26	0.82	0.00	0.31	19.84
GR	0.00	-0.03	-0.10	0.00	-0.04	-0.06	-0.41	-0.08	-0.92	0.00	-0.04	-0.74
HR	0.00	-0.07	-0.26	0.00	-0.10	-0.14	-1.05	-0.22	-2.35	-0.01	-0.10	-1.88

<sup>7</sup> Same as in previous figure 3, the renewable energy added to the EAM does not equal the renewable energy taken out of it. For more information refer to footnote 4.

	RE unspeci- fied	RE biomass	RE solar	RE geother- mal	RE wind	RE hydro	Nuclear	FO unspeci- fied	FO hard coal	FO lignite	FO oil	FO gas
HU	0.00	-0.11	-0.38	0.00	-0.14	-0.21	-1.53	-0.32	-3.43	-0.01	-0.15	-2.75
IE	0.00	0.31	0.01	0.00	2.75	0.00	0.00	0.28	3.75	0.31	0.46	10.02
IS	0.00	-0.20	-0.68	-0.10	-0.25	-0.37	-2.78	-0.57	-6.22	-0.02	-0.27	-4.99
IT	0.00	-0.42	-1.47	0.00	-0.54	-0.80	-5.96	-1.23	-13.32	-0.03	-0.57	-10.68
LT	0.00	-0.02	-0.05	0.00	-0.02	-0.03	-0.22	-0.05	-0.49	0.00	-0.02	-0.39
LU	0.00	-0.01	-0.02	0.00	-0.01	-0.01	-0.09	-0.02	-0.21	0.00	-0.01	-0.16
LV	0.00	-0.06	-0.22	0.00	-0.08	-0.12	-0.88	-0.18	-1.97	-0.01	-0.08	-1.58
ME	0.01	0.00	0.00	0.00	0.11	0.68	0.00	0.00	0.69	0.00	0.00	0.00
MT	0.00	-0.01	-0.02	0.00	-0.01	-0.01	-0.10	-0.02	-0.22	0.00	-0.01	-0.18
NL	0.00	1.36	10.19	0.00	0.60	0.04	0.02	0.00	12.24	0.00	1.24	14.61
NO	0.00	-1.20	-4.16	0.00	-1.53	-2.26	-16.92	-3.48	-37.82	-0.10	-1.63	-30.32
PL	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.16	0.00	0.00	0.02
PT	0.00	-0.26	-0.89	0.00	-0.33	-0.49	-3.63	-0.75	-8.12	-0.02	-0.35	-6.51
RO	0.00	-0.01	-0.05	0.00	-0.02	-0.03	-0.20	-0.04	-0.45	0.00	-0.02	-0.36
RS	0.00	-0.08	-0.28	0.00	-0.10	-0.15	-1.15	-0.24	-2.57	-0.01	-0.11	-2.06
SE	0.00	0.45	0.35	0.00	0.09	0.21	4.02	0.26	0.00	0.00	0.08	0.04
SI	0.00	-0.08	-0.28	0.00	-0.10	-0.15	-1.13	-0.23	-2.52	-0.01	-0.11	-2.02
SK	0.00	0.00	-0.01	0.00	0.00	0.00	-0.03	-0.01	-0.07	0.00	0.00	-0.06

## 5.2 Environmental indicators

According to directive 2019/944/EC, Annex 1(5), electricity suppliers shall (together with energy origin disclosure) disclose “information on the environmental impact, in at least terms of CO2 emissions and the radioactive waste resulting from the electricity produced by the overall energy mix of the supplier over the preceding year”. The calculation of the environmental indicators goes hand in hand with the calculation of energy source shares in the residual mix:

- The CO2 factor of the production mix is obtained by multiplying each energy in the production mix with the CO2 factor of that energy source for that country (nationally reported data or Ecoinvent database).
- The emissions of the Domestic Residual Mix are the emissions of the Production Mix adjusted with the Issued and Expired Attributes for each energy source respectfully,
- For surplus countries, CO2 factor in Final RM is equal to the CO2 factor in Domestic RM. For deficit countries, CO2 is added to the Domestic RM by multiplying the volume of deficit with the CO2 factor of the EAM.

The process is identical for radioactive waste, but the source data is as described in the introduction.



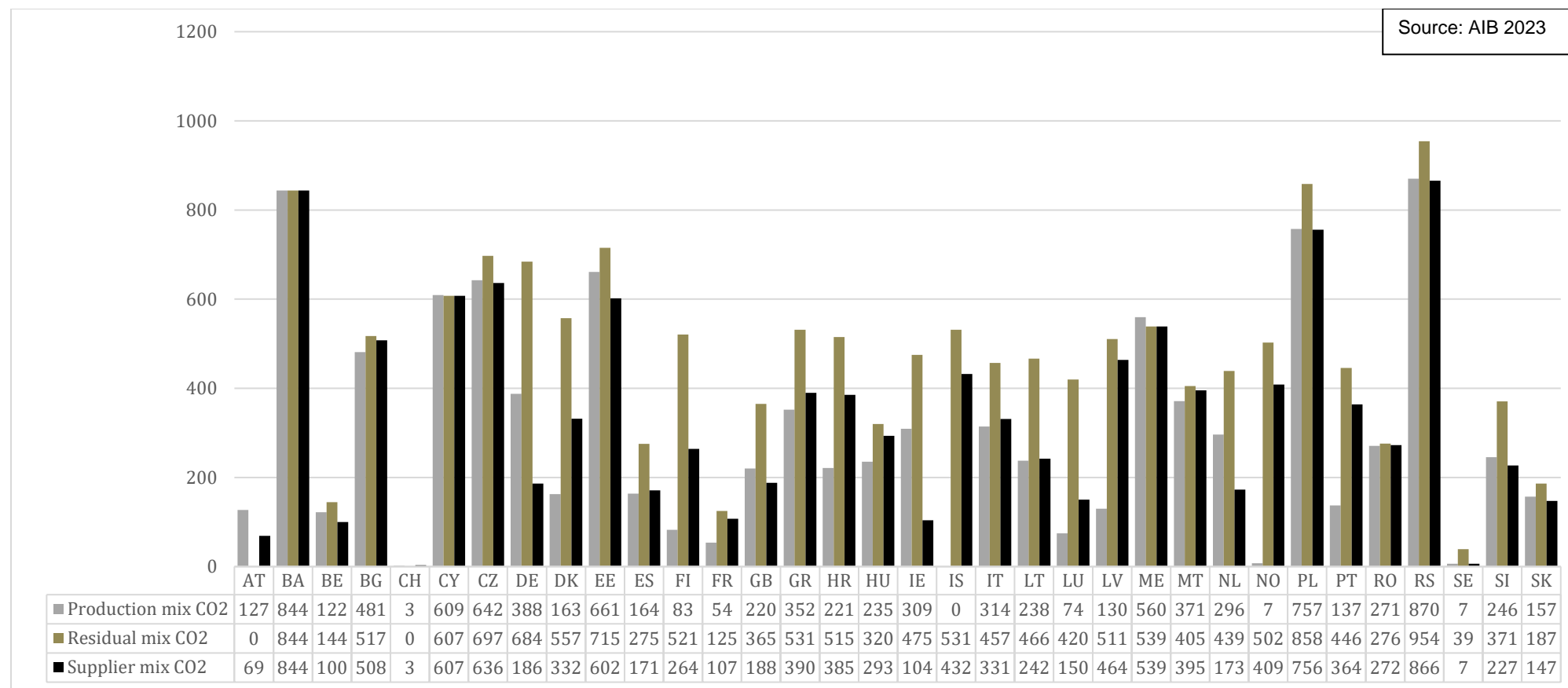


Figure 4: Direct CO<sub>2</sub> content in Production, Residual and Total Supplier mix 2022 [gCO<sub>2</sub>/kWh]

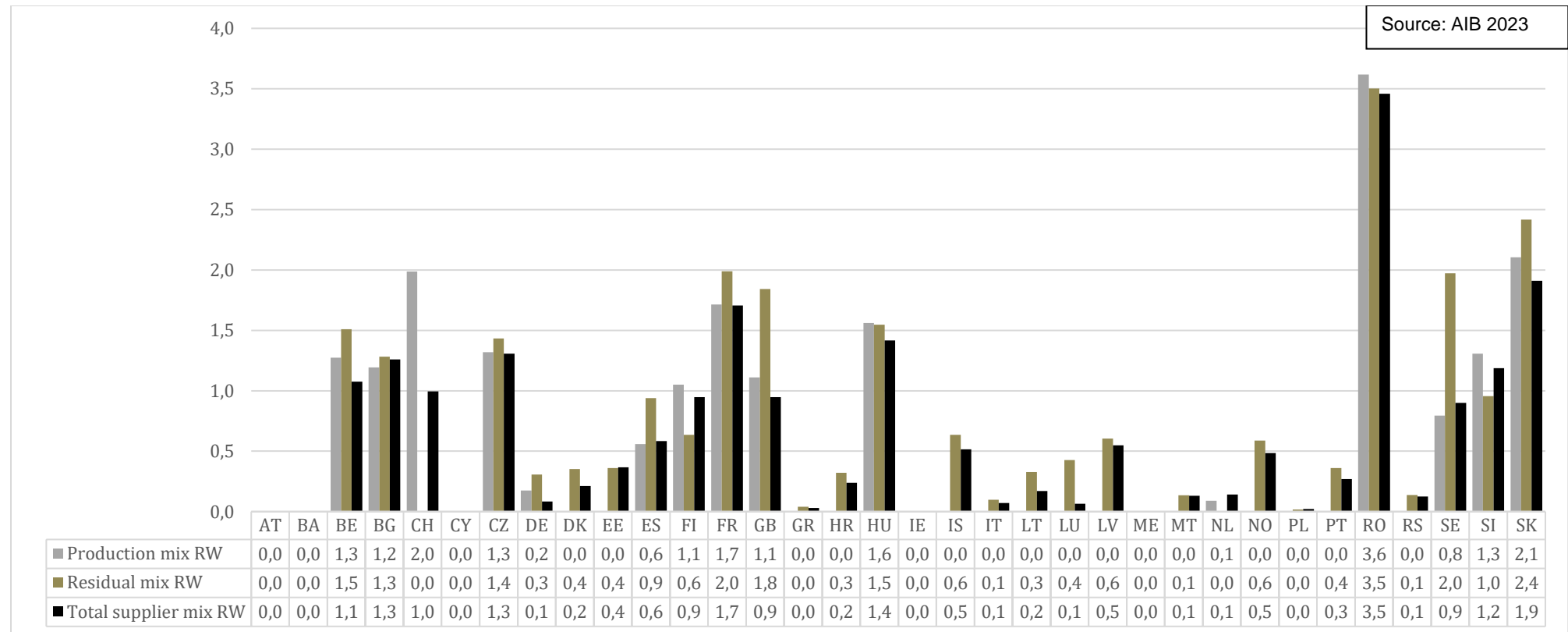


Figure 5: Highly active radioactive waste content in Production, Residual and Total Supplier Mix 2022 [mgRW/kWh]

### 5.3 The total supplier mixes and production mixes

The total supplier mix (Table 4, Figure 6, Figure 7) represents the total consumption mix of a country, i.e. it is the sum of attributes of 1) cancelled GOs as well as 2) the final residual mix. Thus, both explicitly tracked and available remaining electricity attributes are included in the TSM, which equals in physical volume with the country's total electricity consumption. For understanding, it might help to consider that without the international transferability of GOs and electricity, the TSM would equal the production mix of the country.

