

Supplementary Materials: The Social Costs of Electricity Generation—Categorising Different Types of Costs and Evaluating Their Respective

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File S1: Input parameters for plant-level LCOE calculations

This supplementary file provides detailed information about how the plant-level LCOE values (ranges and central values) in the article for selected types of newly-built power plants in Europe and the USA were derived. In the article, these LCOE values are depicted in Figure 2, discussed in Section 3.1.5 and used as input for the social cost overview in Section 4.

Plant-level LCOE values are calculated for the following technologies:

- Nuclear power plants;
- Hard coal power plants;
- Natural gas power plants (combined-cycle gas turbine, CCGT);
- Onshore wind turbines;
- Offshore wind turbines;
- Solar PV power plants (utility-scale).

LCOE values for both Europe and the USA are calculated for current newly-built power plants. For the renewable energy technologies (i.e. onshore wind, offshore wind and solar PV), plant-level LCOE values are also calculated for power plants to be built in the year 2040, based on projections of future capital and O&M costs found in the literature. For nuclear, coal and natural gas power plants, plant-level LCOE values are assumed to remain constant at current values, so for these technologies no additional calculations were made for the year 2040.

As explained in the article, a discount rate of 3% is generally used, with a sensitivity case analysis shown for nuclear power plants using a 6% discount rate, reflecting the assumption that these plants exhibit higher investments risks than other types of power plants (particularly renewable energy plants) and that these additional risks can be captured by the higher discount rate.

The publicly available spreadsheet calculator from the Danish Energy Agency (<https://ens.dk/en/our-responsibilities/global-cooperation/levelized-cost-energy-calculator>) was used as a tool to calculate the plant-level LCOE values. While this calculator includes default values for the technical and economic parameters required to calculate LCOE values for various electricity generation technologies, many of these default values were adjusted to take up-to-date values and estimates for Europe and the USA into account, as provided by several literature sources.

CO₂ costs and transmission costs are not included in the plant-level costs as defined in the article, but are considered as external costs (CO₂) and system costs (transmission costs). Therefore, these costs are not included in this paper's LCOE calculations. No other external or system costs are included either, although the LCOE generator from the Danish Energy Agency allows costs for various external and system costs to be assigned and taken into account.

While grid connection costs are included in the overnight investment costs of wind and solar PV technologies, they are not taken into account by [1], the primary source used for the investment costs of nuclear, hard coal and natural gas power plants. While this omission gives conventional plants a slight advantage over renewables, this is not deemed to be significant as grid connection costs for conventional plants are reported to make up less than 5% of investment costs [2].

For reasons of simplification it is assumed that none of the power plant technologies exhibit reductions in conversion efficiency or any other deteriorations in technical characteristics or operational costs over their technical lifetime. Furthermore, transport costs of fossil fuels from the point of import or extraction to the respective power plants are not included.

The following tables list the input values used for the key LCOE parameters and the sources of the respective values. Tables are shown separately for Europe and the USA for the current situation and for the year 2040. US Dollar values found in the literature are converted to Euros using a conversion rate of 1.1 US Dollar per Euro.

The central values represent plants with typical or median costs, while the ranges are derived by varying capital costs (all technologies), full load hours (onshore wind, offshore wind and solar PV), fuel costs (coal and natural gas) and technical lifetime (nuclear power) within typically observed ranges. These ranges are documented in the tables.

The tables with the relevant input parameters are grouped into the following three categories:

- A. Assumptions on future natural gas, hard coal and uranium price developments;
- B. Technology-specific assumptions for current newly-built power plants;
- C. Technology-specific assumptions for renewable energy power plants to be built in 2040.

A. Assumptions on future natural gas, hard coal and uranium price developments

Table A1: Natural gas price development assumed for low end of LCOE price range.

Year	Price (in EUR/GJ)		Source	Comment
	Europe	USA		
2015	6.0	2.2	[3]	Historic value
2020	5.9	3.4	[3]	450 Scenario
2030	8.1	4.1	[3]	450 Scenario
2040 and beyond	8.5	4.7	[3]	450 Scenario

Table A2: Natural gas price development assumed for central LCOE estimate.

