John Cays

An Environmental Life Cycle Approach to Design

LCA for Designers and the Design Market

Springer

An Environmental Life Cycle Approach to Design

John Cays

An Environmental Life Cycle Approach to Design

LCA for Designers and the Design Market

Springer

John Cays
New Jersey Institute of Technology
College of Architecture and Design
Newark, NJ, USA

ISBN 978-3-030-63801-6 ISBN 978-3-030-63802-3 (eBook)
https://doi.org/10.1007/978-3-030-63802-3

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To my family—my parents, John Bennett and Victoria Torres Cays, who taught me and my brother Stephen, and sisters Elizabeth and Kathrine, that there is always enough; my wife Angela who patiently walks with me on the path of living each day simply and sanely; and my daughter Sara who is my absolute favorite person on the planet. Thank you all for giving this journey meaning and joy.

Preface

The designer's primary job is to present compelling synthetic solutions that meet people's needs. Good design, at every scale, wins both hearts and minds. It can stir the emotions while satisfying multiple utilitarian requirements. At this point in human evolution, however, it is necessary—and possible—to do more.

Every 4 days, a million babies are born to families around the world. As more and more people strive for better lives, how do we design a world that not only significantly reduces our already outsized global footprint but also changes negative environmental impacts into positive ones? This is arguably the largest design challenge in the history of the world.

Design professionals entrusted with protecting public health, safety, and welfare, as their primary public charge, can now shape humankinds' response to this challenge. To practice ethically, we must now evaluate each new product's potential to physically impact the earth's ecosystems *throughout its entire life cycle prior* to bringing it into the world. How our species survives and thrives throughout the next 50 years and beyond depends on the individual and collective choices we make about how and what we design, make, and consume.

Science-based design approaches can positively influence those decisions. Life cycle assessment methods and tools can provide a clearer picture of how to optimize individual designs that not only do less harm but also promote healing in our ecosystem. This book clarifies the terms and root causes of the environmental dilemma we face today—the result of market responses to *both* rational and irrational human demands—and presents life cycle assessment (LCA) within this context as an illuminating, data-driven methodology to help designers and their clients make better, evidence-based decisions.

In order to affect positive environmental change, it is not enough to provide facts. Data quality increases our abilities to precisely describe and present realistic solutions to problems that humankind presently faces. Change is possible, but only when design operates with an awareness of the larger context, that is, the constant psychological, political, and economic forces at work. Arguments fueled by fear, mistrust, greed, and inertia, made by the very people for whom we are designing,

can undercut facts and best intentions to sustainably meet the world's design challenges.

Effective and iconic designs typically emerge as elegant manifestations that move people. Today, they must also function to heal the planet. This will require all the ingenuity our species can muster, and it cannot happen without establishing an underlying system, like LCA, to track our progress toward the goal of a truly sustainable marketplace.

That said, design is primarily a visual discipline. Many practitioners, having been educated in schools of art and design, may not be naturally inclined to embrace such technically driven design methods, preferring instead to rely on more heuristic or intuitive approaches. This book will introduce designers to a complementary set of science-based perspectives and techniques that address a global market that increasingly demands proof that things perform ecologically as advertised. Just as good design wins minds by solving people's everyday problems and wins hearts through solutions that move beyond the mere utilitarian to inspire delight, LCA data-supported design solutions win minds through proof and hearts through trust.

While this book will provide some detailed information about LCA, and refers to the latest research in the field, it is not a technical compendium. Rather, it is a bridge for those in the design fields who are uninitiated to but interested in how LCA is helping to solve the grand environmental challenges of today and tomorrow through data-driven, science-based techniques. Since our existential challenges are not merely technical but are also rooted in misperception, misinformation, fear, and confusion, some chapters in the book contextualize the problems for which LCA and related analytical and visualization techniques can provide solutions. Other chapters work to cast LCA as a normal part of the designer's workflow.

Designers and their clients are primarily focused on appearance and performance; environmental impact issues are minor considerations relative to cost, utility, and aesthetics. Billions of consumers playing by traditional rules of the marketplace will only accelerate ecological destruction. Environmentally responsive designs may never be realized if they are cost prohibitive. Complex and expensive regulatory or product certification systems create excuses for not bringing the best solutions to market. Smoothing the path for designers to easily "bake in" invisible ecological benefits to everything they do, at little or no extra cost, requires awareness, understanding, and evolution in twenty-first-century tools and work habits. This book is a guide and an exhortation to work smarter, provide added value to clients, and to make these changes now.

