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INTRODUCTION TO THE IPHE METHODOLOGY

Determining the greenhouse gas emissions associated with the production of hydrogen via electrolysis of water

IMPRINT

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PREFACE

This briefing provides an introduction to the IPHE methodology for determining the greenhouse gas (GHG) emissions associated with the production of hydrogen. The purpose of this paper is to inform regulatory authorities and private sector stakeholders in potential hydrogen-producing countries about the content, context, and relevance of the IPHE methodology.

Information provided in this briefing focusses on the production of hydrogen from electrolysis of water using electricity. However, the IPHE methodology also describes methods to determine GHG emissions for other hydrogen production pathways.

The main questions discussed in this briefing are:

- What is the IPHE methodology and to which extent could it become relevant?
- Which provisions are made and what is the overall scope of the methodology?
- What data needs to be reported by hydrogen producers?
- What are possible shortcomings of the methodology and how could they be addressed?

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What is the IPHE methodology and to which extent could it become relevant?

Who is the IPHE and what is the overarching goal of their methodology?

Behind the IPHE methodology stands the **International Partnership for Hydrogen and Fuel Cells in the Economy**. As the name suggests, it is an international collaborative initiative which aims at fostering a global ramp-up of hydrogen at government-to-government level. At the time of writing, the partnership comprises 24 countries across all continents as well as the European Commission[1].

One of the goals of the IPHE is to develop a common methodology on how to determine the GHG emissions of hydrogen production. Accordingly, the *Hydrogen Production Analysis Task Force* (*H2PA Task Force*) **provided an approach on how to calculate GHG emissions for hydrogen production as well as conditioning and conversion of hydrogen.**[2] It covers several pathways for hydrogen production, including electrolysis, steam methane reforming (with CCS), coal gasification (with CCS), hydrogen as an industrial co-product, and hydrogen from biomass as a feedstock (with CCS) (see figure below). **The IPHE methodology is the basis for this 'Introduction to the IPHE methodology'.**

What does the methodology address?

Up to now, two versions of the methodology have been published as IPHE Working Papers (H2PA Task Force 2022; 2021). A third version is in preparation which will complete the methodological approach (IRENA; RMI 2023). With each version, the methodology is expanded to include additional hydrogen and PtX production pathways, hydrogen carriers or system boundaries. Detailed information on how the versions have developed is illustrated in the chart below.

Which production pathways are covered in the IPHE methodology?

