

# Towards social Life Cycle Assessment of Energy Systems: a case study on offshore wind farms from companies' perspective

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**Abstract.** Within the energy transition context, private and public decision-makers must choose between different energy scenarios. Hence, environmental, and social impacts incurred from the development of renewable energies need to be investigated to ensure their alignment with energy transition objectives.

Social Life Cycle Assessment (S-LCA) is one of the most appropriate methods to analyse social and socio-economic impacts with a life cycle perspective. However, social impacts included in sustainability analyses of energy systems mostly focus on employment or health and safety issues. Few studies in the literature present a rigorous approach to account for social impacts affecting different stakeholder categories.

The present work is supported by a close collaboration with key industrial partners of the energy sector to overcome the above-mentioned limitation. Hence, it contributes to the definition of the goal and scope phase of a S-LCA study through the integration of companies' perception. Thus, it aimed to highlight the priority of social impact subcategories and related stakeholders in the context of offshore wind farms (OWF). As a result, a core set of impact categories that were perceived as the most relevant is proposed.

## 1 Introduction

Social Life Cycle Assessment (S-LCA) allows analysing social and socio-economic impacts throughout the life cycle of products and services [1]. It has been recognised by both private and public actors in the energy sector as an appropriate methodology for identifying potential positive and negative impacts, especially within the growing market of renewable energies [2, 3]. However, given the complexity of actors' network and stakeholders that are likely to be affected or involved, as well as the divergence of their needs and interests, their identification can be challenging. Moreover, the definition of impact subcategories to be covered by S-LCA studies relies on the stakeholders that have been considered in the assessment. In this regard, more transparent and consistent approaches are needed to define the stakeholder groups and their associated impact subcategories to be analysed within the social life cycle impact assessment (S-LCIA) phase.

This work aimed to integrate the perception of companies in the prioritization of stakeholders and social impacts to be considered in the offshore wind sector. Conducting a survey at energy companies for the identification and prioritization steps of S-LCA should

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provide insights into the social hotspots of the sector under investigation. Through a systematic approach, the present work was conducted in collaboration with a panel of eight companies: six operators in the energy sector and two component suppliers for Offshore Wind Farms (OWF). The results may support the definition of impact subcategories to be considered within S-LCA studies. Moreover, the proposed approach may serve as a basis to compare the different perceptions of companies and external stakeholders' (i.e., local socio-economic actors, local authorities, policymakers, etc.) on the importance of social impacts. Such comparison must highlight how the perception of the companies must be completed to ensure the most accurate representation of the social impacts of the sector.

## 2 Methodology

Figure 1 illustrates the approach proposed in the present work to integrate companies' perspective. In step 1, UNEP Guidelines (2020) are used as a basis for the design of a survey to be addressed to industrial representatives. Steps 1 to 3, corresponding to the preparation of the survey, are presented in section 2.1 and steps 4 to 5, which entail the design of the prioritization step, are presented in section 2.2. The approach proposed in our study is adapted from the S-LCA prioritization method developed by Bouillass et al. (2021) [4].

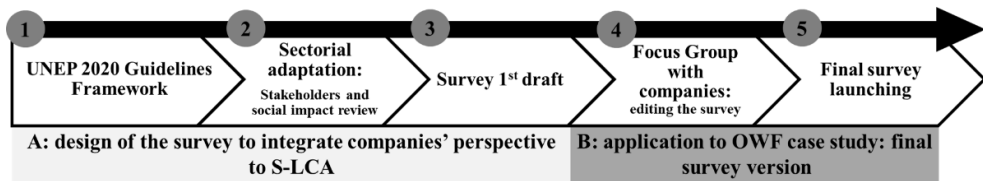


Figure 1. Main steps to co-construct the survey to collect companies' perspective

### 2.1 Design of the survey to integrate companies' perspective in S-LCA

Phase A aims to prepare the elements required to co-construct the survey together with companies. The list of recommended stakeholders and impact subcategories is used (step 1) and adapted in regards to sectoral context (step 2). These information allow to build a first draft of prioritization survey (step 3) that is used in phase B.

