Data Article

Life Cycle Inventories datasets for future European electricity mix scenarios

Maria Laura Parisi\textsuperscript{a,b,c,*}, Simone Maranghi\textsuperscript{a,b}, Riccardo Basosi\textsuperscript{a,b,c}, Adalgisa Sinicropi\textsuperscript{a,b,c}

\textsuperscript{a} R\textsuperscript{2}ES Laboratory, Department of Biotechnology, Chemistry and Pharmacy, University of Siena, Via Aldo Moro 2, 53100 Siena, Italy
\textsuperscript{b} Center for Colloid and Surface Science-CSGI, Via della Lastruccia 3, 50019 Sesto Fiorentino, Italy
\textsuperscript{c} Institute for the Chemistry of Organometallic Compounds (CNR-ICCOM), Italian National Council for Research, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Italy

\textbf{A R T I C L E   I N F O}

\textbf{Article history:}
Received 2 March 2020
Accepted 20 March 2020
Available online 8 April 2020

\textbf{Keywords:}
Energy system
Future electricity mix
Renewable energy
Innovative technologies
Life Cycle Assessment
Long-term prospective analysis

\textbf{A B S T R A C T}

Datasets concerning the European electricity mix, built employing the Ecoinvent database v.3.3 processes, are reported in this paper. Foreseen future scenarios are modelled based on acknowledged projections for energy market in Europe in 2050. These electricity mix data inventories could be useful for any academic or stakeholder interested in performing long-term prospective assessment of innovative generation technologies in the future European energy market.

© 2020 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license. ([http://creativecommons.org/licenses/by-nc-nd/4.0/](http://creativecommons.org/licenses/by-nc-nd/4.0/))
Specifications table

| Subject | Renewable Energy, Sustainability and the Environment |
|---------|-------------------------------------------------------|
| Specific subject area | Life Cycle Assessment and Energy Systems |
| Type of data | Tables |
| How data were acquired | Ecoinvent 3.3 Database and scientific literature |
| Data format | Raw |
| Parameters for data collection | Technological, temporal and geographical representativeness of data are described in Ecoinvent 3.3 reports |
| Description of data collection | Data collection is performed employing the Ecoinvent database v3.3. When the required information is not available from the Ecoinvent database, secondary data are acquired from literature |
| Data source location | Institution: Ecoinvent |
| | City/Town/Region: Zurich |
| | Country: Switzerland |
| Data accessibility | The Life Cycle Inventories are reported with this article |

Value of the data

- Datasets for building Life Cycle Inventories of 2050 European electricity mix scenarios are provided.
- Comprehensive and up-to-date datasets are built based on the outcomes and recommendation of the NEEDS project and IEA-PVPS Task 12 technical reports.
- Technical data and averages concerning the energy sources for future European electricity mix scenarios are modelled and customised according to the Ecoinvent v 3.3 and ensuring easy employment and reproducibility also for successive versions of the life cycle inventory database.
- The usefulness of such data for the scientific community is fulfilled in the application of life cycle assessment for the calculation of the environmental burdens associated to different electricity generation technologies in a long-term prospective approach.

1. Data

The development of innovative technologies for energy production should be always supported by sustainability assessment to provide a reliable evaluation of their environmental performances and implications in the future energy market [1,2]. In this context, reliable Life Cycle Inventories (LCIs) of future energy mixes are pivotal in order to guarantee consistency and reproducibility of prospective Life Cycle Assessment (LCA) studies. Datasets presented in this article concern the LCIs of future European electricity mix. These datasets have been built employing the Ecoinvent database v 3.3 [3] energy production processes and modelling the three main scenarios that are foreseen to characterise the shares of energy sources employed in Europe in 2050. The three scenarios (Table 1) are business-as-usual (BAU), realistic (REAL) and optimistic (OPT) and they have been modelled according to the results of the NEEDS (New Energy Externalities Development for Sustainability) project [4–6] and as described in the IEA-PVPS (International Energy Agency Photovoltaic Power Systems Programme) reports [7,8].

To reproduce these shares of energy sources using the Ecoinvent database v 3.3 [3], a new European electricity mix process was built by specifying the percentages of the energy sources as inputs (Tables 2 and 3). This European electricity mix process features the same input and output flows of the “Electricity, high voltage [ENTSO-E] production mix” process provided by the Ecoinvent database v 3.3. The difference is the way in which each input is reported. In fact, in the Ecoinvent database, the European electricity production mix is built as a process with a long list of input flows. These input flows refer to the electricity generated by all the energy sources (e.g., hard coal, lignite, oil, natural gas, nuclear, biomass, hydropower, wind and other sources) in all the European countries. Differently, in this study the input flows referring to each
Table 1
Shares of energy sources for BAU, REAL and OPT scenarios of electricity mix production in Europe in 2050, based on the NEEDS project and IEA-PVPS reports.

|            | BAU     | REAL    | OPT    |
|------------|---------|---------|--------|
| Hard coal  | 26.4%   | 5.9%    | 2.9%   |
| Lignite    | 9.7%    | 0.05%   | 0.05%  |
| Oil        | 0.6%    | 0.2%    | 0.05%  |
| Natural gas| 18.6%   | 41.5%   | 16.8%  |
| Nuclear    | 22.0%   | 24.4%   | 0.05%  |
| Biomass    | 3.6%    | 3.3%    | 15.8%  |
| Hydropower | 14.3%   | 15.1%   | 24.2%  |
| Wind       | 4.6%    | 7.0%    | 32.3%  |
| Others     | 3.4%    | 2.55%   | 7.85%  |

Table 2
Ecoinvent 3.3 dataset of electricity production mix in Europe (i.e., ENTSO-E countries).

| OUTPUT - Product |          |         |
|------------------|----------|---------|
| Electricity, high voltage [EURO] electricity production mix | 1.000   | kWh     |

| INPUT – Electricity/heat |          |         |
|--------------------------|----------|---------|
| Electricity, high voltage [EURO] electricity production, hard coal | 0.148   | kWh     |
| Electricity, high voltage [EURO] electricity production, lignite    | 0.119   | kWh     |
| Electricity, high voltage [EURO] electricity production, oil         | 0.016   | kWh     |
| Electricity, high voltage [EURO] electricity production, natural gas | 0.159   | kWh     |
| Electricity, high voltage [EURO] electricity production, nuclear     | 0.270   | kWh     |
| Electricity, high voltage [EURO] electricity production, biomass     | 0.024   | kWh     |
| Electricity, high voltage [EURO] electricity production, hydropower  | 0.182   | kWh     |
| Electricity, high voltage [EURO] electricity production, wind        | 0.046   | kWh     |
| Electricity, high voltage [EURO] electricity production, other       | 0.036   | kWh     |

energy sources are grouped to give the following percentage energy sources composition for the European electricity mix:

- Hard coal: 14.77%;
- Lignite: 11.93%;
- Oil: 1.56%;
- Natural gas: 15.94%;
- Nuclear: 27.04%;
- Biomass: 2.43%;
- Hydropower: 18.18%;
- Wind: 4.60%;
- Other: 3.55%.

In this context, a specific LCI has been built for each energy source. These datasets are reported in Tables 3–11. The electrical losses during the transformation of electricity from high to medium voltage have been accounted for (Table 12) and they were taken from the Worldbank data website [9].

The LCI of European electricity scenarios in 2050 are reported in Tables 13–18. Datasets provided in this work can be easily customised also for more recent version of the Ecoinvent database.

