Documentation for included technology data and fuel costs

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Renewable Energy Investment Strategies –
A two-dimensional interconnectivity approach

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D-2.2: Documentation for included Technology Data and fuel costs

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1 Introduction

This report includes the database for technologies data and fuel costs. Whenever is possible the Danish Energy Agency technology catalogue (November 2019 version) [1] has been used. Nuclear, coal and lignite power plants are not included in the DEA technology catalogue, so we have used Lazards report (version 13) [8]. When a range is provided, we use the median value. For biomass CHP and HOP (Heat Only Plant), DEA technology catalogue includes costs for straw, wood pellets, wood chips and urban waste. So far, we are only using those corresponding to straw.

Table 1 gathers the capital costs projection for the different technologies in 2020, 2030, 2040 and 2050. A significant cost reduction is expected for some of the technologies. To exemplify this, the evolution of relative annualized cost for some selected technologies are depicted in Figure 1.

Table 2 includes the main technological parameters, *i.e.,* fixed operation and maintenance (FOM) cost as a percentage of capital cost, lifetime and efficiency.

Finally, table 3 gathers the costs and emissions factors for the different fuels.

Below some additional comments for specific technologies are included:

- For solar PV, the DEA database assumes a lifetime of 40 years (from 2040 onwards). We considered this value to be too optimistic and have then considered a different source for solar PV data [6, 7]. The annualised cost for rooftop and utility-scale photovoltaics is similar for both databases, see Figure 2.

- For nuclear, there is a wide range of costs being reported. For instance, the Lazards report [8] shows a range of 6,900 – 12,200 $/kW. We have followed a conservative approach and selected the intermediate value in that range.

- For decentral (individual) heat pumps, there are large costs differences depending on their scale, for instance when taking the case of single family or multifamily building applications of this technology. The costs presented here show this differentiation for decentral heat pump costs on existing buildings based on the categories presented in the DEA's technology catalogue.

2 Capital cost and forecast evolution in time

Technology	Unit	2020	2025	2030	2035	2040	2045	2050	source
Onshore Wind	e/kWel	1118	1077	1035	1006	977	970	963	[1]
Offshore Wind	e/kWel	2128	2031	1934	1871	1808	1792	1777	[1]
Solar PV (utility-scale)	e/kWel	398	326	254	221	188	169	151	[6]
Solar PV (rooftop)	e/kWel	1127	955	784	723	661	600	539	[7]
OCGT	e/kWel	453	444	435	429	423	417	411	[1]
CCGT	e/kWel	880	855	830	822	815	807	800	[1]
Coal power plant (subcritical process)	e/kWel	3845	3845	3845	3845	3845	3845	3845	[8]
Coal power plant (supercritical process)	ekWel	1900	1880	1860	1841	1822	1803	1783	[1]
Lignite	e/kWel	3845	3845	3845	3845	3845	3845	3845	[8]
Nuclear	e/kWel	7940	7940	7940	7940	7940	7940	7940	[8]
Reservoir hydro	e/kWel	2208	2208	2208	2208	2208	2208	2208	[9]
Run of river	e/kWel	3312	3312	3312	3312	3312	3312	3312	[9]
PHS	e/kWel	2208	2208	2208	2208	2208	2208	2208	[9]
Gas CHP	e/kWel	590	575	560	550	540	530	520	[1]
Biomass CHP	e/kWel	3500	3400	3300	3224	3150	3075	3000	[1]
Coal CHP	e/kWel	1900	1880	1860	1841	1822	1803	1783	[1]
Biomass central heat plant	e/kWel	890	865	840	820	800	780	760	[1]
Biomass power plant	e/kWel	3500	3400	3300	3224	3150	3075	3000	[1]
HVDC overhead	e/MWkm	400	400	400	400	400	400	400	[4]
HVDC inverter pair	e/MW	150000	150000	150000	150000	150000	150000	150000	[4]
Battery storage	e/kWh	232	187	142	118	94	84	75	[1]
Battery inverter	e/kWel	270	215	160	130	100	80	60	[1]
Electrolysis	e/kWel	600	575	550	537	525	512	500	[1]
Fuel cell	e/kWel	1300	1200	1100	1025	950	875	800	[1]
H2 storage underground	e/kWh	3	2.5	2	1.8	1.5	1.4	1.2	[1]
H2 storage tank	e/kWh	57	50	44	35	27	24	21	[1]
DAC (direct aire capture)	e/(tCO2/a)	730	534	338	287	237	218	199	[5]
Methanation + DAC	e/kWH2	1000	1000	1000	1000	1000	1000	1000	[2]
Central gas boiler	e/kWth	60	55	50	50	50	50	50	[1]
Decentral gas boiler	e/kWth	312	304	296	289	282	275	268	[1]

