Technical Appendix

Enabling investment in clean primary steel: The case for subsidy-and-recharge policies

Introduction

This Technical Appendix accompanies the report 'Enabling investment in clean primary steel: The case for subsidy-and-recharge policies'. In it, we provide the methods and assumptions underlying our estimates of steel production costs and impacts on product costs from the policies explored in the main report.

While we hope this document provides a useful reference and have aimed to use representative and realistic values in our assumptions, these values should be viewed as illustrative estimates produced for the purpose of meaningfully comparing the impacts of different policy options rather than as a precise calculation of costs.

Contents

1 Levelised cost of steel estimates

Method

We use a simple model to estimate the cost of steel production, with data specific to each region gathered from a variety of sources.

We consider steel production costs as a levelised cost per tonne of crude steel produced (LCOS), according to the following formula:

$$\text{LCOS} = \left[\sum_{\text{materials}} (\text{material usage}) \times (\text{material cost})\right] + \text{Labour} + \text{Other Opex} + \text{Levelised Capex} \quad (1)$$

For the BF-BOF production pathway, we use estimates for levelised Capex directly from other references. The material costs we consider separately are:

- Iron ore
- Electricity
- Coking coal
- Pulverised coal
- Biomass (used in the case of Brazil only)
- Scrap.

All other input materials and operating costs are included as part of the 'Other Opex' term.

For the H_2-DRI-EAF production pathway, we estimate levelised Capex for each region according to:

$$\text{Levelised Capex} = \frac{Cr}{1 + (1 - r)^{-n}} \quad \$/\text{tCS} \quad (2)$$

C – Capex, \$/tCS capacity
r – interest rate, %
n – equipment lifetime = 25 years

We also estimate the levelised cost of hydrogen according to:

$$\text{LCOH} = C\left[\frac{r}{1 + (1 - r)^{-n}} + f\right]\frac{\theta}{e * 365 * 24} + \frac{p}{1000}\frac{\theta}{e} \quad \$/\text{kg} \quad (3)$$

C – capex, \$/kW
r – interest rate, %
n – electrolyser lifetime, years = 25 years
f – fixed opex per year, % of capex = 3%
θ - hydrogen heating value (lower heating value), kWh/kg = 33.33 kWh/kg
e – efficiency, kWh H_2/kWh electricity
p – electricity price, \$/MWh

The other material costs we consider separately are:

- Iron ore
- Electricity

- Scrap.

Table 1 and Figure 1 show our LCOS estimates. In Tables 2 and 3 we list the assumptions used to produce these estimates, with the sources for these assumptions given in Table 4.

Results

Table 1: Levelised cost of steel estimates.

	Units	China	India	EU	Brazil	UK
BF-BOF pathway						
LCOS component - Capex	$/tCS	56	47	17	100	17
LCOS component - Iron ore	$/tCS	144	133	165	88	154
LCOS component - Electricity + coal + biomass	$/tCS	136	192	207	171	187
LCOS component - Scrap	$/tCS	89	46	74	74	93
LCOS component - Other opex	$/tCS	98	79	132	65	132
Total LCOS	**$/tCS**	**523**	**497**	**595**	**498**	**583**
H_2-DRI-EAF pathway						
LCOS component - Capex	$/tCS	111	92	102	207	84
LCOS component - Iron ore	$/tCS	138	111	140	84	89
LCOS component - Electricity	$/tCS	82	25	104	60	103
LCOS component - Hydrogen	$/tCS	214	235	290	239	214
LCOS component - Scrap	$/tCS	89	64	74	74	225
LCOS component - Other opex	$/tCS	98	73	102	65	132
Total LCOS	**$/tCS**	**731**	**638**	**812**	**730**	**847**
Cost difference	$/tCS	209	127	218	232	264
Cost difference	%	40%	26%	37%	47%	45%

Figure 1: Levelised cost of steel estimates for the BF-BOF production pathway.