2. Experimental design, materials and methods

Data are shown in Tables divided in two sections: Inputs and Outputs

- In the first column, the name of the Ecoinvent process is reported.
- In the second column, the amount of energy is provided.
- In the third column, the unit of measure is described.
Table 3
Dataset concerning European electricity production by hard coal.

| OUTPUT - Product | INPUT - Electricity/heat |
|------------------|--------------------------|
| Electricity, high voltage (EURO)] electricity production, hard coal | Electricity, high voltage [AT] electricity production, hard coal |
| 1.000            | 8.97E-03 kWh            |
|                  | Electricity, high voltage [AT] heat and power co-generation, hard coal |
|                  | 7.24E-04 kWh            |
|                  | Electricity, high voltage [BE] electricity production, hard coal |
|                  | 7.53E-03 kWh            |
|                  | Electricity, high voltage [BG] electricity production, hard coal |
|                  | 5.97E-03 kWh            |
|                  | Electricity, high voltage [CZ] electricity production, hard coal |
|                  | 4.80E-03 kWh            |
|                  | Electricity, high voltage [CZ] heat and power co-generation, hard coal |
|                  | 5.40E-03 kWh            |
|                  | Electricity, high voltage [DE] electricity production, hard coal |
|                  | 2.16E-01 kWh            |
|                  | Electricity, high voltage [DE] heat and power co-generation, hard coal |
|                  | 3.17E-02 kWh            |
|                  | Electricity, high voltage [FI] electricity production, hard coal |
|                  | 6.15E-03 kWh            |
|                  | Electricity, high voltage [FI] heat and power co-generation, hard coal |
|                  | 9.31E-03 kWh            |
|                  | Electricity, high voltage [FR] electricity production, hard coal |
|                  | 4.08E-02 kWh            |
|                  | Electricity, high voltage [GB] electricity production, hard coal |
|                  | 3.15E-01 kWh            |
|                  | Electricity, high voltage [HR] electricity production, hard coal |
|                  | 4.73E-03 kWh            |
|                  | Electricity, high voltage [IE] electricity production, hard coal |
|                  | 1.20E-02 kWh            |
|                  | Electricity, high voltage [IT] electricity production, hard coal |
|                  | 1.05E-01 kWh            |
|                  | Electricity, high voltage [NL] electricity production, hard coal |
|                  | 3.85E-02 kWh            |
|                  | Electricity, high voltage [NL] heat and power co-generation, hard coal |
|                  | 1.48E-02 kWh            |
|                  | Electricity, high voltage [NO] heat and power co-generation, hard coal |
|                  | 8.30E-05 kWh            |
|                  | Electricity, high voltage [PL] heat and power co-generation, hard coal |
|                  | 1.68E-01 kWh            |
|                  | Electricity, high voltage [SE] heat and power co-generation, hard coal |
|                  | 1.07E-03 kWh            |
|                  | Electricity, high voltage [SK] heat and power co-generation, hard coal |
|                  | 2.75E-03 kWh            |

Table 4
Dataset concerning European electricity production by lignite.

| OUTPUT - Product | INPUT - Electricity/heat |
|------------------|--------------------------|
| Electricity, high voltage [EURO)] electricity production, lignite | Electricity, high voltage [BA] electricity production, lignite |
| 1.000            | 2.58E-02 kWh            |
|                  | Electricity, high voltage [BG] electricity production, lignite |
|                  | 5.30E-02 kWh            |
|                  | Electricity, high voltage [CZ] electricity production, lignite |
|                  | 7.78E-02 kWh            |
|                  | Electricity, high voltage [CZ] heat and power co-generation, lignite |
|                  | 2.43E-02 kWh            |
|                  | Electricity, high voltage [DE] electricity production, lignite |
|                  | 4.07E-01 kWh            |
|                  | Electricity, high voltage [DE] heat and power co-generation, lignite |
|                  | 1.69E-02 kWh            |
|                  | Electricity, high voltage [GR] electricity production, lignite |
|                  | 5.45E-02 kWh            |
|                  | Electricity, high voltage [GR] heat and power co-generation, lignite |
|                  | 2.23E-02 kWh            |
|                  | Electricity, high voltage [HR] electricity production, lignite |
|                  | 4.80E-05 kWh            |
|                  | Electricity, high voltage [HU] electricity production, lignite |
|                  | 1.67E-02 kWh            |
|                  | Electricity, high voltage [IT] electricity production, lignite |
|                  | 2.25E-03 kWh            |
|                  | Electricity, high voltage [MK] electricity production, lignite |
|                  | 1.13E-02 kWh            |
|                  | Electricity, high voltage [PL] heat and power co-generation, lignite |
|                  | 1.40E-01 kWh            |
|                  | Electricity, high voltage [RO] electricity production, lignite |
|                  | 6.04E-02 kWh            |
|                  | Electricity, high voltage [RS] electricity production, lignite |
|                  | 6.95E-02 kWh            |
|                  | Electricity, high voltage [SI] electricity production, lignite |
|                  | 1.59E-03 kWh            |
|                  | Electricity, high voltage [SI] heat and power co-generation, lignite |
|                  | 1.13E-02 kWh            |
|                  | Electricity, high voltage [SK] heat and power co-generation, lignite |
|                  | 5.30E-03 kWh            |
### Table 5

Dataset concerning European electricity production by oil.

| INPUT – Electricity/heat | OUTPUT - Product |
|--------------------------|------------------|
| Electricity, high voltage [AT] | Electricity production, oil |
| Electricity, high voltage [AT] | heat and power co-generation, oil |
| Electricity, high voltage [BA] | electricity production, oil |
| Electricity, high voltage [BE] | electricity production, oil |
| Electricity, high voltage [BE] | heat and power co-generation, oil |
| Electricity, high voltage [BG] | electricity production, oil |
| Electricity, high voltage [BG] | heat and power co-generation, oil |
| Electricity, high voltage [CZ] | electricity production, oil |
| Electricity, high voltage [CZ] | heat and power co-generation, oil |
| Electricity, high voltage [DE] | electricity production, oil |
| Electricity, high voltage [DE] | heat and power co-generation, oil |
| Electricity, high voltage [EE] | electricity production, oil |
| Electricity, high voltage [FI] | heat and power co-generation, oil |
| Electricity, high voltage [FI] | electricity production, oil |
| Electricity, high voltage [FR] | electricity production, oil |
| Electricity, high voltage [FR] | heat and power co-generation, oil |
| Electricity, high voltage [GB] | electricity production, oil |
| Electricity, high voltage [GB] | heat and power co-generation, oil |
| Electricity, high voltage [GR] | electricity production, oil |
| Electricity, high voltage [GR] | heat and power co-generation, oil |
| Electricity, high voltage [HR] | electricity production, oil |
| Electricity, high voltage [HR] | heat and power co-generation, oil |
| Electricity, high voltage [HU] | electricity production, oil |
| Electricity, high voltage [IE] | electricity production, oil |
| Electricity, high voltage [IE] | heat and power co-generation, oil |
| Electricity, high voltage [IS] | electricity production, oil |
| Electricity, high voltage [IT] | electricity production, oil |
| Electricity, high voltage [IT] | heat and power co-generation, oil |
| Electricity, high voltage [LT] | heat and power co-generation, oil |
| Electricity, high voltage [LU] | heat and power co-generation, oil |
| Electricity, high voltage [LV] | heat and power co-generation, oil |
| Electricity, high voltage [MK] | electricity production, oil |
| Electricity, high voltage [NL] | electricity production, oil |
| Electricity, high voltage [NL] | heat and power co-generation, oil |
| Electricity, high voltage [NO] | electricity production, oil |
| Electricity, high voltage [PL] | heat and power co-generation, oil |
| Electricity, high voltage [RO] | electricity production, oil |
| Electricity, high voltage [RO] | heat and power co-generation, oil |
| Electricity, high voltage [RS] | heat and power co-generation, oil |
| Electricity, high voltage [SE] | electricity production, oil |
| Electricity, high voltage [SE] | heat and power co-generation, oil |
| Electricity, high voltage [SI] | electricity production, oil |
| Electricity, high voltage [SK] | electricity production, oil |
| Electricity, high voltage [SK] | heat and power co-generation, oil |