Table 4: Total Supplier Mix 2022

	Volume (TWh)	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
AT	75.95	0.04%	5.52%	2.97%	0.05%	10.94%	64.69%	0.00%	0.24%	0.00%	0.00%	0.00%	15.55%	69.01	0.00
BA	11.55	0.01%	0.00%	0.56%	0.00%	2.68%	30.79%	0.00%	0.00%	65.96%	0.00%	0.00%	0.00%	843.93	0.00
BE	78.94	0.15%	6.65%	7.39%	0.22%	13.68%	9.63%	39.82%	0.17%	1.95%	0.00%	0.01%	20.32%	99.82	1.08
BG	33.54	0.01%	4.21%	4.08%	0.00%	3.35%	3.91%	35.98%	0.00%	43.50%	0.00%	0.83%	4.13%	507.61	1.26
CH	57.02	0.00%	0.71%	2.73%	0.14%	2.45%	73.21%	20.14%	0.15%	0.00%	0.00%	0.00%	0.47%	2.75	0.99
CY	5.02	0.12%	0.77%	11.57%	0.00%	5.27%	0.00%	0.00%	0.00%	0.00%	0.00%	82.27%	0.00%	607.38	0.00
CZ	62.97	0.02%	6.19%	2.13%	0.11%	1.55%	3.74%	37.36%	0.12%	43.34%	0.00%	0.10%	5.35%	636.11	1.31
DE	474.45	0.32%	4.58%	13.84%	0.45%	28.17%	25.40%	3.09%	1.46%	15.70%	0.00%	0.41%	6.57%	186.32	0.08
DK	34.64	0.00%	3.19%	6.05%	0.00%	32.79%	8.02%	5.72%	3.39%	26.46%	0.03%	1.09%	13.25%	331.76	0.21
EE	8.46	0.00%	9.06%	3.74%	0.00%	3.22%	3.76%	10.26%	35.92%	18.17%	0.15%	0.78%	14.93%	601.70	0.37
ES	250.49	0.00%	2.91%	8.24%	0.02%	23.53%	5.05%	21.63%	0.00%	3.00%	0.00%	1.17%	34.45%	170.99	0.58
FI	81.70	0.09%	8.26%	2.67%	0.06%	9.00%	14.32%	30.06%	2.16%	19.73%	0.03%	0.71%	12.92%	263.99	0.95
FR	459.30	0.01%	1.90%	3.56%	0.02%	5.53%	7.95%	62.54%	0.38%	4.64%	0.01%	0.65%	12.82%	107.25	1.71

	Volume (TWh)	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
GB	306.50	0.00%	13.12%	6.68%	0.00%	27.57%	3.18%	11.84%	2.13%	1.39%	0.00%	0.52%	33.56%	187.83	0.95
GR	53.08	0.00%	1.37%	13.32%	0.16%	16.79%	7.93%	0.78%	0.59%	4.01%	10.19%	7.39%	37.49%	389.65	0.03
HR	16.36	0.10%	5.10%	2.14%	0.37%	8.57%	19.69%	6.42%	1.32%	23.08%	0.04%	1.12%	32.06%	385.36	0.24
HU	45.66	0.58%	4.61%	5.97%	0.03%	2.68%	4.48%	40.07%	3.19%	7.50%	5.95%	0.42%	24.51%	293.14	1.42
IE	40.59	0.75%	4.30%	5.44%	0.18%	46.94%	18.20%	0.00%	0.00%	0.00%	0.00%	0.00%	24.19%	103.83	0.00
IS	20.12	0.00%	0.99%	3.41%	9.45%	3.21%	9.09%	13.84%	2.85%	30.94%	0.08%	1.34%	24.80%	432.20	0.52
IT	314.29	0.07%	7.24%	6.94%	2.08%	7.48%	10.26%	1.90%	1.98%	8.84%	0.01%	3.24%	49.95%	331.35	0.07
LT	11.08	0.19%	3.20%	4.04%	0.00%	41.48%	10.79%	4.60%	1.65%	5.68%	0.01%	2.90%	25.45%	242.01	0.17
LU	5.30	0.42%	3.95%	6.44%	0.02%	7.78%	59.31%	1.73%	11.17%	3.87%	0.01%	0.17%	5.13%	150.36	0.06
LV	7.11	0.00%	3.70%	3.88%	0.00%	3.73%	10.84%	14.76%	2.63%	29.74%	0.07%	1.19%	29.46%	463.92	0.55
ME	3.35	0.45%	0.00%	0.21%	0.00%	7.57%	45.23%	0.00%	0.00%	46.53%	0.00%	0.00%	0.00%	538.59	0.00
MT	2.79	0.00%	0.27%	8.20%	0.00%	0.60%	2.34%	3.51%	0.72%	7.85%	0.02%	2.41%	74.08%	395.49	0.13
NL	114.09	0.01%	3.94%	8.23%	0.01%	42.11%	3.35%	5.20%	1.94%	4.21%	0.00%	0.25%	30.76%	172.93	0.14
NO	131.81	0.02%	1.27%	3.88%	0.11%	4.10%	20.29%	13.04%	4.27%	28.69%	0.07%	1.23%	23.00%	408.63	0.48
PL	158.71	0.02%	4.11%	4.25%	0.00%	9.44%	2.11%	0.61%	0.37%	72.01%	0.00%	0.00%	7.06%	755.63	0.02
PT	50.35	1.61%	2.79%	5.00%	0.00%	7.28%	8.97%	7.22%	7.92%	16.13%	0.04%	0.71%	42.33%	363.67	0.27
RO	51.54	0.06%	0.82%	3.46%	0.00%	13.73%	26.26%	20.83%	0.85%	16.88%	0.00%	0.11%	17.00%	272.36	3.46
RS	34.43	0.00%	0.96%	0.86%	0.00%	3.07%	14.96%	3.33%	0.69%	7.45%	58.29%	0.32%	10.06%	865.50	0.12
SE	136.94	0.05%	9.79%	2.66%	0.00%	12.21%	40.73%	33.35%	0.85%	0.01%	0.02%	0.23%	0.11%	6.62	0.90
SI	13.26	0.00%	2.06%	11.84%	0.00%	0.92%	8.65%	37.50%	1.75%	19.51%	0.05%	0.83%	16.90%	226.89	1.19
SK	25.05	0.34%	4.15%	3.47%	0.00%	0.62%	19.75%	54.56%	1.79%	2.61%	2.97%	1.51%	8.22%	147.35	1.91

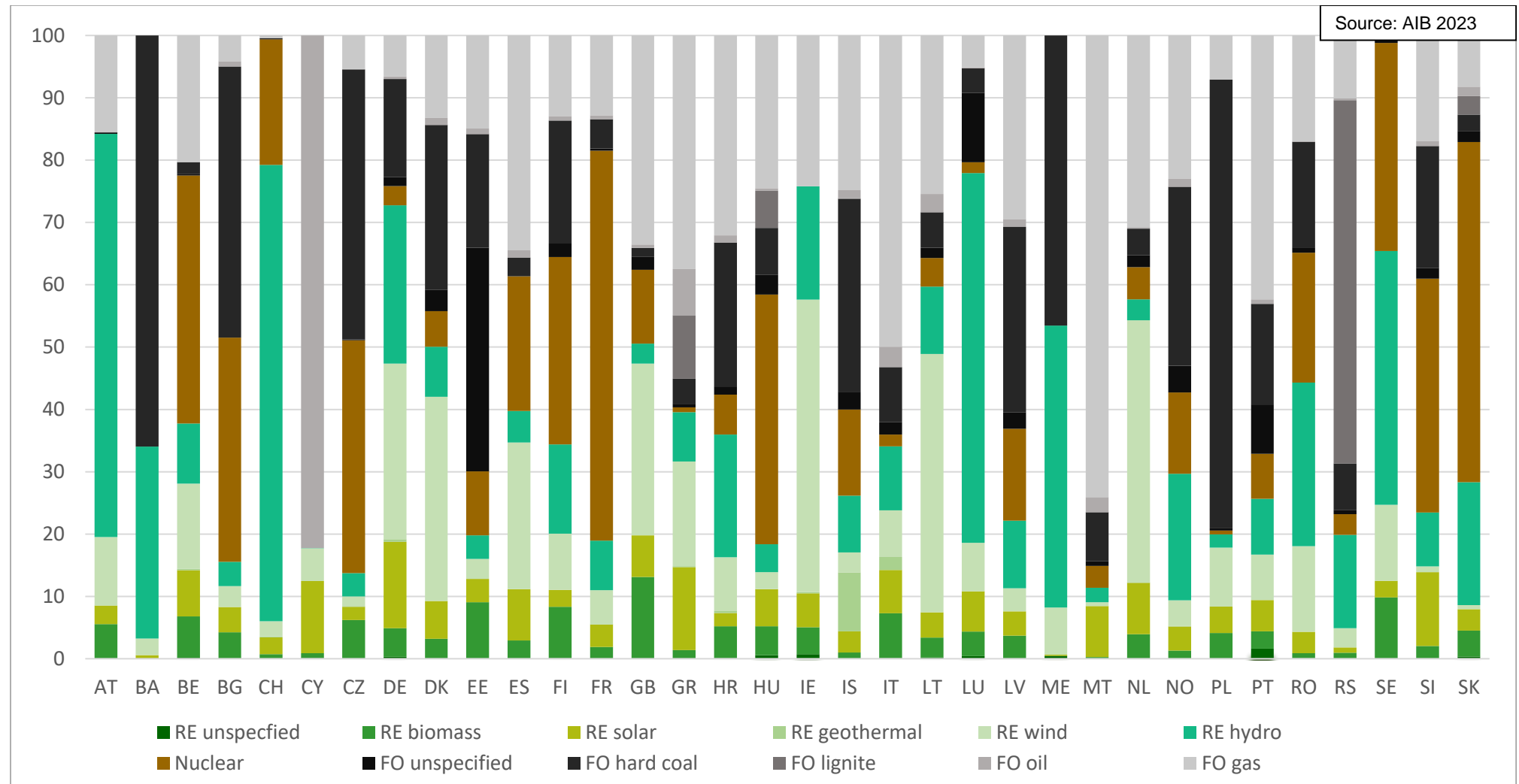


Figure 6 Total Supplier Mix 2022 (detailed fuel categories)

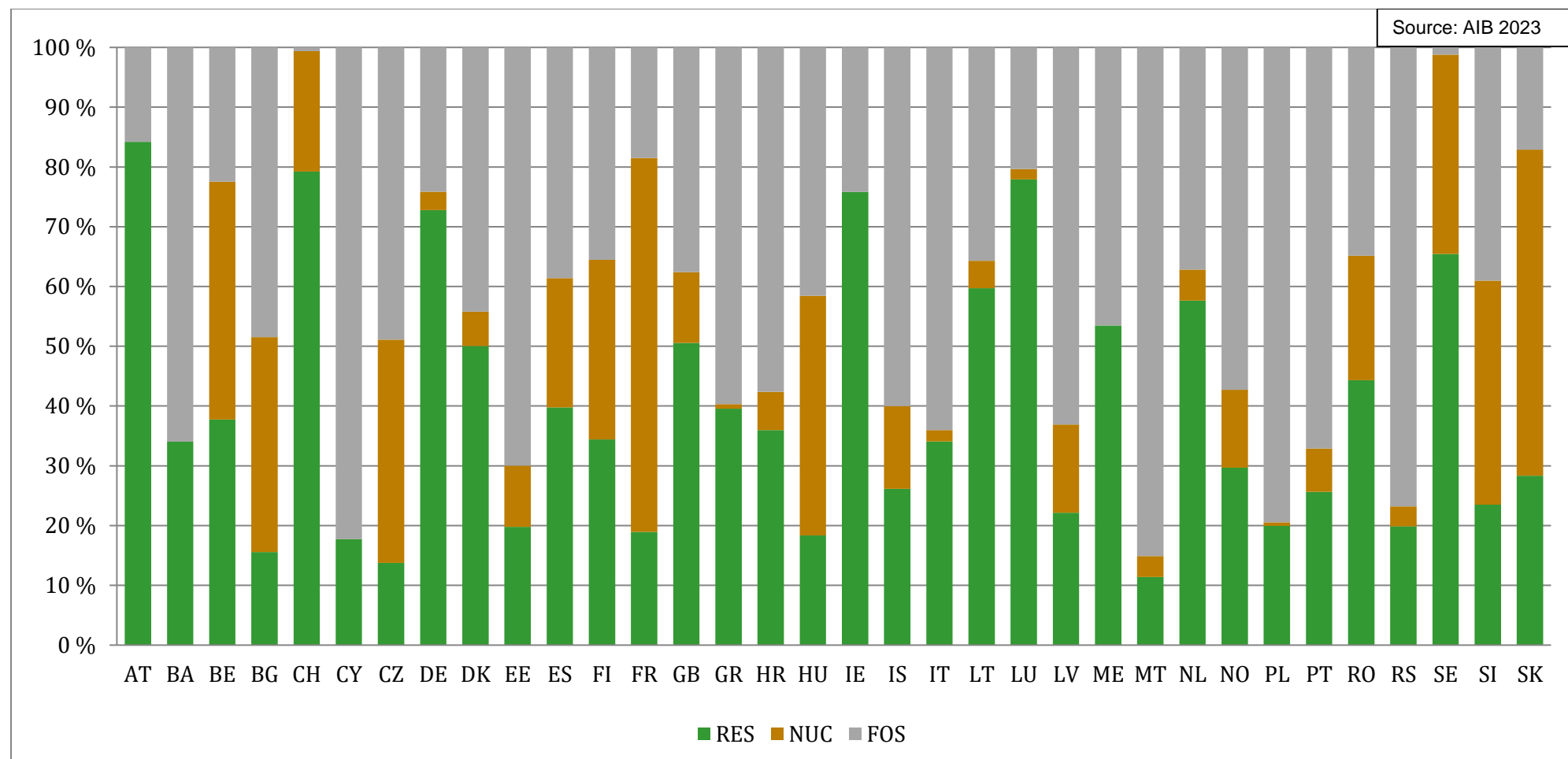


Figure 7: Total Supplier Mix 2022 (simple fuel categories)