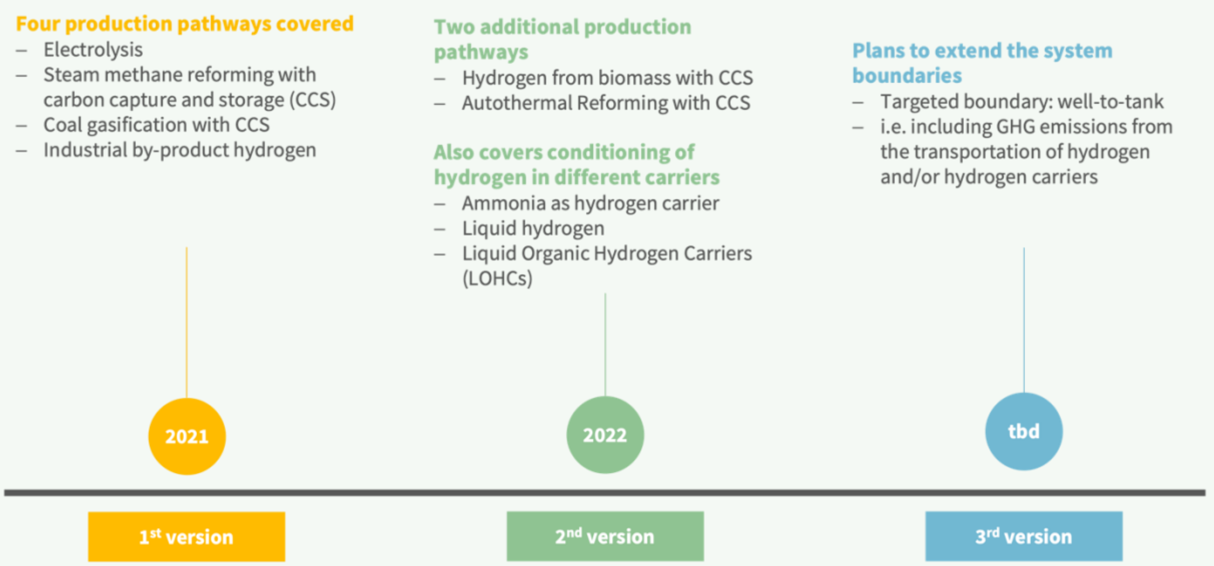

Figure 1: Own illustration based on H2PA Task Force (2021; 2022) and IRENA; RMI (2023)

[1] https://www.iphe.net/partners
[2] https://www.iphe.net/_files/ugd/45185a_03457347901844c3856e196689f3227c.pdf

To which extent could it become relevant for the global hydrogen trade?

The aim of the *H2PA Task Force* is to develop the IPHE methodology as a framework that is mutually agreed upon by interested IPHE member countries. On many points, however, it offers a basis from which a globally common methodology can potentially be built (adelphi; Oeko-Institut 2021).

In fact, over the next two years, **the International Organization for Standardization (ISO) aims at developing an international standard on the basis of the IPHE methodology** (IRENA; RMI 2023). The ISO is an independent, non-governmental international organisation with the goal to establish 'voluntary, consensus-based and market-relevant international standards'[3]. Being integrated into an ISO standard, the IPHE methodology would develop into an internationally recognised reference to consistently quantify greenhouse gas emissions of multiple hydrogen production pathways. Specific national laws or regulations may refer to the ISO standard to make it applicable in a country. Which country will integrate such a standard or another GHG accounting method for hydrogen remains to be seen. For example, it is questionable if EU countries will refer to the IPHE methodology or a respective ISO Standard, as the European Commission has developed its own GHG emission accounting method for hydrogen (Annex to the European Commission's Delegated Act on Article 28 of the Renewable Energy Directive (RED) II[4]).

As a commonly agreed-upon reference framework, a method to determine the GHG emissions associated with the production of hydrogen is also a starting point needed for certification. [5] **Already now, the IPHE methodology is used in voluntary schemes and standards** such as the *Green Hydrogen Standards* by the *Green Hydrogen Organisation (GH2)* or the *Australia Clean Energy Regulator Hydrogen Guarantee of Origin* as a guidance on how to calculate the GHG intensity of products and to evaluate them accordingly (IRENA; RMI 2023). It can be assumed that when adopted as an ISO standard, the method will find widespread use as a reference analytical framework in certification mechanisms and standards worldwide. System boundaries for emissions considered in the methodology.

To be able to calculate GHG emissions, one needs to know the system boundaries of the GHG emissions to be considered. These are defined by the IPHE methodology.

The IPHE methodology defines a 'well-to-gate' system boundary. This implies that all GHG emissions are being considered that are emitted

- upstream (energy feedstock, extraction of feedstock and delivery),
- during the production of hydrogen and
- finally, during the distribution and storage of hydrogen.

The 'well-to-gate' system boundary does not include

- GHG emissions associated with the construction, manufacturing and decommissioning of any capital goods nor
- non-technical emissions associated with employees etc.

Emissions occurring from transport and storage have not been integrated into the IPHE methodology yet. However, an **update of the methodology including transport and storage is expected to be published in 2023.**

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[3] https://www.iso.org/about-us.html

[4] https://energy.ec.europa.eu/system/files/2023-02/C_2023_1086_1_EN_annexe_acte_autonome_part1_v4.pdf

[5] More information on certification can be found here: https://ptx-hub.org/wp-content/uploads/2023/05/International-PtX-Hub_202305_Certification-for-green-hydrogen-and-PtX.pdf