| Voltage | kWh |
|---------|-----|
| 5      | 1.00 |
| 5      | 4.00E-04 |
| 5      | 1.51E-02 |
| 5      | 5.60E-04 |
| 5      | 1.39E-03 |
| 5      | 5.36E-03 |
| 5      | 8.50E-04 |
| 5      | 3.59E-03 |
| 5      | 4.70E-04 |
| 5      | 1.32E-03 |
| 5      | 9.48E-02 |
| 5      | 5.89E-02 |
| 5      | 1.09E-03 |
| 5      | 2.55E-03 |
| 5      | 3.87E-03 |
| 5      | 5.68E-02 |
| 5      | 3.16E-02 |
| 5      | 2.42E-02 |
| 5      | 3.96E-02 |
| 5      | 9.54E-02 |
| 5      | 1.92E-02 |
| 5      | 4.96E-03 |
| 5      | 6.77E-03 |
| 5      | 3.55E-03 |
| 5      | 4.24E-03 |
| 5      | 8.90E-04 |
| 5      | 8.00E-05 |
| 5      | 7.29E-02 |
| 5      | 3.16E-01 |
| 5      | 4.84E-03 |
| 5      | 2.00E-05 |
| 5      | 2.00E-05 |
| 5      | 1.77E-03 |
| 5      | 2.27E-02 |
| 5      | 2.27E-02 |
| 5      | 8.50E-04 |
| 5      | 4.03E-02 |
| 5      | 1.51E-03 |
| 5      | 1.36E-02 |
| 5      | 1.35E-03 |
| 5      | 1.32E-03 |
| 5      | 1.23E-02 |
| 5      | 1.70E-04 |
| 5      | 3.30E-04 |
| 5      | 9.65E-03 |
Table 6
Dataset concerning European electricity production by natural gas.

| OUTPUT - Product | Quantity | kWh |
|------------------|----------|-----|
| Electricity, high voltage [EURO]] electricity production, natural gas | 1.000 | kWh |
| Electricity, high voltage [AT] electricity production, natural gas, combined cycle power plant | 4.32E-03 | kWh |
| Electricity, high voltage [AT] electricity production, natural gas, conventional power plant | 2.03E-03 | kWh |
| Electricity, high voltage [AT] heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 1.03E-02 | kWh |
| Electricity, high voltage [AT] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 3.14E-03 | kWh |
| Electricity, high voltage [BE] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 1.03E-04 | kWh |
| Electricity, high voltage [BE] electricity production, natural gas, combined cycle power plant | 1.85E-02 | kWh |
| Electricity, high voltage [BE] electricity production, natural gas, conventional power plant | 4.31E-03 | kWh |
| Electricity, high voltage [BE] heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 7.73E-03 | kWh |
| Electricity, high voltage [BE] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 1.80E-02 | kWh |
| Electricity, high voltage [BG] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 2.40E-05 | kWh |
| Electricity, high voltage [BG] heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 2.76E-04 | kWh |
| Electricity, high voltage [BG] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 4.36E-03 | kWh |
| Electricity, high voltage [CH] electricity production, natural gas, 10 MW | 7.20E-14 | kWh |
| Electricity, high voltage [CH] heat and power co-generation, natural gas, 1 MW electrical, lean burn | 3.16E-04 | kWh |
| Electricity, high voltage [CH] heat and power co-generation, natural gas, 200 kW electrical, lean burn | 2.64E-04 | kWh |
| Electricity, high voltage [CH] heat and power co-generation, natural gas, 500 kW electrical, lean burn | 1.80E-04 | kWh |
| Electricity, high voltage [CZ] electricity production, natural gas, combined cycle power plant | 1.70E-05 | kWh |
| Electricity, high voltage [CZ] electricity production, natural gas, conventional power plant | 7.10E-05 | kWh |
| Electricity, high voltage [CZ] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 2.24E-03 | kWh |
| Electricity, high voltage [DE] electricity production, natural gas, 10 MW | 5.10E-13 | kWh |
| Electricity, high voltage [DE] electricity production, natural gas, combined cycle power plant | 2.85E-02 | kWh |
| Electricity, high voltage [DE] electricity production, natural gas, conventional power plant | 2.85E-02 | kWh |
| Electricity, high voltage [DE] heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 1.76E-02 | kWh |
| Electricity, high voltage [DE] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 1.75E-03 | kWh |
| Electricity, high voltage [EE] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 1.05E-01 | kWh |
| Electricity, high voltage [FI] electricity production, natural gas, combined cycle power plant | 2.33E-04 | kWh |
| Electricity, high voltage [FI] electricity production, natural gas, conventional power plant | 1.84E-04 | kWh |
| Electricity, high voltage [FI] heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 1.60E-05 | kWh |
| Electricity, high voltage [FI] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 2.18E-03 | kWh |
| Electricity, high voltage [FR] electricity production, natural gas, combined cycle power plant | 1.12E-02 | kWh |
| Electricity, high voltage [FR] electricity production, natural gas, combined cycle power plant | 1.24E-02 | kWh |
| Electricity, high voltage [FR] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 2.39E-03 | kWh |
| Electricity, high voltage [GB] electricity production, natural gas, combined cycle power plant | 2.87E-02 | kWh |
| Electricity, high voltage [GB] electricity production, natural gas, conventional power plant | 6.84E-02 | kWh |
| Electricity, high voltage [GB] heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 9.92E-02 | kWh |
| Electricity, high voltage [GB] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 2.31E-02 | kWh |
| Electricity, high voltage [GR] electricity production, natural gas, combined cycle power plant | 1.34E-02 | kWh |
| Electricity, high voltage [GR] electricity production, natural gas, conventional power plant | 1.70E-02 | kWh |
| Electricity, high voltage [GR] heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 5.20E-03 | kWh |
| Electricity, high voltage [GR] heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 1.41E-03 | kWh |
| Electricity, high voltage [HR] electricity production, natural gas, combined cycle power plant | 7.00E-05 | kWh |