Table 5: Production Mix 2022<sup>8</sup>

	Volume [TWh]	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
AT	60.32	0.00%	5.05%	0.00%	0.00%	13.42%	57.04%	0.00%	1.13%	3.37%	0.00%	1.09%	18.92%	127.07	0.00
BA	14.61	0.01%	0.00%	0.56%	0.00%	2.68%	30.79%	0.00%	0.00%	65.96%	0.00%	0.00%	0.00%	843.93	0.00
BE	88.29	0.00%	4.56%	7.71%	0.00%	12.96%	0.22%	47.18%	0.98%	2.31%	0.00%	0.02%	24.06%	121.77	1.27
BG	45.79	0.01%	3.99%	4.44%	0.00%	3.28%	8.21%	34.12%	0.00%	41.24%	0.00%	0.79%	3.92%	481.35	1.19
CH	55.85	0.00%	2.08%	4.94%	0.00%	0.27%	50.75%	41.40%	0.03%	0.00%	0.00%	0.00%	0.53%	2.55	1.99
CY	5.02	0.12%	0.78%	12.16%	0.00%	4.47%	0.00%	0.00%	0.00%	0.00%	0.00%	82.48%	0.00%	608.94	0.00
CZ	77.83	0.01%	6.45%	2.93%	0.00%	0.81%	2.71%	37.72%	0.12%	43.76%	0.00%	0.10%	5.40%	642.25	1.32
DE	509.45	0.00%	3.40%	12.04%	0.04%	25.01%	2.84%	6.44%	3.05%	32.65%	0.00%	0.86%	13.68%	387.63	0.17
DK	33.27	0.03%	16.44%	5.69%	0.00%	57.11%	0.04%	0.00%	2.32%	14.47%	0.00%	0.58%	3.32%	162.83	0.00
EE	7.53	0.00%	18.29%	6.71%	0.00%	8.81%	0.29%	0.00%	65.11%	0.00%	0.20%	0.00%	0.60%	660.99	0.00
ES	270.29	0.32%	1.74%	11.85%	0.00%	22.65%	5.75%	20.71%	0.00%	2.87%	0.00%	1.12%	32.99%	163.72	0.56
FI	69.19	0.02%	17.41%	0.55%	0.00%	16.71%	19.30%	35.01%	1.20%	8.06%	0.00%	0.22%	1.53%	82.58	1.05
FR	439.65	0.00%	2.40%	4.23%	0.00%	8.80%	9.89%	63.46%	0.01%	0.66%	0.00%	0.50%	10.04%	53.57	1.71
GB	311.70	0.00%	10.11%	4.46%	0.00%	25.73%	1.70%	13.89%	2.50%	1.64%	0.00%	0.61%	39.36%	220.32	1.11

<sup>8</sup> The physical electricity imports and exports outside of the Residual mix calculation area are not included in these figures.



	Volume [TWh]	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
GR	52.24	0.00%	1.47%	13.63%	0.00%	21.15%	8.56%	0.00%	0.45%	0.00%	10.69%	7.57%	36.48%	351.83	0.00
HR	13.67	0.12%	7.24%	0.59%	0.44%	16.84%	39.11%	0.00%	0.00%	10.46%	0.00%	0.61%	24.59%	221.41	0.00
HU	33.51	0.00%	5.28%	13.69%	0.01%	1.74%	0.51%	44.61%	0.74%	0.00%	8.09%	0.13%	25.20%	235.04	1.56
IE	41.15	0.86%	2.04%	0.40%	0.00%	35.08%	1.74%	0.00%	0.68%	9.11%	0.76%	1.12%	48.20%	308.91	0.00
IS	20.12	0.00%	0.00%	0.00%	29.38%	0.03%	70.58%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.15	0.00
IT	272.07	0.00%	6.29%	10.13%	2.00%	7.48%	9.62%	0.00%	1.84%	5.32%	0.00%	3.54%	53.78%	314.38	0.00
LT	3.28	0.65%	5.99%	2.36%	0.00%	46.74%	13.55%	0.00%	4.05%	0.00%	0.00%	9.17%	17.48%	237.81	0.00
LU	1.25	1.77%	28.27%	23.41%	0.00%	27.66%	5.71%	0.00%	4.54%	0.00%	0.00%	0.00%	8.64%	74.42	0.00
LV	4.82	0.00%	14.61%	0.62%	0.00%	3.91%	56.66%	0.00%	0.00%	0.00%	0.00%	0.00%	24.20%	129.89	0.00
ME	3.23	0.68%	0.00%	0.08%	0.00%	9.99%	44.20%	0.00%	0.00%	45.04%	0.00%	0.00%	0.00%	559.64	0.00
MT	2.15	0.00%	0.02%	9.28%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.69%	88.01%	371.10	0.00
NL	118.38	0.02%	7.26%	14.98%	0.00%	17.94%	0.04%	3.33%	1.36%	13.98%	0.00%	1.32%	39.76%	296.34	0.09
NO	144.35	0.00%	0.17%	0.00%	0.00%	10.27%	88.07%	0.00%	1.49%	0.00%	0.00%	0.00%	0.00%	7.23	0.00
PL	161.81	0.02%	4.02%	4.97%	0.00%	11.45%	1.16%	0.00%	0.70%	70.73%	0.00%	0.00%	6.94%	757.46	0.00
PT	48.43	1.34%	2.87%	4.84%	0.00%	26.77%	28.73%	0.00%	6.72%	0.00%	0.00%	0.00%	28.73%	137.20	0.00
RO	50.35	0.06%	0.75%	3.48%	0.00%	13.72%	27.40%	20.09%	0.00%	17.05%	0.00%	0.08%	17.36%	270.77	3.62
RS	31.67	0.00%	0.07%	0.05%	0.00%	2.95%	25.68%	0.00%	0.00%	0.00%	66.62%	0.00%	4.64%	870.24	0.00

	Volume [TWh]	RE unspecified	RE biomass	RE solar	RE geothermal	RE wind	RE hydro	Nuclear	FO unspecified	FO hard coal	FO lignite	FO oil	FO gas	CO2 (gCO2/kWh)	Rad waste (mg/kWh)
SE	169.96	0.02%	7.76%	1.16%	0.00%	19.46%	40.91%	29.46%	0.89%	0.01%	0.00%	0.23%	0.11%	6.62	0.80
SI	12.19	0.28%	1.57%	2.94%	0.00%	0.05%	25.42%	43.56%	0.07%	22.68%	0.00%	0.42%	3.02%	245.71	1.31
SK	24.68	0.38%	4.14%	2.57%	0.00%	0.01%	14.79%	60.11%	1.95%	2.55%	3.28%	1.66%	8.56%	156.93	2.10

## 5.4 Various total mixes

Table 6: European Total Production Mix, Total Attributes in Final Residual Mixes and European Attribute Mix 2022<sup>9</sup>

	Production mixes	Residual mixes	European attribute mix
Volume [TWh]	3161.22	1821.51	326.04
RE unspecified %	0.07%	0.01%	0.00%
RE biomass %	4.78%	1.39%	1.22%
RE solar %	6.81%	3.57%	4.20%

<sup>9</sup> The EAM volume and percentages presented here do not exactly match numbers provided in Table 1. This is due to some countries having negative renewable energy balance in domestic residual mixes (caused by variation in disclosure periods and GO lifetimes overlapping two disclosure periods). This negativity is transferred into the EAM before considering the domestic residual mix attribute surpluses and deficits. This negativity correction is included in this Table 6 for statistics purposes. For any member state residual mix calculation the values from the Table 1 should be used.

<b>RE geothermal %</b>	0.37%	0.01%	0.00%
<b>RE wind %</b>	16.47%	1.82%	1.55%
<b>RE hydro %</b>	14.42%	2.29%	2.29%
<b>Nuclear %</b>	19.74%	30.10%	17.01%
<b>FO unspecified %</b>	1.49%	2.29%	3.50%
<b>FO hard coal %</b>	13.28%	22.39%	38.02%
<b>FO lignite %</b>	0.94%	1.56%	0.10%
<b>FO oil %</b>	1.06%	1.81%	1.63%
<b>FO gas %</b>	20.57%	32.76%	30.48%

## 6 Comparisons

The following graphs and tables are meant for background information. They compare different mixes of the same year or the evolution of mixes on an annual level. Figure 8 compares the production mix of the country with its residual mix. Figure 8 and Figure 9 compare the production mix and the residual mix.

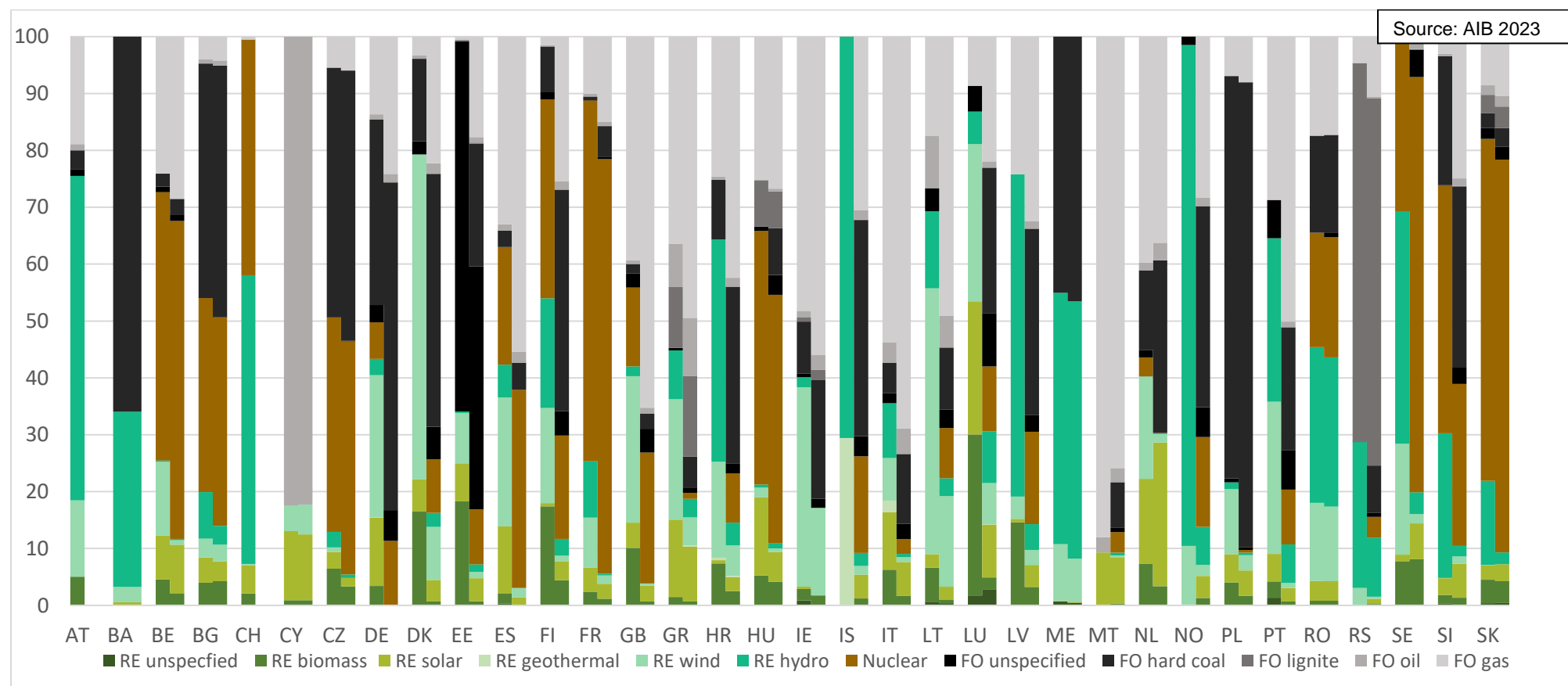


Figure 8: Production Mix (left) and Final Residual Mix (right) 2022 (detailed fuel categories)

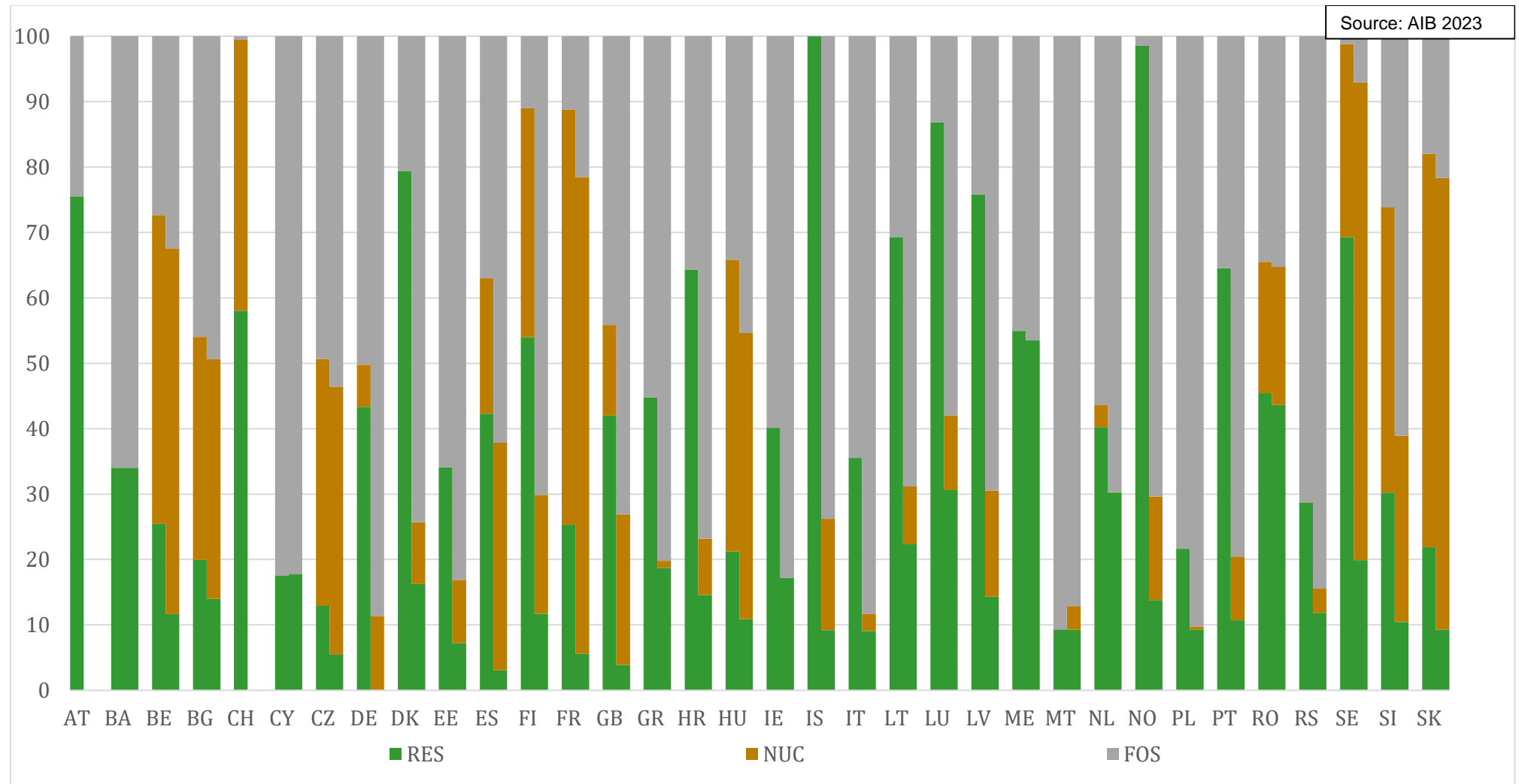


Figure 9 Production Mix (left) and Final Residual Mix (right) 2022 (simple fuel categories)