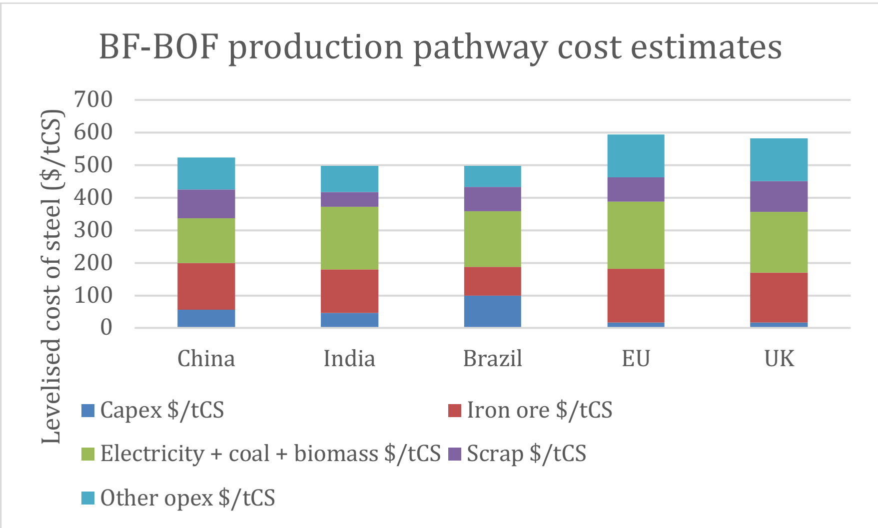
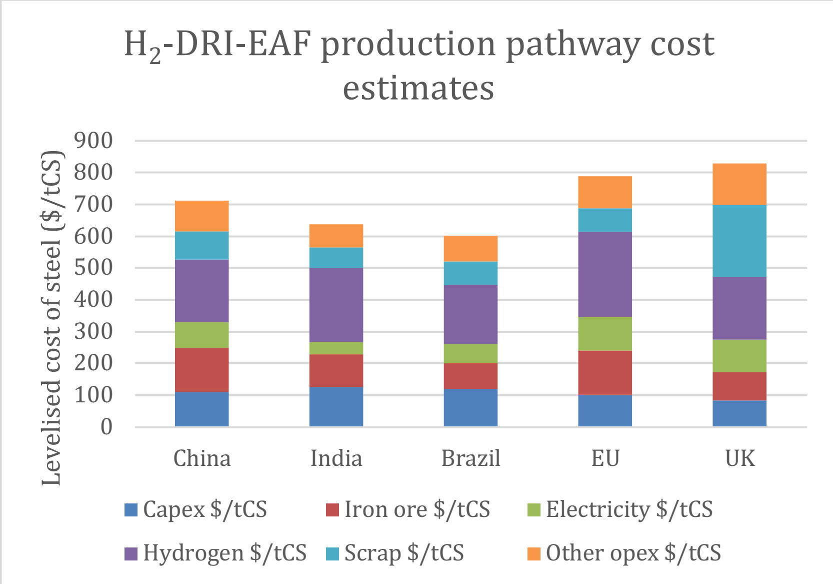


Figure 2: Levelised cost of steel estimates for the H_2-DRI-EAF production pathway.



Assumptions

Table 2: BF-BOF production pathway cost assumptions.

