

THIRD EDITION

THE
GREEN STUDIO
HANDBOOK

Environmental Strategies for Schematic Design

ALISON G. KWOK, AIA + WALTER GRONZIK, PE



THE GREEN STUDIO HANDBOOK

The Green Studio Handbook remains an essential resource for design studios and professional practice. This extensive and user-friendly tool presents practical guidelines for the application of green strategies during the schematic design of buildings. Students and professionals can quickly get up to speed on system viability and sizing. Each of the 43 environmental strategies includes a brief description of principles and concepts, step-by-step guidance to integrate the strategy during the early stages of design, annotated tables and charts to assist with preliminary sizing, key issues to consider when implementing the strategy, and pointers to further resources. Ten new in-depth case studies illustrate how diverse and successful green buildings integrated design strategies and how the whole process comes together. This third edition features updated tables and charts that will help to save energy, water, and material resources during the early stages of design. More than 500 sketches and full-color images illustrate how to successfully apply strategies. A glossary, a project index listing 105 buildings in 20 countries, updated tables and drawings, and I-P and SI units increase the usefulness of *The Green Studio Handbook*.

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ENVIRONMENTAL STRATEGIES FOR SCHEMATIC DESIGN

Third Edition

Alison G. Kwok and Walter Grondzik

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CONTENTS

Acknowledgments	vii
Preface	ix
CHAPTER 1 Green	1
CHAPTER 2 The Studio	9
CHAPTER 3 The Handbook	25
CHAPTER 4 Design Strategies	29
Envelope	31
Site Analysis	33
Insulation Materials	41
Strawbale Construction	47
Structural Insulated Panels	53
Glazing	59
Double Envelopes	65
Green Roofs	71
Lighting	77
Daylight Factor	79
Daylight Zoning	85
Toplighting	91
Sidelighting	97
Light Shelves	103
Internal Reflectances	109
Shading Devices	115
Electric Lighting	123
Heating	129
Direct Gain	131
Indirect Gain	137
Isolated Gain	145
Active Solar Thermal Energy Systems	151
Ground Source Heat Pumps	157
Cooling	163
Cross Ventilation	165
Stack Ventilation	171
Evaporative Cool Towers	177
Night Ventilation of Thermal Mass	183
Earth Cooling Tubes	189
Earth Sheltering	195
Absorption Chillers	201
Energy Production	207
Plug Loads	209

	Air-to-Air Heat Exchangers	213
	Energy Recovery Systems	219
	Photovoltaics	223
	Wind Turbines	231
	Microhydro Turbines	239
	Hydrogen Fuel Cells	245
	Combined Heat and Power Systems	251
	Water and Waste	257
	Water Accounting	259
	Water Reuse/Recycling	269
	Water Catchment Systems	275
	Pervious Surfaces	281
	Bioswales	287
	Retention Ponds	293
	Living Machines	299
	Composting Toilets	303
	CHAPTER 5 Case Studies	307
	A Roadmap to Strategies and Case Studies	309
	Centre for Mathematical Sciences	311
	Council House 2 (CH2)	317
	Exploratorium	325
	GRoW Home Decathlon House	333
	NASA Sustainability Base	341
	Rocky Mountain Institute Innovation Center	347
	SOS Children's Village	355
	Stellar Apartments	361
	Techstyle Haus	371
	ZEB Pilot House	377
	APPENDICES	383
	1. Before You Commit to a Strategy	383
	2. Estimating Design Heat Loss and Cooling Load	387
	3. Psychrometric Charts	391
	4. Glossary of Buildings	393
	5. Glossary of Case Studies from the 1st and 2nd Editions of <i>The Green Studio Handbook</i>	397
	6. Going Green . . . and Going Greener	399
	7. Glossary of Terms	401
	Index	415

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This edition is dedicated to the memory of Michael Toland Grondzik (1976–2016) and to the aspirations of his amazing sisters: Kelsey, Nikki, and Tasha.