Figure 10 presents the sum of different energy sources in the combined production and residual mixes of all countries as well as in the European Attribute Mix (surplus pool).

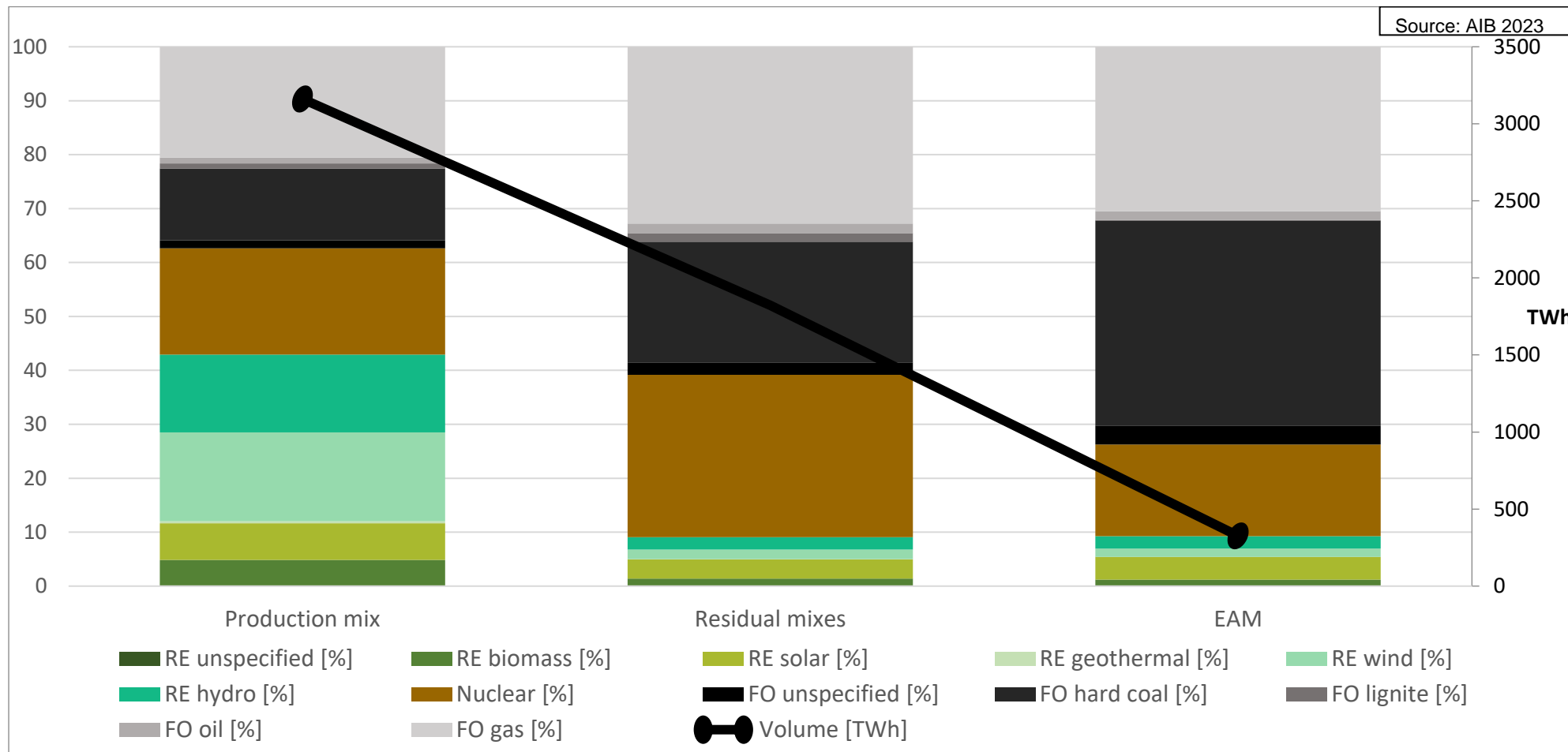


Figure 10: European Total Production Mix (left), Attributes in Final Residual Mixes (middle) and EAM (right) 2022

The following figures compare the production and total supplier mixes both in % and TWh. This provides an interesting viewpoint showing the difference of the production and consumption mix of countries. Countries with a “greener” consumption mix than their respective production mix are typically GO net importers and vice-versa.

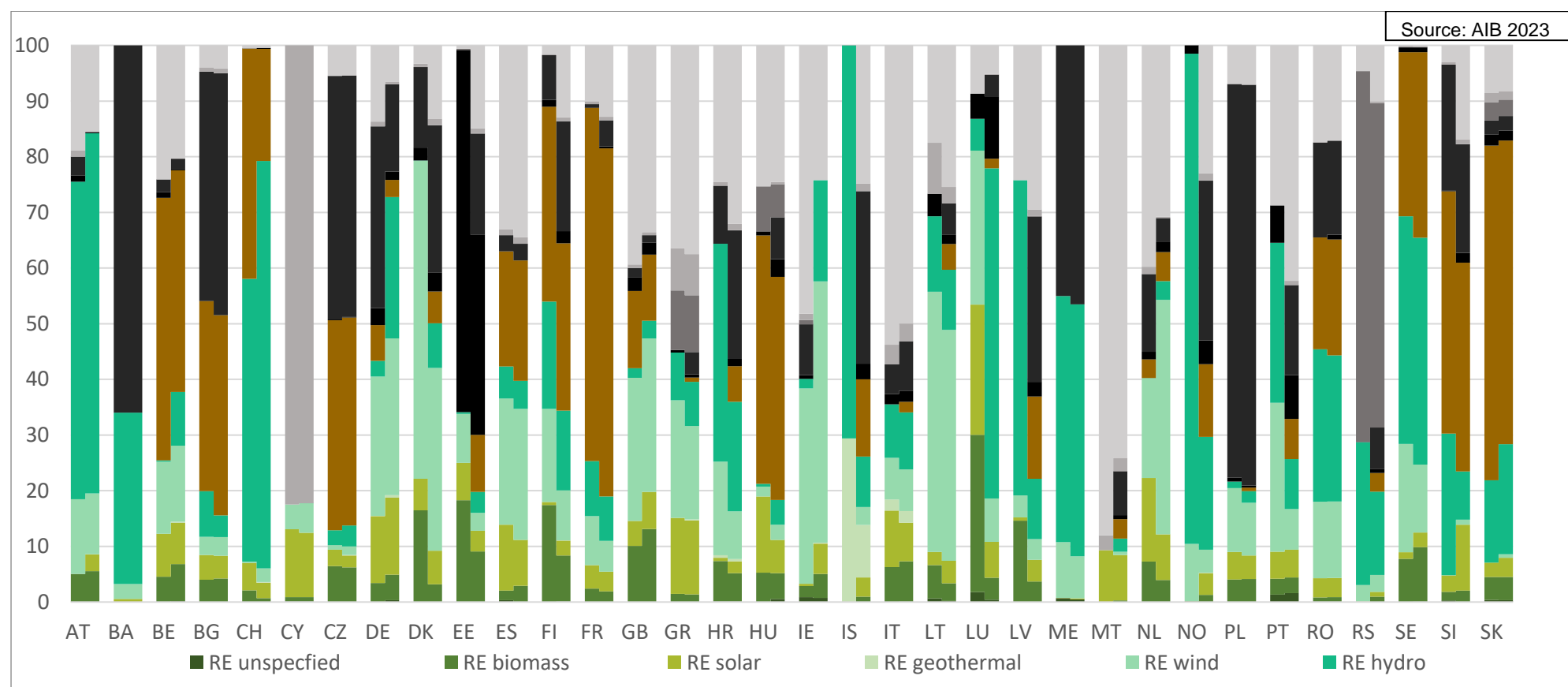


Figure 11 Production Mix (left) and Total Supplier Mix (right) 2022 % (detailed fuel categories)



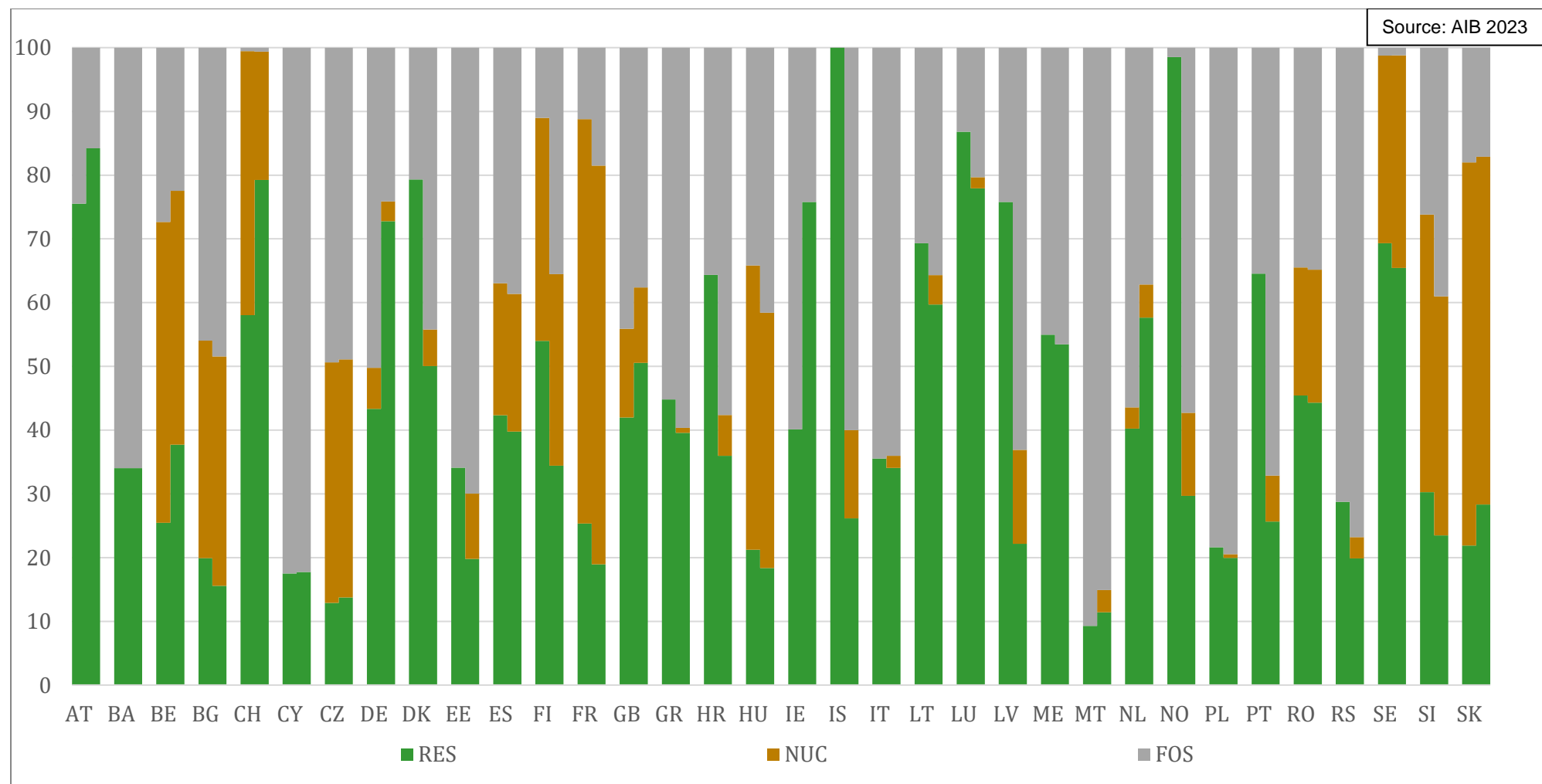


Figure 12: Production Mix (left) and Total Supplier Mix (right) 2022 % (simple fuel categories)

