Department for Energy Security & Net Zero

UK Low Carbon Hydrogen Standard

Guidance on the greenhouse gas emissions and sustainability criteria

Version 2

April 2023

Any enquiries regarding this publication should be sent to us at:
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Executive Summary

To support the implementation of the UK Hydrogen Strategy and Energy Security Strategy, the UK Low Carbon Hydrogen Standard ('the standard' or the LCHS) defines what constitutes 'low carbon hydrogen' at the point of production. The standard sets out in detail the methodology for calculating the emissions associated with hydrogen production and the requirements producers are expected to meet to prove that the hydrogen they produce is compliant. The intent of the standard is to ensure new low carbon hydrogen production supported by government makes a direct contribution to GHG emission reduction targets under the Climate Change Act.

Hydrogen producers proving compliance with the standard are required to:

- meet a GHG emissions intensity of 20 gCO_2e/MJ_{LHV} of produced hydrogen or less for the hydrogen to be considered low carbon.

- calculate their greenhouse gas (GHG) emissions up to the 'point of production', accounting for the following emissions categories:

$$E_T = E_{feedstock\ supply} + E_{energy\ supply} + E_{input\ materials} + E_{process\ CO_2} + E_{fugitive\ non\text{-}CO_2} + E_{CO_2\ capture\ and\ network\ entry} - E_{CO_2\ sequestration} + E_{compression\ and\ purification} + E_{waste\ fossil\ counterfactual}$$

- account for the emissions associated with meeting a theoretical minimum pressure level of 3MPa and a theoretical minimum purity of 99.9% by volume at the production plant gate, in the emissions calculations.

- include in the emissions calculation those emissions associated with capture, compression and transport of CO_2 until entry into a CO_2 network. While some of the associated infrastructure may be located outside the point of production, the related emissions were generated due to the hydrogen production and so are considered within the scope of the standard. CO_2 network operational and fugitive emissions are not in scope.

- account for the use of electricity:

  - using actual data to demonstrate that the hydrogen production facility is operating at the same time as the electricity input source.

  - evidencing hydrogen producers have exclusive ownership of the electricity used to cover the amount of hydrogen produced.

- set out a risk mitigation plan for fugitive hydrogen emissions including:

  - Risk Reduction Plan: Produce a plan demonstrating how fugitive hydrogen emissions at the production plant shall be minimised.

- Risk Plan: Provide estimates of expected rates of remaining fugitive hydrogen emissions by the plant. (Noting that these are not accounted for in the GHG emissions calculation above).
- Risk Monitoring: Prepare a monitoring methodology for fugitive hydrogen.

- and meet additional requirements for the use of biogenic inputs, where relevant and as appropriate for the feedstock source and classification:
  - demonstrate compliance with the land, soil carbon and forest criteria.
  - satisfy the minimum waste and residue requirement.
  - report on estimated indirect land-use change (ILUC) GHG emissions (noting that these are not accounted for in the GHG emissions calculation above).

This document describes the methodology to calculate GHG emissions associated with the production of low carbon hydrogen in the UK and sets out the specific criteria for several hydrogen production pathways:

- Electrolysis.
- Natural gas reforming (with CO_2 capture and storage).
- Biomass/waste conversion to hydrogen (with/without CO_2 capture and storage).

Update notice: LCHS Version 2 (April 2023)

In the Government's response to the UK Low Carbon Hydrogen Standard consultation, we signalled our intent to update the standard following regular review points, to ensure that the guidance remains fit for purpose and reflects our growing understanding of how new technologies work in practice, including how hydrogen production interacts with the broader energy system. Engagement with stakeholders over the past year has improved our understanding of the LCHS's practical applications, highlighting areas where additional clarity is needed for its implementation. This includes, for example, a new approach to consignments which has been harmonised across all production pathways.

In this Version 2, we are also introducing policies that were part of the 2021 consultation on a UK Low Carbon Hydrogen Standard, but which had, due to lack of precedents, been deferred to a subsequent update so that more evidence could be considered. Amongst other clarifications, this version includes the introduction of a materiality threshold to ease the reporting and verification burden; a waste fossil feedstock counterfactual emissions methodology to reflect their system-wide emissions benefits; a revised process for including new technology pathways; and a new chapter on consignments. These updates and clarifications have been informed by industry engagement and feedback, including a questionnaire to stakeholders.

We expect to publish a further review later this year which will resolve outstanding issues to ensure the LCHS requirements are clearer, so they can be more effectively applied under the Hydrogen Production Business Model contract.

The Version 2 updates include:

- Chapter 1
  - Updated introduction to reflect the evolving nature of the standard.
- Chapter 2
  - Clarification of the terminology for CO_2 capture and sequestration, emissions categories, energy allocation and lower heating values.
  - Addition of definitions for wastes, residues, co-products, products and steps in the production pathway.
- Chapter 3
  - Reformatting of the scope and clarification of the process to add new technology pathways to the eligible list.
- Chapter 6
  - 6.4. Reworked equation to include the waste fossil counterfactual and clarification of the lower heating value formula.
  - 6.4.1. Introduction of the cumulative allocation factor, clarification around negative upstream feedstock emissions, clarification of electrolysis energy vs feedstock supply categories.

- 6.4.2. Introduction of the hydrogen production plant allocation factor, clarification around energy supply negative emissions intensity.
- 6.4.3. Clarification around input material negative emissions intensity.
- 6.4.4. Clarification of $E_{process\ CO2\ emissions}$.
- 6.4.6. Clarification of the liability in cases of downstream CO_2 emissions.
- 6.4.7. Clarification of permanently stored CO_2 and negative emissions.
- 6.4.8. Specification of the two applicable cases for $E_{compression\ and\ purification}$.
- 6.4.9. Introduction of waste fossil feedstock counterfactual emissions, including two worked examples.
- 6.4.10. Clarification of LHV energy allocation, introduction of the allocation factor for (co-)products, LHV formula for (co-)products and a worked example.

- Chapter 7
  - New chapter to separate out non-GHG emissions sustainability criteria
- Chapter 8
  - A revised chapter on consignments and monthly averaging, introducing a new harmonised approach across different production pathways.
  - 8.1. Reworked section on consignment definitions.
  - 8.1.1. New section on generating separate consignments, harmonisation of 30-minute consignments across all technology pathways.
  - 8.1.2. Clarification of input specific requirements for consignments.
  - 8.2. Clarification of which emissions and hydrogen production are included when calculating a consignment GHG intensity, and treatment of additional emissions generated without hydrogen production.
  - 8.3. Introduction of a materiality threshold.
  - 8.4. More detail on the option for weighted average of consignments for monthly reporting.
- Chapter 10
  - 10.2.3. Clarification of data completeness in relation to the new materiality threshold.

Contents

1. Introduction

To support the implementation of the UK Hydrogen Strategy and Energy Security Strategy, the UK Low Carbon Hydrogen Standard (‘the standard’) defines what constitutes ‘low carbon hydrogen’ up to the point of production. The intent of the standard is to ensure new low carbon hydrogen production supported by government makes a direct contribution to our GHG emissions reduction targets. As we look to grow the UK’s nascent hydrogen economy, we must consider the range of methods that could be used to produce low carbon hydrogen, covering a wide variety of feedstocks, energy inputs and technology processes, all with different GHG emissions intensities.

This guidance document and accompanying annexes set out the details of the methodology for calculating hydrogen production GHG emissions under the standard. It aims to assist hydrogen producers in their GHG emissions reporting, meeting any relevant biomass sustainability criteria, and establishes an approach for considering fugitive hydrogen emissions. This document should therefore be used as guidance for government schemes and policies that apply the standard.

We expect to update this document and accompanying annexes at regular review points, to ensure they remain fit for purpose and reflect our growing understanding of how new technologies work in practice, including how hydrogen production interacts with the broader energy system.

2. Terminology

The following terminology will be used throughout this document:

- **Actual data:** Historical data measured or calculated by producers based on the hydrogen production process.
- **Allocation factor:** The % of upstream and step emissions assigned to a (co)product from a step in the production pathway, based on the energy content of the specific (co)product divided by the energy content of all (co)products from that step. See ‘energy allocation’ definition.
- **Carbon/GHG Intensity:** Life cycle emissions of greenhouse gases from the production pathway. It is expressed in units of carbon dioxide equivalents per megajoule of hydrogen using lower heating values (gCO_2e/MJ_{LHV}).
- **Carnot Efficiency:** The maximum theoretical efficiency that a heat engine may have operating between two given temperatures. It is used in the energy allocation

methodology when heat or steam is a co-product, to convert MJ energy values for steam/heat into MJ useful energy values.

- **CO_2 capture and sequestration (CCS):** Infrastructure for capturing CO_2 from a process stream in the hydrogen production plant, any purification and compression of the CO_2, then transportation including via a CO_2 network before injection into geological storage.
- **Cumulative allocation factor:** A measure of what % of emissions from a step will end up in the final hydrogen product, based on multiplying the hydrogen allocation factor for the final production step with all previous step allocation factors back up the feedstock supply chain, up to and including the allocation factor from the step of interest.
- **Emissions category:** A part of the production pathway for which emissions are required to be calculated. These are emissions from Feedstock supply, Energy supply, Input materials, Process CO_2, Fugitive non-CO_2, CO_2 capture and infrastructure, CO_2 sequestration, any Compression and purification, and any Waste fossil feedstock counterfactual emissions. See section 6.4 for more details.
- **Co-products:** Electricity, useful heat outputs or materials that are not wastes or residues, that are produced at the same time as a main product from a step in the production pathway.
- **Energy allocation:** The energy allocation approach assigns upstream and step emissions to the products and co-products from that step, according to their proportion of the step's total useful output energy as measured on a lower heating value basis (excluding the latent heat of vaporisation of moisture). See section 6.4.10 for more details.
- **Default data**: Data provided for use by production pathways where actual data or projected data is unavailable. Default data will be provided only for some emissions categories and will be conservative, based on expected values multiplied by a factor of 1.4.
- **Delivery partner**: Where a government scheme applies the standard as eligibility criteria and requires compliance with the standard, the government may work with external partners to collect and assess data from projects to prove compliance with the standard.
- **Greenhouse gas (GHG):** Gases in the atmosphere, both naturally occurring and generated from human activity, that cause global warming. These gases can absorb infrared radiation (net heat energy) emitted from Earth's surface and re-radiate it back to the Earth's surface. Greenhouse gases considered in this methodology are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and sulphur hexafluoride (SF_6).
- **Global Warming Potential (GWP):** For any Greenhouse Gas (GHG), the Global Warming Potential (GWP) is the amount of carbon dioxide (CO_2) that would cause an equivalent amount of global warming as the selected GHG over a given time period. This measures the radiative forcing (causing global warming) from the emission of one

mass unit of a given GHG in the present-day atmosphere integrated over a chosen time horizon, relative to the emissions of one mass unit of carbon dioxide (CO_2). The GWP of fossil CO_2 is assigned a value of 1.

- **Hydrogen Emissions Calculator (HEC):** A freely available tool for hydrogen producers to use to test whether the hydrogen in their facility is likely to comply with the GHG requirements of the standard.
- **Input:** Materials or energy flow that enters a unit process.
- **Life Cycle Assessment (LCA):** Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a production pathway as defined by the system boundary.
- **Lower Heating Value (LHV):** A measure of the energy content of a substance, also known as Net Calorific Value. Specifically, it is the amount of heat released in the combustion of a specified quantity of the substance. For the purposes of consignment sizes and step efficiencies, this LHV measure includes the latent heat of vaporisation of any moisture in the substance, whereas this term is excluded for (co-)product energy allocation calculations.
- **Output:** Material or energy flow that leaves a unit process.
- **Power Purchase Agreement (PPA):** A Power Purchase Agreement (PPA) is usually a long-term contract under which a business agrees to purchase electricity directly from an electricity generator.
- **Product:** A material, electricity or useful heat output that is the primary aim of a step in the production pathway; or alternatively a material that has been intentionally modified or contaminated in an attempt to classify it as a residue or waste.
- **Production pathway:** A combination of a feedstock supply chain (where relevant) and production process used to make hydrogen.
- **Projected data:** Future data projected by hydrogen producers based on the design and expected performance of the facility.
- **Renewable electricity:** Electricity generated by a renewable non-fossil energy source e.g. wind, solar, geothermal, wave, tidal and hydropower**.**
- **Renewable Electricity Guarantee of Origin (REGO):** Each Renewable Energy Guarantee of Origin (REGO) certificate represents the ‘energy attribute’, associated with 1MWh of renewable electricity generated.
- **Reporting party:** The ‘project’ or ‘operator of the hydrogen production facility’ responsible for reporting the emissions associated with hydrogen production.
- **Residue:** A substance that is not the end product sought directly from the pathway step; the production of which is not a primary aim of the step; and which has a low economic value in relation to the (co-)products from the step.

- **Residues from agriculture, aquaculture, fisheries or forestry:** residues that are directly generated by agriculture, aquaculture, fisheries or forestry. These do not include residues from related industries or processing.
- **Scope 1 emissions[1]:** A production pathway's direct GHG emissions.
- **Scope 2 emissions:** GHG emissions associated with the generation of electricity outside of the hydrogen production facility, heating/cooling, or steam purchased for own consumption.
- **Scope 3 emissions:** A production pathway's indirect GHG emissions other than those covered in scope 2. In the case of this standard, partial scope 3 emissions shall be covered which includes upstream supply chain emissions only, not downstream emissions from hydrogen distribution and use.
- **Step:** Any physical stage in the production pathway from feedstock through to hydrogen production. Steps include (where relevant) feedstock production, any intermediate pre-processing, feedstock storage & transport, as well as the industrial processing facility generating hydrogen (the final step in the production pathway).
- **System boundary:** defines which steps in the product's (i.e. the hydrogen's) life cycle should be included in the life cycle assessment, and at what point an input or output to the production pathway is included within the life cycle assessment.
- **Waste:** Any substance or object which the holder discards or intends or is required to discard. This definition excludes substances that have been intentionally modified or contaminated for the purpose of transforming it into a waste.

3. Scope

The guidance document should be used by hydrogen producers seeking to claim low carbon credentials for their hydrogen production, for the purposes of policies that apply the standard.