### 2.2 Application to OWF case study: final survey version

To ensure the representativeness of companies' perspective and motivate them to respond, their members were involved in the design of the survey. Thus, a focus group (step 4) was organised to introduce S-LCA interests and main definitions, as well as to collect companies' feedbacks to improve the survey. The discussion with the panel allowed the survey to be adjusted. Some feedbacks suggested to distinguish between direct and indirect workers. Concerning the scoring criteria, only two were kept and reformulated: *Influence* (i.e., assessing the level of impact of the stakeholder on the project) and *Hotspot* (i.e., assessing the degree of impact of the project on the stakeholder). To assign the scores, a semi-quantitative scale was used, including: "NA - Not influential - Low influential - Influential - Very influential" for Influence and "NA - Very low impact - Low impact - Moderate impact - High impact" for Hotspot. Each level was associated with a value from 0 to 4. This scoring system allowed the stakeholders' sub-groups for each stage of the life cycle to be prioritized based on the percentage of the maximum score obtained, calculated as the sum of average influence and hotspot for each sub-group divided by the sum of the maximum influence and hotspot. Each stakeholder sub-group was ranked for these two criteria and for each stage of the life cycle, which allowed the identification of the most relevant ones in table 1.

Table 1. Stakeholders' categories and subgroups for OWF context and the corresponding life cycle steps (1: resource extraction; 2: components manufacturing; 3: components transport; 4: farm construction; 5: operation – exploitation – consumption; 6: dismantling – recycling – landfill; 0: all steps)

Stakeholders' categories	Stakeholders' subgroups	Sources	Life cycle steps						
			1	2	3	4	5	6	0
Direct workers	R&D / Design	[5]	x						
	Control						x		
	Operation						x		
	Power connection					x	x		
	Other direct workers					x	x	x	
	Unions	[6]				x	x	x	
Value Chain	Turbine makers	[5]	x						
	Electricity distributors	Additional proposal					x		
	Industrial competitors	[7]					x		
	Other component manufacturers	[8]		x					
	Consultants			x					
	Raw material suppliers			x					
	Civil engineering						x		
	Service providers (Transport)						x		
Others indirect workers or organizations		x	x		x	x	x		
Local community	Local public actors	[9]					x	x	x
	Residents						x	x	x
	Fishermen						x	x	x
	Recreational sea users						x	x	x
	Other professionals (including tourism)						x	x	x
	NGO (local scale)						x	x	x
	Others local communities	Additional proposal	x	x					
Consumers	Industrial consumers	Additional proposal					x		
	Households	Additional proposal					x		
Society	Public and media	Additional proposal							x
	NGO (large scale)								x
	Public authority (National, European)								x
	Academic								x
	Financial – shareholders								x
	Rating agencies								

Impact subcategories from UNEP guidelines were adapted to the OWF context thanks to feedbacks from participants in the focus group. For example, indicators such as "ability to communicate on electricity supply as a supplier", "energy autonomy and local supply" and "grid stability" were added for consumers subcategories. After validating the final version of survey, it was launched. For the interpretation of results, the average ranking position was calculated. A dispersion index was also determined to identify possible divergences or convergences in responses.

### 3 Results and discussion

#### 3.1 Companies' perspective: stakeholders' rating

Results highlight some relevant stakeholder sub-groups (figure 2). In particular, component suppliers were identified as the most sensitive stakeholders by the respondent companies. In the case of turbine manufacturers, the score was 65% of the maximum score for both criteria combined. Suppliers of other components, such as cables, floats and anchors, scored 80%. In the upstream of OWF exploitation also, R&D and designing professions were represented (63%). Among other stakeholders, Local community category was the next one perceived as more relevant, mainly related to construction, operation and end-of-life phases. Impacts in these phases concerned stakeholders such as local public actors, local NGO and professional fishermen, for whom there may be conflicts about occupation of the maritime area.

