CHAPTER 1

THE LENS OF UPFRONT CARBON

Pick up your phone and feel its weight. It's not much; probably not much different than my iPhone 11 Pro, which weighs 188 grams, or 6.63 ounces. Apple has designed it to be incredibly efficient and run all day on a small battery, so it takes almost no energy to run.

The iPhone is a complicated mix of aluminum, carbon, silicon, cobalt, hydrogen, lithium, tantalum, vanadium, and gold. Materials come from the Democratic Republic of the Congo, Indonesia, Brazil, and China. Metallurgist David Michaud told Brian Merchant, author of *The One Device*, that about 75 pounds of ore were mined to make the phone. Most people could lift that if they had to.

But Apple, one of the few companies to provide the public with a full life cycle analysis showing the carbon emissions of their products, tells us that my phone emits 80 kilograms (176.3 pounds) of carbon dioxide over its lifetime: 13 percent comes from the electricity for operating the phone, 3 percent for transportation, and an astonishing 83 percent from making the phone, the materials that go into it, and the manufacturing. Between manufacturing and shipping, 86 percent of the life cycle carbon is emitted before you open the box. That's 68.8 kilograms, or about 150 pounds—twice as heavy as the ore mined to make the phone.

Lifting your phone is easy, but imagine if it actually weighed 150 pounds. This is serious weightlifting.

The amount of energy that goes into making a product used to be called "embodied energy," defined as "the sum of all the energy required to produce any goods or services, considered as if that energy was incorporated or 'embodied' in the product itself."[1] However, we are in a climate crisis caused by carbon dioxide, methane, and other greenhouse gas emissions, so instead of measuring embodied energy, we started measuring what became known as "embodied carbon." But the dictionary definition of embodied is "include or contain (something) as a constituent part." The carbon is most definitely not a constituent part; it is in the atmosphere.

In a world where we must reduce and eventually eliminate carbon dioxide emissions, this is important. Before you pick up your phone at the store, those carbon emissions have contributed to climate change. They could be considered "now" emissions, compared to "later" emissions, but they are certainly not embodied emissions.

I thought embodied carbon was a terrible name. In a Twitter discussion with New Zealand architect Elrond Burrell, we tried to come up with a better one. Elrond suggested "burped" or "vomited" carbon to make it obvious that they were a giant cloud of carbon emitted during manufacture. Others suggested "front-loaded emissions." Jorge Chapa of the Green Building Council of Australia tweeted, "I also wonder how much people dismissing embodied carbon is the way we talk about it. Instead of embodied carbon, perhaps we should consider renaming it as upfront emissions." I tweeted back, "I think you nailed it!" and added a word, coming up with "Upfront Carbon Emissions."

Writing a year later, author and sustainability provocateur Martin Brown credited me with the coinage:

> Lloyd Alter writing in Treehugger established upfront carbon as a key concept term in addressing the climate emergency. 'Embodied carbon' is not a difficult concept at all; it is just a misleading term.... I have concluded that it should be called upfront carbon emissions, or UCE."

> (By the way, Lloyd's article "Let's Rename 'Embodied Carbon' to 'Upfront Carbon Emissions'" is a must-read that also illustrates how Twitter conversations with Elrond Burrell can lead to improved industry thinking.)[2]

I may have given it wings, but in all fairness, it was a discussion among Elrond, Jorge, and myself, and "upfront carbon emissions" is now an accepted term. Jorge Chapa and the World Green Building Council were the first to officially use it in a publication titled "Bringing Embodied Carbon Upfront." Chapa explains why he thinks it is useful:

> We were trying to get funding to do some work on embodied carbon, and while explaining it to a number of funders, about 10 minutes into the conversation one of them stopped us, apologized, and asked a question, "Why do you keep saying embodied carbon is a problem? Isn't embodied carbon good? It's in the product, that's what embodied means, isn't it?" Biggest penny drop I ever had.

However, upfront carbon is not strictly the same thing as embodied carbon, as I will explain later. And whether it's burped, vomited, or just upfront, it is what is going into the air now; it's what is important now; it's the 150 pounds of iPhone upfront carbon that matters in the fight against climate change. When you look at the world through the lens of upfront carbon, everything changes.

