UK Government

Data Annex

Data for calculating Greenhouse Gas Emissions under the UK Low Carbon Hydrogen Standard

January 2026

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Contents

Contents 3
Reference Update Notice 4
List of Tables 6
Introduction 7
Global Warming Potentials (GWP) 8
Typical Data 10
Feedstock Supply 10
Energy Supply 15
Input Materials 28
Process CO_2 emissions 31
Fugitive non-CO_2 emissions 32
CO_2 Capture and Network Entry 32
CO_2 Sequestration 32
Solid Carbon Distribution 32
Solid Carbon Sequestration 33
Compression and Purification of hydrogen 34
Fossil Waste/Residue Counterfactual 37
Default Data 39
Use of Default Data 39
Default Data tables 42
Sustainability Criteria 44
Useful References 45
Sources of data for Lower Heating Values 45
Unit conversions for pure hydrogen 45

Reference Update Notice

This Data Annex has been updated. Please note that references to specific paragraph numbers in Version 3 of the Low Carbon Hydrogen Standard (LCHS) may not directly correspond to the paragraph numbering in this updated annex.

The tables below provides information on where readers can now find information referenced in Version 3 of the LCHS, or in a previous version of the Data Annex, where the referenced paragraph numbers or equations have changed.

Reference in Version 3 of LCHS	Reference for updated Data Annex (January 2026)	Data Annex Section heading
DA.25-DA.28	DA.25-DA.29	Electricity sourced from the Electricity Grid and not linked to a specific generator
DA.50	DA.52	CO2 Sequestration
DA.54	DA.57	Solid Carbon Sequestration
DA.55	DA.58	Solid Carbon Sequestration
DA.56-DA.65	DA.59-DA.68	Compression and Purification of hydrogen
DA.66-DA.72	DA.69-DA.75	Fossil Waste/Residue Counterfactual
DA.70-71	DA.73-DA.74	Refinery Off-Gases (Residue) counterfactual
DA.73-DA.85	DA.76-DA.88	Default Data
DA.86	DA.89	Sustainability Criteria
DA.87	DA.90	Sources of data for Lower Heating Values

Previous Data Annex (December 2023) Reference to LCHS	Updated Data Annex (January 2026) Reference to LCHS
DA.24: Annex B Paragraphs B.25-B.30 and Annex C Paragraphs C.27-C.31	DA.24: Annex B and Annex C
DA.34: Annex C Paragraphs C.10-C.12	DA.35: Annex C
DA.35: Annex C Paragraphs C.13-C.14	DA.36: Annex C
DA.40: Equation 59	DA.41: Equation 68
DA.50: Paragraph 5.49	DA.52: CO_2 Sequestrations Emissions Category of the Standard Document
DA.54: Paragraphs 4.4-4.7	DA.57: Adding New Pathways to the scope of the Standard section of the Standard Document
DA.55: Paragraph 5.57	DA.58: Solid Carbon Sequestration section of the Standard Document
DA.55: Equation 64	DA.58: Equation 74 to calculate Pure Solid Carbon sequestered in Annex H

List of Tables

Table 1: IPCC AR5 Global Warming Potential (GWP) of GHGs without climate feedback 8

Table 2: ILUC values of biomass groups 11

Table 3: Crude oil GHG Emission Intensity, delivered to the UK.. 12

Table 4: Electricity generation GHG Emission Intensities (prior to any Transmission and Distribution Losses).. 16

Table 5: GB and NI grid average electricity GHG Emission Intensity delivered to pre-operational facilities (after Transmission and Distribution Losses).. 18

Table 6: Conservative Self Discharge Loss values for Electricity Storage Systems................. 20

Table 7: Conservative Round Trip Efficiencies for Electricity Storage Systems 21

Table 8: Projected Transmission and Distribution Losses for pre-operations........................... 22

Table 9: Fuel GHG Emission Intensity (production & supply, without combustion/conversion) 24

Table 10: Input Materials GHG Emission Intensities (manufacture & supply, no combustion/conversion) 29

Table 11: Fuel combustion CO_2 Emission Intensity (no production or supply emissions included).. 31

Table 12: Terms and units for Compression and Purification calculations 36

Table 13: Line of best fit parameters for Equation 5 at specific temperatures.......................... 36

Table 14: Ability to use default factors for pre-operational Pathway Emission Categories....... 40

Table 15: Default Data for Feedstock Supply 42

Table 16: Default Data for Energy Supply 43

Table 17: Default Data for Input Materials... 43

Table 18: Example conversion factors from 1.0 gCO_2e/MJ_{LHV} pure H_2 46

Introduction

DA.1. This document contains Typical Data, Default Data, and other useful conversion factors, which shall be used towards determining compliance with the GHG Emission Intensity Threshold and other requirements which make up the Low Carbon Hydrogen Standard (the 'Standard'). It is intended to complement the contents of the Standard Document with supporting quantitative and qualitative data (or references to data sources) which are necessary or auxiliary to determining Standard Compliance. It will not introduce new policies, nor will it contradict the contents of the Standard Document.

DA.2. This document will be reviewed and updated on a regular basis (subject to relevant datasets being published). Updates will incorporate developments in the industry (for example, improving default efficiencies for Default Data values), changes in the referenced datasets, and/or changes to the most appropriate datasets to use.

DA.3. In cases where a Hydrogen Production Facility calculates GHG Emissions Intensity to support claims of *likely* Standard Compliance (see Paragraph 3.2 of the Standard Document), the Data Annex shall be effective immediately upon its publication. For all Hydrogen Production Facilities that are demonstrating Standard Compliance (e.g. producing Consignments of Hydrogen Product), the updates in this version of the Data Annex shall be effective as of 1st March 2026. See Chapter 3 for further details on the application of 'Standard Compliance'. Future updates to the Data Annex shall be effective from a specified date in the updated Data Annex – for Hydrogen Production Facilities producing Hydrogen Product, this date will be the start of the calendar month following a minimum of 28 days from the date of publication of the updated Data Annex.

Global Warming Potentials (GWP)

DA.4. Table 1 shows the GWP values of CO_2, CH_4, N_2O, SF_6, NF_3, perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs) for a period of 100 years according to the 2018 Fifth Assessment Reports (AR5) of the Intergovernmental Panel on Climate Change (IPCC). These values shall be applied across all GHG emissions calculations under the Standard.

Table 1: IPCC AR5 Global Warming Potential (GWP) of GHGs without climate feedback[1]

GHG	GWP value (in gCO_2e/g)
CO_2 (fossil)	1
CO_2 (biogenic)	0
CH_4	28
N_2O	265
SF_6	23,500
NF_3	16,100
Perfluorocarbons (PFCs)	
PFC-14 (CF_4)	6,630
PFC-116 (C_2F_6)	11,100
PFC-218 (C_3F_8)	8,900
PFC-318 (c-C_4F_8)	9,540
PFC-31-10 (C_4F_{10})	9,200
PFC-41-12 (C_5F_{12})	8,550
PFC-51-14 (C_6F_{14})	7,910
PFC-91-18 ($C_{10}F_{18}$)	7,190
Trifluoromethyl sulphur pentafluoride (SF_5CF_3)	17,400
Perfluorocyclopropane (c-C_3F_6)	9,200
Hydrofluorocarbons (HFCs)	
HFC-23	12,400
HFC-32	677
HFC-41	116
HFC-125	3,170
HFC-134	1,120
HFC-134a	1,300
HFC-143	328
HFC-143a	4,800
HFC-152	16
HFC-152a	138
HFC-161	4
HFC-227ea	3,350

[1] https://ghgprotocol.org/sites/default/files/2024-08/Global-Warming-Potential-Values%20%28August%202024%29.pdf

HFC-236cb	1,210
HFC-236ea	1,330
HFC-236fa	8,060
HFC-245ca	716
HFC-245fa	858
HFC-365mfc	804
HFC-43-10mee	1,650

Typical Data

DA.5. The Standard Document breaks down the Hydrogen Product GHG Emission Intensity calculation into the following Emission Categories.

Equation 1

$$E_T = E_{Feedstock\ Supply} + E_{Energy\ Supply} + E_{Input\ Materials} + E_{Process\ CO_2} + E_{Fugitive\ non\text{-}CO_2} + E_{CO_2\ Capture\ and\ Network\ Entry} - E_{CO_2\ Sequestration} + E_{Solid\ C\ Distribution} - E_{Solid\ C\ Sequestration} + E_{Compression\ and\ Purification} + E_{Fossil\ Waste/Residue\ Counterfactual}$$

Where E_T = total GHG emissions in gCO_2e over the Reporting Unit for the Discrete Consignment.

DA.6. Instructions on which emissions shall be included within the calculations for each of these Emission Categories are given in Chapter 5 of the Standard Document, whereby Activity Flow Data is combined with GHG Emission Intensities for the Inputs to the Pathway, or Activity Flow Data is combined with GWPs for relevant Outputs of the Pathway. The sections below provide the Typical Data and data sources that shall be used for these GHG Emission Intensities, along with any further guidance regarding Solid Carbon Permissible End Uses and identification of fossil Waste/Residue feedstock counterfactuals that are not given in the Standard Document.

DA.7. Guidance on whether Default Data can be used before a Hydrogen Production Facility is operational (instead of Projected Data) is given in Paragraphs DA.76 - DA.88.

Feedstock Supply

DA.8. Pathways without feedstocks (e.g. electrolysis) have no emissions to report under the Feedstock Supply Emission Category. The emissions associated with any Input electricity derived from biomass or Waste Inputs shall be accounted for under the Energy Supply Emissions Category.

DA.9. Fossil gas reforming with CCS Pathways, or gas splitting with solid carbon Pathways that consume natural gas from the UK Gas Network, shall calculate the Feedstock Supply emissions for these Discrete Consignments using the natural gas GHG Emission Intensity value given in Table 9 (depending on which UK Gas Network their natural gas is being withdrawn from), combined with the Activity Flow Data for their consumption of natural gas.