(continued on next page)
| Electricity | high voltage \[HR\]| electricity production, natural gas, conventional power plant | 1.50E-05 kWh |
|-------------|-----------------|--------------------------------------------------|------------------|
| Electricity | high voltage \[HR\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 3.76E-03 kWh |
| Electricity | high voltage \[HU\]| electricity production, natural gas, combined cycle power plant | 1.2E-03 kWh |
| Electricity | high voltage \[HU\]| electricity production, natural gas, conventional power plant | 4.73E-03 kWh |
| Electricity | high voltage \[HU\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 3.02E-03 kWh |
| Electricity | high voltage \[HU\]| heat and power co-generation, natural gas, conventional power plant | 8.63E-04 kWh |
| Electricity | high voltage \[HU\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 9.97E-03 kWh |
| Electricity | high voltage \[IE\]| electricity production, natural gas, combined cycle power plant | 1.60E-02 kWh |
| Electricity | high voltage \[IE\]| electricity production, natural gas, conventional power plant | 7.62E-03 kWh |
| Electricity | high voltage \[IE\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 4.06E-03 kWh |
| Electricity | high voltage \[IT\]| electricity production, natural gas, combined cycle power plant | 8.42E-02 kWh |
| Electricity | high voltage \[IT\]| electricity production, natural gas, conventional power plant | 2.26E-02 kWh |
| Electricity | high voltage \[IT\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 9.51E-02 kWh |
| Electricity | high voltage \[IT\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 5.86E-02 kWh |
| Electricity | high voltage \[LT\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 2.20E-04 kWh |
| Electricity | high voltage \[LT\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 5.47E-03 kWh |
| Electricity | high voltage \[LU\]| heat and power co-generation, natural gas, conventional power plant, 400 MW electrical | 3.96E-03 kWh |
| Electricity | high voltage \[LU\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 9.64E-04 kWh |
| Electricity | high voltage \[LV\]| heat and power co-generation, natural gas, conventional power plant, 400 MW electrical | 1.93E-03 kWh |
| Electricity | high voltage \[LV\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 2.13E-03 kWh |
| Electricity | high voltage \[MK\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 4.97E-04 kWh |
| Electricity | high voltage \[MK\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 9.10E-05 kWh |
| Electricity | high voltage \[NL\]| electricity production, natural gas, 10 MW | 1.20E-13 kWh |
| Electricity | high voltage \[NL\]| electricity production, natural gas, combined cycle power plant | 2.13E-02 kWh |
| Electricity | high voltage \[NL\]| electricity production, natural gas, conventional power plant | 1.07E-02 kWh |
| Electricity | high voltage \[NL\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 4.47E-02 kWh |
| Electricity | high voltage \[NL\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 3.70E-02 kWh |
| Electricity | high voltage \[NO\]| electricity production, natural gas, combined cycle power plant | 2.91E-03 kWh |
| Electricity | high voltage \[NO\]| electricity production, natural gas, conventional power plant | 2.28E-03 kWh |
| Electricity | high voltage \[PL\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 9.08E-03 kWh |
| Electricity | high voltage \[PL\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 3.03E-03 kWh |
| Electricity | high voltage \[RO\]| electricity production, natural gas, conventional power plant | 4.77E-03 kWh |
| Electricity | high voltage \[RO\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 8.82E-04 kWh |
| Electricity | high voltage \[RO\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 1.16E-02 kWh |
| Electricity | high voltage \[RS\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 9.42E-04 kWh |
| Electricity | high voltage \[SE\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 1.84E-03 kWh |
| Electricity | high voltage \[SI\]| electricity production, natural gas, conventional power plant | 1.30E-05 kWh |
| Electricity | high voltage \[SI\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 9.80E-04 kWh |
| Electricity | high voltage \[SK\]| electricity production, natural gas, combined cycle power plant | 9.05E-04 kWh |
| Electricity | high voltage \[SK\]| electricity production, natural gas, conventional power plant | 6.90E-04 kWh |
| Electricity | high voltage \[SK\]| heat and power co-generation, natural gas, combined cycle power plant, 400 MW electrical | 2.22E-03 kWh |
| Electricity | high voltage \[SK\]| heat and power co-generation, natural gas, conventional power plant, 100 MW electrical | 1.52E-03 kWh |
Table 7
Dataset concerning European electricity production by nuclear.

| OUTPUT - Product | 1.000 | kWh |
|------------------|--------|-----|
| INPUT - Electricity/heat |         |     |
| Electricity, high voltage (BE)] electricity production, nuclear | 4.74E-02 | kWh |
| Electricity, high voltage (BG)] electricity production, nuclear, pressure water reactor | 1.86E-02 | kWh |
| Electricity, high voltage (CH)] electricity production, nuclear, boiling water reactor | 1.57E-02 | kWh |
| Electricity, high voltage (BR)] electricity production, nuclear, pressure water reactor | 1.78E-02 | kWh |
| Electricity, high voltage (CZ)] electricity production, nuclear, pressure water reactor | 3.57E-02 | kWh |
| Electricity, high voltage (DE)] electricity production, nuclear, boiling water reactor | 2.50E-02 | kWh |
| Electricity, high voltage (FI)] electricity production, nuclear, pressure water reactor | 9.21E-02 | kWh |
| Electricity, high voltage (FR)] electricity production, nuclear, boiling water reactor | 1.73E-02 | kWh |
| Electricity, high voltage (FR)] electricity production, nuclear, pressure water reactor | 9.76E-03 | kWh |
| Electricity, high voltage (FR)] electricity production, nuclear, pressure water reactor | 5.0E-01 | kWh |
| Electricity, high voltage (FR)] electricity production, nuclear, boiling water reactor | 7.22E-02 | kWh |
| Electricity, high voltage (FR)] electricity production, nuclear, pressure water reactor | 1.07E-02 | kWh |
| Electricity, high voltage (FR)] electricity production, nuclear, pressure water reactor | 1.86E-02 | kWh |
| Electricity, high voltage (FR)] electricity production, nuclear, boiling water reactor | 4.62E-03 | kWh |
| Electricity, high voltage (RO)] electricity production, nuclear, pressure water reactor, heavy water moderated | 1.35E-02 | kWh |
| Electricity, high voltage (SE)] electricity production, nuclear, boiling water reactor | 5.30E-02 | kWh |
| Electricity, high voltage (SE)] electricity production, nuclear, pressure water reactor | 2.23E-02 | kWh |
| Electricity, high voltage (SE)] electricity production, nuclear, pressure water reactor | 6.51E-03 | kWh |
| Electricity, high voltage (SK)] electricity production, nuclear, pressure water reactor | 1.82E-02 | kWh |

Table 8
Dataset concerning European electricity production by biomass.

| OUTPUT - Product | 1.000 | kWh |
|------------------|--------|-----|
| INPUT - Electricity/heat |         |     |
| Electricity, high voltage (AT)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 5.24E-02 | kWh |
| Electricity, high voltage (BE)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 5.13E-02 | kWh |
| Electricity, high voltage (BG)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 9.19E-04 | kWh |
| Electricity, high voltage (CH)] heat and power co-generation, wood chips, 2000 kW, state-of-the-art 2014 | 3.70E-03 | kWh |
| Electricity, high voltage (CZ)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 2.53E-02 | kWh |
| Electricity, high voltage (DE)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 1.68E-01 | kWh |
| Electricity, high voltage (EE)] heat and power co-generation, wood chips, 6667 kW | 1.37E-02 | kWh |
| Electricity, high voltage (FI)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 1.49E-01 | kWh |
| Electricity, high voltage (FR)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 2.42E-02 | kWh |
| Electricity, high voltage (GB)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 9.81E-02 | kWh |
| Electricity, high voltage (HU)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 5.57E-04 | kWh |
| Electricity, high voltage (RO)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 1.86E-02 | kWh |
| Electricity, high voltage (SE)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 2.51E-03 | kWh |
| Electricity, high voltage (EE)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 3.59E-02 | kWh |
| Electricity, high voltage (FI)] heat and power co-generation, wood chips, 6667 kW | 2.51E-03 | kWh |
| Electricity, high voltage (FR)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 9.75E-04 | kWh |
| Electricity, high voltage (HU)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 5.51E-02 | kWh |
| Electricity, high voltage (RO)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 3.61E-03 | kWh |
| Electricity, high voltage (RO)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 1.33E-01 | kWh |
| Electricity, high voltage (RO)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 2.65E-03 | kWh |
| Electricity, high voltage (SE)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 1.46E-01 | kWh |
| Electricity, high voltage (SE)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 1.59E-03 | kWh |
| Electricity, high voltage (SK)] heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | 1.01E-02 | kWh |
### Table 9