Central resistive heater	e/kWth	70	65	60	60	60	60	60	[1]
Decentral resistive heater	e/kWth	100	100	100	100	100	100	100	[42]
Central water tank	e/kWh	3	3	3	3	3	3	3	[1]
Decentral water tank	e/kWh	18	18	18	18	18	18	18	[1, 3]
Decentral air-sourced heat pump, single family housing (SFH)	e/kWth	940	894	850	827	804	782	760	[1]
Decentral air sourced heat pump. multifamily housing (MFH)	e/kWth	353	335	318	309	301	293	285	[1]
Central ground-sourced heat pump	e/kWth	657	625	592	577	562	547	532	[1]
Decentral ground-sourced heat pump, SFH	e/kWth	1500	1450	1400	1349	1299	1250	1200	[1]
Decentral ground sourced heat pump. MFH	e/kWth	622.5	591.2	560	546.2	532.5	518.7	505	[1]

Table 1. Overnight investment cost assumptions per technology and year. All costs are given in real 2015 money.

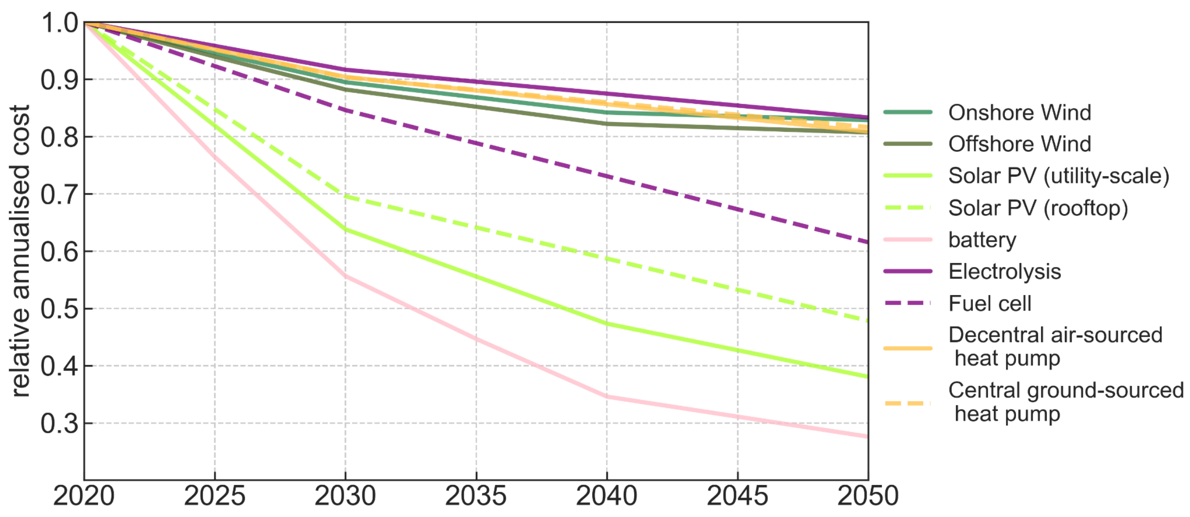

Figure 1: Evolution of annualised costs, relative to 2020, for some selected technologies.7% discount rate is assumed for cost annualization.