When Apple did its life cycle analysis, it attributed 13 percent of emissions to the electricity used to charge the phone based on the average American electricity supply, much of which is still made with coal and natural gas and produces significant carbon emissions. However, if you live in Montreal or Vancouver, where your electricity is generated with water power, that 13 percent drops to almost zero, and the upfront carbon increases as a percentage. The same thing is true if you are driving a Ford F-150 lightning electric pickup truck in Montreal or Oslo where the electricity is low carbon, or you build an all-electric home in Reykjavik: there are no carbon emissions from running the phone, the car, or the house—it's all upfront. As we ramp up renewables and switch to electric vehicles for driving and heat pumps for heating, this leads to what I have called the ironclad rule of upfront carbon:

> As our buildings and everything we make become more efficient and we decarbonize the electricity supply, emissions from embodied and upfront carbon will increasingly dominate and approach 100 percent of emissions.

Everything becomes like your phone with tonnes and tonnes of carbon emissions before you drive the electric car off the lot or step into your new home or unbox a pair of shoes. For products such as your shoes or your sofa, there are no operating emissions; they are almost 100 percent upfront carbon, with just a bit ascribed to maintenance and end of life.

This is why what we make and how much we consume becomes as or more important than how much energy it takes to operate. This is why **sufficiency**, or making and buying just what we need, has become as important as **efficiency**. This is why when you look at the world through the lens of upfront carbon, everything changes.

"Embodied carbon" is doubly confusing because not only is it not embodied, it is not even carbon. Our problem is carbon dioxide, which forms when we burn carbon to generate heat, which happens when a carbon molecule has an exothermic reaction with two molecules of oxygen to make carbon dioxide. So, burning a one-kilogram lump of coal actually has about 3.67 kilograms (8 pounds) of upfront carbon emissions because of the weight of the oxygen.

We also talk about carbon dioxide equivalents (CO_2e), measuring the impact of methane or refrigerants in terms of their effectiveness as greenhouse gases compared to CO_2. It's messy because they are not really equivalent; methane, for example, decomposes in about twenty years, whereas CO_2 stays up in the atmosphere. But for convenience and brevity, when we say carbon, we mean CO_2 or CO_2e, even though what we call carbon is 3.67 times the weight of (solid) carbon.

What Are Upfront Carbon Emissions and Why Are They Important?

When you buy a car, it's easy to find out the fuel economy, the miles per gallon, or, as they do it backward in Canada, the liters per hundred kilometers. It's the law; the Environmental Protection Agency (EPA) mandates the tests on every car. The tests are done to ensure that companies are hitting their targets set by regulation for Corporate Average Fuel Economy (CAFE). The EPA publishes the city and highway fuel economy numbers to encourage the public to compare and buy more efficient vehicles. It's an artifact from when governments were concerned about how much fuel was imported from foreign sources before anyone cared about carbon dioxide emissions.

Today, because we know that carbon dioxide is a greenhouse gas that contributes to global heating, we care a lot about how much CO_2 emissions come out of our tailpipes, which are the car's operating emissions. They are proportionate to the fuel economy; burning a liter of gas emits 2.3 kilograms (5 pounds) of CO_2.[3] That's why governments are promoting electric cars—they have no direct tailpipe operating emissions. They are not emission-free because of the emissions from generating electricity, which is why the EPA conveniently provides a calculator that tells you about the emissions from your electric car depending on the model and where you live based on the cleanliness of your electrical supply and will give you the miles-per-gallon equivalent.[4]

What few companies tell you is what the upfront carbon emissions are—how much carbon dioxide and other greenhouse gases were emitted while actually making the car. There are emissions from making steel, glass, aluminum, and plastics, and in the new electric cars, the stuff that goes into the batteries. There are more emissions from moving these parts around the globe.

When you look at any pie chart showing where carbon emissions come from, these are all attributed to the "industrial" sector, and not to the car. These emissions are considerable, and can be close to the emissions that come out of the tailpipe over the entire lifetime of a gasoline-powered car.[5] An electric car running on clean power is subject to that ironclad rule, and approaches 100 percent upfront carbon.

Upfront carbon emissions are the front end of a life cycle assessment (LCA), a concept that was developed in the early years of the environmental movement and the energy crisis. According to "Life Cycle Assessment: Past, Present, and Future" by Jeroen Guinée:

> The study of environmental impacts of consumer products has a history that dates back to the 1960s and 1970s.... It has been recognized that, for many of these products, a large share of the environmental impacts is not in the use of the product, but in its production, transportation, and disposal. Gradually, the importance of addressing the life cycle of a product, or of several alternative products, thus became an issue in the 1980s and 1990s.