Newark, NJ, USA John Cays

Acknowledgments

I would like to express my sincere gratitude to my colleagues at the New Jersey Institute of Technology and the Hillier College for creating and supporting an atmosphere of free inquiry. To Dean Urs Gauchat who first encouraged me to look into the topic of life cycle assessment and how it might benefit the world in the hands of designers. He insisted that I set aside dedicated time each day to learn and write about this topic to help make the planet better for my daughter, her friends, and their children. To Dean Tony Schuman who continues to serve as an example of an activist scholar. To Dean Branko Kolarevic who enthusiastically made sure I completed the mission. To Provost Fadi Deek, who always gave gentle encouragement to persist in writing a first book.

Special thanks go out to David Brothers, Martina Decker, Christine Liaukus, Darius Sollohub, and Andrzej Zarzycki for their sincere interest in the subject of LCA in design and their perennial invitations for me to introduce it to their design students. Also to Glenn Goldman who encouraged me to think broadly, be curious, and to see the vital connections between design and technology. To Maya Gervits who could always anticipate my questions and needs on which library resources would best lead me to fertile areas of exploration, and also for the generous support she provided with library resources on extended loan.

To Ed Mazria who, well over a decade ago, set the aspirational goal for every student in every university design studio to have a constantly updating digital readout on the ecological impact status of their designs, and to the tireless work of the LCA researchers and practitioners without whose work over the past five decades this would be impossible to achieve.

To my sangha and my teachers, who continue to teach me to be mindful of and advocate for all the vitally important things that cannot be seen. To Cynthia Imperatore who always reminded me that people need more than technical facts to care about something. You are so missed. To Laura Peterson and Lou Kilgore for keeping me going every Sunday.

To the American Center for Life Cycle Assessment community for inviting a wider set of contributors to add their voices and ideas to broaden LCA adoption. Your encouragement, leadership, and messaging makes a tremendous difference.

To all the members of the Springer editorial team who have been most patient and supportive as life and work prolonged delivery of a final manuscript.

To all the design students in my classes over the years who asked honest and earnest questions to learn and practice how to back up their sustainable design claims. And to the skeptical ones who needed to dig deeper to know how we know what we know about our individual and collective impact on this living world. I especially want to thank Erin Heidelberger who followed farther than any Hillier design student and tenaciously persisted in an entire year of rich and challenging dialogue. She appeared at the perfect time in her own soft-spoken but determined way to make meaningful contributions to this book through revisiting a major design studio project, her illustrations, and detailed research on how designers and design students can actually *use* LCA. She is well on her way to help design make a *measurable* difference.

Contents

About the Author

John Cays is Associate Dean for Academic Affairs and Interim Director of the School of Art + Design in the New Jersey Institute of Technology's J. Robert and Barbara A. Hillier College of Architecture and Design. He is a licensed professional architect. He holds a Bachelor of Science in Architecture from the University of the Arts and Master of Architecture from Princeton University.

Prior to cofounding GRADE Architects, an architecture and interior design firm in NYC in 2001, he was a project manager at Robert A.M. Stern Architects. Since 2005, he has been responsible for overseeing the development and use of "Kepler," NJIT's transparent digital repository, and the qualitative data-driven design curriculum management and assessment system. In 2008, Kepler served as the engine behind the nation's first fully digital NAAB accreditation visit. He served as North East Regional Director for the Association of Collegiate Schools of Architecture from 2014 to 2017 and as Director on the National Architectural Accrediting Board from 2017 to 2020. He is an active member of the ACLCA Education Committee.

His research focuses on visualization, translation, and advocacy to increase the adoption and use of quantitative life cycle assessment methods and tools in the design fields.

Chapter 1
Do Nothing: The Danger of Believing in a World Without Limits

Abstract Human desire and ingenuity have shaped the modern world. The natural human need to consume and fears of scarcity drive desire for more and more creature comforts. We must and can improve the way we consume.

The *American Way of Life* is often interpreted as an exhortation to freely pursue individual happiness without regard for physical limits or finite resources. Engendered at the end of the eighteenth century in a new nation, this worldview is rooted in the pragmatic and powerful impulse to satisfy individual well-being at a time when nature's abundance seemed limitless. That idea continues to beckon us to live large. It is still the context in which we consume nearly two-and-half centuries later.

The penchant for planning, making, and consuming is normal; it is what humans do. Yet as technological innovation has removed nearly all natural limits to our species growth, it has also produced myriad, unintended, negative environmental consequences. Reversing these effects requires us to coordinate "best practices" to guide our individual and collective decisions.

New and constantly evolving tools, data, and methodologies reveal our impact on the planet as we design each new product and service. They allow us to quantify, evaluate, and improve the environmental impacts. It promotes system-wide approaches to innovate truly sustainable ways to satisfy growing global demand.