Data set concerning European electricity production by hydro.

| OUTPUT - Product | INPUT – Electricity/heat |
|------------------|-------------------------|
| Electricity, high voltage [EUR] electricity production, hydropower | kWh |
| 1.000 | kWh |

| Electricity, high voltage [AT] electricity production, hydro, pumped storage | kWh |
| 7.18E-03 | kWh |
| Electricity, high voltage [AT] electricity production, hydro, reservoir, alpine region | kWh |
| 2.02E-02 | kWh |
| Electricity, high voltage [AT] electricity production, hydro, run-of-river | kWh |
| 6.06E-02 | kWh |
| Electricity, high voltage [BA] electricity production, hydro, pumped storage | kWh |
| 9.00E-06 | kWh |
| Electricity, high voltage [BA] electricity production, hydro, reservoir, alpine region | kWh |
| 2.72E-03 | kWh |
| Electricity, high voltage [BA] electricity production, hydro, run-of-river | kWh |
| 5.05E-03 | kWh |
| Electricity, high voltage [BE] electricity production, hydro, pumped storage | kWh |
| 2.40E-03 | kWh |
| Electricity, high voltage [BE] electricity production, hydro, run-of-river | kWh |
| 6.58E-04 | kWh |
| Electricity, high voltage [BG] electricity production, hydro, pumped storage | kWh |
| 1.39E-03 | kWh |
| Electricity, high voltage [BG] electricity production, hydro, run-of-river | kWh |
| 5.95E-03 | kWh |
| Electricity, high voltage [CH] electricity production, hydro, reservoir, alpine region | kWh |
| 2.03E-02 | kWh |
| Electricity, high voltage [CH] electricity production, hydro, run-of-river | kWh |
| 1.93E-02 | kWh |
| Electricity, high voltage [CZ] electricity production, hydro, pumped storage | kWh |
| 1.35E-03 | kWh |
| Electricity, high voltage [CZ] electricity production, hydro, reservoir, non-alpine region | kWh |
| 9.81E-04 | kWh |
| Electricity, high voltage [CZ] electricity production, hydro, run-of-river | kWh |
| 2.94E-03 | kWh |
| Electricity, high voltage [DE] electricity production, hydro, pumped storage | kWh |
| 1.23E-02 | kWh |
| Electricity, high voltage [DE] electricity production, hydro, reservoir, non-alpine region | kWh |
| 6.25E-03 | kWh |
| Electricity, high voltage [DE] electricity production, hydro, run-of-river | kWh |
| 3.28E-02 | kWh |
| Electricity, high voltage [EE] electricity production, hydro, run-of-river | kWh |
| 7.70E-05 | kWh |
| Electricity, high voltage [FI] electricity production, hydro, reservoir, non-alpine region | kWh |
| 2.33E-02 | kWh |
| Electricity, high voltage [FI] electricity production, hydro, run-of-river | kWh |
| 7.77E-03 | kWh |
| Electricity, high voltage [FR] electricity production, hydro, pumped storage | kWh |
| 9.00E-03 | kWh |
| Electricity, high voltage [FR] electricity production, hydro, reservoir, alpine region | kWh |
| 1.82E-02 | kWh |
| Electricity, high voltage [FR] electricity production, hydro, run-of-river | kWh |
| 9.10E-02 | kWh |
| Electricity, high voltage [GB] electricity production, hydro, pumped storage | kWh |
| 5.47E-03 | kWh |
| Electricity, high voltage [GB] electricity production, hydro, run-of-river | kWh |
| 9.75E-03 | kWh |
| Electricity, high voltage [GR] electricity production, hydro, pumped storage | kWh |
| 3.47E-04 | kWh |
| Electricity, high voltage [GR] electricity production, hydro, run-of-river | kWh |
| 8.12E-03 | kWh |
| Electricity, high voltage [HR] electricity production, hydro, pumped storage | kWh |
| 2.97E-04 | kWh |
| Electricity, high voltage [HR] electricity production, hydro, reservoir, alpine region | kWh |
| 8.38E-03 | kWh |
| Electricity, high voltage [HR] electricity production, hydro, run-of-river | kWh |
| 1.71E-04 | kWh |
| Electricity, high voltage [HU] electricity production, hydro, run-of-river | kWh |
| 3.93E-04 | kWh |
| Electricity, high voltage [IE] electricity production, hydro, pumped storage | kWh |
| 3.91E-04 | kWh |
| Electricity, high voltage [IE] electricity production, hydro, run-of-river | kWh |
| 1.48E-03 | kWh |
| Electricity, high voltage [IS] electricity production, hydro, reservoir, non-alpine region | kWh |
| 4.32E-02 | kWh |
| Electricity, high voltage [IT] electricity production, hydro, pumped storage | kWh |
| 3.65E-03 | kWh |
| Electricity, high voltage [IT] electricity production, hydro, reservoir, alpine region | kWh |
| 4.32E-02 | kWh |
| Electricity, high voltage [IT] electricity production, hydro, run-of-river | kWh |
| 2.78E-02 | kWh |
| Electricity, high voltage [LT] electricity production, hydro, pumped storage | kWh |
| 9.53E-04 | kWh |
| Electricity, high voltage [LT] electricity production, hydro, run-of-river | kWh |
| 7.80E-04 | kWh |
| Electricity, high voltage [LU] electricity production, hydro, pumped storage | kWh |
| 1.96E-03 | kWh |
| Electricity, high voltage [LU] electricity production, hydro, run-of-river | kWh |
| 1.79E-04 | kWh |
| Electricity, high voltage [LV] electricity production, hydro, run-of-river | kWh |
| 6.84E-03 | kWh |
| Electricity, high voltage [MK] electricity production, hydro, reservoir, alpine region | kWh |
| 1.57E-03 | kWh |
| Electricity, high voltage [MK] electricity production, hydro, run-of-river | kWh |
| 3.46E-04 | kWh |
| Electricity, high voltage [NL] electricity production, hydro, run-of-river | kWh |
| 1.92E-04 | kWh |
| Electricity, high voltage [NO] electricity production, hydro, pumped storage | kWh |
| 1.98E-03 | kWh |
| Electricity, high voltage [NO] electricity production, hydro, reservoir, alpine region | kWh |
| 2.62E-01 | kWh |
| Electricity, high voltage [PL] electricity production, hydro, pumped storage | kWh |
| 7.89E-04 | kWh |
| Electricity, high voltage [PL] electricity production, hydro, run-of-river | kWh |
| 3.76E-02 | kWh |
| Electricity, high voltage [RO] electricity production, hydro, pumped storage | kWh |
| 5.05E-04 | kWh |
| Electricity, high voltage [RO] electricity production, hydro, run-of-river | kWh |
| 2.23E-02 | kWh |
| Electricity, high voltage [RS] electricity production, hydro, pumped storage | kWh |
| 2.29E-03 | kWh |
| Electricity, high voltage [RS] electricity production, hydro, reservoir, alpine region | kWh |
| 2.56E-03 | kWh |
| Electricity, high voltage [RS] electricity production, hydro, run-of-river | kWh |
| 1.34E-02 | kWh |
| Electricity, high voltage [SE] electricity production, hydro, pumped storage | kWh |
| 2.32E-04 | kWh |
| Electricity, high voltage [SE] electricity production, hydro, reservoir, non-alpine region | kWh |
| 2.91E-02 | kWh |
| Electricity, high voltage [SE] electricity production, hydro, run-of-river | kWh |
| 1.16E-01 | kWh |
| Electricity, high voltage [SI] electricity production, hydro, pumped storage | kWh |
| 3.47E-04 | kWh |
| Electricity, high voltage [SI] electricity production, hydro, run-of-river | kWh |
| 7.18E-03 | kWh |
| Electricity, high voltage [SK] electricity production, hydro, pumped storage | kWh |
| 6.20E-04 | kWh |
| Electricity, high voltage [SK] electricity production, hydro, reservoir, non-alpine region | kWh |
| 1.89E-03 | kWh |
| Electricity, high voltage [SK] electricity production, hydro, run-of-river | kWh |
| 5.67E-03 | kWh |
| OUTPUT - Product                      | Electricity, high voltage (EURO) | electricity production, wind | 1.000 | kWh |
|--------------------------------------|----------------------------------|------------------------------|-------|-----|
| INPUT - Electricity/heat             | Electricity, high voltage (AT)   | electricity production, wind | <1 MW turbine, onshore | 6.06E-04 | kWh |
|                                      | Electricity, high voltage (AT)   | electricity production, wind | >3 MW turbine, onshore | 5.95E-04 | kWh |
|                                      | Electricity, high voltage (AT)   | electricity production, wind, 1–3 MW turbine, onshore | 1.68E-02 | kWh |
|                                      | Electricity, high voltage (BE)   | electricity production, wind | <1 MW turbine, onshore | 2.87E-04 | kWh |
|                                      | Electricity, high voltage (BE)   | electricity production, wind | >3 MW turbine, onshore | 1.25E-03 | kWh |