'Well-to-gate' system boundary

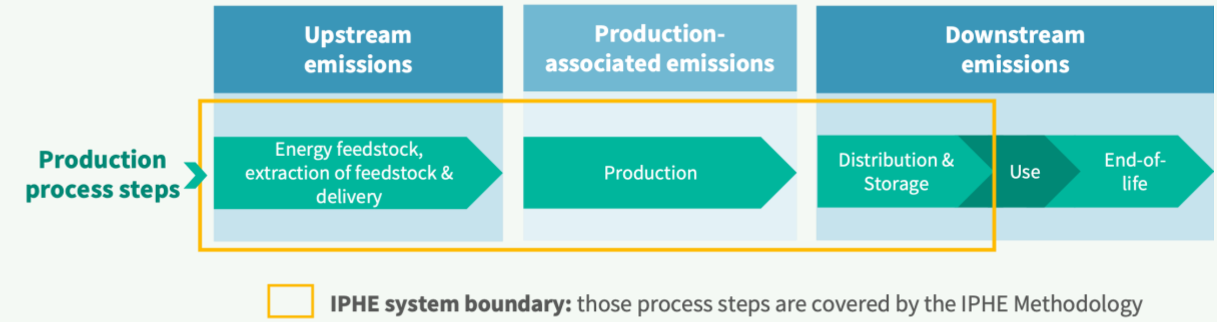

Figure 2: Based on H2PA Task Force (2022, p. 29)

How does the IPHE methodology determine the GHG emissions of electricity?

The IPHE methodology describes how to calculate the GHG emissions associated with the use of electricity in section 6.3.3.4.1[6]. These specifications are central to the GHG assessment, as the emissions deriving from the electricity input into the electrolysis of water strongly impact the overall GHG emissions of the resulting hydrogen.

Which uses of electricity are considered?

Electricity used for electrolysis is the most relevant input in terms of possible GHG emissions. Yet, also other electricity used is covered in the methodology:

- Electricity for hydrogen production incl. buffer storage operation
- Electricity for compression, purification, drying and cooling
- Electricity for water treatment

According to the IPHE methodology, the GHG emissions associated with the use of electricity include:

- Emissions that arise from the life cycle of the electricity supply system. These are emissions such as the exploitation and transport of fuels.
- Emissions that occur during the generation of electricity, including losses during generation and transportation.

There are two options of sourcing electricity covered in the methodology: the first one sourcing on-site electricity generation, the second one sourcing electricity from the grid.

On-site electricity generation

If electricity is generated on-site, consumed for the hydrogen production and no contractual instruments have been sold to a third party, only emissions of this electricity generation are relevant. In this case no other upstream emissions have to be considered. In case the on-site generation is renewable, per definition the associated GHG emissions are zero.

Electricity from the grid

In case the hydrogen production plant uses electricity from the grid, GHG electricity emissions refer to the electricity consumed by the plant, considering upstream, operational, and downstream emissions as

6 https://www.iphe.net/_files/ugd/45185a_03457347901844c3856e196689f3227c.pdf

well as losses during the generation and transport of electricity.

For cases where electricity is taken from the grid, **the IPHE methodology defines two general settings**:

- If there is a **dedicated transmission line** between the electricity supplier and the hydrogen production plant, the GHG emission factor from the electricity supplier can be used. This can only be done if no contractual instruments have been sold to a third party.
- **All other settings** in which the electrolysis uses electricity from the grid.

The reporting method of emissions, according to *H2PA Task Force*, section 6.3.3.4.1 (2022), builds on dual reporting requirements – 'location-based' and 'market-based' – according to the GHG protocol[7]. However, the IPHE methodology suggests using the market-based approach where possible.[8]

- **Location-based method**: depicts the average emissions from the relevant regional grid in the time of production (hourly). The quantity of electricity consumed must be multiplied by the average grid emission factor from the region in which consumption occurs (where state- or province-level grid factors are preferred to country level).
- **Market-based method**: depicts the emissions from Power Purchase Agreements (PPA) or Renewable Energy Certificates (REC). This means, the hydrogen producer can buy RECs or contract renewable energy (RES-E) plants *via* PPAs according to the amount of electricity needed, and this proves that the electricity input is fully renewable.

In case the regional regulation creates potential for double counting[9] of renewable energy between the location-based and market-based method, a **residual mix factor** should be applied for those volumes of the respective electricity market which are not explicitly marketed and claimed. This factor then has to be applied within the market-based method in those cases when the hydrogen producer does not make a specific purchase of electricity, building on specific documentation like e.g. Guarantees of Origin (GOs) in the EU.

