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METHODOLOGICAL FRAMEWORK FOR ASSESSING THE ENVIRONMENTAL IMPACTS OF PHOTOVOLTAICS SYSTEMS USING THE LCA METHOD

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ABSTRACT

This paper presents the guidelines for environmental assessment of photovoltaic systems in France by considering the total life cycle. It aims at helping designers of photovoltaic systems to evaluate the environmental impacts of producing electricity using the rules set out in the methodological framework. A specific common framework is created to conduct LCA (functional unit, system boundaries and product categories). A reference database of impact factors is developed allowing analysts to perform LCA in a simple manner. Some of the default impact factors are intentionally conservative. This choice is made to encourage manufacturers of photovoltaic system components to replace them with their own value to better match their systems impacts. This framework is available since the beginning of 2013.

INTRODUCTION

The increasing demand for photovoltaic (PV) systems in France and the growing interests for environmental issues have encouraged the French government to better consider the environmental aspects of the PV sector. To support the development of photovoltaic installations, new French regulations are now heading to take into account an assessment of the environmental footprint of energy production systems over their entire life cycle by introducing LCA results in call for tenders as a significant criterion. Recognizing that a wide variability in assumptions that can affect the validity and reliability of the results from PV LCAs, the French Environment and Energy Management Agency (ADEME) has set a methodological framework to help installers and designers of PV systems to undertake these LCAs with common and coherent rules to meet these new requirements (Payet et al., 2013).

METHODS

This methodological framework, mainly based on ISO standard 14040 and 14044 (ISO, 2006) and provisions of the ILCD handbook (European Commission, 2010) takes into account the technical and geographic characteristics of a PV system. An impact factors database has been specifically designed to build default values to allow the user to calculate the environmental assessment of a series of PV categories.

Product category

The environmental assessment set out in this framework applies to the product categories defined in Table 1. Three main product categories are proposed in accordance with the technical systems characterization.

Table 1. Product categories covered by the framework

<table>
<tr><th>Product categories</th><th>Power P_{max}</th><th>Voltage range</th><th>Description of PV system installation</th></tr>
<tr><td>Category 1</td><td>Above 0 kVA and under 36 kVA</td><td>Low Voltage single phase or three phases</td><td>System integrated into or connected to building or installed on roof</td></tr>
<tr><td>Category 2.a</td><td rowspan="2">Strictly above 36 kVA and under 250 kVA</td><td rowspan="2">Low Voltage three phases</td><td>System integrated into or connected to building or installed on roof</td></tr>
<tr><td>Category 2.b</td><td>System installed on ground</td></tr>
<tr><td>Category 3.a</td><td rowspan="2">Strictly above 250 kVA</td><td rowspan="2">Medium Voltage</td><td>System integrated into or connected to building or installed on roof</td></tr>
<tr><td>Category 3.b</td><td>System installed on ground</td></tr>
</table>

The methodological framework is a general method that can be applied to all PV systems installed in France except for concentration PV systems (CPV). Single-crystal silicon and thin-layer technologies are singled out in the framework. It applies exclusively for grid-connected PV installations.

Definition of the scope of LCA study

The basic function of the PV installations analysed using the methodological framework is electricity production. The functional unit of the LCA should be determined in conjunction with the function of the system observed and should serve as a basis of comparison for analyzing the results of the different PV systems producing electricity. Consequently, functional unit of the assessment is defined as one kWh produced by a photovoltaic system during its lifespan and either injected into the distribution or transport network or consumed.

The system boundaries are defined: it includes extraction and production of PV system components, installation, use and maintenance, dismantling and end-of-life processing (recycling, incineration and/or landfill of materials composing the PV system).

For assessing the environmental impacts, the methodological framework sets a number of environmental impact indicators and energy flow indicators. The used impact indicators and the methods are in accordance with the recommendations set out by the European Commission's Joint Research Centre (European Commission, 2011). The energy flow indicators describe consumption of fossil, nuclear and renewable energy sources throughout a PV system's life cycle. The Cumulative Energy Demand method is applied to quantify consumption of both renewable primary energy (i.e. geothermal hydraulic, solar, wind and biomass) and non-renewable primary energy (i.e. fossil and nuclear) (Frischknecht et al., 2007). Some of the methodological framework's impact categories are obligatory – i.e. users are obliged to calculate impacts for these impact categories, while others are optional – i.e. users can enter them if they choose (Table 2).

