USING DATA TO DESIGN FOR SUSTAINABILITY

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Abstract

According to the EU Science Hub, 80% of products' impacts are built during the design phase. 80%! So, what to do? We know that the designers voice is used for everything from branding, aesthetics, strategy, function, packaging— but not often enough with environmental sustainability.

At our organization what we find is that the topic seems to belong to so many others in an organization - Environmental Health and Safety, Operations, Energy Management, Marketing, Legal, Codes and Standards, or Corporate Affairs — but what we see practically is that needed changes are identified too late in the product launch process to make a meaningful difference. With 80% on the table, it's time to take ownership of the conversation.

Practice bringing your voice to the Design for Sustainability (DfS) table through a fun, educational and thought-provoking exercise by which you will learn how to identify what matters, practice best in class DfS with a concrete example that supports hard questions and the creative process. Reflect with your peers on how to best tackle the challenge in your own world where this must be approached as a team sport, with members who today don't understand the need for flat-out collaboration and levelling up to the best results possible. Back at the office, everyone's contribution matters - we'll show you how that works and provide tools to take home.

In the 20-minute interactive conversation, we will show you how data can inform the design process and inspire your functional team to reimagine what's possible.

USING DATA TO DESIGN FOR SUSTAINABILITY

MAKING MEANINGFUL CHANGE

Designing products, processes, and packaging to meet sustainability goals, standards, and requirements, is an exciting challenge and practice to undertake. As designers, we think about 'the thing' we are designing and the context in which it is designed. We think about how the product can be optimized, but also the system in which it is designed within. In other words, how can we design for better outcomes and replicate the process for future products [or packaging or services]. Designing for Sustainability or DfS addresses embedding sustainable design considerations for the product development process with recognition to a greater enterprise strategy to support DfS goals and requirements.

Integration of Design for Sustainability enables companies to embrace meaningful change by means of several key aspects including:

- Confidence: Your company and its stakeholders have a clear understanding of what sustainability means to the company and its most effective levers for better outcomes.
- Prioritization: A boost to the product and process innovation engine using a sustainability lens.
- Knowledge: Increased engagement and pride fueling results the business already values.
- Industry + Brand Recognition: Customers can make your company's more sustainable outcomes their own, driving preference.

Embedding DfS into the usual workflow, processes and checkpoints of complex enterprises can be straightforward when the organization understands the issues and potential opportunities. It is the job of the designer to support that process and insist on the right tools for the job.

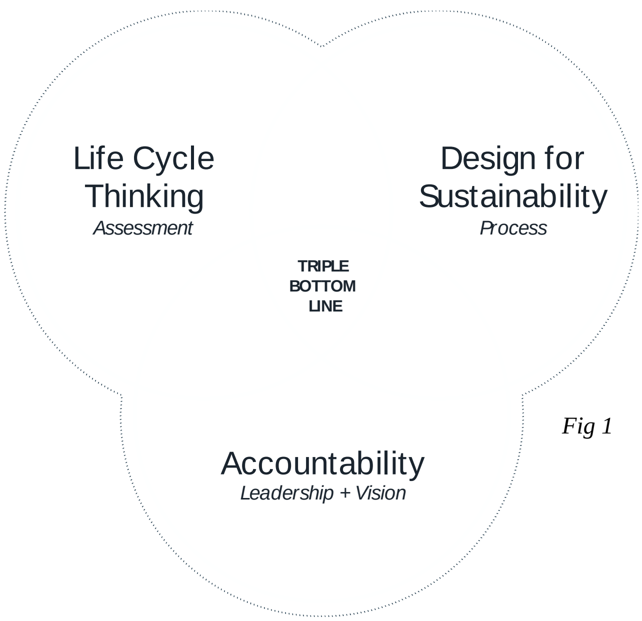


Fig 1

PROCESS, ASSESSMENT, AND ACCOUNTABILITY

Design for Sustainability in combination with Life Cycle Thinking and accountability, overlap to ensure successful business outcomes. DfS provides the process in which to operate, life cycle thinking provides means for assessment based in credible data by measuring impacts, and accountability is established as means to have transparency on metrics, credibility and enable aligned action.

While all three aspects are critical to making change, perhaps the key to unlocking the potential or degree of change is ones' ability to understand the data to inform decision making. Throughout this paper we will introduce fundamental concepts about how to read data to understand where to focus and look at data to understand comparison.

