THWART CLIMATE CHANGE NOW

Reducing Embodied Carbon Brick by Brick

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Dedicated to
Common Sense

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Prologue

"The most alarming of man's assaults upon the environment is the contamination of the air, earth, rivers and sea with dangerous and even lethal materials."[1] Rachel Carson's words in *Silent Spring* referred to chemicals, the massive use of pesticides. The year was 1962. *Silent Spring* provided a catalyst for the modern environmental movement more than a half-century ago spawning grassroots activities across the country. A new consciousness awakened that led to the first Earth Day on April 22, 1970. Twenty million Americans participated in calling for a green environment, and to this day, Earth Day events are celebrated annually around the world. The U.S. Environmental Protection Agency was also founded that year, "born in the wake of elevated concern about environmental pollution."[2] While 2020 marked the 50th anniversary of both, we still face the reality of our current assault on the environment—greenhouse gas (GHG) emissions—as we approach Earth Day 2022.

During those 50 years, we learned that gases emitted while burning carbon-based fuels are just as dangerous to our survival as the indiscriminate use of pesticides revealed in *Silent Spring.* Not only emissions from powering transportation, lighting, heating, cooling, and industrial production, but also those associated with fabricating buildings and infrastructure—from mining and processing raw materials to final construction. Unfortunately, as in 1962, we have been assaulting the environment through complacency. Yet since that time, our drive and technological prowess carried people to the moon and back and remotely directed vehicles across the surface of Mars. Despite our engineering capability and knowledge of sustainable design we ignored the detrimental effects of consumption and pollution, and continue to construct our built environment with such disregard. We continue to consume our planet's resources at an expanding rate, producing waste and pollution in ever-increasing quantities. This is especially egregious considering the commercial availability of clean energy from solar, wind, geothermal, and hydrothermal sources, and because architects, planners, and policymakers have been educated in environmental design strategies. Science and engineering have brought numerous energy-efficient building products to fruition as

1. Rachel Carson, Silent Spring 6 (1962) [hereinafter Carson].
2. EPA History, https://www.epa.gov/history (Dec. 18, 2018).

well as a fivefold increase in insulating capabilities. Though aware of global warming and the impact of GHGs, society continues to ignore the ecological impact of its creative output—of what we design, fabricate, and build. What is wrong with this picture? In 1962, Carson noted the irony that "man might determine his own future by something so seemingly trivial as the choice of an insect spray."[3] Today, ironically, while facing the current crises of global warming and pollution, we draw comfort from green and sustainable design labels, rather than their veracity and efficacy which are the very key to humanity's future. Our love affair with the notion of what we call sustainable and green is palliative. Their mere mention sparks approvals rarely questioned, often feckless like the *Emperor's New Clothes* but regrettably less transparent. It is time to wake up. Too often, the buildings and products we design and construct fail to constitute "sustainable" design regardless of their certification, recognition, or awards received. Too often, their materials and fabrication overuse resources, produce excessive waste, generate pollution, or function inefficiently. This need not be so.

Growth of the built environment presents a significant problem—from new buildings to renovations to retrofits, from temporary structures to infrastructure. After all, what we build today will stand for 50 to 100 years. With 8 billion square feet (7.7 billion m^2)[4] of new construction projected each year through 2030, more than 11 billion metric tons of carbon dioxide (CO_2)[5] will be released to the atmosphere from building operations and new construction—annually. This is nearly 40% of all energy-related carbon emissions worldwide. We have the opportunity to reduce such emissions significantly through serious sustainable design. Given the prevailing knowledge of sustainable and green design techniques, our technical capability, and the media's broad coverage of architectural achievements, one might assume that meaningful emissions reductions have been achieved. Although the proliferation of awards, certifications, fawning reviews, and art installations convey that impression—it is simply not so. Despite substantial gains achieved through the use of light-emitting diodes (LED), energy-efficient appliances, and renewable energy, gains derived from the science of building are severely lacking, with addressing "embodied carbon" emissions among the most overlooked. This failure to take the fundamentals of sustainable design

3. Carson, *supra* note 1, at 8.
4. International Energy Agency (IEA), Perspectives for the Clean Energy Transition: The Critical Role of Buildings (Apr. 2019).
5. IEA & United Nations Environment Programme, 2018 Global Status Report: Towards a Zero-Emission, Efficient, and Resilient Buildings and Construction Sector (2018). According to the report, "total buildings-related CO_2 emissions amounted to more than 11 $GtCO_2$ in 2017." 1 Gt = 1 billion metric tons.

