The Surfboard Cradle-to-Grave Project
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What is the Surfboard Cradle-to-Grave Project?

It wasn't that long ago that people would avoid you in the line-up if you talked too much about the environmental footprint of surfing. But things have changed—as the world has pricked its ears to the idea of "sustainability," the interest in creating a surfboard from "green" materials has grown exponentially.

When I began my studies in Sustainable Engineering at UC Berkeley, I searched the libraries diligently for a life cycle assessment (LCA) of a surfboard, but found none. It turns out that were even further away from the reality of a "green" surfboard than I had supposed; a LCA of a common surfboard had never been conducted.

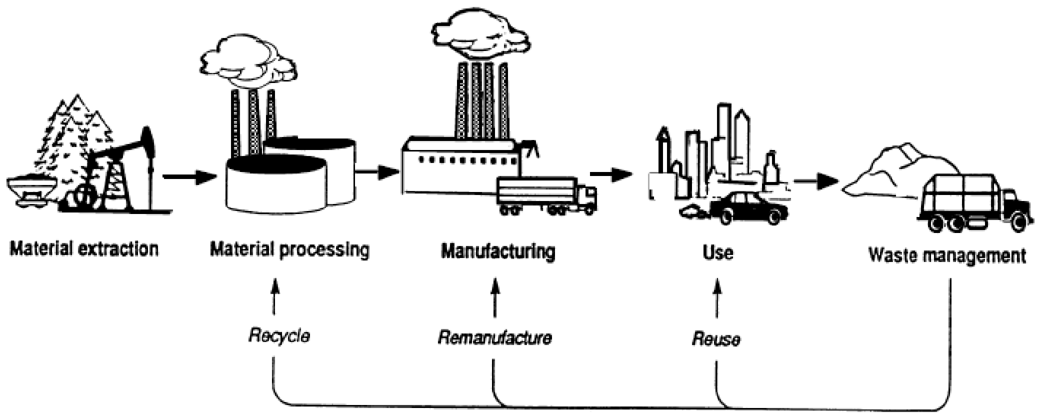
Without an LCA for the baseline materials used in surfboard manufacture, it is impossible to make informed decisions to reduce the footprint of the sport. What part of the board contributes the most to the environmental footprint? Which areas need the most improvement? Which will be the easiest, and cheapest to improve? These are the types of questions the surf community needs to answer before real improvements can be made; these are the questions I began the Surfboard Cradle-to-Grave (SCG) Project to answer.

In the SCG, you can now find the carbon footprint of polyurethane (P/U) and expanded polystyrene (EPS) surfboards, the two most common types of board—they make up about 95% of boards in the water. There are many other types of surfboards, but I couldn't possibly assess every new board type invented—the number grows every day.

By treating P/U and EPS as baseline materials, and comparing the environmental footprints of future boards against them, we can find out which new types of board are truly "greener" than your typical stick.

What is life cycle assessment?

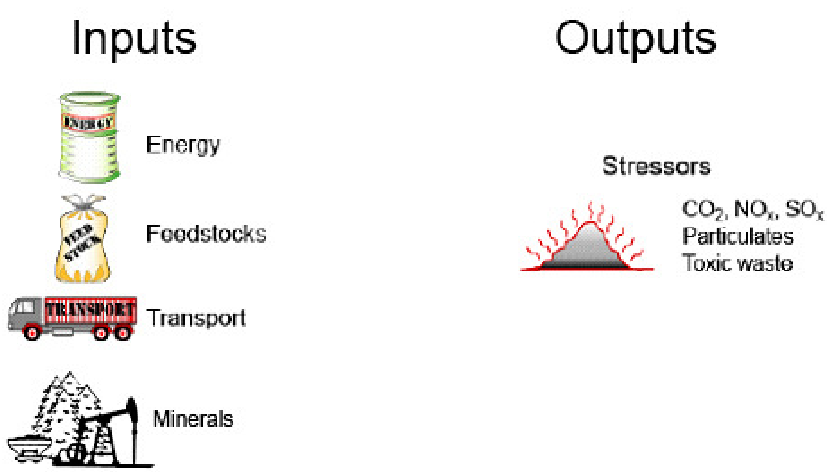
All the products you buy go through the same five steps in their "life cycle"; Material Extraction, Material Processing, Manufacturing, Use, and Disposal. Surfboard blanks come from petroleum taken from underground (Material Extraction), which is processed into polyurethane or polystyrene (Material Processing), and shaped into a surfboards (Manufacturing).



