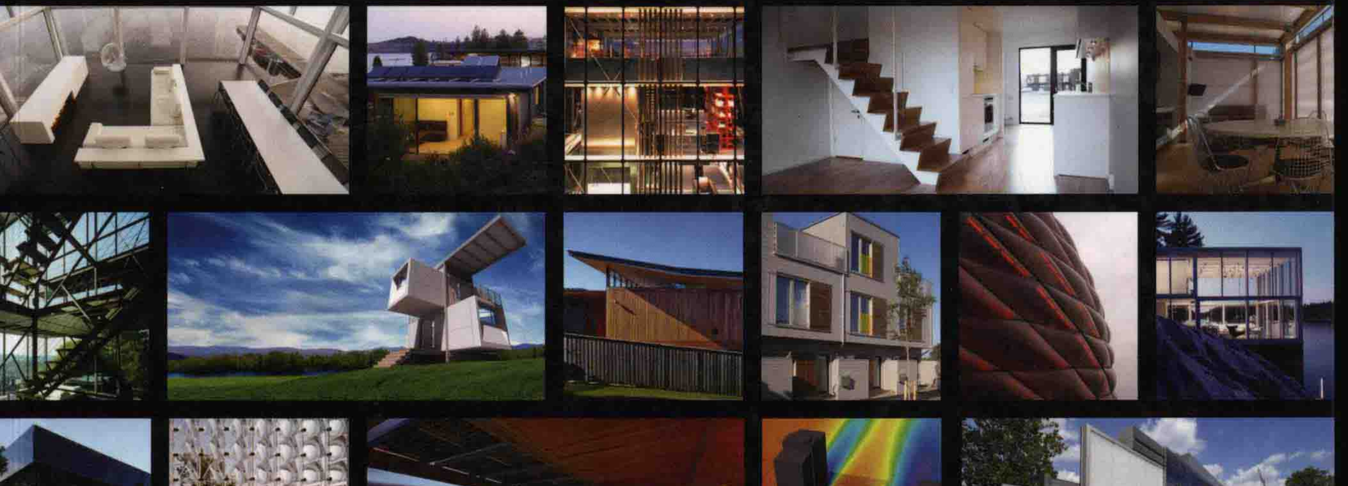
DESIGN AND CONSTRUCTION OF HIGH-PERFORMANCE HOMES

Building Envelopes, Renewable Energies and Integrated Practice



Edited by
Franca Trubiano

ROUTLEDGE

Design and Construction of High-Performance Homes

Building Envelopes, Renewable Energies and Integrated Practice

Edited by
Franca Trubiano

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2013
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Simultaneously published in the USA and Canada
by Routledge
711 Third Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group, an informa business

© 2013 selection and editorial Franca Trubiano; individual chapters, the contributors

The right of the editor to be identified as the author of the editorial material, and of the authors for their individual chapters, has been asserted in accordance with sections 77 and 78 of the Copyright, Designs and Patents Act 1988.

Every effort has been made to contact and acknowledge copyright owners. The publishers would be grateful to hear from any copyright holder who is not acknowledged here and will undertake to rectify any errors or omissions in future printings or editions of the book.

All rights reserved. No part of this book may be reprinted or reproduced or utilized in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying and recording, or in any information storage or retrieval system, without permission in writing from the publishers.

Trademark notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
Trubiano, Franca.
Design and construction of high-performance homes: building envelopes, renewable energies, and integrated practice / Franca Trubiano.
p. cm.
Includes index.
1. Ecological houses—Design and construction. I. Title. II. Title: Building envelopes, renewable energies, and integrated practice.
TH4860.T78 2012
728'.047—dc23
2011041919

ISBN: 978-0-415-61528-0 (pbk)

Designed and typeset by Alex Lazarou

Printed and bound in India by Replika Press Pvt. Ltd.

Design and Construction of High-Performance Homes

Both professionals and students are increasingly committed to achieving high-performance metrics in the design, construction and operation of residential buildings. This book responds to this demand by offering a comprehensive guide which features:

- architectural innovations in building skin technologies which make lighter more transparent buildings high performing;
- energy-free architectural design principles and advances in building-integrated photovoltaics;
- essential engineering principles, controls and approaches to simulation for achieving net zero;
- the advantages of integrated design in residential construction and the challenges and opportunities it engenders;
- detailed case studies of innovative homes which have incorporated low-energy design solutions, new materials, alternative building assemblies, digital fabrication, integrated engineering systems and operational controls.