DA.10. Pathways using biomass or Waste feedstocks shall calculate their Feedstock Supply emissions for the UK segments of their supply chain, using the same

GHG Emission Intensities for Inputs to this supply chain (such as energy and materials) as given in Paragraphs DA.20-DA.46. For biomass and Waste feedstocks sourced from abroad, appropriate up-to-date national GHG Emission Intensities shall be sourced and evidenced for input energy and materials used within overseas segments of the supply chain.

Direct land use change (DLUC)

DA.11. For relevant biomass feedstocks, these DLUC calculations are carried out according to the methodology in Annex E of the Standard Document and included within the Feedstock Supply Emission Category result.

DA.12. Based on the location of the DLUC, climate, ecological zone and soil type can be taken from maps and data provided by the Joint Research Centre (JRC)[2].

DA.13. The Food and Agriculture Organisation of the United Nations (FAO)[3] provides similar information.

DA.14. In most cases, it is possible to find values for the different parameters required under Annex E of the Standard Document within the look-up tables in the Renewable Transport Fuel Obligation (RTFO) standard values[4].

DA.15. For C_{DOM} the value of 0 may be used, except forest land (excluding forest plantations) with more than 30% canopy cover.

DA.16. CF_B can be taken to be 0.47; CF_{DW} can be taken to be 0.5; CF_{LI} can be taken to be 0.4.

Indirect land use change (ILUC) – reporting purposes only

DA.17. The ILUC emissions values in Table 2 shall be used when reporting the estimated ILUC emissions associated with use of cereals and other starch-rich crops, sugars or oil crops. Note that the values provided are in gCO_2e/MJ_{LHV} biomass, so require conversion into gCO_2e/MJ_{LHV} Hydrogen Product values based on the usage of the biomass within the Pathway.

DA.18. ILUC emissions shall be reported as being zero for all other types of biomass.

Table 2: ILUC values of biomass groups

Biomass group	ILUC values (gCO_2e/MJ_{LHV} biomass)
Cereals and other starch-rich crops	12
Sugars	13
Oil crops	55

[2] https://esdac.jrc.ec.europa.eu/projects/RenewableEnergy/
[3] https://www.fao.org/forest-resources-assessment/remote-sensing/global-ecological-zones-gez-mapping/en/
[4] https://www.gov.uk/government/publications/renewable-transport-fuel-obligation-rtfo-compliance-reporting-and-verification

Crude oil supply

DA.19. Pathways that utilise crude oil as a feedstock shall use the country-specific delivered GHG Emission Intensity values in Table 3 below to derive a weighted average for their crude oil mix. These values combine upstream production and midstream transport emissions to the UK mainland, so are only applicable to UK refineries. Upstream production emissions in 2023 are from The Archie Initiative (2023)[5] and converted to a per MJ_{LHV} basis using regional average volumetric energy contents in Dixit et al (2023)[6]. Midstream transport emissions use a crude tanker shipping intensity from UK Government (2025)[7], pipeline electricity usage from GREET[8] and 2023 country grid electricity intensities (Ember, 2025)[9], and a crude oil LHV from UK DUKES (2025)[10]. Key production regions and ports were identified to derive pipeline distances[11] then shipping distances to the UK were estimated for arrival in Immingham, UK from the main export port in each country using Sea Distances[12].

Table 3: Crude oil GHG Emission Intensity, delivered to the UK

Country	GHG Emission Intensity (gCO_2e/MJ_{LHV})
Albania	14.2
Algeria	11.7
Angola	9.1
Argentina	9.9
Australia	9.6
Austria	4.7
Azerbaijan	7.2
Bahrain	2.4
Brazil	3.9
Brunei Darussalam	7.9
Cameroon	11.7
Canada	14.4
Chad	5.1
Chile	7.6
China	11.1
Colombia	6.9
Congo	14.7

[5] https://app.archieinitiative.org/map?mode=oil
[6] https://www.nature.com/articles/s41467-023-41701-z
[7] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2025
[8] https://onlinelibrary.wiley.com/doi/am-pdf/10.1111/jiec.13262
[9] https://ember-energy.org/data/yearly-electricity-data/
[10] https://www.gov.uk/government/statistics/dukes-calorific-values
[11] using great-circle distances from https://www.gpsvisualizer.com/calculators, and a representative tortuosity factor of 1.23 based on Based on the CPC pipeline (1,511km length vs 1,229km great-circle distance) https://www.chevron.com/worldwide/kazakhstan
[12] Distance from the key port in the selected country, to Immingham in the UK https://sea-distances.org/

Cote d'Ivoire	3.4
Croatia	13.7
Democratic Republic of Congo	5.9
Denmark	4.8
Ecuador	10.0
Egypt	8.6
Equatorial Guinea	7.7
France	2.6
Gabon	9.6
Germany	7.2
Ghana	8.4
Greece	7.3
Guatemala	17.5
Guyana	5.8
Hungary	54.1
India	10.0
Indonesia	12.5
Iran	15.6
Iraq	10.3
Italy	3.8
Japan	5.4
Jordan	22.4
Kazakhstan	10.3
Kuwait	3.6
Libya	10.8
Malaysia	10.6
Mexico	10.7
Myanmar	8.0
Netherlands	7.6
New Zealand	5.5
Niger	7.1
Nigeria	12.7
Norway	2.4
Oman	11.2
Pakistan	12.1
Papua New Guinea	13.9
Peru	10.4
Philippines	34.7
Poland	7.4
Qatar	6.1
Romania	13.1
Russian Federation	12.5

Saudi Arabia	2.7
Serbia	32.6
South Sudan	7.6
Spain	8.2
Sudan	15.6
Suriname	4.5
Syria	25.0
Thailand	8.7
Trinidad and Tobago	9.7
Tunisia	17.1
Turkey	6.9
Turkmenistan	9.3
Ukraine	8.8
United Arab Emirates	4.8
United Kingdom	4.1
United States	8.4
Uzbekistan	15.8
Venezuela	16.5
Vietnam	11.3
Yemen	12.4

Energy Supply

DA.20. Energy Supply emissions cover the generation and supply of electricity, steam, heat, and fuels for hydrogen production.

Electricity

Electricity sourced from a specific generator via an Eligible PPA (or equivalent), or sourced from a Private Network and not linked to a specific generator, excluding grid import to the Private Network

DA.21. When calculating the emissions associated with the generation of electricity from a specific generator or from a weighted average of generators on a Private Network, the Typical Data electricity generation GHG Emission Intensity in Table 4 shall be used by the Hydrogen Production Facility (or Electricity Storage System). Note that the values given in Table 4 include estimated emissions upstream of the electricity generators.

DA.22. Values are not provided in Table 4 for biomass or Waste electricity generators. Given the diversity of supply chains and conversion efficiencies, the GHG Emission Intensities for biomass or Waste electricity generation shall be calculated following the methodology given in Annex G of the Standard Document. The same applies to any combined heat and power generation or any electricity generation involving CO_2 capture, given the diversity of conversion efficiencies.

DA.23. If the Hydrogen Production Facility (or Electricity Storage System) is consuming electricity from an onsite or adjacent electricity generation asset, the generation GHG Emission Intensity values in Table 4 can be used directly as the delivered GHG Emission Intensity without any Transmission and Distribution Losses being applied. If the Hydrogen Production Facility (or Electricity Storage System) is sourcing electricity from the electricity generation asset via the Electricity Grid or via a Private Network, then any Transmission and Distribution Losses will need to be accounted for in the delivered GHG Emission Intensity, following Annex B of the Standard Document.

Table 4: Electricity generation GHG Emission Intensities (prior to any Transmission and Distribution Losses)

Generator	gCO_2e/kWh_e	gCO_2e/MJ_e	Sources and supporting notes
Onshore wind	0.0	0.0	JEC (2020) Well-to-tank report v5[13], WDEL1
Offshore wind	0.0	0.0	JEC (2020) Well-to-tank report v5[13], WDEL1
Solar	0.0	0.0	IPCC (2014) Technology-specific cost and performance parameters[14], Table A.III.2
Hydro-electric dam	0.0	0.0	IPCC (2014) Technology-specific cost and performance parameters[14], Table A.III.2
Run-of-river hydro	0.0	0.0	IPCC (2014) Technology-specific cost and performance parameters[14], Table A.III.2
Geothermal	0.0	0.0	IPCC (2014) Technology-specific cost and performance parameters[14], Table A.III.2, assuming geothermal power generation has not led to any increase in venting of geological CO_2. Any increase requires a GHG emissions factor to be calculated instead
Natural gas CCGT	471.6	131.0	JEC (2020) Well-to-tank report v5[13], GPEL1a
Oil	811.1	225.3	JEC (2020) Well-to-tank report v5[13], FOEL1
Coal	1,009.8	280.5	JEC (2020) Well-to-tank report v5[13], KOEL1
Nuclear	4.43	1.23	UNECE (2022) Carbon Neutrality in the UNECE Region[15], Table 14, land use change excluded. Construction (14%) and decommissioning (2%) emissions also excluded (using Figure 35 split)

DA.24. Within the Standard Document, Annex B and Annex C require the evidencing of REGOs, with the number of REGOs depending on the electricity generation source. The REGO Percentage of electricity generated from wind, solar, hydropower, tidal, wave, hydrothermal, aerothermal, geothermal and biogenic feedstocks will be between 100% and 0%, depending on whether the specific generator is registered with the REGO scheme and generates REGOs, and the proportion of the generation exported that generates REGOs. Any non-renewable electricity generation sources will not generate REGOs, and therefore have a REGO Percentage of 0%.