(1)

All of these steps—even recycling and reuse!—require resources ("inputs"), and emit pollution ("outputs"). Inputs include raw materials that are incorporated into the product—like petroleum and sand, respectively used to make blanks and fiberglass. But also included are indirect inputs, which aren't part of the product, but necessary to its production (energy, for example).

Outputs include all kinds of things—carbon dioxide, toxic emissions, health hazards, and even noise pollution. The outputs you decide to measure depend on what pollutants you care about!



(2)

Life cycle assessment is the quantitative study of the inputs and outputs that occur during all the phases of a product's life cycle—from manufacturing through disposal. These environmental effects are complex and multifaceted, and understanding the life cycle of even one product—(like a surfboard)—is no simple matter.

The SCG focuses on one output; lifetime carbon footprint.

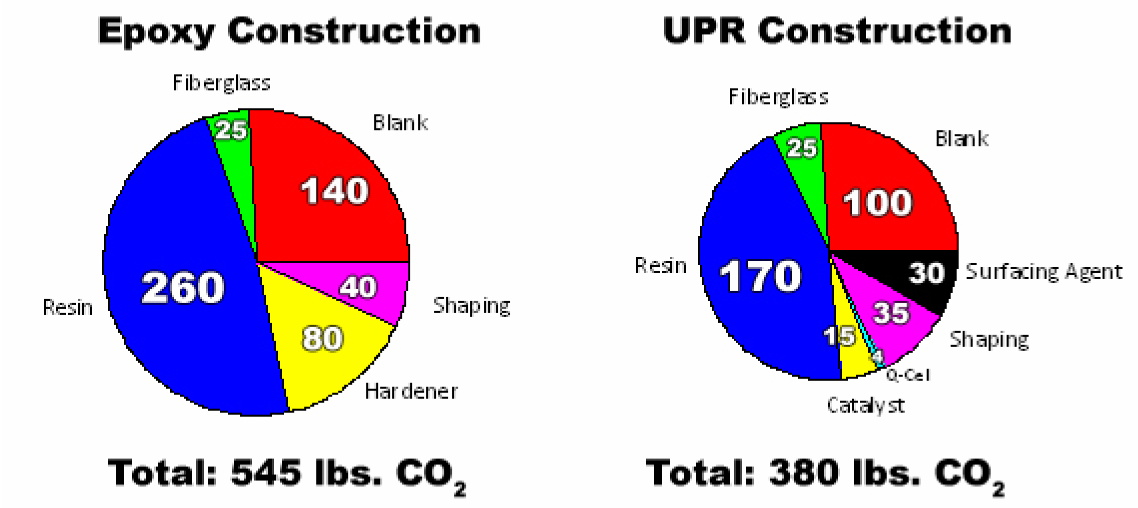
Notes on the LCA Used in the Surfboard Cradle-to-Grave

Life cycle assessments differ in their particulars from product-to-product; here are the main assessment techniques I used in the SCG:

- *I separately assessed the six components that contribute to the lifetime footprint: the manufacture of blanks, fiberglass, resin, catalyst/hardener, surfacing agent, and the emissions resulting from board shaping.* Ding repairs are included in these numbers. Using this strategy, I was able to identify the "dirtiest" parts of surfboard production.
- *I assessed hand-shaped boards only; I didn't look at "blown" EPS, or machine-shaped boards of any kind.* Hand-shaped P/U and EPS boards are made the same way; the blank is shaped, fiberglass is laid on it, and then soaked in resin. The blank gives the board its shape; the resin-soaked fiberglass gives the board its strength.
- *I considered P/U core boards made with unsaturated polyester laminating resin (UPR), and EPS core boards made with epoxy resin.* From now on, I'll call the two types of construction UPR and epoxy. There are different combinations of materials possible—epoxy resin and a P/U blank, for example. To find out the footprint of these "hybrid" boards, just mix and match the footprint of the various components.
- *This footprint analysis is calculated for a 6'0" shortboard.* You can get a very rough idea of the footprint of longer boards by breaking out your bathroom scale, and multiplying by the ratio of their weights. For example, a typical 6'0" UPR board weighs around 5 lbs: so a 15 lb UPR longboard could be roughly estimated to have about three times the footprint.
- *I circulated a Board Lifetime survey to find out how much longer epoxy boards last than UPR.* To truly compare epoxy and UPR construction, it's important to take into account their differing durability; we all know epoxy boards last longer, which means you don't have to replace them as often, which results in lower emission overall. I used the Board Lifetime survey to find out just how much longer epoxy boards last.
- *The results here are for boards made in the continental United States, with all materials manufactured in the country.* Variation in manufacturing processes, transportation distances, and many other factors will result in a different footprint for a surfboard made in China or Europe, for example. In reality, most surfboards surfed in the U.S. are made in the U.S., so this is a good assumption for American surfers.
- *The carbon footprint I present here can be taken as a lower limit for surfboards made overseas.* The manufacturing base in the United States is actually clean when compared to most other parts of the world. To find the footprint of the board made in another country, another LCA must be performed, which must include the emissions due to overseas transportation.