There are numerous pathways to produce hydrogen from various primary energy sources. This document describes the methodology to calculate GHG emissions associated with the production of low carbon hydrogen in the UK only and sets out specific criteria for several hydrogen production pathways in the annexes.

The hydrogen production pathways currently considered within scope of the standard, and therefore eligible to comply, are set out below (with more detail in the annexes):

- Electrolysis.
- Natural gas reforming (with CO_2 capture and storage).

[1] https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf"

- Biomass/waste conversion to hydrogen (with or without CO_2 capture and storage).

Our analysis suggests that each of the listed technology pathways has the potential to produce hydrogen with GHG emissions complying with the standard, along with the other required sustainability characteristics. Inclusion on this list does not, however, guarantee the hydrogen produced will comply with the standard – producers will need to design and operate their hydrogen production facilities in the appropriate way to ensure the standard is met in practice, and on an ongoing basis.

Other hydrogen production pathways may also be able to meet the standard GHG emissions threshold and criteria. Before these pathways are eligible to comply with the standard, they need to be added to the list of eligible technology pathways above. Stakeholders wishing to add production pathways to this list are invited to submit evidence to DESNZ, covering:

- The likely GHG emissions intensity of hydrogen produced by this pathway, under a range of different scenarios with reasonable assumptions. This should use the standard's GHG methodology as closely as practicably possible, highlighting where a new or different approach is adopted.
- The ability to meet the non-GHG emissions sustainability criteria set out in the standard highlighting any risks of non-compliance.
- The strategic case for the pathway's inclusion in the standard, highlighting its ability to make a direct contribution to GHG emission reduction targets under the Climate Change Act. This should consider the ability for the technology to be further decarbonised over time (e.g. scope for future innovation), the opportunities and risks it poses to wider decarbonisation efforts (e.g. the emissions impact of the low carbon hydrogen production pathway on the energy system, emissions impact of co-products from the pathway, etc.), and other relevant environmental impacts (e.g. resource impacts, other pollutants, fit with resource or waste policies).

Evidence can be submitted to DESNZ via hydrogenproduction@beis.gov.uk by individuals or organisations involved in or looking to develop low carbon hydrogen production projects. DESNZ will scrutinise the evidence provided and respond within 30 working days of the submission. This initial response will set out the next steps before a decision can be confirmed, which will vary according to the complexity of information that needs to be considered. Further, or amended evidence submissions or modelling may be requested. The initial response will not provide a final decision, but will provide a likely timescale over which a decision can be expected, provided that the next steps are followed.

The decision will be communicated to the party which has submitted evidence, with a justification. If a decision is made to include the pathway in the list of eligible technology pathways, DESNZ will develop further detail for inclusion in an updated version of this guidance document and relevant appendices as appropriate. The decision will only come into effect once updated guidance is released with the pathway listed.

The process of adding new production pathways to the approved list can take place independently of wider updates to the standard. Guidance which is updated to include a new production pathway may therefore be released separately to other updates to the standard.

4. GHG emissions threshold

To demonstrate compliance with the low carbon hydrogen standard, producers of low carbon hydrogen must be able to report a GHG emissions intensity of 20 gCO_2e/MJ_{LHV} of produced hydrogen or less.

5. Normative references

The emissions accounting methodology is intended to apply to all hydrogen production pathways equally, based on international standards for GHG emissions accounting. The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

- ISO 14040 Environmental Management Life Cycle Assessment Principles and Framework.
- ISO 14044 Environmental Management Life Cycle Assessment Requirements and Guidelines.
- ISO 14067[2] Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification.
- GHG Protocol A Corporate Accounting and Reporting Standard. Revised Edition.

[2] Referring to ISO 14067, the following criteria shall be applied:

a. the product category definition and description of the investigated pathways are identical;
b. the declared unit is identical;
c. the system boundary is equivalent;
d. the description of data is equivalent;
e. the criteria for inclusion of inputs and outputs are equivalent;
f. the data quality requirements (e.g. coverage, precision, completeness, representativeness, consistency and reproducibility) are the same;
g. assumptions especially for the delivery stage are the same;
h. specific GHG emissions and removals are treated identically;
i. the following criteria shall be applied for the life cycle inventory and LCIA phase:
    a. the methods of data collection and data quality requirements are equivalent;
    b. the calculation procedures are identical;
    c. the allocation of the flows is equivalent;
    d. the applied GWPs are identical.

6. Assessing the GHG emissions intensity of low carbon hydrogen

6.1. GHG accounting and reporting system boundary

The GHG calculation methodology described in this guidance is based on a 'point of production' system boundary, including Scope 1, Scope 2, and partial Scope 3 emissions. Partial Scope 3 emissions considered include associated impacts from the raw material acquisition phase, raw material transportation phase and hydrogen generation phase.

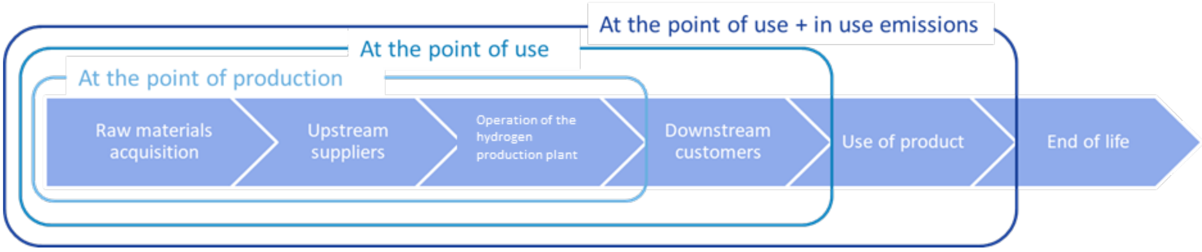

Figure 1: "Point of Production" system boundary adopted for this guidance

The emissions from the construction, manufacturing, and decommissioning of the capital goods (including hydrogen production plant, vehicles etc.), business travel, employee commuting, and upstream leased assets are not within scope. Excluding these emissions ensures consistency with GHG reporting for other energy vectors. Should the international or national reporting requirements change in future, the standard shall be updated to include these emissions.

If storage is integrated within the hydrogen production plant, then emissions associated with the energy consumption related to the operation of storage facilities within the plant shall be included. Buffer storage may be required to facilitate plant operation or accumulate batches short term ready for dispatch. If storage is shared with other producers and/or users, then energy allocation shall be used to allocate the emissions to the hydrogen producer (see section 6.4.10).

6.2. Units

GHG contributions are defined in terms of grams of carbon dioxide equivalent per megajoule of produced hydrogen using lower heating values (gCO_2e/MJ_{LHV}).

6.3. Applied global warming potential factors

Greenhouse gases considered in this methodology are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and sulphur hexafluoride (SF_6). The global warming potential (GWP) of the various GHGs are expressed in CO_2e. The impact of the global warming potential of the GHGs shall be assessed over a period of 100 years. This is in line with current international and domestic carbon accounting practices.

Table 1 shows the GWP factors of CO_2, CH_4, N_2O, HFCs and SF_6 for a period of 100 years according to the 2018 Fifth Assessment Reports (AR5) of the Intergovernmental Panel on Climate Change (IPCC). The GWP factors measure the radiative forcing (causing global warming) from the emission of one mass unit of a given GHG in the present-day atmosphere integrated over a chosen time horizon, relative to the emissions of one mass unit of carbon dioxide (CO_2).

Table 1: IPCC AR5 Global warming potential (GWP) of GHGs without climate feedback

AR5 GWPs without climate feedback	
GHG	**GWP factor (in gCO_2e/g)**
CO_2	1
CH_4	28
N_2O	265
SF_6	23,500
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
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

6.4. GHG emissions accounting

An overview of the GHG emissions accounting methodology applied to each production pathway is summarised below. This section breaks down the emissions categories to be accounted for under the standard, providing detail on the emissions that are likely to occur within those categories.

Emissions include all Scope 1 and 2 and partial Scope 3 emissions calculated at the “point of production” boundary as defined in section 6.1. This includes GHG emissions (in gCO_2e/MJ_{LHV} hydrogen) from the hydrogen production pathways arising from feedstock extraction, collection and transportation, and from hydrogen production processing facilities (including emissions from fuel, heat, steam and electricity use), including the benefit of any CO_2 sequestration.

The equation below shows the breakdown of the emissions within the scope of the standard into the various required (emissions categories).

$$E_T = E_{feedstock\ supply} + E_{energy\ supply} + E_{input\ materials} + E_{process\ CO_2} + E_{fugitive\ non\text{-}CO_2} + E_{CO_2\ capture\ and\ network\ entry} - E_{CO_2\ sequestration} + E_{compression\ and\ purification} + E_{waste\ fossil\ counterfactual}$$

Where E_T = the total GHG emissions in gCO_2e over the relevant time period for the hydrogen consignment (see section 8 for further details).

$$E = E_T / P$$

Where P = the total quantity of hydrogen, in MJ_{LHV}, that is produced for valorisation by the plant (i.e. excluding any fugitive hydrogen, but including any hydrogen sold or sent to storage) over the relevant time period for the consignment, and E = the raw GHG emissions intensity per unit of hydrogen produced, in gCO_2e/MJ_{LHV} hydrogen. E should be reported to the nearest 0.1 gCO_2e/MJ_{LHV}.

Default data is provided in gCO_2e/MJ_{LHV} hydrogen for a few of the above emissions categories, but not all categories (see the Data Annex for further details). Actual or projected data is required for the rest of the emissions categories.

For any calculation relating to P, consignment sizes or step efficiencies (to calculate the emissions contribution of upstream supply chain steps), the energy flows in these calculations should use lower heating values calculated with the formula below:

*Material MJ_{LHV} = Material kg (as received) * Material Lower Heating Value MJ/kg (dry) * (1 – % moisture content of as received material)*.

Dry material is at 0% moisture content, and the % moisture content is the kg of water present in 1 kg of as received material. Note this formula differs from the LHV definition used for coproduct energy allocation in section 6.4.10. The standard will also provide further guidance on the treatment of impurities within these LHV formulae during a future review.

6.4.1. Feedstock supply emissions

$$E_{feedstock\ supply} = \sum_i E_{feedstock\ supply\ emissions,i} \times CAF_i$$

Where $E_{feedstock\ supply\ emissions}$ are the GHG emissions arising from feedstock extraction, cultivation, collection, harvesting, pre-processing, storage and transportation steps, and CAF_i is the cumulative allocation factor for each individual supply chain step down to the point of delivery to the hydrogen production facility (see section 6.4.10).

The emissions in this category could cover the following feedstock inputs (depending on the production pathway):

- **Natural gas:** includes extraction, processing and transportation. To account for natural gas inputs, producers should use the average UK gas network value provided in the Data Annex if they are connected to the UK gas network, or actual data they have generated in all other cases.
    - Upstream emissions for natural gas provided directly from a facility should be provided via the methodology set out in Annex B.
    - Upstream emissions for natural gas imported directly from an international transmission system should be provided via the methodology and requirements in Annex B.
- **Biomass feedstocks:** includes emissions from cultivation, harvesting, pre-processing, storage and transport, as well as biomethane production and transport where relevant. Emissions associated with direct land-use change should be included, and indirect land use change should be reported separately – further guidance on emissions related to land-use change can be found in Annex C. Impacts related to avoided emissions (e.g. avoided landfill methane emissions) are not included.

- **Waste feedstocks (with fossil or biogenic content):** includes emissions from collection, sorting, pre-processing and transport to the point of hydrogen production.

Additional feedstock streams may be considered on a case-by-case basis and should be fully accounted for using the broad methodology for feedstock supply emissions.

If a producer uses a certain input (e.g. natural gas) both as the feedstock and as a fuel to their processing plant, these inputs should always be combined and considered as only a feedstock, and the related emissions reported under the feedstock category.

Any feedstock arriving at the hydrogen production plant with a negative emissions intensity (e.g. due to upstream pre-processing with CCS or direct land use change benefits from biomass cultivation) must be reported as having a nil emissions intensity within this Feedstock supply emissions category. Similarly, any negative emissions intensity energy or materials used in the upstream production and supply of feedstocks must also be reported as having a nil emissions intensity when calculating the Feedstock supply category emissions. This approach ensures separate accounting of greenhouse gas removals and consistency with sections 6.4.2 and 6.4.3 below, but will remain under review as policy on greenhouse gas removal develops.

Electrolysis pathways will not have Feedstock supply category emissions, only Energy supply emissions (including electricity) and Input materials emissions (including water) as detailed in sections 6.4.2 and 6.4.3 respectively below. If an electrolysis pathway is specifically generating electricity, heat or steam from fossil, biomass or waste feedstocks for the purposes of supplying an electrolysis plant, the scope of the system boundary is to be expanded to follow the above bulleted feedstock rules in terms of GHG emissions calculations and feedstock sustainability criteria. However, the combined feedstock and energy generation GHG emissions upstream of the electrolysis plant are to be only accounted for within the Energy supply category below, not in this category. Any negative emissions intensity energy supplied to the electrolysis plant must be reported as having a nil emissions intensity in the hydrogen intensity calculations.

6.4.2. Energy supply to hydrogen production

Energy supply emissions are broken down into four sub-categories: electricity, steam, heat and fuels, with further details given below. $AF_{production}$ is the allocation factor for the hydrogen production step (see section 6.4.10). To ensure separate accounting of greenhouse gas removals, any input energy source with a negative emissions intensity (e.g. bioenergy with CCS) must be reported as having a nil emissions intensity under the standard.

$$E_{energy\ supply} = E_{electricity\ supply} + E_{steam\ supply} + E_{heat\ supply} + E_{fuel\ supply}$$

Electricity supply

$$E_{electricity\ supply} = \sum_{k} E_{electricity\ supply\ emissions,k} \times AF_{production}$$

Where $E_{electricity\ supply\ emissions}$ is the emissions of carbon dioxide, methane and nitrous oxide (as applicable), associated with supply of electricity to the hydrogen production process measured in grams CO_2e. This includes (but is not limited to) emissions associated with electricity used for the production and drying processes. Full details on the reporting requirements and evidence needed to calculate electricity input emissions are included in Annex A.

