True sustainability in the PV industry: The case for carbon footprint certification

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ABSTRACT

How much carbon is emitted in producing a solar PV module and launching it on the market? This could be an important question which project developers, installers, investors, government agencies and end customers might ask solar PV manufacturers in the future. To answer it, producers need to know the direct emissions from the manufacturing process, as well as those generated from the activities of manufacturers in the upstream supply chain (including raw material acquisition, upstream energy use, packaging, transportation and procurement), and also those arising from module usage and eventual recycling. This paper, written in a cooperation between EuPD Research and Deutsches CleanTech Institut (DCTI), presents an overview of PV's carbon footprint.

Background

PV is seen by the general public as an environmentally friendly source of energy, but little attention is paid to the PV production process and its impact on the environment. Proactively pursuing environmentally sound production practices and communicating this to environmentally aware customers provides an opportunity for manufacturers to differentiate their products from those of their competitors. However, in the future it may not only be a differentiation strategy but also a cost-reducing measure: as carbon regulations are implemented across the globe, the work on improving the carbon footprint can often lead to a reduction in process costs.

This section presents a discussion of the tools available for calculating and validating the carbon footprint of a product and an analysis of the current status, in general, of the carbon footprint of PV technologies. Furthermore, these results are placed in the context of fossil fuels and competing renewable energy sources. The question of what the current demand from end customers is for carbon footprint practices is also looked at, and how upcoming legal frameworks could change this demand.

Carbon footprint: differentiator, cost reduction driver or both?

By the end of 2012 the PV market will cease to be bottlenecked; offering a competitive, cost-effective and high-performance product will therefore be even more important in the future. Focusing on product competitiveness alone will no longer be a sufficient strategy, and product differentiation will become a higher priority for manufacturers than at present. Product technologies can help to differentiate in terms of conversion efficiency or real-life performance, but within a technology, these differences are considered to be marginal. For example, there are currently 16 manufacturers of µc-Si modules, but no manufacturer's flagship panel offers a substantial technological advantage over any other.

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In 2010 the buying decisions of customers did not depend on technical matters; instead, price level and product availability were the most important factors influencing purchasing decisions. As of 2012, however, marketing and