If electricity used by the electrolysis plant is **imported**, the emissions factor from the exporting country should be used for the non-renewable share of this electricity. What do hydrogen producers need to report?

What do hydrogen producers need to report?

Details on what information needs to be reported for calculations following the IPHE methodology are listed in the appendices of the IPHE methodology. The information required varies between the different production pathways covered in the two versions of the methodology.

This briefing, however, only focusses on the hydrogen production pathway – electrolysis. What producers need to report for this pathway can be found in Appendix P1.5 of the methodology's latest, 2nd version (H2PA Task Force 2022, p. 52). The table below compiles this information accordingly.

It is important to note that information on the amount and GHG emissions of the product always refers to a batch. A batch is defined by a start and end date as well as a quantity of product produced.

[7] https://ghgprotocol.org/sites/default/files/2023-03/Scope%202%20Guidance.pdf

[8] While one might assume that this is meant as being a preference of the market-based method over and above the location-based method, it rather seems to simply underline that also the market-based method should be used in parallel to the location-based method in the framework of dual accounting whenever the national regulatory and market framework allows for such individual claims at all. In non-liberalised markets the market-based method might not be applicable at all for practical reasons (GHG Protocol Chapter 6.2). Furthermore, it should be pointed out that the dual reporting requirements of the GHG Protocol actually require dual calculation and reporting for scope 2 emissions (electricity from the grid). However, for the calculation of a more comprehensive inventory including scope 1 and scope 2 emissions, the GHG Protocol allows to choose one of both methods (GHG Protocol chapter 7.1).

[9] Double counting could occur if the same unit of renewable energy is sold to a hydrogen producer via contractual arrangements (e.g. renewable energy credits) and also accounted for in the renewable content of the regional grid. To mitigate double counting in such situations, if a hydrogen producer is using the market-based method, a residual mix factor should be used to depict the emissions intensity of the regional grid.' (H2PA Task Force 2022, p. 37)

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CATEGORY	INFORMATION THAT NEEDS TO BE PROVIDED
Facility details	• What is the identifier of the producing facility? • Where is the producing facility located? • How large is the facility's capacity? • When did the facility first start operation?
Production	• Which production pathway has been chosen?
Product specification	• How much H_2 is produced [kg]? • What is the H_2 pressure level at gate? • What is the H_2 purity level at gate? • What type of contaminants are associated with/contained in the product?
GHG emissions overview	• How emission intensive is the H_2 batch?
Batch details	• What is the start/end date of the produced batches? • How much is the (respective) batch quantity?
Electricity[10]	**Location-based emissions accounting** • How much grid electricity [kWh] is used? • Which location-based emission factor is used [kgCO_2e/kWh]? **Market-based emissions accounting** • How much grid electricity [kWh] is used? • How much renewable electricity [kWh] and/or associated Guarantees of Origin (GO) or Renewable Energy Certificates (REC) is/are contracted? • What type of GOs or RECs is contracted? • What is the amount of the 'residual electricity' used? • What is the residual mix emission factor [kgCO_2e/kWh]? **On-site electricity generation** • How much electricity [kWh] is generated on-site? • What is the emission factor for on-site electricity generation (as applicable) [kgCO_2e/kWh]?
Other utilities	• What source/s of water are used in other utilities? • What source/s of steam are used in other utilities? • How much water is purchased [kg]? • How much steam is purchased [kg]? • How much steam is exported [kg]?
Fuel feedstock	• What types of fuels are combusted? • How much fuel is combusted [L, kg]? (to be specified for each fuel type) • What relevant emissions are calculated, and which factors are used?
Process	• Which water treatment technology is used? • Which electrolyser technology is used? • Which H_2 purification technology is employed?
Water feedstock	• What source/s of water are used as feedstock? • How much water is used as feedstock? (to be specified for different sources)?
Waste and/or co-products	• How much oxygen is produced [kg]? • How much of the produced oxygen is sold [kg]? • How many emissions are allocated to oxygen produced in the process?

[10] H2PA Task Force (2022, p. 52): 'In a country where GO system and residual mix system are not used for electricity emission counting, reporting of GO and residual mix related matters cannot be necessary.'