seriously is long overdue for correction. Whether or not Nero fiddled while Rome burned is academic; our present fiddling with future solutions while temperatures rise is real. *Thwart Climate Change Now: Reducing Embodied Carbon Brick by Brick* seeks to shed light on the built environment's unseen emissions and lay a pathway to their reduction "now," before a precarious concentration of atmospheric carbon has been set in concrete. In 1910, the atmospheric concentration of CO_2 reached 300 parts per million (ppm) for the first time in more than 300,000 years. It averaged only 317 ppm in 1960 while Rachel Carson was penning *Silent Spring*—increasing merely 17 ppm over 50 years. The next 50 were less gentle. By 2010, the increase in CO_2 concentration was four times that, and on its way toward 417 ppm in 2021.[6] Keep that in mind as you read this book.

Bill Caplan
September 2, 2021

6. Earth System Research Laboratories' Global Monitoring Laboratory of the National Oceanic & Atmospheric Admin., Ed Dlugokencky & Pieter Tans, *NOAA/ESRL*, www.esrl.noaa.gov/gmd/ccgg/trends. Data for 1910 and 1960 is: *Ice Core Data Adjusted for Global Mean*, *in* NASA Goddard Institute for Space Studies: Forcings in GISS Climate Mode, Well-Mixed Greenhouse Gases, Historical Data (2014).

Introduction

Metaphorically, the path to sustainability was laid "brick by brick."
Buildings emerge "brick by brick."
So do carbon emissions.

Thwart Climate Change Now: Reducing Embodied Carbon Brick by Brick addresses an imperative—to slow the pace of climate change within the upcoming decade; now rather than in the distant future. This can be achieved by significantly reducing the carbon footprint of the "physical" environment we construct and renovate. When future energy supplies worldwide approach "*carbon-free*," atmospheric carbon levels should stabilize—*but what do we do until we get there?* With temperatures continuing to rise, people around the world have taken note. The handwriting is on the wall; human activity has impacted the earth's environment; our climate is already changing. Accordingly, 196 nations signed the United Nations Framework Convention on Climate Change (UNFCCC) known as the Paris Agreement:

> [T]o strengthen the global response to the threat of climate change [by] holding the global average temperature increase to well below 2°C above pre-industrial levels while pursuing a lesser increase of only 1.5°C.[1]

How? By reaching the "global peaking of greenhouse gas emissions as soon as possible" and undertaking "rapid reductions thereafter"; by achieving "a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century"; all within "the context of sustainable development and efforts to eradicate poverty."[2] As such, policymakers, scientists, and engineers around the globe are pursuing the means to limit global warming to less than 2 degrees Celsius (°C) (3.6 Fahrenheit (°F)) while targeting a temperature rise of no more than 1.5°C (2.7°F). Reducing the emissions from electricity generation and the consumption of energy by transportation, agriculture, construction, and building operations has become paramount. Power sources produce more than two-thirds of all global emissions, 40% of those owing to the energy consumed and the byproducts released by *manufacturing building materials,*

constructing buildings, and their post-occupancy operations. In short, our built environment represents the largest contributor to greenhouse gas (GHG) emissions of any sector other than the production of energy itself. Residential buildings—providing shelter—comprises its largest share.[3]

Although society has awakened to the need to address our future through green and sustainable actions, too often the *future-addressing activities* themselves provide a false sense of progress, and with some, more lip-service than follow-through. Beware of manufacturers' public relations and Internet misinformation. Beware of platitudes, awards, and certifications. Beware of the cover of labels such as "sustainable" and "green." Beware of fictitious claims. Many wishful solutions ignore their own inherent environmental cost. Even seemingly emissions-free energy, such as from solar panels, emit greenhouse gases (GHGs) during their manufacture. The same applies to energy-conserving solutions such as triple-pane windows. The elephant in the room is invisible, an *embodiment* of carbon emissions—embodied carbon; the carbon footprint of everything we construct and manufacture. Not a physicality itself, embodied carbon is the realization of a building's carbon footprint from cradle through construction to completion—of GHGs *already emitted, already contributing* to global warming. It also represents the recognition of emissions to come from a building's maintenance and eventual demise. Embodied emissions must be the first tally of sustainability when weighing success or failure—they already abide in our atmosphere, heretofore absorbed. This holds true for every new structure built and every old structure renovated or replaced. By the time a building is ready for occupancy, most of its embodied emissions have been released to the environment. Because this is *fait accompli* on a building's first day of operation without recourse, and it increases the underlying rate of global warming, minimizing embodied carbon in buildings still on the drawing board or already in construction must take priority. Yes, the ultimate solution of zero-carbon energy is on the horizon, achieving that goal on a global scale remains several decades away. Because of that reality, lessoning the buildup of "embodied" carbon at this moment is essential. We must curtail its escalation until the gradual implementation of carbon-free energy gains meaningful traction on a worldwide scale. Embodied carbon is the poison in our dwellings, and in everything else we construct or manufacture.