Surprisingly, one of the first to use LCAs was the Coca-Cola Company in 1969, probably to justify the elimination of returnable bottles. According to "A Brief History of Life Cycle Assessment," the study "laid the foundation for the current methods of life cycle inventory analysis in the United States. In a comparison of different beverage containers to determine which container had the lowest releases to the environment and least affected the supply of natural resources, this study quantified the raw materials and fuels used and the environmental loadings from the manufacturing processes for each container."[6]

In his 2008 book *Sustainable Energy Without the Hot Air* David MacKay includes a chapter titled "Stuff," where he discusses the energy required for raw materials (R), production (P), use (U), and disposal (D). Writing about the energy costs of phases R and P, he notes that "These energy costs are sometimes called the 'embodied' or 'embedded' energy of the stuff—slightly confusing names, since usually that energy is neither literally embodied nor embedded in the stuff."[7]

It's one of the earliest references to the embodied energy of stuff, and it's amusing that MacKay noted a decade before I did that the names are confusing. When we talk of embodied carbon, it is even more confusing since it is obviously in the atmosphere and not in the stuff. Many still confuse the terms embodied energy and embodied carbon, even though they are very different.

MacKay includes everything in stuff, such as cars and houses, but it is the building sector that was the first to take the issue seriously.

Today, an LCA is something that most companies can do relatively easily; there are many databases and software programs where you enter the amount of material and multiply that by the CO_2 emissions per kilogram. The programs know the emissions from the power supply where the material is made and the shipping to get it to where it is used. But very few companies reveal the information, even if they have it, possibly because people might be shocked.

As Paolo Natali of RMI wrote about electric cars:

> The truth is that the accumulated carbon footprint of materials in a newly bought gasoline-fueled car is the same order of magnitude as the footprint of its lifetime fuel consumption—so by buying an electric vehicle and securing green electricity, you are only part of the way through abating your car's total carbon footprint.
>
> What can we do to change this? Because what is out of sight is often out of mind, the first step is to calculate and communicate the CO_2 emissions that are embedded in produced goods. Until people know the CO_2 footprint of the products they're using, it will be impossible for them to demand lower-carbon goods.[8]

But the data aren't there for us to calculate the upfront carbon emissions of a car. One of the first to try was Mike Berners-Lee, author of *How Bad Are the Bananas*, one of the inspirations for this book. Back in 2010, he described in the *Guardian* how hard it is; first you have to draw a fence around it:

> To give just one simple example among millions, the assembly plant uses phones and they in turn had to be manufactured, along with the phone lines that transmit the calls. The ripples go on and on for ever. Attempts to capture all these stages by adding them up individually are doomed from the outset to result in an underestimate, because the task is just too big.

They then did what they call an input-output analysis, determining the total consumption of different materials that the auto industry consumed, the emissions from making those materials, and then divided it by the total amount of money spent on cars, and came up with the number 720 kilograms (1,587.3 pounds) of CO_2e for every thousand UK pounds spent on a car.

My first thought was that this is silly; you can have a Toyota and a Lexus that are identical under the skin but have very different prices, but Berners-Lee calls it "a reasonable ballpark estimate." There are likely much better numbers and approaches that one would take today, but without hard data from the manufacturer, it is impossible to know the true number.

For example, the most popular vehicle in North America is the Ford F-150 pickup truck. A few years ago, Ford started making the truck out of aluminum instead of steel to make the vehicle lighter and get better fuel economy—or, if you are a cynic like me, make it even bigger. Virgin aluminum has a vastly higher carbon footprint than steel, but Ford doesn't tell us whether they are using virgin or recycled aluminum with 95 percent fewer emissions. They make a very big deal about recycling their pre-consumer scrap aluminum, which is greenwashing; every company does that. Nobody will throw away

30 to 40 percent of the aluminum left after stamping out a part. But they don't tell us where the original aluminum sheet comes from, and without knowing that, you can't even ballpark a number.

Without transparency and openness, we will never have accurate information, and with the automotive industry, we will never have transparency. They want to sell big high-end vehicles, which have massive upfront carbon emissions no matter what they run on, and are directly proportional to the size and weight.

Why We Are Fixated on Energy, Not Carbon

In October 1973, the Organization of Arab Petroleum Exporting Countries declared an oil embargo aimed at nations that supported Israel in the Yom Kippur War. The price of oil tripled, and governments worried about their dependence on foreign energy sources. To reduce energy consumption, speed limits were lowered, efficiency standards for cars were introduced, and building codes were tightened.