[13] https://publications.jrc.ec.europa.eu/repository/handle/JRC119036
[14] https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf
[15] https://unece.org/sites/default/files/2022-04/LCA_3_FINAL%20March%202022.pdf

Electricity sourced from the Electricity Grid and not linked to a specific generator

DA.25. For operational Hydrogen Production Facilities in Great Britain (GB) consuming electricity from the Electricity Grid that is not linked to a specific generator, the GHG Emission Intensity per Reporting Unit for GB from the NESO Dashboard[16] shall be used. These values already include Transmission and Distribution Losses, but do not yet include any emissions upstream of GB electricity generators (these may be added in future versions of the Data Annex).

DA.26. For operational Hydrogen Production Facilities in Northern Ireland (NI) consuming electricity from the Electricity Grid, 30-minute GHG Emission Intensities per Reporting Unit for NI from the EirGrid Smart Dashboard[17] shall be used. These values already include Transmission and Distribution Losses, but do not yet include any emissions upstream of NI electricity generators (these may be added in future versions of the Data Annex). Note that the EirGrid data gives GHG Emission Intensities every 15 minutes, therefore the 30-minute NI Electricity Grid GHG Emission Intensity shall be a simple arithmetic mean of two 15-minute periods (for example, the GHG Emission Intensity between 10:00 - 10:30 shall be a simple arithmetic mean of the two GHG Emission Intensities at 10:00 and 10:15 respectively).

DA.27. For Hydrogen Production Facilities, the REGO Percentage of electricity volumes from the Electricity Grid that are not linked to a specific generator shall be set as 0%.

DA.28. For pre-operational Hydrogen Production Facilities in GB planning to consume electricity from the GB Electricity Grid, the Projected GB grid average electricity GHG Emission Intensity data in Table 5 for the relevant year shall be used. Annual generation GHG Emission Intensities from the NESO (2025) Future Energy Scenarios[18] are combined with the GB Transmission and Distribution losses from Table 8. The resulting delivered GHG Emission Intensity values do not include any emissions upstream of GB electricity generators (these may be added in future versions of the Data Annex). Table 5 shall not be used once the Hydrogen Production Facility is operational.

DA.29. For pre-operational Hydrogen Production Facilities in NI planning to consume electricity from the NI Electricity Grid, the Projected NI grid average electricity GHG Emission Intensity data in Table 5 for the relevant year shall be used. Generation data is combined with grid loss data, both from the SONI (2025)

[16] https://www.nationalgrideso.com/future-energy/our-progress-towards-net-zero/carbon-intensity-dashboard

[17] https://www.smartgriddashboard.com/ni/co2/, selecting Northern Ireland drop-down option, selecting the CO_2 tab, selecting Month within CO_2 intensity over time, then View in Table, download .CVS. Data from earlier periods are available with the correct manual input of start and end dates in the address bar (note the dates that successfully output data do not exactly match month start and month end dates)

[18] https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes/fes-documents Holistic Transition, CO2 intensity of generation excluding BECCS

Tomorrow's Energy Scenarios[19]. The resulting delivered GHG Emission Intensity values do not include any emissions upstream of NI electricity generators (these may be added in future versions of the Data Annex). Table 5 shall not be used once the Hydrogen Production Facility is operational.

Table 5: GB and NI grid average electricity GHG Emission Intensity delivered to pre-operational facilities (after Transmission and Distribution Losses)

Year	GB grid electricity (gCO_2e/kWh_e delivered)	GB grid electricity (gCO_2e/MJ_e delivered)	NI grid electricity (gCO_2e/kWh_e delivered)	NI grid electricity (gCO_2e/MJ_e delivered)
2025	130.9	36.4	184.3	51.2
2026	44.6	12.4	172.3	47.9
2027	34.6	9.6	160.4	44.5
2028	41.4	11.5	148.4	41.2
2029	30.3	8.4	136.5	37.9
2030	15.7	4.4	124.5	34.6
2031	12.3	3.4	112.6	31.3
2032	7.5	2.1	100.6	27.9
2033	7.1	2.0	88.7	24.6
2034	6.8	1.9	76.7	21.3
2035	6.2	1.7	64.8	18.0
2036	5.6	1.6	52.8	14.7
2037	4.6	1.3	40.9	11.4
2038	4.7	1.3	28.9	8.0
2039	3.9	1.1	17.0	4.7
2040	2.1	0.6	5.0	1.4
2041	2.1	0.6	0	0
2042	1.9	0.5	0	0
2043	2.0	0.6	0	0
2044	2.1	0.6	0	0
2045	1.8	0.5	0	0
2046	1.7	0.5	0	0
2047	1.5	0.4	0	0
2048	1.5	0.4	0	0
2049	1.4	0.4	0	0
2050	1.3	0.4	0	0

[19] https://www.soni.ltd.uk/future-energy/tomorrows-energy-scenarios Self-Sustaining scenario, calculated from 2040 grid mix and 2040 grid losses provided, assuming a straight-line trajectory from the 2025 YTD NI delivered grid electricity intensity, and nil intensity from 2041 onwards

Electricity Curtailment Avoidance

DA.30. Where an operational Hydrogen Production Facility can evidence Electricity Curtailment Avoidance, the GHG Emission Intensity for this volume of electricity shall use the appropriate regional GHG Emission Intensity figure for the Reporting Unit. Evidence of Bid Offer Acceptances within GB is provided via Elexon's Balancing Mechanism Reporting Service[20] or NESO's Data Hub[21], and within NI is provided by SEM-O Market Data[22].

DA.31. For Hydrogen Production Facilities in GB, the regional GHG Emission Intensity value to be used for the Reporting Unit shall be determined by the Distribution Network Operator licenced area in which the Hydrogen Production Facility Balancing Mechanism Unit is located. These regional GHG Emission Intensities are only to be used for the volumes of electricity relating to Bid Offer Acceptance within the Balancing Mechanism – not any volumes involving contracted import of grid average electricity. Regional electricity GHG Emission Intensity data across GB is available using the NESO approved "Carbon Intensity API"[23], and values already include Transmission and Distribution Losses (but no emissions upstream of generation). This regional 30 minute data shall be used for the relevant Reporting Unit once the Reporting Unit has passed – earlier forecast data for the Reporting Unit shall not be used (as this is updated every 30 minutes ahead of the Reporting Unit).

DA.32. For Hydrogen Production Facilities in GB, if the required regional GHG Emission Intensity value is not available for the Reporting Unit, the GB average GHG Emission Intensity for the Reporting Unit from the NESO Dashboard[24] shall be used instead for the Bid Offer Acceptance volumes. This NESO dataset already includes Transmission and Distribution Losses (but no emissions upstream of generation).

DA.33. For Hydrogen Production Facilities in NI, Northern Ireland will be treated as its own region for purposes of determining the GHG Emission Intensity of any Bid Offer Acceptance under the Balancing Market. Per Reporting Unit, 30-minute GHG Emission Intensities for NI from the Eir Grid Smart Dashboard[25] shall be used. These values already include Transmission and Distribution Losses (but no emissions upstream of generation). Note that this 30-minute GHG Emission Intensity shall be taken as a simple arithmetic mean of two 15-minute periods, for example, the GHG Emission Intensity between 10:00 - 10:30 is a mean of the two GHG Emission Intensities at 10:00 and 10:15 respectively.

[20] https://www.bmreports.com/bmrs/?q=help/about-us
[21] https://www.nationalgrideso.com/data-portal
[22] https://www.sem-o.com/market-data/
[23] https://carbonintensity.org.uk/
[24] https://www.nationalgrideso.com/future-energy/our-progress-towards-net-zero/carbon-intensity-dashboard
[25] https://www.smartgriddashboard.com/ni/co2/, selecting Northern Ireland drop-down option, selecting the CO_2 tab, then View in Table, download .CVS

DA.34. For Hydrogen Production Facilities in GB or NI, the REGO Percentage of any Bid Offer Acceptance electricity volumes shall be set as 0%.

Stored Electricity via an Energy Storage System

DA.35. Hydrogen Production Facilities shall either use the 30-minute Self Discharge Loss values in Table 6, or evidence the 30-minute Self Discharge Loss value for the Electricity Storage System from which they source their electricity, as per Annex C of the Standard Document.

Table 6: Conservative Self Discharge Loss values for Electricity Storage Systems

Electricity Storage System	Loss per 30 minutes
Lithium ion battery[26]	0.0028%
Lead acid battery[27]	0.0083%
Nickel cadmium battery[26]	0.014%
Nickel metal hydride battery[26]	0.017%
LSD-nickel metal hydride battery[26]	0.0028%
Zinc manganese battery[26]	0.00035%
Pumped storage hydroelectricity[27]	0.00042%
Compressed air energy storage[27]	0.021%
Liquid air energy storage[28]	0.0042%
Flywheel[27]	7.5%
Solid gravity energy storage[29]	0%
Liquid CO_2 energy storage[30]	0.021%
Sensible heat energy storage[31]	0.021%
Latent heat energy storage[31]	0.021%
Thermochemical energy storage[31]	0.021%
Supercapacitor[31]	0.83%
Superconducting magnetic energy storage[27]	0.31%

[26] Umweltbundesamt Table 3, Page 20 https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4414.pdf
[27] https://sei.info.yorku.ca/files/2013/03/Sauer2.pdf
[28] https://www.epj-conferences.org/articles/epjconf/pdf/2014/16/epjconf_e2c2013_03002.pdf
[29] https://www.mdpi.com/1996-1073/16/2/825
[30] https://www.sciencedirect.com/science/article/pii/S2352152X22017704
[31] https://www.sciencedirect.com/science/article/pii/S1364032122001368

DA.36. Hydrogen Production Facilities shall either use the Round Trip Efficiency values in Table 7, or evidence the Round Trip Efficiency of the Electricity Storage System from which they source their electricity, as per Annex C of the Standard Document. The Round Trip Efficiency values in Table 7 are calculated from charging and discharging losses, electrical equipment losses and from any cooling requirements.