1.1 Living Large: The American Dream

Some of us live large. Not content with mere survival, we take in and give back significantly more than we need to maintain internal physiological balance—homeostasis—in our environment. Every day, more people around the world embrace an ethos of overconsumption. Fueled by imagined, personal, future gains, it is a hedge against suffering that expresses itself as acquisition, a desire for more and more stuff. The starkest expression of this ethos is, perhaps, the aspirational American dream. No longer confined to the culture that coined the term, it is magnified by at least three orders of magnitude as continues to spread across the globe.

While more than half of the earth's seven billion people live on less than $10 per day (Rosling et al. 2020), the number of people able to participate in acquisitional pursuits, representing individuals in every country and culture, is still measured in

J. Cays, *An Environmental Life Cycle Approach to Design*,
https://doi.org/10.1007/978-3-030-63802-3_1

the billions. Meanwhile, the other half live in relative poverty. Forced to live a frugal existence, they demonstrate everyday what the human body needs to survive, the basics—food, water, shelter, and the most basic transportation means. But all people dream. In a connected world, comparisons are ever present and beckon those without to join in the pursuit of more and better.

As we strive to do better on and for our finite planet, it is impossible to take fundamental human needs *and human desire* out of the equation. As designers, charged with manifesting those desires in the marketplace, we can do better for everyone. But without reimagining and redefining what living well means and how more people can reach that standard, our current models will be increasingly unable to support the "self-evident truths" espoused a quarter millennium ago by the framers of the US Constitution. Without a detailed consideration of specific means and methods to sustainably promote them, Life, Liberty, and the Pursuit of Happiness will increasingly diverge as achievable ends for almost everyone.

1.2 The American Way of Life

"Way of life" is a phrase that is, at once, fluid and solid. It implicitly acknowledges processes that respond to conditions along a variable path and, at the same time, forms a fixed, monolithic idea. Our way of life emerges each moment and evolves through the choices we make. It is an organic expression of what is possible within the complex set of perceptions, circumstances, and forces that simultaneously allow and limit its progress. The way emerges from its conditions just as a river flows through terrain, guided by forces of gravity and friction that work as part of much larger cycles.

In the United States, politicians from both dominant parties invoke "the American Way of Life" as a solid and singular thing that we must, at all costs, protect and preserve. Coined by James Truslow Adams, the term captures such concepts as "bigger and better" and "a better, richer, and happier life for all citizens of every rank" (Adams 2017) and has provided a powerful metaphor throughout the twentieth and into the twenty-first centuries. Barak Obama launched his 2008 presidential bid by sharing his "thoughts on reclaiming the American dream" and extending it to people who felt they had lost or never had the ability to realize it (Obama 2006). Eight years later, Donald Trump built an ultimately successful campaign on promising his electoral base all the material trappings of what it represents. The candidate, who is out of touch with how far people feel they are from attaining all its promises, risks losing an election. It has proven to be a powerful ideal that is firmly set in the minds of most people, not only in the United States but also around the world. It implies both expectations and behaviors of free individuals earning a livelihood and pursuing happiness.

1.2.1 The Pursuit of Happiness

Written into the first sentence of the Preamble to the US Declaration of Independence, "the Pursuit of Happiness" is an aspirational and beguiling principle that has propelled the American Way of Life ever since it was penned. It promises every citizen the possibility of attaining *security, comfort,* and *prosperity*. What has followed, since the founding fathers codified the powerful open-ended notion in the summer of 1776, is an unrelenting pursuit that continues to manifest as consequences and byproducts.

"The Pursuit of Happiness" as a key principle is most compelling perhaps because it does not consider any external effects or limits. It says nothing of means or costs to be considered in the pursuit. It was written at a time when the world seemed limitless and foresaw only benefits to both the individual and the growing community through the development of new enterprises. A steady increase in negative ecological impacts, however, closely correlates with the burgeoning wealth that was created from the end of the eighteenth through the start of the twenty-first century.

1.3 No Going Back: Impossible to Do Nothing

Many blame modern political, social, and economic structures for all woes and suffering on the planet. Some advocate for a complete "reset" through various means, implemented either gradually or suddenly. It is, however, impossible to stop or move backward to "a simpler time." Even if every one of the nearly eight billion people alive today were to agree to simply stop, to abandon the chase altogether in order to reduce our collective impact on the planet to zero, we must realize that it is impossible to actually *do nothing.*

To be requires the human body to ceaselessly do something. Even before we are born, we are each, already, doing something. From soon after conception until we take our last breath, we take oxygen and nutrients into our bodies and expel waste. Sitting perfectly still, even sleeping, the body must consume energy and resources to live. All human beings alive on the planet today *take in and give back* each second of each day we are alive and beyond. Only death can stop our ceaseless consuming and release the stored biochemical energy in our bodies to dissipate back into the larger ecosphere over time. An incalculable number of other organisms, large and small, inhabiting the land, sea, and sky, also take in and give back. It is what defines being alive and part of the earth's *ecosphere*.