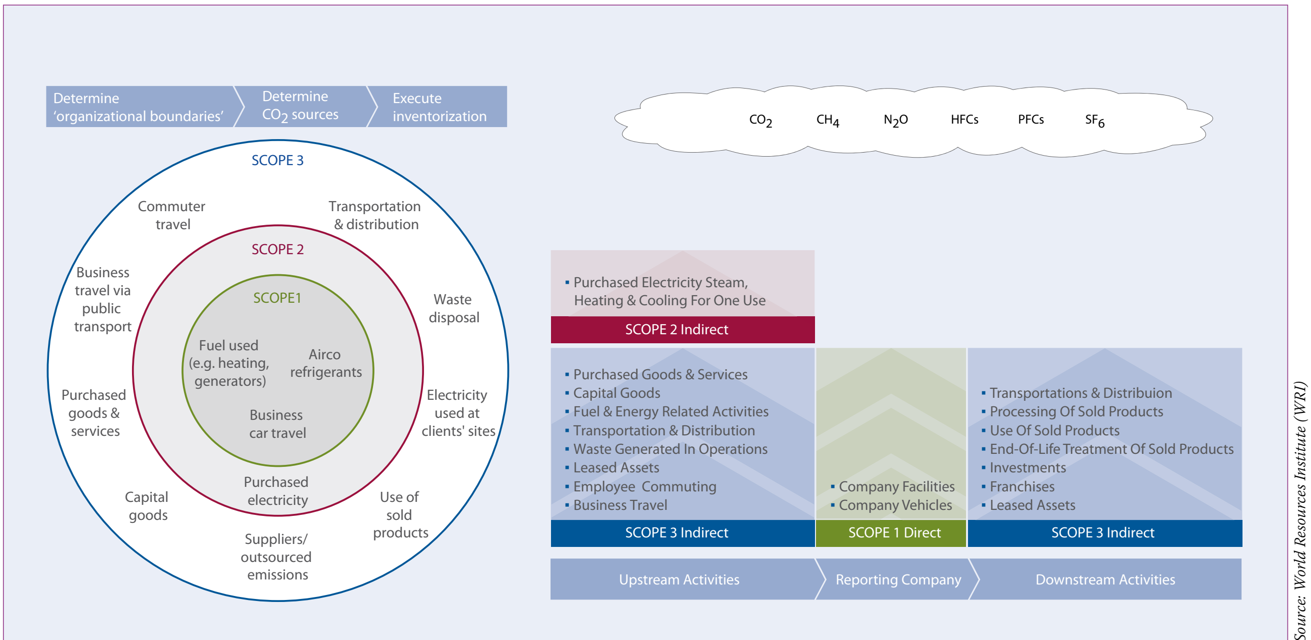

Figure 1. The Greenhouse Gas Protocol Initiative.

sales will gain in importance in order to communicate a manufacturer's distinct product differentiation. This is where carbon footprinting holds the promise of becoming a competitive advantage that can be communicated easily to customers.

Carbon footprinting could become a marketing tool that creates a unique selling point (USP) and helps to build up a premium brand, as well as being proactive in relation to upcoming legislation on this topic. This agrees with findings in the current study by EuPD Research [1]. Project developers and installers state that the carbon footprint is a decisive buying argument (under conditions of similar price and technology offers).

PV received much support and public attention initially because it promised to be a sustainable energy source with low carbon emissions. That is why customers bought it before competitive ROI periods and will do so again in the future. Currently, customers perceive that manufacturers are not active in reducing carbon emissions, but providing more information on carbon footprints of modules could help to educate the customer. Those manufacturers who fail to act in this way will be missing an opportunity, as there exists a huge potential for differentiating between products. Communicating and certifying the carbon footprint of modules could lead to direct benefits for the manufacturers. These benefits may represent an improvement of competitive position through a USP that leads to increased sales (as suggested by this market research) and premium brand building, allows for premium pricing, quality improvement and energy cost reductions, and contributes to the corporate image, to name just a few of the advantages.

The competitive advantage of a low carbon footprint is highlighted in the following example. The direct on-site electricity requirement for manufacturing a μc-Si laminate is estimated to be 44kWh/m^2; the grid emission factor for producing a laminate is 0.54t/MWh for Germany and 0.89t/MWh for China. Using this information, and all other factors being equal, the CO_2 emissions for a 1.4m^2 laminate produced in Germany would be 22kg lower than for a laminate produced in China – a significant difference. Customers thinking more about the environment than about a return on investment (ROI) will then obviously lean towards purchasing the German product. As shown by the recent results of an end-customer market analysis, this shift in customer thinking is now taking place.

Methodologies, tools and global standards

In recent years, thinking about the impact of a product on the environment throughout its entire lifetime has become a key focus in environmental policymaking. A wide variety of tools and standards for evaluating such impacts have been developed: the worldwide leading standards adhere to the ISO Life Cycle Assessment standards 14040 and 14044, as well as following the leading Greenhouse Gas Protocol Initiative of the World Resources Institute for calculating a company footprint.

ISO defines life cycle assessment (LCA) as a 'compilation and evaluation of the inputs and outputs and the potential environmental impacts of a product system throughout its life cycle.' In general, an LCA consists of the following four steps:

1. Goal and scope definition: defining where the boundary of a product's impact lies.
2. Inventory analysis: accounting for all energy, materials and other inputs required in a process.
3. Impact assessment: calculating direct emissions and environmental impact.
4. Interpretation: analyzing results to deduce solutions for reduction of environmental impact.

One type of LCA is carbon footprinting, in which the analysis is limited to greenhouse gas (GHG) emissions that have an effect on climate change. A product carbon footprint (PCF) can therefore be defined as the GHG emissions produced throughout the entire life cycle of a product in a defined application and expressed using a specific functional unit. In relation to PV, emissions are measured in units of CO_2 equivalent (CO_2-eq) and expressed on a per kWh basis using an estimation of the kWh to be produced for the lifetime of a PV module. This type of assessment is used to:

- investigate sustainability of different PV technologies;
- make fair comparisons between energy technologies;
- identify areas for improvement in PV production processes.

The main challenge for PCF methodologies, in general, is to achieve the right balance between practicality and environmental integrity/credibility, and PV is no exception to this.

