The Therme Spa: A Carbon Explainer

Prepared by Lloyd Alter/ 15 November 2023

I have been asked by Ontario Place for All to draft an "explainer" about the carbon impact of the Therme Spa and the related parking garage. I am an environmental journalist and a retired architect, now teaching sustainable design at Toronto Metropolitan University, and author of the upcoming book "The Story of Upfront Carbon."

Summary

Consultants for the Therme Spa estimate its "upfront carbon" to be roughly 30,000 metric tonnes of carbon dioxide emissions. I have not seen an estimate for the parking garage, but based on rules of thumb, it could be between 60,000 and 90,000 tonnes of carbon dioxide emissions, yielding a total upfront carbon footprint of close to 100,000 tonnes, equivalent to driving 22,000 cars for a year.

The trees currently store about 840 tonnes of carbon and continue to remove carbon dioxide from the atmosphere. Their removal for the construction of the spa will result in the release of as much as 3,083 tonnes of CO2. Replacement trees will take decades before they are large enough to remove as much CO2 as is currently being absorbed.

With a rapidly shrinking carbon budget to stay under 1.5°C of global heating, many professionals and jurisdictions are questioning the "value for carbon." In the UK, significant projects have been cancelled by the authorities because the proposed

use did not justify the carbon cost. In North America, parking requirements are being eliminated because of the high carbon footprint of building underground parking spaces.

Background

The 2015 Paris Agreement was based on carbon budgets determined by the Intergovernmental Panel on Climate Change (IPCC), which estimated the amount of carbon dioxide and equivalents that could be added to the atmosphere to limit global warming. In 2020, the IPCC calculated that a maximum of 500 gigatonnes was the remaining budget to have a 50% chance of limiting the temperature rise to 1.5°C; a recent study published in Nature Climate Change has reduced that by half.

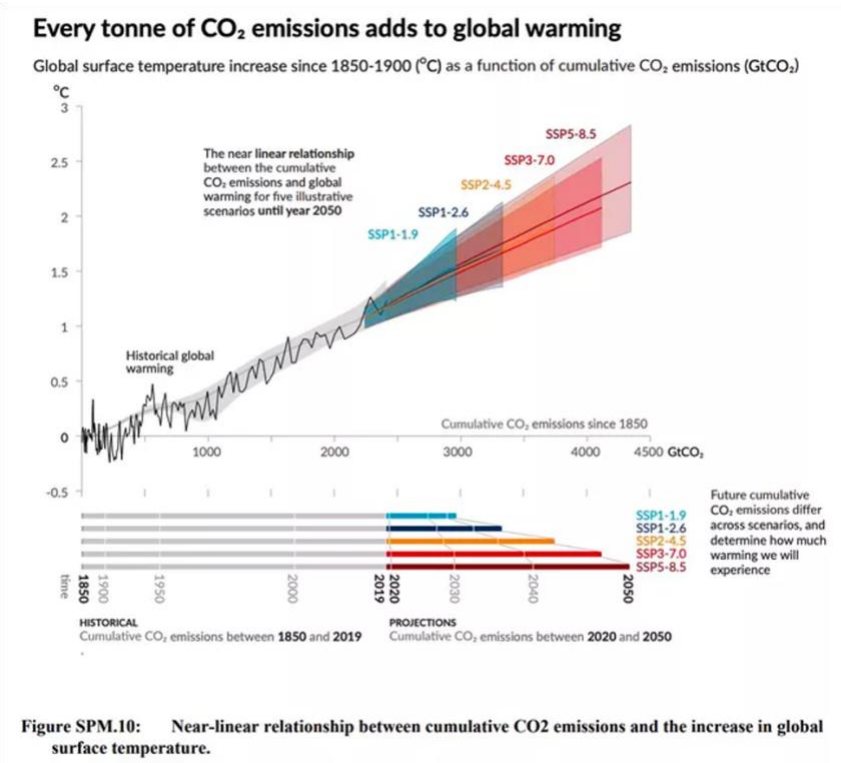


Figure SPM.10: Near-linear relationship between cumulative CO2 emissions and the increase in global surface temperature.

To set a path for carbon reductions, the carbon budgets were interpreted as requiring emissions to be cut by 45% by 2030 and to net zero by 2050, but the

reality is that every tonne of CO2 emissions adds to global warming. This has nothing to do with 2030; it matters now.

For many years, our thinking and our regulations for buildings were based on concerns for energy conservation and minimizing operating energy consumption. There was little concern about what was called “embodied energy,” the energy used to make the materials and the buildings because it was usually small in comparison and was swamped by the operating energy.