Year	Price (in EUR/GJ)		Source	Comment
	Europe	USA		
2015	6.0	2.2	[3]	Historic value
2020	6.1	3.5	[3]	New Policies Scenario
2030	8.9	4.7	[3]	New Policies Scenario
2040 and beyond	9.9	5.9	[3]	New Policies Scenario

Table A3: Natural gas price development assumed for high end of LCOE price range.

Year	Price (in EUR/GJ)		Source	Comment
	Europe	USA		
2015	6.0	2.2	[3]	Historic value
2020	6.3	3.7	[3]	Current Policies Scenario
2030	9.6	5.1	[3]	Current Policies Scenario
2040 and beyond	11.2	6.8	[3]	Current Policies Scenario

Table A4: Hard coal price development assumed for low end of LCOE price range.

Year	Price (in EUR/GJ)		Source	Comment
	Europe	USA		
2015	2.0	1.8	[3]	Historic value
2020	2.0	1.9	[3]	450 Scenario
2030	2.0	1.8	[3]	450 Scenario
2040 and beyond	1.8	1.7	[3]	450 Scenario

Table A5: Hard coal price development assumed for central LCOE estimate.

Year	Price (in EUR/GJ)		Source	Comment
	Europe	USA		
2015	2.0	1.8	[3]	Historic value
2020	2.2	1.9	[3]	New Policies Scenario
2030	2.6	2.0	[3]	New Policies Scenario
2040 and beyond	2.7	2.1	[3]	New Policies Scenario

Table A6: Hard coal price development assumed for high end of LCOE price range

Year	Price (in EUR/GJ)		Source	Comment
	Europe	USA		
2015	2.0	1.8	[3]	Historic value
2020	2.3	2.0	[3]	Current Policies Scenario
2030	2.8	2.1	[3]	Current Policies Scenario
2040 and beyond	3.1	2.2	[3]	Current Policies Scenario

Table A7: Uranium price development assumed for full LCOE range

Year	Price (in EUR/GJ)		Source	Comment
	Europe	USA		
Entire period	2.4	2.4	[1]	Includes back-end fuel cycle costs

B. Technology-specific assumptions for current newly-built power plants

Table B1: Technological and economic assumptions for current new nuclear power plants in Europe and the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	4000	Own assumption	Based on [1,4–7]
Overnight investment cost (central cost estimate)	Thousand €/MW	5500	Own assumption	
Overnight investment cost (high cost estimate)	Thousand €/MW	6500	Own assumption	
Fixed O&M	€/MW/a	62,545	[1]	Median values from all nuclear power plants listed
Variable O&M	€/MWh	6.3	[1]	
Net electrical efficiency	%	n. a.	-	-
Full load hours	Hours/year	7446	[1]	Capacity factor of 85%
Technical lifetime (low cost estimate)	Years	60	[1]	-
Technical lifetime (central cost estimate)	Years	50	Own assumption	Mean value of the values provided by [1] and [8]
Technical lifetime (high cost estimate)	Years	40	[8]	
Construction time	Years	7	[1]	-

Table B2: Technological and economic assumptions for current new hard coal power plants in Europe.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	1470	[1]	Lowest value for new hard coal plants in Europe
Overnight investment cost (central cost estimate)	Thousand €/MW	2300	[1]	Median value for new hard coal plants in Europe
Overnight investment cost (high cost estimate)	Thousand €/MW	2790	[1]	Highest value for new hard coal plants in Europe
Fixed O&M	€/MW/a	34,221	[1]	Median values from all new hard coal plants
Variable O&M	€/MWh	3.1	[1]	
Net electrical efficiency	%	46	[1]	Median value for new hard

				coal plants in Europe
Full load hours	Hours/year	7446	[1]	Capacity factor of 85%
Technical lifetime (low cost estimate)	Years	40	[1]	-
Construction time	Years	4	[1]	-