In non-scientific terms, the evaluation of the carbon footprint can be described as the difference between the CO_2 emissions

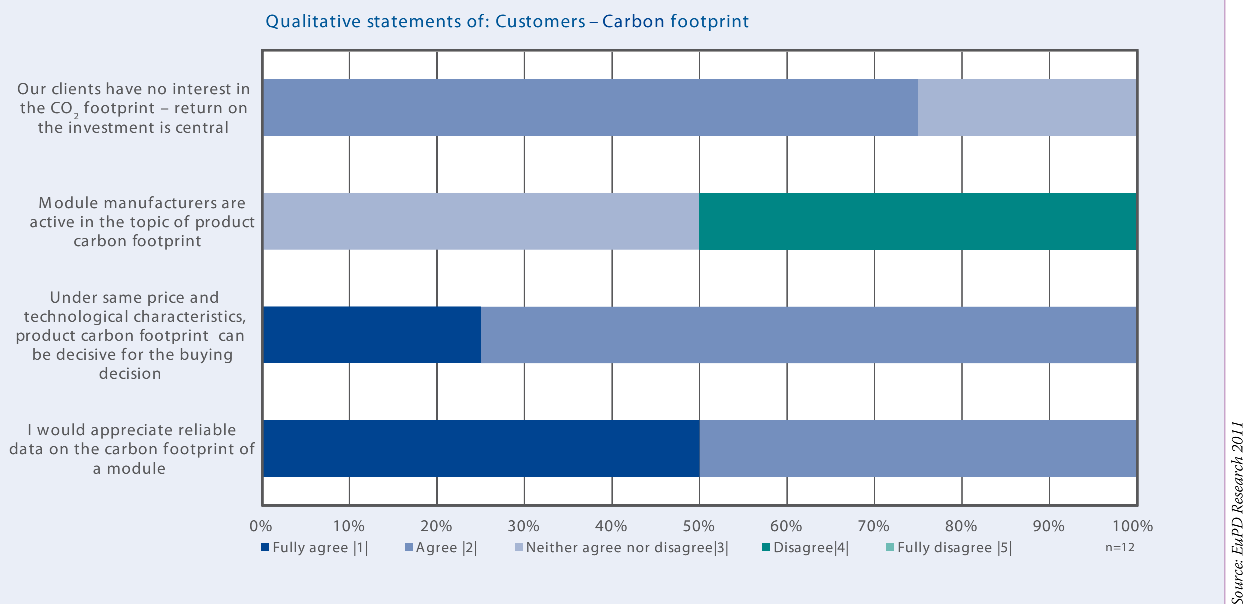

Figure 2. Market research into the attitudes of PV module customers towards carbon footprint certification.

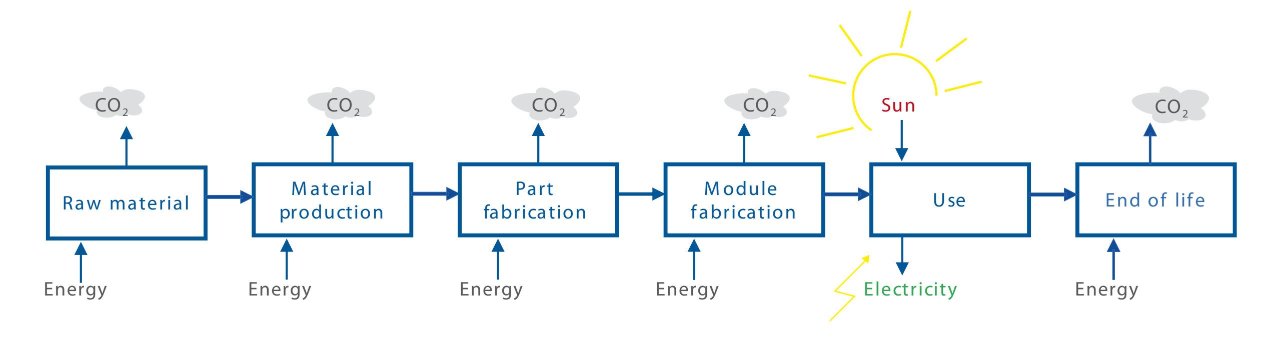

Figure 3. Flow chart of an emissions analysis of a PV module life cycle.

caused by production, transportation, operation and disposal of a product and the CO_2 emissions saved by its operation.

