ACCURATELY MEASURING THE SUSTAINABILITY OF BUILDING PRODUCTS

Understanding Embodied Carbon, EPDs, and Cradle-to-Gate vs. Cradle-to-Grave

What is Embodied Carbon?

Although not readily evident from the terminology, embodied carbon refers to the total amount of carbon dioxide (CO_2) emissions released during a portion of the life cycle of tangible goods. It encompasses the CO_2 created from gathering raw materials, transporting them to the site of manufacture, as well as the manufacturing process itself. CO_2 is generated in all manufacturing processes including all roofing materials like PVC membranes, for example.

However, the energy used by a building after it is constructed also contributes to carbon emissions. This is called operational carbon. Taking into account both embodied carbon and operational carbon is the most accurate way to get a full picture of a building product's complete carbon footprint.

Embodied Carbon

Most Environmental Product Declarations Don't Factor in Operational Carbon

To manage carbon, most building and construction experts make decisions based on disclosures made through life cycle assessments and related ISO Type III Ecolabels, like environmental product declarations (EPDs). These documents use international standards (ISO 14040 and ISO 14044) developed by ISO Technical Committee 207 on Environmental Management. Life cycle assessments collect environmental information throughout a product's life cycle – from raw material extraction through product final use. Because these documents are often lengthy, they usually include a summary page of the results. EPDs are one such standardized summary of a life cycle assessment.

Operational Carbon

EPDs are created within boundaries described in a product category rule (PCR) as defined by ASTM International. The PCR for single ply roofing membranes, which includes PVC, permits the use of either information from extraction, transport to factory, and manufacture, called a declared unit ("cradle-to-gate") or all of that plus service life and recyclability, called a functional unit ("cradle-to-grave").

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Since there is no requirement in the PCR to include the functional unit in their EPDs, many manufacturers elect to use the declared unit, the cradle-to-gate method, to derive content for their EPDs. When there are tools in the marketplace that are only pulling portions of the cradle-to-gate modules, it is important for users to understand the limitations on comparability when important product attributes, such as durability and recyclability, are not being considered. The absence of these factors may result in less sustainable product selections. Purchasers should consider this when making purchasing decisions.

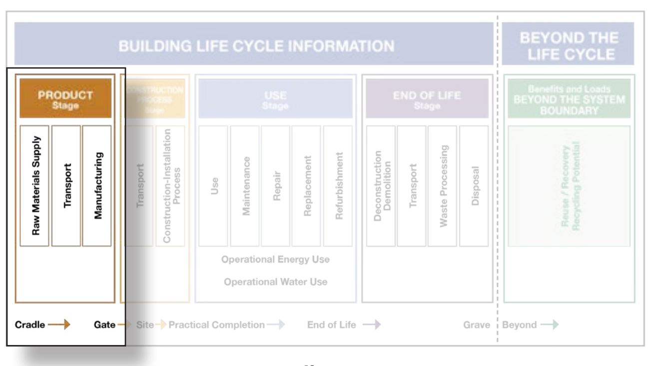
Most, if not all, Product Category Rules (PCRs) for construction materials draw from ISO 21930:2017. For example, the PCR for single ply roofing membranes notes in section 5.5, comparability of EPDs for construction products:

- ***"...It shall be stated in EPDs created using this PCR that only EPDs prepared from cradle-to-grave life-cycle results...can be used to assist purchasers and users in making informed comparisons between products."***
- ***"EPDs based on 'cradle-to-gate' and 'cradle-to-grave' with options' information modules shall not be used for comparisons. EPDs based on a declared unit shall not be used for comparisons."***

Cradle-to-gate values are accurate to a point, but can be misleading and not paint the full picture. Design professionals must exercise due diligence by selecting materials that are suited for the specific requirements of individual buildings and applications.

How Embodied Carbon Calculations Miss the Big Picture

From the perspective of the Chemical Fabrics and Film Association's (CFFA) Vinyl Roofing Division, there are shortcomings with the way carbon data is reported. Since these calculators, to date, have been limited to what are referred to as the A1-A3 impacts (i.e., cradle-to-gate) for a single purchase of a product, they should not be used for direct comparisons of products. What these calculations do not take into account are the longevity of the finished product, and the embodied carbon that would result from multiple installations with an overall building's service life, as well as its contributions to reductions in energy and waste consumption over decades.



Cradle-To-Gate*

This obviously paints an inaccurate picture of the overall CO2 emissions associated with a product like PVC roofing because factors like the "Use" and "End of Life" stages are not being considered. Further CO2 emissions are either reduced or never created when using PVC roofing as a building material, because these roofs dramatically reduce a building's energy consumption.

