FC-Hy Guide

# Operational LCA guidance for hydrogen production

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**Aachen**

**Germany**

FC-Hy Guide

# Operational LCA guidance for hydrogen production: Methodological approach and first results

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FC-Hy Guide

# Content

- About FC-HyGuide
- Overview of hydrogen production types
- LCA case study on hydrogen production via steam-reforming

# Compliance

ISO

- ISO 14040 describes the principles and framework for Life Cycle Assessment (LCA)
- ISO 14044 specifies requirements and provides guidelines for LCA

International Reference Life Cycle Data System (ILCD) – ILCD Handbook

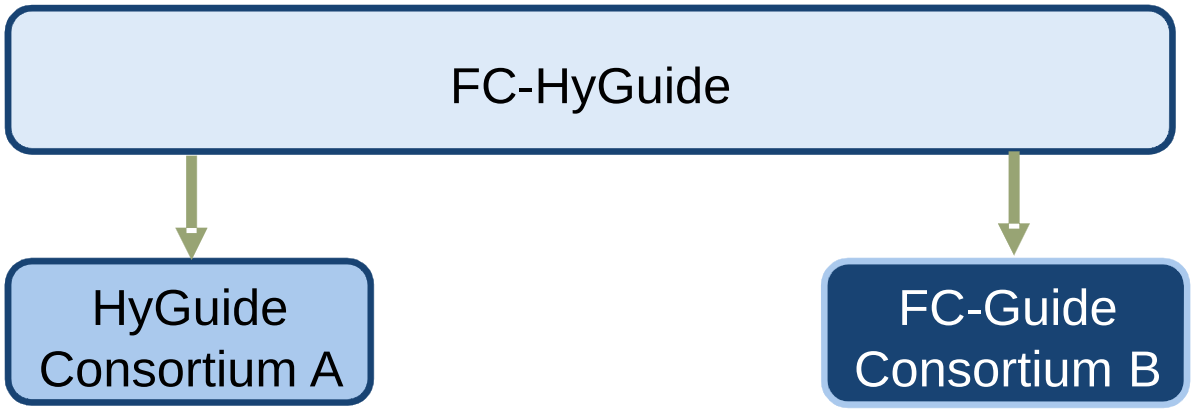
- General guide for LCA which provides detailed guidance on how to conduct a LCA to quantify the emissions, resources consumed and influences on the environment and human health that can be attributed to a product.
- In line with the ISO standards, further specifying and complementing them.
- It has been co-developed by the JRC-IES, Platform on LCA

# Goal of the FC-HyGuide project

**Expected results:**

- A guidance document – based on the ILCD handbook – that is scientifically sound, industry accepted and quality assured (reviewed)
- LCA study reporting template, tailor-made to hydrogen and fuel cell technologies
- Broad dissemination among LCA practitioners and industry,
- A project website (http://www.fc-hyguide.eu/), as a central information point and as fully integrated component of the ILCD data network, with public and restricted access areas.

# FC-HyGuide - Project Overview

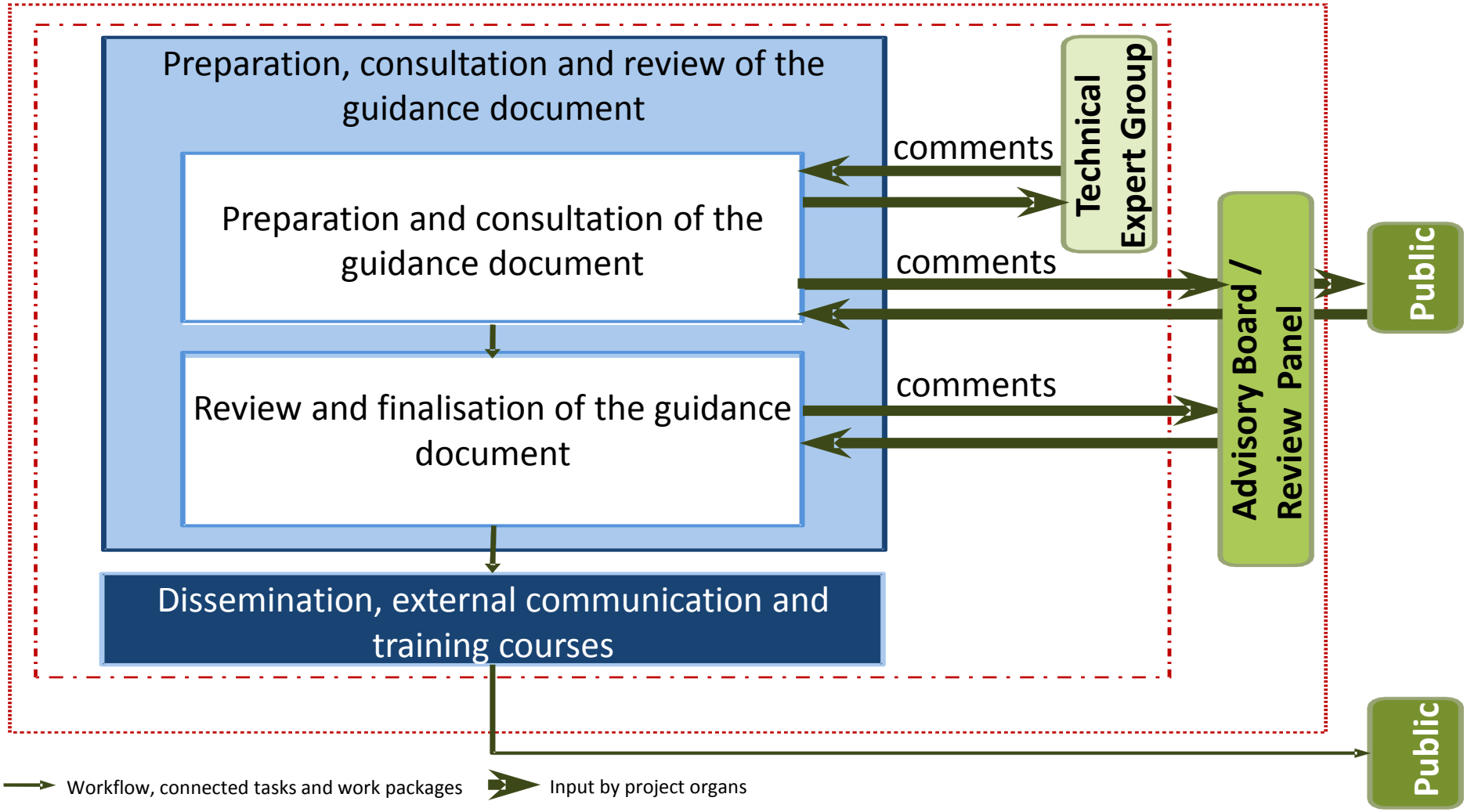



"Hydrogen production systems"