USING LIFE CYCLE DATA TO ASSESS DESIGN

Fig 2

The appropriate metrics for informing business and design decisions through a sustainability lens are provided by Life Cycle Assessment (LCA). LCA is a framework for evaluating environmental impacts of systems, products, and services over the entire life cycle, starting from raw materials acquisition all the way through the end-of-life stage. Life Cycle Assessment allows for many things: substantiation, highlighting opportunities, building internal (and external) credibility, and can be used to track progress and build metrics.

This full life cycle view is crucial to ensure that design decisions which appear to improve the sustainability position of a product at one stage, do not inadvertently cause trade-offs at a different stage which undermine true improvement. For example, it is important to look beyond the impacts generated on-site in a company’s operations and consider upstream operations (suppliers).

When carrying out an LCA study, practitioners first collect data about inputs and emissions produced during the five stages of a product’s life cycle (*see fig 2 above*). During what is called the “impact assessment” phase, this inventory of data is translated into impacts to humans and ecosystems through standardized, science-based calculations. The “carbon footprint” of a product is a well-known example of an LCA impact category. However, many other footprints can be studied, such as depletion of resources, use of available land, eutrophication of fresh and marine water or toxicity to human health. Depending on your respective industry, it may be important to look beyond carbon.

Interpretations generally fall into two categories: an "impact breakdown" tells us which life cycle stages or components contribute most significantly to overall impacts of a single product. The pie chart in figure 3 is one type of impact breakdown, highlighting the biggest drivers of greenhouse gas emissions of our product. In this case, it is the extraction of aluminum ore that causes the greatest release of greenhouse gases. Other notable drivers are the production of ABS granulate and electricity employed to run the product during the use phase.

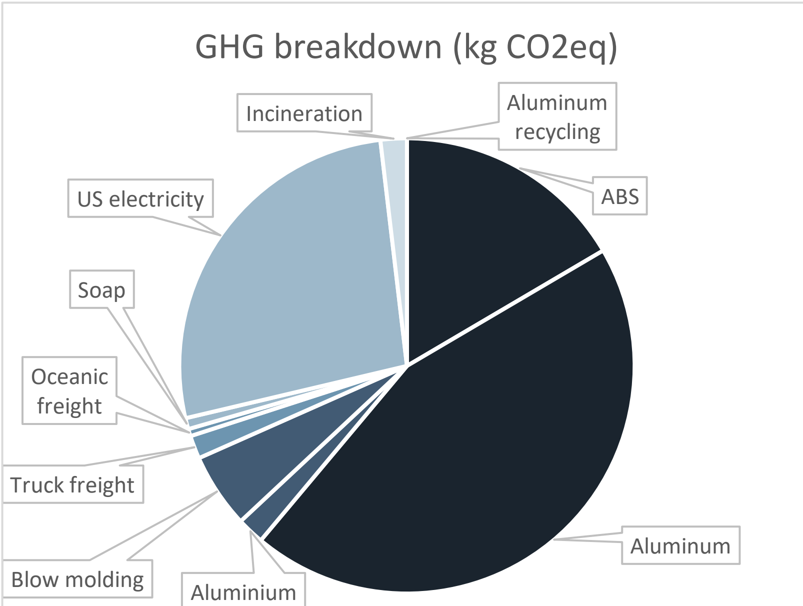
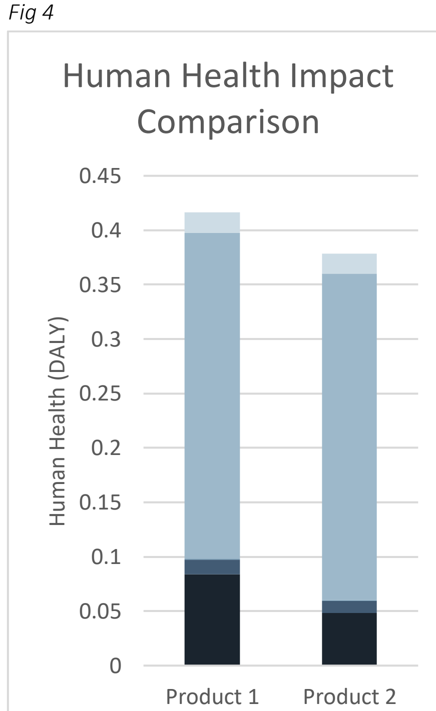


Fig 3

The other major interpretation of LCA data in support of DfS comes in the form of "impact comparisons". In this case, the life cycle impacts of two different products are analyzed head-to-head to understand which product generates a bigger burden on the environment, and why. Impact comparisons require first that a *functional unit* is defined. This is a common measurable unit describing the useful work that the products provide. A functional unit is important for comparing apples-to-apples: if product A can provide twice as much useful work over its lifetime than product B, we must consider the life cycle impacts of two units of product B to those of product A.