Table B3: Technological and economic assumptions for current new hard coal power plants in the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	2270	[1]	-
Overnight investment cost (central cost estimate)	Thousand €/MW	3310	[4]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	4,490	[4]	-
Fixed O&M	€/MW/a	38,273	[4]	-
Variable O&M	€/MWh	4.2	[4]	-
Net electrical efficiency	%	43		-
Full load hours	Hours/year	7446	[1]	Capacity factor of 85%
Technical lifetime (low cost estimate)	Years	40	[1]	-
Construction time	Years	4	[1]	-

Table B4: Technological and economic assumptions for current new natural gas power plants (CCGT) in Europe.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	860	[1]	Lowest value for new plants in Europe
Overnight investment cost (central cost estimate)	Thousand €/MW	890	[1]	Median value for new plants in Europe
Overnight investment cost (high cost estimate)	Thousand €/MW	1003	[1]	Highest value for new plants in Europe
Fixed O&M	€/MW/a	26,759	[1]	Median values from all new natural gas CCGT plants
Variable O&M	€/MWh	2.5	[1]	
Net electrical efficiency	%	60	[1]	Median value for new plants in Europe
Full load hours	Hours/year	7446	[1]	Capacity factor of 85%
Technical lifetime (low cost estimate)	Years	30	[1]	-
Construction time	Years	2	[1]	-

Table B5: Technological and economic assumptions for current new natural gas power plants (CCGT) in the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	760	[1,4]	-
Overnight investment cost (central cost estimate)	Thousand €/MW	890	[1,4]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	1,450	[1,4]	-
Fixed O&M	€/MW/a	10,000	[4]	-
Variable O&M	€/MWh	3.2	[4]	-
Net electrical efficiency	%	60	[1]	-
Full load hours	Hours/year	7446	[1]	Capacity factor of 85%
Technical lifetime (low cost estimate)	Years	30	[1]	-
Construction time	Years	2	[1]	-

Table B6: Technological and economic assumptions for current new onshore wind turbines in Europe.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	1050	[9]	-
Overnight investment cost (central cost estimate)	Thousand €/MW	1660	[9]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	2200	Own assumption	Value provided by [9] (3370) was adjusted downward ^a
Fixed O&M	€/MW/a	44,545	[1]	Median values from all new onshore wind turbines
Variable O&M	€/MWh	0	[1]	
Net electrical efficiency	%	n. a.		-
Full load hours (low cost estimate)	Hours/year	4468	[9]	-
Full load hours (central cost estimate)	Hours/year	2365	[9]	-
Full load hours (high cost estimate)	Hours/year	1900	Own assumption	Value provided by [9] (1226) was adjusted upward ^a
Technical lifetime (low cost estimate)	Years	25	[1]	-
Construction time	Years	1	[1]	-

^a See footnote to Table B7.Table B7: Technological and economic assumptions for current new onshore wind turbines in the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	1150	[9]	-
Overnight investment cost (central cost estimate)	Thousand €/MW	1570	[9]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	2400	Own assumption	Value provided by [9] (2560) was adjusted downward ^a
Fixed O&M	€/MW/a	46,364	[10]	-
Variable O&M	€/MWh	0	[10]	
Net electrical efficiency	%	n. a.	-	-
Full load hours (low cost estimate)	Hours/year	4468	[9]	-
Full load hours (central cost estimate)	Hours/year	3592	[9]	-
Full load hours (high cost estimate)	Hours/year	2200	Own assumption	Value provided by [9] (1927) was adjusted upward ^a
Technical lifetime (low cost estimate)	Years	25	[1]	-
Construction time	Years	1	[1]	-

^a Values provided by [9] were adjusted to reflect the fact that the lowest full load hours and the highest overnight investment costs do not typically coincide at one power plant project. While the LCOE *range*, the overnight investment cost *range* and the full load hour *range* of the sum of all projects identified by [9] were available to the author, the respective *individual values* for each project were not. Therefore, the LCOE range provided by [9] was used to contain the high cost values for overnight investment costs and full load hours. A respective adjustment of the low cost values turned out to be unnecessary.