Alison G. Kwok and Walter T. Grondzik

PREFACE

The first two editions of *The Green Studio Handbook* were written to serve as a reference guide—as well as a source of inspiration for students in design studios and architects in professional practice. This book was founded upon the premise that there would be more green buildings if the technics of green—the underlying strategies that save energy, water, and material resources—were more accessible to the designer. This premise remains the driving force behind the third edition.

A student should find *The Green Studio Handbook* a useful introduction to green design strategies and the associated green design process. An architect, already convinced of the merits of green building and familiar with design process, can use the *Handbook* as an accessible supplement to augment his/her basic knowledge of green building strategies.

The Green Studio Handbook is not intended to serve as a green building checklist, nor as a textbook for environmental technology. Instead it provides the information needed to make judgments about the appropriate use of green strategies and to validate design decisions regarding these strategies. It also provides tools for preliminary sizing of strategies and their components during the early, schematic stages of design. We hope designers will be able to realistically incorporate such strategies in their schematic design work. Project aesthetics are left to the designer and project context, but numerous examples illustrating the application of strategies are provided to spark ideas and encourage implementation.

Each strategy in *The Green Studio Handbook* includes a description of principle and concept, suggestions for integrating the strategy into a green building, step-by-step procedures to assist with preliminary sizing of components, and references to standards, guidelines, and further information. Conceptual sketches and examples illustrate each strategy. To further the goal of integrative design, each strategy is linked to relevant complementary strategies.

The Green Studio Handbook is intended for use in university design studios and/or seminar courses and in professional office practice. Astute building owners might also use this book as a way of becoming better informed about green design projects. The focus is upon strategies that have the greatest impact on building form and that must be considered very early in the design process. The book assumes that users have a basic knowledge of environmental technology and the design process and access to conventional design resources such as sun path diagrams, material R-values, thermal load calculation information, lighting standards, air quality guidelines, and the like.



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CHAPTER 1

GREEN

Green is an important word—it represents one-third of the main title of this book. More critically, green is an important adjective—it accurately describes the limits of what a resource such as this book can rationally and honestly address at this point in time. Green is worthy of discussion.

It would have been easy to name this book *The Sustainable Studio Handbook*. Sustainable, unfortunately remains undefined by the design community in any day-to-day operational sense. There is no way (even today) to rationally demonstrate that a building is sustainable. It is, however, woefully easy to claim so. We do not want this book to contribute to the essentially meaningless babble about “sustainable” features, “sustainable” systems, and/or “sustainable” buildings that is so common in design circles today. We *do* want to contribute to the ability of designers to produce high-performance green buildings. Sustainability will (and must) come—but it must do so rationally and not through self-assured and totally mistaken declarations of victory that would make the Federal Trade Commission cringe.

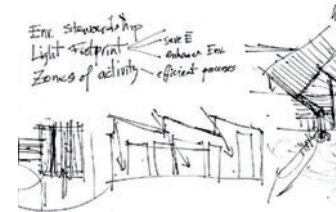
Green building design, on the other hand, is a fairly well-defined and understood concept. This has not always been the case, but the development and ready adoption of numerous transparent rating systems (such as LEED, Green Globes, the Building Research Establishment’s BREEAM, Smart Homes, Built Smart, EcoHomes, ASHRAE Standard 189, the International Green Construction Code, and others) have allowed the design professions to use the term “green” with confidence and assurance. This confidence extends to discussions with clients and the general public. If a project is claimed to be green, “prove it” would be a reasonable client request. Such proof may be burdensome and expensive to assemble, but the quest for verification—against a generally respected national or international benchmark—is not an impossible task.

We define a green building as one that complies with the minimum requirements for certification under one of the several available green building rating systems (such as those noted above). Sustainable buildings are another story. Sustainable is still over the horizon—aspirational, but not operational.

Relative to green buildings, which rating system is used is not of too much importance. This book is not intended to directly assist in the building certification process; it is intended to assist with the design of more environmentally-responsive buildings. Having said this, however, it is useful to discuss green building certifications in order to get a feeling for this powerful force that is causing a serious rethink of building design and performance.