|                                      | Electricity, high voltage (BE)   | electricity production, wind, 1–3 MW turbine, offshore | 7.96E-03 | kWh |
|                                      | Electricity, high voltage (BE)   | electricity production, wind, 1–3 MW turbine, onshore | 1.06E-02 | kWh |
|                                      | Electricity, high voltage (BG)   | electricity production, wind | <1 MW turbine, onshore | 1.48E-03 | kWh |
|                                      | Electricity, high voltage (BG)   | electricity production, wind, 1–3 MW turbine, onshore | 1.87E-03 | kWh |
|                                      | Electricity, high voltage (CH)   | electricity production, wind, 1–3 MW turbine, onshore | 5.56E-03 | kWh |
|                                      | Electricity, high voltage (CH)   | electricity production, wind, <1 MW turbine, onshore | 5.00E-07 | kWh |
|                                      | Electricity, high voltage (CH)   | electricity production, wind, 1–3 MW turbine, onshore | 5.00E-06 | kWh |
|                                      | Electricity, high voltage (CZ)   | electricity production, wind | <1 MW turbine, onshore | 3.29E-04 | kWh |
|                                      | Electricity, high voltage (CZ)   | electricity production, wind | 1–3 MW turbine, onshore | 2.70E-03 | kWh |
|                                      | Electricity, high voltage (DE)   | electricity production, wind | <1 MW turbine, onshore | 5.06E-02 | kWh |
|                                      | Electricity, high voltage (DE)   | electricity production, wind | >3 MW turbine, onshore | 3.04E-02 | kWh |
|                                      | Electricity, high voltage (DE)   | electricity production, wind, 1–3 MW turbine, offshore | 1.06E-02 | kWh |
|                                      | Electricity, high voltage (EE)   | electricity production, wind, 1–3 MW turbine, onshore | 2.78E-01 | kWh |
|                                      | Electricity, high voltage (EE)   | electricity production, wind | <1 MW turbine, onshore | 8.50E-05 | kWh |
|                                      | Electricity, high voltage (EE)   | electricity production, wind, 1–3 MW turbine, onshore | 1.26E-04 | kWh |
|                                      | Electricity, high voltage (FI)   | electricity production, wind | <1 MW turbine, onshore | 2.95E-03 | kWh |
|                                      | Electricity, high voltage (FI)   | electricity production, wind, 1–3 MW turbine, onshore | 2.03E-04 | kWh |
|                                      | Electricity, high voltage (FI)   | electricity production, wind, <3 MW turbine, onshore | 1.64E-03 | kWh |
|                                      | Electricity, high voltage (FI)   | electricity production, wind, 1–3 MW turbine, offshore | 1.21E-04 | kWh |
|                                      | Electricity, high voltage (FI)   | electricity production, wind, 1–3 MW turbine, onshore | 1.63E-03 | kWh |
|                                      | Electricity, high voltage (FR)   | electricity production, wind | <1 MW turbine, onshore | 6.54E-03 | kWh |
|                                      | Electricity, high voltage (FR)   | electricity production, wind, 1–3 MW turbine, offshore | 4.20E-04 | kWh |
|                                      | Electricity, high voltage (FR)   | electricity production, wind, 1–3 MW turbine, onshore | 6.50E-05 | kWh |
|                                      | Electricity, high voltage (FR)   | electricity production, wind, 1–3 MW turbine, onshore | 1.02E-01 | kWh |
|                                      | Electricity, high voltage (GB)   | electricity production, wind, <1 MW turbine, onshore | 9.76E-03 | kWh |
|                                      | Electricity, high voltage (GB)   | electricity production, wind, 1–3 MW turbine, onshore | 5.68E-03 | kWh |
|                                      | Electricity, high voltage (GB)   | electricity production, wind, >3 MW turbine, onshore | 4.65E-02 | kWh |
|                                      | Electricity, high voltage (GB)   | electricity production, wind, 1–3 MW turbine, onshore | 8.09E-02 | kWh |
|                                      | Electricity, high voltage (GR)   | electricity production, wind, <1 MW turbine, onshore | 8.94E-03 | kWh |
|                                      | Electricity, high voltage (GR)   | electricity production, wind, >3 MW turbine, onshore | 3.94E-03 | kWh |
|                                      | Electricity, high voltage (GR)   | electricity production, wind, 1–3 MW turbine, onshore | 1.52E-02 | kWh |
|                                      | Electricity, high voltage (HR)   | electricity production, wind, <1 MW turbine, onshore | 3.46E-04 | kWh |
|                                      | Electricity, high voltage (HR)   | electricity production, wind, 1–3 MW turbine, onshore | 2.05E-03 | kWh |
|                                      | Electricity, high voltage (HU)   | electricity production, wind, <1 MW turbine, onshore | 1.05E-04 | kWh |
|                                      | Electricity, high voltage (HU)   | electricity production, wind, <3 MW turbine, onshore | 2.09E-04 | kWh |
|                                      | Electricity, high voltage (HU)   | electricity production, wind, 1–3 MW turbine, onshore | 5.30E-03 | kWh |
|                                      | Electricity, high voltage (IE)   | electricity production, wind, <1 MW turbine, onshore | 5.39E-03 | kWh |
|                                      | Electricity, high voltage (IE)   | electricity production, wind, >3 MW turbine, onshore | 9.49E-04 | kWh |
|                                      | Electricity, high voltage (IE)   | electricity production, wind, 1–3 MW turbine, offshore | 3.30E-04 | kWh |
|                                      | Electricity, high voltage (IE)   | electricity production, wind | 1–3 MW turbine, onshore | 2.26E-02 | kWh |
|                                      | Electricity, high voltage (IT)   | electricity production, wind, <1 MW turbine, onshore | 2.74E-02 | kWh |
|                                      | Electricity, high voltage (IT)   | electricity production, wind, >3 MW turbine, onshore | 8.38E-03 | kWh |
|                                      | Electricity, high voltage (IT)   | electricity production, wind, 1–3 MW turbine, onshore | 6.20E-02 | kWh |
|                                      | Electricity, high voltage (LT)   | electricity production, wind, <1 MW turbine, onshore | 2.04E-04 | kWh |
|                                      | Electricity, high voltage (LT)   | electricity production, wind, >3 MW turbine, onshore | 2.04E-04 | kWh |
|                                      | Electricity, high voltage (LT)   | electricity production, wind, 1–3 MW turbine, onshore | 3.55E-03 | kWh |
|                                      | Electricity, high voltage (LU)   | electricity production, wind, <1 MW turbine, onshore | 1.10E-04 | kWh |
|                                      | Electricity, high voltage (LU)   | electricity production, wind, 1–3 MW turbine, onshore | 4.37E-04 | kWh |
|                                      | Electricity, high voltage (LV)   | electricity production, wind, <1 MW turbine, onshore | 4.40E-04 | kWh |
|                                      | Electricity, high voltage (LV)   | electricity production, wind, 1–3 MW turbine, onshore | 3.91E-04 | kWh |
|                                      | Electricity, high voltage (NL)   | electricity production, wind, <1 MW turbine, onshore | 9.61E-03 | kWh |
|                                      | Electricity, high voltage (NL)   | electricity production, wind, >3 MW turbine, onshore | 6.08E-03 | kWh |
|                                      | Electricity, high voltage (NL)   | electricity production, wind, 1–3 MW turbine, offshore | 2.83E-03 | kWh |
|                                      | Electricity, high voltage (NL)   | electricity production, wind, 1–3 MW turbine, onshore | 1.78E-02 | kWh |