1.3.1 Humans in the Ecosphere

The earth's ecosphere, of which we are a small but disproportionately active part, is a self-contained system powered by the sun. This interconnected network and its support system reaches through the rock and soil under our feet, permeates the deepest ocean waters, and extends high into the thinnest air. This system maintains a dynamic equilibrium. It self-regulates through short weather cycles as well as longer climate patterns. As these natural cycles and patterns shift and change over time, life becomes easier for some and harder or impossible for others. We are one of millions of species that have evolved, adapted, and survived as the earth has cooled or warmed throughout the ages.

Several distinguishing behaviors make us, perhaps, the most adaptable species to a changing climate of all life forms alive today. We *think*. Abstract ideas, concepts, concerns, and plans occupy nearly every waking hour. We *express* ourselves. We communicate our thoughts, feelings, and perceptions about our world and our place in it through signs and symbols. The largest and most lasting physical impact, though, comes from how we *act* and what we *make.*

Our collective actions physically transform the ecosphere. The things we make persist through time to form a complex support infrastructure called the technosphere. As an artificial subset of the ecosphere, it disrupts and delays the impact of natural forces to break apart and recycle things back into constituent elements and compounds in forms typically found in nature.

1.3.2 Creating the Technosphere (30,000 BCE)

Over the last trillion seconds, we humans have been recording and sharing our experiences; our ancestors drew the earliest records of human activities in caves a little over 30,000 years ago. Since then, we have formally manifested our ideas through an increasing array of physical and, very recently, virtual media. We started in earnest *only* around a trillion seconds ago, setting ourselves apart from the rest of nature by not only manipulating nature to satisfy our individual and collective desires but also by recording the details of what and how we lived and did things using the most durable media available to paint on the walls of caves (see Fig. 1.1). Thus, our growing technical abilities have allowed us to become much more than a simple collection of individuals progressing through our own *purely* biological life cycles. Our species' ambitions and appetites have grown over the millennia along with our technical means satisfy them. We continue to invent new ways to provide for our growing numbers. As our ability to feed, clothe, house, medically treat, communicate with, educate, and entertain ourselves increases, so does our collective rate of taking in and giving back—with significant negative implications for us and for the interconnected web of living beings.

Fig. 1.1 *Fragment of* prehistoric cave painting using earth pigments in the "Hall of the Bulls" at Lascaux (28,000–17,000 BCE). The cave is located in the Aquitaine region of France, in the Dordogne department in the commune of Montignac. (Image courtesy of Peter 80 (2005), CC Attribution-Share Alike 3.0 Unported license)

Fig. 1.2 The Black Marble. Lights burn steadily every night as glowing embers on a continental scale. (Image Credit: NASA Earth Observatory image by Joshua Stevens, using Suomi NPP VIIRS data from Miguel Román, NASA's Goddard Space Flight Center (2016))

As humans, we continuously develop new technologies that allow us to ever more effectively magnify our ideas and turn them into objects, large and small, in the physical world. Mastery of science, economics, and design and a steady supply of abundant energy and raw materials allow us to turn pockets of night into day (Fig. 1.2) and have allowed some to realize their most complex plans in order to make and distribute nearly anything wherever and whenever they want at massive scales and in annual quantities counted in the billions and even trillions.

Every invention comes from the rational impulse to address a real human need. Each thing we synthesize from natural elements, then use and dispose of, comprises and then "lives" in the *technosphere,* the sum total result of all human activity on the planet. We constantly remove and transform elements from the ecosphere. We harness the embodied energy of animals, plants, and minerals for our own use every day. The instant we tap any biological, geological, hydrological, or atmospheric element as a resource to make something, it begins its own *artificial life cycle that* ends when it either gets repurposed or eventually completely "metabolized" by natural forces back into the ecosphere.

1.3.3 The Holocene (11,700 Years)

Over approximately the last 12,000 years, since the end of the last Ice Age that roughly defines the Holocene Period, icy glaciers retreated and human civilization flourished. As human populations grew, migrated, and permanently occupied an increasingly ice-free world, so did human ideas and technology. Individual inventions multiplied and coalesced into two intertwined parts of our technosphere. One is composed of supportive and useful objects, the celebrated inventions that make life safer and more comfortable; the other is the sum total of what we have tried, unsuccessfully, to throw away, our waste.