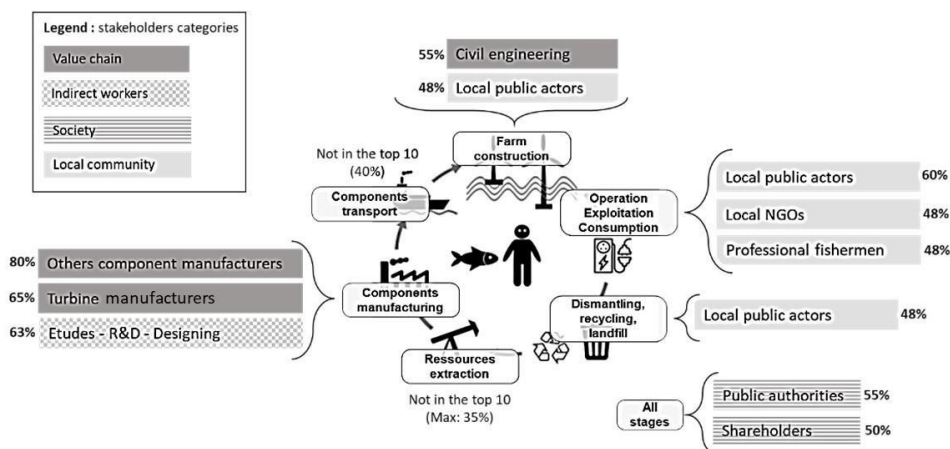


Figure 2. Prioritization results for top 10 stakeholders

Stakeholders at the very beginning of the life cycle (e.g., suppliers of raw materials) were perceived by interviewed companies as less sensitive. Probably, this under-representation is due to a lack of knowledge about the social impacts linked to these sectoral and geographical contexts. Among stakeholders with the lowest scores were industry competitors (13%) and rating agencies (10%), which suggests that social performance is perceived by the panels less relevant for benchmarking practices or attracting extra-financial investors.

#### 3.2 Companies' perspective: social subcategories' ranking

Regarding the ranking of social impact subcategories, results show a great variability in perceptions among companies. Indeed, most of the dispersion indices are high. However, it is possible to identify some social impact subcategories with high average rank and relatively low dispersion index. "Health and safety" tends to be in the first position for all concerned stakeholder categories. Child labour is absent among the top 3 subcategories for Direct workers, but present for Indirect workers. This can be simply explained by the fact that indirect workers of the value chain are distributed not only within France but also abroad where the traceability of working conditions seems more difficult.

Table 2. Results of social subcategories ranking (top 3)

	Rank 1		Rank 2		Rank 3	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
<b>Direct workers</b>	Health and safety		Social benefits / social security		Equal opportunities discrimination	
	1.3	0.50	3.3	2.06	4.3	3.30
<b>Indirect workers</b>	Health and safety		Child labor		Fair salary	
	2.8	2.87	3.5	1.00	4.8	2.87
<b>Value chain</b>	Promoting social responsibility		Fair competition		Supplier relationships	
	2.3	1.50	2.8	0.96	2.8	2.06
<b>Local community</b>	Safe and healthy living conditions		Local employment		Secure living conditions	
	1.8	0.50	2.5	3.00	3.0	1.15
<b>Consumers</b>	Health and Safety		Transparency		Consumer privacy	
	1.0	0.00	2.3	0.50	3.0	0.82
<b>Society</b>	Contribution to economic development		Poverty alleviation		Public commitments to sustainability	
	3.3	2.22	3.3	1.71	3.3	2.63

For the local community category, local employment impact subcategory is in the top 3. This issue is often mentioned by companies as an argument to strengthen the legitimacy of their projects’ development. However, it can be complex to study this issue in depth. Indeed, even if an emerging sector such as OWF may create jobs, some concerns arise among other activities already established in the territories (e.g., tourism and fishing). As such, we could expect cultural heritage social impact– which can be linked to landscape issues – to be found among the highest positions in ranking, whereas this was not the case in the current study. This impact subcategory is nevertheless recurrent in public debates.

In summary, the gathered feedback reveal that the social impact subcategories’ ranking is sensitive. Despite the information provided to clarify the methodology, it was difficult for the panel to conduct ranking. Some time and effort are needed to get familiar with the methodology, so as to understand all the indicators that define each subcategory.

## 4 Conclusions and perspectives

In this work, an approach was proposed and applied to OWF in order to identify and prioritize stakeholders and social impact subcategories according to companies’ perspective. The application of the subjective approach revealed limitations linked to the lack of knowledge of social practices and of the awareness of potential risks in early stages of the supply chain. Several respondents mentioned the uncertain nature of their answers. It is interesting to note the possible job-related bias, since most of the respondents are LCA users or practitioners. This kind of background may be linked to a broad view of the sector. However, other professionals such as business developers may have different points of view about social concerns. Also, clearly defining the stakeholder categories and subgroups is necessary to remove any ambiguity.

Furthermore, it is important to highlight the main aim of S-LCA which is to identify the main social hotspots in the sector. In conclusion, prioritizing the stakeholders and social impact subcategories within S-LCA is essential, but sensitive. Indeed, one single stakeholder’s perspective may not be representative enough and thus, the application of S-LCA may require the intersection of as many stakeholders as possible. Addressing other stakeholders’ perspectives will be necessary to complement companies’ perspective in further stages of the study.

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