Table B8: Technological and economic assumptions for current new offshore wind turbines in Europe.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	2950	[11]	-
Overnight investment cost (central cost estimate)	Thousand €/MW	4460	[11]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	5000	Own assumption	Value provided by [11] (5820) was adjusted downward so as to obtain a reasonable high cost LCOE estimate (in line with the one found in [11])
Fixed O&M	€/MW/a	125,455	[10]	-
Variable O&M	€/MWh	0	[10]	-
Net electrical efficiency	%	n. a.	-	-
Full load hours (low cost estimate)	Hours/year	4786	Own assumption	Value for central cost estimate +30%
Full load hours (central cost estimate)	Hours/year	3682	[12]	-
Full load hours (high cost estimate)	Hours/year	3000	Own assumption	Value was chosen so as to obtain a reasonable high cost LCOE estimate (in line with the one found in [11])
Technical lifetime (low cost estimate)	Years	25	[1]	-
Construction time	Years	1	[1]	-

Table B9: Technological and economic assumptions for current new offshore wind turbines in the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	2820	[8]	-
Overnight investment cost (central cost estimate)	Thousand €/MW	4400	[10]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	5000	Own assumption	Value provided by [4] (5760) was adjusted downward so as to obtain a reasonable high cost LCOE estimate (in line with the one found in [11])
Fixed O&M	€/MW/a	125,455	[10]	-
Variable O&M	€/MWh	0	[10]	-
Net electrical efficiency	%	n. a.	-	-
Full load hours (low cost estimate)	Hours/year	4829	Own assumption	Value for central cost estimate +30%
Full load hours (central cost estimate)	Hours/year	3714	[10]	-
Full load hours (high cost estimate)	Hours/year	3000	Own assumption	Value was chosen so as to obtain a reasonable high cost LCOE estimate (in line with the one found in [11])
Technical lifetime (low cost estimate)	Years	25	[1]	-
Construction time	Years	1	[1]	-

Table B10: Technological and economic assumptions for current new solar PV power plants (utility-scale) in Europe.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	1230	[8]	Data from the USA, but costs are here assumed to be identical in Europe
Overnight investment cost (central cost estimate)	Thousand €/MW	1360	[8]	
Overnight investment cost (high cost estimate)	Thousand €/MW	1590	[8]	
Fixed O&M	€/MW/a	22,557	[1]	-
Variable O&M	€/MWh	0	[1]	-
Net electrical efficiency	%	n. a.		-
Full load hours (low cost estimate)	Hours/year	1680	[13]	-
Full load hours (central cost estimate)	Hours/year	1190	[13]	Median value of all values shown
Full load hours (high cost estimate)	Hours/year	960	[13]	-
Technical lifetime (low cost estimate)	Years	30	[13]	-
Construction time	Years	1	[1]	-

Table B11: Technological and economic assumptions for current new solar PV power plants (utility-scale) in the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	1230	[8]	-
Overnight investment cost (central cost estimate)	Thousand €/MW	1360	[8]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	1590	[8]	-
Fixed O&M	€/MW/a	19,818	[4]	-
Variable O&M	€/MWh	0	[4]	-
Net electrical efficiency	%	n. a.		-
Full load hours (low cost estimate)	Hours/year	3066	[14]	-
Full load hours (central cost estimate)	Hours/year	2260	[15]	Average value for the year 2015
Full load hours (high cost estimate)	Hours/year	1752	[14]	-
Technical lifetime (low cost estimate)	Years	30	[13]	-
Construction time	Years	1	[1]	-

C. Technology-specific assumptions for new renewable energy power plants to be built in 2040

Table C1: Technological and economic assumptions for new onshore wind turbines built in 2040 in Europe.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	1025	Own assumption	Assumes that the lowest overnight investment costs will be 30% lower than central value
Overnight investment cost (central cost estimate)	Thousand €/MW	1464	[16]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	1903	Own assumption	Assumes that the highest overnight investment costs

				will be 30% higher than central value
Fixed O&M	€/MW/a	37,273	[16]	-
Variable O&M	€/MWh	0	[16]	-
Net electrical efficiency	%	n. a.		-
Full load hours (low cost estimate)	Hours/year	4468	[9]	-
Full load hours (central cost estimate)	Hours/year	2365	[9]	-
Full load hours (high cost estimate)	Hours/year	1900	Own assumption	-
Technical lifetime (low cost estimate)	Years	25	[1]	-
Construction time	Years	1	[1]	-

