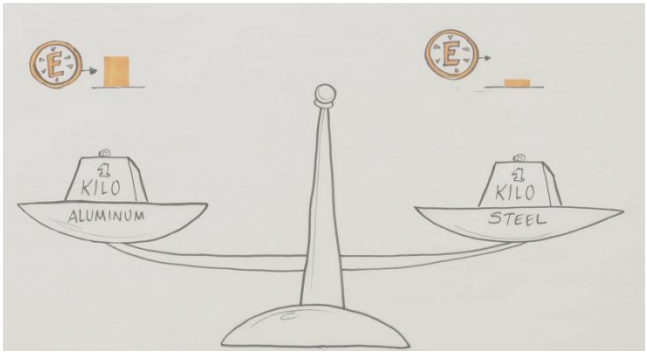
Material Selection: Physical Properties of Materials

Companion to the video: Script and Illustrations

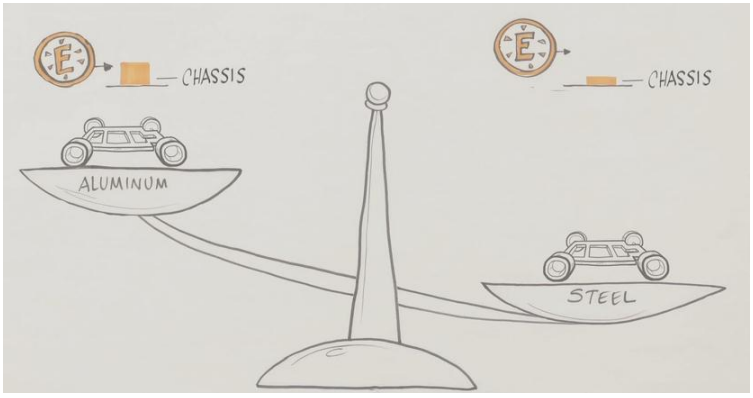
Selecting greener materials is all about tradeoffs. And it's not just environmental impact vs. cost. You need to think about the product's whole lifecycle - and performance tradeoffs can get tricky.

Let's say you're deciding between steel and aluminum for a car chassis. Aluminum has about six times the embodied energy per kilo. So it's six times as BAD, right?



Not necessarily.

Aluminum is up to two and a half times stronger per unit mass as steel, so you can make a lighter chassis from it.



See, even when you consider all of the material that goes into making a car, MOST of the car's environmental impact comes from the energy used driving it.

And that depends on how much weight it's carrying around.

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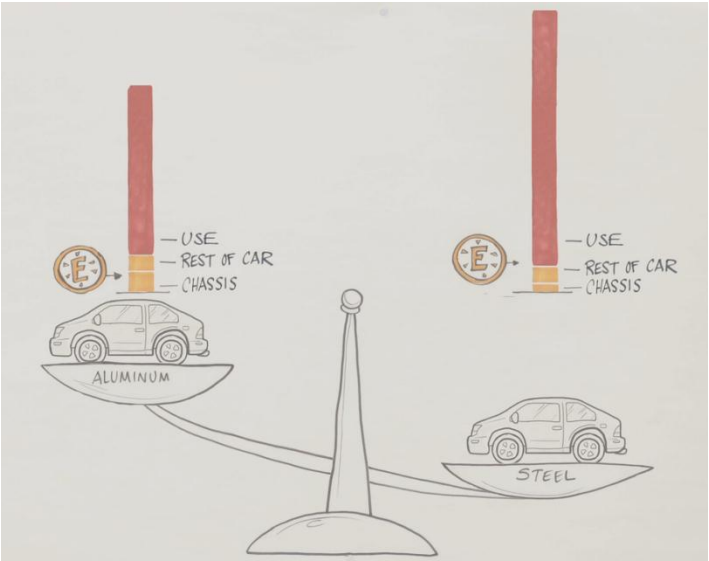
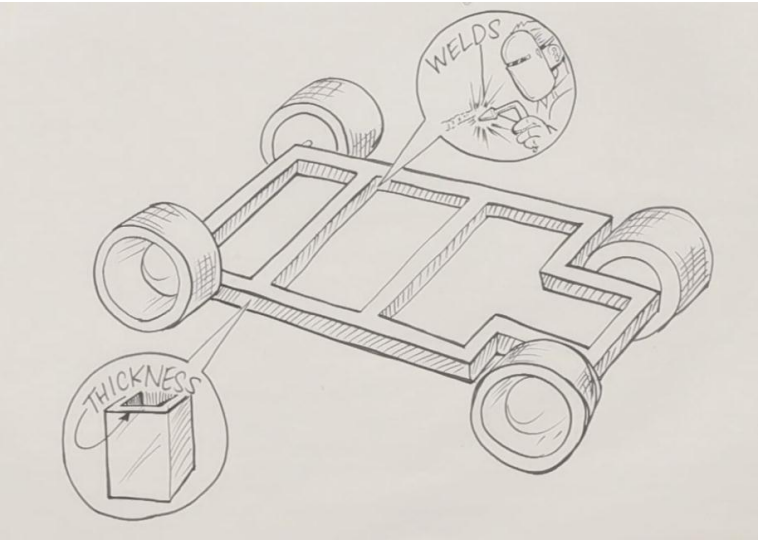
Since a car with an aluminum chassis can weigh forty percent less, it can use about thirty-five percent less energy over its life, making its total LIFETIME energy use much lower.