In 1977, President Jimmy Carter called dealing with the energy crisis "the moral equivalent of war," declaring that "the cornerstone of our policy is to reduce the demand through conservation. Our emphasis on conservation is a clear difference between this plan and others which merely encouraged crash production efforts. Conservation is the quickest, cheapest, most practical source of energy." He called for the insulation of 90 percent of American homes and all new buildings, solar energy, and smaller cars. "Those who insist on driving large, unnecessarily powerful cars must expect to pay more for that luxury." In what today sounds like a discordant note, Carter also called to "increase our coal production by about two-thirds to more than 1 billion tons a year."[9]

In the forty-five years since that speech, governments have come and gone, but the preoccupation with energy has not. Jimmy Carter could call for more coal production because he was dealing with energy consumption, not carbon emissions, which are two very different problems. For forty-five years, we have measured miles per gallon or energy consumption of our homes and businesses because using energy meant burning fossil fuels. We used vast amounts of energy to boil rocks in Alberta to achieve energy independence. We would spray our homes with polyurethane foam insulation or wrap them in Styrofoam to reduce our gas consumption because we worried about how much fuel it took to run things, what became known as operating energy.

The energy that it took to make things wasn't seen as a big issue back in the energy crisis days; major industrial processes such as making electricity, steel, or concrete used coal, not oil, and it was not imported, so it didn't matter. This was not an energy crisis, but an oil crisis. And while Jimmy Carter tried to address the demand side to reduce consumption, his successor, Ronald Reagan, had other ideas, and worked the supply side. As Indrajit Samarajiva writes:

> The response to pressure from oil-producing countries could have been to use less oil, but no. The response was to produce more oil. The policy running all the way through Obama and Trump and Biden has been oil independence, not independence from oil.[10]

Ronald Reagan gets all the credit for ending the oil crisis by deregulating the price of crude oil in 1981 and letting the industry drill offshore—both the North Sea and Prudhoe Bay in Alaska came online—and just about anywhere else, but Jimmy Carter set him up for success. The average fuel economy of cars went from 20 miles per gallon (mpg) in 1978 to 28 mpg in 1985, while homeowners in droves switched from oil to gas and electricity for heating.[11] There were also geopolitics in play—Iraq was at war with Iran, and both were dumping oil on the market to pay for it. There are some who say that Reagan made a deal with Saudi Arabia to pump more oil and drop the price to destroy the Soviet Union, which then, as now, depended on fossil fuels for most of its income.[12] Oil went from being scarce to being a glut, and the price collapsed.

Oil got cheap and stayed cheap for a long time, making it very hard to get anyone to care much about using less of it. And as codes and regulations kept making cars and buildings more energy efficient, they just kept getting bigger because if you are a consumer, why not? It doesn't cost you any more to operate them. But as they got both bigger and more efficient, people started noticing that more and more energy was being used to make things in relation to how much it took to operate them. Academics called this "embedded energy" or "embodied energy." Here's an interesting definition from the *Encyclopedia of Energy*, published in 2004:

> Embodied energy, or "embedded energy," is a concept that includes the energy required to extract raw materials from nature, plus the energy utilized in the manufacturing activities. Inevitably, all products and goods have inherent embodied energy. The closer a material is to its natural state at the time of use, the lower its embodied energy. Sand and gravel, for example, have lower embodied energy as compared to copper wire. It is necessary to include both renewable and nonrenewable sources of energy in an embodied energy analysis.[13]

Note that they do not include the emissions from the schlepping of the heavy sand and gravel, nor the difference between renewable and nonrenewable sources of energy. That's the preoccupation with energy, not carbon, writ large.

Carbon Takes Command

The energy crisis faded in the onslaught of "unconventional" resources, as hydraulic fracturing (fracking) unleashed vast quantities of oil and more natural gas than we could use. In Canada, the oil companies got better at squeezing oil out of the rocks of what became recognized as the fourth-largest petroleum reserve in the world.[14] There was a brief flurry of worry about "peak oil," but companies kept finding more of the stuff, especially gas, and we kept burning more of it as economies grew along with the cars and houses. The party continues because it's what drives our economies; as Vaclav Smil noted in his book *Energy and Civilization: A History*:

> By turning to these rich stores we have created societies that transform unprecedented amounts of energy. This transformation brought enormous advances in agricultural productivity and crop yields; it has resulted first in rapid industrialization and urbanization, in the expansion and acceleration of transportation, and in an even more impressive growth of our information and communication capabilities; and all of these developments have combined to produce long periods of high rates of economic growth that have created a great deal of real affluence, raised the average quality of life for most of the world's population, and eventually produced new, high-energy service economies.