Green Building Rating Systems

Introduction. How does a designer decide which strategies to use? How green will a proposed project be? How can design and construction practices



1.1 Exploring intentions with an initial gestural sketch. ALEX WYNDHAM

be changed to produce greener buildings—that may eventually lead to ever-higher performance and eventually sustainability? Rating systems can offer design guidance, serve as a decision-making tool, provide metrics by which to assess environmental impact, and act as a lever for change. Used skillfully, rating systems can promote a more integrated design process, reduce environmental impacts and life-cycle costs, and prompt major changes in the building industry. But like any powerful tool, rating systems can be used clumsily or be misunderstood. In such instances they may lead to unrealistic expectations, added project costs and complexity, and may be blamed (instead of the design team) when a building does not perform as expected.

Just as designers grapple with the emerging technologies and long-standing strategies described in this book, they also grapple with the evolving language and shifting requirements of green building rating systems. As strategies are evaluated for their suitability for a given project, so may the framework provided by a particular rating system be evaluated for applicability to a particular project.

Rating Systems Context. Since the Code of Hammurabi, written around 2000 BCE, laws have governed some aspects of building as a means of protecting human life. Architects and engineers are legally bound to protect the public's health, safety, and welfare, and governments have adopted codes that define exactly how this is to be achieved. To some extent such codes have made our buildings greener by requiring ventilation, windows, or insulation and prohibiting certain harmful toxins/practices (such as asbestos, lead paint, and chamber pots being emptied onto a street). The public's concern for health and welfare, however, is always tempered by countervailing concerns for the cost of building.

Standards and guidelines have a different status than codes. Codes are adopted and enforced by some governmental body (a country, a state, a municipality). Standards and guidelines are enforced by contract law to the extent that they are written into specifications and professional services agreements for building projects. Guidelines are generally not as refined as standards. Often some aspect of design guidance will start as a guideline, be refined into a standard, and eventually be adopted as a code. Most (but not all) green rating systems currently reside at the guideline stage, but they make reference to accepted industry standards in many performance areas in order to avoid reinventing the wheel.

In the long history of codes and standards, green rating systems were born yesterday. Mid-twentieth-century writers, such as Aldo Leopold, began to articulate a land ethic that values conserving nature, not just for what it supplies us, but for its own sake. Rachel Carson's (1962) *Silent Spring* exposed how our industries produced chemicals that accumulated in wildlife and plants—to the point where human health and survival were at risk. The OPEC oil embargo of the 1970s jolted Western society and spurred the building industry to improve energy efficiency. Codes requiring better insulation and reduced infiltration/ventilation were quickly implemented (beginning with ASHRAE Standard 90-75).

With relatively little understanding of how building equipment and assemblies interacted in a complex system, these early code requirements often had the unintended consequence of producing sick building syndrome. Water vapor and off-gassing of volatile organic compounds from carpets, paints, and glues went unnoticed in leaky, well-ventilated buildings; but tight buildings allowed

mold growth and chemical concentrations to trigger widespread illness. Essentially, it became clear to many that environmental responsiveness involved more than reduced energy consumption.

For many years, legislation was the primary tool of green building (green environment) advocates. The Clean Air Act, the Clean Water Act, and the Endangered Species Act passed in the 1960s and 1970s allowed environmentalists to challenge development seen as threatening the environment and human health, but this approach led to a legacy of confrontation between development and the environment that lasted many decades. When a wave of concern for environmentally-responsive buildings entered the collective consciousness in the early 1990s many unsubstantiated (and unsubstantiable) claims about building (and designer) performance were made. Thus was born the idea of a green building rating system.

A Sampling of Rating Systems

BRE Environmental Assessment Method (BREEAM) is a voluntary rating system for green buildings that was established in the UK by the Building Research Establishment (BRE) in 1990. Since its inception, it has grown in scope and dispersed geographically, being exported in various guises across the globe. Its progeny in other regions include LEED and Green Globes in North America and Green Star in Australia.