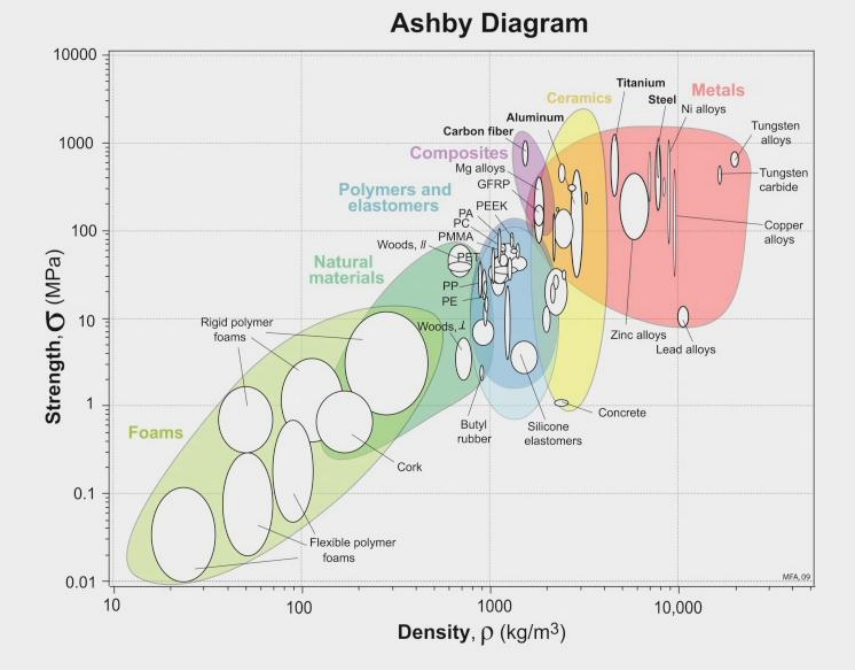
But keep in mind that different materials may need different geometry and manufacturing.

For example, aluminum parts in a chassis will have thicker walls and different welds.



Software tools like Inventor's Eco Materials Advisor and Granta's CES Selector can help you compare materials based on this type of data.

When you graph materials based on their properties, it's called an Ashby diagram. Here's one of strength versus density to help us find strong and light materials for the chassis.