The Results

The charts below contain the emissions from the life cycle of one surfboard, comparing UPR and epoxy construction. They take into account the whole lifetime of a surfboard, from the day materials come out of the ground, to the day the board is discarded.



Numbers might not add perfectly, due to rounding. Emissions are for a 6'0" shortboard.

At face value, epoxy boards have a larger carbon footprint; but this doesn't take into account the fact that epoxy boards last longer than UPR boards. The Board Lifetime survey showed that epoxy boards last about one and a half times longer—once this longer lifetime is taken into account, epoxy and UPR boards have about the same carbon footprint, since you won't have to replace your epoxy board as often.

Resin and blanks are the two biggest carbon contributors to the footprint of a surfboard by far. Together they account for nearly ¾ of the emissions from the lifetime of either type of board. Fiberglass, by contrast, makes a small contribution, around 5% for both types of construction.

What does it mean?

Over their lifetimes, epoxy and UPR respectively contribute 545 and 380 pounds of CO_2 to the atmosphere—that sounds like a lot of carbon, right? I needed to put these numbers into context for the footprint to make any sense.

One way to do this was by doing an external cost valuation. An "external cost" is the cost of a pollutant to society in general; this includes medical costs due to poisoning, or clean-up costs due to serious contamination, for example.

To analyze the true cost of CO_2 emissions, answers must be found to questions such as; how much will building seawalls cost, if sea level rises; or if climate patterns change significantly, how much more expensive will it be to get water, and grow food?

Obviously these are incredibly hard (and controversial) questions to answer—but their answers are critical to a true understanding of the footprint of a surfboard (or for footprint of any other product, for that matter).

To reach my conclusions, I used an estimate of cost from the scientific literature of about $20 per metric ton of CO_2. CO_2 is not the only pollutant that surfboard production creates, and I included estimates for some other common air pollutants to get the final external price of a surfboard.

Board Type	External Cost (2009 $)
UPR Construction	$5.60
Epoxy Construction	$8.19

This isn't a whole lot of money—only about 1% the cost of a new board. And it's not a whole lot of carbon, especially when compared to some of the other activities intimately related to surfing.

While it might be tempting to leave the analysis at this level, I decided I needed to examine these numbers in their real context, which is the actual practice of surfing. After all, we buy our boards to surf on them, not to sit in our garage. *Surfboards* are used for *surfing,* so the carbon emissions associated *with the activity of surfing* must be included in the LCA.

I decided to find out what the biggest carbon emitter was *for a given surf session, rather than simply for a given board.*