LEED began in the United States in 1993 with the formation of a building industry coalition to promote green building strategies and shift the market toward greener products and systems. Using BREEAM as the foundation, LEED sought to dangle a carrot in front of the building industry instead of threatening it with the stick of legal action.

Version 1.0 of LEED (a voluntary, third-party rating system) set a benchmark for green buildings and addressed the growing problem of “green washing.” Buildings designed to code are sometimes described as “the worst building you can build without going to jail.” LEED upped the ante by establishing performance levels above code minimums. Since its early focus on institutional/commercial buildings, LEED has expanded its coverage to a wide range of building types. Buildings achieve LEED certification based primarily on their potential (as revealed through design and construction documentation—versus their in-use performance), and are intended to represent the upper 25 percent of the market in terms of environmental performance.

LEED has been criticized for not being based in whole or in part on actual performance. As the first rating system to achieve widespread acceptance in the United States, many believe it would not have been so widely adopted if in-situ performance tracking had been central to the ratings.

The Green Globes rating system began in 1996 as a Canadian rating system based upon BREEAM. It was adopted by the Green Building Initiative (GBI) for use in the United States in 2002, partly to provide an alternative to LEED. It is intended to provide greater flexibility to design teams with less administrative effort and cost.

The system was initially criticized for being less rigorous than LEED since it relied more on self-reporting of green measures and the governing body was seen as being influenced by industry groups that provided much of the

initial funding and administration. As the standard evolved, it included more rigorous third-party review and the governing body expanded to represent broader input from the design and construction fields.

Much of the debate between advocates of LEED and Green Globes has focused on the issue of certification of wood products. LEED has historically only accepted the Forest Stewardship Council (FSC) certification for sustainably harvested wood, while Green Globes has adopted the Sustainable Forestry Initiative (SFI) standard. SFI was developed with support from the forest products industry, and has been criticized for being less rigorous than FSC.

The Living Building Challenge was launched in 2006 and is managed by the International Living Future Institute after development by the Cascadia Region Green Building Council, a chapter of both the U.S. Green Building Council and the Canada Green Building Council. The program was conceived as a means of complementing LEED (and other rating systems) while challenging the industry to move as close to a “fully sustainable” building as possible. Using the metaphor of a flower, the Living Building Challenge (LBC) is comprised of seven performance areas or ‘Petals’: Site, Water, Energy, Health, Materials, Equity, and Beauty. Petals are subdivided into a total of twenty Imperatives, each of which focuses on a specific set of issues.

The LBC may have set the highest bar yet for green rating systems: it seeks to create buildings that, like a flower, are autonomous and regenerative. It starts with the concept of “triple-net zero” where a project generates all of its energy on site with renewable energy systems such as photovoltaic (PV) or wind, harvests all of its water from the precipitation that falls on the site, and processes all of the water and sewage that leave the site. Materials containing chemicals on a “Red List”—such as PVC, formaldehyde, and phthalates—are prohibited, except where no alternatives can be found. Rather than choosing from many optional credits, projects must demonstrate they meet all 20 program requirements by showing a full year of operating data.

As both an aspirational challenge and a tool for promoting change, the LBC allows for some exceptions where projects are unable to negotiate code exceptions or find products that meet the requirements. A limited number of projects have been certified at the time this was written; but that is to be expected for an aspirational rating system.

ASHRAE Standard 189, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*, was released in 2009. Its aim is to create green building guidance written in the prescriptive language and format of a standard that can be adopted as code or referenced in specifications. Developed jointly with the U.S. Green Building Council (USGBC) and the Illuminating Engineering Society of North America (IESNA), the Standard 189 committee also includes stakeholders from the design, construction, and manufacturing industries.

With many similarities to LEED, the standard represents the next step in the progression from guideline to standard to code that signals a maturing body of knowledge and practice. Standard 189 is updated on a regular basis (not necessarily the case with LEED or Green Globes) and is likely to merge with the International Green Construction Code in the near future.