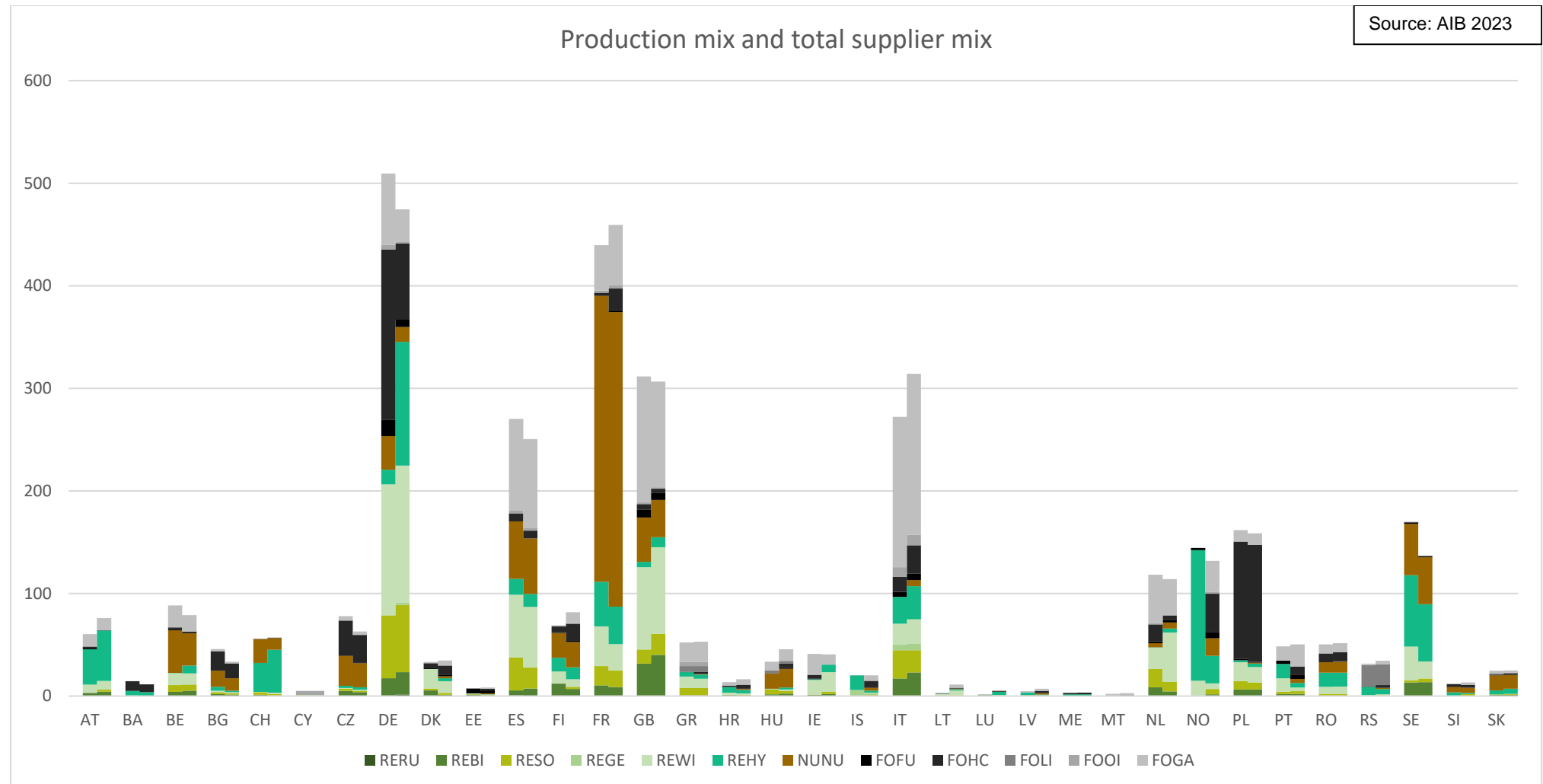


Figure 13 Production Mix (left) and Total Supplier Mix (right) TWh 2022 (detailed fuel categories)

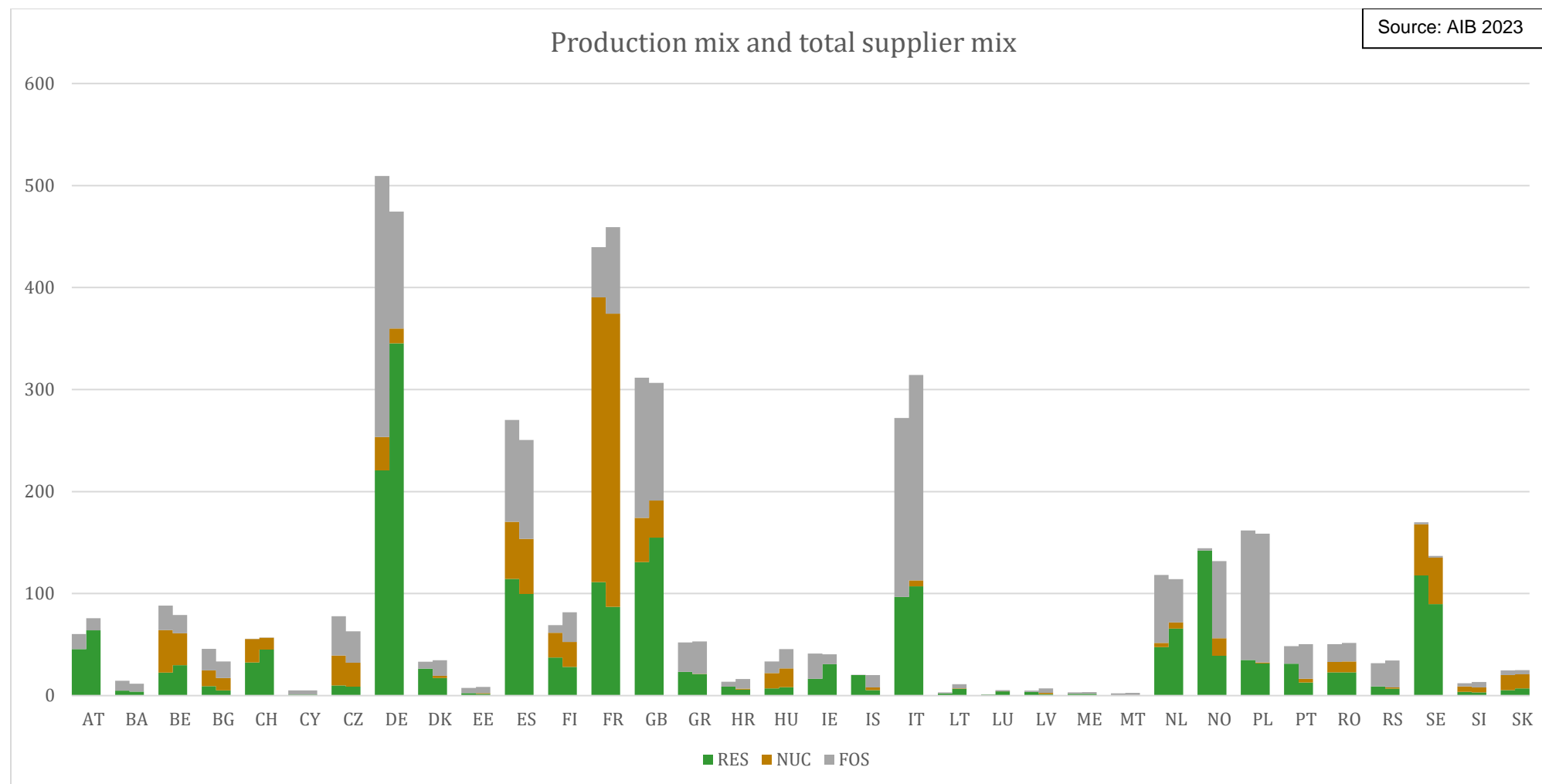


Figure 14 Production Mix (left) and Total Supplier Mix (right) TWh 2022 (simple fuel categories)

Figure 15 and Table 7 compare the residual mixes of 2020, 2021 and 2022.

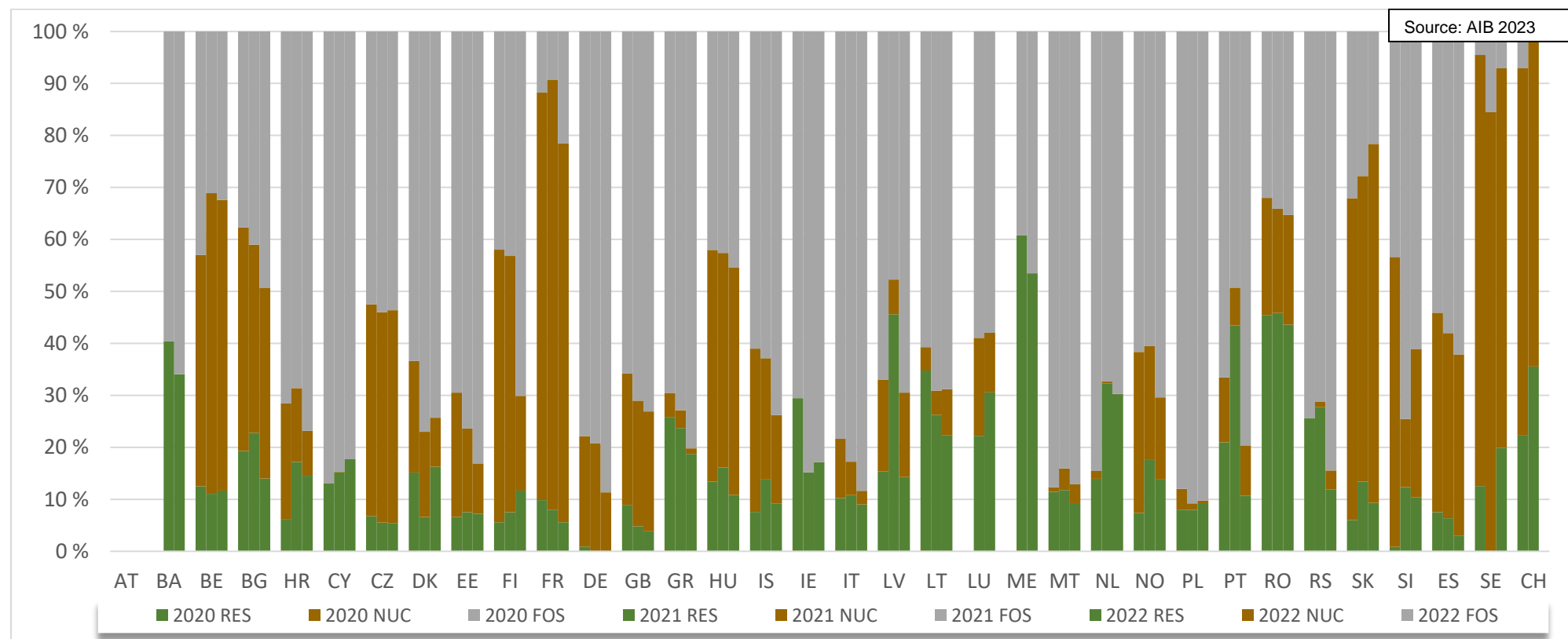


Figure 15: Residual Mixes 2020, 2021 and 2022<sup>10</sup>

<sup>10</sup> For the first time all three years are with Issuing Based methodology. Earlier years up to 2018 were calculated with the Shifted Transaction Based method.