(continued on next page)
Table 10 (continued)

| Description                                                                 | Value     |
|----------------------------------------------------------------------------|-----------|
| Electricity, high voltage [NO] electricity production, wind, <1 MW turbine, onshore | 2.26E-04 kWh |
| Electricity, high voltage [NO] electricity production, wind, >3 MW turbine, onshore | 3.72E-04 kWh |
| Electricity, high voltage [NO] electricity production, wind, 1–3 MW turbine, offshore | 2.70E-05 kWh |
| Electricity, high voltage [NO] electricity production, wind, 1–3 MW turbine, onshore | 1.07E-02 kWh |
| Electricity, high voltage [PL] electricity production, wind, <1 MW turbine, onshore | 1.28E-03 kWh |
| Electricity, high voltage [PL] electricity production, wind, >3 MW turbine, onshore | 4.44E-04 kWh |
| Electricity, high voltage [PL] electricity production, wind, 1–3 MW turbine, onshore | 3.29E-02 kWh |
| Electricity, high voltage [RO] electricity production, wind, <1 MW turbine, onshore | 5.02E-04 kWh |
| Electricity, high voltage [RO] electricity production, wind, >3 MW turbine, onshore | 4.12E-03 kWh |
| Electricity, high voltage [RO] electricity production, wind, 1–3 MW turbine, onshore | 1.46E-02 kWh |
| Electricity, high voltage [SE] electricity production, wind, <1 MW turbine, onshore | 7.34E-03 kWh |
| Electricity, high voltage [SE] electricity production, wind, >3 MW turbine, onshore | 2.46E-04 kWh |
| Electricity, high voltage [SE] electricity production, wind, 1–3 MW turbine, offshore | 2.10E-03 kWh |
| Electricity, high voltage [SE] electricity production, wind, 1–3 MW turbine, onshore | 4.26E-02 kWh |
| Electricity, high voltage [SK] electricity production, wind, <1 MW turbine, onshore | 4.40E-05 kWh |

Table 11

Dataset concerning European electricity production by others (geothermal and biogas).

| OUTPUT - Product | INPUT – Electricity/heat |
|------------------|--------------------------|
| Electricity, high voltage [EURO] electricity production, other | 1.000 kWh |
| Electricity, high voltage [AT] electricity production, deep geothermal | 1.00E-05 kWh |
| Electricity, high voltage [CH] electricity production, deep geothermal | 7.00E-06 kWh |
| Electricity, high voltage [DE] electricity production, deep geothermal | 2.87E-04 kWh |
| Electricity, high voltage [IS] electricity production, deep geothermal | 4.78E-02 kWh |
| Electricity, high voltage [IT] electricity production, deep geothermal | 5.13E-02 kWh |
| Electricity, high voltage [AT] heat and power co-generation, biogas, gas engine | 6.10E-03 kWh |
| Electricity, high voltage [BE] heat and power co-generation, biogas, gas engine | 7.77E-03 kWh |
| Electricity, high voltage [CH] heat and power co-generation, biogas, gas engine | 2.49E-03 kWh |
| Electricity, high voltage [CZ] heat and power co-generation, biogas, gas engine | 1.40E-02 kWh |
| Electricity, high voltage [DE] heat and power co-generation, biogas, gas engine | 2.64E-01 kWh |
| Electricity, high voltage [EE] heat and power co-generation, biogas, gas engine | 1.53E-04 kWh |
| Electricity, high voltage [FI] heat and power co-generation, biogas, gas engine | 1.33E-03 kWh |
| Electricity, high voltage [FR] heat and power co-generation, biogas, gas engine | 1.23E-02 kWh |
| Electricity, high voltage [GB] heat and power co-generation, biogas, gas engine | 5.62E-02 kWh |
| Electricity, high voltage [GR] heat and power co-generation, biogas, gas engine | 1.95E-03 kWh |
| Electricity, high voltage [HR] heat and power co-generation, biogas, gas engine | 5.74E-04 kWh |
| Electricity, high voltage [HU] heat and power co-generation, biogas, gas engine | 2.02E-03 kWh |
| Electricity, high voltage [IE] heat and power co-generation, biogas, gas engine | 1.90E-03 kWh |
| Electricity, high voltage [IT] heat and power co-generation, biogas, gas engine | 7.40E-02 kWh |
| Electricity, high voltage [LT] heat and power co-generation, biogas, gas engine | 3.83E-04 kWh |
| Electricity, high voltage [LU] heat and power co-generation, biogas, gas engine | 5.55E-04 kWh |
| Electricity, high voltage [LV] heat and power co-generation, biogas, gas engine | 2.10E-03 kWh |
| Electricity, high voltage [NL] heat and power co-generation, biogas, gas engine | 9.64E-03 kWh |
| Electricity, high voltage [NO] heat and power co-generation, biogas, gas engine | 1.05E-04 kWh |
| Electricity, high voltage [PL] heat and power co-generation, biogas, gas engine | 5.40E-03 kWh |
| Electricity, high voltage [RO] heat and power co-generation, biogas, gas engine | 1.91E-04 kWh |
| Electricity, high voltage [RS] heat and power co-generation, biogas, gas engine | 5.70E-05 kWh |
| Electricity, high voltage [SE] heat and power co-generation, biogas, gas engine | 1.91E-04 kWh |
| Electricity, high voltage [SI] heat and power co-generation, biogas, gas engine | 1.46E-03 kWh |
| Electricity, high voltage [SK] heat and power co-generation, biogas, gas engine | 1.82E-03 kWh |