Divided into four parts, the book discusses the requisite AEC (Architecture, Engineering and Construction) knowledge needed when building a high-performance home. It also communicates this information across four case studies, which provide the reader with a thorough overview of all aspects to be considered in the design and construction of sustainable homes. With contributions from experts in the field, the book provides a well-rounded and multi-faceted approach.

This book is essential reading for students and professionals in design, architecture, engineering (civil, mechanical and electrical), construction and energy management.

Franca Trubiano is a Registered Architect (O.A.Q., Int. Assoc. AIA) and Assistant Professor at Penn Design, University of Pennsylvania, where she received her doctoral degree and conducts research in construction technology, emerging materials, tectonic theory, integrated design and architectural ecologies.

CONTRIBUTORS

Tristan Al-Haddad is an Assistant Professor in the School of Architecture at the Georgia Institute of Technology. His research and teaching is focused on the application of digital technology in the design and fabrication of geometrically complex structures. In addition to his academic research, he is also a working designer and visual artist. His work has been exhibited in many venues including the High Museum of Art in Atlanta and the Center for Architecture in Manhattan. He was a Fulbright Scholar and Artadia Artist awardee in 2009.

Anne Beim is a Professor of Architectural Technology at the Royal Danish Academy of Fine Arts (RDAFA) School of Architecture, from where she holds a PhD in Architecture. She teaches courses in architectural technology and tectonics in the graduate and undergraduate programs, and supervises research.

William W. Braham, FAIA, is an Associate Professor of Architecture at the University of Pennsylvania, where he is Director of the Master of Environmental Building Design. He received an engineering degree from Princeton University and an M. Arch and Ph.D. Arch from the University of Pennsylvania, where he has taught since 1988. At Penn he teaches graduate courses on ecology, technology, and design.

Jeffrey R. S. Brownson is a faculty member in the John and Willie Leone Family Department of Energy & Mineral Engineering, College of Earth & Mineral Sciences, at the Pennsylvania State University. He served as the Director of the *Natural Fusion* team at Penn State for the Solar Decathlon 2009. His research team achieves a unique integration of disciplines: materials research, integrative solar system design, and energy systems simulations for analysis of new technologies.

Robert Dunay, FAIA, is an ACSA Distinguished Professor, and three-time recipient of Design Intelligence's Most Admired Educator. As Director of the Center for Design Research at Virginia Tech, he is chief protagonist exploiting the territories of opportunity that reside between disciplines. His research concerns the integration of energy performance in buildings and architectural quality as demonstrated in the 2002, 2005 and 2010 Solar Decathlon Competitions, culminating with *Lumenhaus*©.

T. Russell Gentry is an Associate Professor in the School of Architecture at the Georgia Institute of Technology and a registered professional engineer. His research focuses on the development and performance assessment of building materials and systems, on the environmental impact of buildings, and on the representation of design and fabrication knowledge in computational environments.

Lisa D. Iulo is an Assistant Professor of Architecture at the Pennsylvania State University and a Registered Architect, Professional Planner, and LEED Accredited Professional (LEED AP). Her work has been recognized in research and practice related to residential green building practices and affordable housing, energy efficiency, and strategies for the implementation of renewable energy at the building and community scale.

Robert P. Schubert is a Professor and member of the College of Architecture and Urban Studies at Virginia Polytechnic Institute and State University. His research is in the area of energy and building design with an emphasis on promoting architectural solutions that minimize the dependence on non-renewable energy sources and environmental degrading processes.

Ryan E. Smith and **Jörg Rügemer** are Directors of an interdisciplinary design and engineering research group called the Integrated Technology in Architecture Center (ITAC) at the University of Utah. They research, write, teach and speak on the integrated paradigm, and develop processes and products that lead to sustainable and energy-efficient design and construction. Their work has been funded by federal, public and private organizations. They are recipients of the ACSA Collaborative Practice Award (2006), ACSA Creative Achievement Award (2009, 2011) and the ARCC Research Award (2011) for their innovative industry collaborative teaching, research and outreach.