Fig 4


The bar charts in Fig compare the impacts of two products providing the same amount of function. In this case, Product 2 shows the same life cycle as Product 1, but with a single material substitution of ABS granulate for HDPE granulate. Since ABS contains Styrene, which is an endocrine disruptor, replacing it with HDPE produces a positive change in human health impacts.

In the following section it will be explained how LCA is leveraged in the DfS process for product development.

A PROCESS TO DESIGN FOR SUSTAINABILITY

Fig 5

The Design for Sustainability Process is centered around a structured, divergent-thinking workshop where domain experts, sustainability professionals and key extended new product development team members collaborate to imagine all the ways the product could be improved environmentally. Before an innovative workshop session can occur, some key activities need to happen first to ensure a successful outcome and efficient use of time.

Design thinking methods are used in conjunction with LCA data to uncover innovation opportunities for better environmental and business outcomes. The general process schematic follows four steps, illustrated in the figure above and further explained in the following section.

1 DEFINE BASELINE

An LCA practitioner will analyze life cycle data to better understand where to start. This first step of DfS is selecting the reference product(s) or solution(s) against which the sustainability position of your new solution will be measured. This is called defining the baseline. Choosing an adequate baseline is critical to the DfS process since we will determine the "success" of the intervention by comparing impacts between the baseline and the new product.

Photo Credit: Harvard Innovation Lab

The baseline answers the question "what would the customer buy if our new product didn't exist?". Different baselines will allow us to track internal improvements over time, compare against a competitor's offering, and to find opportunities for innovation. If there is no market solution offering the same functionality as our new product, the baseline might be made up of multiple products. For example, the image above depicts the evolution of an office desk over the past 40 years. The modern computer has displaced the need for several old technologies. Thus, if we wish to set a 1980s baseline against which to compare the environmental impacts of a state-of-the-art MacBook, we will need to choose a combination of calculators, fax machines, encyclopedias and more.

2 IDENTIFY OPPORTUNITIES

Meaningful sustainability improvements can only be achieved if we address the design decisions causing the greatest impacts on the environment. To uncover these "environmental hotspots", the baseline is studied using life cycle assessment tools. Figure shows the drivers of greenhouse gas emissions throughout the life cycle of a flashlight using a "tree map". The tree map reveals two levels of insight: first it shows that the life cycle stages which most significantly contribute to emissions are the extraction of raw materials and need for inputs during use. We can also dive more deeply into each stage to discover individual components and/or processes which are driving these impacts – in this case, the aluminum casing, LED bulbs, batteries and electricity used for recharging the batteries.