In all these years after 1973 when we worried about our "energy crisis"—which was really a politically motivated gasoline crisis—scientists were beginning to understand that we were going to find ourselves in a carbon dioxide crisis. Back in 1981, the warmest year on record at that time, even the oil companies could see this coming.

M.B. Glaser, manager of the Environmental Affairs Program at Exxon, told his bosses in 1981 that "our best estimate is that doubling of the current concentration could increase average global temperature by about 1.3 degrees Celsius to 3.1 degrees Celsius." Glaser also noted—in 1981!—that "mitigation of the 'greenhouse effect' would require major reductions in fossil fuel combustion."[15] Needless to say, this report never saw the light of day.

There was also solid evidence that chlorofluorocarbon (CFC) from leaky fridges and air conditioners were causing atmospheric changes, including the enlargement of the "ozone hole." Somehow, the nations of the world got together to ban Freon and regulate CFC with the Montreal Protocol of 1987, which became the definitive model for international cooperation; it demonstrated that even in the face of industry and ideological objections to regulation, agreements could be reached that could come up with market-oriented mechanisms for solving the problem.[16]

In 1988, in the face of an increasing pile of evidence about the dangers of greenhouse gases, the Intergovernmental Panel on Climate Change (IPCC) was founded by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO). The intent was to examine the data, understand the dangers, and determine solutions based on the Montreal model of international cooperation, agreement, and action.

Shortly thereafter, the fossil fuel and automotive industries founded the Global Climate Coalition, whose mission, according to Spencer Weart in his book *The Discovery of Global Warming*, was to disparage every call for action against global warming.

> This effort followed the pattern of scientific criticism, advertising, and lobbying that industrial groups had earlier used to cast doubt on warnings against ozone depletion, acid rain, and other dangers as far back as automobile smog and leaded gasoline. But the most obvious model was the long-sustained and dishonest campaign by the tobacco industry, which had shortened many millions of lives by persuading people that the science of smoking was controversial.[17]

This worked remarkably well, delaying the implementation of agreements literally by decades. There are still what we used to call climate skeptics, then deniers, and now climate arsonists in conservative parties around the world. Even governments that are trying to make the kind of changes needed to honour the agreements they already made make little progress because of entrenched interests. It's also why it has been so difficult even to get people to understand the issues of carbon, let alone regulate them; there is so much disinformation and wishful thinking, and people still are thinking about energy, not carbon. The fossil fuel industries like it that way; they have lots of energy to sell.

If people were not talking enough about carbon before the war in Ukraine, there has not been a peep about it since. Energy has been back on the front burner since Russia cut off supplies of natural gas to Europe in 2022, causing massive disruption in economies around the world and a big spike in fossil fuel prices. People and politicians are not worrying about carbon emissions these days; Alberta sees a natural gas gold mine, and Britain's energy minister says, "We need to be thinking about extracting every last cubic inch of gas from the North Sea." Jacob Rees-Mogg may yet send children back into the coal mines.

The IPCC Does Not Say We're Doomed

The IPCC has been churning out Assessment Reports since 1990, and has now completed six cycles. In 1992, the United Nations Framework on Climate Change (UNFCC), a "universal convention that recognizes the existence of climate change due to human activity," was signed in Rio de Janeiro by nations that became known as the Conference of the Parties (COP), which has been partying annually ever since to determine collective responses to the IPCC reports.

In 2015, the COP signed the Paris Agreement, where Party nations would come up with plans for climate action called Nationally Determined Contributions (NDC) required to keep global heating under 2°C.

In 2018, a special report was published titled "Global Warming of 1.5°C," which included what was described by author Daniel Yergin as "one of the most important sentences of last few centuries. It has provided an incredibly powerful traffic signal to tell you where things are going."[18] It is certainly not written in words to stir one's soul:

> In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO_2 *emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range).*

This sentence has generated a thousand graphs of emission gaps, showing how we are failing to cause those emissions to decline. It has also been the basis of a thousand pledges to reach net zero by 2050, while studiously avoiding doing very much at all right now or even by 2030.

But Daniel Yergin is wrong. The sentence is not a driver of carbon reductions or even a target; it is an excuse for maintaining the status quo and pushing the problem down the road.

I believe that the sentence for the ages is in the Working Group I's Sixth Assessment Report:

> To limit global warming to 1.5°C above pre-industrial levels with either a one-in-two (50%) or two-in-three (67%) chance, the remaining carbon budgets amount to 500 and 400 billion tonnes of CO_2, respectively, from 1 January 2020 onward.

It is followed with the note: "Currently, human activities are emitting around 40 billion tonnes into the atmosphere in a single year."