When carbon emissions became a concern, the term “embodied carbon” was adopted to describe the carbon emissions “associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure.” It is a confusing term because “embodied” means “included or a constituent part” and the CO2 is not embodied; it is in the atmosphere.

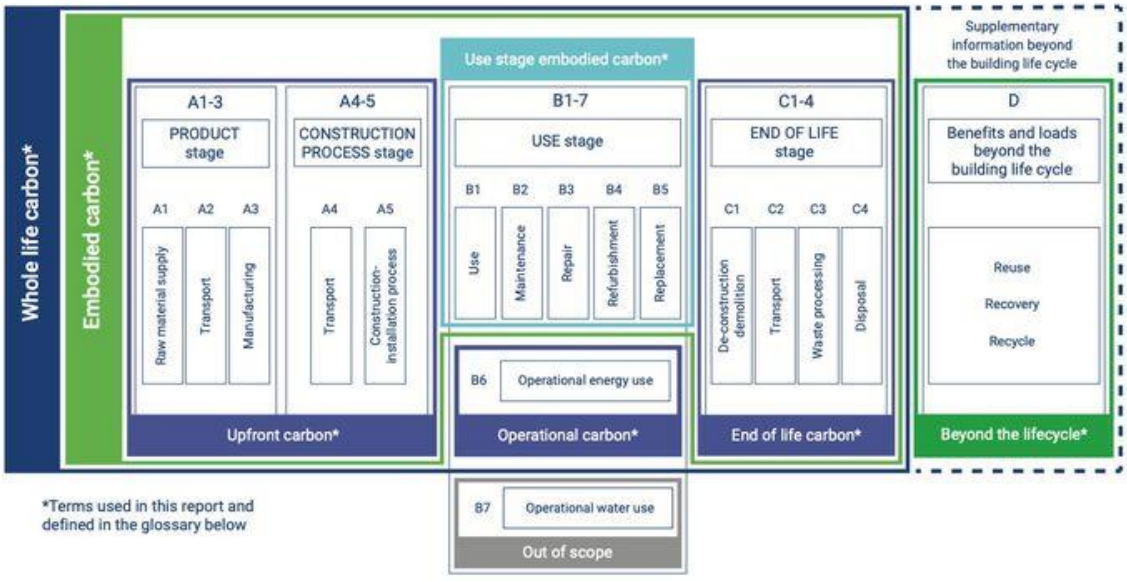
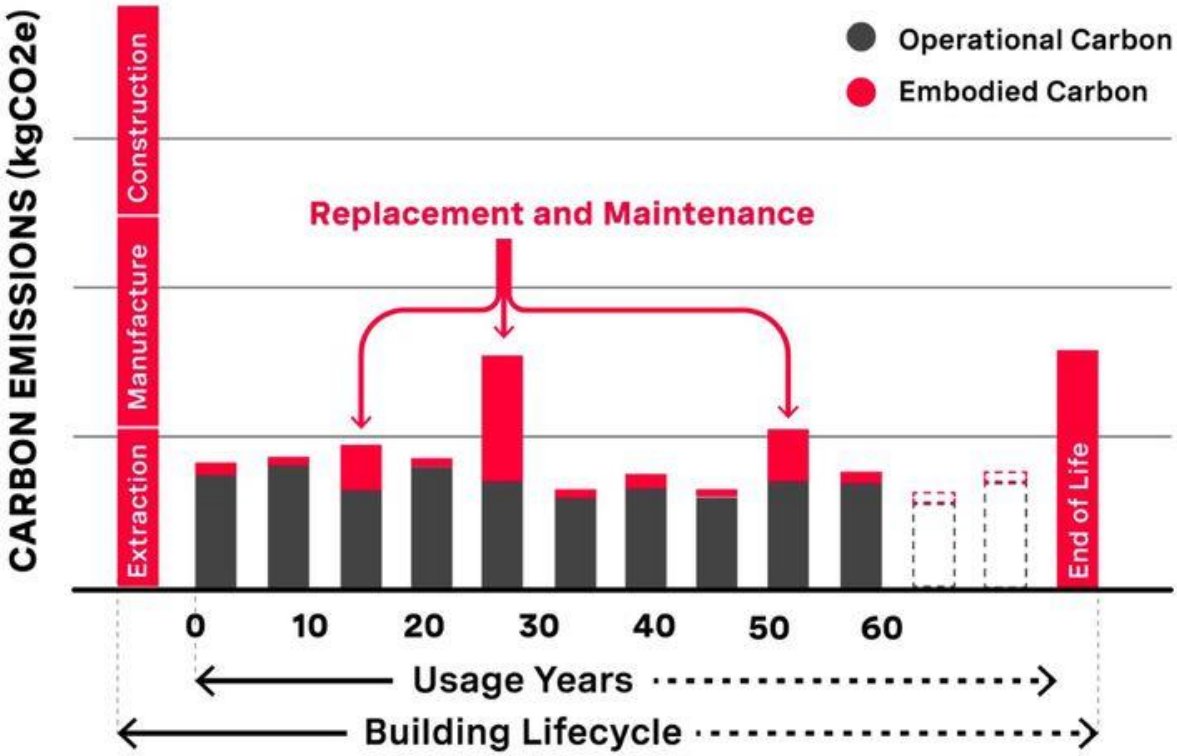


