Multi-Carrier Model Data

Detailed Version

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Numerical Data

Table 1: Capacities and costs of various technologies

Technology	κ_0^x GW(h)	κ_{max}^x GW(h)	ζ^x k€/MW(h)	θ_f^x M€/GW*year	θ_v^x €/MWh	Lifetime years	Source
Solar PV	4.0	40.0[1]	510.0	8.8	0.0	30	[12, 2]
Wind onshore	2.8	8.4[1]	910.0	22.3	2.3	30	[12, 2]
Wind offshore	2.3	8.0[1]	2000.0	37.8	2.7	30	[11, 2]
OCGT	0.0	N/A	560.0	18.6	4.2	25	[2]
CCGT	0.0	N/A	830.0	27.8	4.2	25	[2]
Fuel Cells	0.0	N/A	2000.0	100.0	0.0	20	[2]
Nuclear	3.0[2]	N/A	N/A	93.0	2.1	N/A	[1]
CHP	1.8	1.8	N/A	40.0	0.0	N/A	[13]
Biomass	0.3	0.3	N/A	92.3	3.7	N/A	[2]
Waste	0.9	0.9	N/A	175.6	2.5	N/A	[2]
Electrolysis	0.0	N/A	600.0	30.0	0.0	20	[2]
Methanation	0.0	N/A	400.0	30.0	0.0	20	[24]
SMR	0.0	N/A	400.0	20.0	0.0	25	[18]
Pumped-hydro	1.3 GW / 5.3 GWh	1.3 GW / 5.3 GWh	N/A	45.0	8.0	N/A	[7]
Batteries[4]	0 GW / 0 GWh	N/A	108.0 (p) / 326.5 (e)	5.4 (p) / 16.3 (e)	0.0	25	[19, 20]
Hydrogen Storage	0.0	N/A	8.4	0.0	0.0	30	[4]
Nat. Gas Storage	8000.0	8000.0	N/A	0.0	2.5[5]	N/A	
Post-Combustion CC[6]	0.0	N/A	2160.0 (WS, BM) / 3150.0 (NG, SMR)	N/A	N/A	25	[21]
Direct Air CC[6]	0.0	N/A	7500.0	N/A	25.0	25	[17]

[1] Variable renewable generation technical potential across all scenarios, unless otherwise stated.
[2] Capacity assumed available in one of the selected scenarios.
[3] Pumped-hydro and battery storages have distinct power (p) and energy (e) components.
[4] Costs retrieved from consultations with the industrial partner.
[5] Both capacities and costs of the carbon capture technologies are expressed on a kT/h basis.

Table 2: Other capacities and costs

Parameter	Unit	Value	Source
Electricity imports capacity	GW	6.5	[6]
Electricity imports costs	€/MWh	Time Series	[22]
Hydrogen import capacity	GWh	165.0	Energy volume per tanker.
Hydrogen imports costs	€/MWh	160.0	[16]
Natural Gas import costs	€/MWh	time series	Confidential data provided by the industrial partner.
Biomass fuel cost	€/MWh	35.0	[15]
Waste fuel cost	€/MWh	10.0	Assumed.
CO2 transport capacity	kT/h	3.5	Assumed from [21, 25].
CO2 storage capacity	kT	100.0	Assumed.
CO2 transport cost	€/t	2.0	[21]
CO2 emission price	€/t	80.0	Assumed.
VoLL (electricity)	€/MWh	3000.0	[8]
VoLL (hydrogen)	€/MWh	500.0	Retrieved from consultations with the industrial partner.
VoLL (natural gas)	€/MWh	500.0	Retrieved from consultations with the industrial partner.

Table 3: Operational parameters of various technologies

Technology	η[1]	Δ_-/Δ_+[2]	μ[3]	ν	ϕ	Source
	%	% of IC	%	tCO2/MWh	MWh/tCO2	
OCGT	41.0	100.0/100.0	0.0	0.202	N/A	[2, 14]
CCGT	58.0	100.0/100.0	0.0	0.202	N/A	[2, 14]
Fuel Cells	50.0	100.0/100.0	0.0	0.0	N/A	[2, 14]
Nuclear	N/A[4]	1.0/1.0	20.0	0.0	N/A	[1]
CHP	49.0[5]	30.0/25.0	20.0	0.218[6]	N/A	[13, 14]
Biomass	28.1	30.0/25.0	20.0	0.4	N/A	[2, 14]
Waste	22.7	30.0/25.0	20.0	0.33	N/A	[2, 14]
Electrolysis	62.0	100.0/100.0	5.0	N/A	N/A	[2, 23]
Methanation	78.0	100.0/100.0	5.0	N/A	N/A	[5]
SMR	80.0	N/A	0.0	0.202	N/A	[18, 14]
Pumped-hydro	80.0	N/A	N/A	N/A	N/A	[2]
Batteries	85.0 (99.9)	N/A	N/A	N/A	N/A	
Hydrogen Storage[7]	96.4	N/A	N/A	N/A	N/A	
Nat. Gas Storage[7]	99.0	N/A	N/A	N/A	N/A	
Post-Combustion CC	90.0	N/A	N/A	N/A	0.4125[8]	[3]
Direct Air CC	N/A	N/A	N/A	N/A	0.35/1.45[9]	[17]

[1] For power generation technologies, the electrical efficiency is provided. For conversion technologies, we refer to the overall process efficiency, considering the LHV of the output fuel. For storage technologies, round-trip efficiency is provided, while batteries include also a non-negligible self-discharge factor, mentioned in parantheses. For carbon capture technologies, the value represents the share of CO2 captured.
[2] Assumed values.
[3] Assumed values.
[4] Nuclear power plant capacity represents the electrical output.
[5] Only the electrical side is considered.
[6] Value taking into account 90% of units running on natural gas and the rest on biomass [9].
[7] Values obtained following discussions with the industrial partner.
[8] Electricity demand per unit of captured CO2.
[9] Electricity and natural gas, respectively, demands per unit of captured CO2.

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