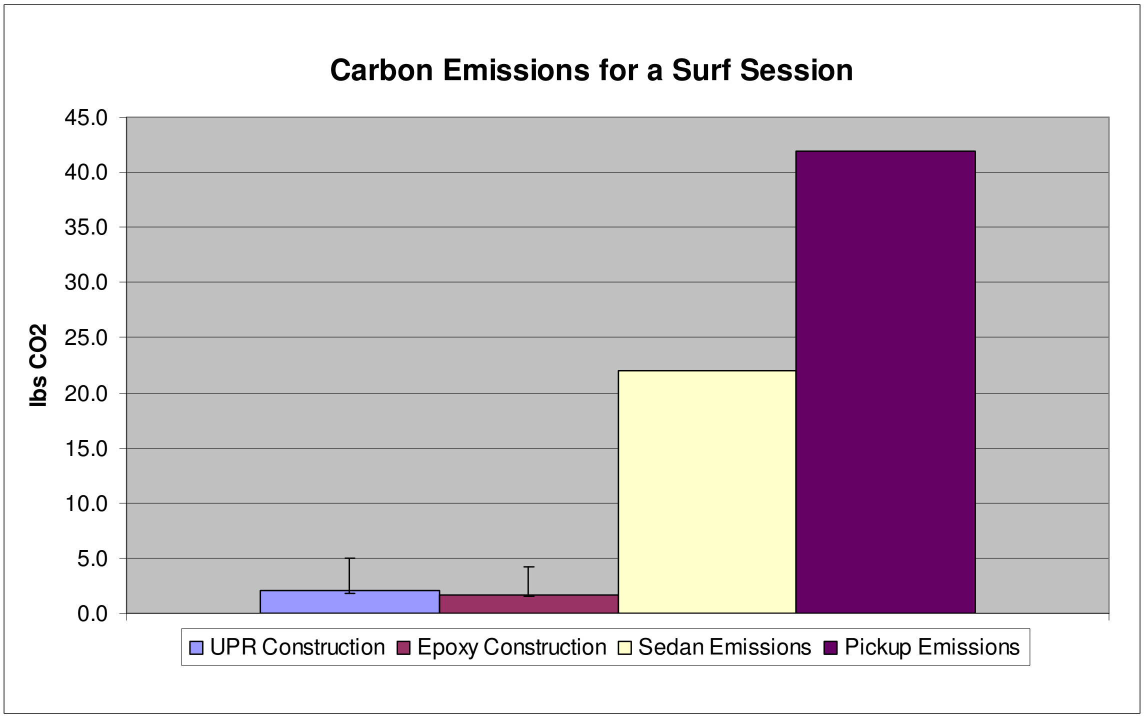
Carbon Footprint of a Surf Session

How much carbon gets emitted every time you go down to enjoy the surf? "None" you might say—it takes nothing to paddle out! But every time we surf, we put wear and tear on our boards, taking them one step closer to oblivion, and the time we have to go buy a new one. Using board lifetime information, I was able to estimate how much carbon can be attributed to each surf session from the surfboard alone.

But what about driving? Most of us are not blessed to live within walking distance of perfect waves, and we spend plenty of time roaming the coast to find the best peaks.

I didn't look at other parts of the surf session, like wax, leash, trunks, and wetsuits. Though not necessarily inconsequential, the carbon footprint of these products is almost certainly much smaller than board manufacture and driving. I did not have the capacity to focus on their carbon footprints, but it's a great area for future research.

To look at car emissions, I included the whole life cycle—including fuel use, fuel manufacture, car manufacture, car maintenance, and even the carbon emissions coming from road maintenance. All of these factors must be included, to make a real evaluation of the environmental footprint of surfing-related driving. I evaluated both sedans and pick-up trucks, which are pretty reflective of your typical surfmobile.



Comparing carbon emissions for a surf session, compared to driving an automobile 10 miles (5 one-way) to go surf.

The emissions from driving dominate, when we look at the LCA of surfing in this way. UPR and epoxy have about the same emissions for a given surf session—around 2 pounds of CO_2—but driving a sedan results in more than 20 pounds, which is greater by a factor of 10. And pick-up trucks emit almost twice that!

These conclusions are based on a 5-mile drive down to the beach (10 miles total)—some of us drive less, but many of us drive more. I have to drive more than 20 each way to the surf; CO_2 emissions for my typical surf session would be off the page on this graph.

With these results, I am ready to make some recommendations, both for people in the board producing industry (manufacturers and board shapers), and for all of us regular joe surfers, looking to chip in to help save the planet.

Recommendations for Board Producers

A repetition: When the longer lifetime is considered, epoxy construction has about the same footprint as UPR. Especially when data uncertainties are taken into account, neither epoxy nor UPR is a clear “winner” environmentally.

One more repetition: For both epoxy and UPR construction, resin and blank manufacture make up the lion’s share of the footprint, more than 70% in both cases. Blank manufacture makes up about 25% of the footprint, and resin between 45-50%. Fiberglass, meanwhile, makes a paltry contribution in both cases—around 5%—less than emissions from shaping and sanding. Epoxy hardener takes up a bigger chunk (15%) than UPR catalyst (4%), mostly because you need to use more hardener in epoxy construction than catalyst in UPR.