Table 7: Conservative Round Trip Efficiencies for Electricity Storage Systems

Electricity Storage System	Round Trip Efficiency
Lithium ion battery[32,33,34]	71.0%
Lead acid battery [32,33,34]	44.4%
Nickel cadmium battery[32,33,34]	62.1%
Nickel metal hydride battery[32,33,34]	57.7%
Pumped storage hydroelectricity[35]	45.7%
Compressed air energy storage[35]	34.7%
Liquid air storage[35]	34.7%
Flywheel[36]	77.2%
Solid gravity energy storage[35]	62.9%
Liquid CO2 storage[35]	62.9%
Sensible heat storage[35]	44.0%
Latent heat storage[35]	16.3%
Thermochemical storage[31]	25.4%
Supercapacitor[36]	81.9%
Superconducting magnet[27]	72.4%

Projected data for Transmission and Distribution Losses pre-operations

DA.37. Where a pre-operational Hydrogen Production Facility or Electricity Storage System in GB or NI intends to claim the delivered GHG Emission Intensity of a specific generation asset (or Electricity Storage Systems) via an Eligible PPA, Table 8 provides the projected Transmission and Distribution Losses that shall be used for the respective GB or NI Electricity Networks. These projected Transmission and Distribution Losses have been calculated using the NESO "Holistic Transition" Future Energy Scenario[37] for GB, and the SONI "Self-

[32] Heating and cooling loss of battery Figures 18 and 19 https://onlinelibrary.wiley.com/doi/epdf/10.1002/ecj.12221
[33] Cooling equipment COP efficiency Air chiller and water chiller https://www.sciencedirect.com/science/article/pii/S1876610214033372#:%7E:text=Under%20standard%20rating%20conditions%20at,6.39%20for%20water%2Dcooled%20chillers
[34] Battery Charging and Discharging Losses: Frontiers of Mechanical Engineering, Table 1, https://link.springer.com/article/10.1007/s11465-018-0516-8
[35] McKinsey (2023) Net-zero power: Long duration energy storage for a renewable grid, Exhibit 9, available at: https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/net%20zero%20power%20long%20duration%20energy%20storage%20for%20a%20renewable%20grid/net-zero-power-long-duration-energy-storage-for-a-renewable-grid.pdf
[36] https://eprints.whiterose.ac.uk/154479/1/2016_05_05_MA_Modified_Manuscript_NotMarked.pdf
[37] NESO FES 2025 Data Workbook, "ED1" tab, 2025-2050 columns, using the Holistic Transition pathway. https://www.nationalgrideso.com/future-energy/future-energy-scenarios/documents

Sustaining" Tomorrow's Energy Scenario[38] for NI. For electricity delivered to an NI user via an Eligible PPA, the final column losses for NI shall be applied, regardless of the specific generation asset and user connections to the NI Electricity Network. For electricity delivered to a GB user via an Eligible PPA, the GB column losses shall be applied based on the Network(s) between the specific generation asset and the user. Table 8 shall not be used once Facilities or Electricity Storage Systems are operational.

Table 8: Projected Transmission and Distribution Losses for pre-operations

Year	GB Transmission Loss	GB Distribution Loss	GB Total T&D Loss	NI Total T&D Loss
2025	2.0%	6.0%	7.9%	8.0%
2026	2.0%	6.0%	7.8%	8.0%
2027	2.0%	5.9%	7.8%	8.0%
2028	2.0%	5.9%	7.7%	8.0%
2029	1.9%	5.9%	7.7%	8.0%
2030	1.9%	5.9%	7.7%	8.0%
2031	1.9%	5.8%	7.7%	7.7%
2032	1.9%	5.8%	7.7%	7.7%
2033	1.9%	5.8%	7.7%	7.7%
2034	2.0%	5.8%	7.7%	7.7%
2035	2.0%	5.8%	7.6%	7.7%
2036	2.0%	5.8%	7.6%	7.5%
2037	1.9%	5.7%	7.6%	7.5%
2038	1.9%	5.7%	7.5%	7.5%
2039	1.9%	5.7%	7.5%	7.5%
2040	1.9%	5.6%	7.4%	7.5%
2041	1.9%	5.6%	7.4%	7.5%
2042	1.9%	5.5%	7.3%	7.5%
2043	1.9%	5.5%	7.3%	7.5%
2044	1.9%	5.5%	7.2%	7.5%
2045	1.8%	5.4%	7.1%	7.5%
2046	1.8%	5.3%	7.1%	7.5%
2047	1.8%	5.3%	7.0%	7.5%
2048	1.8%	5.3%	7.0%	7.5%
2049	1.8%	5.2%	7.0%	7.5%
2050	1.8%	5.2%	7.0%	7.5%

[38] SONI TES Databook, NI Demand tab, Figure 6.5 Self-Sustaining, dividing Losses by the total of the demand rows including Losses. In the absence of more granular data, assumed 2035 value applies to 2031-35, 2040 value to 2036-40, 2045 value to 2041-45 and 2050 value to 2046-50. https://www.soni.ltd.uk/future-energy/tomorrows-energy-scenarios Current 8% loss from Full TES Report, page 63, assumed to apply to 2025-30.

Typical data for Transmission and Distribution Losses during operations

DA.38. If both the operational Hydrogen Production Facility and specific generation asset are located in GB, the Facility shall determine Transmission Loss Multipliers (TLMs) and Distribution Line Loss Factors (LLFs) using data from the Elexon Portal[39].

DA.39. If both the Hydrogen Production Facility and specific generation asset are based in Northern Ireland, the following sources shall be used for these factors:

- Transmission Loss Adjustment Factors (TLAFs) are available via Eir Grid[40].
- The Distribution Loss Adjustment Factors (DLAFs) are located in the NIE Networks Statement of Charges for use of the Distribution System (DuoS)[41].

Heat and steam

DA.40. Typical values for heat and steam generation GHG Emission Intensities are not provided and shall be calculated following the methodology given in Annex G of the Standard Document. This is because the input sources, conversion efficiencies and system configurations for steam and heat generation vary widely. Thermal losses during the supply of steam and/or heat from the generation asset to the Hydrogen Production Facility also need to be factored in to derive a delivered heat and/or steam GHG Emission Intensity (in gCO_2e/MJ_{th}) for use by the Hydrogen Production Facility.

DA.41. If there is Useful Heat or Useful Steam exported by generation asset for heating buildings at a temperature below 150°C (423.15 Kelvin), the Carnot Efficiency C_h used in Equation 70 of the Standard Document can be set as 0.3546. Similarly, if the Hydrogen Production Facility exports Useful Heat or Useful Steam for heating buildings at a temperature below 150°C (423.15 Kelvin), the Carnot Efficiency C_h used in Equation 70 of the Standard Document can be set as 0.3546.

Fuel

DA.42. When calculating the emissions associated with the production and supply of fuels, the following fuel GHG Emission Intensities in Table 9 shall be used in conjunction with the fuel Activity Flow Data. These GHG Emission Intensities already consider representative transport emissions associated with delivery to a Hydrogen Production Facility site, and so do not need any adjustment for transportation.

[39] https://www.elexonportal.co.uk/registration/newuser
[40] https://www.eirgridgroup.com/customer-and-industry/general-customer-information/tlafs/
[41] https://www.nienetworks.co.uk/about-us/regulation/network-charges

Table 9: Fuel GHG Emission Intensity (production & supply, without combustion/conversion)

Fuel	gCO_2e/MJ_{LHV}	Sources and supporting notes
Diesel	17.5	UK Government (2025) Conversion factors[42], 100% Mineral Diesel
Petrol	18.3	UK Government (2025) Conversion factors[42], 100% Mineral Petrol
Natural gas (from Transmission Network, 7-94bar)	6.2	UK National Statistics (2025) Energy Trends[43] and DUKES (2023)[44] for the UK mix of natural gas sources; NSTA (2025)[45] for GHG intensities, except IEA (2025)[46] for US LNG; Energy Institute (2025)[47] for MJ/boe, UK Government (2025) Conversion factors[48] for LHV & HHV, IPCC (2024) for methane GWP[1]; Boothroyd et al. (2018)[49] for NTS losses, National Gas (2025)[50] for NTS own use of gas; Environment Agency (2016)[51] for composition data.
Natural gas (from intermediate/medium pressure Distribution Network, 75mbar to 7bar)	6.9	As above, but also including MP leakage, own use and theft, from JOGT (2023)[52]
Natural gas (from low pressure Distribution Network, up to 75mbar)	8.5	As above, but also including, own use and theft, from JOGT (2023)[52]
Marine gas oil	17.5	UK Government (2025) Conversion factors[42]
Fuel oil	17.5	UK Government (2025) Conversion factors[42]
Fossil methanol	28.2	JRC (2019) Definition of input data to assess GHG default emissions from biofuels in EU legislation[53]
Biomethanol	37.6	UK Government (2025) Conversion factors[42]
Bioethanol	28.9	UK Government (2025) Conversion factors[42]

[42] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
[43] https://www.gov.uk/government/statistics/gas-section-4-energy-trends
[44] https://www.gov.uk/government/statistics/natural-gas-chapter-4-digest-of-united-kingdom-energy-statistics-dukes
[45] https://www.nstauthority.co.uk/news-publications/emissions-monitoring-report-2025/
[46] https://iea.blob.core.windows.net/assets/5ad737ee-750d-460e-8c33-fb9140f1043d/AssessingemissionsfromLNGsupplyandabatementoptions.pdf
[47] https://www.energyinst.org/statistical-review/about
[48] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
[49] https://www.sciencedirect.com/science/article/pii/S0048969718306399
[50] https://www.nationalgas.com/balancing/unaccounted-gas-uag
[51] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/545567/Material_comparators_for_fuels_-_natural_gas.pdf
[52] https://www.gasgovernance.co.uk/index.php/shrinkage/aa2024
[53] https://publications.jrc.ec.europa.eu/repository/handle/JRC115952