An LCA carbon footprint is the CO_2 emission balance sheet of a product. Within a PV-specific context, the question arises as to how this 'product' can be defined. From a module manufacturer's point of view the 'product' is the module. The 'main task' of a module manufacturer is assessing the CO_2 emissions caused by module production. A proper choice of units for such an assessment could be CO_2-eq per Wp or per m^2. However, a module does not save any CO_2-eq if it is not installed in a PV system. Therefore, when assessing the CO_2-eq emissions of PV, it is necessary to think in terms of systems. Accordingly, emissions caused by the production, transportation, operation and disposal of all components must be considered. In this case, the usual unit for reporting the impact on global warming is CO_2-eq per kWh. When considering the entire system, it is also possible to calculate the energy payback time – another key indicator.

How to reduce the carbon footprint

Determining a company's CO_2 footprint is a first step towards a carbon management system that reduces its footprint by implementing CO_2 (and cost) reduction measures, and by monitoring, reporting and communicating CO_2 performance. The business objectives of a manufacturer can be the following:

- to quantify the total carbon impact of the company and its products (CO_2 footprint verification);
- to identify the low-hanging fruits along with the major opportunities for reducing a carbon footprint (interestingly this can generally be done with a positive ROI);
- to monitor scope 1, 2 and 3 emissions and report them to, for instance, the Carbon Disclosure Project and other international standards;
- to build a brand and increase competitiveness by certifying the full life cycle CO_2 footprint of a PV module in order to create an additional USP.

This life cycle PV module CO_2 footprint is a standardized (ISO 14025/TR) third-party product certificate that allows customers to compare the full module CO_2 footprint (from cradle to grave). It shows the direct emissions from produced modules (scopes 1 and 2), and indirect CO_2 emissions (scope 3) from life cycle stages such as raw material acquisition, upstream energy use, packaging, transportation, product use, and recycling. Offering PV modules that hold a trustworthy certificate will encourage customers to buy modules whose production is environmentally sound.

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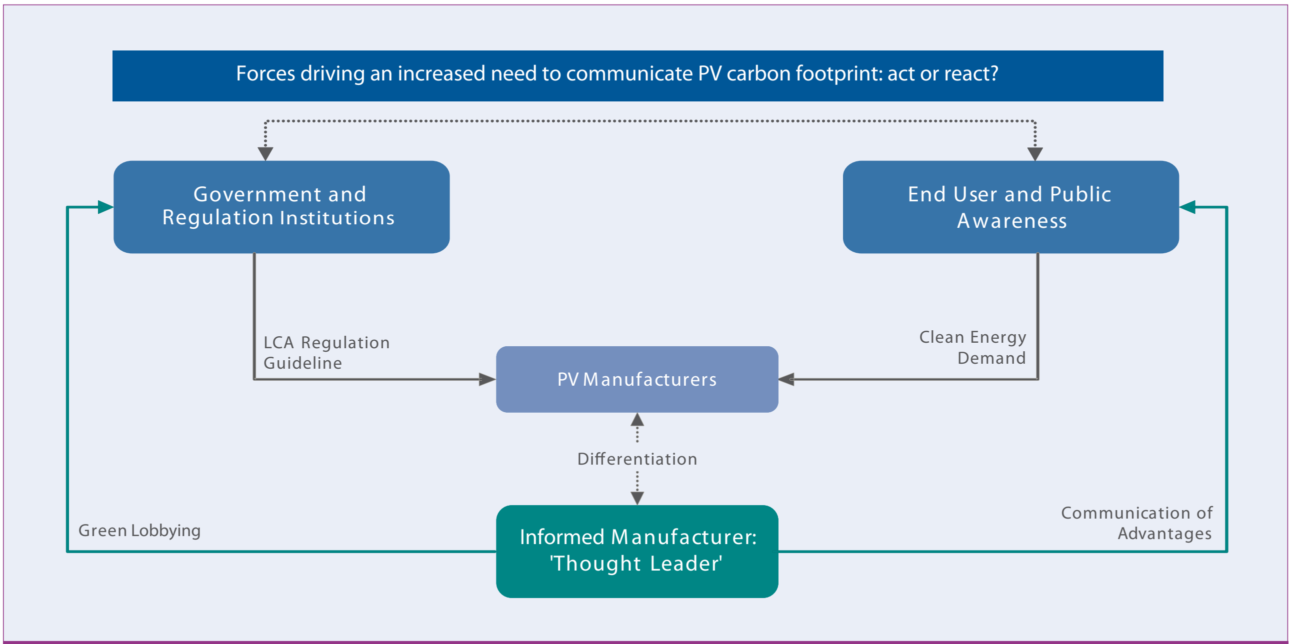
Status quo – where does PV stand today?