These results outweigh and offset any CO2 emitted during its creation. In other words, while you have to break a few eggs (emit CO2) to make PVC roofing, once it is installed, no more eggs are broken for the 20- to 30-year life of the roof. Solar rays are reflected, keeping the building cooler, which requires less climate control, which lowers demand on the power grid, which saves energy and reduces CO2 emissions – and so on, for decades. The energy-saving benefits of PVC roofing are well-documented. It's a product that deserves a more accurate method of conveying embodied carbon to end-users.

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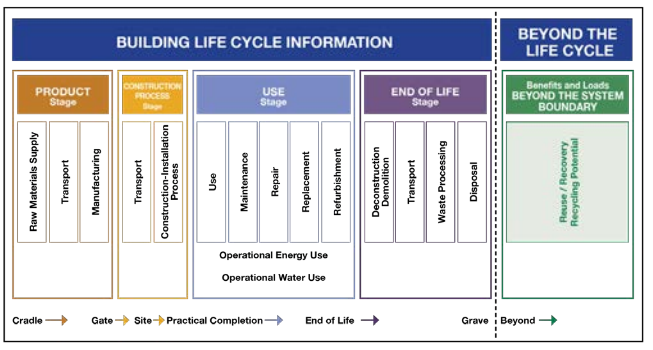

Cradle-To-Grave*

A more accurate way to measure embodied carbon is through "cradle-to-grave" calculations, which take into account the entire product life cycle. These cradle-to-grave calculations factor in the kinds of energy-saving benefits as well as recycled content of the product, and end-of-life material that is recycled once again, reducing landfill deposits. It's a much more complete measurement of a product's environmental impact.

How to Reduce Embodied Carbon in Construction

Reducing carbon in construction focuses on building products that are long-lasting and resilient, can reduce operational carbon, and are made or partially made of recycled content. PVC roofing checks all three boxes.

PVC roofing that has reached the end of its use phase is recyclable and can be repurposed into new roofing material or other vinyl-based products. Post-consumer recycling of PVC roofing began in 1999 in the United States, and the industry continues to make strides in increasing this recycled content in its products. Currently, roughly one million pounds are recycled each year at the end of a PVC roof's useful life. Estimates indicate approximately 45 million pounds of PVC roofing membranes are currently available for recycling, based on historical volumes of installed roofs and average life cycle of the material. The CFFA's goal is to increase the number of PVC roof membrane recovery projects each year, resulting in an increased amount of material being diverted from the landfill.

There's More to Sustainability than Measuring Embodied Carbon

Embodied carbon is merely one attribute to consider in the product evaluation process. For roofing, informed decisions on product specifications should be made in the context of the application. Using a multi-attribute approach and looking at aspects such as performance, durability, and reference service life (RSL) provides a more comprehensive measurement of the sustainability and impact of a product.

The longer a roof lasts, and the more resilient it is in standing up to weather, fire, and other environmental conditions, the longer it stays out of landfills and the less likely it will need to be replaced with new materials. This durability and longevity in PVC roofing materials contribute greatly to its reputation as a green building material choice.

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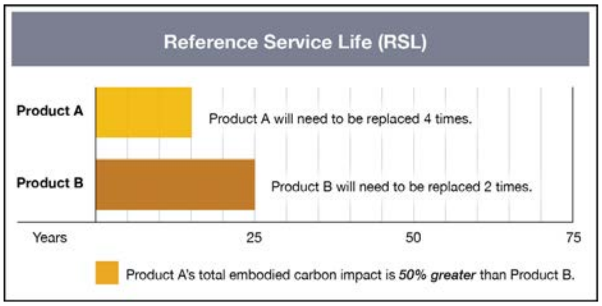
Many building envelope systems will be replaced multiple times throughout the generally accepted baseline RSL of 75 years for long-life buildings. The RSL of such systems and products is often the largest driver of their embodied carbon impact over the life of the building. For example, if Product A has an RSL of 15 years and Product B an RSL of 25 years, the products will be replaced four and two times respectively after the original installation.



Even if Product A's embodied carbon is 10% less than Product B's, during the building's RSL, Product A's total embodied carbon impact will be 50% greater than Product B's – because Product A needs to be replaced more often. Even with a 15% differential, Product A's total impact will be 41% greater than Product B's over the building's RSL.

This example demonstrates why it is vital to consider multiple performance attributes for material selection. Because reliance on a cradle-to-gate scenario for embodied carbon may lead to unintended consequences, considering more than one metric in assessing a material's carbon impact, such as its RSL and/or replacement cycles, provides a truer estimate of the product's impacts over the life of a building.

* *Source: The Institution of Structural Engineers: How to calculate embodied carbon*