Figure 1: Terminology used in this report cross-referenced to terms and lifecycle stages defined in EN 15978

This is why the term “upfront carbon” is becoming more common as a description of the carbon emissions associated with the materials and the

construction processes prior to the completion of construction. The product stage (A1-3) is often called “cradle to gate” where the product is picked up, and is the majority of the emissions. The construction process, A4-5, delivering product to the site and assembling it, is smaller and often difficult to calculate at the early stages of the project. When added to the product stage, it is sometimes called “cradle to completion.”

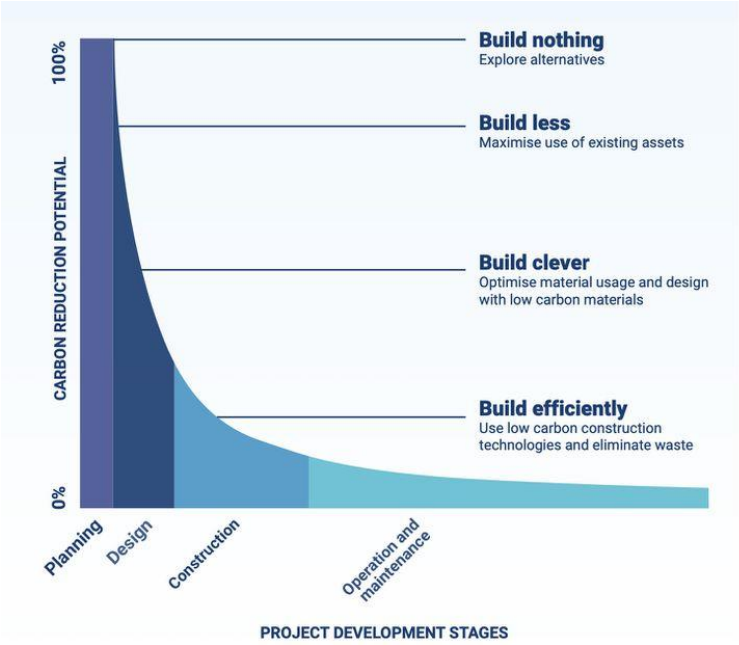


The upfront carbon emissions from extraction, manufacture and construction can easily dominate the emissions of a project, especially in buildings heated and cooled with clean electricity. These are the emissions that are added to the atmosphere now, rather than in the usage years. As architect Larry Strain noted, there is a time value to carbon emissions:

"When we evaluate emission reduction strategies, there are two things to keep in mind: the amount of reduction, and when it happens. Because emissions are cumulative and because we have a limited amount of time to reduce them, carbon reductions now have more value than carbon reductions in the future. The next couple of decades are critical."

IMPACT OF UPFRONT CARBON ON DESIGN AND CONSTRUCTION

I have written, "When you look at the world through the lens of upfront carbon, it changes everything." It is the reason that more buildings are being constructed of mass timber; it has far lower upfront carbon than the more traditional concrete or steel. It's one reason that cities are reducing parking standards; underground concrete parking garages are "carbon icebergs."



Many are adopting the building hierarchy promoted by the World Green Building Council, where the first step is to decide whether you need this project at all, whether you should renovate an existing building, and only then build and with low-carbon materials.

The question of whether one "needs" a project becomes an important value judgement; one might justify the pouring of concrete to build a hospital but question it for, say, a day spa. Similar to questioning value for money, many now question the "value for carbon." This was an issue in the United Kingdom in the decision to kill "The Tulip," a tall tower that was touted as an "educational facility." From the 2021 decision:

Overall, the Secretary of State agrees with the Inspector that the extensive measures that would be taken to minimise carbon emissions during construction would not outweigh the highly unsustainable concept of using vast quantities of reinforced concrete for the foundations and lift shaft to transport visitors to as high a level as possible to enjoy a view."