此为试读，需要完整PDF请访问：www.ertongbook.com

Geoffrey Thün is an Associate Professor and **Kathy Velikov** is an Assistant Professor at the University of Michigan Taubman College of Architecture and Urban Planning. They are principals of the research-based practice RVTR. Their design work, research and writing focuses on built environments and landscapes that are shaped and mediated by advanced materials, technologies and energies, within the context of complex ecological, economic, and social systems.

Franca Trubiano is a Registered Architect (O.A.Q.) and Assistant Professor at the University of Pennsylvania with research areas in construction technology, materials, tectonic theory, and architectural ecologies. She is a member of the DOE-sponsored Greater Philadelphia Innovation Cluster in the Retrofit of Energy-Efficient Buildings and Co PI of a research project on Integrated Practice. In 2006, while an Assistant Professor at the Georgia Institute of Technology, she was lead architecture faculty and co-recipient of a DOE/NREL Solar Decathlon Grant to design, build and operate a zero-energy house on the Natural Mall in Washington DC. The house won the BP Green Award for innovation. She holds degrees from the University of Pennsylvania and McGill University.

Kasper Sánchez Vibæk has been an architectural researcher at the Royal Danish Academy of Fine Arts (RDAFA) School of Architecture since 2004. He received a PhD on Systems in Architecture in 2011. He also holds a Master of Architecture degree with a supplementary degree in sociology.

Joseph Wheeler is an Associate Professor of Architecture at Virginia Tech School of Architecture + Design and a Co Director of the Virginia Tech Center for Design Research. He pursues professional research in environmental and sustainable design and assumes leadership positions in the implementation of design theory and ideas. Recent awards include a National AIA Honor Award for Architecture, the NCARB Prize for creative collaboration between the academy and the profession, the Virginia Society AIA Research Prize, and the Xcaliber University Prize for Excellence in Outreach.

Yun Kyu Yi is an Assistant Professor at the University of Pennsylvania where he teaches environmental and sustainable technology and computational building simulation. He is a member of the TC Chan Center for Building Simulation and Energy Studies at Penn and has lectured at several universities. His research includes performance-driven design processes and the integration of simulation domains and decision making. At the Chan Center, his most recent project is developing measurements for different sustainable building criteria by performance-based rather than prescriptive measures.

ACKNOWLEDGMENTS

There are many to thank for their support and contributions to this work. Some have offered their expertise and some their sound advice. Routledge editors Fran Ford and Laura Williamson guided the process in a spirit of great mutuality and collaboration.

Contributing authors participated with much enthusiasm and commitment and to them I am most grateful. Architects graciously responded to my invitation to publish their creative work and the book is a better publication for featuring the high-performance homes they've designed and built.

I benefitted from the technical know-how of various industry representatives including Kevin Lechwar from PPG Industries, Jocelyn O'Shea as Associate Director for Vector Foiltec Ltd, and Michael Hindle from the PHIUS (Passive House Institute, US).

To my colleagues Ruchi Choudhary, T. Russell Gentry and Godfried Augenbroe who first initiated me to the subject and who patiently answered all of my questions during our early collaborative adventures, I am most thankful.

Many of my colleagues at the University of Pennsylvania including Dean Marilyn Taylor, Architecture Chairs William Braham and David Leatherbarrow, Undergraduate Chair Richard Wesley, Winka Dubbeldam, Lindsay Falck, Annette Fierro, Ali Malkawi, Cathrine Veikos, Yun Kyu Yi and Raffaella Fabiani Giannetto, supported this project in various ways, and for this I am very grateful. Architecture students, who participated in seminars on high performance, materials and energy, contributed valuable observations, questions, and challenges to the book and its thesis.

To my friend Joanna Merwood who offered her editing wisdom and to doctoral student Eric Bellin who administered with diligence and rigor many of my editorial functions, I am truly appreciative.

To Yves Gauthier, whose strength and affection continues to guide me in project after project, I offer my deepest gratitude.