- **Off-grid generation (via physically linked renewable or low carbon electricity generation):** Where evidence can be provided showing electricity used for hydrogen production is off-grid (e.g. using on-site physically linked renewable or low carbon electricity generation) and consumed in the hydrogen production process, then the emissions would be any scope 1 emissions resulting from generating that electricity.

- **Grid connected low carbon electricity via contractual link (such as PPA or wholesale procurement) :** Where evidence can be provided renewable or nuclear electricity has been used for hydrogen production (by meeting Annex A Technical Requirements; temporal correlation, low carbon generation sourcing attributes and energy attribute information) and the grid has only been used to transmit renewable or nuclear electricity with no further import, the emissions are assumed to be the actual emissions of the low carbon generation source in real time. Nuclear energy includes impacts from uranium extraction to nuclear electricity (and heat) production. Where the grid is used to transmit electricity, evidence will need to be provided that transmission and distribution losses have been considered in emissions calculations.

Grid imported electricity: Grid imported emissions can be calculated using actual national grid average GHG intensity data per 30-minute settlement period. This figure should include the combustion emissions of generation on the UK grid, and transmission and distribution losses from generation to use. Upstream emissions of UK generation plants are not included due to a lack of time to analyse upstream emissions data.[3] Further detail on how to account for grid imported electricity emissions is provided in Annex A.

Steam supply

$$E_{steam\ supply} = \sum_{k} E_{steam\ supply\ emissions,k} \times AF_{production}$$

Where $E_{steam\ supply\ emissions}$ is the emissions associated with supply of steam to the hydrogen production process. For steam supply (i.e. where steam is purchased from an entirely separate

[3] Feedstock emissions before these UK generation plants such as feedstock extraction, refining and transportation of fuels for electricity generation prior to the point of combustion are not included due to data availability, but will be included when considering any future methodology.

process or is purchased from a third party provider), GHG emissions should be accounted for by the supplier with an emission factor provided to the buyer by the supplier. Where the steam is derived from a separate process on the same site, the operator should calculate the emission factor. These factors need to be documented with complete data on fuel used, efficiency of conversion and all losses or leakages.

Heat supply

$$E_{heat\ supply} = \sum_{k} E_{heat\ supply\ emissions,k} \times AF_{production}$$

Where $E_{heat\ supply\ emissions}$ is the emissions associated with supply of heat to the hydrogen production process. For heat supply (i.e. where heat is purchased from an entirely separate process or is purchased from a third party provider), GHG emissions should be accounted for by the supplier with an emission factor provided to the buyer by the supplier. Where the heat is derived from a separate process on the same site, the operator should calculate the emission factor. These factors need to be well documented with complete data on fuel used, efficiency of conversion and all losses or leakages.

Fuel supply

$$E_{fuel\ supply} = \sum_{k} E_{fuel\ supply\ emissions,k} \times AF_{production}$$

Where $E_{fuel\ supply\ emissions}$ refers to upstream GHG emissions associated with sourcing and supplying any input fuels to the hydrogen production plant (other than the Feedstock supply emissions and Input material emissions categories, which are considered separately). These fuels include (but are not limited to) coal, oil, diesel, natural gas, biomethane, biomass and wastes, provided these are not the main feedstock. Note that GHG emissions arising from the combustion/use of fuels onsite are considered under either Process CO_2 emissions or Fugitive non-CO_2 emissions categories below, and not in this category. If the fuel used is also the main feedstock, then the sourcing and supply emissions related to that fuel should all be accounted for under $E_{feedstock\ supply}$, and not included in this category.

6.4.3. Input materials emissions in hydrogen production

$$E_{input\ materials} = \sum_{k} E_{input\ material\ emissions,k} \times AF_{production}$$

$E_{input\ materials\ emissions}$ refers to upstream GHG emissions associated with the production and supply of an input material to the production pathway (other than the Feedstock supply emissions and Energy supply emissions considered separately), where the purpose of the input material is not to provide energy to the hydrogen production process. This could include input materials such as water, oxygen, salts, catalysts, solvents, acids etc. Additional input streams may be considered as needed, pending materiality, such as chemicals used for CO_2 capture. $AF_{production}$ is the allocation factor for the hydrogen production step (see section 6.4.10). Only input materials generated offsite and brought across the system boundary into the hydrogen production process will be accounted for – any materials generated onsite should be split into their constituent input materials and any input energy required for their generation, and these inputs accounted for in the relevant emission categories.

To ensure separate accounting of greenhouse gas removals, any input material with a negative emissions intensity (e.g. a biogenic material produced with CCS) must be reported as having a nil emissions intensity under the standard.

6.4.4. Process CO_2 emissions in hydrogen production

$$E_{process\ CO_2} = \sum_k E_{process\ CO_2\ emissions,k} \times AF_{production}$$

Where $E_{process\ CO_2\ emissions}$ are the grams of carbon dioxide generated from the hydrogen production process including use of feedstocks, fuels and input materials in the hydrogen processing plant, prior to any CO_2 capture. $AF_{production}$ is the hydrogen allocation factor for the hydrogen production step (see section 6.4.10).

$E_{process\ CO_2\ emissions}$ will include (but is not limited to) the combustion, conversion or otherwise use of feedstocks, fuels (solid, liquid and gaseous fuels such as diesel, coal, natural gas, biofuels, wastes) and input materials in the hydrogen processing plant. This category accounts for any fossil CO_2 generated (including from waste fossil feedstocks) using a GWP of 1.0, whereas biogenic CO_2 generated or CO_2 generated from carbon recently captured from the atmosphere will both be accounted for but assigned a nil GWP. All values are given prior to any CO_2 capture, which is considered separately in section 6.4.7 below.

6.4.5. Fugitive non-CO_2 GHG emissions in hydrogen production

$$E_{fugitive\ non-CO_2} = \sum_k E_{fugitive\ non-CO_2\ emissions,k} \times AF_{production}$$

Where $E_{fugitive\ non-CO_2\ emissions}$ are the operational emissions of methane, nitrous oxide, sulphur hexafluoride (SF_6), perfluorocarbons (PFC) and hydrofluorocarbons (HFCs) (as applicable), released as fugitive emissions from the hydrogen production process. $AF_{production}$ is the allocation factor for the hydrogen production step (see section 6.4.10).

This includes all operational losses due to the technology deployed and plant management respectively, such as leakages and accidental losses, as well as other losses due to poor management of plant operations. Activities such as venting waste streams have to be included within assessments of fugitive emissions.

Emissions arising from the accidental release of specific non-CO_2 gases used across a number of industry activities are also included (e.g. hydrofluorocarbons (HFCs) used in industrial refrigeration and/or cooling systems, and sulphur hexafluoride (SF_6) used in electrical switchgear).

These fugitive emissions shall be calculated by producers through recorded or estimated leakage rates based on the best available data, or changes in stock levels of the relevant substances as measured throughout the relevant consignment period. These are generally expected to be relatively minor emissions sources.

The Environmental Permitting Regulations 2016 (England and Wales), the Pollution Prevention and Control (Industrial Emissions) Regulations NI 2013, and the Pollution Prevention and Control (Scotland) Regulations 2012, require the use of best available techniques in design, operation and maintenance which would include preventing or minimising fugitive emissions. Therefore, producers should already be recording their levels of fugitive emissions and looking to reduce these through their facilities.

For most hydrogen producers, fossil fuels are provided by a third party, so fugitive emissions associated with the collection, purification, transmission and distribution of the fossil fuels shall be captured by either the Feedstock supply or Energy Supply (fuels) emissions, depending on the pathway.

Evidence shows that hydrogen behaves as an indirect greenhouse gas and therefore reducing the amount of hydrogen vented into the atmosphere during the production process or onsite storage is key. While hydrogen fugitive emissions are not expected be accounted for within the GHG emissions calculations at this stage, we expect producers to minimise and report on these fugitive hydrogen emissions and follow the guidelines set out below (see Section 9).

6.4.6. Emissions for CO_2 capture and entry into CO_2 network

$$E_{CO_2\ capture\ and\ network\ entry} = \sum_k E_{CO_2\ capture\ and\ network\ entry,k} \times AF_{production}$$

Where $E_{CO2\ capture\ and\ network\ entry\ emissions}$ includes GHG emissions impacts from CO_2 capture, any purification, compression and transport, until entry into a CO_2 network, where these emissions are not already considered within the processing plant Energy supply, Input Materials or Process CO_2 emissions or Fugitive non-CO_2 emissions categories. $AF_{production}$ is the allocation factor for the hydrogen production step (see section 6.4.10). Transportation of CO_2 to the network may include transport modes such as trucks or trains and therefore involve emissions from the upstream supply and combustion of transport fuels that are not already accounted for within the processing plant Energy supply emissions category. Similarly, compressors for inputting CO_2 into the network may also involve use of fuels or electricity that are not already accounted for elsewhere and need to be included within this category.

Any fugitive CO_2 emissions from the capture, temporary onsite storage, compression and transport of CO_2 prior to entering the CO_2 network should be accounted for by a reduction in the amount of CO_2 sequestered (section 6.4.7), and should not be accounted for in this emissions category. Any fugitive CO_2 emissions once the CO_2 liability has been transferred to the CO_2 network operator are outside of the scope of the standard, i.e. any leaks or venting of CO_2 from the CO_2 network or geological storage sites do not need to be included within the hydrogen emissions intensity calculations.

6.4.7. CO_2 sequestration

$$E_{CO_2\ sequestration} = \sum_k E_{CO_2\ sequestration\ emissions,k} \times AF_{production}$$

Where $E_{CO2\ sequestration\ emissions}$ are CO_2 emissions captured and permanently sequestered in geological storage through use of CO_2 capture and storage technology, and $AF_{production}$ is the allocation factor for the hydrogen production plant (see section 6.4.10). For emissions to be accounted for under this category, the following conditions need to be met:

- CO_2 emissions must be captured and stored permanently in geological storage. Avoided emissions (through a displacement or change in fossil fuel use) or capture and utilisation of CO_2 do not meet this condition. There must be evidence provided by the CO_2 network operator that the CO_2 injected into the network by the hydrogen producer will be permanently sequestered.
- For the purposes of hydrogen emissions reporting under the standard, it is assumed that once CO_2 is injected into the CO_2 network, and the liability for the CO_2 is transferred between parties, there is zero leakage in the CO_2 network and storage sites.
- Any emissions accounted for under this category should not be credited or claimed elsewhere (e.g. as a carbon credit). If credited elsewhere, the emissions sequestration benefit can no longer be included in the overall emissions calculation for the purposes of the standard.
- Any emissions accounted for under this category must be directly related to processes within the evaluation scope of the standard. Carbon offsets (or similar) from other processes cannot be claimed under the standard.

All Process CO_2 emissions and emissions from transporting and injecting the CO_2 into the network should be reported across the earlier emission categories. Only the CO_2 captured from hydrogen production that is successfully injected into the CO_2 network, with evidence of its ultimate sequestration, should be reported under this category.

If a producer's CO_2 capture equipment stops working or CO_2 capture rates are reduced (resulting in full or partial venting of CO_2 onsite), or there is a CO_2 network outage and the hydrogen producer cannot inject captured CO_2 into the network (and instead has to vent it), or there is a leak or fugitive CO_2 emissions occurring prior to injection into the network, these additional CO_2 emissions must be accounted for as a reduction in the CO_2 sequestration credit, not additional emissions under a different category. Further details are outlined for pathways with CO_2 capture and sequestration in Annex B.

A reduction in the sequestration credit could produce non-compliant hydrogen that has an emissions intensity significantly above the emissions threshold. UK policies relying on the standard may potentially offer certain waivers for circumstances outside of the hydrogen producer's control, but this would be separate from the hydrogen emissions intensity calculations which still need to be conducted following the methodology in this standard.

For some production pathways, the CO_2 sequestration credit will be large enough to result in the total hydrogen emissions intensity becoming negative. Negative emission intensity hydrogen is permitted under the standard provided these negative emissions have resulted from credits under the standard, rather than resulting from negative emissions intensity feedstocks, input energy or materials.

6.4.8. Compression and purification of hydrogen

$$E_{compression\ and\ purification} = \sum_k E_{compression\ and\ purification\ emissions,k}$$

Where $E_{compression\ and\ purification\ emissions}$ are the emissions associated with the supply of energy used to compress or purify hydrogen in one of two specific cases, set out below. The standard sets a theoretical minimum pressure level of 3 MPa and a theoretical minimum purity of 99.9% by volume. The actual pressure and purity of hydrogen produced should be dictated by offtaker and/or end use requirements. For the purpose of GHG emissions reporting under the standard, hydrogen producers should account for the emissions from the projected or actual energy used to reach their output pressure and purity within the Energy supply category above. This emissions category will therefore only be non-zero in two cases:

- Hydrogen producers outputting hydrogen below the theoretical minimum(s) of 3MPa pressure and 99.9% by volume purity. They must account for the additional emissions associated with theoretical compression and/or theoretical purification to reach the theoretical minimum(s). The data and methodology required to do these theoretical calculations is provided in the Data Annex.
- Hydrogen producers outputting hydrogen above the theoretical minimum(s) of 3MPa pressure and 99.9% by volume purity, but that are using default data for the Energy supply category. The default data only accounts for compression to 3MPa and purification to 99.9% by volume purity, so the calculation methodology in the Data

Annex must be used, starting from 3MPa and 99.9% purity, to calculate the additional emissions required to reach the actual expected pressure and purity output.

In either case, the additional emissions required are reported in this emissions category (and will be non-negative, given the energy input intensity reporting requirements of section 6.4.2 to be followed). Any CO_2 generated in Compression and purification should be accounted for within the Process CO_2 emissions category above, any other GHG emissions released should be accounted for within the Fugitive non-CO_2 emissions categories above, and any CO_2 capture and sequestered accounted for within the CO_2 sequestration category above.

Emissions associated with hydrogen infrastructure after the hydrogen production gate (e.g. off-site liquefaction, hydrogenation into a hydrogen carrier) and transportation to the consumption location are outside of the scope of the standard.