Table 12

Medium voltage European electricity mix (assumption: network electricity losses = about 3%).

| OUTPUT - Product | INPUT – Electricity/heat |
|------------------|--------------------------|
| Electricity, medium voltage [EURO] electricity production mix | 1.000 kWh |
| Electricity, high voltage [EURO] electricity production, hard coal | 1.030 kWh |
Table 13
European electricity mix (high voltage) in 2050 according to BAU scenario.

| INPUT – Product | OUTPUT – Product |
|----------------|------------------|
| Electricity 2050-BAU, high voltage [EURO] electricity production mix | 1.000 kWh |
| Electricity, high voltage [EURO] electricity production, hard coal | 0.264 kWh |
| Electricity, high voltage [EURO] electricity production, lignite | 0.097 kWh |
| Electricity, high voltage [EURO] electricity production, oil | 0.006 kWh |
| Electricity, high voltage [EURO] electricity production, natural gas | 0.186 kWh |
| Electricity, high voltage [EURO] electricity production, nuclear | 0.220 kWh |
| Electricity, high voltage [EURO] electricity production, biomass | 0.036 kWh |
| Electricity, high voltage [EURO] electricity production, hydropower | 0.143 kWh |
| Electricity, high voltage [EURO] electricity production, wind | 0.046 kWh |
| Electricity, high voltage [EURO] electricity production, other | 0.034 kWh |

Table 14
European electricity mix (medium voltage) in 2050 according to BAU scenario. Assumption: network electricity losses = about 1.5% (considering a technological improvement of the network in next decades).

| INPUT – Product | OUTPUT – Product |
|----------------|------------------|
| Electricity BAU, medium voltage [EURO] electricity production mix | 1.000 kWh |
| Electricity BAU, high voltage [EURO] electricity production mix | 1.015 kWh |

Table 15
European electricity mix (high voltage) in 2050 according to REAL scenario.

| INPUT – Product | OUTPUT – Product |
|----------------|------------------|
| Electricity REAL, high voltage [EURO] electricity production mix | 1.000 kWh |
| Electricity, high voltage [EURO] electricity production, hard coal | 0.059 kWh |
| Electricity, high voltage [EURO] electricity production, oil | 0.002 kWh |
| Electricity, high voltage [EURO] electricity production, natural gas | 0.415 kWh |
| Electricity, high voltage [EURO] electricity production, nuclear | 0.244 kWh |
| Electricity, high voltage [EURO] electricity production, biomass | 0.033 kWh |
| Electricity, high voltage [EURO] electricity production, hydropower | 0.151 kWh |
| Electricity, high voltage [EURO] electricity production, wind | 0.070 kWh |
| Electricity, high voltage [EURO] electricity production, other | 0.026 kWh |

Table 16
European electricity mix (medium voltage) in 2050 according to REAL scenario. Assumption: network electricity losses = about 1.5% (considering a technological improvement of the network in next decades).

| INPUT – Product | OUTPUT – Product |
|----------------|------------------|
| Electricity REAL, medium voltage [EURO] electricity production mix | 1.000 kWh |
| Electricity REAL, high voltage [EURO] electricity production mix | 1.015 kWh |

Table 17
European electricity mix (high voltage) in 2050 according to OPT scenario.

| INPUT – Product | OUTPUT – Product |
|----------------|------------------|
| Electricity OPT, high voltage [EURO] electricity production mix | 1.000 kWh |
| Electricity, high voltage [EURO] electricity production, hard coal | 0.029 kWh |
| Electricity, high voltage [EURO] electricity production, oil | 0.005 kWh |
| Electricity, high voltage [EURO] electricity production, natural gas | 0.005 kWh |
| Electricity, high voltage [EURO] electricity production, nuclear | 0.169 kWh |
| Electricity, high voltage [EURO] electricity production, biomass | 0.158 kWh |
| Electricity, high voltage [EURO] electricity production, hydropower | 0.242 kWh |
| Electricity, high voltage [EURO] electricity production, wind | 0.323 kWh |
| Electricity, high voltage [EURO] electricity production, other | 0.079 kWh |
Table 18
European electricity mix (medium voltage) in 2050 according to OPT scenario. Assumption: network electricity losses = about 1.5% (considering a technological improvement of the network in next decades).

| OUTPUT - Product | 1.000 kWh |
|------------------|-----------|
| Electricity OPT, medium voltage (EURO) | electricity production mix |
| INPUT – Electricity/heat | 1.015 kWh |
| Electricity OPT, high voltage (EURO) | electricity production mix |

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

Acknowledgements

Authors acknowledge MIUR Grant—Department of Excellence 2018–2022 and the European Union’s Horizon 2020 Framework Program for funding Research and Innovation under Grant agreement no. 764047 (ESPResSO) for funding.

References

[1] M.L. Parisi, S. Maranghi, L. Vesce, A. Sinicropi, A. Di Carlo, R. Basosi, Prospective life cycle assessment of third-generation photovoltaics at the pre-industrial scale: a long-term scenario approach, Renew. Sustain Energy Rev. 121 (2020) 109703.
[2] S. Maranghi, M.L. Parisi, R. Basosi, A. Sinicropi, Environmental profile of the manufacturing process of perovskite photovoltaics: harmonization of life cycle assessment studies, Energies 12 (2019) 3746.
[3] G. Wernet, C. Bauer, B. Steubing, J. Reinhard, E. Moreno-Ruiz, B. Weidema, The ecoinvent database version 3 (part I): overview and methodology, Int. J. Life Cycle Assess. 21 (2016) 1218–1230.
[4] V. Fthenakis, R. Frischknecht, M. Raugei, H.C. Kim, E. Alsema, M. Held, et al., Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity, 2nd edition, IEA PVPS Task 12, International Energy Agency Photovoltaic Power systems Programme (2011).
[5] R. Frischknecht, W. Krewitt, M. Tuchschmid, Meeting the NEEDS of European environmental sustainability assessment., in: Proceedings of the 14th SETAC Europe LCA Case Study Symposium, Gothenburg, 2007, p. 8610. December 3 to 4, 2007.
[6] R. Frischknecht, NEEDS: effective assessment of long-term sustainable energy policies in Europe by integrating LCA, external costs and energy planning models, Der Systemblick auf Innovation, Technikfolgenabschätzung in der Technikgestaltung, Berlin, 2010, pp. 24–26.
[7] R. Frischknecht, G. Heath, M. Raugei, P. Sinha, M. de Wild Scholten, Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity, 3rd ed., IEA PVPS T, 2016.
[8] Frischknecht R., Itten R., Wyss F., Blanc I., Heath G., Raugei M., et al. Life Cycle Assessment of Future Photovoltaic Electricity Production From Residential - Scale Systems Operated in Europe. 2014.
[9] World bank 2016. https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS.