eGHOST
eco-design Guidelines for Hydrogen Systems and Technologies

D2.2 Metrics in Social Impacts

WP2 Definition of FCH products systems

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EXECUTIVE SUMMARY

This deliverable defines the Social Life Cycle Assessment approach to be followed in the eGHOST project, with a focus on a proposed list of social life-cycle indicators to be evaluated for the fuel cells and hydrogen (FCH) products involved in the project.

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ABBREVIATIONS

EU	European Union
FCH	Fuel Cells and Hydrogen
FU	Functional Unit
GDP	Gross Domestic Product
GHG	Greenhouse Gas
LCA	Life Cycle Assessment
PEMFC	Proton-Exchange Membrane Fuel Cell
PSILCA	Product Social Impact Life Cycle Assessment
SDG	Sustainable Development Goal
S-LCA	Social Life Cycle Assessment
S-LCI	Social Life Cycle Inventory
S-LCIA	Social Life Cycle Impact Assessment
SOEC	Solid Oxide Electrolysis Cell
UNEP	United Nations Environment Programme
USD	United States Dollar

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REPORT

1. INTRODUCTION TO SOCIAL LIFE CYCLE ASSESSMENT OF PRODUCTS

Social Life Cycle Assessment (S-LCA) is a "methodology to assess the social impacts of products and services across their life cycle" [1]. It complements environmental Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) to provide a holistic impact assessment of products and organisations, eventually embracing social aspects. The impact categories included in an S-LCA aim to comprise the different stakeholders potentially affected by the product throughout its supply chain or life cycle. Stakeholder categories, impact subcategories and social indicators are addressed in Section 3.2.

The general principles and framework for S-LCA are similar to those reported in the international standards for LCA [2,3]. Thus, S-LCA involves four phases (Figure 1): goal and scope definition, social life cycle inventory (S-LCI) analysis, social life cycle impact assessment (S-LCIA), and interpretation.

"Goal and scope definition" is the first step of the S-LCA methodology. The purpose of the study and the functional unit (FU) used to quantify the function of the product system are set in this step. Additionally, the unit processes included in the analysis should be identified, thus defining the boundaries of each system. Hence, the definition of a supply chain for the product under study is needed. The subsequent inventory and the interpretation phases will be strictly linked to the defined product supply chain.

S-LCI analysis is the second step. It involves data collection for the unit processes embedded in the boundaries of the product system. Working hours per FU are commonly used as the activity variable [4-6].

S-LCIA is the third step. It addresses the evaluation of the potential social impacts or social risks associated with the supply chain of the product system. To that end, activity variables are transformed into potential social impacts or risks by using an impact assessment method. In eGHOST, **a Reference Scale Approach is used as the impact assessment approach** [1], conducting an **S-LCA database analysis** as detailed in Section 3.1. Under this approach, **social risks linked to the product under study are quantified**. Therefore, the results of the assessment correspond to the social risks associated with the product supply chain, establishing no cause-effect relationship (no impact pathway, unlike environmental LCA).

Interpretation is the final step, in which the results of the previous steps are reviewed and discussed in depth to provide conclusions and recommendations. Depending on the results and the goal of the study, this phase may include additional analyses (completeness check, consistency check, sensitivity and data quality check, etc.), besides conclusions, limitations and recommendations.

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While the fundamentals of the goal and scope definition and inventory phases of the study are addressed in the eGHOST deliverable D2.1, the present deliverable focuses on the S-LCIA phase (viz., evaluation method and choice of social indicators).

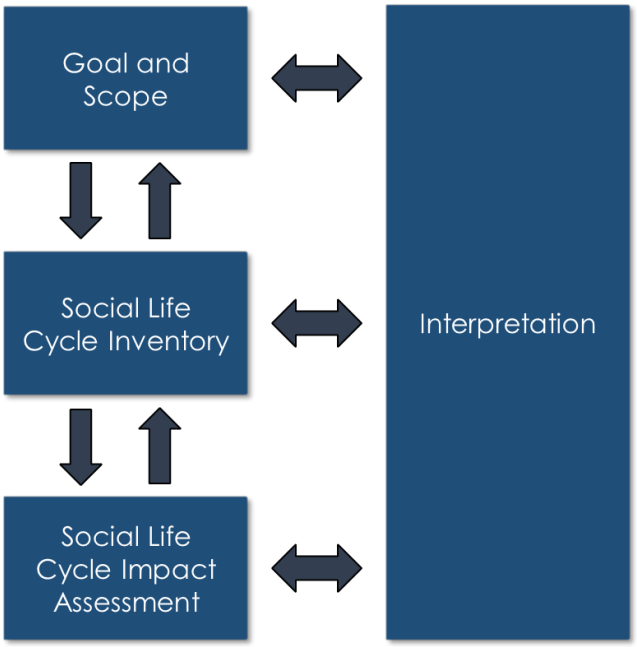

FIGURE 1. GENERAL S-LCA FRAMEWORK.