It is the first known case where a project was cancelled because the upfront carbon emissions could not be justified by the proposed use. Many might say the same could be said about the Therme Spa and the proposed parking garage.

The Parking Garage

Underground parking garages are among the most carbon-intensive building types, and have been called "carbon icebergs" because they are unseen, usually under buildings. In an open letter published in Canadian Architect, Kelly Alvarez Doran noted that in Toronto buildings, "Foundation works, underground parking structures, and below-grade floor area have disproportionate impacts on a project's embodied carbon. For mid-rise and high-rise structures, between 20 to 50 percent of each project's total volume of concrete was below grade."

When asked about the rough carbon emissions per underground parking space, Alvarez Doran told me, "20-30 tonnes per parking space. And add another 10-15 for the bath-tubbing." Bath-tubbing refers to the additional layer of concrete and waterproofing measures when building below the water table. This very rough rule of thumb puts the 2118 parking space garage at Ontario place somewhere between 63,540 and 95,310 tonnes of carbon emissions.

The Therme Spa

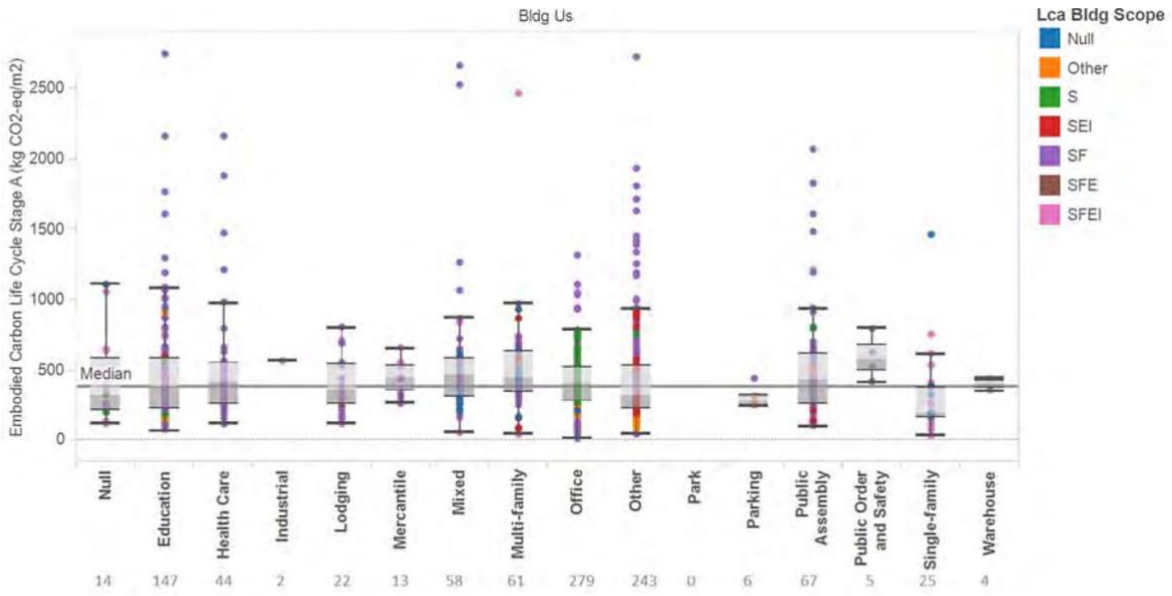


Figure 1: Embodied Carbon per m², no removal of outliers (1,007 buildings)
(S=Structure, SEI=Structure/Enclosure/Interior, SF=Structure/Foundation, SFE=Structure/Foundation/Enclosure, SFEI=Structure/Foundation/Enclosure/Interiors)

NOTE: 54 observations have value greater than 1,000: 953 observations have value below 1,000 kgCO2e/m2.

When I first looked at the question of the upfront carbon emissions of the Therme spa, I looked for comparables and rough rules of thumb, and could find none for a spa. I assumed the closest use to be "public assembly" at the very high end, between 1000 and 2000 kg of CO2 equivalents per square meter, and way above the median of about 450. At 61,342 square meters according to the September 18 submission, that would yield upfront carbon of roughly between 60,000 and 120,000 tonnes.

4.3. Carbon Emissions for Each Life-cycle Stage

Life-cycle Stage				Carbon Emissions from Mandatory Materials (kg CO_2e)	Carbon Emissions from Optional Materials (kg CO_2e)
Upfront	Product	A1	Raw Material Supply	24 858 221	
		A2	Transport (to factory)		
		A3	Manufacturing		
	Construction	A4	Transport (to site)	4 185 912	
		A5	Construction & Installation	1 108 157	
			Total Upfront Carbon	**30 152 290**	

Subsequent to that, I received a copy of the ZBA energy strategy prepared by Ensight Solutions for Therme, in which they calculate the upfront carbon to be considerably less, 30,152 tonnes of upfront carbon emissions, or 491 kg CO2/m2.