Table 7: Residual Mixes 2020, 2021 and 2022

		2020	2021	2022
AT	RES	0.0 %	0.0 %	0.0 %
	NUC	0.0 %	0.0 %	0.0 %
	FOS	0.0 %	0.0 %	0.0 %
BA	RES	0.0 %	0.0 %	34.0 %
	NUC	0.0 %	0.0 %	0.0 %
	FOS	0.0 %	0.0 %	66.0 %
BE	RES	12.5 %	11.0 %	11.7 %
	NUC	44.5 %	57.9 %	55.9 %
	FOS	43.0 %	31.1 %	32.4 %
BG	RES	19.3 %	22.8 %	14.0 %
	NUC	43.0 %	36.2 %	36.7 %
	FOS	37.7 %	41.0 %	49.4 %
HR	RES	6.2 %	17.2 %	14.6 %
	NUC	22.2 %	14.2 %	8.6 %
	FOS	71.5 %	68.6 %	76.8 %
CY	RES	13.0 %	15.2 %	17.7 %
	NUC	0.0 %	0.1 %	0.0 %
	FOS	87.0 %	84.7 %	82.3 %
CZ	RES	6.8 %	5.6 %	5.5 %
	NUC	40.8 %	40.4 %	40.9 %
	FOS	52.5 %	54.0 %	53.6 %
DK	RES	15.2 %	6.6 %	16.3 %
	NUC	21.5 %	16.3 %	9.4 %
	FOS	63.4 %	77.0 %	74.3 %
EE	RES	6.6 %	7.5 %	7.2 %
	NUC	23.9 %	16.1 %	9.7 %
	FOS	69.5 %	76.4 %	83.1 %
FI	RES	5.6 %	7.5 %	11.7 %

		2020	2021	2022
DE	RES	0.9 %	0.0 %	0.0 %
	NUC	21.2 %	20.8 %	11.4 %
	FOS	77.8 %	79.2 %	88.6 %
GB	RES	8.9 %	4.8 %	3.9 %
	NUC	25.3 %	24.2 %	23.0 %
	FOS	65.7 %	71.0 %	73.1 %
GR	RES	25.9 %	23.7 %	18.7 %
	NUC	4.6 %	3.4 %	1.1 %
	FOS	69.5 %	72.9 %	80.2 %
HU	RES	13.4 %	16.1 %	10.9 %
	NUC	44.5 %	41.2 %	43.7 %
	FOS	42.0 %	42.6 %	45.4 %
IS	RES	7.6 %	13.8 %	9.2 %
	NUC	31.4 %	23.3 %	17.0 %
	FOS	61.0 %	62.9 %	73.8 %
IE	RES	29.5 %	15.2 %	17.2 %
	NUC	0.0 %	0.0 %	0.0 %
	FOS	70.5 %	84.8 %	82.8 %
IT	RES	10.2 %	10.8 %	9.0 %
	NUC	11.4 %	6.4 %	2.6 %
	FOS	78.3 %	82.8 %	88.3 %
LU	RES	0.0 %	22.2 %	30.6 %
	NUC	0.0 %	18.9 %	11.4 %
	FOS	0.0 %	58.9 %	58.0 %
LV	RES	15.4 %	45.6 %	14.3 %
	NUC	17.7 %	6.6 %	16.2 %
	FOS	66.9 %	47.7 %	69.4 %
LT	RES	34.8 %	26.3 %	22.3 %

		2020	2021	2022
NL	RES	14.0 %	32.3 %	30.2 %
	NUC	1.5 %	0.3 %	0.1 %
	FOS	84.6 %	67.3 %	69.7 %
NO	RES	7.4 %	17.6 %	13.8 %
	NUC	31.0 %	21.9 %	15.8 %
	FOS	61.7 %	60.5 %	70.4 %
PL	RES	8.0 %	7.9 %	9.3 %
	NUC	4.0 %	1.3 %	0.5 %
	FOS	88.0 %	90.8 %	90.2 %
PT	RES	21.0 %	43.5 %	10.7 %
	NUC	12.5 %	7.2 %	9.7 %
	FOS	66.5 %	49.3 %	79.6 %
RO	RES	45.5 %	45.8 %	43.6 %
	NUC	22.5 %	20.1 %	21.1 %
	FOS	32.0 %	34.1 %	35.3 %
RS	RES	25.6 %	27.7 %	11.9 %
	NUC	0.0 %	1.0 %	3.7 %
	FOS	74.4 %	71.2 %	84.4 %
SK	RES	6.0 %	13.4 %	9.3 %
	NUC	61.9 %	58.8 %	69.1 %
	FOS	32.1 %	27.8 %	21.6 %
SI	RES	0.9 %	12.3 %	10.4 %
	NUC	55.8 %	13.1 %	28.5 %
	FOS	43.4 %	74.6 %	61.1 %
ES	RES	7.5 %	6.4 %	3.1 %
	NUC	38.4 %	35.6 %	34.8 %
	FOS	54.1 %	58.0 %	62.1 %
SE	RES	12.5 %	0.0 %	19.9 %

FR	NUC	52.4 %	49.3 %	18.2 %
	FOS	42.0 %	43.2 %	70.1 %
	RES	9.9 %	8.0 %	5.6 %
	NUC	78.4 %	82.7 %	72.9 %
	FOS	11.8 %	9.3 %	21.6 %

ME	NUC	4.5 %	4.7 %	8.9 %
	FOS	60.7 %	69.1 %	68.8 %
	RES	0.0 %	0.0 %	53.5 %
	NUC	0.0 %	0.0 %	0.0 %
	FOS	0.0 %	0.0 %	46.5 %
MT	RES	11.4 %	11.8 %	9.3 %
	NUC	0.9 %	4.1 %	3.6 %
	FOS	87.7 %	84.1 %	87.1 %

CH	NUC	82.9 %	84.5 %	73.0 %
	FOS	4.5 %	15.5 %	7.1 %
	RES	22.3 %	35.6 %	0.0 %
	NUC	70.7 %	64.3 %	0.0 %
	FOS	7.1 %	0.1 %	0.0 %

## 7 Annex 1: Fuel Categories

Table 8: Fuel category breakdown

Fact Sheet 5 compliance		Fuel code	Fuel description (including all subcategories)	Sub-table reference	T1	Hard coal sub-categories		
Renewable	Unspecified & Other	F01000000	Renewable - Unspecified			0	F0201010 Unspecified	
		F01040300	Renewable - Heat - Aerothermal			1	F0201010 Anthracite	
		F01040400	Renewable - Heat - Hydrothermal			2	F0201010 Bituminous coal	
		F01040501	Renewable - Heat - Process heat - Biogenic			3	F0201010 Coking coal	
		F01050000	Renewable - Mechanical source or other - Unspecified			4	F0201010 Coke-oven coke	
	Solar	F01040100	Renewable - Heat - Solar			5	F0201010 Lignite coke	
	Wind	F01050100	Renewable - Mechanical source or other - Wind					
	Hydro & Marine	F01050200	Renewable - Mechanical source or other - Hydro & Marine			T2	Brown coal sub-categories	
	Geothermal	F01040200	Renewable - Heat - Geothermal			0	F0201020 Unspecified	
	Biomass	F01010000	Renewable - Solid			1	F0201020 Sub-bituminous coal	
F01020000		Renewable - Liquid			2	F0201020 Lignite		
F01030000		Renewable - Gaseous			3	F0201020 Brown coal briquette		
F03010100		Nuclear - Solid - Radioactive fuel			4	F0201020 Peat briquette		
		F02000000	Fossil - Unspecified					
Nuclear		F02010000	Fossil - Solid - Unspecified			T3	Petroleum products sub-categories	
Fossil	Unspecified & Other	F02010400	Fossil - Solid - Municipal waste			0	F0202030 Unspecified	
		F02010500	Fossil - Solid - Industrial and commercial waste			1	F0202030 Ethane	
		F02020000	Fossil - Liquid - Unspecified			2	F0202030 Naphtha	
		F02030000	Fossil - Gaseous	T4		3	F0202030 Aviation gasoline	
		F02040000	Fossil - Heat			4	F0202030 Motor gasoline	
	Hard Coal	F02010100	Fossil - Solid - Hard coal	T1		5	F0202030 Aviation turbine fuel	
	Brown Coal / Lignite	F02010300	Fossil - Solid - Peat			6	F0202030 Other kerosene	
		F02010200	Fossil - Solid - Brown coal	T2		7	F0202030 Gas and diesel oil	
		F02030100	Fossil - Gaseous - Natural Gas			8	F0202030 Fuel oil low-sulphur	
	Natural Gas	F02020200	Fossil - Liquid - Natural gas liquids			9	F0202030 Fuel oil high-sulphur	
		F02020100	Fossil - Liquid - Crude oil			10	F0202030 Liquid petroleum gas	
		F02020300	Fossil - Liquid - Petroleum products	T3		11	F0202030 Orimulsion	
						12	F0202030 Bitumen	
					13	F0202030 Lubricants		
					14	F0202030 Petroleum coke		
					15	F0202030 Refinery feedstock		
						T4	Gaseous sub-categories	
					0	F0203000 Unspecified	Unspecified	
					20	F0203020 Coal-derived gas	Unspecified	
					21	F0203020 Coal-derived gas	Blast furnace gas	
					22	F0203020 Coal-derived gas	Coke-oven gas	
					30	F0203030 Petroleum products	Unspecified	
					31	F0203030 Petroleum products	Propane	
					32	F0203030 Petroleum products	Butane	
					33	F0203030 Petroleum products	Refinery gas	
					34	F0203030 Petroleum products	Chemical waste gas	
					40	F0203040 Municipal gas plant	Unspecified	
					50	F0203050 Process gas	Unspecified	
					51	F0203050 Process gas	Carbon monoxide	
					52	F0203050 Process gas	Methane	
					53	F0203050 Process gas	Hydrogen (fossil sourced)	
					54	F0203050 Process gas	Phosphor gas	
					55	F0203050 Process gas	Oxy gas	



## 8 Annex 2: Data Source Matrix

	Production data	Consumption data	Exchange with third countries	Tracking data Gos	CO2 emissions	Radio-active waste
AT	a	b	-	d,h	i	k
BA	a	b	-	-	i	k
BE	a	b	-	d,e,h	i	k
BG	a	b	c	f,h	i	k
CH	Nationally provided information	Nationally provided information	-	d,e,f,h	i	k
CY	a	b	-	d,h	i	k
CZ	a	b	-	d,h	i	k
DE	a	b	-	d,h, EEG supported considered as RTS*	i	k
DK	a	b	-	d,h	i	k
EE	Nationally provided information	Nationally provided information	c	d,h	i	k
ES	Nationally provided information	Nationally provided information	-	d,f,h	i	k
FI	a	b	c	d,e,h	i	k
FR	Nationally provided information	Nationally provided information	-	d,h	j	k
GB	Nationally provided information	Nationally provided information	-	f,h	i	k
GR	Nationally provided information	Nationally provided information	c, Nationally provided information	d,e,f,h	i,j	k
HR	a	b	-	d,f	i	k
HU	Nationally provided information	Nationally provided information	c	d,f,h	i	k
IE	Nationally provided information	Nationally provided information	-	d,f,h	i	k

<b>IS</b>	Nationally provided information	Nationally provided information	-	d	i	k
<b>IT</b>	Nationally provided information, fossil generation distributed based on proportions from (a)	Nationally provided information	-	d,h	i	k
<b>LT</b>	a	b	c	d,f,h	i	k
<b>LU</b>	a	b	-	d,f,h	j	k
<b>LV</b>	Nationally provided information	Nationally provided information	c	d,h	i	k,j
<b>ME</b>	a	b	c	-	i	k
<b>MT</b>	Nationally provided information	Nationally provided information	-	h	i,j	k
<b>NL</b>	a	b	-	d,e,h	i	k
<b>NO</b>	Nationally provided information	Nationally provided information	-	d,e,h	i	k
<b>PL</b>	a	b	c	f,h	i	k
<b>PT</b>	Nationally provided information	Nationally provided information	-	d,f,h	i	k
<b>RO</b>	a	b	c	h	i	k
<b>RS</b>	Nationally provided information	Nationally provided information	c	d,f,h	i	k
<b>SE</b>	a	b	-	d,e,f,h	i	k
<b>SI</b>	a	b	-	d,f	i	k,j
<b>SK</b>	Nationally provided information	Nationally provided information	c	d,h	i	k

a [https://ec.europa.eu/eurostat/web/products-datasets/-/nrg\\_cb\\_pem](https://ec.europa.eu/eurostat/web/products-datasets/-/nrg_cb_pem)

b [https://ec.europa.eu/eurostat/web/products-datasets/-/nrg\\_cb\\_em](https://ec.europa.eu/eurostat/web/products-datasets/-/nrg_cb_em)

c Entso-e Transparency Platform Cross-Border Flows: <https://transparency.entsoe.eu/transmission-domain/physicalFlow/show>

d EECS Activity statistics <https://www.aib-net.org/facts/market-information/statistics/activity-statistics-all-aib-members>

e EECS Ex-domain cancellations by country, by energy source, collected from DCBs

f DCB provided information on other reliable tracking means

- h Ex-domain cancellations from other countries
- i Ecoinvent
- j Nationally provided factors
- k [http://reliable-disclosure.org/upload/250-D5.3 Direct and weighted emissions.pdf](http://reliable-disclosure.org/upload/250-D5.3_Direct_and_weighted_emissions.pdf)

\* <https://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/eeg-in-zahlen-xls.html>

## 9 Annex 3: Update of underlying emission factors for residual mix fuel categories

# **Appendix to “European Residual Mixes: Results of the calculation of Residual Mixes for the calendar year 2022”**

Update of underlying emission factor for residual mix  
fuel categories  
(2023-05-31)

Müller J.

## **Table of contents**

Terms  
Introduction  
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Outlook

## Terms

- **ecoinvent:** ecoinvent is an internationally active, mission-driven organization devoted to supporting high-quality, science-based environmental assessments. Its activities include publishing and maintaining the ecoinvent database, a comprehensive life cycle inventory database that provides reliable and transparent information on the environmental impacts of various products and services. It is used by companies, researchers, and policymakers to analyse the environmental impact of their operations, make informed decisions, and develop sustainable practices. [www.ecoinvent.org](http://www.ecoinvent.org)
- **ecoinvent database:** Refers to the database published by ecoinvent. The ecoinvent database is a Life Cycle Inventory (LCI) database that supports the assessment of environmental impacts. More information: <https://ecoinvent.org/the-ecoinvent-database/>
- **ecoinvent datasets:** These datasets describe a specific activity producing a product and its associated environmental impacts. In this appendix the ecoinvent datasets will be referred to by their “activity name” and “geography” and are sourced from [v3.9.1](#) of the ecoinvent database using the [system model](#) “Allocation, cut-off”.
- **Fuel category emission factor:** Refers to the amount of direct carbon dioxide (CO<sub>2</sub>) emitted for the production of 1 kWh of electricity for a country and fuel category as defined in Table 8 of AIB (2022).

