Heating, Cooling, Ventilation, Daylighting and More Using



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PASSIVE SOLAR ARCHITECTURE

HEATING, COOLING, VENTILATION, DAYLIGHTING, AND MORE USING NATURAL FLOWS



David A. Bainbridge and Ken Haggard

PASSIVE SOLAR ARCHITECTURE

Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows

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Chelsea Green Publishing
White River Junction, Vermont

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Project Manager: Patricia Stone
Developmental Editor: Cannon Labrie
Copy Editor: Laura Jorstad
Proofreader: Susan Barnett
Indexer: Shana Milkie
Designer: Maureen Forys, Happenstance Type-O-Rama
Printed in the United States of America
First printing July, 2011
10 9 8 7 6 5 4 3 2 1 11 12 13

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Library of Congress Cataloging-in-Publication Data

Bainbridge, David A.
Passive solar architecture : heating, cooling, ventilation, daylighting and more using natural flows / David Bainbridge and Ken Haggard.
p. cm.
ISBN 978-1-60358-296-4
1. Solar energy—Passive systems. 2. Architecture and energy conservation. I. Haggard, Kenneth L. II. Title.

TH7413.B345 2010
690'.8370472--dc22

2010030052

Chelsea Green Publishing Company
Post Office Box 428

(802) 295-6300
www.chelseagreen.com

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Illustration Credits

Acknowledgments

Preface

Sick building syndrome is a term used to describe situations in which building occupants experience discomfort and even acute health problems that appear to be related to time spent in the building.

—Mohamed Boubekri, 2008

Buildings matter. We spend more and more of our lives inside them, and poorly designed, built, and maintained buildings are a common cause of human suffering, illness, and death. People are too often hot in summer, cold in winter, and face real danger if the power goes off. Many more suffer at work or at home from poor air quality. Sealed buildings, flawed building materials, and poor design lead to leaks and mold unless installation and maintenance are perfect—and they rarely are. In 1998, World Health Organization research suggested that 30 percent of all the new and remodeled buildings in the world were afflicted with sick building syndrome. The annual cost of poor indoor air quality in the United States alone has been estimated at $160 billion by the Department of Energy, more than the gross national product of most countries. In contrast, sustainable buildings, to those who live and work in them, pay large dividends as human comfort and health improve and productivity increases. The value of productivity gains alone is often a hundred times greater than energy savings.

Buildings are also a major user of materials and energy. They account for as much as a third of all the flow of materials (water, metals, minerals, et cetera) each year in the United States and are also responsible for 40 percent of the country's greenhouse gas emissions. And this is not just a local problem. When Stefan Bringezu and co-workers computed the resource intensity of the fifty-eight sectors of the German economy, they concluded that buildings and dwellings consumed between 25 and 30 percent of the total nonrenewable material flow in Germany.

Buildings not only are material-intensive but also require massive amounts of energy and water and are a source of many toxic and ecotoxic materials, including paints, plastics, cleaning solutions,

roofing and pipes. Floods and fires release a wide range of toxins from buildings. Air pollution from buildings and from the power generation needed to heat and cool them causes far-reaching ecosystem damage and disruption locally, across the country, and around the world.

Why have we been so fuelish? As Amory Lovins and others have noted, small but important signals and incentives make it most profitable for designers, engineers, builders, and installers to create inefficient, costly, and unhealthful developments and buildings. This has been compounded by poor training in schools, particularly in architecture and engineering, lack of training for builders, and government subsidies that artificially reduce the cost of energy, water, and building materials.

Almost all of the adverse impacts of building can be avoided by good design and construction. New buildings in any climate can be solar-oriented, naturally heated and cooled, naturally lit, naturally ventilated, and made with renewable materials.

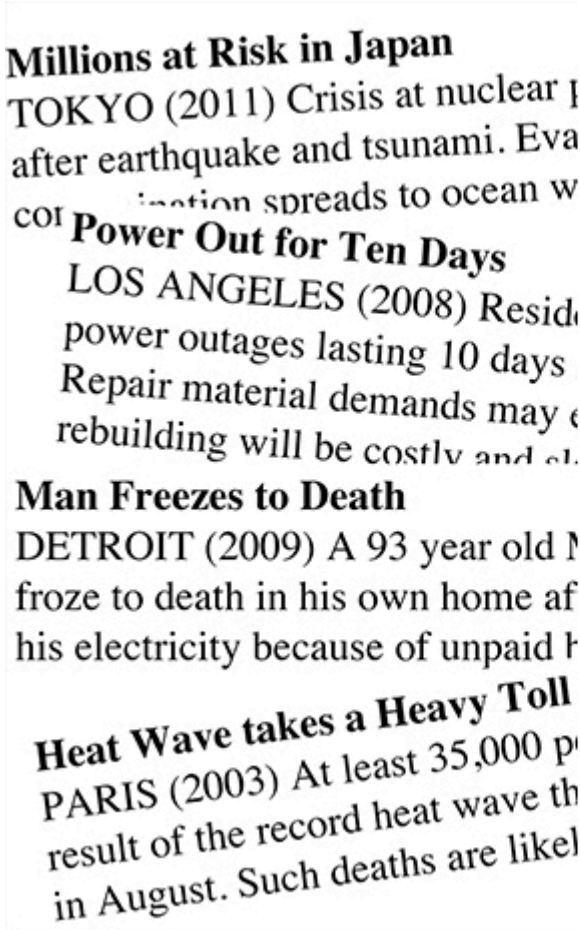
In most climates, proper building orientation can dramatically reduce building energy demand for heating and cooling at no cost increase. In a study of more sustainable home design (validated by actually building the home) in Davis, California, the home summer peak energy demand dropped from 3.6 kilowatt-hours (kWh) to 2 kWh, and annual energy use for heating and cooling dropped 67 percent. This improvement didn't cost anything; in fact, it reduced the cost of construction.

The goal of the sustainable building (also called green building) movement is to improve the comfort and health of the built environment while maximizing use of renewable resources and reducing operating and life-cycle costs. The savings are particularly important for retirees and for institutions that cannot count on increasing income in the future to offset projected large increases in cost for energy, water, and other resources. Comfort and health, security and safety in power outages, energy and water use, waste, recyclability, and cost are key issues. Systems considerations are critical in siting buildings, building orientation, design, and operation, but they are usually ignored.

Buildings Matter for Ill…

The Importance of Seemingly Simple Choices

The simple choice of window orientation can have large implications for cost, energy use, building codes is on reducing energy use for winter heating, but in many areas cooling is equ winter can reduce summer cooling demand as well, since facing south allows easy solar contr is not orienting the house properly, something that has been well understood for more than t "They lacked the knowledge of houses turned to face the sun."



Millions at Risk in Japan

TOKYO (2011) Crisis at nuclear
after earthquake and tsunami. Eva
cor ination spreads to ocean w

Power Out for Ten Days

LOS ANGELES (2008) Resid
power outages lasting 10 days
Repair material demands may
rebuilding will be costly and

Man Freezes to Death

DETROIT (2009) A 93 year old
froze to death in his own home af
his electricity because of unpaid

Heat Wave takes a Heavy Toll

PARIS (2003) At least 35,000 p
result of the record heat wave th
in August. Such deaths are likel

Fig. 0.1

Besides discomfort, poor orientation is expensive to building owners, society, and the planet. calculated to be $40,000 over a thirty-year period if you add up the added air-conditioning c simple choice. If the three million houses built in California since 1980 had been well designed



Fig. 0.2. *Even when the power is off, a sustaina*