Contents

Contributors vii
Acknowledgments ix

PART 0 Introduction

0.1 High-Performance Homes: Metrics, Ethics and Design 3
FRANCA TRUBIANO

0.2 Household Power: How Much is Enough? 23
WILLIAM W. BRAHAM

PART 1 Building Envelopes, New Materials and Architectural Design 35

1.1 Energy-Free Architectural Design: The Case of Passivhaus and Double-Skin Façades 37
FRANCA TRUBIANO

1.2 Translucent Building Skins: Advancing the Technology of Light Transmission 55
FRANCA TRUBIANO

1.3 Responsive Building Envelopes: Characteristics and Evolving Paradigms 75
KATHY VELIKOV + GEOFFREY THÜN

1.4 Nanomaterial + Super-Insulator = Aerogel 93
FRANCA TRUBIANO

PART 2 Renewable Energies, Building Systems and Simulations 105

2.1 The Design Integration of Renewable Energies 107
FRANCA TRUBIANO + T. RUSSELL GENTRY

2.2 Systems-Integrated Photovoltaics (SIPVs) 127
JEFFREY R. S. BROWNSON

2.3 Building Systems, Controls and Automation 139
T. RUSSELL GENTRY

2.4 Building Performance and Computational Simulation 163
YUN KYU YI

PART 3 | **Integrated Practice and Residential Construction** 179

3.1 Integrated Project Delivery: Contracting for High Performance 181
RYAN E. SMITH + JÖRG RÜGEMER

3.2 Energy and the Integrative Design Process: Defining the Team of Experts 193
LISA D. IULO

3.3 The Construction of Affordable Low-Energy Prefabricated Housing in Denmark 203
ANNE BEIM + KASPER SÁNCHEZ VIBÆK

3.4 From Modeling to Making: Parametric Design and Digital Fabrication 217
TRISTAN AL-HADDAD

PART 4 | **High-Performance Homes: Case Studies** 233

4.1 *Lumenhaus*© and the Eclipsis Sun Control System© 235
ROBERT DUNAY, JOSEPH WHEELER + ROBERT P. SCHUBERT

4.2 *Project Icarus*: Optimizing Light and Energy in the Design of a Translucent Roof 249
FRANCA TRUBIANO

4.3 *North House*: Climate-Responsive Envelope and Control System 265
GEOFFREY THÜN + KATHY VELIKOV

4.4 Modular Building: Three Scales/Three Strategies 283
LISA D. IULO

Image credits 296
Index 297

Part 0 Introduction

0.1 High-Performance Homes: Metrics, Ethics and Design 3
FRANCA TRUBIANO

0.2 Household Power: How Much is Enough? 23
WILLIAM W. BRAHAM

此为试读，需要完整PDF请访问：www.ertongbook.com

Chapter 0.1

High-Performance Homes: Metrics, Ethics and Design

FRANCA TRUBIANO

1.0 Defining high performance

From racecars to computers, the phrase 'high performance' is used to describe objects, buildings, environments, industrial processes and even human organizations. In fact, so frequently and widely is the term employed one would think it has lost much of its specificity and/or relevance. A most ubiquitous term in architecture, it is used to qualify the design, construction, and operation of materials, products, building systems, entire buildings, and even construction delivery methods.[1]

Yet when describing the home, there exists no more incongruous a phrase. Many reject the mere thought of living environments being subject to the qualifier 'high performance'; to their rationalization, analysis and evaluation. Surely, reducing the home to a series of numerical measures poorly captures the fullness of dwelling. The most personal of building programs is ill suited for the scientific method. And yet, we hold no such reservations for environments in which we conduct business, save lives and educate. In fact, we seek the most advanced expression of technology for vehicles, buses and trains that transport us to and from the home, while shunning the same for spaces wherein families are raised. Why has the detached single-family house been reticent to acknowledge technological change? Why has the housing industry been recalcitrant in altering its methods of construction, failing to integrate the benefits of new materials and improved construction methods developed during the past six decades of continued industrialization?[2]

During the past thirty years of unchecked home building in the United States, which, albeit, came to an end during the global financial crisis of 2008, little substantive research was conducted in the technological advancement of single-family homes. The housing industry remains fragmented and uninterested in advancing the technology of building. A substantial lag in technology continues to burden homebuilders, as they too are reluctant to incorporate scientific advances in the design, construction and operations of the home. Moreover, the industry overlooks most opportunities to alter its consumptive and wasteful procedures, rejecting all responsibility for producing living environments which have a modicum of performance integrity. Surely, this modus operandi is untenable in a world of diminished material and energy resources.