2. OBJECTIVE

The objective of this report is to define the methodology followed in eGHOST as regards the S-LCIA of the FCH products under consideration. To that end, it details the evaluation procedure and provides a list of social/socio-economic areas and indicators to be assessed for the FCH products involved in the project.

3. SOCIAL LIFE CYCLE IMPACT ASSESSMENT

The phases "goal and scope definition" and "S-LCI analysis" are specifically addressed in the eGHOST deliverable D2.1. In this regard, the devices under study are a Proton-Exchange Membrane Fuel Cell (PEMFC) stack and a Solid Oxide Electrolysis Cell (SOEC) stack. The related FU is one stack of each product. All relevant activities and processes within the product supply chain have to be included in the analysis. In this sense, the product system can be understood as a set of blocks or plants [4].

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As regards the S-LCIA phase, the proposed framework is based on the (scarce) literature available on S-LCA of FCH products [4-6], thus considering the **implementation of the S-LCIs in openLCA and the use of PSILCA as both a database and an evaluation method** [7].

3.1 Evaluation procedure

The evaluation method employed for S-LCIA follows the procedure explained in Valente et al. [4]. **Social indicators are estimated from the following parameters: (i) the working hours at each plant *p* per FU (W_p), and (ii) the risk factor for each social indicator *j* and plant *p*** ($R_{j,p}$, expressed in medium risk hours, mrh, per working hour). Each social indicator (S_j, in mrh per FU) is therefore assessed according to Eq. 1:

$$S_j = \sum_{p=1}^{n} W_p \cdot R_{j,p} \qquad \text{Eq. (1)}$$

where *n* is the number of plants included in the product system. It should be noted that social indicators may also express a positive social impact. In that case, the "risk" factor is expressed in medium opportunity hours (moh).

In this calculation procedure, W_p, as the activity variable, quantifies "the share of a given activity associated with each unit process" [1], while the risk factor $R_{j,p}$ quantifies the risk associated with each unit process, being specific not only to each plant (*p*) but also to each social indicator (*j*). The activity term, in this case the working hours, can be quantified directly or indirectly. On the one hand, the direct approach is typically followed when plant-specific inventories are available for the study under investigation. On the other hand, the indirect approach is used to estimate the working hours from inventoried economic flows according to Eq. 2:

$$W_p = V_p \cdot W'_p \qquad \text{Eq. (2)}$$

where V_p is the economic value in United States Dollars (USD) per FU linked to the plant *p*, and W'_p is the number of working hours per USD for the plant *p*, which can be found –for the country and sector associated with this plant– in the PSILCA database [7].

3.2 Social life-cycle indicators

3.2.1 Overview of social life-cycle indicators

Stakeholder categories represent the group types that can be affected by the processes and activities involved in the life cycle of the product [1]. Within each stakeholder category (SH_i), there are several **impact subcategories** related to a specific social or socio-economic aspect (e.g., forced labour). Finally, for a given impact subcategory (IC_k), various **social indicators** are proposed (S_j) [7]. In Figure 2 an illustrative structure of a stakeholder category is shown.

