

Supplementary Material for ‘Energy system impacts of fossil-free steelmaking using hydrogen direct reduction’

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Cost Inputs for H-DR/EAF Steelmaking

Description	Value	Unit
Price of iron ore pellets	90.91	[£/t]
Maintenance and operation cost	3	[% of CAPEX]
Price of fluxes to EAF	81.82	[£/t]
Price of scrap	163.64	[£/t]
Cost of labour	48.36	[£/tLS]
Price oxygen can be sold	55.27	[£/t]
Share of oxygen possible to sell	60	[%]
Cost of alloys	1615.45	[£/t alloys]
Consumption of alloys	11	[kg/tLS]
Coking coal cost for BF/BOF route	50.64	[£/tLS]
EAF CAPEX	167.27	[£/t capacity]
DR shaft CAPEX	209.09	[£/t capacity]
Lifetime of EAF and shaft	20	[y]
Discount rate	5	[%]
Consumption of graphite electrodes	2	[kg/tLS]
Cost of graphite electrodes	3636.36	[£/t electrodes]
OPEX of BF/BOF plant	276.36	[£/tLS]
CAPEX of BF relining	43.91	[£/tCS capacity]
CAPEX of BF/BOF brownfield investment	154.55	[£/tCS capacity]
CAPEX of BF/BOF greenfield investment	401.82	[£/tCS capacity]
Emissions intensity BF/BOF route	1.87	[tCo2/t crude steel]
Emissions intensity H-DR route	0.053	[tCo2/t crude steel]

All values above taken from ref. [1], with costs converted from EUR to GBP using a conversion rate of 1.10 EUR/GBP.

Discounted Capacity Costs for Electricity Generation and Electrolysers

	Onshore Wind (£/kW)	Solar PV (£/kW)	CCGT + CCUS (£/kW)	Biomass + CCUS (£/kW)	Electrolyser (£/kW)
2025	1531	617	2149	6236	506
2030	1536	610	2050	6236	439
2035	1441	502	1709	5308	371
2040	1446	496	1709	5308	338

Generation technology cost projections from ref. [2] (central projections used). Electrolyser cost projections developed using ‘average’ capacity cost in 2020 of 770 USD/kW (converted to 540 GBP/kW using a conversion rate of 1.42 USD/GBP) from ref. [3] and learning rates for electrolysers derived from ref. [4].

Projected Fuel and Carbon Prices

Biomass Prices

Biomass price is forecast to remain at £19/MWh, as projected in ref. [5].

Gas Prices [6]

	p/therm		
	Low	Central	High
2021	33	49	74
2022	33	50	75
2023	34	51	76
2024	35	52	77
2025	36	53	78
2026	37	54	79
2027	37	56	80
2028	38	57	81
2029	39	58	82
2030	40	59	83
2031	41	60	84
2032	41	61	85
2033	42	62	86
2034	43	63	87
2035	43	64	88
2036	43	64	88
2037	43	64	88
2038	43	64	88
2039	43	64	88
2040	43	64	88

CO₂ Transportation and Storage Costs

Following the approach used in ref. [5], the medium 2016 DECC estimation of CO₂ transportation and storage costs of £19/tCO₂ has been used [7].

Carbon Prices [8]

	Traded, GBP/tCO ₂		
	Low	Central	High
2021	4	21	37
2022	8	27	46
2023	12	34	56
2024	16	41	65
2025	20	47	74
2026	24	54	84
2027	28	61	93
2028	32	67	103
2029	36	74	112
2030	40	81	121
2031	44	88	132
2032	48	96	144
2033	52	103	155
2034	55	111	166
2035	59	118	178
2036	63	126	189
2037	67	133	200
2038	70	141	211
2039	74	148	223
2040	78	156	234
2041	82	163	245
2042	85	171	256
2043	89	178	268
2044	93	186	279
2045	97	193	290
2046	100	201	301
2047	104	208	313
2048	108	216	324
2049	112	223	335
2050	115	231	346
2051	118	239	360
2052	121	247	373
2053	124	255	386
2054	126	263	400
2055	129	271	413
2056	131	278	426
2057	133	286	439
2058	135	293	451
2059	137	300	464
2060	138	307	476
2061	139	313	486
2062	140	318	497
2063	141	323	506
2064	141	328	515

2065	141	332	523
2066	141	336	531
2067	141	340	538
2068	140	343	545
2069	140	345	551
2070	139	348	556
2071	138	350	561
2072	137	352	566
2073	136	353	570
2074	135	354	574
2075	133	355	577
2076	131	355	579
2077	130	355	581
2078	128	355	582
2079	126	354	583
2080	124	353	582
2081	122	353	584
2082	120	352	584
2083	118	351	584
2084	115	350	584
2085	113	349	584
2086	111	347	582
2087	109	345	581
2088	106	343	579
2089	104	340	576
2090	101	338	574
2091	99	335	572
2092	97	333	570
2093	94	331	567
2094	92	328	564
2095	89	325	561
2096	87	322	557
2097	85	319	554
2098	82	316	549
2099	80	313	546
2100	77	309	541

References

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