Alongside their rejection of advancements in building science, representations of 'home' are predominantly focused on building elements that support a language of cultural tradition, even when the language is without functional veracity. Single-family homes are identified with notions of comfort, handicraft, and small town life more akin to rural life in the nineteenth century than to the realities of the twenty-first. And notwithstanding the social, economic and political origins of the North American middle class, the image of the single-family home sought by most remains aligned with the trappings of a genteel bourgeois life; limited only by lot size and the requirement of modern commutes. Can the home, therefore, ever become a viable site for the embodiment and representation of 'high performance'? Can its design and construction point to a possible integration of dwelling and technology in a manner that is both sustainable and ethical?

The search for answers to these questions is challenged by the lack of an agreed definition of 'high performance'. For some, the term is loosely associated with sustainable design practices that result in 'green' buildings and carbon-neutral designs. For others, it is aligned with the specific gains of prefabrication and new materials. And for others still, 'high performance' describes building systems that operate more efficiently by using less energy for supplying light, air and heat. Rarely are these positions reconciled in one all encompassing definition of high performance, at the center of which is the equal importance of metrics, ethics and design.

1.1 Metrics

The field of high performance is predicated on metrics, measurements, certifications and benchmarks. Data and numerical measures of all kinds are used to establish expectations as well as to evaluate outcomes. Building simulations completed during the design stage of a project and energy audits conducted during the building's operations result in a wealth of comparative figures. The virtual analysis of a building prior to its construction by energy, lighting and ventilation experts is a practice essential to high-performance design, as is the quantitative assessment of a building and its systems carried out according to consensus-based methods.[3]

At present, the energy expended and materials consumed during the construction and operation of a building, are of most interest. The impact of non-renewable fossil fuels, the embodied energy of materials, carbon emissions resulting from building construction, operations and decommissioning are all featured in performance calculations. A number of significant institutional standards already exist for evaluating the performance of buildings. The most prominent include LEED (Leadership in Energy and Environmental Design), BREEAM (BRE Environmental Assessment Method) and Green Globes; all of which are highly participatory assessment programs for designers, builders and occupants committed to knowledge building, information sharing and technology transfers. In the United States, the Home Energy Rating System (HERS) focuses on the design of homes. Administered by the Residential Energy Services Network (RESNET), it is responsible for certifying the cadre of professionals known as home energy raters. These experts in the field of energy-responsive building design are trained to evaluate residential environments for the effectiveness of their construction techniques, material choices and systems design. Barely two decades since instituting the first of these environmental rating systems, a more informed group of practitioners is now conversant with the tools used in designing the building infrastructure of a more sustainable planet.

Moreover, a growing number of organizations and industry partners are dedicated to the growth and dissemination of 'high-performance' metrics. The National Institute of Building Science in the United States is dedicated to the delivery of 'a successful high-performance building by applying an integrated design and team approach to the project during the planning and programming phases'.[4] They promote the *Whole Building Design Guide* in which a building and its systems are conceived as wholly interdependent and their integration sought for improved performance. Eleven governmental agencies participate in its goals, including the Department of Energy (DOE) and the General Services Administration (GSA), who are committed to implementing the Federal 'High Performance and Sustainable Building' (HPSB) Requirements.

Alongside these efforts are research initiatives in material science, building envelope design and building systems engineering. Publications such as the *Journal of Advanced and High Performance Materials,* the *Journal of Building Enclosure Design* and *High Performing Buildings* attest to the large number of design and engineering professionals working in the field. And the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has, in collaboration with other industry partners, established the 'High Performance Building Design Professional Certification' program which trains building experts in the field of 'high-performance' systems evaluation.[5]

Typically, for these participants, the phrase 'high performance' is synonymous with 'net-zero energy'.[6] A high-performance building wisely manages energy expenditures to reduce the operational energy needed to supply its thermal and power needs to nearly zero. To this end, emphasis is placed on implementing design and construction strategies that eliminate the need for 'artificial' environmental systems. The building's site, orientation, footprint, extents, sectional profile, material choices and construction details can all contribute to achieving the metric of net-zero energy. And where architectural strategies fail to attain the net-zero benchmark, alternative forms of renewable energy, such as solar thermal, solar electric or wind, are introduced. A building, which consumes 'zero' amounts of non-renewable energy, is surely well performing.