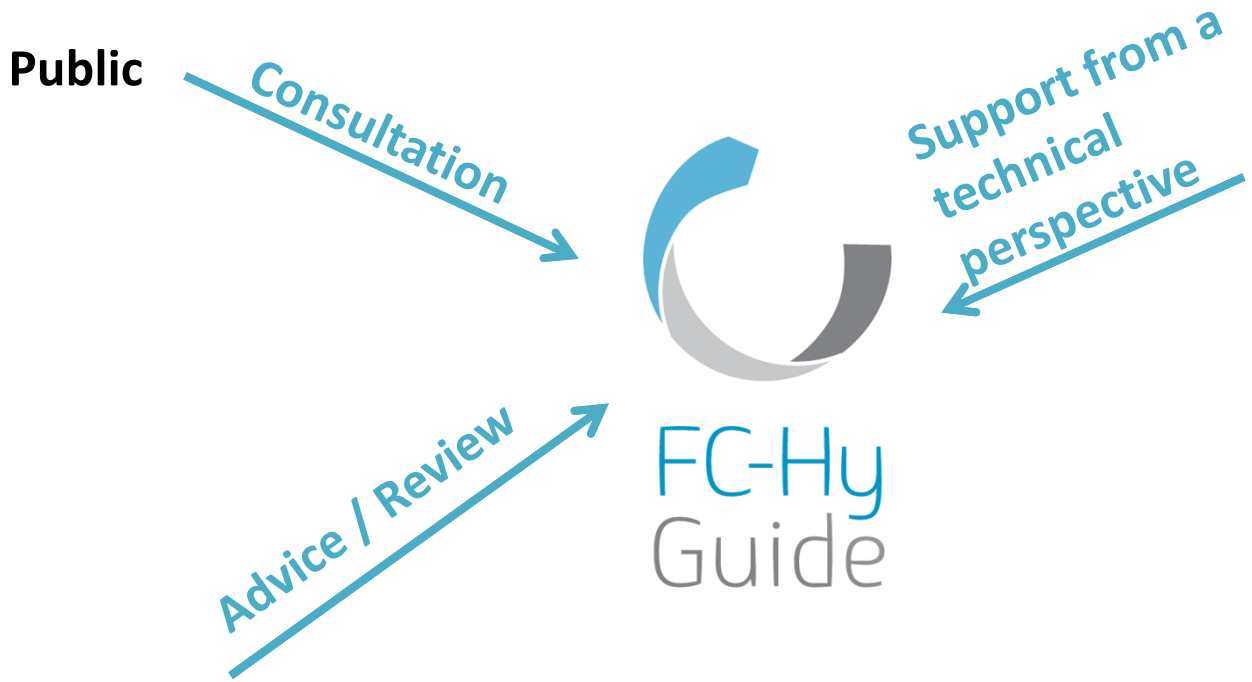
"Fuel Cell technologies"