Here are some recommendations, based on these considerations:

- *Find resin and blanks which are truly "green"—meaning a carbon footprint has been performed, and shown to be less than these standard materials.* This can be a decidedly non-sexy recommendation, and even save you money—small efficiency improvements in resin and blank manufacture can decrease the footprint of a surfboard notably.
- *Find clean epoxy resins.* Most UPR mixes on the market have the same toxic constituents; but there are epoxy resins on the market with no toxics at all. This will mean they're healthier for you to use, though it doesn't indicate they have a smaller carbon footprint. You can read more about the toxic constituents of UPR and epoxy resin in the Surfboard Cradle-to-Grave Technical Report.
- *Don't sweat the small stuff.* Fiberglass, shaping, surfacing agent, and catalyst together make up less than 25% of a surfboard footprint; improvements in these areas can be expensive, and not make much of a difference.

Finding "green" options for fiberglass, for example, can lead to at best 5% carbon reductions; this means making a board with substitutes for fiberglass—balsa wood or bamboo, for example—do not produce boards with a significantly smaller footprint, even in a best case scenario. And remember, just because it's made from a "natural" material doesn't mean it is truly "green"—agriculture, cutting, milling, shaping, transportation, and etc., all have their own environmental footprints which must be taken into account.

Recommendations for Surfers

For the art of surfing, driving dominates the carbon footprint. Based on this fact, some of the recommendations for surfers don't even involve buying boards:

1) *Live closer to the ocean.* If you can walk or bike to your break, there are no carbon emissions associated with surfing-related driving, taking an enormous chunk out of your carbon footprint. Unfortunately, living within walking distance of a break can be impossible for many surfers—I know we'd all love an oceanfront home in Pleasure Point or on the North Shore, but let's be realistic. But even if you still have to drive, going less distance will result in less pollution; living as close as possible to the beach is my first recommendation.
2) *Purchase a more fuel-efficient vehicle.* The difference in CO_2 emissions between a pick-up truck and a sedan is large. If you drive a pickup with fuel economy below 20mpg, you can halve your carbon footprint if you upgrade to a vehicle which gets 40mpg. This does not mean you have to shell out dollars for an expensive hybrid; changing your ride from a low efficiency pickup truck to a medium

economy sedan (25-30mpg, for example) will mean large carbon savings—and this can help your pocketbook, rather than hurt it.

3) *Buy used surfboards from your local surf shop.* By purchasing a used board, you can skip the manufacturing process entirely; this will result in an absence of toxic emissions, and big reductions in the carbon footprint of your board. But shop local! Driving two cities over to get that 1960's single-fin from craigslist might be great for your style, but the driving emissions will overwhelm the carbon savings.
4) *Buy a board made with "green" resins or blanks.* As noted, these are by far "dirtiest" parts of a surfboard. "Green" substitutes for fiberglass or catalysts will not result in significant environmental improvements.

Based on this analysis, one recommendation stands out for both board producers and general surfers:

If you want a truly green stick, look for resin and blanks which have carbon footprints proven to be less than the UPR and epoxy baselines set here.

Wrap-Up

The carbon footprint is a very good indicator for the pollution arising from a product in general; using the recommendations I presented, we can all start to gauge the best ways to improve our environmental footprint, both for carbon, toxic by-products, and whatever other outputs we are concerned about.

If you're interested in finding out more about the toxic by-products and toxic constituents of surfboards, take a look at the Surfboard Cradle-to-Grave Technical Report, which has that information in all its scientific glory.

I like to think that this Report will be the first step in cleaning up our act as surfers. Thanks for reading.

Thanks To:
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and to everyone who took the Board Lifetime Survey.

Image Credits:

(1) taken from "Life Cycle Assessment: History and Framework" by H. Scott Matthews, CEE, Carnegie Mellon University
(2) "New approaches to Materials Education" - a course authored by Mike Ashby and David Cebon, Cambridge, UK, 2007
---thanks to Ryan for finding these pictures!
(3) All charts are from the SCG project, by Tobias Schultz

Dedication:
For Salsipuedes, the best wave I've ever surfed and the first I saw get paved over by development. I wouldn't have started this project without seeing the effects of irresponsible stewardship firsthand.