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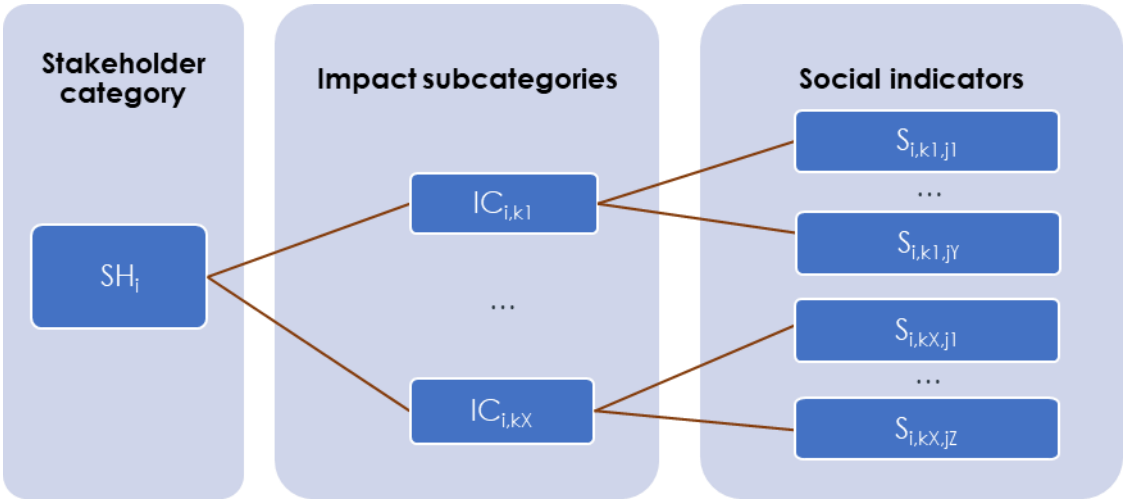

FIGURE 2. ILLUSTRATIVE STRUCTURE OF A STAKEHOLDER CATEGORY

In particular, the PSILCA database establishes four stakeholder categories: workers, local community, society, and value chain actors [7]. These categories are disaggregated into 25 subcategories and, subsequently, into 69 social indicators. Subcategories are linked to one or various of the United Nations Sustainable Development Goals (SDGs) [1]. Table 1 presents the impact subcategories available in the PSILCA v.3 database.

TABLE 1. IMPACT SUBCATEGORIES IN PSILCA V.3

Stakeholder category	Impact subcategory
Workers	Child labour, forced labour, working time, discrimination, fair salary, health and safety, social benefits, workers' rights
Local community	Access to material resources, respect of indigenous rights, safe and healthy living conditions, local employment, migration, greenhouse gas (GHG) footprints, environmental footprints, labour footprints
Society	Contribution to economic development, health and safety, prevention and mitigation of conflicts
Value chain actors	Fair competition, corruption, promoting social responsibility

The choice of the social indicators to be considered highly depends on the goal and scope of the study, taking into account which social groups are affected along the product life cycle (stakeholder categories), which areas are relevant to the product (impact subcategories), and on which basis they are measured (social indicators).

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3.2.2 Selection of social life-cycle indicators

The set of stakeholders, impact subcategories and social indicators to be studied is based on the specific goal and features of the eGHOST project, literature results from previous S-LCA studies of FCH and energy systems [4-6,8], available guidelines [1,7,9,10], and the SDGs. A limited number of social indicators is selected to make their subsequent consideration in the eco-design of both products effective. Nevertheless, additional subcategories and indicators might be included as the project develops. This is in line with the guidelines from the United Nations Environment Programme (UNEP), which state that "an iterative refinement is recommended for the subcategory/impact category selection, comparing Goal and Scope and Impact Assessment phases when results have been obtained" [1].

Workers and society are initially selected as the stakeholder categories under study. As the project develops, local community and value chain actors could also be included depending on the definition of the supply chains and the associated social risks. Figure 3 shows the particular social/socio-economic aspects and social indicators (in italics) to be addressed. The connection of these impact subcategories with the SDGs is also represented.