- FC-HyGuide = HyGuide + FC-Guide

# FC-HyGuide Project structure



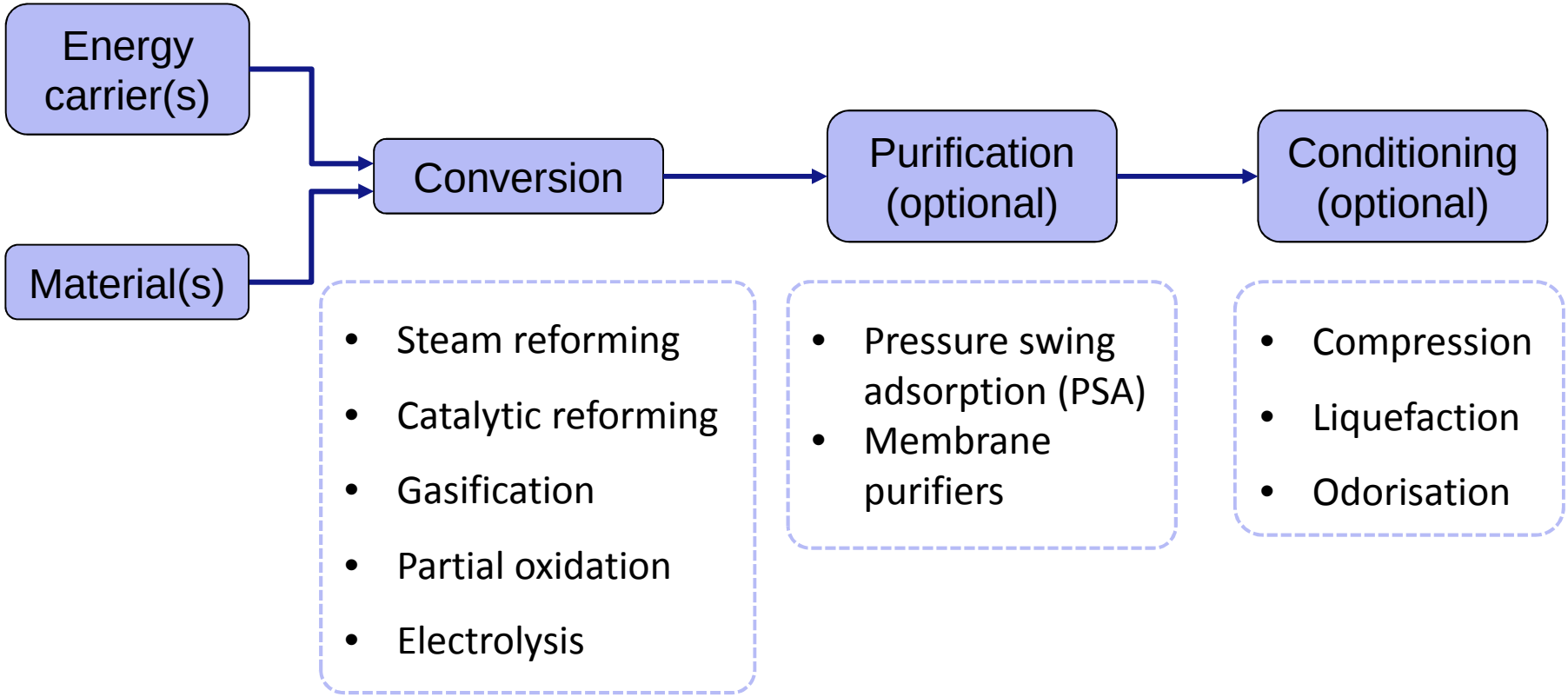
# FC-HyGuide Management structure




**Advisory Board / Review panel**

JRC – IES Platform for LCA: Kirana Chomkamsri (advisory board only)
TU Berlin: Prof. Dr. Matthias Finkbeiner
GIGA: Dr. Pere Fullana
MiBo Consult: Michael Bode

# Evaluation of hydrogen pathways



# Conducting the case studies

General LCA phases:

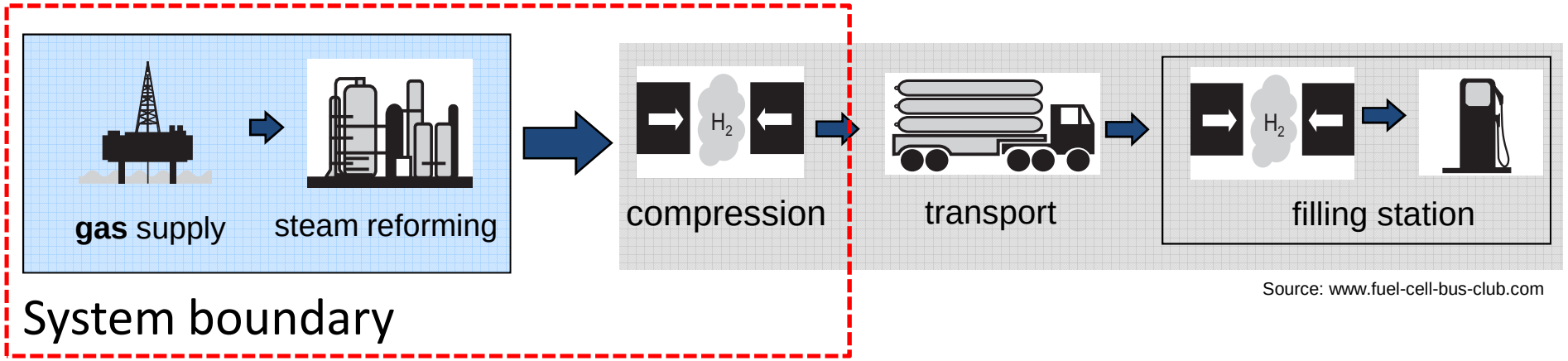
1. Goal of the LCA study
2. Scope of the LCA study
3. Life Cycle Inventory Analysis
4. Life Cycle Impact Assessment
5. Interpretation and quality control
6. Critical Review

# 1. Goal of the study

- Intended application*: Evaluation of the production of hydrogen*
- Method, assumptions and impact limitations: *"full"-LCA*
- Reasons for carrying out the study: *e.g. Case study*
- Target audience: *technical and non-technical audience*
- Comparisons intended to be disclosed to the public: *are possible*
- Commissioner of the study: *e.g. Project consortium FC-HyGuide*