	Units	China	India	EU	Brazil	UK
Scrap charge	%	20%[1]	9%[2]	20%[1]	20%[1]	20%[1]
Specific material consumption						
Iron ore	t/tCS	1.29[3]	1.60[4]	1.41[5]	1.29[3]	1.30[3]
Electricity	MWh/tCS	0.21[6]	0.29[7]	0.00[8]	0.11[3]	0.11[3]
Coking coal	t/tCS	0.40[3]	0.63[9]	0.55[10]	0.34[11]	0.40[3]
Pulverised coal	t/tCS	0.13[12]	0.13[9]	0.13[5]	0.12[11]	0.20[3]
Biomass	t/tCS	-	-	-	0.16[11]	-
Scrap	t/tCS	0.23[3]	0.09[2]	0.21[5]	0.23[3]	0.23[3]
Unit costs						
Iron ore	$/tonne	111.3[13]	83.0[13]	116.8[13]	68.0[14]	118.5[13]
Electricity	$/MWh	68.0[15]	48.0[16]	-	50.0[17]	116.5[18]
Coking coal	$/tonne	257.7[13]	249.1[19]	325.9[13]	377.7[13]	336.5[13]
Pulverised coal	$/tonne	153.2[13]	165.2[19]	214.1[13]	198.2[13]	206.1[13]
Biomass	$/tonne	-	-	-	85.0[20]	-
Scrap	$/tonne	386.0[21]	512.0[22]	353.0[23]	321.1[13]	406.0[13]
Labour	$/tCS	13.0[24]	15.0[24]	61.7[25]	8.2[24]	56.0[24]
Other opex	$/tCS	85.0[24]	64.0[24]	70.5[26]	57.0[24]	76.0[24]
Levelised capex	$/tCS	56.0[24]	46.6[24]	16.5[27]	100.0[24]	16.5[27]

Table 3: H_2-DRI-EAF production cost assumptions.

	Units	China	India	EU	Brazil	UK
Scrap share	%	20%[1]	13%[2]	20%[1]	20%[1]	50%[28]
Specific material consumption						
Iron ore	t/tCS	1.24[3]	1.24[3]	1.20[29]	1.24[3]	0.75[3]
Hydrogen	kg/tCS	45.2[3]	67.7[30]	40.8[29]	45.2[3]	27.3[3]
Electricity	MWh/tCS	1.20[3]	0.53[31]	1.00[29]	1.20[3]	0.89[3]
Scrap	t/tCS	0.23[3]	0.13[2]	0.21[29]	0.23[3]	0.55[3]
Unit costs						
Iron ore	$/tonne	111.3[13]	89.6[13]	116.8[13]	68.0[14]	118.5[13]
Electricity	$/MWh	68.0[15]	48.0[16]	104.4[32]	50.0[17]	116.5[18]
Scrap	$/tonne	386.0[21]	512.0[22]	353.0[23]	321.1[13]	406.0[13]
Labour	$/tCS	13.0[32]	15.0[32]	61.7[32]	8.2[32]	56.0[32]
Other opex	$/tCS	85.0[32]	64.0[32]	39.9[29]	57.0[32]	76.0[32]
Capex						
Cost of capital	%	6.6%[3]	10.0%[35]	5.7%[3]	15.0%[36]	6.5%[3]
Capex	$/tCS capacity	1341[37]	835[37]	1341[37]	1341[37]	1023[37]
Levelised capex	$/tCS	111.0[38]	92.0[38]	101.9[38]	207.5[38]	83.9[38]
Hydrogen costs						
Electrolyser capex	$/kW	900[39]	1100[40]	2300[39]	2300[39]	2300[39]
Electrolyser efficiency	%	56%[39]	56%[39]	62%[39]	62%[39]	62%[39]
Electricity cost	$/MWh	68.0[15]	45.0[41]	104.4[32]	50.0[17]	116.5[18]
Levelised cost of hydrogen	$/kg	4.74[42]	3.73 [42]	7.11 [42]	5.30 [42]	7.84 [42]

Table 4: Production cost assumptions used for steel production with imported iron in the UK.

