The Impact of Product Carbon Footprint Calculation Methodologies on Carbon Footprint Values

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Abstract

As consumer awareness of product carbon footprints increases, AUO has developed a precise carbon footprint calculation methodology based on ISO 14067:2018. A comparison of AUO's High-Precision Methodology (APM) with commonly used calculation tools revealed discrepancies in the data. Utilizing actual production data is essential for accurately reflecting carbon footprints and identifying effective reduction strategies.

Author Keywords

Product carbon footprint, High-Precision Methodology

1. Introduction

The scope and guidelines for calculating product carbon footprints have evolved from the early PAS 2050 to today's ISO 14067:2018 standards, gradually becoming widely used in this calculation scope. In recent years, with the continuous impact of climate change, various countries has set clear net zero pathways.

However, the calculation capabilities of the supply chain were uneven in the past, particularly with the high difficulty in data traceability, most leading brands currently rely on popular estimation methods available in the market, such as PAIA or SimaPro LCA software, to calculate the carbon footprint of panels. Additionally, within the framework of ISO 14067:2018 calculation method guidelines, based on the PCR (Product Category Rule) document scope of the panel industry, there are still many differences in calculation methods, such as the adoption of allocation principles based on actual measurements or value distribution. This leads to noticeable discrepancies in calculation accuracy across various methodologies.

Therefore, this article will explore the impact of carbon footprint values under different calculation rules and analyze product carbon footprint hotspots using APM.

2. Commonly used calculation methods in the market

It is common to see carbon footprint information disclosed on the websites of major brands. However, upon closer examination, constraints in supply chain capabilities and the logic of simplification may lead these brands to use more available calculation tools like PAIA or SimaPro to estimate the carbon footprint of panels. Based on current assessment tools, only some simple information such as size, resolution, product weight, and production region are necessary to calculate the product carbon footprint of panels. This calculation concept involves a lookup table and multiplier calculation logic, using specific coefficients or data estimation methods, which may not show the actual production conditions of panel manufacturers.

Using the example of direct carbon emissions from the manufacturing process (Scope 1), AUO's continuously developed GHG destruction device as local scrubber can achieve over 99% GHG elimination without causing GHG dispersal (reference [1]). Such differences in GHG emissions between manufacturing facilities with this designed system and those without it are significant. Therefore, using simple estimation methods currently available on the market cannot accurately reflect these differences, let alone drive manufacturers to voluntarily reduce carbon emissions, which is not good effect we expect.

Through this, we propose APM and scope for calculating complete carbon footprints, encouraging industry peers and supply chains to evaluate the effectiveness of carbon reduction efforts in this spirit, and we also provide the differences between various methodologies. Although high-precision calculations require a relative cost investment, the actual implementation of carbon reduction efforts can be shown in the performance of product carbon footprints, making the product more carbon competitive.

3. Comparison results between APM and commonly used methods for carbon footprint of panel module products

There is an increasing request for carbon footprint calculation, based on ISO 14067:2018 and supported by the rules of the PCR document under ISO 14025:2006 (reference [2]), which broadly delineates the items to be calculated. However, upon detailed examination of the content, many ambiguous areas can still be found. According to years of accumulated experience and knowledge in carbon calculating, AUO has established the calculation content for 14 items as shown in Table 1.

Table 1. AUO presents the internal carbon footprint calculation items and calculation logic, where (*) denotes key carbon calculation items that require calculation based on actual activity data.

Calculation stage	Item	Calculation logic
Material Stage	Upstream transportation	Obtained through documents
	Material (with water) (*)	Obtained through manufacturing work orders
	Consumables	Reasonable allocation
	Interplant Material Transportation	Reasonable allocation
Production Stage	Power consumption for manufacturing (*)	Obtained based on measurements from manufacturing equipment, with other shared power allocated through a reasonable methodology
	Other emissions sources from the manufacturing	Reasonable allocation
	Interplant Transportation	Calculated based on product characteristics
	Waste generated from manufacturing	Reasonable allocation
	Outsourced manufacturing	Calculated based on product characteristics
Distribution Stage	Customer transportation	Calculated based on product characteristics
	Customer transportation of materials	Reasonable allocation
Use Stage	Product power consumption (*)	Calculated based on product characteristics
End-of-Life Stage	Disposal and transportation of finished products	Assumption scenario, and calculated based on product characteristics (such as weight).
	Disposal of finished products	

Based on these 14 items, we aim for data refinement as the calculation goal. The data processing method requires obtaining actual activity data for key items, while calculations for items with uniform disposal are done through a reasonable allocation method. With these calculation rules, we can effectively implement organizational carbon management and product carbon management into the product carbon footprint, as shown in Figure 1.