Discussion of the IPHE methodology

The methodology proposed by the IPHE and described above could have a strong impact on the global hydrogen market as it might become the first ISO standard on how to determine GHG emissions from hydrogen production. This in mind, we discuss possible shortcomings of the methodology, their effects and how it could be improved in the following sections. Just as in the entire briefing, the focus here lies on the treatment of GHG emissions occurring from hydrogen production through water electrolysis.

No additionality requirement for RES-E plants can underestimate GHG-emissions of hydrogen production

Possible shortcoming

The IPHE methodology refers to the GHG Protocol and its Scope 2 Guidance Paper[11] when it comes to the treatment of electricity taken from the grid. As described above, the GHG Protocol addresses the location-based method (average GHG emissions within the local grid) as well as the market-based method (GHG emissions associated with the electricity purchased). Both approaches do not incentivise the deployment of additional RES-E plants to cover the additional demand by the electrolysis plant.

Possible effects

While the GHG Protocol is mainly aimed at companies reporting their GHG emissions, the large-scale production of hydrogen will require considerable amounts of electricity and, therefore, will substantially increase total electricity demand within an electricity market. As a result, an additional electrolysis plant will increase the demand for electricity which – unless regulated otherwise – will be provided by the existing generation plants in the short term. In many cases, fossil power plants will step up generation to meet the rise of overall power demand due to hydrogen production. This increases the overall GHG emissions of the whole system.

Even if – using the 'market-based' approach – RES-E is purchased but no additional RES-E generation is stimulated, RES-E generation for green hydrogen will just be virtually shifted from existing consumers to hydrogen production. While no emissions will be associated with the hydrogen production itself, GHG emissions of the whole electricity system will likely increase.

Therefore, the IPHE methodology may underestimate GHG emissions attributed to the hydrogen produced. The way it is currently designed, it does not adequately reflect the actual effects on the system-wide GHG emissions that are associated with the additional electricity demand needed to produce large amounts of hydrogen.

Improvements

The methodology should introduce the concept of additionality when determining GHG emissions from electricity generation. Within the methodology, zero GHG emissions for the electricity input should only be accounted for if additional RES-E plants have been contracted to supply this electricity.

Quality of data for average GHG emissions of electricity from the grid might not be comparable across countries

Possible shortcoming

When using the 'location-based' method to define the GHG emissions associated with the electricity input, average emissions from the relevant regional grid should be used. According to the IPHE methodology, this data is to be supplied by the grid operator. However, it cannot be assumed that all the relevant data is recorded and made available in a consistent – and thus comparable – manner across potential hydrogen-producing countries worldwide.

Possible effects

If average GHG emissions of electricity input are not accurately comparable between countries, the overall emissions from hydrogen production will not be comparable either. This can lead to advantages or

[11] https://ghgprotocol.org/sites/default/files/2023-03/Scope%202%20Guidance.pdf

disadvantages for some countries in competition within an international hydrogen market.

Improvements

The IPHE methodology should suggest a method (including verification) on how to measure and calculate average GHG emissions from the grid. Regional focus on provinces can underestimate average GHG emissions of the electricity grid

Regional focus on provinces can underestimate average GHG emissions of the electricity grid

Possible shortcoming

To determine the GHG emissions of the electricity taken from the grid in the 'location-based' method, the IPHE methodology suggests using data from state or even province level. However, many electricity markets cover a larger region than this level. It can be assumed that an increase in demand for electricity will hence be met on this larger market area and not only on state or province level.

Possible effects

Based on this provision, hydrogen plants might preferably be built in provinces with low average GHG emissions. Calculating according to the methodology with data on state or province level can lead to an underestimation of GHG emissions. This is the case if average grid emissions on province level are low (for example due to a high share of RES-E in this province), but in reality, additional electricity demand for hydrogen production leads to an increase in fossil electricity generation in the relevant market.

Improvements

Rather than depending on data on state or province level, data should be drawn from the electricity market in which the hydrogen production is incorporated. At least the IPHE methodology should foresee reporting on how average GHG emissions in the local grid (state or province) differ from the ones in the relevant electricity market. If systematic differences occur, double reporting should take place.

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