# 2. Scope of the study (1/6)

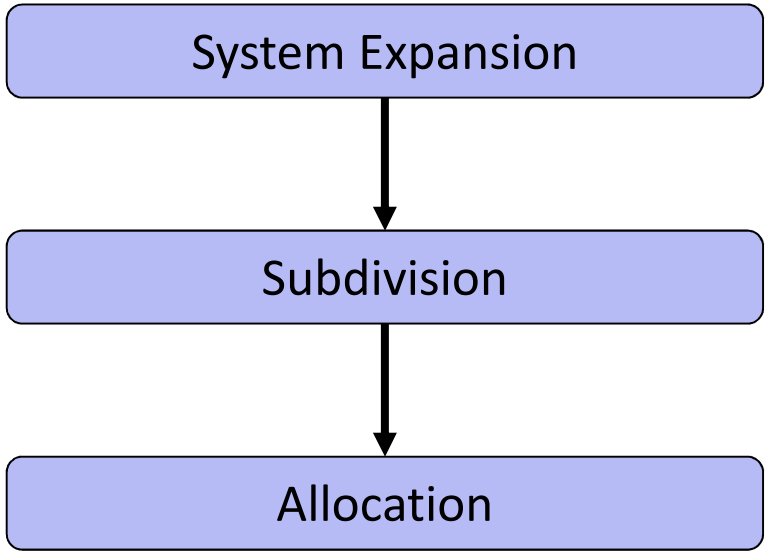
- Function, functional unit and reference flow:
  *1MJ $H_2$ @ XX bar, YY °C, ZZ,ZZ% purity*
- LCI modelling: *Attributional, according to situation A in the ILCD handbook*




Source: www.fuel-cell-bus-club.com

# 2. Scope of the study (2/6)

- Multi-functionality: *Following the ILCD Handbook and ISO a hierarchy is demanded:*




If possible

Point out if the subdivided process is suitable

a) Physical properties

b) Economic properties

# 2. Scope of the study (3/6)

- System boundaries:
  - Geographical boundaries: *EU-27*
  - Reference year: *2011*
  - Limitation within the life cycle (LC): *none*

- Definition of relevant (energy & material) flows
  - *e.g. input of energy carriers, electricity*

- Cut-off criteria: *5%-rule, based on environmental relevance*

# 2. Scope of the study (4/6)

- LCIA method chosen: *CML impact method*
- LCIA categories selected: *midpoint; $GWP_{100}$, AP, EP, POCP*
- Further indicators evaluated: *$PED_{fossil}$, $PED_{renewable}$*
- Type, quality and sources of required data and information:
  - *Specific primary data on main processes, e.g. how much natural gas, electricity is consumed by steam-reforming*
  - *Generic (average) data on background data, e.g. LCI of natural gas extraction (to be taken from ELCD database)*