The Passive House (Passiv Haus) “standard” was developed in Germany as an extension of the “super-insulation” movement of the 1970s. The

standard functions much like a rating system in that it provides design guidance, a performance modeling tool, and performance requirements for air tightness that require an integrated, systems approach to building design. The objective is very high levels of energy savings. Applicable to both residential and commercial buildings, the standard calls for outstanding insulation, glazing, and envelope air-tightness performance that will allow for a drastic downsizing of climate control system capacity. Mechanical ventilation with heat recovery ensures good air quality and reduces heat losses. Many cold climate Passive Houses have been heated comfortably with a heating coil not much bigger than a hair dryer.

By focusing almost exclusively on energy efficiency and airtightness, Passive House reflects the belief that climate change is an issue that eclipses concerns such as recycled content, landscape design, or forest certification. Extensive post-occupancy research has shown Passive House modeling to be more effective than other simulations at predicting actual building energy consumption, and many of the projects have achieved 70–80 percent reductions in energy use for heating, and 50–70 percent reductions in total energy use. The Passive House standard was launched in the United States in 2006 by the Passive House Institute U.S. (PHIUS), which recently introduced climate-specific design targets that should be more appropriate for the diverse North American climate palette.

The Comprehensive Assessment System for Built Environment Efficiency (CASBEE) was developed in Japan in 2005—and was also based upon work of BREEAM and LEED. One notable difference is the creation of four rating tools to address environmental performance at four stages of the building lifecycle: pre-design, construction, existing building operations, and renovations. It was also developed to address conditions specific to Japan and Asia, and to be as simple to implement as possible. The program was developed by partners in government, academia, and industry and is managed by the JSBC (Japan Sustainable Building Consortium).

The International Green Construction Code (IgCC) represents the evolutionary sequence from a green guideline (such as LEED) to a standard (such as ASHRAE 189) to a model code (such as the *International Building Code*). Developed in collaboration with the USGBC, GBI, and ASHRAE, the first public draft was released in 2010. Instead of a voluntary rating system, the IgCC defines design and construction requirements that can be adopted by building authorities. It still provides flexibility to project teams by giving several options for compliance—both in the types of strategies than can be used and the means by which they are documented.

The National Green Building Standard was created by the National Association of Home Builders (NAHB) specifically for single-family homes, multi-family projects, associated site work, and renovation projects. Released in 2008, it covers very similar territory to the LEED-Homes rating system. LEED-Homes puts a bit more weight on location and site selection issues; with slightly lower rating costs and submission requirements. NAHB's NGBS is comparable to, if slightly less rigorous than, LEED-Homes.

Local green building certifications are also common. Several states and municipalities have developed their own green certifications, especially for residential projects, in response to local demand and context—some having

done so before a national rating system was available or widely adopted. With time, these local ratings are likely to be replaced by national/international codes and standards, but may retain favor among builders who wish to differentiate their projects from the rest of the market.

Rating System Challenges

Initially, rating systems provided a voluntary, third-party benchmark that gave greater credibility to the green claims of projects and project designers. Over time they became a roadmap for increasing numbers of mainstream projects that wanted to provide higher performance (whether for market differentiation, perceived benefits for occupants, organizational mission, or long-term cost savings). Now, with growing public and political support for green buildings, requirements for beyond-code performance are beginning to appear in client programs, municipal development agreements, and the building regulations of some government entities. When a previously voluntary system becomes a requirement—whether by law, to qualify for incentives, or fulfill a contractual agreement—several things can happen. Several of these challenges are outlined below.

Industry Pressure. Manufacturers who see the competitiveness of their products as being even slightly disadvantaged by a rating system will be motivated to lobby for requirements that “level the playing field.” The more they stand to lose, the harder they will fight.

Growing Pains. Often a non-profit entity, an organization developing a rating system may experience rapid growth and the chaos that often comes with it. Such rapid growth will also come with greater scrutiny, potential conflicts of interest, and competition for “market share” in the ratings world.

Moving Targets. Rating systems often require incremental improvements over a baseline (or typical) level of performance. How is that baseline defined? Is a project compared to the average performance of all buildings, or ones built to the current code in a given area? If green building performance is indexed to codes, which edition of a code (typically updated on a three-year cycle) should be used as the benchmark?