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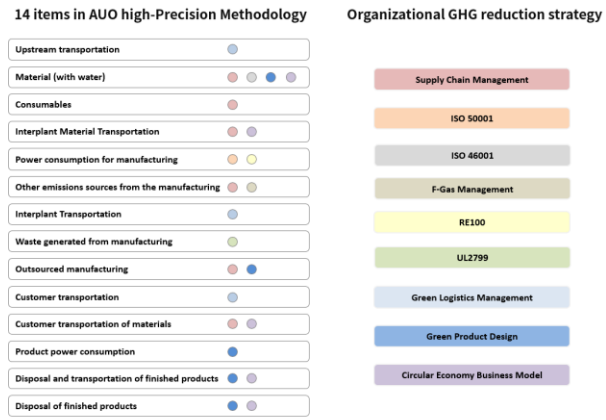

Figure 1. Relationship between organizational and product alignment with APM items.

Through APM, we can accurately calculate the product carbon footprint. Taking two 16-inch products from AUO as examples, these two products are a Simple Process Product Model (M1) and a Complex Process Product Model (M2). By comparing the calculation tools of PAIA, SimaPro's LCD factors (Reference [3]), and APM, the calculations using the PAIA and SimaPro tools do not reflect the differences between the two models while APM could clearly show the impact by the difference of the process complexity. There are significant discrepancies in the data between different methodologies, as shown in Figure 2.

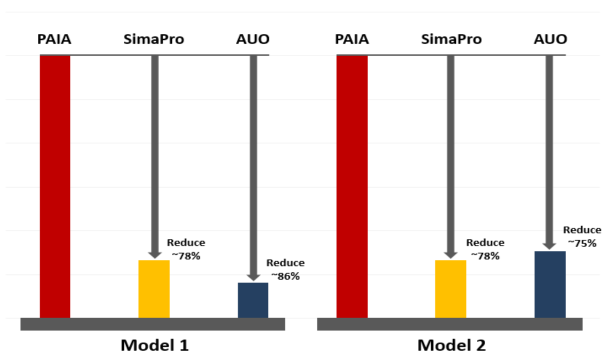

Figure 2. Discrepancies in the carbon footprint (cradle to gate) of two 16-inch panels, with red indicating the results of PAIA calculations, yellow indicating the results of SimaPro's LCD factors calculations, and blue indicating the results of APM calculations

For the selected characteristics of the two products, we believe that the carbon emissions generated by the manufacturing process of M1 will be significantly lower based on AUO's experience than M2. Therefore, we infer that the carbon footprint (cradle to gate) of M1 should be smaller than the carbon footprint of M2 with reasonable assumptions. However, the difference between the calculations of the PAIA tool and our results are noticeable, and they fail to effectively response the impact of different processes. Additionally, the results from the SimaPro's LCD factors calculations cannot effectively reflect the impact of actual production conditions as they are based solely on weight and carbon emission coefficients. Under APM and calculation scope, the impact of different process conditions can be effectively identified, showing significantly higher carbon emissions for complex process products compared to simple process products.

Therefore, we can see that the calculation methodology will yield significant differences. Through APM and calculation scope, we can incorporate actual activity data into the calculation process, effectively recognize carbon hotspots and improvements, as well as the impacts of various carbon reduction measures on the product.

4. Product carbon footprint hotspot analysis based on APM calculations

AUO has rich and professional panel production experience, including LCD and OLED technologies for commercial products. Since APM calculations are based on actual measured values, even in the same manufacturing Fab, we can still differentiate between various products through data collection. In notebook product, as shown in Figure 3, through APM calculations, whether using LCD or OLED technology, we can find that materials used (including raw materials in processes and finished goods), electrical power used in manufacturing, and electrical power used in use phase account for over 98% under the limited conditions of internal analysis. Therefore, in technical analysis, these three phases will be adopted as the basis for evaluation.