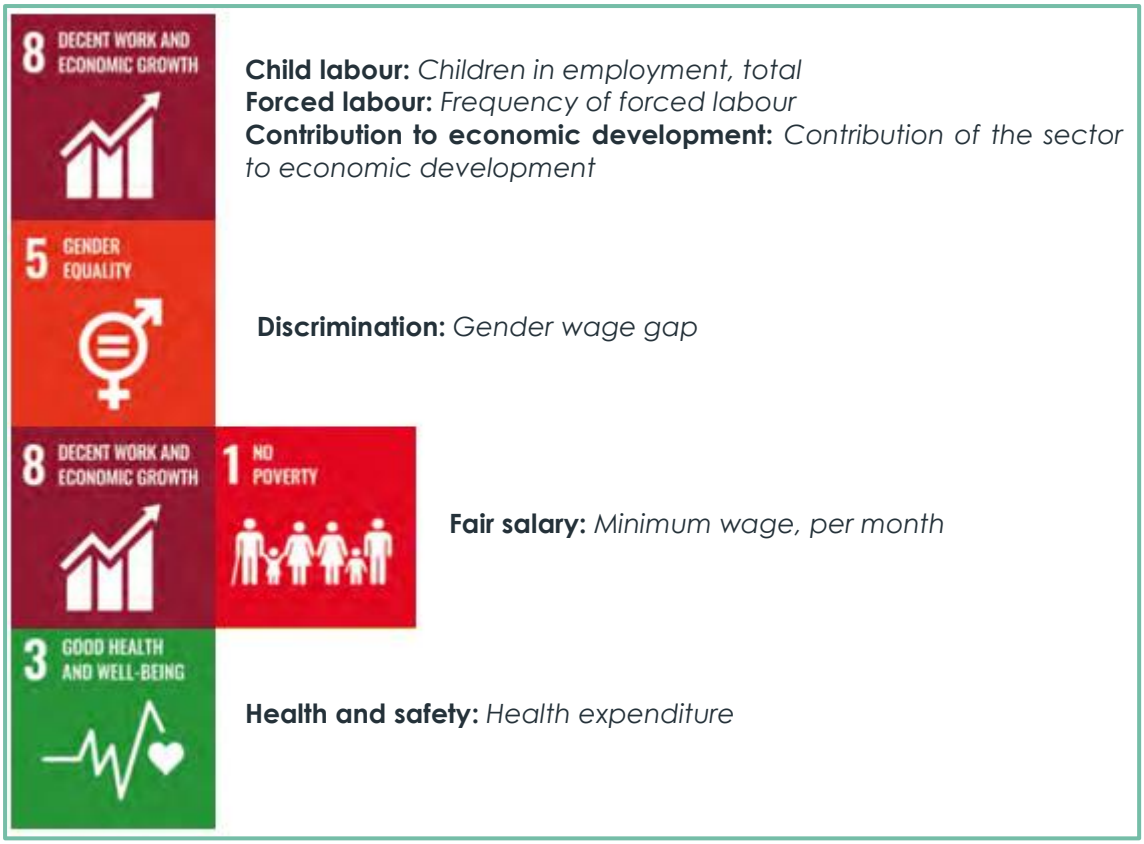

FIGURE 3. SELECTED IMPACT SUBCATEGORIES AND INDICATORS

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Attention is paid to avoid double counting concerning impact subcategories and social indicators, following UNEP recommendations [11] and taking into account aspects covered in other sections of the eGHOST project (for instance, in LCC and environmental LCA). Only in the case of child and forced labour a discussion may arise within the selected set of subcategories and indicators. However, based on the primary models and statistics on which PSILCA is based [12,13], it is concluded that they do not overlap: frequency of forced labour includes, among other issues, forced labour of children, but it is identified as a critical data gap [12], while child labour refers to all the children in employment (i.e., working at least one hour in the reference period for the production of a good or service) [13].

Regarding the stakeholder category "workers", the impact subcategories of child labour, forced labour, discrimination, and fair salary are selected. These are usually of particularly high relevance when dealing with multiregional supply chains. The social indicators of children in employment (total) and gender wage gap are chosen based on the available S-LCA literature on hydrogen systems [4,10]. Regarding forced labour, its frequency is selected as indicator since it involves a broad spectrum also accounting for human trafficking, debt bondage, forced or servile marriage, and the sale or exploitation of children [7]. This definition is consistent with the SDG target 8.7, which calls to "take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking" [14]. As regards fair salary, minimum wage is selected as indicator since the established risk scale reflects the risk of having workers with a remuneration that is not sufficient to achieve minimum decent living conditions [7].

Besides social risks, it is also necessary to address the potential social opportunities that FCH systems may present. In this sense, **the impact subcategory of contribution to economic development –within the stakeholder "society"– is selected** in order to assess the potential economic growth the involved countries could experience with the diffusion of these technologies. Thus, contribution of the sector to economic development is selected as indicator.

Still within the stakeholder "society", the impact subcategory **"health and safety" is also selected** based on project goals and specific literature [4,5,10]**.** This social area complements the aforementioned aspects and leads to address another SDG. In particular, health expenditure is selected as social indicator [4,5,10], which takes into account public and private investment on health relative to the Gross Domestic Product (GDP).

Overall, the social indicators proposed as starting point are closely linked to central pillars of sustainable development such as human rights and economic development. Other stakeholder categories, impact subcategories and indicators might be included in light of the results found for the different FCH products as the project develops.

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CONCLUSIONS

A list of social life-cycle indicators to be evaluated for the FCH products involved in the eGHOST project is now available, along with the proposed framework to be followed for their quantification. The proposed social metrics is expected to be subsequently used throughout the project to support the deployment of the EU Taxonomy and Corporate Social Responsibility.

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