This problem extends far beyond the growth and renewal of our existing urban and suburban areas; it prevails magnified in developing nations worldwide and in refugee settlements as well. The path from substandard

3. Data and computations from United Nations Environment Programme, Emissions Gap Report 2019 (Nov 2019).

to permanent housing progresses from wood, corrugated metal, and tent structures to more impactful concrete block and brick. The initial increase in embodied emissions to upgrade dwellings for more than a billion poorly housed people will be substantial. The movement of populations from mountainous regions, river valleys, shorefronts, and farmlands to ever-growing urban areas will in turn require vertical housing. Unfortunately, as embodied emissions are related to a building's floor area, they increase exponentially with each added floor of a high-rise residential building. Improved cooking facilities and sanitation will add more, especially for the billion people currently without access to electricity. Little of this has been factored in the mitigation solutions at hand, nor in the modeling of future cities. While we envision futuristic urbanization through a low-carbon lens we cannot ignore its coincident explosion in energy consumption and the emissions embodied in construction. They will continue to grow. With scientists warning we have little more than a decade to decrease greenhouse emissions, we must deal with such curtailment today. As the days of reckoning become more apparent, parsing the efficacy of our near-term actions remains elusive. Addressing tough choices with platitudes rather than substantive action has become the norm, even when confronted with an existential threat.

Creating shelter for survival dates back to early humans and environmental design has been with us in one form or another for several millennia, but the need to address *humanity's impact* on the environment has surfaced only recently. While sustainable and green thinking has been gaining traction for 50 years, the technical prowess to effectively implement their precepts is relatively new. Unfortunately, the commercial exploitation of the terms *sustainability* and *green* has blossomed to obscure their meaningful application. The paths to tackle carbon emissions rely on technology, policy, and politics requiring a long timeline to navigate, with little opportunity to short circuit. Nevertheless, the built environment emerges one building at a time, both large and small. Although total emission reductions depend on the future availability of low-carbon power, the built environment's embodied carbon can be reduced fairly quickly—brick by brick: by the developers, architects, engineers, and designers that dictate its structure, materials, and environmental interface. Attention to embodied carbon in the *design* of our buildings and infrastructure, as well as attention to the impact of embodied carbon in "green" policies and incentives on a local level, can reduce carbon emissions within a decade.

Part One, *Sustainability*, traces the emergence of sustainable design as we have come to know it—its roots, how one perceives it, its efficacy, its role as placebo, and our current quest for zero-carbon energy. Commencing with a reality check, Part One provides the background material and perspectives that illuminate our current situation, elaborating on the development of environmental design, sustainability and green, and the nuances of carbon emissions. It closes with a call for action that addresses the urgency of thwarting climate change now, without waiting for the long-term solutions. The first chapter, Buzzwords & Muddle, reveals sustainable design to be more elusive than one would think. Cherry-picked facts proffer misleading illusions and published assertions are more muddy than clear. Chapter Two, From Instinct to Science; Philosophy to Practice, provides historical insight into the *environment* functioning as a vector of design and the quest for energy conservation over the last three decades. Chapter Three, Parsing Carbon, Sustainability, and Green, elucidates the subtleties of carbon emissions and the concepts of "sustainability" and "green" to add clarity to the current issues at hand. Reality and the Call for Action—the final chapter—explores the issues and dilemmas that must be addressed to retard emissions-induced global warming in real time, while we wait for the future solve-all, zero-carbon energy worldwide.