# 2. Scope of the study (5/6)

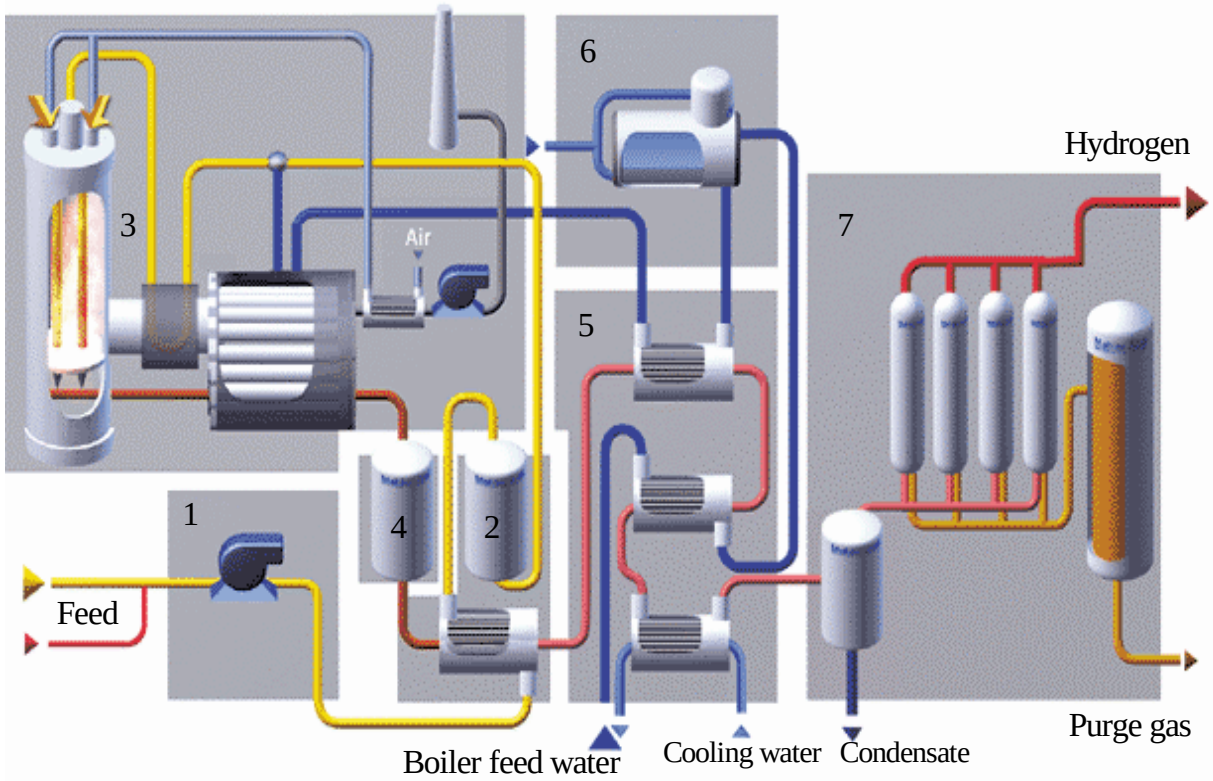
- Data quality requirements (Technical, time-related, geographical representativeness, completeness, precision / uncertainty, methodological appropriateness and consistency): *E.g. Measured natural gas consumption of an average size steam-reforming process over a period of on year in regular operation*
- Comparisons between systems: *can be conducted with this guide*
- Intended reporting: *Third party use*

# 2. Scope of the study (6/6)

- Identification of critical review needs:
  - *Non-comparative studies to be disclosed to the public*
    - *→ Independent external reviewer*
  - *Comparative assertions disclosed to the public*
    - *→ Independent external review panel*

- Intended reporting: *e.g. internal report; third party report*

# 3. Life Cycle Inventory analysis




| | |
|---|---|
| 1 Compression<br>2 Desulfurisation and Hydrogenation<br>3 Reforming<br>4 CO-Conversion | 5 Heat recovery<br>6 Generation of Steam<br>7 Purification by PSA |

Source: www.fuel-cell-bus-club.com

- Planning data collection
- Collection of unit process data
- Filling data gaps and usage of background data sets (e.g. ELCD)
- Set up of LCA model(s)
- Calculation of LCI results

# 3. Data collection questionnaire – general part –

| Part I: General information on hydrogen production | | unit |
|---|---|---|
| ***Please attach an additional sheet including a system functioning scheme and system's basic components*** | | |
| **Hydrogen related information** | | |
| ***[please add rows and other fields if needed]*** | | |
| Purity of the hydrogen (XX %) | | % |
| Aggregate state (liquid or gaseous) of the hydrogen | | |
| Pressure of the hydrogen (YY bar) | | bar |
| Temperature of the hydrogen (ZZ °C) | | °C |
| Impurities (please state them below, if known) | | % |
| Type of Impurities | | |
| Amount | | % |
| Quantity produced by volume | | $Nm^3/h$ or $Nm^3/year$ |
| Quantity produced by mass | | kg/h or kg/year |
| **Description of hydrogen producer (general information on the producer)** | | |
| ***[please add rows and other fields if needed]*** | | |
| Overall hydrogen production capacity (of the production company) | | $m^3$ |
| Number of hydrogen production sites | | No. |
| Hydrogen production technologies used (e.g. steam reformer, electrolysis etc.) | | |
| Geographical coverage by region (where are the major production locations of the producer) | | country or region |
| **Description of the product system under investigation** | | |
| ***[please add rows and other fields if needed]*** | | |
| Hydrogen production technology used | | |
| Location of the production site | | country or region |
| Year of construction | | |
| Is there electricity produced on-site used | | yes/no |
| Amount of electricity produced on-site used (if applicable) | | kWh/MJ hydrogen |
| Type of electricity production on-site (if applicable) | | |
| Is there heat produced on-site used in the production of $H_2$ | | |
| Type of heat production on-site, e.g. gas boiler, oil CHP etc. (if applicable) | | |
| Amount of heat production on-site (if applicable) | | MJ/MJ hydrogen |
| $H_2$ production capacity per day | | $Nm^3$/year or MJ/year |
| $H_2$ production capacity per year | | $Nm^3$/year or MJ/year |
| Technical service life of $H_2$ production | | |
| Scale of production site (laboratory, pre-commercial, commercial scale) | | |
| Type of storage (including e.g. liquefaction facility or other device) | | |
| Capacity of storage | | $Nm^3$ |