Biodiesel FAME	11.9	UK Government (2025) Conversion factors[42]
Biodiesel HVO	16.4	UK Government (2025) Conversion factors[42]
Biomethane from wet manure (open digestate, no off-gas combustion) delivered via gas grid	146.2	DfT (2024) RTFO and SAF Mandate Technical Guidance[54]. Filling station compression emissions have been removed.
Biomethane from wet manure (open digestate, off-gas combustion) delivered via gas grid	125.2	As above
Biomethane from wet manure (closed digestate, no off-gas combustion) delivered via gas grid	32.6	As above
Biomethane from wet manure (closed digestate, off-gas combustion) delivered via gas grid	11.6	As above
Biomethane from maize whole plant (open digestate, no off-gas combustion) delivered via gas grid	73.5	As above
Biomethane from maize whole plant (open digestate, off-gas combustion) delivered via gas grid	52.5	As above
Biomethane from maize whole plant (closed digestate, no off-gas combustion) delivered via gas grid	50.9	As above
Biomethane from maize whole plant (closed digestate, off-gas combustion) delivered via gas grid	29.9	As above
Biomethane from biowaste (open digestate, no off-gas combustion) delivered via gas grid	70.7	As above
Biomethane from biowaste (open digestate, off-gas combustion) delivered via gas grid	49.7	As above
Biomethane from biowaste (closed digestate, no off-gas combustion) delivered via gas grid	35.0	As above
Biomethane from biowaste (closed digestate, off-gas combustion) delivered via gas grid	14.0	As above

54 https://www.gov.uk/government/publications/rtfo-and-saf-mandate-technical-information

Biomethane from sewage sludge (closed digestate, off-gas combustion) delivered via gas grid	20.5	JEC (2020) Well-to-tank report v5[55], OWCG3
Biomethane from wet manure (open digestate, no off-gas combustion) delivered via truck	147.7	DfT (2024)[54] for biomethane production emissions. Trucking distance from Ricardo (2015) Biomethane for Transport from Landfill and Anaerobic Digestion[56]; diesel use from JEC (2020)[55] and biomethane LHV from UK Government (2025) Conversion factors[42]
Biomethane from wet manure (open digestate, off-gas combustion) delivered via truck	126.7	As above
Biomethane from wet manure (closed digestate, no off-gas combustion) delivered via truck	34.1	As above
Biomethane from wet manure (closed digestate, off-gas combustion) delivered via truck	13.1	As above
Biomethane from maize whole plant (open digestate, no off-gas combustion) delivered via truck	75.0	As above
Biomethane from maize whole plant (open digestate, off-gas combustion) delivered via truck	54.0	As above
Biomethane from maize whole plant (closed digestate, no off-gas combustion) delivered via truck	52.4	As above
Biomethane from maize whole plant (closed digestate, off-gas combustion) delivered via truck	31.4	As above
Biomethane from biowaste (open digestate, no off-gas combustion) delivered via truck	72.2	As above
Biomethane from biowaste (open digestate, off-gas combustion) delivered via truck	51.2	As above
Biomethane from biowaste (closed digestate, no off-gas combustion) delivered via truck	36.5	As above

[55] https://publications.jrc.ec.europa.eu/repository/handle/JRC119036
[56] https://assets.publishing.service.gov.uk/media/5a7f191f40f0b62305b850e9/biomethane-for-transport.pdf

Biomethane from biowaste (closed digestate, off-gas combustion) delivered via truck	15.5	As above
Biomethane from sewage sludge (closed digestate, off-gas combustion) delivered via truck	22.0	JEC (2020) Well-to-tank report v5[55], OWCG3. Trucking distance from Ricardo (2015)[56]; diesel use from JEC (2020)[55] and biomethane LHV from UK Government (2025) Conversion factors[42]

DA.43. If calculating the emissions associated with the piped supply of a gaseous fuel that is not listed in Table 9, the following transportation loss assumptions may be used in converting a fuel production GHG Emission Intensity into a delivered fuel GHG Emission Intensity, accounting for any fugitive methane, fossil CO_2 generated and reduced energy delivered:

- 0.13% loss per 1,000km for gas pipeline transport across Europe to UK[57]
- 0.10% leakage within UK NTS (above 7bar)[49]
- 0.082% own use of gas within UK NTS (above 7bar)[50]
- 0.14% leakage within UK intermediate/medium-pressure network (75mbar to 7bar)[52]
- 0.016% own use of gas within UK intermediate/medium-pressure network (75mbar to 7bar)[52]
- 0.30% leakage within UK low-pressure network (below 75mbar)[52]
- 0.016% own use of gas within UK low-pressure network (below 75mbar)[52]

For any trucking, liquefaction, shipping, regasification, and storage, producers shall use measured or project-specific data, or reference values from recognised voluntary schemes (e.g. ISCC, RED II) or infrastructure operators. These values must be evidenced and justified.

[57] https://assets.publishing.service.gov.uk/media/6758544782c7cd4258eb64a8/rtfo-biomethane-guidance.pdf

Input Materials

DA.44. When calculating the emissions associated with the provision of Input Materials, the following GHG Emission Intensities in Table 10 shall be used in conjunction with material Activity Flow Data. These GHG Emission Intensities include manufacture of the material, and based on the references provided, are assumed to also include transport to a Hydrogen Production Facility. The exceptions are for desalinated water, oxygen and nitrogen, where the values given are for manufacture by a co-located third party directly adjacent to the Hydrogen Production Facility, so transport emissions shall be calculated and added if required for these Inputs. Future versions of the Data Annex may provide more explicit transport assumptions for all the Input Materials listed.

DA.45. The Table 10 factors do not consider emissions resulting from the combustion or conversion of these Input Materials within the Hydrogen Production Facility (these combustion/conversion emissions are to be covered within the Process CO_2 and Fugitive non-CO_2 Emission Categories).

DA.46. If using a material that is not listed in Table 10, the references given in the bullets below shall be consulted to source and evidence a suitable GHG Emission Intensity, or else a robust value from peer reviewed academic literature shall be evidenced, with justification for the applicability of the value chosen.

- UK Government conversion factors for Company Reporting[58]
- RTFO & SAF Mandate technical guidance[59]
- RTFO Carbon Calculator[60]
- RTFO carbon intensity templates[61]
- RED III text[62]
- JEC WTT v5[63]
- JRC updated input data for biofuel GHG default values[64]
- JRC updated data for solid/gaseous biogenic GHG default values[65]
- JRC comparison of hydrogen delivery options[66]

[58] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
[59] https://www.gov.uk/government/publications/rtfo-and-saf-mandate-technical-information
[60] https://www.gov.uk/government/publications/biofuels-carbon-calculator-rtfo
[61] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/947712/carbon-intensity-data-templates-2021.ods
[62] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02018L2001-20231120
[63] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/jec-well-tank-report-v5
[64] https://op.europa.eu/en/publication-detail/-/publication/7d6dd4ba-720a-11e9-9f05-01aa75ed71a1
[65] https://publications.jrc.ec.europa.eu/repository/handle/JRC104759
[66] https://publications.jrc.ec.europa.eu/repository/handle/JRC137953

- Biograce II biomass electricity, heating, cooling calculator (RED II compliant)[67]
- Biograce I biofuels calculator (RED I compliant)[68]
- EcoInvent database of GHG emissions[69] (old values[70])
- IEA Net Zero Emissions by 2050 scenario[71]

Table 10: Input Materials GHG Emission Intensities (manufacture & supply, no combustion/conversion)

Material	gCO_2e/kg	Sources and supporting notes
Mains water	0.19	UK government (2025) Conversion factors[42]
Desalinated water from co-located third party, using grid power	0.89	Fayyaz at al. (2023)[72] for efficiency of large-scale Reverse Osmosis of sea water; GB grid electricity factor applied; Najjar et al. (2021)[73] for emissions associated with input chemicals
Oxygen (liquid) from co-located third party, using grid power	32.1	Hersari (2020)[74] for power usage in cryogenic separation; GB grid electricity factor applied
Oxygen from co-located third party, using wind/solar	0.0	Nil intensity, due to nil intensity of input power
Nitrogen (gaseous) from co-located third party, using grid power	14.5	JRC (2019) Definition of input data to assess GHG default emissions from biofuels in EU legislation[53]; GB grid electricity factor applied
Nitrogen (liquid) from co-located third party, using grid power	33.8	Wu et al. (2020)[75] for power usage in cryogenic separation, and GB grid electricity factor
Nitrogen from co-located third party, using wind/solar	0.0	Nil intensity, due to nil intensity of input power
Sodium hydroxide (NaOH) solution	533	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Potassium hydroxide (KOH) solution	420	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Calcium oxide (CaO, pure)	1,193	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied

[67] https://www.biograce.net/biograce2/
[68] http://www.biograce.net/home
[69] https://ecoinvent.org/the-ecoinvent-database/use-of-the-ecoinvent-database/
[70] https://web.archive.org/web/20190605065129/http://www.arb.ca.gov/fuels/lcfs/workgroups/lcfssustain/ISCC_EU_205_GHG_Calculation_and_GHG_Audit_2.3_eng.pdf
[71] https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf
[72] https://www.sciencedirect.com/science/article/abs/pii/S0959652622048739
[73] https://www.sciencedirect.com/science/article/pii/S2352484721005710
[74] https://www.jgt.irangi.org/article_251658_2f9cc90ad987bb1250c10a292d975504.pdf
[75] https://www.sciencedirect.com/science/article/abs/pii/S0959652620330729
[76] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02022R0996-20231230