The key difference between Daniel Yergin's favorite sentence and mine is that Yergin thinks that the carbon budget is a budget and not a ceiling. Think of it as a person's fixed retirement nest egg. If every penny matters, then you would cut your spending fast and hard. But instead, people are saying, "I'll buy that yacht I have always wanted right now, but I'll eat cat food in 2030," while thinking, "I'll be long dead in 2050." Mine has a ceiling that is based on hard science: global heating is proportional to the amount of carbon dioxide and equivalents in the atmosphere, and every molecule of CO_2 that we add to the atmosphere is subtracted from that budget. As Kimberley Nicholas noted in her book *Under the Sky We Make*:

> Because carbon is essentially forever, the carbon budget is forever too. If I use up more than my share, this leaves less space for you. This is true today across places: between rich and poor countries and between high- and low-emitting individuals. This tug-of-war is also true stretching across time: between previous generations, those of us alive today, and all humanity to follow.

It has also become fashionable to, as *The Economist* magazine put it, "Say Goodbye to 1.5°C." Or as the environmental website Grist asked, "The world's most ambitious climate goal is essentially out of reach. Why won't anyone admit it?"[19] Shannon Osaka of Grist wrote that after cherry-picking a line from the Working Group III: Mitigation of Climate Change Assessment Report that came out in April 2022: "Hidden on page 25 of the 'Summary for Policymakers' was an even grimmer note: That even in the IPCC's most optimistic models, the chances of holding global warming to less than 1.5 degrees Celsius (2.7 degrees Fahrenheit)—compared to the pre-industrial average—is only around 38 percent.... For all intents and purposes, the 1.5-degree threshold has already passed. We just don't know it yet."

All I can say is that I must be reading a different assessment report because I couldn't find that on page 25, and found that the rest of the document laid out a path to staying under 1.5 degrees. It's all in the title: "Mitigation of Climate Change" through greater efficiency, increased use of renewables, and "demand mitigation."

> Demand-side mitigation encompasses changes in infrastructure use, end-use technology adoption, and socio-cultural and behavioural change. Demand-side measures and new ways of end-use service provision can reduce global GHG emissions in end-use sectors by

> 40–70% by 2050 compared to baseline scenarios, while some regions and socioeconomic groups require additional energy and resources. Demand-side mitigation response options are consistent with improving basic well-being for all.

Demand-side mitigation is about asking, "What is enough?" Do we need a pickup when an e-bike might do? Would that leave enough metal and lithium that we could give e-bikes to people who would have their lives improved by them? How big an apartment do I need? How many pairs of shoes? Do I need the latest iPhone? Another word for it is **sufficiency**.

Working Group I studied the physical science basis and concluded, "It's real!" Working Group II looked at the impacts and vulnerability and concluded, "It's bad!" The key takeaway:

> Global warming, reaching 1.5°C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans (very high confidence). The level of risk will depend on concurrent near-term trends in vulnerability, exposure, level of socioeconomic development and adaptation.

Working Group III concludes: "We can fix it!" Climate journalist Amy Westervelt nailed it in her analysis in the *Guardian*: "The report made one thing abundantly clear: the technologies and policies necessary to adequately address climate change exist, and the only real obstacles are politics and fossil fuel interests."[20]

OK Doomer

About a decade ago, climate journalist Dana Nuccitelli described the five stages of climate denial as the IPCC released its fifth round of reports. They were:

Stage 1: Deny the problem exists. We are well past that now, although a few flat-out deniers still exist in comments sections of newspapers.

Stage 2: Deny humans are the cause. There are still a few of these about, still blaming sunspots and claiming that the earth goes through natural cycles.

Stage 3: Deny it's a problem. More CO_2 means more plants! More warming means more Canada!

Stage 4: Deny we can solve it. It's too expensive; it will hurt the poor; it will trash the economy. This is the popular one right now with Lomborg, Shellenberger, and other eco-modernists.

Stage 5: It's too late. When Nuccitelli wrote these, he noted that "few climate contrarians had reached this level." Today, the world is full of what author and climate scientist Michael Mann called "doomists."[21]

> Exaggeration of the climate threat by purveyors of doom—we'll call them "doomists"—is unhelpful at best. Indeed, doomism today arguably poses a greater threat to climate action than outright denial. For if catastrophic warming of the planet were truly inevitable and there were no agency on our part in averting it, why should we do anything? Doomism potentially leads us down the same path of inaction as outright denial of the threat. Exaggerated claims and hyperbole, moreover, play into efforts by deniers and delayers to discredit the science, posing further obstacles to action.[22]

Hannah Ritchie of Our World in Data recently raised the same point, suggesting that doomers were worse than deniers.