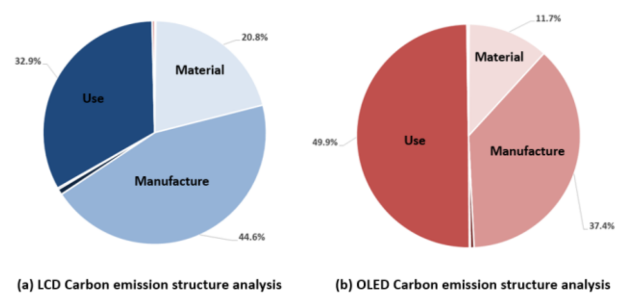

Figure 3. Based on the production experience of AUO's G6 Fab, the carbon emission structure of 16-inch (a) LCD and (b) OLED panels can be analyzed. It is found that more than 98% of the carbon emissions can be attributed to three key calculation items.

In this case, we can observe some unique characteristics in the category of notebook products, which demand slimness and low power consumption. The impact of slim design results in that the material used in the LCD module is not the primary hotspot in overall carbon emissions, as lightweight materials are used in metals and optical films, despite the existence of backlight modules. As notebooks are often used in non-plugged scenarios, low product power consumption is also a specific requirement. However, under such conditions, the low power panel technologies result in high carbon emissions impacts in manufacturing. Additionally, we will also conduct an analysis of OLED in these three aspects. The characteristics of OLED panels is that they do not require an additional backlight module, leading to significantly smaller material usage compared to the other two hotspots. However, the manufacturing process of OLED technologies is more complex than LCD, and the product's power consumption performance tends to be relatively high. It can be observed that their hotspots will be in manufacturing electricity usage and operational power consumption categories. We focus on the research findings related to internal production experiences, we also see that under similar display conditions, the carbon emissions of LCD panel is around 35% lower than OLED panel. Above analysis shows that products will result in various carbon footprint based on different designs, and from our experience, we typically find that the carbon emissions of LCD may be approximately 20-40% lower than OLED.

The carbon footprint structures of different products should indicate different carbon reduction methods. Through carbon emission analysis, we can also observe the differences in carbon emission hotspots between these two technologies, as shown in Figure 4. Introducing renewable energy into the manufacturing processes of both technologies to reduce carbon emissions is essential. In LCD technology, the focus should be on reducing carbon emissions at the material stage, particularly due to the increased carbon emissions associated with the use of backlight modules. In addition to integrating more recycled materials, LCD technology's high modularity allows for material refurbishment and reuse, contributing to a significant reduction in carbon emissions from material usage through circular economy practices. Conversely, OLED technology should prioritize the development of energy-efficient technologies to further decrease its environmental impact.

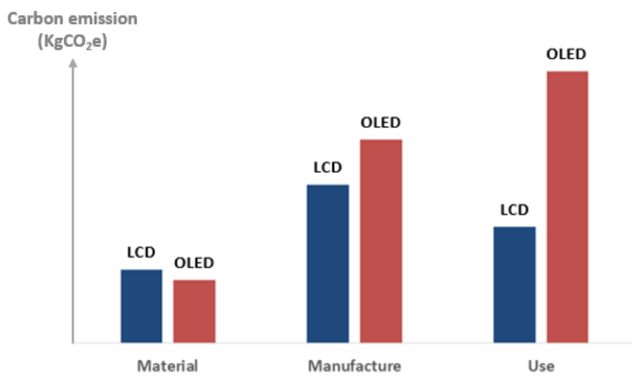

Figure 4. The carbon emission structure differences between LCD and OLED technologies can be observed.

5. Conclusion

In recent years, both international advocacy and certification initiatives have emphasized product carbon footprint and supply chain management. If brand owners do not have a high level of data readiness for their supply chains, or if the supply chain's calculation capabilities cannot be enhanced, it can lead to significant distortions in carbon footprint data and potentially result in misjudgments in planning the reduction path of their product's carbon footprint. In addition to methodological research, AUO has incorporated APM logic into the carbon management system. This allows various carbon reduction pathways for organizations and products to be effectively reflected in the product's carbon footprint, enabling customers to have precise insights. Therefore, integrating high-precision calculation methodology into management systems is a necessary and vital step for manufacturers today.

6. References

1. In AUO's 2023 ISO 14064-1 certificate, it mentions "Reduced Fluorinated GHG emissions / Fluorinated GHG emissions if without abatement system= 99.46%"
2. The PCR document approved by the Environmental Protection Administration of the Taiwan, titled "Liquid Crystal Display", with document number 20-059, is valid until February 7, 2026.
3. The information on the coefficient name "Liquid crystal display" accessed from SimaPro, ecoinvent database.