And yet, this is only partially true. The definition of a 'high-performance' building may include, but is not limited to, an account of the energy it consumes. Vastly more expansive a characterization of high performance is required for naming the qualitative measures of excellence and innovation so important to its definition.

1.2 Ethics

Much of our contemporary language of performance is focused on the physical definition of the building; an object that responds to climatic conditions given the availability of material and energy resources. Rarely, however, are questions of equity, human behavior, and quality of life positioned at the center of what we intend by high performance. If a building saves energy it is assumed to be of benefit to its occupants. This, however, may not necessarily be the case. Office buildings designed to save energy during the early 1980s also succeeded in making their inhabitants sick when their air change frequency was decreased to reduce the amount of fresh air requiring conditioning.[7] Schools designed to reduce thermal heat load also reduced the amount of natural daylight of use to young students who subsequently faired poorly in their academic endeavors. Many similar examples exist of the negative consequences resulting from the pursuit of 'high performance'.

In response, new theoretical models have been devised in which human values are posited alongside the more traditional numerical values of high performance. In *Cradle to Cradle*, by William McDonough and Michael Braungart, the definition of sustainability is clearly predicated on the triangulation of Ecology, Economy and Equity.[8] Cultural values are unambiguously promoted in their 'triple bottom line' approach to sustainability. Factors aligned with justice are as important as those associated with cost, for only in this way can a true measure of sustainability be identified for all building-related processes. Job creation, access to food and transportation, and the health of our built environments are issues much larger in scope than those generated by any one house or any one client and should be addressed when considering the importance of social equity and public policy.[9]

'High-performance' outcomes are also a function of human desire. Building environments designed to operate at optimal efficiencies often fail miserably when faced with the uncertainty of occupant behavior. Pre-sets for building systems are often overridden and even sabotaged by unsatisfied occupants. And post-occupancy evaluations have struggled with how best to capture and quantify the wide range of human preferences that condition the way in which inhabitants use a building.[10]

In Sibyl Moholy-Nagy's text from 1955, 'Environment and Anonymous Architecture', a simple yet effective, interpretation of how human habitats can teach us important lessons about performance, beyond the dictates of measure and proof, is articulated. Herein, Moholy-Nagy addressed the modern challenge facing many architects when designing single-family homes in decentralized and suburban America. She reminded her readers that while 'tradition is the deposit and tyranny of IDEAS; *bruach* or observance is the acknowledgement of past PERFORMANCE' (emphasis Moholy-Nagy).[11] Committed to the self-evident truths of anonymous architecture from the Lake Dwellers of the Alps, the Cavete Lodges of the Pueblo farmers, and the early religious buildings in Ephrata Pennsylvania, Moholy-Nagy chose the German word *brauch* to speak of that particular form of knowledge that results from use and habit. Access to building-related customs successfully organized vernacular building activities for hundreds of years and for Moholy-Nagy this was a valuable avenue for understanding 'performance'.

So stated, the definition of 'performance' could be expanded to include considerations beyond the metrics of building and those in excess of design intentionality. As described by David Leatherbarrow in his text 'Architecture's Unscripted Performance', a building's performance is more than the sum of its design and construction techniques and more than the idea and practices it represents.[12] For to believe otherwise, 'at risk in such an approach is architecture's perfect rationality, for it will be seen that performances or events depend in part on conditions that cannot be rationalized'.[13] Buildings do, in fact, behave in ways that are less than objective, and are used for functions and in ways they were not designed for. They are the settings for actions whose exact unfolding is difficult to predict.[14] A building's performance can never be entirely known or measured and this is surely the case in what concerns the natural and environmental actions to which it is subject. Leatherbarrow reminds us once more, that buildings are by definition never inert or static. Constantly given to resisting the forces of nature, they struggle against their own entropy, their own demise. Processes of degradation, ruination and weathering that accompany the life of a building are always in opposition to the range of engineered performances for which the building was designed.[15] And it is this most unavoidable and unpredictable event in the life of a building that holds ethical consequences for high-performance homes.