Environmental impact / energy flow	Calculation of life cycle impact values in the framework
Climate change	Obligatory
Respiratory inorganics	Obligatory
Resource depletion, water	Obligatory
Primary energy consumption, renewable	Obligatory
Primary energy consumption, non-renewable	Obligatory
Ozone depletion	Optional
Human toxicity, cancer effects	Optional
Human toxicity, non-cancer effects	Optional
Ionizing radiation, human health	Optional
Ionising radiation, ecosystems	Optional
Photochemical ozone formation	Optional
Acidification	Optional
Eutrophication, terrestrial	Optional
Eutrophication, freshwater	Optional
Eutrophication, marine	Optional
Ecotoxicity, freshwater	Optional
Land use	Optional
Resource depletion, mineral, fossil and renewable	Optional

Table 2. Environmental impact indicators and energy flows indicators

Calculating the environmental impacts of PV systems
LCAs studies are time demanding and can make heavy demand on the resources on LCA practitioners, mainly on the Life Cycle Inventory (LCI) phase. The quality of a LCI directly influences the overall quality of an LCA (Mongelli et al., 2005). To ease such demanding step, the methodological framework provides three steps to calculate the PV system's impact factors.

Step 1 – Identification of the product category: The user of the methodological framework identifies the product category.

Step 2 – Calculation of the impact factors per process: For each product category considered, the user calculates the impact factor for each PV system process. Default values are provided in the methodological framework. Some of the default values proposed to users of this methodological framework are intentionally conservative. This choice of conservative values is devised to encourage manufacturers of photovoltaic system components to substitute these conservative values with their own value to better match the actual environmental conditions of the PV system's components. The impact factors proposed in the methodological framework are either conservative (marked *FI*) or not conservative (marked *fi*). This distinction was established when the methodological framework was drawn up and is based on identifying the significant or insignificant proportion that each of these processes contributes to the entire PV system's environmental impact. Processes that strongly influence the LCA are characterized by *FI*, while processes that have a relatively low influence on the results are characterized by *fi*. This distinction has been derived from feedback on environmental analyses of PV systems.

Step 3 – Calculation of the PV system's impact factors: Depending on the decomposition of the PV system, the impacts of each process are calculated to obtain the impacts corresponding to each PV sub-system. The PV system's impacts are finally obtained by adding the impacts of each PV sub-system.

RESULTS AND CONCLUSIONS

This guide is available since early 2013. The methodological framework should be used for environmental assessments when making public policy decisions regarding the implementation of photovoltaic systems. This methodological framework was developed after consulting a working group representing professionals from the French PV industry (i.e. industrials, professional trade unions, engineering consultancy firms, project developers, PV system designers and operators, ministerial representatives, research and certification bodies).

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REFERENCES

European Commission – Joint Research Center – Institute of Environment and Sustainability. (2010). *International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment – Detailed guidance* (1st ed.). Luxembourg: Publications Office of the European Union. doi: 10.2788/94987

European Commission – Joint Research Center – Institute of Environment and Sustainability. (2011). *International Reference Life Cycle Data System (ILCD) Handbook - Recommendations for life cycle impact assessment in the european context - based on existing environmental impact assessment models and factors* (1st ed.). Luxembourg: Publications Office of the European Union, Luxembourg. doi: 10.278/33030

Frischknecht, R., Althaus, H. J., Dones, R., Hischier, R., Jungbluth, N., Nemecek, T., ... & Wernet, G. (2007, December). Renewable Energy Assessment within the Cumulative Energy Demand Concept: Challenges and Solutions. In *proceedings from: SETAC Europe 14th LCA case study symposium: Energy in LCA-LCA of Energy* (pp. 3-4).

International Organization for Standardization (ISO). (2006). *Environmental Management – Life Cycle Assessment – Principles and framework* (2nd ed.), Geneva.

Mongelli, I., Suh, S., & Huppes, G. (2005). A Structure Comparison of two Approaches to LCA Inventory Data, Based on the MIET and ETH Databases (10 pp). *The International Journal of Life Cycle Assessment*, *10*(5), 317-324. doi: 10.1065/lca2004.12.198

Payet, J ., Evon, B., Sie, M., Blanc, I., Beloin Saint-Pierre, D., Guermont, C., Adra, N., Raison, E., Puech, C., & Durand, Y. (2013). Référentiel d'évaluation des impacts environnementaux des systèmes photovoltaïques par la méthode d'Analyse du Cycle de Vie. Retrieved from http://www.ademe.fr/