6.4.9. Waste fossil feedstock counterfactual emissions

Utilising waste fossil feedstock for hydrogen production diverts this feedstock away from its existing counterfactual use/fate (e.g. incineration to generate electricity or heat). The utility that is no longer generated must now be provided from another source, such as UK grid electricity or natural gas from the UK gas grid. Under the standard, these additional emissions are attributed to the hydrogen production pathway. However, diversion of the feedstock also results in the counterfactual no longer releasing fossil feedstock CO_2 emissions to atmosphere. This category captures therefore considers the impact of these changes in emissions, as illustrated in Figure 2.

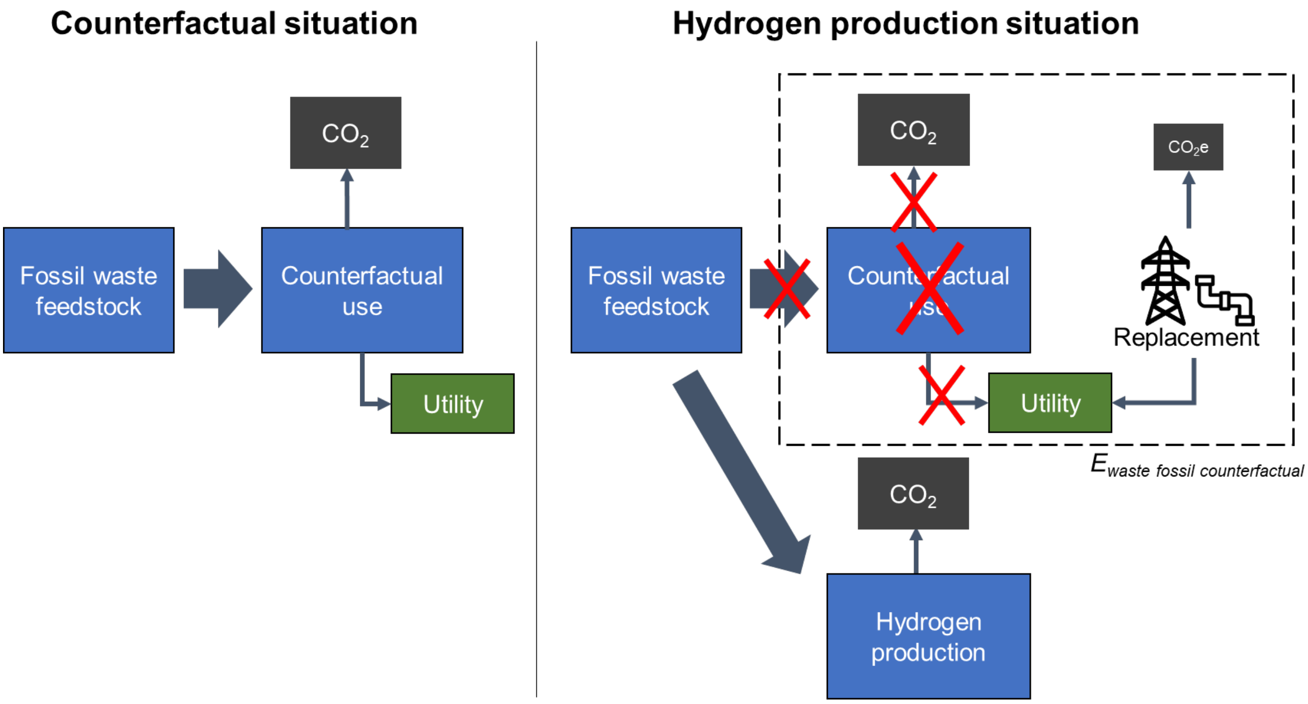

Figure 2: Illustration of the emissions changes from a waste fossil feedstock counterfactual

Counterfactual emissions only apply to waste fossil feedstocks (definition provided in section 2) being used under the standard, such as the fossil fraction of refuse derived fuel (RDF). For waste feedstocks with a mix of biogenic and fossil fractions, the counterfactual is only applied to the fossil fraction of the waste feedstock and not to the biogenic fraction. No counterfactual emissions are applied to biomass feedstocks or to non-waste fossil feedstocks.

$$E_{waste\ fossil\ counterfactual} = (\ E_{displaced\ utility} - \ E_{waste\ fossil\ counterfactual\ CO_2\ emitted}) \times \ CAF_{Chain}$$

$$E_{displaced\ utility} = MJ_{feedstock} \times \ Eff_{counterfactual} \ \times \ CI_{energy}$$

Where:

$E_{waste\ fossil\ counterfactual}$ is the GHG emissions (in gCO_2e) from replacing the displaced utility in the counterfactual, less the waste fossil feedstock CO_2 emissions released to atmosphere in the counterfactual;

$E_{displaced\ utility}$ is the GHG emissions (in gCO_2e) arising from replacement of the displaced utility when a waste fossil feedstock is diverted to hydrogen production;

$E_{waste\ fossil\ counterfactual\ CO2\ emitted}$ are the waste fossil feedstock CO_2 emissions that would be released to the atmosphere in the counterfactual (in gCO_2e). Note this excludes other non-CO_2 emissions, and other sources of fossil CO_2 generated in the counterfactual that are not from the waste fossil feedstock carbon itself;

$Eff_{counterfactual}$ is the LHV efficiency of converting waste fossil feedstock into energy in the counterfactual use (in MJ_{LHV} energy/MJ_{LHV} feedstock);

CI_{energy} is the GHG emissions intensity of the displaced energy in the counterfactual (in gCO_2e/MJ_{LHV} energy);

CAF_{Chain} is the cumulative allocation factor for the whole production pathway from waste fossil feedstock to hydrogen (see section 6.4.10);

$MJ_{feedstock}$ is the total amount of waste fossil feedstock diverted to hydrogen production from the counterfactual use (in MJ_{LHV}, using the LHV formula at the start of section 6.4).

If the specified counterfactual application releases all the carbon within the waste fossil feedstock to the atmosphere (e.g. via unabated combustion to CO_2), then the $E_{waste\ fossil\ counterfactual\ CO2\ emitted}$ term will likely cancel out the waste fossil feedstock's contributions to the Process CO_2 emissions category. If the specified counterfactual does not release all of the carbon within the waste fossil feedstock to the atmosphere (e.g. due to some CO_2 capture applied in the counterfactual), then the $E_{waste\ fossil\ counterfactual\ CO2\ emitted}$ term is likely to be smaller than the Process CO_2 category emissions, leading to a higher hydrogen emissions intensity. Conversely, capturing and sequestering any feedstock fossil CO_2 from the hydrogen production plant, that would have otherwise been released to the atmosphere in the counterfactual, could lead to emission savings compared to the counterfactual but will be accounted for separately within the CO_2 sequestration category.

For the avoidance of doubt, in all cases the CO_2 generated from the waste fossil feedstock during hydrogen production, along with other onsite sources of fossil CO_2, e.g. from the combustion of natural gas or diesel fuels, still need to be accounted for within the Process CO_2 emissions category.

The current counterfactual to be applied for the fossil fraction of RDF feedstock is given in the Data Annex. For waste fossil feedstocks other than RDF, evidence must be provided that heating uses have not been displaced, and if they have, a heating counterfactual must be applied. For consistency, if heating uses have not been displaced, the same counterfactual as for the fossil fraction of RDF can be applied by the hydrogen producer. However, a producer using waste fossil feedstocks other than RDF can also submit evidence to propose an alternative counterfactual to the RDF counterfactual, which will be reviewed by DESNZ.

DESNZ will keep a watching brief on the appropriateness of the counterfactual provided in the Data Annex, including alignment with other relevant policy and the opportunities or risks that may be posed to system-wide environmental and decarbonisation efforts. If necessary, DESNZ will update the counterfactual or counterfactual methodology at a future review point. Producers considering waste pathways should also note any future updates to DESNZ's broader hydrogen production strategy, which looks at the expected role and impact of different production routes in the short and longer term.

Example one (noting that this purely illustrative example does not indicate the appropriate counterfactual to be used, as per the Data Annex): 100 MJ_{LHV} of the fossil fraction of RDF is used in a gasification facility, to produce 50 MJ_{LHV} of hydrogen. The appropriate counterfactual, as prescribed by the LCHS at the time, is in this example an unabated Energy from Waste power plant that has 22% net electrical efficiency, that would have released 9,300 gCO_2 to atmosphere from combustion of the 100 MJ_{LHV} of waste fossil feedstock. The electricity grid intensity in this example is 35 gCO_2e/MJ_e, the cumulative allocation factor for the whole production pathway is 65.5%, with the hydrogen production plant allocation factor of 72.8% and pre-processing step allocation factor of 90% (i.e. significant co-products are present along the hydrogen production pathway).

- $E_{waste\ fossil\ counterfactual}$ would then be = (100 * 22% * 35 – 9,300) * 65.5% = (770 – 9,300) * 65.5% = -5,587 gCO_2e. The contribution of $E_{waste\ fossil\ counterfactual}$ to the final hydrogen intensity would then be -5,587 / 50 = -111.7 gCO_2e/MJ_{LHV}.
- However, the hydrogen production plant Process CO_2 emissions will be likely be approaching 9,300 * 90% = 8,370 gCO_2 due to fossil CO_2 generated from conversion of the pre-processed waste feedstock, prior to any CO_2 capture and emissions allocation to co-products. $E_{process\ CO2}$ would then be = 8,370 * 72.8% = 6,093 gCO_2e. The contribution of $E_{process\ CO2}$ to the final hydrogen intensity would then be 6,093 / 50 = +121.9 gCO_2e/MJ_{LHV}.

The net result in this example where both the hydrogen production and waste fossil feedstock counterfactual are unabated is therefore strongly influenced by the efficiency of the counterfactual and the displaced emissions intensity.

Example two (noting that this purely illustrative example does not indicate the appropriate counterfactual to be used, as per the Data Annex): 100 MJ_{LHV} of fossil plastic is used in a gasification facility, to produce 55 MJ_{LHV} of hydrogen. The counterfactual is in this example an unabated furnace for cement kiln heating, that would have released 10,300 gCO_2 to atmosphere from combustion of the 100 MJ_{LHV} of waste fossil feedstock. The natural gas grid intensity in this example is 6.29 gCO_2e/MJ_{LHV} for supply and 56.63 gCO_2e/MJ_{LHV} for combustion, there is no difference assumed between furnace heating efficiencies when using natural gas or plastic, and there are no co-products in the hydrogen production pathway.

- $E_{waste\ fossil\ counterfactual}$ would then be = (100 * (6.29 + 56.63) – 10,300) * 100% = (6,292 – 10,300) = -4,008 gCO_2e. The contribution of $E_{waste\ fossil\ counterfactual}$ to the final hydrogen intensity would then be -4,008 / 55 = -72.9 gCO_2e/MJ_{LHV}.
- $E_{process\ CO2}$ would then likely be = 10,300 * 100% = 10,300 gCO_2e. The contribution of $E_{process\ CO2}$ to the final hydrogen intensity would then be 10,300 / 55 = +187.3 gCO_2e/MJ_{LHV}.

The net result in this example is that the hydrogen will not be compliant with the standard, due to the high emissions of the displaced heating in the counterfactual, unless significant CO_2 capture were implemented at the hydrogen production plant.

6.4.10. LHV energy allocation for coproduct emissions

Production pathways for hydrogen typically result in various waste materials, residue materials and (co-)products, with definitions for these classifications given in section 2. This section covers the rules for assigning GHG emissions to co-products from hydrogen production pathways.

In considering the appropriate classification for an input feedstock or output material, a set of principles are applied to determine whether a feedstock or material resulting from a step in the production pathway is a product, co-product, residue or waste under the standard. Consideration will be given to the definitions in section 2 of the main guidance; existing classifications in other relevant UK policy such as the RTFO; alignment with the waste hierarchy; and the economic value of the substance in relation to the (co-)products from the specific step on both a £/tonne and £/year basis.

ISO 14044 and the GHG Protocol Product Life Cycle Accounting and Reporting Standard distinguish between the product which is being studied as part of the GHG inventory preparation and other co-product(s) which “have value as an input into another product’s life cycle” (GHG Protocol, 2011). Consequently, the total emissions resulting from inputs and outputs from the hydrogen production process should be separated between the hydrogen and those co-products that are valorised (sold on). By contrast, waste or residue materials output from a process have no emissions allocated to them. The classification of an output material can therefore have a significant impact on the hydrogen GHG emissions intensity, as co-product materials will be allocated some of the step and upstream GHG emissions, reducing the emissions burden on the final hydrogen product, whereas residues and wastes will not be allocated any of the step or upstream GHG emissions.

Similarly, the classification of an input feedstock can also have a significant impact on hydrogen GHG emissions, as a (co-)product feedstock will arrive with the upstream GHG emissions from its production plus any pre-processing, storage and transport, whereas residue and waste feedstocks are assigned nil GHG emissions at the point of collection so will only have some pre-processing, storage and transport emissions to account for.

The LHV energy allocation method allocates emissions to co-products from a step in the production pathway, in proportion to the LHV energy content of each co-product from the step as compared to the total LHV energy contents of all products and co-products from the step combined.

$$Allocation\ factor\ for\ (co)product_j = \frac{MJ\ energy\ of\ (co)product_j}{Total\ MJ\ energy\ of\ all\ (co)products}$$

For the purposes of allocating emissions between products and co-products, the MJ energy content of (co-)products in both the numerator and denominator of the above formula should be determined based on the following LHV formula:

(*Co-)product MJ = (Co-)product kg (as received) * { (Co-)product Lower Heating Value MJ/kg (dry) * (1 – % moisture content) – 2.441* % moisture content }, with a lower bound of zero.*

Dry is at 0% moisture content, and the % moisture content is the kg of water present in 1 kg of as received (co-)product. This formula excludes the latent heat of vaporisation of water at 25°C, expressed as 2.441 MJ/kg. Additionally, the formula uses zero as a lower bound to stop very wet (co)products having a negative LHV. Note that, as is the case for the Renewable Transport Fuel Obligation, this co-product allocation formula is different from the LHV formula used for step efficiencies and consignment sizes elsewhere in the standard.