Calcium carbonate ($CaCO_3$, pure)	39.1	JRC (2019) Definition of input data to assess GHG default emissions from biofuels in EU legislation[53]
Sodium carbonate (Na_2CO_3, pure)	1,258	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Sodium hypochlorite (NaClO)	740	Euro Chlor (2022)[77]
Sodium methoxide ($NaCH_3O$)	2,445	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Sodium bisulphite ($NaHSO_3$)	440	Winnipeg (2012)[78]
Salt (NaCl)	13.4	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Hydrochloric acid (HCl) solution	1,069	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Sulphuric acid (H_2SO_4)	218	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Phosphoric acid (H_3PO_4)	3,155	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Boric acid (H_3BO_3)	495	Türkbay (2022) Life Cycle Assessment of Boron Industry from Mining to Refined Products[79]
Lubrication oils	947	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Cyclohexane	723	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Monoethanolamine (MEA)	3,400	Cuellar-Franca et al. (2016)[80]
Ammonia (NH_3) from unabated natural gas	2,351	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Urea (CH_4N_2O) from unabated natural gas	1,852	EU Commission Implementing Regulation (EU) 2022/996[76]; AR5 GWP values applied
Activated carbon	9,500	Vilen et al. (2022)[81]
Pellet binder	1,000	Chemigate (2020)[82]
Propylene glycol	3,275	JRC (2019) Definition of input data to assess GHG default emissions from biofuels in EU legislation[53]
Ferric (Iron (III)) chloride	1,406	GREET (2024) R&D GREET[83]
Citric acid	1,274	GREET (2024) R&D GREET[83]

77 https://www.eurochlor.org/wp-content/uploads/2022/02/2022-Euro-Chlor-Eco-profile.pdf
78 https://www.winnipeg.ca/finance/findata/matmgt/documents/2012/682-2012/682-2012_Appendix_H-WSTP_South_End_Plant_Process_Selection_Report/Appendix%207.pdf
79 https://hal.science/hal-03585831/document
80 https://pubs.rsc.org/en/content/articlepdf/2016/fd/c6fd00054a
81 https://www.sciencedirect.com/science/article/pii/S0301479722019296
82 https://chemigate.fi/en/chemigates-modified-starch-helps-protect-the-environment/
83 https://greet.anl.gov/index.php?content=greetdotnet

Process CO_2 emissions

DA.47. To calculate the amount of CO_2 generated from the conversion/combustion of feedstock, or feedstock material also used as a fuel, Hydrogen Production Facilities shall use the methodology set out in Annex H of the Standard Document. The values in Table 11 shall not be used to calculate the amount of CO_2 generated from the conversion of feedstocks.

DA.48. When calculating the amount of CO_2 generated from the combustion of any non-feedstock fuels (prior to any CO_2 Capture), the following CO_2 Emission Intensities in Table 11 shall be used in conjunction with the fuel Activity Flow Data. Note that these factors do not include the input production and supply of these fuels to the hydrogen production site, which are considered in the Fuel Supply Emission Category.

DA.49. If using a fuel or material that is not listed in Table 11, the same references as in Paragraph DA.46 shall be consulted to evidence a suitable CO_2 Emission Intensity, or else a robust value from peer reviewed academic literature shall be evidenced, with justification for the applicability of the value chosen.

Table 11: Fuel combustion CO_2 Emission Intensity (no production or supply emissions included)

Source	gCO_2/MJ_{LHV}	gC_{fossil}/kg	Sources and supporting notes
Diesel	73.5	864	UK Government (2025) Conversion factors[42], 100% Mineral Diesel
Petrol	70.2	856	UK Government (2025) Conversion factors[42], 100% Mineral Petrol
Natural Gas	56.8	709	UK Government (2025) Conversion factors[42], 100% Mineral Blend
Marine gas oil	75.3	875	UK Government (2025) Conversion factors[42]
Fuel oil	78.9	878	UK Government (2025) Conversion factors[42]
Fossil methanol	68.9	374	UK Government (2025) Conversion factors[42], using biomethanol Outside of Scopes
Biomethanol	0	0	UK Government (2025) Conversion factors[42]
Bioethanol	0	0	UK Government (2025) Conversion factors[42]
Biodiesel FAME	0	0	UK Government (2025) Conversion factors[42]
Biodiesel HVO	0	0	UK Government (2025) Conversion factors[42]
Biomethane	0	0	UK Government (2025) Conversion factors[42]

Fugitive non-CO_2 emissions

DA.50. No Typical Data is provided for this Emissions Category.

CO_2 Capture and Network Entry

DA.51. Pathways where the Inputs of energy and materials to operate CO_2 Capture and Sequestration equipment are not already included in the above Emission Categories, and/or those Pathways where CO_2 is transported, purified, and/or compressed offsite prior to the CO_2 T&S Network Delivery Point shall calculate their emissions under this category using the same Typical GHG Emission Intensities given in Paragraphs DA.20 - DA.46 used to calculate the emissions for Energy Supply and Input Materials Emission Categories.

CO_2 Sequestration

DA.52. All CO_2 sources (e.g. fossil, biogenic) are treated equally under this Emission Category, with 1 tonne of CO_2 meeting the requirements of the CO_2 Sequestration Emissions Category of the Standard Document being given a credit of 1 tonne of CO_2 for this Emission Category.

Solid Carbon Distribution

DA.53. Pathways where Solid Carbon is collected, transported, stored, purified or densified offsite prior to its final use shall calculate their emissions under this Emission Category using the same Typical GHG Emission Intensities for Energy Supply and Input Materials as given in Paragraphs DA.20 - DA.46.

DA.54. This term only applies to Solid Carbon generated from gas splitting Pathways and does not apply to other Pathways.

DA.55. Any losses of fossil Solid Carbon during these Distribution steps shall be assigned an emissions value of 3.664 gCO_2e/gC lost within this Emission Category (using the elemental carbon within the Solid Carbon). Any losses of biogenic Solid Carbon during these Distribution steps shall be assigned an emissions value of 0 gCO_2e/gC lost.

Solid Carbon Sequestration

DA.56. This Emission Category only currently applies to solid carbon generated from gas splitting Pathways and does not apply to other Pathways.

DA.57. Hydrogen produced from a gas splitting Pathway shall only be eligible under the Standard, where the corresponding solid carbon generated is used in one of the following Solid Carbon Permissible End Uses:

- incorporated into concrete for construction, including via incorporation into cement for concrete manufacturing;
- incorporated into asphalt for construction, provided that the bitumen content of the final mixture does not exceed 10% by mass;
- kept in inert underground storage. For the purposes of the Standard, 'inert' means the solid carbon does not physically disperse and remains chemically stable under storage conditions without requiring active management. Acceptable storage types include disused mines, salt caverns, and geological disposal facilities.

DESNZ may consider adding further Solid Carbon Permissible End Uses in the future, based on any evidence submitted as per the process set out in the Adding New Pathways to the scope of the Standard section of the Standard Document.

DA.58. Solid Carbon arising from fossil Inputs meeting the conditions of the Solid Carbon Sequestration section of the Standard Document shall be assigned a nil sequestration credit for this Emission Category. Solid Carbon arising from biogenic Inputs meeting the conditions of the Solid Carbon Sequestration section of the Standard Document shall be assigned a sequestration credit of 3.664 gCO_2e/gC for this Emission Category (using the elemental carbon within the Solid Carbon, see Equation 74 to calculate Pure Solid Carbon sequestered in Annex H of the Standard Document)[84].

[84] https://www.rsc.org/periodic-table Molecular weight of CO2 (44.010 g/mol) divided by the molecular weight of carbon (12.011 g/mol).

Compression and Purification of hydrogen

Compression of hydrogen

DA.59. DESNZ may update the theoretical compression method outlined in this section in the future in line with industry developments, along with more regularly updating the relevant GHG Emission Intensities.

DA.60. **If using Projected or Measured Data for Energy Supply, and H_2 Output pressure is below 3MPa.** Paragraph DA.64 below shall be used to calculate the additional theoretical GHG Emission Intensity required to achieve an outlet pressure of p_1 = 3MPa, to add to the GHG Emission Intensity result.

DA.61. **If using Default Data for Energy Supply and H_2 Output pressure is below 3MPa**. The emissions associated with hydrogen compression to 3MPa have already been accounted for within the Energy Supply Default Data, so Paragraph DA.64 below shall not be used.

DA.62. **If using Projected or Measured Data for Energy Supply and H_2 Output pressure is above 3MPa.** The total emissions associated with compression to the outlet pressure shall be accounted for within the Energy Supply Emission Category, and Paragraph DA.64 below shall not be used.

DA.63. **If using Default Data for Energy Supply and H_2 Output pressure is above 3MPa.** If a pre-operational Hydrogen Production Facility is using Default Data for the Energy Supply Emission Category, they shall use Paragraph DA.64 below to calculate the theoretical additional GHG emissions associated with raising the hydrogen pressure p_0 from the 3 MPa already included within the Default Data to their expected outlet pressure p_1.

DA.64. The GHG emissions from energy use for (theoretical) compression shall be calculated as follows:

Equation 2

$$\boldsymbol{EI}_{\boldsymbol{compression}} = A \times B \times \frac{1kg}{120\ MJ_{LHV}}$$

Where:

- *$EI_{compression}$* = Hydrogen Product added GHG Emission Intensity from electricity use for theoretical compression, in gCO_2e/MJ_{LHV} H_2.
- A = Electricity required to compress hydrogen (with losses), in kWh_e/kg H_2.
- B = Delivered electricity GHG Emission Intensity, in gCO_2e/kWh_e, adjusting for any Transmission and Distribution Losses. B shall be at least as large as the annual weighted average GHG Emission Intensity of the electricity

sources consumed by the Hydrogen Production Facility (e.g. a nil GHG Emission Intensity cannot be assumed for B if the Facility only consumes grid average electricity). If grid average electricity is used as part of the annual weighted average mix of electricity sources being claimed under B, use Table 5 for the grid imported electricity volumes if the Hydrogen Production Facility is pre-operational, or if operational, use the annual average data from the latest Government conversion factors for company reporting[85] (30 minute grid GHG Emission Intensity data is not required for theoretical compression calculations).