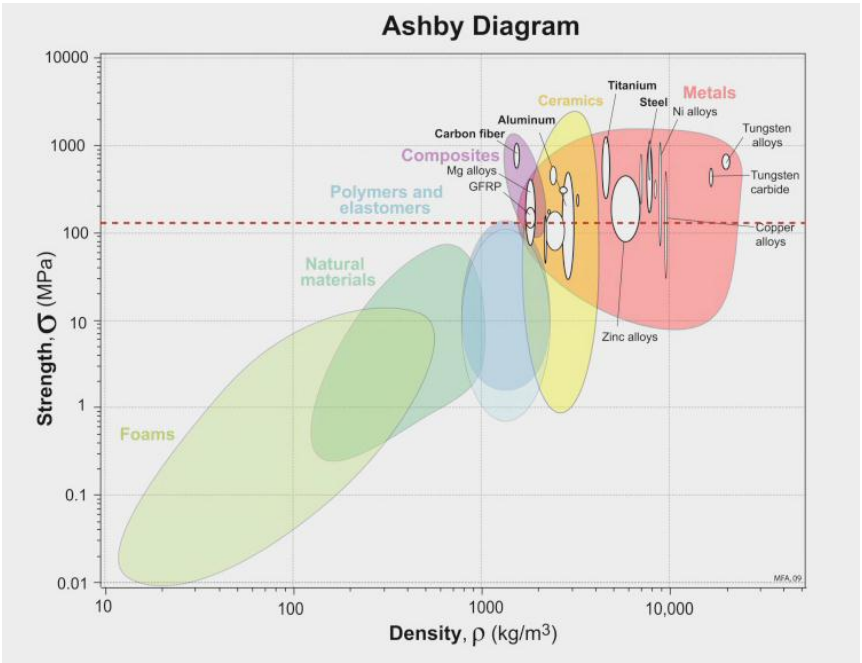
Here's steel, and here's aluminum… now let’s see what other materials might work.

As you consider alternatives, first screen out materials that you're certain aren't options.

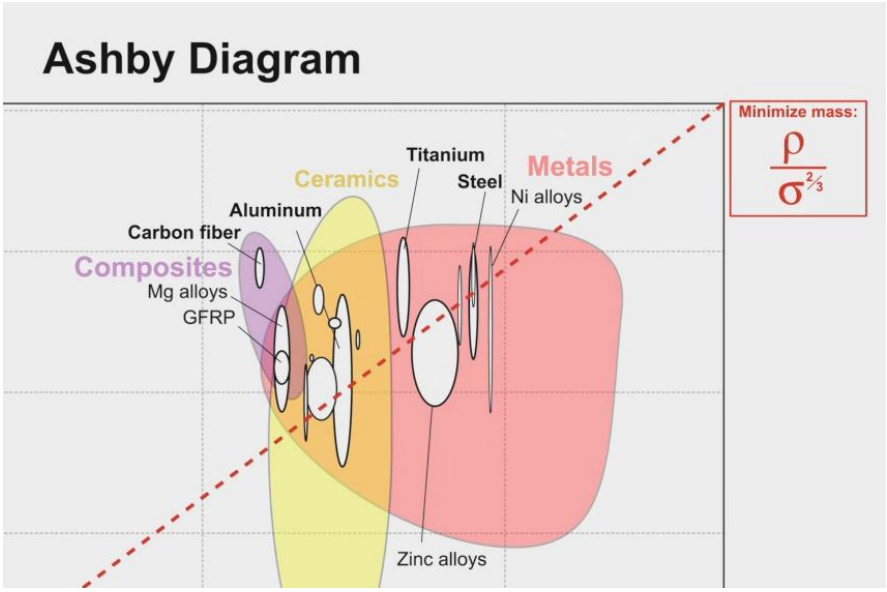
Don’t set arbitrary constraints like "it has to be metal." The best constraints are performance-based.

This allows materials to be suggested that you might never have thought of!

Based on strength requirements, you’ll eliminate a lot of materials, like polymer foams.



To optimize your choice among the remaining materials, you can plot a guideline based on your objectives, constraints, and geometry.



In this example, materials on the line perform equally well and those above the line perform better. So you can see aluminum, steel, titanium, and carbon fiber could all be good options.

As always, you'll need to consider cost. Titanium will be too expensive.

Still, prices do change. Carbon fiber is getting cheaper all the time. One day all cars might be made from it.

In selecting materials, tradeoffs are inevitable. But you can more confidently make the right decisions when you know what aspect of your design is the most important to optimize.

Using the right tools and understanding material properties will help you make far more sustainable design decisions.