Producers with heat or steam co-products are expected to apply the Carnot efficiency for those heat or steam co-products so that only the useful energy content is counted (in both the allocation numerator for that co-product and in the allocation denominator for the sum of all products and co-products). The useful part of the heat or steam co-product is found by multiplying its energy content with the Carnot efficiency, C_h, calculated as follows:

$$C_h = \frac{(T_h - T_0)}{T_h}$$

Where: T_h =Temperature, measured in absolute temperature (Kelvin), of the useful heat at the point of delivery. T_0 = Temperature of surroundings, set at 273.15 Kelvin (equal to 0°C). ‘Useful heat’ means heat generated to satisfy an economical justifiable demand for heat, for heating or cooling purposes, and ‘economically justifiable demand’ means the demand that does not exceed the needs for heat or cooling and which would otherwise be satisfied at market conditions. If the useful heat/steam is exported for heating of buildings at a temperature below 150°C (423.15 Kelvin), C_h can be set as 0.3546.

Some pathways will produce hydrogen as the main output and will not valorise other outputs such as heat or oxygen – these other outputs will then be classified as wastes or residues, not co-products. Should other outputs be valorised and classified as co-products (as per section 2 definitions), this should be evidenced, and emissions should be allocated to co-products using the LHV energy allocation methodology above. However, this LHV energy allocation methodology is to be applied even in cases where valorised co-products have no LHV energy content, i.e. there are no emissions allocated to co-products that have a nil LHV. For example, if oxygen is valorised as a co-product of electrolysis, since oxygen has nil LHV (0 MJ/kg), no emissions will be allocated to the oxygen, and 100% of the electrolysis emissions will still be allocated to the hydrogen product.

Example: An illustration of how 1,000 $kgCO_2e$ of emissions might be allocated to hydrogen and various other outputs from a theoretical process is presented below in Table 2.

Table 2: Example for allocating 1,000 $kgCO_2e$ of GHG emissions

Output	Output	LHV dry (MJ/kg)	Useful output (MJ)	Allocation (% of useful output)	Emissions allocated ($kgCO_2e$)	Emissions (gCO_2e/MJ_{LHV} useful output)
Main product hydrogen (dry)	833 kg	120	100,000	72.8%	728	7.3
Co-product electricity	10,000 MJ	NA	10,000	7.3%	73	7.3
Co-product steam @200°C	10,000 MJ	NA	4,227	3.1%	31	7.3
Co-product oxygen	100 kg	0	0	0%	0	0
Co-product methane (dry)	400 kg	50	20,000	14.6%	146	7.3
Co-product solid @50% moisture	400 kg	18	3,112	2.3%	23	7.3
Co-product sludge @90% moisture	100 kg	18	0	0%	0	0
Waste solid (dry)	100 kg	5	500	0%	0	0

A production pathway from feedstock to hydrogen production can have multiple steps, with each step potentially generating products and co-products. If so, the % allocation factors for each step are calculated individually, using the above LHV energy allocation methodology.

- $AF_{production}$ is the allocation factor for the hydrogen production step, calculated as the MJ of hydrogen product divided by the MJ sum of all (co-)products from the hydrogen production step.

- Each upstream step in the supply chain will have one intermediate (co-)product that will ultimately end up as hydrogen, and any other (co-)products from that upstream step will not form hydrogen but instead exit the system boundary taking some emissions with them. The allocation factor for an upstream step in the supply chain, AF_i, is calculated as the MJ of intermediate (co-)product of interest to the hydrogen production pathway, divided by the sum of the MJ of all (co-)products from that step.

A cumulative allocation factor for the whole production pathway from feedstock to hydrogen, CAF_{Chain}, can then be calculated by multiplying all of the intermediate (co-)product allocation factors and final hydrogen production process allocation factor together. This value is used in the waste fossil feedstock counterfactual formula in section 6.4.9.

Cumulative allocation factors are also generated for each step in the supply chain, $CAFi$, starting with the hydrogen production plant and multiplying allocation factors back up the feedstock supply chain until reaching and including the allocation factor from the step of interest. These cumulative allocation factors for each upstream step are applied to the GHG emissions generated in that step, before the Feedstock emissions are totalled across the upstream steps in section 6.4.1.

The allocation factor for the hydrogen production step, $AF_{production}$, is applied to the emissions from Energy supply, Input materials, Process CO_2 emissions, Fugitive non-CO_2 emissions, CO_2 capture and infrastructure and CO_2 sequestration categories. Finally, the Compression and purification category is always accounted for assuming a 100% allocation factor. For further explanation of how these cumulative allocation factors work in practice, please see the 'Guidance Summary GHG' worksheet in the Hydrogen Emissions Calculator.

Example: An illustrative pathway with upstream waste pre-processing ends up with the hydrogen production step given in Table 1 above. 350,000 MJ of raw waste is collected, transported, and then in the upstream pre-processing step is converted into 270,000 MJ of processed waste, 30,000 MJ of co-product electricity and 50,000 MJ of unutilised heat. The processed waste is the intermediate product of interest to the hydrogen production pathway, and the allocation factor for this step is 270,000 / (270,000 + 30,000) = 90%. The processed waste is then transported to the hydrogen production plant. The hydrogen production plant step allocation factor is 72.8%, from Table 1. This means the cumulative allocation factor for the whole production pathway from feedstock to hydrogen is 90% * 72.8% = 65.5%. The hydrogen GHG intensity calculations would therefore calculate E_T as:

- 65.5% of any Waste fossil feedstock counterfactual emissions;
- 65.5% of the raw waste collection, raw waste transport and pre-processing emissions, and 72.8% of the processed waste transport emissions. These four upstream steps would then be combined to form the Feedstock supply emissions category, noting the different cumulative allocation factors applied within this category;
- 72.8% of the hydrogen production step emissions for all the remaining emissions categories (excluding the Compression and purification emissions category).

- 100% of any Compression and purification emissions.

7. Non-GHG criteria for biogenic inputs

To comply with the standard, hydrogen derived from biogenic inputs must also meet sustainability criteria in addition to satisfying the GHG emissions threshold. These sustainability criteria apply both to hydrogen production pathways that use biogenic feedstocks, as well as to production pathways without feedstocks that use biogenic energy inputs (e.g. electrolysis from specific bio-electricity plants). DESNZ may expand this coverage in future reviews of the standard to cover any biogenic input to a hydrogen production pathway (e.g. biomass heating used in a natural gas reforming pathway), so following these sustainability guidelines for all biogenic inputs is strongly encouraged.

The relevant criteria vary according to the input classification and source:

- By default, all hydrogen derived from biogenic inputs needs to satisfy the GHG emissions threshold and **land criteria.**
    - The **land criteria** prohibit the sourcing of biomass inputs for hydrogen production from land that has or previously had a certain status, to preserve biodiversity and carbon stocks.
- Hydrogen derived from residues and wastes from agriculture must also meet the **soil carbon criteria.**
    - The **soil carbon criteria** ensure that monitoring or management plans are in place to address the impacts on soil quality and soil carbon of harvesting the biogenic input concerned.
- Hydrogen derived from any kind of forest biomass (including wastes and residues) must meet the **forest criteria**, instead of the land criteria.
    - The **forest criteria** ensure that monitoring and management plans are in place to address potential negative impacts (related to biodiversity, carbon stocks, soil quality etc.) of harvesting the biogenic input concerned.
- Hydrogen derived from biogenic wastes and residues not from agriculture, aquaculture, fisheries or forestry does not need to meet any criteria in addition to the GHG emissions threshold.

Further details of these sustainability requirements (or “non-GHG criteria”), and the rules for demonstrating compliance with them, are provided in Annex D.

Hydrogen derived from any (mix of partially) biogenic feedstocks, or electrolytic hydrogen derived from bioenergy generation plants, must also demonstrate compliance with the **minimum waste and residue requirement**. This sets a minimum threshold (50% by LHV energy content) for the proportion of biohydrogen produced (that must be derived from inputs classified as biogenic wastes or residues. Further details are given in Annex C, section 1.2.

8. Consignments and monthly averaging

Hydrogen producers will be generating hydrogen over many days, months and years, and the GHG intensity of this hydrogen production will in most cases vary over time, given changes in the performance of the hydrogen production pathway and its various inputs and outputs that are accounted for under the GHG methodology in section 6.4. The standard therefore sets 30 minutes as the common time period for measuring and reporting the GHG intensity of hydrogen production when a facility is operational. Monthly weighted averaging rules are discussed below in section 8.4.

8.1. Consignment definition

The hydrogen produced within a 30-minute period should be divided into separate blocks (on a MJ_{LHV} energy basis), where within a block all the hydrogen shares the same characteristics. Each discrete block of hydrogen is defined as a ‘consignment’.

For hydrogen production pathways with a feedstock, to be considered a discrete consignment of hydrogen, the following environmental characteristics should be identical:

- the feedstock input.
- the feedstock form i.e., solid, liquid, gas.
- feedstock production process.
- country of origin.
- feedstock classification (e.g. waste, residue, co-product)
- feedstock type (biogenic, fossil, nuclear, renewable fuel of non-biological origin)
- compliance with the additional sustainability criteria and other criteria for biogenic inputs
- GHG emissions intensity of the hydrogen produced.

However, for those production pathways without a feedstock, e.g. electrolysis pathways, then to be considered a discrete consignment of hydrogen, the following environmental characteristics should be identical:

- the energy input
- the energy input form i.e., electricity, heat, steam.
- the energy generation process.

- country of origin.
- energy input type (biogenic, fossil, nuclear, renewable energy of non-biological origin)
- compliance with the additional sustainability criteria and other criteria for biogenic energy inputs, where relevant
- GHG emissions intensity of the hydrogen produced.

If any of the above environmental characteristics differ, the hydrogen generated from these different inputs should be split into different consignments. Some hydrogen producers may have multiple feedstocks or energy inputs with different associated upstream emissions and sustainability characteristics. Hydrogen producers may also use mixed feedstocks that have component fractions with different associated upstream emissions and sustainability characteristics.

The standard requires separate consideration of the hydrogen made from these different feedstocks (or feedstock components) or energy inputs. Examples of how this should be achieved are set out in sections 8.1.1 and 8.1.2 below. More detailed information on how these environmental characteristics apply to different inputs can be seen in the relevant annexes to this document – see Annex A for electricity inputs, Annex B for natural gas inputs and Annex C for biomass and/or waste inputs.

New consignments of hydrogen are generated every 30 minutes. Subject to any monthly weighted averaging that is allowed under the standard (see section 8.4), consignments will be reported and assessed separately against the requirements of the standard as to their compliance (or non-compliance). Note that consignments are amounts of hydrogen, and not amounts of feedstock or energy inputs.

8.1.1. Generation of separate consignments

There are more specific consignment rules for certain inputs given in section 8.1.2, but there are also some common high-level consignment rules that apply to all pathways and inputs:

- Hydrogen produced during a 30-minute time period, where all the hydrogen shares an identical set of environmental characteristics (as defined in 8.1.2) shall be considered as a single consignment. Even if the hydrogen produced always has the same unchanging characteristics across multiple days and weeks, hydrogen production still needs to be split into 30 minute consignments (monthly weighted averaging rules are discussed below in section 8.4).
- Hydrogen produced during a 30-minute time period, where not all the hydrogen produced shares the same identical set of environmental characteristics across the entire 30-minute time period due to the presence of multiple/mixed inputs, shall be split into separate consignments. For example, three measurably different feedstocks used in parallel during the 30-minute period would form three separate hydrogen consignments within the 30-minute period.

- The use of grid average electricity during a 30-minute period is not to be split into its component parts (e.g. gas, coal, nuclear, wind, solar power etc).
- Provided there is at least one feedstock for the hydrogen production pathway, imported electricity, heat or steam can be treated as single inputs (each with one GHG emissions intensity) for a given 30-minute period, and do not have to be split into component parts with different characteristics. In other words, where there is at least one feedstock for the hydrogen production pathway, consignments are driven by the differences in feedstocks alone.
- If there is no feedstock for the pathway (e.g. electrolysis pathways), and there are multiple sources for the imported electricity, heat or steam, differences in these energy sources should be considered as resulting in separate consignments.

An indicative example of how different consignments might be generated across the space of a few hours of hydrogen production is given below, where each block on the top row is indicatively 1 MJ_{LHV} of hydrogen:

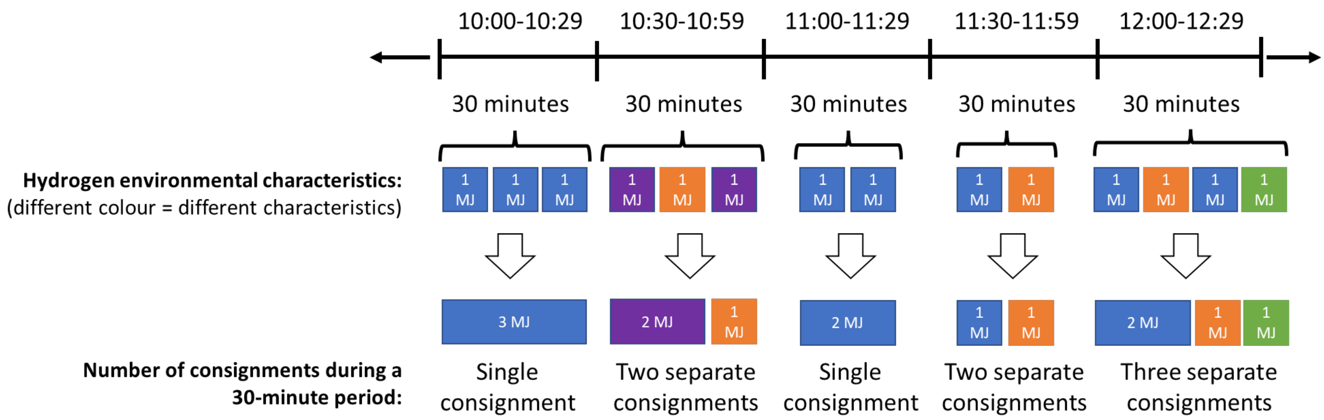

Figure 3: Illustrative diagram for generation of consignments

8.1.2. Input specific requirements

Examples of inputs

- Wholesale grid imported electricity.
- Direct or Sleeved Power Purchase Agreement (PPA) with a renewable or low-carbon electricity generator.
- Off-grid on-site connection to a renewable or low-carbon electricity generator.
- Natural gas from the gas grid.
- Direct connection to natural gas extraction or natural gas import facility.
- Biomethane from a direct connection to an anaerobic digestion facility.
- Municipal solid waste (biogenic fraction and fossil fractions considered separately).