Compression energy, A, is calculated as follows:

Equation 3

$$\mathbf{A} = \frac{\mathrm{W}}{3.6 \times \eta}$$

Where W is defined as the specific compression power, and η is the adiabatic efficiency, which can be taken from Table 12.

Equation 4

$$\boldsymbol{W} = \left[\frac{n}{n-1}\right] \times p_0 \times V_0 \times \left[\left(\frac{p_1}{p_0}\right)^{\frac{(n-1)}{n}} - 1\right]$$

Where n is the adiabatic coefficient, p_o and p_1 are the respective inlet and outlet pressures, as defined in Table 12. V_0 is the input specific volume (of hydrogen), as defined below.

Equation 5

$$\boldsymbol{V_0} = k \times p_0{}^{\alpha}$$

Where α is the power law exponent and k is a constant. The values of α and k shall be taken from Table 13. (derived using a line of best fit derived from hydrogen density data[86]), using the temperature closest to the compressor inlet temperature. For example, a hydrogen production outlet temperature of 40°C shall use the α and k values for 50°C.

85 Government conversion factors for company reporting of Greenhouse Gas emissions, Full set workbook, summing factors for UK electricity generation and Transmission & Distribution, https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
86 https://h2tools.org/hyarc/hydrogen-data/hydrogen-density-different-temperatures-and-pressures, data source NIST Reference Fluid Thermodynamic and Transport Properties Database (REFPROP): Version 8.0

Table 12: Terms and units for Compression and Purification calculations

Term	Provided value	Units	Definition
A	Equation 3	kWh_e/kg	Compression energy
W	Equation 4	MJ/kg	Specific compression power
p_o	Operator	MPa	Input pressure
p_1	Operator	MPa	Output pressure
V_0	Equation 5	m^3/kg	Input specific volume
n	1.41	-	Adiabatic coefficient
η	70%	%	Adiabatic efficiency
α	Table 13	-	Power law exponent
k	Table 13	-	Constant
P_C	0.0013	kWh_e/kgH_2	Purity correction factor[87] (assuming starting pressure ≥ 3MPa)

Table 13: Line of best fit parameters for Equation 5 at specific temperatures

Temperature (°C)	k	α
0	1.1651	-0.935
25	1.2691	-0.939
50	1.373	-0.943
75	1.4767	-0.946
100	1.5804	-0.949
125	1.6839	-0.952

Purification of hydrogen

DA.65. DESNZ may update the theoretical purification method outlined in this section in the future in line with industry developments, along with more regularly updating the relevant GHG Emission Intensities.

DA.66. Hydrogen producers with Measured hydrogen purity of less than 99.9% by volume shall calculate the theoretical emissions associated with theoretical purification up to 99.9% by volume. The following theoretical purification Equation 6 shall be used, and assumes a minimum starting pressure of 3MPa is input into pressure swing absorption equipment.

DA.67. To utilise Equation 6, the GHG emissions associated with compression to a minimum of 3MPa must have already been accounted for either in the Energy Supply Emission Category, or theoretically using Paragraphs DA.59 - DA.64.

[87] Idaho National Laboratory Table 2, https://art.inl.gov/NGNP/INL%20Documents/Year%202010/Sensitivity%20of%20Hydrogen%20Production%20via%20Steam%20Methane%20Reforming%20to%20High%20Temp%20Gas-Cooled%20Reactor%20Outlet%20Temp%20Process%20Analysis.pdf

DA.68. If Energy Supply Default Data is being used for a pre-operational Hydrogen Production Facility, the GHG emissions associated with purification to 99.9% (or higher) by volume have already been accounted for, and Equation 6 shall not be used.

Equation 6

$$\boldsymbol{EI_{purification}} = P_c \times B \times \frac{1kg}{120\ MJ_{LHV}}$$

Where:

- $EI_{purification}$ = Hydrogen Product added GHG Emission Intensity from electricity use for theoretical purification, in gCO_2e/MJ_{LHV} H_2.
- P_C = Electricity required to purify hydrogen of 3MPa or higher to a purity of 99.9% (with losses), in kWh_e/kg H_2, as found in Table 12.
- B = as defined above in Paragraph DA.64.

Fossil Waste/Residue Counterfactual

Fossil fraction of MSW counterfactual

DA.69. DESNZ may update the counterfactual outlined in this section in the future based on the development of the UK Waste industry and other relevant UK policies.

DA.70. The current counterfactual for the fossil fraction of Municipal Solid Waste (MSW) shall be an energy from waste (EfW) plant that produces only electricity at 22% net electrical Lower Heating Value (LHV) efficiency, without Useful Heat sales and without any CCS. The current counterfactual is focused only on the fossil Waste/Residue feedstock CO_2 emissions emitted (and displaced utility), but not any non-CO_2 emissions arising from conversion of the fossil Waste/Residue feedstock in the counterfactual, nor any change in other inputs used in the counterfactual (for example, fossil heating oil use for plant start-up), nor any change in the supply chain for fossil Waste/Residue feedstocks.

DA.71. The displaced electricity is assumed to be supplied by UK grid average electricity, with the annual average GHG Emission Intensity data from the latest Government conversion factors for company reporting[88] if the Hydrogen Production Facility has started operations, or from Table 5 for GB/NI in the relevant future year of operations if the Hydrogen Production Facility is yet to

[88] Government conversion factors for company reporting of Greenhouse Gas emissions, Full set workbook, summing factors for UK electricity generation and Transmission & Distribution, https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

start operations. Note that 30 minute grid electricity intensity data is not required for counterfactual emissions calculations – only annual average data is required.

DA.72. If hydrogen is generated via electrolysis using electricity generated in a specific EfW plant, then instead of the generic EfW counterfactual assumption above, the counterfactual shall instead be taken as the specific EfW plant. This means the Hydrogen Production Facility shall use the electricity and heat efficiencies from the specific EfW plant to calculate the displaced electricity (and any heat), along with the GHG Emission Intensity of the grid electricity (and any replacement natural gas for heating) in the relevant year of operations. In this particular case, any CCS at the specific EfW plant will not impact the overall hydrogen GHG Emission Intensity, as CCS is used regardless of the destination of the diverted electricity.

Refinery Off-Gases (Residue) counterfactual

DA.73. DESNZ may update the counterfactual outlined in this section in the future based on the development of the UK refining industry, CO_2 T&S Networks and other relevant UK policies.

DA.74. If ROG is classified as a Residue, the counterfactual for ROG shall be the unabated use of fossil natural gas. It is assumed that ROG and fossil natural gas would have the same LHV energy efficiency ($MJ_{th}/MJ_{LHV\ gas}$) when converted in onsite furnaces to heat or in onsite boilers to steam regardless of where ROG-derived hydrogen is used. The natural gas supply GHG Emission Intensity in Table 9 (for Transmission Network withdrawals) shall be added to the natural gas CO_2 Emission Intensity in Table 11, and this combined intensity result (in gCO_2e/MJ_{LHV} natural gas) shall be assigned to the ROG at the start of the Pathway GHG Emission Intensity calculations (the same value in gCO_2e/MJ_{LHV} ROG). After conversion efficiency impacts, these high counterfactual GHG emissions will be largely, but likely not entirely, cancelled out by the CO_2 Sequestration Emission Category credit for reforming with CCS Pathways.

DA.75. If ROG is classified as a Co-Product, then no counterfactual applies. If ROG is classified as a Residue and meets the conditions set out in Paragraph D.14 of the Standard Document, then the counterfactual can be disapplied.

Default Data

Use of Default Data

DA.76. Prior to Hydrogen Production Facility operations commencing, if Projected Data is not available, Default Data can be used instead of Projected Data for a few of the Emission Categories. Default Data is only provided for the Feedstock Supply, Energy Supply and Input Materials Emission Categories, and is only provided for the following Pathways:

- Steam methane reformation (SMR) using UK natural gas with CCS
- Auto thermal reformation (ATR) using UK natural gas with CCS
- Food waste biomethane directly connected to autothermal reformation (ATR) with CCS (if CCS not implemented, the Default Data provided for the Pathway with CCS can still be used)
- Forestry residue gasification with CCS (if CCS is not implemented, the Default Data provided for the Pathway with CCS can still be used)
- Biogenic and fossil fractions of mixed municipal solid waste (MSW) gasification with CCS (if CCS is not implemented, the Default Data provided for the Pathway with CCS can still be used)
- Electrolysis using grid average electricity
- Electrolysis using wind/solar electricity
- Electrolysis using nuclear electricity

DA.77. If pre-operational electrolysis Hydrogen Production Facilities plan to use different electricity sources to the list above, they may still use the Default Data for the Input Materials Emission Category (but not the Energy Supply Emission Category). If pre-operational fossil gas reforming with CCS Hydrogen Production Facilities plan to use different gas feedstocks to the list above, they may still use Default Data for the Energy Supply and Input Materials Emission Categories (but not the Feedstock Supply Emission Category). Pre-operational gasification Hydrogen Production Facilities using different biomass or Waste feedstocks to the list above shall not use Default Data, due to potentially significant changes in their Inputs. Prior to operations, any Pathway not listed above shall use Projected Data in their hydrogen GHG Emission Intensity calculations. Table 14 below summarises which Default Data values can currently be applied across which pre-operational Pathway Emission Categories.