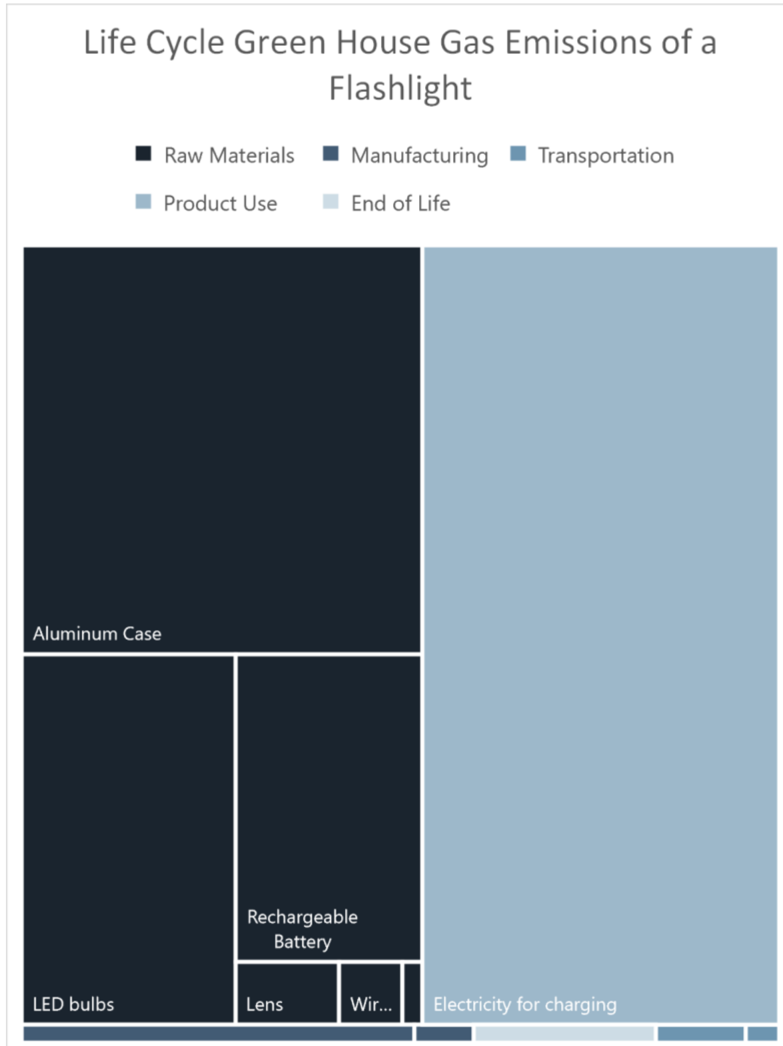


Figure 6

To effectively take advantage of the time set aside, it is important to put together a list of areas or design questions where teams will focus during a DfS Workshop. These questions should address the LCA hotspots, but also take into account business concerns such as regulations, competition, time to market, customer expectations, design brief requirements and constraints. We call these focus areas DfS Opportunities.

DfS Strategies within the Process

The following Design for Sustainability strategies match up to lifecycle thinking. In order to create actionable DfS ideas to be considered for application in product development, it is important to understand the strategies within the process that match the scope of the design process. During ideation the following outlines prompts for consideration of different design aspects of the product [package or system].

Rethink Function:
Investigate innovative ways to provide the benefit.

Supply Chain + Partnerships:
Prioritize fair and sustainable procurement.

Materials:
Choose the least impactful material available being sure to consider the full life cycle.

Operations:
Choose efficient manufacturing processes.

Packaging:
Make responsible material choices for packaging such as reduction of materials.

Transportation + Distribution:
Keep shipping in mind when designing product.

Use:
Optimize energy and water efficiency. Leverage consumer behavior.

Longevity:
Bolster durability and inspire product retention.

End-of-life:
Promote recyclability. Choose materials with low-impact end of life.

3 WORKSHOP INNOVATION SESSION

As previously mentioned, the creative portion of the DfS Process is centered around a structured, divergent-thinking workshop where domain experts, sustainability professionals and key extended NPD team members collaborate to imagine all the ways the product could be improved environmentally within the constraints of the prior Identify Opportunities step.

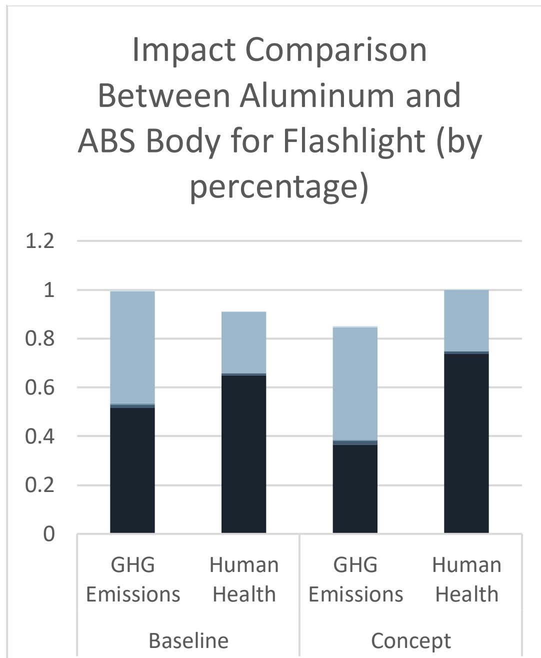
During the workshop, the DfS Opportunities are ideated on using the different Design for Sustainability Strategies to frame the brainstorming. They can range from material substitutions, to studying distribution chains to exploring different options at end-of-life. Together, the workshop attendees generate and discuss possible design improvements which may improve the sustainability profile of the product within market expectations and project scope.