Table C2: Technological and economic assumptions for new onshore wind turbines built in 2040 in the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand € ₂₀₁₅ /MW	1025	Own assumption	Assumes that the lowest overnight investment costs will be 30% lower than central value
Overnight investment cost (central cost estimate)	Thousand € ₂₀₁₅ /MW	1464	[16]	-
Overnight investment cost (high cost estimate)	Thousand € ₂₀₁₅ /MW	1903	Own assumption	Assumes that the highest overnight investment costs will be 30% higher than central value
Fixed O&M	€/MW/a	37,273	[16]	-
Variable O&M	€/MWh	0	[16]	-
Net electrical efficiency	%	n. a.		-
Full load hours (low cost estimate)	Hours/year	4468	[9]	-
Full load hours (central cost estimate)	Hours/year	3592	[9]	-
Full load hours (high cost estimate)	Hours/year	2200	Own assumption	-
Technical lifetime (low cost estimate)	Years	25	[1]	-
Construction time	Years	1	[1]	-

Table C3: Technological and economic assumptions for new offshore wind turbines built in 2040 in Europe.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	1973	[11]	Assumes that the lowest overnight investment costs will be 30% lower than central value
Overnight investment cost (central cost estimate)	Thousand €/MW	2818	[16]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	3664	Own assumption	Assumes that the highest overnight investment costs will be 30% higher than central value
Fixed O&M	€/MW/a	98,182	[16]	-
Variable O&M	€/MWh	0	[16]	-
Net electrical efficiency	%	n. a.	-	-
Full load hours	Hours/year	4786	Own assumption	Value for central cost

(low cost estimate)				estimate +30%
Full load hours (central cost estimate)	Hours/year	3682	[12]	-
Full load hours (high cost estimate)	Hours/year	3000	Own assumption	-
Technical lifetime (low cost estimate)	Years	25	[1]	-
Construction time	Years	1	[1]	-

Table C4: Technological and economic assumptions for new offshore wind turbines built in 2040 in the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	1973	[11]	Assumes that the lowest overnight investment costs will be 30% lower than the central value
Overnight investment cost (central cost estimate)	Thousand €/MW	2818	[16]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	3664	Own assumption	Assumes that the highest overnight investment costs will be 30% higher than the central value
Fixed O&M	€/MW/a	98,182	[16]	-
Variable O&M	€/MWh	0	[16]	-
Net electrical efficiency	%	n. a.	-	-
Full load hours (low cost estimate)	Hours/year	4829	Own assumption	Value for central cost estimate +30%
Full load hours (central cost estimate)	Hours/year	3714	[10]	-
Full load hours (high cost estimate)	Hours/year	3000	Own assumption	-
Technical lifetime (low cost estimate)	Years	25	[1]	-
Construction time	Years	1	[1]	-

Table C5: Technological and economic assumptions for new solar PV power plants (utility-scale) built in 2040 in Europe.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	750	Own assumption	Assumes that the lowest overnight investment costs will be 10% lower than the central value
Overnight investment cost (central cost estimate)	Thousand €/MW	840	[16]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	920	Own assumption	Assumes that the highest overnight investment costs will be 10% higher than the central value
Fixed O&M	€/MW/a	8182	[16]	-
Variable O&M	€/MWh	0	[16]	-
Net electrical efficiency	%	n. a.	-	-
Full load hours (low cost estimate)	Hours/year	1680	[13]	-
Full load hours (central cost estimate)	Hours/year	1190	[13]	Median value of all values shown
Full load hours (high cost estimate)	Hours/year	960	[13]	-

Technical lifetime (low cost estimate)	Years	30	[13]	-
Construction time	Years	1	[1]	-

Table C6: Technological and economic assumptions for new solar PV power plants (utility-scale) built in 2040 in the USA.