1.3 Design

> *Only* by competent design *may the increasing problems of a multiplying society be resolved in physically adequate manner; that only by design may sufficiently more be done with less.*[16]

The search for an agreed to definition of 'high performance' began as early as the 1970s when its tenets were associated with the drive for 'energy conservation'. In 1977, in the midst of the first 'energy' crisis to hit the United States, Richard Stein called his fellow architects to action.[17] In *Architecture and Energy: Conserving Energy through Rational Design*, Stein developed a comprehensive and convincing argument for recognizing that problems of energy conservation were, in fact, problems of design. After all, it was by design that office buildings were transformed into sealed artificial environments requiring tremendous inputs of air-conditioning energy; it was by design that post-war developments favored the growth of suburban sprawl; it was by design that tall buildings were conceived with building façades inarticulate as to their solar orientation; and it was by design that the profession had relegated all knowledge of vernacular strategies for energy-free architectural design to the dark recesses of history.[18] Hence, it was only by design that radical change could be effected to our highly energy-consumptive building culture.

Stein's analysis is as relevant today as it was then. He identified the planned obsolescence of building products and equipment as highly problematic, citing the necessity for life-cycle assessments. He noted the substitution of natural materials with petro-chemicals, as vinyl replaced rubber, plastics replaced wood and polyesters replaced natural fibers. He even asserted that architectural design as practiced in 1977, rarely invested building form and geometry with productive environmental constraints. New buildings poorly capitalized on the use of traditional practices that ensured temperate environments without mechanical means. Stein noted how typical buildings, and even more critically, typical homes, had exponentially increased their end use of electrical power since the Second World War by drastically increasing heating, air conditioning and plug-in loads.[19] He cited the largely wasteful initiative launched by power companies in the early 1970s to have residential customers shift their home heating to electricity, an ill conceived enterprise given the highly inefficient process of converting fossil fuels into electricity for producing thermal heat. In this early work, Stein had comprehensively surveyed the factors contributing to the lack of wholesale acceptance of energy conservation measures including those in the law, advertising, public policy, mortgage lending guidelines and building codes.[20] And yet, notwithstanding all of the aforementioned associated factors, the inadequate energy performance of most buildings remained a function of design.

More than four decades later, this is still the case. Then as now, a robust definition of 'high performance' is one that valorizes the role of architectural design alongside that of building metrics. Evaluating the performance of a building requires both a measure of its design excellence as well as an account of the matter and energy it consumes. Design is a projective activity situated within a cultural context and a set of human desires; many of which are difficult, if not impossible, to rationalize within the metrics favored by the sciences. And yet, it must continue to exert a significant influence in expanding the definition of 'high performance'.

2.0 High-performance design and the single-family home

Single-family homes, and the lifestyles they support, continue to burden the world's energy resources. In developed countries, and most particularly in the United States, homes have increased in size during each decade since the end of the Second World War. According to the American Census Bureau, in 2009 new homes were 40 percent larger than in 1980 while the size of the average household decreased by two percent over the same period.[21] Individually, homes represent the smallest square footage of any building type, but cumulatively they surpass all others in total square footage built. No more consumptive a model exists for the depletion of land, the wasteful implementation of building services and the sprawl of transportation infrastructures.[22] Sadly, the energy-consuming detached single-family home has enthralled so many, in so many parts of the world, regardless of cultural or socio-economic background.

Rethinking the single-family home represents, therefore, a unique opportunity to address the question of 'high performance'. Radical new design solutions are required for mitigating the waste, consumption and obsolescence of the present paradigm. What is sought is a rigorous and robust science of 'design' for single-family homes. This book is dedicated to this pursuit, encompassing the fields of architectural design, building engineering and construction management.

此为试读,需要完整PDF请访问: www.ertongbook.com