LCA calculations for PV technologies have been conducted within the industry for more than 15 years, whereas energy payback times of modules have been subject to scrutiny as far back as 1975. At that time, payback was projected to be around 20 years, but today it ranges from 1 to 2 years. In 2005 there was still a lack of updated data on life cycle inventory for PV. Some data for crystalline technologies was 15 years out of date, whereas thin-film data was around 5 to 10 years old. These facts contributed to the popular and rather unfavourable environmental assessments and comparisons of PV technology. This situation is, however, improving rapidly as LCA is becoming increasingly important in the PV industry.

EuPD Research, together with Deutsches CleanTech Institut (DCTI), has observed a significant variation in CO_2 footprints: from 20 to 220g CO_2-eq per produced kWh of solar electricity. Biomass and wind technologies have been reported as yielding life cycle greenhouse gas emissions of 45g and 11g CO_2-eq per kWh electricity, respectively. Of course these results compare favourably against fossil-based options, for which best practices are rated at 400g CO_2/kWh levels (e.g., gas-fired combined-cycle power plants) [2]. Modules based on a-Si show an exceptionally high variation, which results from the difference between the production of a-Si and μ-Si technologies and the manufacturers' usage of strong GHGs in the production process (e.g. the GHGs SF_6 and NF_3 are approximately 20,000 times stronger than CO_2). Only a handful of companies are active in this field, using varying standards. In evaluating the current landscape, it appears that out of all manufacturers, First Solar places the most emphasis on this topic; however, other manufacturers are catching up.

Outlook – the influence of regulations on PV's carbon footprint

Systems based on green certificates or emissions trading are often mentioned as alternatives to FiTs, and both these systems would be directly relevant to the topic of CO_2 reduction. Revenues for power producers under these schemes would depend directly on the amount of CO_2 emission savings achieved. But FiT programmes can also be said to be associated with the topic, as the implementation of renewable energy laws has been driven by environmental issues as well. High internal rates of return (IRRs) might have obscured this link in recent years, but it nevertheless still exists. The discussion about advantages, disadvantages and interdependencies among the different support schemes is ongoing and will continue intensively in the future. While a comprehensive review of this discussion goes beyond the scope of this article, it is crucial to stress the point that there is an inherent interdependence between the public support of renewable



Source: EuPD Research 2011

Figure 4. Drivers for communicating a PV module carbon footprint.

energies and LCA. Some of these interactions can be seen in Fig. 4.

Carbon footprint certification – from a 'nice to have' to a 'must have'

Gradually, the argument is prevailing that grid parity will at best reduce, but not fully eradicate, dependency on political support. This dependency will not be solved until PV is competitive in relation to generation costs. Thus, from a medium-term perspective, PV market development will remain dependent on support mechanisms. Consequently, the positive environmental impact of PV is the main argument for further political financial support. From a politician's point of view, it seems reasonable to require some evidence regarding the LCA of a subsidized product that is supposed to achieve some environmental benefits.

Meanwhile, there is the urgency of differentiating products and offerings, since the industry dynamics will no longer accept a 'stuck in the middle' or 'me too' approach. Now is therefore the time for PV manufacturers to make use of the concept of LCAs to their own advantage. Those who do so can use the opportunity to position themselves as 'thought leaders' and gain considerable market power through the communication of advantages and differentiation that a low carbon footprint provides.

References

[1] Otto, V. et al. 2011, "PV Thin Film Guidebook 2011", EuPD Research report.

[2] de Wild-Scholten, M.J., Alsema, E.A. and Fthenakis, V.M. 2006, "Environmental impact of PV electricity generation – a critical comparison of energy supply options", *Proc. 21st EU PVSEC*, Dresden, Germany.

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