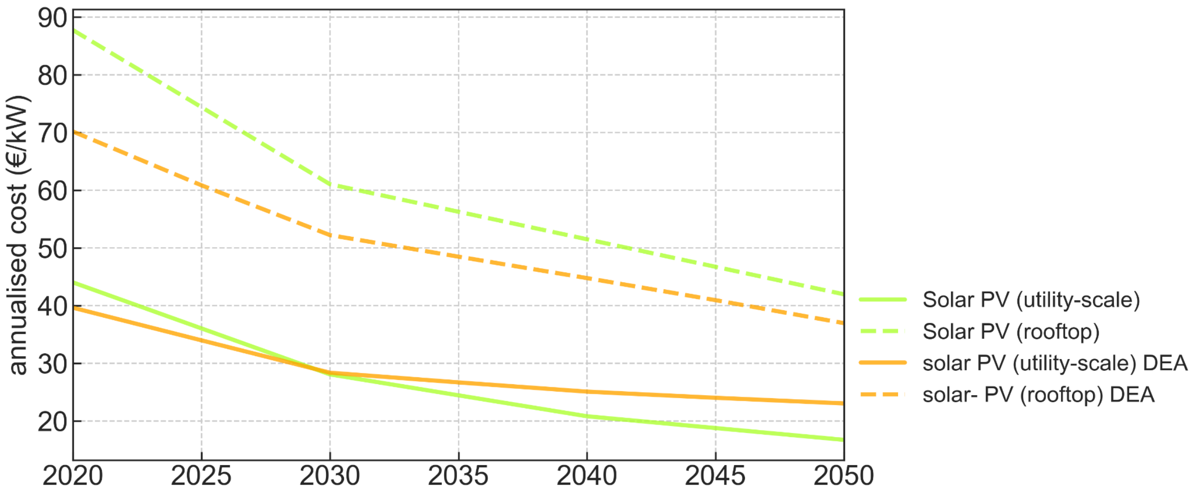

Figure 2. Evolution of annualised cost for rooftop and utility-scale photovoltaic installations.

3 Lifetime, efficiency, and FOM cost

Technology	FOM [%/a]	Lifetime [a]	Efficiency	source
Onshore Wind	1.3	27		[1]
Offshore Wind	1.9	27		[1]
Solar PV (utility-scale)	3	30		[6]
Solar PV (rooftop)	2	30		[7]
OCGT	1.8	25	0.42	[1]
CCGT	3.3	25	0.59	[1]
Coal power plant (subcritical process)	1.6	40	0.33	[8]
Coal power plant (supercritical process)	1.6	25	1	[1]
Lignite	1.6	40	0.33	[8]
Nuclear	1.4	40	0.33	[8]
Reservoir hydro	1	80	0.9	[9]
Run of river	2	80	0.9	[9]
PHS	1	80	0.75	[9]
Gas CHP	3.3	25		[1]
Biomass CHP	3.6	25		[1]
Coal CHP	1.6	25	1	[1]
Biomass central heat plant	5.8	25	1	[1]
Biomass power plant	3.6	25	0.31	[1]
HVDC overhead	2	40		[4]

HVDC inverter pair	2	40		[4]
Battery storage	0	20		[1]
Battery inverter	0.2	20	0.9	[1]
Electrolysis	5	25	0.8	[1,4]
Fuel cell	5	10	0.58	[1,4]
H2 storage underground	2	100	1	[1]
H2 storage tank	1.1	25		[1]
DAC (direct air capture)	4	30		[1]
Methanation	3	25	0.6	[2]
Central gas boiler	2.8	25	1	[1]
Decentral gas boiler	0.1	20	0.97	[1]
Central resistive heater	1.5	20	0.99	[1]
Decentral resistive heater	2	20	0.9	[4]
Central water tank	0.5	20		[1]
Decentral water tank	1	20		[1, 3]
Decentral air-sourced heat pump, SFH	3	18		[1]
Decentral ground-sourced heat pump, MFH	1.2	20		[1]
Central ground-sourced heat pump	0.3	25		[1]
Decentral ground-sourced heat pump, SFH	1.9	20		[1]
Decentral ground-sourced heat pump, MFH	0.7	20		[1]

Table 1. Efficiency, lifetime, and FOM cost per technology (values shown corresponds to 2020).

4 Fuel costs and emission factors

Fuel	Cost [€/MWh_{th}]	Source	Emissions [$tCO2/MWh_{th}$]	Source
coal	8.2	[11]	0.336	[14]
lignite	2.9	[9]	0.407	[14]
gas	20.1	[11]	0.201	[14]
oil	50	[47]	0.266	[14]
nuclear	2.6	[8]	0	
solid biomass	25.2	[12, 13]	0	

***Table 1.** Costs and emissions coefficient of fuels. Raw biomass fuel cost is assumed as the middle value of the range provided in the references for different European countries and types of sustainable biomass.*

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