	Units	Imported pig iron - EAF	Imported H_2-DRI - EAF
Country of iron production		Brazil[43]	India[43]
% scrap	%	50%[28]	50%[28]
Iron production			
Material consumption[44]			
Iron ore	t/t iron	1.4[3]	1.27[3]
Electricity	MWh/t iron	0.12[3]	0.59[31,45]
Coking coal	t/t iron	0.38[11]	-
Pulverised coal	t/t iron	0.13[11]	-
Biomass	t/t iron	0.18[11]	-
Hydrogen	kg/t iron	-	69.4[30]
Material costs			
Iron ore	$/t	68.0[14]	89.6[13]
Electricity	$/MWh	50.0[17]	48.0[16]
Coking coal	$/t	377.7[13]	-
Pulverised coal	$/t	198.2[13]	-
Biomass	$/t	85.0[20]	-
Hydrogen	$/kg	-	3.73[42]
Other materials + opex	$/t iron	36.2[46]	56.7[46]
Levelised capex	$/t iron	55.8[37]	70.5[37]
Levelised cost of iron	$/t iron	**380.9**	**533.8**
Emissions			
Emissions per tonne	CO_2e/t iron	1.7[47]	0.3[47]
Steel production			
Material usage			
Iron	t/tCS	0.547[3]	0.553[3]
Scrap	t/tCS	0.547[3]	0.553[3]
Electricity	MWh/tCS	0.263[3]	0.488[3]
EAF levelised capex	$/tCS	45.1[37]	45.1[27]
Other materials + opex	$/tCS	66[46]	66[46]
Material costs			
Scrap	$/t	406.0[13]	406.0[13]
Electricity	$/MWh	116.5[18]	116.5[18]
Total LCOS	$/tCS	**571.9**	**688.0**
Emissions	tCO_2e/tCS	0.91	0.17

Table 5: Sources for the values used in Tables 2, 3, and 4.

Ref	Source	Comment
[1]	Own assumption.	20% scrap share is assumed as the default across production
[2]	Elango, S. et al. (2023). Evaluating net-zero for the Indian steel industry: marginal abatement cost curves of carbon mitigation technologies. Council on Energy, Environment and Water.	Based on JPC statistics and interviews with industry; scrap availability is lower in India
[3]	Systemiq (2026). Steel-IQ.	Values extrapolated from the Bill of Materials and Cost of Capital analysis used as inputs in the Steel-IQ model.
[4]	JSW Steel (2025). Integrated Report 2024-25.	JSW Steel (among India's largest) reports 1.52 t/tCS for the latest year. Data from SAIL indicates around 1.7 t/tCS.
[5]	Abwärmenutzungspotenziale in Anlagen integrierter Hüttenwerke der Stahlindustrie.	Value reported from existing German plant in 2019.
[6]	Mysteel.com (2023). A review of Energy Consumption in China’s Steel Industry in 2022.	Typical gross electricity consumption is ~460 kWh/tCS, with ~55% self-generation from by-product gas and waste-heat recovery, giving estimated net purchased electricity of ~207 kWh/tCS. Since LCOS electricity cost is calculated using industrial electricity prices, net purchased electricity is considered the most appropriate boundary.
[7]	Jin, P. et al. (2015). The energy consumption and carbon emission of the integrated steel mill with oxygen blast furnace. Resources, Conservation and Recycling.	Based on 0.39 MWh/tCS; about 100 kWh are generated through waste-heat recovery, leaving a net consumption of 0.29 MWh/tCS.
[8]	Own assumption.	In Germany the flue gases are captured and used for onsite power generation, fully meeting the power needs.
[9]	Elango, S. et al. (2023).	Based on interviews with industry; India consumes more coke than average for steel production.
[10]	JRC (2013). Best available techniques (BAT) reference document for iron and steel production.	EU best available techniques.
[11]	Own assumption.	Partial substitution with charcoal and injected biomass lowers demand for metallurgical coke and pulverised coal.
[12]	Metallurgical Industry Press (2024). Review of China’s Ironmaking technology development in 2023. Link.	Derived from the 2023 CISA member-enterprise PCI rate of 152.80 kg/tHM, converted using a hot-metal-to-crude-steel ratio of 0.875 tHM/tCS. Other non-coking coal uses are not included in this component to maintain a consistent model boundary.