# 3. Data collection questionnaire – specific part –

| Part II: Hydrogen production by steam reforming | amount (per unit of product) | unit |
|---|---|---|
| ***Hydrogen production - Functional unit is "1 MJ of hydrogen (net calorific value (NCV) with XX % purity and YY ba*** | | |
| ***[please add rows and other fields if needed]*** | | |
| ***Input*** | | |
| Natural gas (if applicable) | | Nm³/MJ hydrogen |
| Net calorific value of the natural gas used | | MJ/Nm³ |
| Liquefied petroleum gas (if applicable) | | kg/MJ hydrogen |
| Net calorific value of the liquefied petroleum gas used (if applicable) | | kg/Nm³ |
| Refinery gas (if applicable) | | Nm³/MJ hydrogen |
| Net calorific value of the refinery gas used (if applicable) | | MJ/Nm³ |
| Other process gases (e.g. off gas from $H_2$ purification) (please specify if applicable) | | m³/MJ hydrogen |
| Net calorific value of the process gas used (if applicable) | | |
| Composition of the process gas (e.g.% H2, % CO2 etc.) (if applicable) | | |
| Cooling water | | |
| Temperature of the cooling water | | |
| Tap water | | |
| Average temperature of the tap water | | |
| Electricity | | |
| Operating supplies and spare parts (e.g. kg catalyst for reformer) | | |
| Operating supplies for the desulphurisation (e.g. kg catalyst per year) | | |
| Operating supplies for the de-ioniser (if applicable) | | |
| ***Output*** | | |
| $CO_2$ (Emissions) | | |
| $NO_x$ (Emissions) | | |
| CO (Emissions) | | |
| Other emissions (please specify) | | |
| Waste water | | |
| Miscellaneous waste | | |
| Amount of $H_2$ losses during purification | | |
| Are the $H_2$ losses used as process gas? (if yes please specify in proces | | |

| Part III: Hydrogen production by electrolysis | amount (per unit of product) | unit |
|---|---|---|
| ***Hydrogen production - Functional unit is "1 MJ of hydrogen (net calorific value (NCV) with XX % purity and YY ba*** | | |
| ***Method of production: Alkaline electrolysis*** | | |
| ***[please add rows and other fields if needed]*** | | |
| ***Input*** | | |
| Electricity | | kWh/MJ hydrogen |
| Tap water | | m³/MJ hydrogen |
| Potassium hydroxide | | kg/MJ hydrogen |
| Process gases (e.g. off gas from $H_2$ purification) (please specify if applicable) | | m³/MJ hydrogen |
| Net calorific value of the process gas used (if applicable) | | MJ/m³ |
| Composition of the process gas (e.g.% $H_2$, % $O_2$ etc.) (if applicable) | | |
| Operating supplies and spare parts | | |
| ***Output*** | | |
| Is the Oxygen used? (Please state the amount below if yes) | | yes/no |
| Oxygen | | Nm³/MJ hydrogen |
| Amount of $H_2$ losses during purification | | % |
| Are the $H_2$ losses used as process gas? (if yes please specify in process gas column above in inputs) | | yes/no |
| Other emissions (please specify) | | kg/MJ hydrogen |

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# Contact details

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