Human Nature. Buildings do not inherently consume energy—the occupants and their use of the building do. A carefully designed building can be used in unanticipated ways or by people with different habits, priorities, comfort preferences, or schedules than expected. If the first year’s energy bills come back higher than modeled, stakeholders (or grudge holders) may be quick to sound the alarm.

Complexity. As buildings are asked to address more varied, specific, and ambitious requirements, their systems often become substantially more complex. More building trades, more automation, and pressure to embrace the latest, most efficient new technology have the potential for systemic chaos. Commissioning strives to de-bug such systems and their interconnections, but large buildings can still take up to a year to be properly tuned.

Liability. Projects that fail to achieve their intended goals can prompt owners, developers, or even building occupants to take legal action to recover any perceived loss of funding, marketing advantage, value, or performance.

A voluntary rating system, not written in the prescriptive language of codes, can become a legal minefield.

Risk Management. Faced with higher expectations, greater complexity, increased regulatory pressure and/or liability, project teams may spend more time and effort managing rating system requirements to control their risk than in doing creative design work.

Point Chasing. Since no rating system can address all circumstances, designers may have to choose between a strategy that precisely meets a credit requirement but has a lower environmental benefit than a preferred, potentially non-conforming strategy. When there is little money or liability riding on a particular level of certification, designers are more likely to “do the right thing” than engage in “point chasing.”

Applicability/Utility. As long as there have been codes and standards that govern what and how we build, there have been people who have objected to them. Some objections are simply obstructionist, but some are well-founded and can improve the quality and relevance of regulatory requirements. To remain vibrant, green rating systems need accessible and transparent procedures for interpretations and appeals. Tension will always exist between requirements language that is too broad or vague to be easily understood, and language that is too specific and prescriptive to be applied fairly in the real world. In ambiguous cases, projects should be generally assessed for whether they meet the *intent* of a requirement rather than the exact wording.

Leading Change. Critics will often say “we don’t need a rating system to build a better building, a greener building.” This may be true. But if a rating system is going to change practices, improve environmental performance, and increase the demand for greener products throughout the industry, it has to work for the big bulge of the bell curve where most projects are found. There will always be a leading edge of innovators and pioneers who feel that mainstream rating systems set the bar too low. But there will be 10 times as many projects for which the rating system is enough of a stretch to prompt significant changes, but not so much of a stretch that it becomes disruptive and infeasible to follow. The challenge is creating a rating system that can be supported by the pioneers, while being both aspirational and achievable to the bread-and-butter projects that get built by small teams on tight schedules with small margins.

Beyond Green

The terms “green” and “sustainable” are used synonymously by many involved in architectural and engineering design. This is not a good idea! Sustainability is broader in its reach than green, addressing the long-term impacts of the built environment on future generations and demanding an examination of the relationship between ecology, economics, and social well-being. Implicit in this notion (often termed “the triple bottom line”) is the suggestion that the design process will seek to examine and address issues beyond the scope of the traditional building design process.

A green building will be energy-efficient, water-efficient, and resource-efficient, and address on-site as well as off-site impacts on the environment. This is contributory to sustainability, but not identical with sustainability.

We believe that sustainability implies having no net negative impacts on the environment. Paraphrasing the Brundtland Report (*Our Common Future*; World Commission on Environment and Development, 1987), sustainability is meeting the needs of the current generation without impairing the ability of future generations to meet their needs. Green design is a precursor to, a component of, a positive step toward sustainable design. Green design is a means—but not the end. We should surely do no less than green, but also must do more.

This book does not presume to address truly sustainable design. This is, however, OK. Green design and green buildings are a step toward sustainable design and sustainability—and green may honestly be the best that can be accomplished on a large scale in today’s societal context. The need (and demand) for green buildings have become increasingly clear. The means to define specific goals and measurable achievements for green buildings have also been refined through the development of numerous rating systems.