This is a non-exhaustive list and an input being on this list does not mean that hydrogen produced from said input would necessarily be compliant under the standard.

Electricity inputs

- All electricity inputs shall be considered in discrete consignments of 30 minutes, starting at 00:00 UTC and 30-minute increments thereafter.
- Real time tracking of generation and consumption (temporal correlation) is required across all 30-minute consignments.
- Different types of discrete consignment will need to track carbon intensities in different ways:
    - Off-grid physical links must provide generation data matched to hydrogen production consumption per 30 mins.
    - Direct or sleeved PPA must provide generation data matched to hydrogen production consumption per 30 mins (accounting for all transmission and distribution losses).
    - Wholesale grid import must provide actual carbon intensity data per 30 minutes matched to consumption for hydrogen production (accounting for all transmission and distribution losses) using data provided by NGESO.
    - Where a mix of wind/solar, nuclear, grid average import and other low carbon power sources are used these should be separated into individual discrete consignments within the 30-minute period with the % of each input clearly matched to hydrogen output tonnages (and with all transmission and distribution losses factored in).

Example: for one 30-minute period 50 MWh of electrolytic hydrogen is produced using 20% wholesale UK grid electricity and 80% direct connection to a wind farm: this would result in two discrete consignments during the 30 minute period, as this is determined by the energy inputs.

1. 10 MWh of hydrogen based on the grid average electricity GHG intensity.
2. 40 MWh of hydrogen based on a wind electricity GHG intensity (nil).

These discrete consignments of hydrogen can remain as discrete consignments or be included as part of the monthly weighted averaged consignment (see section 87.4 for more details).

Natural gas inputs

- All natural gas inputs shall have a discrete consignment size of 30 minutes, starting at 00:00 UTC and 30 minute increments thereafter.
- Natural gas from the UK gas network is considered as one input, with 30-minute metering.
- The average UK gas network value for upstream natural gas emissions should be applied for gas taken from the UK gas network. This value will be provided in the Data

Annex, section 3. This value will likely be updated approximately every year, as the mix of domestic, piped imported and liquid imported natural gas changes, and emissions intensities of these sources will also change over time.

- In all other cases, producers are expected to use actual data according to the methodology set out in Annex B.
- Where the Data Annex data is used for UK network gas, one discrete consignment can be made every 30 minutes based on the 30-minute metered volumes of natural gas, the published calorific value (CV) for the gas delivered converted to LHV energy content, and the Data Annex feedstock emissions intensity value provided.
- The feedstock emissions can be calculated and should be reported as 30-minute discrete consignments.
- If multiple sources of fossil fuel based natural gas (e.g. the UK gas network & direct connection) are used within a 30 minute period this should be separated into individual discrete consignments within the 30 minute period with the % of each input and the upstream emissions of feedstocks clearly matched to hydrogen output tonnages.

Example: for one 30-minute period, 250 MWh of H_2 is produced in an autothermal reforming plant using 40% UK gas grid and 60% directly imported Norwegian natural gas, whilst using 15 MWh of wholesale UK grid average electricity and 5 MWh of wind power. This plant would produce two discrete consignments, as this is determined by the feedstocks.

1. 100 MWh of hydrogen based on the average UK gas grid GHG intensity, applying a weighted average GHG intensity for the input electricity (three quarters UK grid power with one quarter wind power)

2. 150 MWh of hydrogen based on an imported Norwegian natural gas GHG intensity, applying a weighted average GHG intensity for the input electricity (three quarters UK grid power with one quarter wind power).

The discrete consignments of hydrogen can remain as discrete consignments or included as part of the monthly weighted averaged consignment if they have non-negative emissions intensities. Note that natural gas extracted from the UK gas grid is for the purposes of the standard assumed to be 100% fossil, e.g. biomethane cannot be mass balanced through the gas grid. For natural gas reformation processes using fossil fuel inputs, any specifically sourced biogenic inputs will form separate hydrogen consignments. If these biogenic hydrogen consignments have negative emissions intensities, they cannot be included within the monthly weighted average alongside fossil natural gas consignments, and must be reported as separate discrete consignments. See section 8.4 for more details.

Biomass & Waste inputs

- All biogenic inputs (including wastes and residues) and fossil waste inputs shall have a discrete consignment size of 30 minutes, starting at 00:00 UTC and 30-minute increments thereafter.

- For compliance with the standard, any consignment must be able to evidence compliance with all non-GHG criteria for all biogenic inputs (as well as compliance with the GHG emissions threshold). Consignments must be defined such that all of the hydrogen within a consignment either meets the non-GHG criteria for biogenic inputs, or alternatively all of the hydrogen within a consignment does not meet these sustainability criteria. So even if the rest of the environmental characteristics are identical, a single consignment cannot contain a mix of hydrogen made from both sustainable and non-sustainable biogenic inputs.
- Where a mixed waste input has a biogenic and a fossil component (e.g. municipal solid waste), this should be considered as two distinct inputs to hydrogen production, split in line with the biogenic and fossil fractions of the waste (LHV energy basis). This would create two discrete consignments of hydrogen for each 30 minute period of hydrogen production, each consignment having separate environmental characteristics.
- Biomethane inputs can be reported where there is sufficient evidence that biomethane has been / will be physically supplied to the hydrogen production facility (see Annex E for relevant guidance).
    - Biomethane inputs can be used to create 30-minute discrete hydrogen consignments, with the environmental characteristics associated with the biomethane input, as evidenced by the biomethane supplier.
    - If the supplier provides biomethane produced from multiple inputs with different environmental characteristics, the biomethane input to hydrogen production should be considered as multiple distinct inputs, creating separate 30-minute discrete consignments of hydrogen, with the LHV energy content of each distinct input corresponding to the LHV energy content of hydrogen output.

Example one: over a 30 minute period, 200MWh of H_2 is produced by an SMR, using 40% biomethane via a direct connection to an anaerobic digestion + biomethane upgrading facility and 60% natural gas from the UK gas grid. The biomethane is sourced from 50% food waste and 50% (sustainably-sourced) maize crops. This would produce three discrete consignments, based on the separate feedstocks.

1. 40 MWh of hydrogen based on a sustainable maize-derived biomethane GHG intensity.
2. 40 MWh of hydrogen based on a food waste-derived biomethane GHG intensity.
3. 120 MWh of hydrogen based on the average UK gas grid GHG intensity.

These discrete consignments of hydrogen can remain as discrete consignments or be included as part of the monthly weighted averaged consignment if they have non-negative emissions intensities. However, CO_2 capture for sequestration might be deployed at the reforming plant, leading to some of the hydrogen consignments generated from biomethane to have a negative emissions intensity. Any negative emissions intensity consignments cannot be included in the monthly weighted average and must be reported separately. See section 8.4 for more details.

Example two: for one 30-minute period, 10 MWh of hydrogen is produced by gasification using mixed waste with a composition of 55% biogenic and 45% fossil waste content by LHV energy. This would produce two discrete consignments, based on the feedstock components.

1. 5.5 MWh of hydrogen based on biogenic waste

2. 4.5 MWh of hydrogen based on fossil waste, with the consignment GHG emissions intensity including the waste fossil feedstock counterfactual emissions

These discrete consignments of hydrogen can remain as discrete consignments or be included as part of the monthly weighted averaged consignment if they have non-negative emissions intensities. However, if the gasification plant includes CO_2 capture for sequestration, the biogenic hydrogen consignments are likely to have a negative emissions intensity (as might the fossil waste-derived consignments, depending on the counterfactual). Any negative emissions intensity consignments cannot be included in the monthly weighted average and must be reported separately. See section 8.4 for more details.

8.2. Calculation of consignment emission intensities

8.2.1. Emissions included in consignments

The duration of a discrete consignment is 30 minutes, and all consignments are to be recorded at 30-minute intervals starting at exactly midnight (UTC). The emissions to be included for each consignment of hydrogen follow the emission categories set out in section 6.4. Emissions are therefore calculated based on consumption of inputs and release/capture of outputs within each 30-minute consignment period, irrespective of whether these emissions relate to operation of hydrogen storage or pre/post-production ancillary processes.

Consignment emissions are not based on tracking individual units of hydrogen between time periods, as it is not practical to track the emissions resulting from each sub-process in the plant during each time period. For example, emissions linked to running on-site hydrogen storage are allocated to the consignment of hydrogen produced during those 30-minutes, not to the stored hydrogen.

For inputs that arrive onsite as batches and are therefore stored onsite prior to use, e.g. a truck load of a particular chemical or diesel, emissions are to be accounted for based on the consumption of these inputs within the 30-minute period. This consumption could be metered, measured through other means, estimated directly using process data flows or estimated indirectly via suitable usage rates (e.g. diesel generator output per 30 minutes and the known generator efficiency, or chemical usage rate per MJ hydrogen production). It is expected that estimates will be checked against the available evidence (e.g. invoices, contracts), as discussed in sections 10 & 11.

If a delivery vehicle arrives onsite, all of the emissions contained within that delivery are not to be accounted for within the 30-minute period the vehicle arrives onsite, because this would lead to extremely high emissions intensity in one 30-minute period, and under-estimates of the hydrogen intensities for the rest of the month. However, if an input is provided via a permanent connection (e.g. grid gas, electricity, steam/hot water/water/diesel pipeline), emissions for this input are accounted for based on its arrival onsite, taking the meter as the point of consumption. More information on metering requirements will be provided in the next LCHS review.

Emissions for outputs (e.g. Fugitive non-CO_2 emissions) are to be accounted for within the 30-minute consignment period in which they occur. Similarly, the production of hydrogen and co-products, and emissions allocations to co-products are to be accounted for based on the 30-minute consignment period in which the hydrogen and co-products are generated (this will typically be straightforward if the hydrogen and co-products are generated in a fixed ratio).

8.2.2. Hydrogen production included in consignments

Any hydrogen produced within a 30-minute time period forms a consignment and is measured in MJ_{LHV} hydrogen (using the LHV formula at the start of section 6.4). Any 30-minute time period without hydrogen production does not form a consignment.

An example of how to report the intensity of hydrogen production for different consignments is presented in Table 3. There is no consignment listed when there is no hydrogen production. There may be multiple consignments within a 30-minute period, for example a mix of two different electricity sources being used will produce hydrogen with different environmental characteristics and therefore require generation of two separate consignments.

Table 3: Example of how to generate consignments within each 30 minute period

Time	Consignment number	Electricity source	Hydrogen produced (MJ_{LHV})	Raw intensity (gCO_2e/MJ_{LHV} hydrogen)
00:00 – 00:29	NA	NA	0	NA
…	…	…	…	…
07:00 – 07:29	1	Grid average	20	45.7
07:30 – 07:59	2	Grid average	90	44.3
	3	Wind	30	0
08:00 – 08:29	4	Grid average	20	42.6
	5	Wind	140	0
08:30 – 08:59	6	Wind	150	0
…	…		…	…

8.2.3. Hydrogen emissions intensity calculations for each consignment

The raw emissions intensity calculated for each consignment is calculated as gCO_2e/MJ_{LHV} hydrogen production, based on the emissions incurred within the 30-minute period and the hydrogen produced within the same 30-minute period. Note that the calculation does not use gCO_2e/MJ_{LHV} hydrogen *sold* or gCO_2e/MJ_{LHV} hydrogen *stored*, to avoid charging and discharging of any onsite hydrogen storage leading to large fluctuations in these latter two hydrogen intensity metrics.

If there are any 30-minute periods when no hydrogen is produced but there are still emissions occurring (e.g. hot standby, maintenance), these extra emissions should be summed separately for each calendar month. At the end of the calendar month, the total of these extra emissions is divided by the total hydrogen produced in that calendar month. Note again that this calculation does not use hydrogen stored or hydrogen sold as the denominator.

The resulting extra gCO_2e/MJ_{LHV} hydrogen value then needs to be added onto the raw gCO_2e/MJ_{LHV} hydrogen emissions intensities calculated for every consignment within that month, to achieve the final gCO_2e/MJ_{LHV} hydrogen results for reporting. In other words, the extra emissions occurring when there is no hydrogen production are spread across all the hydrogen produced within that month.

If there are extra emissions occurring but no hydrogen production over a whole month or multiple months, these extra emissions should be accumulated and rolled over into the next month that contains any hydrogen production.

Figure 4 shows an indicative example adding the extra emissions resulting from no hydrogen production (red boxes) to the raw hydrogen emission intensities for each consignment. Adding the extra emissions to each consignment might result in the final emissions intensity for some consignments going above the LCHS emissions threshold.