## Introduction

Up to the calculation of the residual mixes for the year 2021, published in AIB (2022), the calculation of the values for the “CO<sub>2</sub> (gCO<sub>2</sub>/kWh)” column in Table 1, 2, 4, 5 for most countries were based on emission factors (EFs) from the RE-DISS project that ended in 2015. This set of EFs contained one EF for each country and used fuel category.

Due to rising demand for the representation of residual mixes in the ecoinvent database, AIB agreed to the publication and integration of the residual mixes in the ecoinvent database. This integration shed light on certain discrepancies in the underlying fuel category emission factors between the EFs from the RE-DISS project and the EFs in the ecoinvent database. It was decided in accordance with the competent disclosure bodies to aim for alignment of the two sources of EFs in order to publish consistent values for CO<sub>2</sub> emissions in the reporting of the residual mixes on the side of AIB and their implementation in the ecoinvent database.

This appendix explains how the new set of EFs for the fuel categories for the residual mixes were chosen, lists the EFs as well as their origin and gives an outlook of remaining discrepancies and further efforts of alignment.

## Choice of emission factors

In accordance with AIB, the Competent Disclosure Bodies and ecoinvent, it was decided that from the AIB residual mix report 2022 onwards the underlying EFs for the fuel categories would be based on emission data from the ecoinvent database for all the countries where the Disclosure Competent Bodies do not report their own data.

Following this strategy, better alignment between the CO<sub>2</sub> values of the AIB residual mix report and the implementation of the residual mixes in the ecoinvent database is achieved. Additionally, more transparency, traceability and consistency is introduced in the set of EFs used for the calculation of the CO<sub>2</sub> values for the residual mixes. Furthermore, country-specific EFs are available for the electricity imported from countries outside the calculation area of the residual mixes.

For EFs maintained by Competent Disclosure Bodies, ecoinvent will aim to align the emissions in the ecoinvent database for further consistency.

## List of emission factors

**Table 1** shows the fuel category emission factors used for the calculation of the CO<sub>2</sub> values for the residual mixes. The column “Source” indicates the origin of the EF. In the case where the source is the ecoinvent database, the datasets from the ecoinvent database that were used to calculate the EF are listed subsequently. The datasets are listed in the format “<activity name> [<geography>]” and refer to the “Allocation, cut-off” system model in version 3.9.1 of the ecoinvent database. Entries with RE-DISS listed as their source take their value from the RE-DISS project. For those entries their value was retained due to insufficient information on the composition of the “FO unspecified” fuel category. As third option, values can be provided by the corresponding Competent Disclosure Bodies.

**Table 1.** List of emission factors (EF) used for the calculation of the residual mixes for the year 2022.

Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
AT	FO unspecified	0.486	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
AT	FO hard coal	0.862	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [AT] - heat and power co-generation, hard coal [AT]
AT	FO gas	0.436	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [AT] - electricity production, natural gas, conventional power plant [AT] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [AT] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [AT]
AT	FO oil	0.926	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [AT] - heat and power co-generation, oil [AT]

Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
BA	FO lignite	1.279	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [BA] - heat and power co-generation, lignite [BA]
BA	FO oil	0.944	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [BA]
BE	FO unspecified	0.461	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
BE	FO gas	0.396	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [BE] - electricity production, natural gas, conventional power plant [BE] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [BE] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [BE]
BE	FO oil	0.767	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [BE] - heat and power co-generation, oil [BE]
BG	FO lignite	1.105	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [BG] - heat and power co-generation, lignite [BG]
BG	FO hard coal	1.066	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [BG] - heat and power co-generation, hard coal [BG]
BG	FO gas	0.786	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, conventional power plant [BG] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [BG] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [BG]
BG	FO oil	1.383	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [BG] - heat and power co-generation, oil [BG]
BY	FO lignite	1.135	Calculated value based on the following datasets from the ecoinvent database: - electricity production, peat [RoW]
BY	FO gas	0.513	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [RoW] - electricity production, natural gas, conventional power plant [RoW] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [RoW]
BY	FO oil	0.786	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [RoW] - heat and power co-generation, oil [RoW]
BG	FO lignite	1.105	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [BG] - heat and power co-generation, lignite [BG]
BG	FO hard coal	1.066	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [BG] - heat and power co-generation, hard coal [BG]
BG	FO gas	0.786	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, conventional power plant [BG] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [BG] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [BG]
BG	FO oil	1.383	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [BG] - heat and power co-generation, oil [BG]

Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
CH	FO unspecified	0.398	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
CH	FO gas	0.460	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, 500kW electrical, lean burn [CH]
CY	FO oil	0,738	Value provided by Competent Disclosure Body
CZ	FO unspecified	1.297	Calculated value based on the following datasets from the ecoinvent database: - treatment of blast furnace gas, in power plant [CZ] - treatment of coal gas, in power plant [CZ] - electricity, from municipal waste incineration to generic market for electricity, medium voltage [CZ]
CZ	FO lignite	1.528	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [CZ] - heat and power co-generation, lignite [CZ]
CZ	FO hard coal	1.388	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [CZ]
CZ	FO gas	0.596	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [CZ] - electricity production, natural gas, conventional power plant [CZ] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [CZ]
CZ	FO oil	1.236	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [CZ] - heat and power co-generation, oil [CZ]
DE	FO unspecified	0.922	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
DE	FO lignite	1.176	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [DE] - heat and power co-generation, lignite [DE]
DE	FO hard coal	0.900	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [DE] - heat and power co-generation, hard coal [DE]
DE	FO gas	0.436	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [DE] - electricity production, natural gas, conventional power plant [DE] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [DE] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [DE]
DE	FO oil	0.718	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [DE] - heat and power co-generation, oil [DE]
DK	FO unspecified	0.939	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
DK	FO hard coal	0.834	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [DK]
DK	FO gas	0.463	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [DK] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [DK]
DK	FO oil	0.874	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [DK] - heat and power co-generation, oil [DK]
EE	FO unspecified	1.007	Calculated value based on the following datasets from the ecoinvent database: - treatment of coal gas, in power plant [RoW]



Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
			- electricity, from municipal waste incineration to generic market for electricity, medium voltage [RoW]
EE	FO lignite	1.260	Calculated value based on the following datasets from the ecoinvent database: - electricity production, peat [EE]
EE	FO gas	0.473	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [EE]
EE	FO oil	1.007	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [EE] - heat and power co-generation, oil [EE]
ES	FO unspecified	0.433	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
ES	FO lignite	1.030	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [ES]
ES	FO hard coal	0.982	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [ES]
ES	FO gas	0.386	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [ES] - electricity production, natural gas, conventional power plant [ES]
ES	FO oil	0.740	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [ES]
FI	FO unspecified	0.433	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
FI	FO lignite	1.013	Calculated value based on the following datasets from the ecoinvent database: - electricity production, peat [FI]
FI	FO hard coal	0.866	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [FI] - heat and power co-generation, hard coal [FI]
FI	FO gas	0.410	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [FI] - electricity production, natural gas, conventional power plant [FI] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [FI] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [FI]
FI	FO oil	0.594	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [FI] - heat and power co-generation, oil [FI]
FR	FO unspecified	0,988	Value provided by Competent Disclosure Body
FR	FO hard coal	0,986	Value provided by Competent Disclosure Body
FR	FO gas	0,429	Value provided by Competent Disclosure Body
FR	FO oil	0,777	Value provided by Competent Disclosure Body
GB	FO unspecified	0.464	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
GB	FO hard coal	0.895	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [GB]
GB	FO gas	0.475	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, conventional power plant [GB]
GB	FO oil	1.131	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [GB]
GR	FO unspecified	1,255	Value from RE-DISS

Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
GR	FO lignite	1,477	Value provided by Competent Disclosure Body
GR	FO gas	0,354	Value provided by Competent Disclosure Body
GR	FO oil	0,779	Value provided by Competent Disclosure Body
HR	FO hard coal	0.940	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [HR]
HR	FO gas	0.480	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [HR] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [HR] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [HR]
HR	FO oil	0.820	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [HR]
HU	FO unspecified	0.474	Calculated value based on the following datasets from the ecoinvent database: - treatment of blast furnace gas, in power plant [HU] - treatment of coal gas, in power plant [HU] - electricity, from municipal waste incineration to generic market for electricity, medium voltage [HU]
HU	FO lignite	1.354	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [HU] - heat and power co-generation, lignite [HU]
HU	FO hard coal	1.354	#N/A
HU	FO gas	0.479	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [HU] - electricity production, natural gas, conventional power plant [HU] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [HU] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [HU]
HU	FO oil	0.958	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [HU] - heat and power co-generation, oil [HU]
IE	FO lignite	0.990	Calculated value based on the following datasets from the ecoinvent database: - electricity production, peat [IE]
IE	FO hard coal	0.865	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [IE]
IE	FO gas	0.429	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [IE] - electricity production, natural gas, conventional power plant [IE]
IE	FO oil	0.783	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [IE]
IS	FO unspecified	0.486	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
IS	FO oil	1.007	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [IS]
IT	FO unspecified	0.461	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
IT	FO hard coal	0.910	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [IT] - heat and power co-generation, hard coal [IT]
IT	FO gas	0.427	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [IT] - electricity production, natural gas, conventional power plant [IT] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [IT]

Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
			- heat and power co-generation, natural gas, conventional power plant, 100MW electrical [IT]
IT	FO oil	0.794	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [IT] - heat and power co-generation, oil [IT]
LT	FO unspecified	0.620	Calculated value based on the following datasets from the ecoinvent database: - electricity, from municipal waste incineration to generic market for electricity, medium voltage [RoW]
LT	FO gas	0.530	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [LT] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [LT]
LT	FO oil	1.309	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, oil [LT]
LU	FO unspecified	0,809	Value provided by Competent Disclosure Body
LU	FO lignite	1,430	Value provided by Competent Disclosure Body
LU	FO hard coal	1,080	Value provided by Competent Disclosure Body
LU	FO gas	0,436	Value provided by Competent Disclosure Body
LV	FO unspecified	0.620	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
LV	FO lignite	1.135	Calculated value based on the following datasets from the ecoinvent database: - electricity production, peat [RoW]
LV	FO hard coal	1.001	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [RoW]
LV	FO gas	0.537	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [LV] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [LV]
LV	FO oil	1.309	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, oil [LV]
ME	FO lignite	1.243	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [RoW]
MK	FO lignite	1.401	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [MK]
MK	FO gas	0.441	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [MK] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [MK]
MK	FO oil	0.869	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [MK]
MT	FO gas	0,396	Value provided by Competent Disclosure Body
MT	FO oil	0,851	Value provided by Competent Disclosure Body
NL	FO unspecified	0.609	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
NL	FO hard coal	0.841	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [NL] - heat and power co-generation, hard coal [NL]
NL	FO gas	0.399	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [NL]

Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
			<ul style="list-style-type: none"> <li>- electricity production, natural gas, conventional power plant [NL]</li> <li>- heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [NL]</li> <li>- heat and power co-generation, natural gas, conventional power plant, 100MW electrical [NL]</li> </ul>
NL	FO oil	0.915	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, oil [NL]
NO	FO unspecified	0.486	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
NO	FO hard coal	1.175	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [NO]
NO	FO gas	0.376	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [NO] - electricity production, natural gas, conventional power plant [NO]
NO	FO oil	0.430	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [NO] - heat and power co-generation, oil [RoW]
PL	FO lignite	1.117	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [PL] - heat and power co-generation, lignite [PL]
PL	FO hard coal	0.995	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [PL]
PL	FO gas	0.454	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [PL] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [PL]
PL	FO oil	0.754	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [PL] - heat and power co-generation, oil [PL]
PT	FO unspecified	0.461	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
PT	FO hard coal	0.910	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [PT]
PT	FO gas	0.370	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [PT]
PT	FO oil	0.676	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [PT] - heat and power co-generation, oil [PT]
RO	FO unspecified	1.103	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
RO	FO lignite	1.118	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [RO] - heat and power co-generation, lignite [RO]
RO	FO hard coal	1.001	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [RoW]
RO	FO gas	0.572	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, conventional power plant [RO] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [RO] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [RO]
RO	FO oil	1.030	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [RO] - heat and power co-generation, oil [RO]

Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
RS	FO lignite	1.259	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [RS] - heat and power co-generation, lignite [RS]
RS	FO gas	0.675	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [RS]
RU	FO lignite	1.660	Calculated value based on the following datasets from the ecoinvent database: - electricity production, peat [RU] - heat and power co-generation, lignite [RU]
RU	FO hard coal	1.551	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [RU]
RU	FO gas	0.649	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [RU] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [RU]
RU	FO oil	0.985	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, oil [RU]
SE	FO unspecified	0.486	RE-DISS: Value retained from the RE-DISS project due to insufficient data for replacement.
SE	FO lignite	1.135	Calculated value based on the following datasets from the ecoinvent database: - electricity production, peat [SE]
SE	FO hard coal	1.079	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [SE]
SE	FO gas	0.533	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [SE]
SE	FO oil	0.715	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [SE] - heat and power co-generation, oil [SE]
SI	FO lignite	1.171	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [SI] - heat and power co-generation, lignite [SI]
SI	FO hard coal	1.001	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [RoW]
SI	FO gas	0.482	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, conventional power plant [SI] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [SI]
SI	FO oil	0.889	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [SI] - heat and power co-generation, oil [SI]
SK	FO lignite	1.491	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, lignite [SK]
SK	FO hard coal	1.173	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, hard coal [SK]
SK	FO gas	0.482	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [SK] - electricity production, natural gas, conventional power plant [SK] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [SK] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [SK]
SK	FO oil	1.195	Calculated value based on the following datasets from the ecoinvent database: - heat and power co-generation, oil [SK]

Country	Fuel Categories	Value (kgCO <sub>2</sub> /kWh):	Source:
TR	FO lignite	1.231	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [TR]
TR	FO hard coal	0.950	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [TR]
TR	FO gas	0.393	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [TR] - electricity production, natural gas, conventional power plant [TR] - heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical [TR] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [TR]
UA	FO hard coal	1.181	Calculated value based on the following datasets from the ecoinvent database: - electricity production, hard coal [UA] - heat and power co-generation, hard coal [UA]
UA	FO gas	0.788	Calculated value based on the following datasets from the ecoinvent database: - electricity production, natural gas, combined cycle power plant [UA] - electricity production, natural gas, conventional power plant [UA] - heat and power co-generation, natural gas, conventional power plant, 100MW electrical [UA]
UA	FO oil	1.057	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [UA] - heat and power co-generation, oil [UA]
XK	FO lignite	1.243	Calculated value based on the following datasets from the ecoinvent database: - electricity production, lignite [RoW]
XK	FO oil	0.816	Calculated value based on the following datasets from the ecoinvent database: - electricity production, oil [RoW]

## Outlook

Further efforts will be undertaken in order to align the resulting CO<sub>2</sub> values calculated for the residual mixes by AIB and those calculated by ecoinvent. ecoinvent is working on including EFs provided by Competent Disclosure Bodies where appropriate sources and background information is available. Furthermore, future calculations of residual mixes by AIB will benefit from updates of the ecoinvent database.

## References

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# **Appendix to “European Residual Mixes: Results of the calculation of Residual Mixes for the calendar year 2022”**

**Understanding the impact of updated emission factors  
(2023.09.25)**

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# 1 Introduction – Purpose of this document

With the publication of the “Results of the calculation of Residual Mixes for the calendar year 2022” (AIB, 2023) the emission factors (EFs) for the individual fuel categories were changed compared to previous years. In order to facilitate understanding of the effects resulting from the shift from the prior set of emission factors, which stemmed from the RE-DISS project, to the new EFs, we have reevaluated the direct emissions for the preceding three years of residual mix calculations (2019-2021) using the updated EFs. This report provides a supplementary list of reasons explaining the changes in EFs, in addition to those already found in the Appendix of AIB (2023). It presents a comparison of previously published direct emissions of residual mixes with recalculated direct emissions based on the new set of EFs. This comparison aims to quantify the changes to the direct emissions based solely on the methodological change of updating the EFs. Furthermore, this report presents insights and comments regarding special cases where significant changes have occurred (see Appendix of AIB, 2023).

## **2 The sole objective of recalculating historical data using new emission factors is to improve comprehension of the update's impact. It is not our intention for the figures in this Appendix to be used for revising figures from past years disclosed to consumers. Given that not all entities can effectively communicate such historical figure changes, and certain national legislations may even not permit it, the potential confusion generated by such actions would outweigh the benefits of enhanced accuracy. Reasons for change of EFs: Increased accuracy and transparency**

The new set of emission factors is mostly based on v3.9.1 of the ecoinvent database (see Appendix of AIB, 2023). Apart from EFs maintained by the Competent Disclosure Bodies, the previous set of emission factors originated from the RE-DISS project and their derivation is not apparent. The new set of emission factors offers increased transparency as the Unit Processes (UPR) or also called life cycle inventory, i.e. the composition of the datasets describing the electricity-producing technologies, can be viewed with a guest account in the ecoinvent database ([www.ecoinvent.org](http://www.ecoinvent.org)). The ecoinvent database also offers multiple electricity-generating technologies per fuel category and country (e.g. “FO gas” is represented by combined cycle and conventional gas power plants) leading to a better technological representation of each country's EFs. Furthermore, country-specific import EFs for the residual mixes that import electricity from outside the calculation area are

provided, while previously those were based on an average of EFs inside the calculation area. Future calculation of the direct emissions of the residual mixes will also benefit from any updates of the ecoinvent database.

### 3 Table of comparison of previous years with recalculated factors

The first section of Table 1 shows the published values for the direct carbon dioxide emissions (in gCO<sub>2</sub>/kWh) in the yearly reports on the residual mix calculation by AIB for the years 2019-2022. While the years 2019-2021 are based on the previous set of EFs, the year 2022 is based on the new set of EFs. The second section details the recalculated values of the residual mixes of the years 2019-2021 with the new set of emission factors, while the third section presents the percentage change between the published direct carbon dioxide emissions and the recalculated values. The last row lists the values for the European Attribute mix (EAM).

**Table 1:** Published values for direct emissions of the residual mix calculations for years 2019-2021 based on the old set of EFs and the year 2022 based on the new set of EFs, recalculated values for the years 2019 to 2021 based on the new set of EFs and a comparison of published and recalculated values. \*Not applicable (reason: Full Disclosure). \*\* EFs maintained and updated by the national Competent Disclosure Body and thus not recalculated.

	Published values (gCO <sub>2</sub> /kWh)				Recalculated values (gCO <sub>2</sub> /kWh)			Comparison (recalculated vs. published)		
	2019	2020	2021	2022	2019	2020	2021	2019	2020	2021
AT	*	*	*	*	*	*	*			
BA			558.5	843.9			762.0			36.4 %
BE	187.7	204.8	149.2	144.3	172.4	187.1	136.1	-8.1 %	-8.6 %	-8.8 %
BG	437.4	372.1	404.1	517.1	451.5	388.2	421.6	3.2 %	4.3 %	4.3 %
CH	18.5	30.3	19.2	*	18.5	30.4	19.2	0.1 %	0.1 %	0.2 %
CY**	675.6	642.0	625.1	607.4	675.6	642.0	625.1	0.0 %	0.0 %	0.0 %
CZ	595.1	532.4	550.0	697.2	794.1	708.1	671.2	33.4 %	33.0 %	22.1 %
DE	609.4	588.8	617.8	684.0	589.2	568.6	597.5	-3.3 %	-3.4 %	-3.3 %
DK	465.2	427.7	529.3	557.4	478.0	435.4	547.3	2.7 %	1.8 %	3.4 %
EE	757.7	546.9	636.6	715.2	734.7	530.3	618.4	-3.0 %	-3.0 %	-2.9 %
ES	342.7	286.5	295.8	275.1	319.8	261.9	272.9	-6.7 %	-8.6 %	-7.8 %
FI	310.1	268.2	285.3	520.8	304.6	269.6	288.9	-1.8 %	0.5 %	1.3 %
FR**	43.2	58.5	48.6	125.0	43.2	58.5	48.6	0.0 %	0.0 %	0.0 %

	Published values (gCO <sub>2</sub> /kWh)				Recalculated values (gCO <sub>2</sub> /kWh)			Comparison (recalculated vs. published)		
	2019	2020	2021	2022	2019	2020	2021	2019	2020	2021
<b>GB</b>	347.5	316.0	351.2	365.1	352.4	321.7	359.6	1.4 %	1.8 %	2.4 %
<b>GR**</b>	577.4	490.4	444.6	531.4	577.4	490.4	444.6	0.0 %	0.0 %	0.0 %
<b>HR</b>	501.4	468.8	466.5	515.1	486.9	445.9	446.8	-2.9 %	-4.9 %	-4.2 %
<b>HU</b>	285.7	274.1	276.3	320.0	308.5	295.0	289.4	8.0 %	7.6 %	4.8 %
<b>IE</b>	495.2	446.5	570.1	474.8	441.5	403.2	513.8	-10.8 %	-9.7 %	-9.9 %
<b>IS</b>	393.7	401.9	423.5	531.3	387.3	391.3	415.2	-1.6 %	-2.7 %	-2.0 %
<b>IT</b>	465.9	458.6	456.6	457.1	448.8	442.7	438.5	-3.7 %	-3.5 %	-4.0 %
<b>LT</b>	351.9	340.2	384.5	466.4	348.9	330.1	377.6	-0.8 %	-3.0 %	-1.8 %
<b>LU**</b>	449.3	0.0	403.1	419.7						
<b>LV</b>	315.2	421.5	302.6	510.7	286.8	395.7	280.6	-9.0 %	-6.1 %	-7.3 %
<b>ME</b>			439.0	538.6			460.9			5.0 %
<b>MT**</b>	378.3	390.9	370.9	404.9	378.3	390.9	370.9	0.0 %	0.0 %	
<b>NL</b>	555.2	451.7	450.7	439.0	488.8	394.0	399.5	-12.0 %	-12.8 %	-11.4 %
<b>NO</b>	396.3	401.9	404.9	502.3	388.0	389.7	397.1	-2.1 %	-3.0 %	-1.9 %
<b>PL</b>	811.0	798.7	850.2	858.1	799.8	837.8	856.4	-1.4 %	4.9 %	0.7 %
<b>PT</b>	256.0	375.4	281.1	445.5	232.3	344.6	258.3	-9.3 %	-8.2 %	-8.1 %
<b>RO</b>	310.7	265.2	281.7	275.8	299.7	253.1	268.9	-3.5 %	-4.5 %	-4.5 %
<b>RS</b>	765.7	810.8	763.7	954.2	869.8	922.2	868.8	13.6 %	13.7 %	13.8 %
<b>SE</b>	50.2	23.1	76.6	39.0	51.4	23.5	82.7	2.4 %	1.8 %	7.9 %
<b>SI</b>	364.1	345.2	565.4	370.8	409.8	393.6	618.1	12.5 %	14.0 %	9.3 %
<b>SK</b>	198.6	218.2	184.6	186.5	226.6	240.6	202.2	14.1 %	10.2 %	9.5 %

## 4 Selected country or fuel-specific insights

BA (Bosnia and Herzegovina): Statistics used for the calculation of the residual mixes for BA do not distinguish between different coal types. Thus, an average factor for “FO hard coal” was assumed in the year prior 2022. However, electricity from coal in BA relies on

lignite (IEA, 2022) and thus an appropriate factor was chosen for the new set of EFs. As electricity from lignite has a notably higher carbon intensity, this leads to an increase of the EF for BA.

CY (Cyprus): EFs maintained and updated by the national Competent Disclosure Body.

CZ (Czech Republic): A part of electricity in this country is generated by heat and electricity co-generation units. The electricity from these productions is attributed higher emissions compared to a pure electricity generating power plant due lower electrical efficiency of the co-generation plant (Treyer & Bauer., 2016) and the allocation rules applied for co-generation (Primas, 2007).

FR (France): EFs maintained and updated by the national Competent Disclosure Body.

GR (Greece): EFs maintained and updated by the national Competent Disclosure Body.

HU (Hungary): Statistics used for the calculation of the residual mixes for HU do not distinguish between different coal types. Thus, an average factor for “FO hard coal” was assumed in the year prior 2022. However, electricity from coal in HU relies on lignite (Euracoal, 2023) and thus an appropriate factor was chosen for the new set of EFs. As electricity from lignite has a notably higher carbon intensity, this leads to an increase of the EF for HU.

LU (Luxembourg): EFs maintained and updated by the national Competent Disclosure Body.

NL (Netherlands): Set of new emission factors confirmed by national Competent Disclosure Body. Within 5% of the recently published EFs by Statistics Netherlands (CBS, 2023).

MT (Malta): EFs maintained and updated by the national Competent Disclosure Body.

RS (Serbia): A part of electricity in this country is generated by heat and electricity co-generation units. The electricity from these productions is attributed higher emissions compared to a pure electricity generating power plant due lower electrical efficiency of the co-generation plant (Treyer & Bauer., 2016) and the allocation rules applied for co-generation (Primas, 2007).

SI (Slovenia): A part of electricity in this country is generated by heat and electricity co-generation units. The electricity from these productions is attributed higher emissions compared to a pure electricity generating power plant due lower electrical efficiency of the co-generation plant (Treyer & Bauer., 2016) and the allocation rules applied for co-generation (Primas, 2007).

SK (Slovakia): A part of electricity in this country is generated by heat and electricity co-generation units. The electricity from these productions is attributed higher emissions compared to a pure electricity generating power plant due lower electrical efficiency of the

co-generation plant (Treyer & Bauer., 2016) and the allocation rules applied for co-generation (Primas, 2007).

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