4.3.1. Contribution Analysis

Most contributing materials (Global warming)

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)	Sustainable alternatives
1.	Ready-mix concrete, normal strength, generic, C25/30 (3600/4400 PSI) with CEM II/B-V, 30% fly ash content (280 kg/m3; 17.5 lbs/ft3 total cement)	6 336 tonnes CO_2e	25.5 %	Show sustainable alternatives
2.	Aluminium curtain walls, 37 kg/m2	5 109 tonnes CO_2e	20.6 %	Show sustainable alternatives
3.	Reinforcement steel (rebar), generic, 90% recycled content, A615	2 864 tonnes CO_2e	11.5 %	Show sustainable alternatives
4.	Ready-mix concrete, normal strength, generic, C28/35 (4000/5000 PSI) with CEM II/B-V, 30% fly ash content (300 kg/m3; 18.7 lbs/ft3 total cement)	2 848 tonnes CO_2e	11.5 %	Show sustainable alternatives
5.	Steel sheets, generic, 90% recycled content (typical), S235, S275 and S355	2 055 tonnes CO_2e	8.3 %	Show sustainable alternatives

The contribution analysis also shows that the first 5 materials listed out of 25, concrete, steel, aluminum and glass, comprise 77% of the emissions. These are the materials that designers are trying to use less of because they have the highest upfront carbon emissions and with a building like a spa, there are not a lot of better options. The energy strategy report confirms:

"Most of the embodied carbon for the building is in the curtain wall and concrete structure. Significant reductions in embodied carbon are possible with the use of

recycled steel (sheet and rebar). Comparison with benchmarks indicates this project would have a relatively high embodied energy."

Trees and Carbon

The amount of carbon stored or sequestered in trees, the amount released when trees are harvested, and the amount removed from the air by replanted trees is among the most controversial in the built environment world.

Simply put, when trees are living, they remove carbon dioxide from the air, keep the carbon to build more wood and return the oxygen to the atmosphere. Bigger trees have lots of leaves and take in more CO2 than small trees. When a tree is harvested, the absorption of roughly 10 kg of CO2 per tree per year of CO2 stops.

The Koruto Tree Carbon Report for Ontario Place says, "It was determined that the main Therme project plans to remove 100% of the trees in the area, and these would amount to about 450 metric tonnes of biomass, while the total of all proposed removed trees in Ontario Place makes up 84 metric tonnes in total."

The 840 tonnes represent carbon stored in the biomass, not the carbon dioxide absorbed. Based on the ratio of the weight of oxygen to carbon in CO2 (44/12 or 3.67), The CO2 represented by the trees removed is 3,083 tonnes of CO2, absorbed over 40 years, with most of it being recent.

A 2014 study, "Rate of tree carbon accumulation increases continuously with tree size, found that "large, old trees do not act simply as senescent carbon reservoirs but actively fix large amounts of carbon compared to smaller trees; at the extreme, a single big tree can add the same amount of carbon to the forest within a year as is contained in an entire mid-sized tree."

The statement that two trees will be planted to replace each one removed is meaningless; the trees take years before they absorb significant amounts of carbon, and trees planted in the dirt on top of the spa instead of in the ground will likely never grow big.

CONCLUSION

When the British government killed Norman Foster's Tulip, they acknowledged the attempts to make it as green as could be.

"The Secretary of State has taken into account that the schemes would achieve a BREEAM [sort of British LEED] rating of outstanding and acknowledges the enormous lengths to which F+P have gone to make the construction and operation of the scheme as environmentally responsible as possible."

The Energy Strategy report proposes going to significant lengths to reduce upfront and operating carbon emissions, from Passivhaus quality glazing to lake water cooling and heat pumps, and is "targeting" LEED platinum. However, the report also notes, "If insufficient capacity is available from these two sources, then it may be necessary to include natural gas boilers to meet peak demand."

But in a world where we are counting carbon emissions and have carbon budgets, one must look at the bigger picture, whether something is a "nice-to-have" or whether it is a "need-to-have." Between the parking garage and the spa, we have something close to 100,000 tonnes of upfront carbon emissions. Operating carbon emissions won't be insignificant if it uses fossil gas.

That Tulip was killed because the function didn't justify the massive upfront carbon emissions. The Therme spa should be looked at through the same lens: In a

world where we should be counting every kilogram of carbon, can 100,000 tonnes be justified for a day spa?