> Climate deniers want us to *choose* to do nothing; that it's not a problem and doesn't require any action. Climate doomers tell us that we *don't even have a choice* to do something; we're already screwed and it's too late to act. Follow either and we end up in the same place of inaction. That's a place that we can't afford to be.[23]

Author Jonathan Franzen is a key "doomer," as I prefer to call them, telling Australian radio that "We literally are living in end times for civilization as we know it.... We are long past the point of averting climate catastrophe." Brynn O'Brien, executive director of the Australasian Centre for Corporate Responsibility, responded and is quoted in the *New Statesman*:

> The only people who fall for it are rich white people who think they will be spared until everyone and everything else is gone. His position is unscientific, morally careless (at best) and politically blinkered. Things are very bad and will get much worse. But scientifically and politically there are still so many choices we can and must make to avoid all-out catastrophe, to avoid "end times."[24]

The doomers were out in force when the annual Emissions Gap report from the United Nations Environment Programme was released just before COP27. Everyone piled on one sentence: "As climate impacts intensify, the Emissions Gap Report 2022 finds that the world is still falling short of the Paris climate goals, with no credible pathway to 1.5°C in place." They all then proceeded to totally ignore the two sentences which directly followed: "Only an urgent system-wide transformation can avoid an accelerating climate disaster. The report looks at how to deliver this transformation through action in the electricity supply, industry, transport and buildings sectors, and the food and financial systems." The report then laid out what UNEP Executive Director Inger Andersen called a "root and branch transformation" of our economies and societies, with many of the same "demand-side mitigations" called for in the IPCC report. The emissions gap between where we are and where we have to go can be closed with reductions in demand, living in smaller spaces, switching to lower-emitting modes of transport such as bikes and public transit, eating less meat, and building better buildings. These are again all about sufficiency.

But the doomers have a point when they quote the report. In his book *I Want a Better Catastrophe*, Andrew Boyd tries to put the best spin on being a doomer, suggesting that people and organizations may be putting their best spin on bad news.

Inger Andersen calls for a "root and branch transformation," when she knows it is not happening. Is she just telling people the most hopeful version of the truth, as Boyd suggests? Boyd describes the process:

> Try to be as positive and pragmatic as you can be. Tell the best possible version of events. Focus on the promise and potential of the moment. And fight like hell and hope for the best.

This is the position I have taken: that we know what to do. Otherwise I wouldn't have much of a book here. It's hard sometimes when we see so little progress. As I write this, I am trapped inside a cabin in the woods because the air outside is toxic, full of smoke from forest fires in Quebec. But I am still positive and pragmatic. I am not alone; Professor Kevin Anderson of the Tyndall Centre for Climate Change Research, perhaps one of the direst climate experts, said in a recent interview:

> We are going to fail. We are going to go to 3 or 4 degrees Centigrade of warming and we will have to live through or die from all of the repercussions that that will have. That is a terrible prospect and one that I think we have to try everything to avoid. But the message of hope, if there's any thread of hope in this, is that it is a choice to fail…we can choose a different way out of this. Now whether we can still hold to 1.5, it looks incredibly unlikely to me. But incredibly unlikely doesn't mean it's impossible. It is only impossible if we don't try.[25]

And that is why we are here, to fight like hell and hope for the best. And as the UNEP Emissions Gap report notes, we have to do it now, with every decision we make, to avoid what's called "lock-in":

> Decisions made today can define emissions trajectories for decades to come. For example, a building lasts 80 years on average; a coal-fired power plant 45 years;

> a cement plant 40 years. Pipelines and gas connections create decade-long dependencies. Interventions can also lock in behavior and policies that reinforce incumbent systems. Actions today that lock in a high-energy and high-carbon future for decades must be avoided, including avoiding new fossil fuel infrastructure for electricity and industry, car-centered city or regional planning, and inefficient new buildings. These actions do not always result in immediate emission reductions, but are fundamental for the long-term transition.

Lock-in is disastrous when we are talking such small numbers remaining in the carbon budget and so little time to reduce emissions. But lock-in doesn't just happen at the industrial level with highways and cement plants—it happens at the personal level with the decisions that we make in our own lives. In 2014, when renovating my own home, I bought a new gas boiler to pump hot water to our hundred-year-old radiators. Heat pumps were just too expensive at the time, so I locked myself into gas. People do this every day when they buy new cars or new houses in the suburbs; they are locked into fossil fuels for years to come.