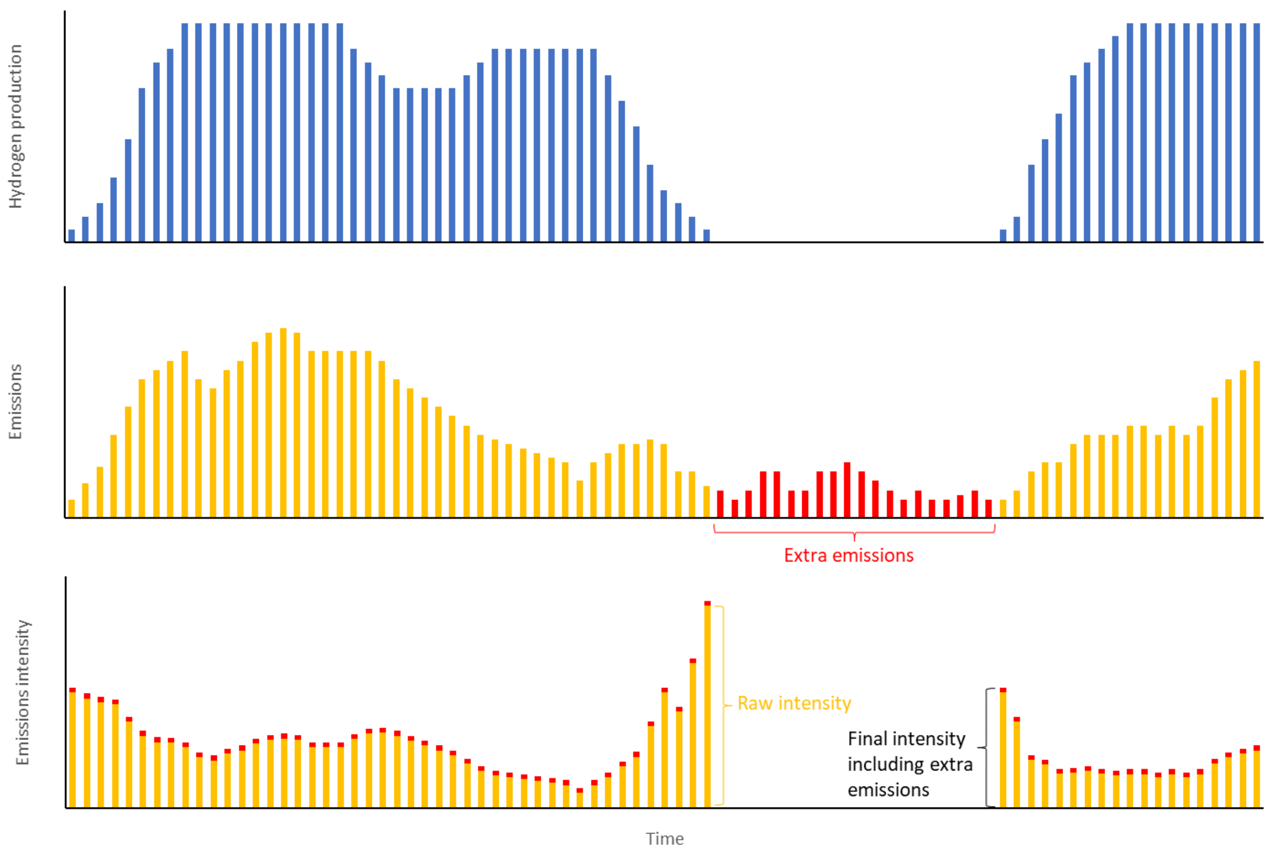

Figure 4: Hydrogen production, emissions and emissions intensity with the reallocation of the extra emissions (red boxes) from periods without hydrogen production

8.3. Materiality

In any hydrogen production pathway, there will be a number of minor emission sources which can be costly to measure, report and verify while their impact on the overall emissions intensity of the hydrogen is insignificant. Life-cycle analyses typically define a "materiality" level below which emission sources can be categorised as "immaterial" and therefore excluded from reporting requirements. These materiality limits are set to ensure confidence in the overall reported emissions intensities, whilst also avoiding unnecessary administrative burdens of reporting and evidencing insignificant emissions sources.

The materiality threshold for an emissions source (any individual input or output) is 1% of the LCHS emissions threshold, i.e. currently a value of 0.2 gCO_2e/MJ_{LHV} hydrogen. Furthermore, no more than a total of 5% of the LCHS emissions threshold can be excluded as being immaterial emissions sources, i.e. currently a value of 1.0 gCO_2e/MJ_{LHV}.

Therefore, if an emission source contributes <0.2 gCO_2e/MJ_{LHV} hydrogen and <1.0 gCO_2e/MJ_{LHV} hydrogen of emissions are excluded as immaterial in total, then the emissions from this source are considered to be immaterial and can optionally be excluded from the hydrogen producers' emissions intensity calculations. If an individual emissions source is <0.2 gCO_2e/MJ_{LHV} hydrogen but deeming it to be immaterial would lead to emissions sources totalling >1.0 gCO_2e/MJ_{LHV} hydrogen being deemed immaterial, this specific emissions source must be deemed material and included in the hydrogen GHG intensity calculations.

Emissions from the same input sources must be considered together to avoid producers making multiple claims of immaterial emissions, which if aggregated would result in material emissions (above the materiality threshold). For example, if five different grades of fossil diesel are used, each of which are individually immaterial, the producer must aggregate these inputs to assess whether the total diesel usage is material or not – whereas use of biodiesel would be assessed separately as to its materiality. In another example, a producer could set up dozens of PPAs with bio-electricity generators, each only contributing 0.1 gCO_2e/MJ_{LHV} hydrogen, but the producer must aggregate these inputs to determine the materiality of all the bio-electricity inputs. For electricity inputs, the following groupings should be used when assessing materiality: wind/solar, grid average or nuclear. For 'other' electricity sources, groupings for determining materiality should be made based on broad electricity generation technologies (e.g. bio-electricity, energy-from-waste, hydropower, natural gas with CCS etc).

All emissions credits (i.e. negative emissions values in the emissions intensities calculations, such as $E_{CO2\ sequestration}$, $E_{waste\ fossil\ counterfactual\ CO2\ emitted}$, any GHG savings from direct land use change) are deemed to be material, regardless of their magnitude.

Note that designation of an emissions source as immaterial in GHG emissions terms does not necessarily impact on any other sustainability criteria, technical requirements or evidence requirements. For example, wind electricity (with nil emissions intensity) or biomass-derived electricity with CCS (that has negative emissions intensity but is declared as having nil emissions intensity under the standard) will still need to meet the technical requirements of Annex A and meet any relevant sustainability criteria.

Examples of potentially immaterial and material emission sources:

- For electrolysis pathways, typical projects might expect that emissions sources such as mains water input, minor chemicals such as acids and alkalis used in water treatment, along with nitrogen supplied for purging, to each be immaterial inputs (<0.2 gCO_2e/MJ_{LHV} hydrogen), but this will vary by project and needs to be confirmed each month in ongoing reporting. Inputs such as diesel used for back-up generators may well be material in a given month.
- For natural gas reforming pathways, typical projects might expect that emissions sources such as mains water input and minor chemicals to each be immaterial inputs, but this will also vary by project and needs to be confirmed each month. Inputs such as amine solution make-up used for CO_2 capture, oxygen deliveries (if not generated onsite) and grid electricity inputs may well be material, as might outputs such as fugitive emissions of methane. It is expected that natural gas supply and process CO_2 emissions will always be material for natural gas reforming pathways.

Emissions sources deemed to be immaterial by the producer need to be agreed with the party responsible for ensuring compliance with the standard (under the Government schemes which apply the standard), based on the producer's initial calculations. The materiality assessment needs to be included within in the scope of the third-party audits to check that emissions have been appropriately excluded. More scrutiny should be paid to those sources likely to be closer to the materiality threshold.

Changes over time in the usage rate of inputs, or use of new inputs, could lead to some emission sources that were previously reported to be immaterial, becoming material. There is a monthly requirement to assess materiality and confirm whether previously claimed immaterial emissions are still below the materiality threshold.

8.4. Optional weighted average of consignments for monthly reporting

Each discrete, 30-minute hydrogen consignment generated during a calendar month should be reported separately at the end of the calendar month.

At the end of each calendar month, for the list of non-negative emissions intensity consignments within that calendar month, the hydrogen producer has the option to average selected (two or more) of these consignments, based on a weighted average of the MJ_{LHV} energy contents of the selected consignments (not a simple arithmetic average of the emissions intensity values), and report this weighted average GHG result for the selected consignments. This weighted average will involve, as a minimum, two discrete consignments, and as a maximum will involve all the discrete non-negative emissions intensity consignments produced in a month.

Hydrogen consignments with negative emissions intensities **cannot** be included in the weighted average and must be reported separately. This is to ensure that negative emissions are reserved for offsetting emissions in the hardest-to-decarbonise sectors of the economy, rather than offsetting high emissions from new hydrogen production facilities.

There is no requirement for the individual consignments included within or excluded from the weighted average to be compliant with the emissions threshold. There is also no requirement that the weighted average itself is compliant with the emissions threshold[4].

Only one weighted average calculation within each calendar month is permitted. For each calendar month, discrete consignments, one weighted averaged consignment or a combination of consignment types (including a maximum of one weighted averaged consignment) can be reported and assessed against the requirements of the standard.

The consignments selected for the weighted average do not have to be from the same or consecutive time periods, nor do they have to contain the same energy content of hydrogen, nor do they have to come from the same feedstock, feedstock classification, country of origin

[4] However, note that discrete consignments or the weighted averaged consignment need to be compliant with the standard to qualify for support from the policies which apply the standard.

or upstream pre-processing pathway. However, only consignments that meet the non-GHG emissions criteria (such as the land, soil and forest or other sustainability criteria where relevant) can be included within the weighted average. Only consignments produced in the reporting month can be included in the monthly weighted average.

The remaining negative emissions intensity consignments, unselected consignments or ineligible consignments that lie outside of the weighted average then also must be reported separately each month.

Figure 5 provides an indicative example of hydrogen consignments produced over a month, ordered by emissions intensity. The width of the columns represents the MJ_{LHV} of hydrogen production which varies between consignments. The height of the columns is the hydrogen emissions intensity of each consignment. If discrete consignments are reported, the green and yellow consignments have an emissions intensity below the LCHS threshold while the MJ of hydrogen in the orange and brown consignments will have an emissions intensity above the LCHS threshold. If a selection of the consignments that are above the LCHS threshold (orange consignments) are combined with consignments below the LCHS threshold (yellow consignments) to result in a weighted average that is still below the LCHS threshold (purple weighted average result of 19.6 gCO_2e/MJ_{LHV} in this example), the MJ of hydrogen that meets the LCHS threshold will increase (green, yellow plus orange consignments). The brown consignments in Figure 5 are not included in the weighted average because they would cause the weighted average to rise above the LCHS emission threshold – they are instead reported separately as non-compliant hydrogen production (which would not be supported through the policies which apply the standard). These . The green consignments are also reported separately and not included in the weighted average due to having negative emissions intensities.

In the indicative example given in Figure 5, if all consignments are reported separately, 740 MJ of hydrogen is below the LCHS threshold while 890 MJ of hydrogen is above the LCHS threshold. If a weighted average is used, the amount of hydrogen that can be reported as being below the LCHS threshold increases to 1,290 MJ (made up of 1,110 MJ within the weighted average in the purple bracket plus 180 MJ of negative emissions consignments in green reported separately), while the remaining 340 MJ of brown, non-compliant consignments above the LCHS threshold are also reported separately.

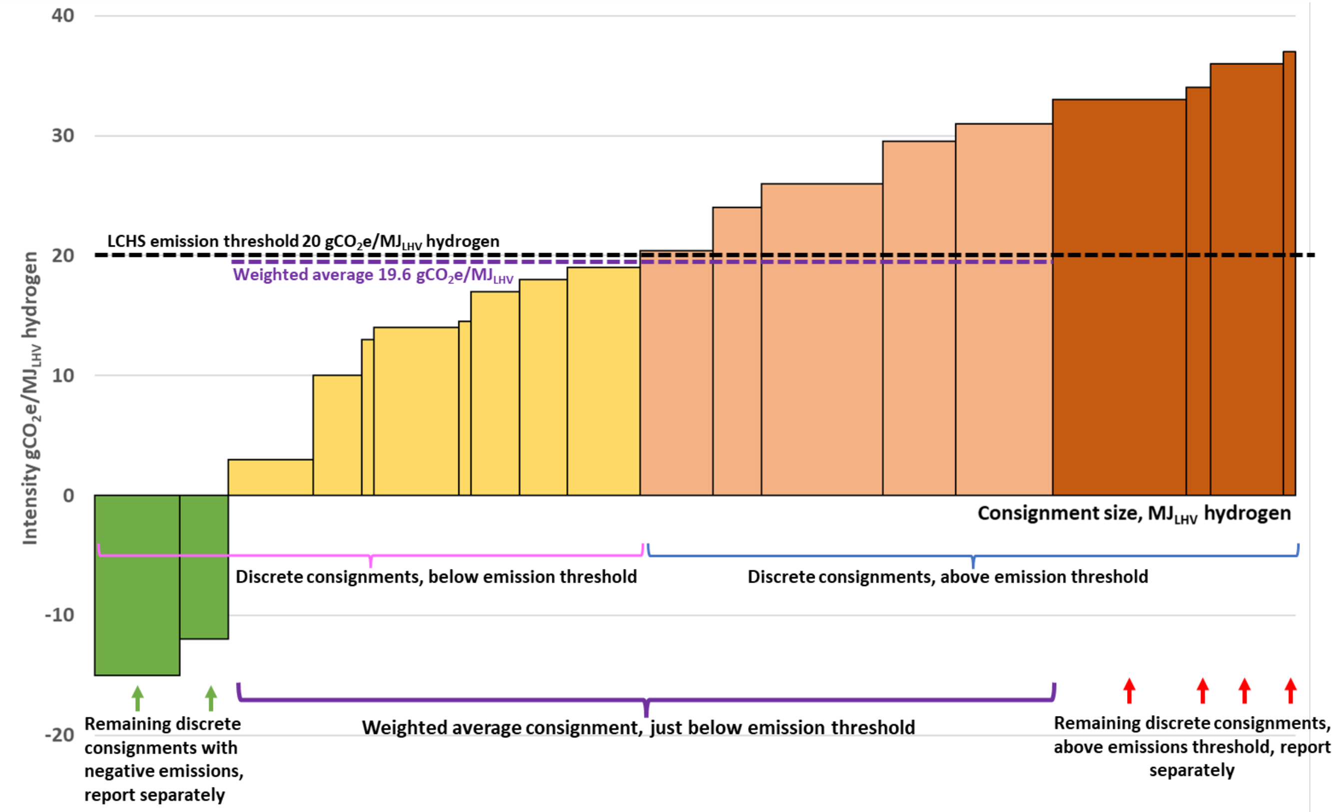

Figure 5: Example of optional monthly weighted averaging

Producers may wish to order their consignments by ascending GHG emissions intensity, with MJ_{LHV} consignment size data also present, in order to calculate a weighted average intensity of as many MJ of hydrogen as possible that still meets the emissions threshold, excluding the highest intensity consignments that would otherwise cause the weighted average to go above the emissions threshold – as well as excluding negative emissions consignments and those consignments that do not meet the non-GHG emissions criteria. A producer could instead choose to report and sell individual consignments that are below the emissions threshold and report a weighted average for all those consignments above the threshold.