[13]	United Nations Statistics Division (2026). UN Comtrade Database.	UN Comtrade price data, 2023–2025 average (imports and exports). Product codes: Iron ore – 2601. Coking coal – 270400. Pulverised coal – 270112. Scrap – 7204.
[14]	Own assumption.	Local "mine-to-mill" prices.
[15]	Own assumption.	
[16]	Derived from Elango, S. et al. (2023).	Inflated to reflect present-day coal prices.
[17]	Internal data.	Based on data from PPAs of steel plants. Generally these are lower than electricity prices for other, smaller industrial sites.
[18]	Department for Business and Trade (2026). The UK Steel Strategy.	Electricity prices of £86/MWh expected with announced industrial energy price relief schemes.
[19]	Department of Commerce, Ministry of Commerce and Industry (2026). Export Import Data Bank: Commodity-wise Export. Government of India.	Based on national trade data and steel sector data from the Annual Survey of Industries.
[20]	Own assumption.	Estimated cost of sustainable eucalyptus charcoal.
[21]	Scrap Steel Recycling Prices - Today's Latest Scrap Iron Price List - MySteel.Com. https://feigang.mysteel.com/	Annual averages for 2023–2025 based on the MySSpic Scrap Steel Absolute Price Index published by Mysteel (Shanghai Ganglian, China's most authoritative ferrous pricing platform).
[22]	Ministry of Statistics and Programme Implementation (2024). Annual Survey of Industries 2023-24.	2023–24 values from the Annual Survey of Industries.
[23]	BDSV (2026). BDSV Average Prices in Germany in €/t (08/2026).	Average German prices between 2020 and 2025 and across scrap quality
[24]	TransitionZero (2022). Global Steel Production Costs - A country and plant-level cost analysis.	Values for cost component 'Labor' used for labour, and 'Other costs' used for Other opex.
[25]	Richstein and Neuhoff (2022). Carbon contracts-for-difference: How to de-risk innovative investments for a low-carbon carbon industry?	
[26]	Vogl, V et al. (2018). Assessment of hydrogen direct reduction for fossil-free steelmaking. Journal of Cleaner Production, 203, 736–745.	Including alloy, flux, O_2, and O&M.
[27]	Vogl, V. et al. (2018).	Brownfield. (No greenfield BF-BOF projects are expected in Europe.)
[28]	Materials Processing Institute (2025). UK Primary Steelmaking Review 2025.	Analysis suggests that due to high scrap quality, even the highest grades of steel can be made with 50% scrap or more in the UK.
[29]	Vogl, V. et al. (2018).	
[30]	Assumptions based on compiled information.	Based on inputs we received from an OEM, counting a 12.5% scrap share to convert from

		tDRI to tCS; here, we assumed that heat in the reactor is provided by burning H_2 and not electricity.
[31]	Own assumption.	Since H_2 is burned for heat, electricity consumption is the same as a regular EAF.
[32]	Own assumption.	Electricity price of 90 €/MWh.
[33]	Own assumption.	We assume the same labour and other opex costs for H_2-DRI-EAF steel production as for BF-BOF.
[35]	Pai (2025). "OPINION | India's High Cost of Capital: The hidden tax on growth." MoneyControl.; RBSA (2023). Cost of Capital in India – 6th Edition.	Declining after the end of the COVID-19 pandemic.
[36]	Own assumption.	
[37]	Systemiq (2026). Steel-IQ.	Based on capital costs of $860/tDRI capacity, and $550/tCS EAF capacity, with the DRI capital costs scaled by the amount of DRI used in each pathway.
[38]	Own calculation.	See Equation 2.
[39]	IEA (2025). Global hydrogen review 2025.	Following assumptions used in hydrogen cost illustrations in this report. Significantly lower electrolyser capex and opex costs have been seen in China compared to other regions, with slightly lower efficiencies.
[40]	Assumptions based on compiled information.	Assumed for 2026; based on earlier work and interviews, Indian electrolyser costs are not far off of Chinese costs and many Indian projects use Chinese electrolysers.
[41]	Derived from Mallya et al. (2024). Unlocking India's RE and Green Hydrogen Potential: An Assessment of Land, Water, and Climate Nexus. New Delhi: Council on Energy, Environment and Water.	Based on LCOE for wind-solar hybrid power plants.
[42]	Own calculation.	See Equation 3. Annualised capex over 25 year lifetime; Opex assumed 3% of capex annually. Calculated using 33.333 HHV conversion value
[43]	Own assumption.	We selected these regions since of those studied in this analysis, production cost estimates indicate that Brazil and India have the lowest cost of pig iron and H_2-DRI production respectively.
[44]	Systemiq (2026). Steel-IQ.	Material usage values for iron production only are extrapolated from those of steel production. Assuming 0.897 t iron/tCS for Brazil BF-BOF (20% scrap), and 0.920 t iron per tonne for India H_2-DRI-EAF (13% scrap).