Parameter	Unit	Value	Source	Comment
Overnight investment cost (low cost estimate)	Thousand €/MW	750	Own assumption	Assumes that the lowest overnight investment costs will be 10% lower than the central value
Overnight investment cost (central cost estimate)	Thousand €/MW	840	[16]	-
Overnight investment cost (high cost estimate)	Thousand €/MW	920	Own assumption	Assumes that the highest overnight investment costs will be 10% higher than the central value
Fixed O&M	€/MW/a	8182	[16]	-
Variable O&M	€/MWh	0	[16]	-
Net electrical efficiency	%	n. a.	-	-
Full load hours (low cost estimate)	Hours/year	3066	[14]	-
Full load hours (central cost estimate)	Hours/year	2260	[15]	-
Full load hours (high cost estimate)	Hours/year	1752	[14]	-
Technical lifetime (low cost estimate)	Years	30	[13]	-
Construction time	Years	1	[1]	-

References

1. International Energy Agency (IEA). *Projected Costs of Generating Electricity, 2015 Edition*; IEA: Paris, France, 2015.
2. Swider, D.J.; Beurskens, L.; Davidson, S.; Twidell, J.; Pyrko, J.; Prügler, W.; Auer, H.; Vertin, K.; Skema, R. Conditions and costs for renewables electricity grid connection: Examples in Europe. *Renew. Energy* **2008**, *33*, 1832–1842.
3. *World Energy Outlook 2016*; IEA Edition; Organisation for Economic Co-operation and Development (OECD): Paris, France, 2016.
4. U.S. Energy Information Administration. *Capital Cost Estimates for Utility Scale Electricity Generating Plants*; U.S. Energy Information Administration: Washington, DC, USA, 2016.
5. Schröder, A.; Kunz, F.; Meiss, J.; Mendelevitch, R.; von Hirschhausen, C. *Current and Prospective Costs of Electricity Generation until 2050*; DIW: Berlin, Germany, 2013.
6. Lévy, J.-B.; Ursat, X. A responsible electricity company, a champion of low carbon energy growth. Presented at EDF Press Conference, 3 September 2015, Paris, France, 2015.
7. Rankin, J. Flamanville: France's beleaguered forerunner to Hinkley Point C. In *The Guardian* 2016; Guardian News & Media: London, UK, 2016.
8. Lazard. *Lazard's Levelized Cost of Energy Analysis*, version 10.0; Lazard: New York, NY, USA, 2016.
9. International Renewable Energy Agency (IRENA). *Renewable Power Generation Costs in 2016*; IRENA: Abu Dhabi, UAE, 2017. [Forthcoming]
10. Moné, C.; Stehly, T.; Maples, B.; Settle, E. *2014 Cost of Wind Energy Review*; National Renewable Energy Laboratory: Golden, CO, USA, 2015.
11. International Renewable Energy Agency (IRENA). *The Power to Change: Solar and Wind Cost Reduction Potential to 2025*; IRENA: Bonn, Germany, 2016.
12. The European Wind Energy Association (EWEA). *Wind in power—2015 European Statistics*; EWEA: Brussels, Belgium, 2016.

13. Vartiainen, E.; Masson, G.; Breyer, C. *PV LCOE in Europe 2014–30*; European Photovoltaic Technology Platform: Munich, Germany, 2015.
14. Bolinger, M.; Seel, J. *Utility-Scale Solar 2015: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*; Lawrence Berkeley National Laboratory: Berkeley, CA, USA, **2016**.
15. U.S. Energy Information Administration *Electric Power Monthly with Data for October 2016*; U.S. Energy Information Administration: Washington, DC, USA, 2016.
16. Teske, S.; Sawyer, S.; Schäfer, O. *Energy [r]evolution—A Sustainable World Energy Outlook 2015—100% Renewable Energy for All*; Greenpeace International, Global Wind Energy Council, SolarPowerEurope: Hamburg, Germany, 2015.