One of the most critical challenges now facing designers—and one of the aspects of “doing more” that must be actively considered—is the problem of climate change fueled by greenhouse gas emissions. Carbon dioxide is a key greenhouse gas and is an insidious product of our current building design, construction, and operation practices. While green design focuses upon reducing the environmental impacts of energy, water, and material usage (including, presumably, carbon emissions), truly informed designs must *explicitly* reduce the carbon dioxide emissions from buildings. Present-day green design efforts may reduce carbon emissions—but not in a manner that is easily quantified or open to accountability. There is little information currently available to help guide designers toward the use of quantifiably carbon-neutral products and processes and unfortunately, the time to seriously begin dealing with carbon-neutral design outcomes appears to have been yesterday. Given this quandary, and until such time as clear-cut carbon-neutral design guidance is available, the prudent course seems to be to “green” every building and to attempt to go deeper green than lighter on every green project.

Green building as a concept may some day be obsolete. In the future, what is universally considered a good, economical, or cost-effective building will also be a green one—but we are not there yet. Order-of-magnitude changes have to come first: an understanding that long-term goals need to trump short-term conveniences; an economic system that better accounts for the costs to society of environmental impacts; and a consensus on how to regulate carbon emissions. Until then, we’ll need resources for those who choose to build in ways that reduce impacts on the environment, while being aware of the limits of such resources.

Further Information

Carson, R. 1962. *Silent Spring*. Houghton Mifflin.

World Commission on Environment and Development. 1987. *Our Common Future*. (The Brundtland Report). Oxford University Press.

This chapter was written as an essay on green buildings by David Posada, Portland, Oregon. It was adapted for The Green Studio Handbook by the book’s authors.

CHAPTER 2

THE STUDIO

THE DESIGN STUDIO is where the architectural action is. There are many ways for a building to obtain green status. This may be done formally via a rating system or informally through a focus on superior performance. It is possible for a green building to do well primarily as a result of active strategies implemented by a consulting engineer. Such strategies are typically implemented during design development and have little impact on building form or orientation. It is also possible to produce a green building primarily as a result of passive (i.e., architectural) systems that are incorporated during conceptual and schematic design. Although the end environmental result of these two approaches may be equivalent, the method of getting there is definitely not. The difference is the architectural design process. And architectural design—in school or in practice—with all its attendant culture (good or bad) occurs within the studio setting.

Informed architectural design is the challenge. Architects must be active participants in shaping green buildings—through early, reasoned, appropriate, and passionate integration of green design strategies. As educators, we believe that this process must happen in the school of architecture design studio where students can learn, acquire skills, test solutions, and be supportively critiqued. Then, we sincerely hope, an ingrained green design philosophy will flow into practice—into the workplace studio. Students will be the agents of change. Practitioners will implement change. Studio is the place.

DESIGN PROCESS¹

The specialist in comprehensive design is an emerging synthesis of artist, inventor, mechanic, objective economist and evolutionary strategist. He bears the same relationship to Society in the new interactive continuities of world-wide industrialization that the architect bore to the respective remote independencies of feudal society.

Buckminster Fuller, “Comprehensive Designing,”
in *Ideas and Integrities*

Design is a multifaceted pursuit. It is at once cultural, technical, formal, and programmatic. An emphasis on one or another of design’s facets affects the outcome of the pursuit and its resulting architectural expression. A comparison of two buildings by two Italian architects practicing in the early twentieth century reveals striking differences emerging from design emphasis. Luigi Nervi’s work is defined by structural logic, wherein force diagrams become the form; while Gio Ponti draws upon a compositional logic that prioritizes the development of the surface. While Ponti’s buildings also have a structural logic and Nervi’s are also compositional, their unique inflections are clear in their works.



2.1 Courtyard sketch—bringing daylight into adjacent rooms. DANIEL JOHNSON

¹ This material on design process appeared in previous editions of *The Green Studio Handbook* and constitutes an essay prepared by Laura Briggs and Jonathan Knowles, New York City. The material has been slightly edited for this third edition.