4 ASSESS ALTERNATIVES

The different proposals which are shown to be feasible are then compared using a data-based method that allows teams to understand how they measure up against each other in support of decision making. During the *Assess Alternatives* step the material, manufacturing, efficiency, product lifetime and other differences are assessed using LCA software or LCA-derived tools, to understand how the proposed changes would affect life cycle burdens in different impact categories.

Special attention should be paid to ensure the proposal does not in fact provoke tradeoffs. This means that improvement in one impact category should not come at the expense of a significant increase of other impacts. Figure 6 compares the impacts of a concept design where the aluminum case from the baseline in Figure 7 is replaced with a slightly heavier ABS body. Although the new design favors a reduction in GHG emissions, this comes at a tradeoff in the form of greater impacts to human health.

Figure 7



Avoiding tradeoffs also means that environmental burden should be measured across the entire life cycle: for example, reducing the impacts of raw material selection is undesirable if it requires a manufacturing process which nullifies the improvements.

The ability to leverage data to inform the right design choices is imperative for Design for Sustainability success. Through process, life cycle thinking, and assessment, designers can make informed changes that directly contribute to bigger organization environmental goals. In the case study that follows we take a closer look at the data, and how it can be used.

LOOKING AT THE DATA TO INFORM DESIGN: THE TOOTHBRUSH

In this section we are going to explore LCA data in support of redesigning a toothbrush for sustainability. The focus is on identifying opportunities for reduced impacts and picking appropriate DfS Strategies to address these opportunities.

A Brief Toothbrush History

3500 B.C. - chew sticks found in Egyptian tombs

1498 - fine bristle toothbrush in China; hog hair bristles + bamboo/bone handle

1885 - mass production of toothbrush in US.; boar bristles + wood/ivory handles

1900s – celluloid handles

1938 – synthetic bristles such as nylon

Case study:

Dr. Smith works at a local dental practice. She considers how important it is to educate on proper preventative care measures for her patients, so they have great oral hygiene from the start. She wants to rethink the toothbrush and develop the most sustainable method of achieving "good oral hygiene" for her patients. She decides to enlist several local sustainability professionals to help her find a suitable solution.

Setting up the Study

The sustainability agency set off to explore the life cycle impacts of a toothbrush using life cycle assessment methodology. The first hurdle is identifying the functional unit, or measurable unit describing the useful work provided by the toothbrush. It would be meaningless to simply choose "one toothbrush" as the functional unit, since a given toothbrush may last longer than another one or clean teeth more efficiently. What's more, this choice would silo DfS ideation into toothbrush modifications, when a novel solution may also provide the same tooth-cleaning function. The sustainability agency settled on the following functional unit for studying and comparing the impacts of different solutions:

[one mouth properly serviced for oral hygiene over one year]

This means we will measure the life cycle impacts on the environment of using a toothbrush to keep one person's mouth clean for a year. If we suppose that toothbrush A lasts 1 year, then we will consider the impacts of raw material extraction, manufacturing, transporting, and disposing of a single toothbrush. For toothbrush B, which lasts only 6 months, we need two toothbrushes to carry out the functional unit. We will then double the materials, manufacturing, transport, and disposal impacts of a single unit of toothbrush B when calculating its lifecycle for comparison. Since the use phase is not affected by durability concerns, we can safely ignore that part when exploring the differences between toothbrush A and B.

Toothbrush Life Cycle Reference Data

As the baseline for toothbrush redesign, the sustainability agency selected a top-selling model of a leading brand. The chosen toothbrush has the following characteristics:

- 15 g polypropylene handle – injection molded
- 3 g nylon bristles
- 1 g rubber tip (for cleaning between teeth)
- Packaging: 7 g cardboard + 10 g thermoformed PVC + 2 0.1 g brass staples

The physical make-up tells us what we need to know for the 'Materials' and 'Manufacturing' stages. To complete the life cycle inventory, several more assumptions on average use-case are needed, which we detail below by stage:

- Lifetime – one toothbrush lasts 6 months meaning two toothbrushes will be needed for the year
- Transportation – 500 miles from factory to end user.
- Use-Stage – User brushes teeth twice daily, using a pea sized amount of toothpaste and 1 gallon of water
- End-of-Life – Both toothbrush and packaging are sent to municipal waste to be incinerated or landfilled.