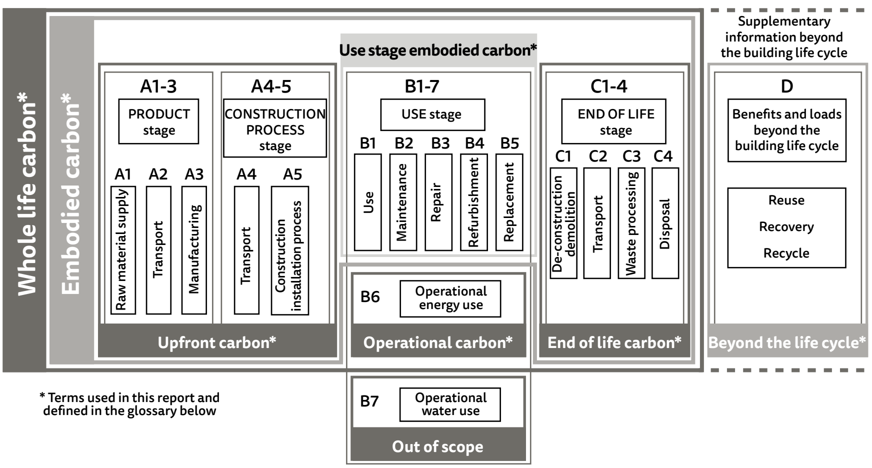
Every giant new pickup truck I see in my neighborhood is lock-in writ large. It seems there should be a Stage 6 of climate denial: "It's happening, it's real, it's someone else's problem, and I don't care."

This is why socio-cultural and behavioral change as well as demand-side mitigation are so critically important. Just as every kilogram of carbon we add to the atmosphere is subtracted from the carbon budget, every new lock-in ensures that we keep subtracting it for years to come.

The Building Industry and Upfront Carbon

The embodied emissions from making the stuff that goes into new construction, concrete, steel, glass, aluminum, and putting it together are responsible for 11 percent of global carbon emissions. With the IPCC calling for reductions in carbon emissions of 65 percent by 2030 to stay under 1.5°C, it became clear that the 11 percent had to be reduced. Architecture 2030 issued a challenge where "The embodied carbon emissions from all buildings, infrastructure, and associated materials shall immediately meet a maximum global warming potential (GWP) of 40% below the industry average today," increasing to 65 percent by 2030 and to 100 percent emissions by 2050.[26] Other organizations hopped on board and governments, particularly in Europe, started demanding data.

Only a small percentage of the profession is doing anything more than paying lip service to reduce upfront carbon, but it is a big enough industry that tools have been developed to measure it. Definitions have also become more precise.



Carbon stages via World Green Building Council

Embodied carbon is now considered to be "the greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials"[27]—basically, everything in the full life cycle of the building, not including the operational carbon (the carbon emitted while operating the building). As shown on this chart from the World Green Building Council, "upfront carbon" is now considered to be the emissions from the product stage, the raw materials, transport to the factory, the manufacture and construction stage, the transport to the site, and the installation. As an aside, this chart and the report it came from was the first to use the term "upfront carbon," and the term is coming into common use in Europe and Canada.

There are now many tools for measuring embodied and upfront carbon in buildings, and life cycle analyses are now often required by some municipalities that have set targets to reduce upfront carbon emissions. These are usually cradle-to-grave studies, but this book focuses on the upfront section, from cradle to installation. And even in the building world, where the issue of embodied carbon is probably as sophisticated as it gets, nobody is quite sure how accurate they are.

Some people are not even sure we are measuring the right thing. Where the World Green Building Council and I include the construction process stage in upfront carbon, carbon pioneer Chris Magwood uses another metric, "Material Carbon Emissions," which only includes the product stage, A1–3 stages, in the table. I asked him why he didn't include A4 and A5, and he told me, "Two reasons they weren't included: They are much less significant than might be expected (3–6 percent of total emissions), and it's impossible to estimate them accurately." He has a point; the transport emissions could be all over the place, depending on the distance from the factory or warehouse. On the other hand, including it has encouraged builders to take delivery of their mass timber by rail rather than truck. And for our purposes, in discussing the carbon footprint of everything, it becomes more important.

The Carbon Footprint of Everything

Every kind of stuff has emitted varying amounts of upfront carbon.

In 2022, I assigned a strange project to my sustainable design students at Toronto Metropolitan University: They were each to pick an object and figure out the upfront carbon from the sourcing of the materials, the manufacture, and the delivery. My intent was that they would get an understanding of the