Table 14: Ability to use default factors for pre-operational Pathway Emission Categories

Production pathway	Feedstock Supply	Energy Supply	Input Materials
UK grid natural gas to SMR with CCS	Yes	Yes	Yes
Other fossil natural gas to SMR with CCS	No	Yes	Yes
Biomethane to SMR with/without CCS	No	Yes	Yes
UK grid natural gas to ATR with CCS	Yes	Yes	Yes
Other fossil natural gas to ATR with CCS	No	Yes	Yes
Food Waste biomethane to ATR with/without CCS	Yes	Yes	Yes
Other biomethane to ATR with/without CCS	No	Yes	Yes
Forestry Residue gasification with/without CCS	Yes	Yes	Yes
Other biomass gasification with/without CCS	No	No	No
Biogenic fraction of mixed MSW gasification with/without CCS	Yes	Yes	Yes
Fossil fraction of mixed MSW gasification with/without CCS	Yes	Yes	Yes
Other Waste gasification with/without CCS	No	No	No
Electrolysis using grid average electricity	NA	No, divide grid electricity GHG Emission Intensity by default electrolysis LHV efficiency (0.501 MJ_{LHV} H_2/MJ_e)	Yes
Electrolysis using wind/solar electricity	N/A	Yes	Yes
Electrolysis using nuclear electricity	N/A	Yes	Yes
Electrolysis using other electricity sources	N/A	No	Yes
Other Pathways not listed above	No	No	No

DA.78. Default Data is not provided for the Process CO_2 emissions, CO_2 Capture and Network Entry, CO_2 Sequestration, Solid Carbon Distribution, Solid Carbon Sequestration, Fugitive non-CO_2 emissions and Fossil Waste/Residue Counterfactual Emission Categories. These Emission Categories will always have to be projected by pre-operational Hydrogen Production Facilities, and once operational shall use Measured Data.

DA.79. For the Compression and Purification Emission Category, the Energy Supply Default Data provided already accounts for the emissions that will be required to reach the theoretical minimum pressure and purity under the Standard (3 MPa and 99.9 vol% purity). However, if non-Default Data is being used for the Energy Supply category, and the hydrogen Output pressure or purity is planned to be below the theoretical minimum, the data and methodology provided in Paragraphs DA.59 - DA.64 shall be used to calculate the theoretical additional emissions. Similarly, if Default Data for the Energy Supply category is being used, but the hydrogen Output pressure or purity is planned to be above the theoretical minimum, the data and methodology provided in Paragraphs DA.59 - DA.64 shall be used to calculate the additional emissions.

DA.80. The Standard Document and Data Annex have been developed into a Hydrogen Emissions Calculator (HEC) to support pre-operational Hydrogen Production Facilities in checking their likely compliance against the Standard. The Default Data provided below, and the theoretical compression and purification calculations, are already built into the HEC.

DA.81. To ensure that the Default Data provided is conservative, the central scenario values taken from DESNZ modelling have each been multiplied by a factor of 1.4 to derive the default values presented in this Annex. The exceptions are Feedstock Supply emissions for natural gas taken from the UK Gas Network, and Energy Supply emissions for electrolysis (which instead applies a conservative efficiency), neither of which were multiplied by the conservative factor.

DA.82. All Default Data for electricity inputs to Pathways have been derived assuming an Estimated 2025 GB grid electricity GHG Emission Intensity of 36.4 gCO_2e/MJ_e. The exception is electrolysis using grid average electricity, where the projected grid average GHG Emission Intensity in the relevant future year (from Table 5) shall be divided by a default electrolysis LHV efficiency of 50.1%[89].

[89] IRENA (2020) Green Hydrogen Cost Reduction. Table 6, mid-point of 2020 PEM system efficiency range (50-83 $kWh_e/kg\ H_2$) taken. https://h2.pe/uploads/IRENA_Green_hydrogen_cost_2020.pdf

Default Data tables

DA.83. DESNZ will update the following Default Data values over time to respond to industry developments and changes in the relevant input GHG Emission Intensities that were used to derive these Default Data values.

Feedstock Supply

DA.84. Feedstock Supply emissions cover the GHG emissions arising from feedstock cultivation, harvesting, collection, pre-processing, storage, and transportation. Depending on the Pathway, this term could include fossil natural gas, uranium, biomethane, solid biomass feedstocks and Waste feedstocks.

DA.85. Note that Feedstock Supply for the food waste biomethane Pathway includes the emissions from food waste collection and transport, anaerobic digestion and biomethane upgrading, and piping via a direct connection up to the point of biomethane delivery at the reformer plant.

DA.86. Counterfactual emissions for Waste/Residue fossil feedstocks are considered separately to this Emissions Category.

Table 15: Default Data for Feedstock Supply

Production pathway	GHG Emission Intensity (gCO_2e/MJ_{LHV} Hydrogen Product)
UK grid natural gas to SMR	8.41
UK grid natural gas to ATR	7.65
Food Waste biomethane to ATR	5.09
Forest Residue gasification	9.44
Biogenic fraction of mixed MSW gasification	0.64
Fossil fraction of mixed MSW gasification	0.64
Electrolysis	NA

Energy Supply

DA.87. Energy Supply emissions are the GHG emissions associated with the supply of electricity, steam, heat, and fuels for hydrogen production (but excluding emissions associated with directly converting feedstock to hydrogen which are separately considered under the Process CO_2 Emissions Category).

Table 16: Default Data for Energy Supply

Production pathway	GHG Emission Intensity (gCO_2e/MJ_{LHV} Hydrogen Product)
SMR	0.76
ATR	4.45
Forestry residue gasification	14.87
Biogenic fraction of mixed MSW gasification	16.04
Fossil fraction of mixed MSW gasification	16.04
Electrolysis using grid average electricity	Use the grid factor in the relevant year and country from Table 5 divided by 50.1% LHV efficiency
Electrolysis using wind/solar electricity	0.00
Electrolysis using nuclear electricity	2.54

Input Materials

DA.88. Input Materials emissions refers to GHG emissions associated with the production and supply of any Input Materials (except those covered in Feedstock Supply and Energy Supply Emission Categories) to a system. This could include Inputs such as oxygen, water, salts, catalysts, solvents, acids, alkali solutions.

Table 17: Default Data for Input Materials

Production pathway	GHG Emission Intensity (gCO_2e/MJ_{LHV} Hydrogen Product)
SMR	0.40
ATR	0.39
Forestry residue gasification	3.55
Biogenic fraction of mixed MSW gasification	3.85
Fossil fraction of mixed MSW gasification	3.85
Electrolysis	0.04

Sustainability Criteria

DA.89. Voluntary schemes[90] that may be used to provide evidence of compliance with the relevant Sustainability Criteria are listed below. Note that the coverage of each is different (some only cover certain feedstocks or pathways), and one scheme may not cover all the Sustainability Criteria that a given Input is required to meet.

- Biomass Biofuels voluntary scheme (2BSvs)
- Better Biomass (formerly NTA 8080)
- Bonsucro EU (formerly Better Sugar Cane Initiative (BSI)
- International Sustainability and Carbon Certification (ISCC EU)
- KZR INiG System
- REDcert-EU
- Red tractor farm assurance combinable crops and sugar beet scheme (Red tractor)
- Roundtable on Sustainable Biomaterials EU RED (RSB EU RED)
- Round Table on Responsible Soy EU RED (RTRS EU RED)
- Scottish Quality farm assured combinable Crops (SQC)
- Trade Assurance Scheme for Combinable Crops (TASCC)

[90] These are the voluntary schemes that are recognised under the RTFO and SAF Mandate. Further information on the schemes can be found here: https://www.gov.uk/government/publications/use-of-voluntary-schemes-as-evidence-of-rtfo-and-saf-mandate-compliance/list-of-voluntary-schemes-approved-for-the-rtfo-and-saf-mandate

Useful References

Sources of data for Lower Heating Values

DA.90. The following references provide useful data on the Lower Heating Values (MJ/kg_{dry}) of various Inputs and Outputs, that for consistency purposes should be used within Activity Flow Data calculations for pre-operational Hydrogen Production Facilities, or if composition data for the Input or Output is not measured as per Annex H for operational Hydrogen Production Facilities:

- RTFO and SAF Mandate standard data[91]
- Greenhouse gas reporting: Conversion factors 2025[92]

Where LHV data for a particular Input or Output is not available in these references, the other references given in Paragraph DA.46 or peer reviewed academic literature may be consulted, with justification given for the applicability of the value chosen.

Unit conversions for pure hydrogen

DA.91. LHV to Higher Heating Value (HHV): To convert an LHV energy content of pure hydrogen into an HHV energy content of pure hydrogen, multiply the LHV amount of energy by 1.182.

DA.92. /MJ to /kWh: To convert from a per MJ H_2 measure to a per kWh H_2 measure, multiply the per MJ H_2 measure by 3.6.

DA.93. /MJ to /kg: To convert from a per MJ_{LHV} pure H_2 measure to a per kg pure H_2 measure, multiply the per MJ_{LHV} pure H_2 measure by 120.0 MJ_{LHV}/kg H_2. To convert from a per MJ_{HHV} pure H_2 measure to a per kg pure H_2 measure, multiply the per pure MJ_{LHV} H_2 measure by 141.8 MJ_{HHV}/kg pure H_2.

DA.94. Note that all these MJ_{LHV} and MJ_{HHV} values are for a pure hydrogen stream, while the Hydrogen Product will contain impurities, and even small %vol impurities can significantly impact the resulting Hydrogen Product LHV or HHV. Table 18 below summarises some of the common unit conversions for pure hydrogen.

[91] https://www.gov.uk/government/publications/rtfo-and-saf-mandate-standard-data
[92] Conversion factors 2025: Full set (for advanced users) – updated 10 June 2025, Excel workbook: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2025

Table 18: Example conversion factors from 1.0 gCO_2e/MJ_{LHV} pure H_2

1.0 gCO_2e/MJ_{LHV} pure H_2 is equal to:
0.846 gCO_2e/MJ_{HHV} pure H_2
3.6 gCO_2e/kWh_{LHV} pure H_2
3,047 gCO_2e/MWh_{HHV} pure H_2
0.12 $kgCO_2e/kg$ pure H_2
0.12 $tCO_2e/tonne$ pure H_2

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