Life Cycle Impact Assessment Results

The LCA data informs us where to focus. In the case of the toothbrush, it's in the use stage. The question that we want DfS to help solve can be asked like this: *How might we develop a product and service that delivers good oral hygiene while being the most sustainable solution possible?*

For this simplified study, we focus on the greenhouse gas (GHG) emissions associated with the different inputs and waste streams due to using the reference toothbrush. (fig 8)

First, we look at impacts as grouped by life cycle stages. This is a great way to achieve a top-level understanding of what DfS strategies may be material in the redesign and help us focus the DfS brainstorming. In the case of cleaning teeth, the use phase is by far the biggest driver of impacts. Even though the amount of water and toothpaste used for each tooth-brushing are quite small, over a years' time this adds up.

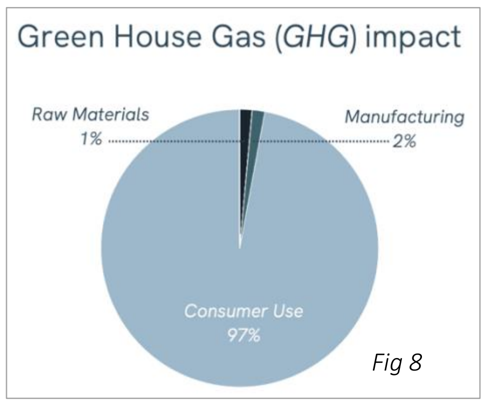


Fig 8

If we break down the use stage to see the detail (fig 9), you can see the balance of impacts that make the use stage so dominant over the course of a year. Toothpaste is also quite high impact, and water use can be very impactful if we don't turn off the tap while brushing.

In looking at the DfS Strategies, we can identify the strategies that will affect the use phase: function, materials, use, and longevity.

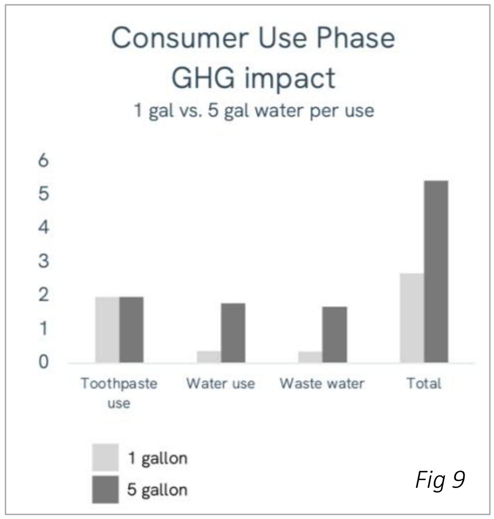


Fig 9

Function:
What is the problem? What is the context of the challenge?

Materials:
A big part of DfS is "How do we make our materials work better for us?"

Use:
How might you deliver the needed function with less environmental impacts? Optimize energy and water efficiency. Leverage consumer behavior. Reduce complexity of cleaning and maintenance. Is there a communication opportunity? Oftentimes, new technology can help with resource utilization in the consumer use stage.

Longevity:
How might you think about the optimal longevity for your product?

When ideating it's also important to write down any barriers, risks and/or trade-offs as you look at the data through the strategies lens. The biggest emphasis in this process is the role designers can and should play. Designers should be expecting and specifying data that allows decision-making that truly incorporates sustainability. As it can take some time to prepare this information, the earlier these data needs are identified, the better. This is why some companies have chosen to create tools that provide the right kind of actionable data on demand, fit for non-LCA practitioners to use.

IN CONCLUSION

Life Cycle Assessment data helps inform where DfS should focus and how to easily compare designs to a baseline. Asking questions in Design for Sustainability is an important piece of making environmental improvements to a designed product. But in order to ask the right questions to inform the right answers, the data must be present. It's easy to make assumptions about what 'more sustainable' may include, but until we can understand the impacts across all stages, it may mean those assumptions are causing greater impacts somewhere else, or our assumptions may lead to designs that are much less consequential than we think.

Design for Sustainability can be the process that enables key team members and project stakeholders to better understand the products they design and fuel better environmental outcomes, influence collaboration, and facilitate education and product transparency. Sustainable design must become part of how design is practiced, and environmental data must become part of that process.