[45]	Rocky Mountain Institute (2024). Green Iron Corridors: Transforming Steel Supply Chains for a Sustainable Future.	Assume an additional 10 kWh/tDRI for hot-briquetting for transport.
[46]	Own assumption.	We attribute half of the labour and opex costs to the iron production phase, and half to the steel production phase.
[47]	Department for Energy Security and Net Zero (2026). UK government conversion factors for company reporting of greenhouse gas emissions; SteelOnTheNet (2026). Steel Industry CO2 Emissions.	We use an emissions factor of 2.667 tCO_2e/t coal, plus an estimated additional 0.3 tCO_2e/t iron for other indirect emissions.

2 Impacts of policies on the costs of steel-containing products

We evaluate the impact on product costs by considering the per-tonne-of-steel cost increase resulting from each policy option multiplied by the estimated steel content of each product, divided by the typical consumer cost of the product.

The policy options considered here are a carbon price that raises the cost of existing steel production to the same cost as clean steel production, and a recharge in the form of a per-tonne levy on steel consumption. The estimated cost premia for each policy option and country/region are given in Table 6, where the carbon price premium is the same as the cost gap estimated in Section 1, and the recharge is estimated from the cost of subsidising 10% of primary steel production (or a 1 Mtpa DRI plant in the UK) recharged across all steel production.

Table 7 gives the product price and steel content assumptions used for each product, along with the resulting percent increase in price due to the carbon price and subsidy-and-recharge policies.

Table 6: Steel cost increases used to estimate impacts on product costs.

Region	Additional cost of BF-BOF production due to carbon price	Recharge on steel consumption
	$/tCS	$/tCS
China	209	22.6
India	127	25.2
EU	218	11.5
Brazil	232	22.3
UK	264	30.5

Table 7: Product cost and steel content assumptions used, and resultant estimates on product cost increases.

Region	Product	Product price	Steel content	Cost increase with carbon price	Cost increase with recharge
		$/product	tCS/product	% product price	% product price
China	Passenger car	23,800[1]	0.900[2]	0.8%	0.09%
India	Passenger car	10,000[3]	0.750[3]	1.0%	0.19%
EU	Passenger car	23,800[1]	0.900[2]	0.8%	0.04%
Brazil	Passenger car	23,800[1]	0.900[2]	0.9%	0.09%
UK	Passenger car	23,800[1]	0.900[2]	1.0%	0.12%
China	Washing machine	218[1]	0.021[1]	2.0%	0.22%
India	Washing machine	215[4]	0.022[5]	1.3%	0.26%
EU	Washing machine	218[1]	0.021[1]	2.1%	0.11%
Brazil	Washing machine	218[1]	0.021[1]	2.2%	0.21%
UK	Washing machine	218[1]	0.021[1]	2.5%	0.29%
China	Refrigerator	483[6]	0.034[7]	1.5%	0.16%
India	Refrigerator	375[8]	0.038[9]	1.3%	0.26%
EU	Refrigerator	420[1]	0.034[1]	1.8%	0.09%
Brazil	Refrigerator	420[1]	0.034[1]	1.9%	0.18%
UK	Refrigerator	420[1]	0.034[1]	2.1%	0.25%
China	Air conditioner	434[1]	0.030[1]	1.4%	0.16%
India	Air conditioner	450[10]	0.015[11]	0.4%	0.08%
EU	Air conditioner	434[1]	0.030[1]	1.5%	0.08%
Brazil	Air conditioner	434[1]	0.030[1]	1.6%	0.15%
UK	Air conditioner	434[1]	0.030[1]	1.8%	0.21%
India	Highway	1.3 million[12]	160[12]	1.6%	0.3%
India	Residential RCC building	27[13]	0.005[13]	2.1%	0.4%
EU	Family house	300,000 [14]	14.67[15]	1.1%	0.1%
EU	Wind power (1 kW capacity)	1,500[16]	0.132[17]	1.9%	0.1%
UK	Steel pipieline (per km)	1.79 million[18]	180[19]	2.7%	0.31%
UK	Railway (HS2)	135 billion[20]	2,500,000[21]	0.5%	0.06%