We are all now dependent on massive and inherently complex systems built to support and improve human life. As appealing as it may be to some, there is no quick transition to simply stop and go back to "a simpler world" devoid of modern technology without increasing physical suffering and shortening the lives of most people living today. Watching what happens when the power goes off for a week or even a few days in our metropolitan areas gives insight to the difficulties that arise. Without the energy and communication infrastructure on which civilization has come to rely, it can mean the difference between life and death for some (Anderson and Bell 2012) Rather than attempting to radically eschew complexity and its inherent challenges and contradictions, the key to our surviving and prospering on this planet is our continuous and successful technological adaptation to changing conditions.

This is not to say that all technology is inherently good (or bad) or that we can suspend thoughtful judgment on the long-term implications of our actions. The technosphere is now inextricably woven into the structure of the ecosphere. It is now an artificial "second nature" to those of us who depend on its systems to support our habits and choices concerning where and how we live in a contingent and uncertain world.

1.3.4 Human Civilization (2500 Years)

The codependent and ephemeral nature of human existence has been a central tenet in both Eastern and Western philosophical traditions from Classical Antiquity. From Hinduism's concept of Samsara (Rodrigues 2006) to the teachings of the Buddha on impermanence (Hanh 1999) and Heraclitus's doctrine of universal flux (Heraclitus 2020 Patrick trans.) for the last quarter of the Holocene interglacial period (2500 years), as human civilization has developed and human thought has evolved, so has the understanding that *change* is the one constant on which we can depend. Civilization has simultaneously built increasingly stronger hedges in an attempt to protect ourselves from life's uncertainties.

We have developed practices, habits, and complex systems, through which we relate to the unpredictable and hostile natural world. Large-scale technological advances in areas including agriculture, energy production, medicine, transportation, and building systems are effective guards against discomfort, insecurity, and scarcity; however, successfully mitigating the vicissitudes of an unmediated existence in the wilderness comes at a price. As these artificial systems have acted to stabilize the conditions in which humankind can survive and grow, they have also accelerated the pace and increased the degree of change in natural systems during this same period.

1.3.4.1 Increases in Population Magnify Impact

As our numbers multiplied at least 50 times over the same 2500 years, from approximately 125 million globally (roughly the size of Japan's current population) to the current number approaching 8 billion, our geographic reach spread over every continent and climate. The ingenious solutions that have allowed us to survive and thrive in places where we are not biologically adapted to live come at a cost. Living in these places is made possible, almost entirely, by extracting natural resources and setting them on fire to generate energy (Fig. 1.3).

This continuous extraction and burning has taken place for hundreds of millennia since we were living in caves. It started the moment our ancestors first harnessed fire. Our latest evolutionary stages were influenced by the fact that they could gather and do things beside a fire where and whenever they chose to build one. For a half million years or more, according to infrared dating techniques, even before our species evolved into modern *Homo sapiens*, our forbearers collectively demanded more of the physical comfort and security that fire provides (Berna et al. 2012). This also allowed them to move into areas that were too cold to inhabit without a controlled and dependable heat source.

Fig. 1.3 A coal power plant in Datteln, Germany. Per capita energy consumption rose by 33 percent between 1990 and 2005. Between 2005 and 2030, per capita energy consumption is expected to increase another 18 percent, meaning that global consumption will rise by 50 percent. The majority (86 percent) of the world's energy needs are met by fossil fuels. (Photo Credit: Arnold Paul | Wikimedia Commons)

1.3.4.2 Urbanization

More than half of the world's population live in cities today. As the world continues to urbanize, in order to support billions more people, we will do nearly anything to continue keep the fires burning for our families and ourselves. Viable human settlements have always needed fire in order to exist. But the type, quantity, and byproducts of the "fire" we now use have far-reaching environmental implications.

Without the continuous burning needed to house and feed people; to heat and cool our homes; and to make, transport, and store our daily necessities, every major city in the United States today would be either uncomfortable or completely uninhabitable for at least part of the year.[1] As the burning continues and increases to power nearly every growing hamlet, village, town, and city around the globe, we are witnessing global-scale changes affecting the fundamental conditions on which most life depends.

[1] The only exceptions of which I am aware may arguably be San Diego, Los Angeles, and Long Branch, CA. These Southern California cities current temperate climate could support a small fraction of the US population without relying on the fruits of technology to maintain year-round thermal comfort. However, abundant fresh drinking water, a steady food supply, advanced medicine, and all other technology-dependent basic systems would still require energy to function.