If the weighted average GHG intensity result is compliant with the emissions threshold, then all hydrogen consignments included within that weighted average will be able to be claimed as complying with the standard, using the weighted average GHG intensity result. Alternatively, if the weighted average GHG intensity result is not compliant with the emissions threshold, then none of the hydrogen consignments included within that weighted average will be able to be claimed as complying with the standard.

9. Fugitive hydrogen emissions

Hydrogen itself does not adsorb infrared radiation and so is not a direct greenhouse gas. However, if released in significant quantities – for instance through fugitive emissions – hydrogen would change the chemistry of the atmosphere and could prolong the lifetime of other direct GHGs, particularly methane. This, in turn, would increase the warming effect of methane released. This and other 'indirect' effects mean emissions of hydrogen have an impact on climate change.

DESNZ commissioned work from the University of Cambridge to understand the climate impact of hydrogen emissions using modern climate models. This has reinforced the finding that hydrogen is an indirect greenhouse gas. We also commissioned work to better understand where fugitive emissions stem from in the production process.

Work is still ongoing to narrow uncertainties for both the GWP impact and leakage rates from hydrogen production, but we expect GWP to be included to the emissions calculation in future. Producers are expected to apply best available techniques set out by government and its agencies. For now, we require producers to take the steps outlined below.

9.1. Specific requirements for hydrogen production plants

9.1.1. Risk Reduction Plan: Produce a plan demonstrating how fugitive hydrogen emissions at the production plant will be minimised.

A plan should be provided demonstrating how the hydrogen production plant will be designed and operated to ensure that fugitive hydrogen emissions are kept as low as reasonably practical. As a minimum, the plan should consider each emission type detailed in the guidance section below (that is relevant to the production plant type). All assumptions should be stated, and justification should be provided where sources of emissions have been deemed negligible.

The guidance below outlines some possible actions that could be taken to minimise fugitive hydrogen emissions.

9.1.2. Risk Plan: Provide estimates of expected rates of remaining fugitive hydrogen emissions by the plant.

Producers should provide an upfront estimate of expected annual fugitive hydrogen emissions from the production plant, in kgH_2/yr. The estimate should include a breakdown of different emissions types considered, and as a minimum should show consideration of each emission type described in the guidance section below (that is relevant to the production plant type). All assumptions should be stated, including where emissions have been considered to be negligible.

9.1.3. Risk Monitoring: Prepare a monitoring methodology for fugitive hydrogen.

A methodology for monitoring overall fugitive hydrogen emissions from the plant in operation should be provided. The methodology should account for each emission type identified in the Risk Plan described above. Emissions that have been identified as negligible in the Risk Plan do not need to be monitored.

The plant operator may use their discretion in determining the monitoring methodology, provided they are able to account for all potential fugitive hydrogen streams. Approaches may include direct-monitoring of hydrogen streams (for example in vent ducts), or mass balance approaches to track overall flows of hydrogen.

9.2. Guidance: Sources of fugitive hydrogen at production plants

The following processes have been identified as being potentially significant sources of fugitive hydrogen at production plants – including compression and purification processes of hydrogen within the production facility and should be duly considered by plant developers when considering how to minimise fugitive hydrogen emissions. The list is not exhaustive and further significant sources may exist.

Process venting

Cold vents are likely to be the most significant source of fugitive hydrogen emissions at a hydrogen production plant:

- “Routine” hydrogen vents may arise because of hydrogen purification or separation steps, where some residual hydrogen remains in a waste stream. Possible occurrences include:
    - Where a purging flow of hydrogen is used to regenerate separation adsorbents;
    - Hydrogen cross-over into the oxygen stream (electrolysis only);
- Hydrogen may also be vented during plant start-up and shut-down when equipment is purged. The significance of this will depend on the frequency of plant start-ups and shut-downs.

Compressors

Hydrogen compressors are likely to be a source of fugitive hydrogen emissions and shall be considered when they are included within the production plant boundary. Fugitive emissions may arise due to:

- Permeation through seals.
- Compressor venting for maintenance (likely to be negligible, depending on frequency).

On-site storage

Above-ground stationary hydrogen storage is likely to be a significant source of fugitive hydrogen emissions and shall be considered when this is included within the production plant boundary:

- Compressed hydrogen cylinders are susceptible to leakage. The significance will depend on the storage pressure, cylinder material, cylinder size and valve type.
- Liquid hydrogen storage may result in fugitive emissions arising from hydrogen boil-off, unless actions are taken to re-use this hydrogen.

Flares (Negligible)

Incomplete combustion in any flares may result in some residual hydrogen being released to the atmosphere. This is expected to be negligible provided flares are well designed and maintained.

Leakage through pipework and joints (Negligible)

Hydrogen leakage through joints etc. is expected to be negligible provided that best practice is followed, including using welded joints wherever possible and ensuring that equipment is maintained in good condition.

9.3. Guidance: Minimising fugitive hydrogen emissions

As a priority, plants should minimise all cold venting of hydrogen. This may be achieved by:

- Ensuring that hydrogen is fully separated from any vented streams (e.g. water vapour).
- Finding alternative uses for the hydrogen within the plant and recirculating it.
- Directing waste streams to flare rather than cold vent.

It is especially important that “routine” vents are minimised. Occasional vents may be permissible, for example if they are deemed to be necessary for safety.

Hydrogen leakage throughout the plant should be minimised by ensuring best practice is followed, including:

- Using welded joints wherever possible.
- Ensuring use of suitable materials and valves, in particular for high pressure equipment.
- Fully leak-testing plants during commissioning.

10. Reporting Requirements

10.1. Evaluation cycle

The evaluation cycle for GHG emissions data is the time period for which the GHG emissions are quantified to represent the emissions from hydrogen production. The standard is designed to calculate GHG emissions on a consignment basis, to ensure each consignment can be considered as compliant with the standard by meeting the GHG emissions threshold and non GHG requirements. The data reporting requirements will depend on the scheme applying the standard. Specific reporting requirements will be set out under guidance for government schemes applying the standard, which will be available upon launch of these schemes.

It is recommended that compliant hydrogen is reported on a monthly basis with annual third-party verification.

10.2. Description of data

The methodology should use data that reduces bias and uncertainty by using the best quality data available.

10.2.1. Actual, Default and Projected Data

Hydrogen producers reporting compliance against the standard should report actual data based on the performance and emissions measured or calculated through the production of hydrogen. However, it is understood that in certain cases the use of 'actual data' may not be possible and in these specific circumstances projected data would be the second preference with default data available as a third preference. Example circumstances include:

- On application for some government schemes, hydrogen producers may not yet have access to 'actual data' if production has not commenced at the time of application. In this case projects should use projected data with clear assumptions set out, or where there is a gap in projected data, certain default data will be available in the Data Annex. This default data will be conservative to encourage projects to move over to projected data as soon as possible. As set out in the Data Annex, default data will not be provided for Process CO_2 and Fugitive non-CO_2 emissions, CO_2 capture and infrastructure, CO_2 sequestration or Waste fossil counterfactual emissions categories, as these values are likely to be specific to individual projects, and producers are expected to have projected or actual data for these categories. Actual data will be expected on the commencement of hydrogen production.

- Where the standard requires theoretical calculations for hydrogen pressure and purity adjustments, the default data to facilitate this will be provided in the Data Annex, and this data will be representative.

Conservative default data will be based on the central estimates from pathway modelling multiplied by a factor of 1.4. Default data will be provided in the Data Annex on an emissions category basis in line with the accounting equation breakdown in section 6.4. For a given emissions category, either only the default value must be used or only projected/actual data. The default data will be updated alongside other revisions to the standard as necessary. The actual data submitted by projects will be used to continue to ensure that the updated default data supplied is representative or conservative as required.

10.2.2. Data Quality

Data quality shall be characterised by both quantitative and qualitative aspects. This characterisation should address the following:

- Time-related coverage: age of data and the minimum length of time over which data should be collected.
- Geographical coverage: geographical area from which data for unit processes should be collected to satisfy the goal of the partial carbon footprint study.
- Technology coverage: specific technology or technology mix.
- Precision: measure of the variability of each data value expressed (e.g. variance).
- Completeness: percentage of total flow that is measured or estimated.
- Representativeness: qualitative assessment of the degree to which the data set reflects the true population of interest (i.e. geographical coverage, time period and technology coverage).
- Consistency: qualitative assessment of whether or not the study methodology is applied uniformly to the various components of the sensitivity analysis
- Reproducibility: qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the partial carbon footprint study.
- Sources of the data.
- Uncertainty of the information.

10.2.3. Data Completeness

If the actual or projected data is known, then it should be included in the emissions intensity calculations instead of any default data. In practice, a lack of data may be a limiting factor. Given the materiality thresholds in place, emissions sources that are likely to be material (above the materiality threshold in section 8.3) should not be excluded, and producers should as a minimum provide an estimate for these source, even if this estimate is uncertain. However, if there is compelling evidence provided that an individual material or energy flow is impossible to quantify or estimate for a particular unit process, despite it being likely to be material, it may be excluded and shall be reported as a data exclusion. Data exclusions must be recorded with evidence for the omission and reported through the annual audit and verification processes. Immaterial emissions sources that are excluded from the hydrogen GHG intensity calculations must also be reported, with brief reasons given for the annual audit and verification process.

11. Eligibility and Compliance

11.1. Eligibility and Compliance overview

The standard will be used to ensure that hydrogen production supported by government schemes and policies that apply the standard, such as the Net Zero Hydrogen Fund (NZHF) and Low Carbon Hydrogen Production Business Model (HPBM), is sufficiently low carbon. Hydrogen producers receiving support from such schemes may be expected to prove ongoing compliance with the standard throughout the agreed period, set out in their funding contract. Further detail on the compliance and monitoring requirements is published within specific scheme guidance and/or contractual terms providing details for ongoing due diligence, monitoring and evaluation of production, contract management and verification processes. The outlined requirements in this section are an example of the data and reporting requirements needed to prove eligibility or ongoing compliance with the standard.

Compliance may be checked at multiple points including at application, during study/construction stages, at build completion, and on an ongoing basis once hydrogen production begins.

The standard methodology has been developed into a comprehensive tool, the ‘hydrogen emissions calculator’ (HEC). This supports the application processes for the NZHF, HPBM and possible future government schemes applying the standard, as producers can check if their hydrogen production pathway would (likely) be standard compliant.

11.2. Compliance to assess eligibility for HPBM and NZHF

Proof of (likely) compliance with the standard is required as an eligibility criterion for the NZHF and HPBM, and possibly for future funding schemes. To prove eligibility for certain funding allocation rounds, hydrogen producers are required to demonstrate through calculation and supporting evidence that hydrogen produced from their facility will likely be able to comply with the GHG emissions requirements and other requirements of the standard.

Hydrogen producers are expected to have projected data and clarity around selected inputs and their associated upstream emissions. However, it is understood that at eligibility stage there may be gaps in hydrogen producers' data and some default data is provided in the Data Annex to support those gaps. Whether default or project data is used, projects would be expected to clearly indicate which data type is being used and any assumptions made, with references to any supporting evidence.

11.3. Compliance during operation

Once the hydrogen production facility is up and running the hydrogen produced can be checked for compliance against the standard.

Hydrogen producers receiving support or funding from government schemes applying the standard should report on compliance with the standard, according to the agreed terms of the relevant scheme. Hydrogen producers receiving government support will be expected to prove ongoing compliance with the version of the standard detailed in their contract throughout the agreed period set out in their contract to receive ongoing funding. We would not expect any changes to the standard to be applied retrospectively to hydrogen producers already awarded funding through the schemes applying the standard unless that is clearly set out in the contractual agreements. Further detail on the compliance and monitoring requirements will be published within the respective scheme guidance and contractual documents.

11.4. Reporting requirements

It is recommended that hydrogen producers be required to report all the required information to demonstrate compliance with the standard along with any supporting evidence to back up the data reported. A tool will be provided to applicants to government schemes applying the standard, which will lay out how the standard can be interpreted in an accessible way. A list of example data/documents that may be required as evidence or for verification is below:

- A scanned copy of the application unit's business license.
- The hydrogen production flow chart of the application unit.
- The main equipment list for hydrogen production.
- Supply agreements for feedstock, fuel, energy and input materials.

- The life cycle of hydrogen production and associated GHG emissions to point of production.
- List of raw materials for hydrogen production and their associated GHGs emissions.
- Energy/mass flow diagram.
- Energy metering system diagram.
- If hydrogen production facilities and equipment involve multiple locations, a list of production locations, processes, and processes of each facility should be maintained.
- Production date and production capacity information.

11.5. Verification process

Data submitted to prove eligibility or compliance with the standard should be subject to verification processes. Hydrogen producers are expected to ensure that all required data is reported fully and accurately to the best of their knowledge as required within the contractual arrangements of the relevant government scheme applying the standard.

11.5.1. Verification at eligibility

Producers should be prepared to provide evidence to back up any data or claims, should such a request be made.

11.5.2. Ongoing verification

For schemes or funds implementing the standard, a level of ongoing verification will be required which should take place at least annually and shortly after the start of operations. This could be done by third party data verification reports and/or independent audits as required within the contractual arrangements of the funding scheme.

Scheme delivery partners may also choose to implement spot check audits if there is a perceived inconsistency with any reporting.

The steps an onsite audit may take are outlined below.

On-site verification steps

- Site visits and surveys.
- Confirm the input and output information of the production pathway boundary and unit process.
- Confirm the completeness and standardisation of the data collection plan and data collection process.
- The accuracy of the level data and the consistency of the data source.

- Check whether the content of the hydrogen life cycle assessment report meets the requirements of this document, and whether the information is correct.
- On-site verification of hydrogen parameters generated by hydrogen production projects, such as hydrogen purity, hydrogen pressure, hydrogen production, etc. Hydrogen production projects should have equipment to measure these hydrogen parameters and have a calibration certificate within the validity period.

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