Table 8: Sources for the values used in Table 7.

Ref	Source
[1]	Statista (2021). European average car prices in 2015-2020, by country.
[2]	Stahl (2026). The Perspective of the Steel Industry in Germany on the Automotive Package.
[2]	Adapted from Maruti Suzuki India (2026). Dzire price list.
[3]	Adapted from SteelOnTheNet (2026). Automotive Materials: Vehicle Steel Weight.
[4]	Joint Plant Committee (2025). Annual Statistics 2023–24.
[5]	Assumptions based on compiled information, drawing on LG Electronics India (2026); Arya, S. and Kumar, S. (2020). E-waste in India at a glance: Current trends, regulations, challenges and management strategies. Journal of Cleaner Production, 271, 122707.
[6]	https://washer.cheaa.com/2026/0202/652655.shtml
[7]	https://www.sgpjbg.com/hyshuju/c9050191db74cab04b33480b2564abe5.html
[8]	Joint Plant Committee (2025). Annual Statistics 2023–24.
[9]	Assumptions based on compiled information, drawing on Samsung Electronics India (2026); Horie, Y. A. (2004). Life Cycle Optimization of Household Refrigerator-Freezer Replacement. Center for Sustainable Systems, University of Michigan; Arya, S. and Kumar, S. (2020).
[10]	Joint Plant Committee (2025). Annual Statistics 2023–24.
[11]	Assumptions based on compiled information, drawing on Li, G. (2015). Investigations of life cycle climate performance and material life cycle assessment of packaged air conditioners for residential application. Sustainable Energy Technologies and Assessments, 11, 114-125.
[12]	Based on compiled information from pre-feasibility reports for five different greenfield highway sections: National Highways Authority of India [NHAI] (2018). Pre-Feasibility Report: Raipur-Visakhapatnam Economic Corridor, Phase 1 (Chhattisgarh), Bharatmala Pariyojana Lot-3/Odisha & Jharkhand/Package-2; NHAI (2018). Pre-Feasibility Report: Bharatmala Pariyojana Sub-Package-3 of Lot 4/Pkg 4, Firozpur Jhirka-Kota Section; NHAI (2021). Pre-Feasibility Report: Construction of Four/Six Lane Greenfield Highway from Palakkad to Kozhikode; NHAI (2018). Pre-Feasibility Report: Development of 8 Lane Greenfield Highway from Etawa to after Chambal River near Durjanpura Village, NH-148N, Bharatmala Pariyojana Lot-4/Pkg-4; NHAI (2021). Pre-Feasibility Report: Construction of 4 Lane Access Controlled New Greenfield Highway Section of Khammam-Vijayawada.
[13]	Assumptions based on compiled information.
[14]	Engel & Völkers (2026). Houses for sale in Germany.
[15]	IOER Information System Built Environment (2026). Single-family house Germany.
[16]	RTE (2021). Les Futurs Énergétiques.
[17]	JRC (2022). Technologies to decarbonise the EU steel industry.
[18]	Ofgem (2007). Gas distribution price control review – Five year control.
[19]	SteelOnTheNet (2026). Steel Industry Facts & Figures – Key Statistics and Data
[20]	BBC News (2026). HS2 could cost up to £102.7bn and trains will be slower than first planned.
[21]	Global Ardour Recycling Limited (2026). How UK Infrastructure Projects Drive Scrap Metal Demand.