Part Two, *Thwarting Climate Change*, lays a path forward to reduce the matter-of-fact acceptance of embodied carbon. Clearly stating what we are up against, as well as the role of design decisions, Part Two addresses the emissions impact of design as well as the tools, policies, and legislation needed to reduce net carbon emissions within a decade. The first two chapters, What We Are Up Against; What Must We Do (Chapter Five) and The Role of Design (Chapter Six) target near-term emissions goals by the means of material choice and design methodology, approaches available to every developer and client, and every architect, engineer, and designer. Chapter Seven, Confronting Embodied Carbon Now focuses on the power of policy to reduce embodied carbon emissions throughout the upcoming decade. The discourse addresses the unintended consequences from policies that ignore embodied carbon emissions that fail to consider embodied carbon while calculating their presumed benefits. The final chapter, Taking the Roads Less Traveled, refers to Rachel Carson's rendering of Robert Frost:

> The road we have long been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at the end lies disaster. The other fork of the road—the one "less traveled by"—offers our last, our only chance to reach a destination that assures the preservation of the earth.

The choice, after all, is ours to make.[4]

Taking the Roads Less Traveled provides policy and legislative actions that are critically needed to reduce embodied carbon from now through 2030-2035.

Many terms currently in use describe or indicate the presence or emission of GHGs such as the abbreviations, symbols, and acronyms GHG, CO_2, CO_2eq, "carbon dioxide," "embodied carbon," "carbon footprint," or simply "carbon." They all refer to gases that capture radiant thermal energy and re-radiate a part that warms the earth's atmosphere and surface. Carbon dioxide gas (CO_2), is by far the most detrimental. Methane, although more potent, is emitted in lower volume and primarily associated with agriculture, animal husbandry, and landfills. Nevertheless, the large leakage of methane gas that occurs during natural gas extraction is receiving more scrutiny. Technical studies and scientific papers typically include the impact of methane and other GHGs by rating their "equivalent" global warming potential (GWP) to that of CO_2. The symbol "CO_2eq" serves to group those GHG emissions with CO_2 in order to indicate their emissions collectively. All energy-related GHG emissions referenced in this text, including CO_2eq, are collectively referred to as "carbon dioxide," "embodied carbon," "carbon footprint," "greenhouse gases," or simply "emissions" or "carbon" in order to provide a more legible discussion for a broad readership.

The emission statistics presented in this book have been sourced or computed from a variety of public documents issued by government agencies, international commissions, institutions, and academic studies. As such, small variances may appear due to the differential between CO_2 and CO_2eq, differing term definitions, computation methodologies, or mathematical rounding, none of which alter the conclusions, recommendations, or relevance of this discourse.

In its broadest definition, "embodied carbon" refers to all carbon gases emitted during processing, manufacturing, and fabricating everything we produce. This includes raw material extraction, transportation, installation, maintenance, and a product's eventual discard. Some emissions result from the energy consumed when using carbon-based fuels and others derive from chemistry changes during material processing. Expressed in the mass of emissions released in kilograms or pounds, "embodied carbon" really means "embodied emissions." Internationally, GHGs are expressed in tonnes, a term also referred to as metric tons. One tonne (metric ton) equates to 1,000

4. Rachel Carson, Silent Spring 277 (1962).

kilograms, 2,200 pounds, or 2.2 tons in the United States. A metric ton (tonne) is 10% more than an imperial ton. A gigatonne (Gt) constitutes one billion tonnes or one billion metric tons.

Thwart Climate Change Now: Reducing Embodied Carbon Brick by Brick emphasizes immediacy, acting "now," achieving significant reductions in carbon emissions within 10 to 15 years—from 2020 through 2035. Scientific consensus warns that we must throttle emissions growth within this period before their immediate warming impact will make capping even a 3°C temperature rise unlikely. "Now," meaning *as quickly as possible*, addresses the upfront emissions inherent in producing the materials we select and caused by our design and construction methodologies—those emitted long before society benefits from operational efficiencies or achieves the long-term goal of a carbon-free energy supply. *Thwart Climate Change Now* explains why some green initiatives are too broadly incentivized and may exacerbate current conditions; and why some energy-efficient upgrades, residential solar panel installations, and net-zero buildings might contribute to global warming within their first decade of operation, and therefore should wait. Most importantly, *Thwart Climate Change Now* is a wakeup call for immediate actions that can be initiated with the design of every new building, renovation, or retrofit.