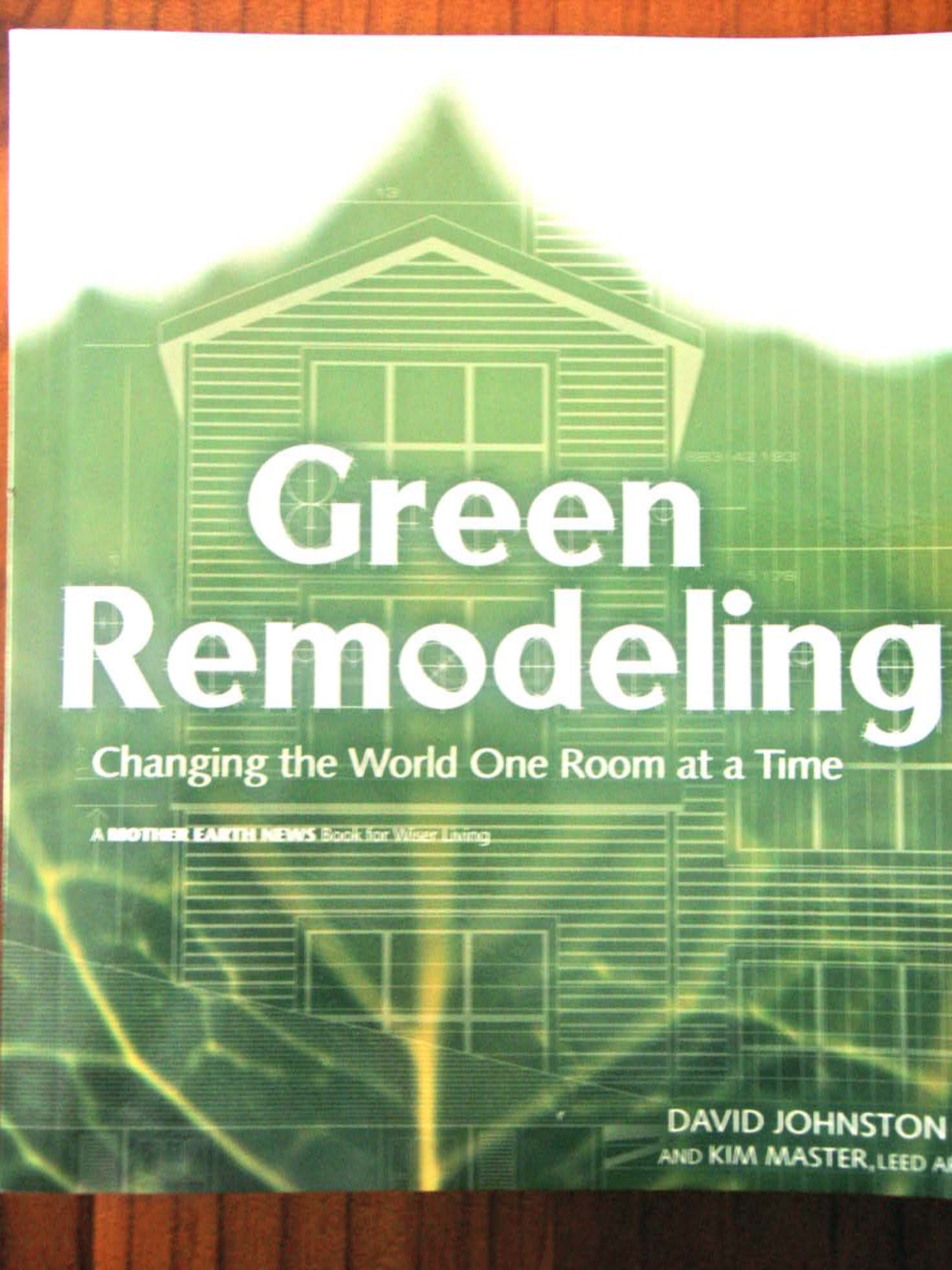
Green Remodeling
Changing the World One Room at a Time
A MOTHER EARTH NEWS Book for Wiser Living
DAVID JOHNSTON
AND KIM MASTER, LEED A

Advance Praise for

Green Remodeling

For 20 years, David Johnston has been a leader in combining environmental design and excellence in residential construction. Now he has put this deep experience into *Green Remodeling*, for the rest of us to draw upon. His on-the-ground experience, through the good and the difficult, makes for entertaining reading, while providing highly useful and accessible information. Not only does it address the latest thinking about green building, it's one of the best guides to building in general. David, as usual, doesn't pull any punches.

— Bill Reed, AIA, LEED® AP, Natural Logic

At a time when every American is feeling helpless about affecting change and seeking ways to make a difference, along comes *Green Remodeling* — one of the most empowering, comprehensive how-to books ever! Yes, we *can* change the world for the better by the way we remodel our home.

— Honorable Claudine Schneider, former US congresswoman, and author of energy efficiency and renewable energy legislation

Imagine having factually accurate *and* emotionally calming info at your finger tips when you remodel your home. Now, add energy-conscious, durable, healthy, and environmentally-responsible. Sound implausible? In *Green Remodeling*, David Johnston uses rich language, anecdotes and anec-don'ts to help homeowners translate their needs and desires into refreshed spaces that are gorgeous, great, and green.

— Helen English, Executive Director, Sustainable Buildings Industry Council

The only solution for the condition of our planet today is for each of us to do all we can to preserve and enhance the natural capital on which the future of our children depends. The air we breathe, the water we drink, and the integrity of the ecosystems on which all life and thus all economic activity depends is vital for a sustainable future. *Green Remodeling* is a tool you can use today to make your contribution to ensuring a secure future for all the world's children.

— Hunter Lovins, president of Natural Capitalism, Inc., and author of *Natural Capitalism*

As co-host of the integral sustainability domain, David is one of the leading thinkers on how to transform our consumer culture to a more sustainable world. Everyone has a role to play in this transition and *Green Remodeling* is a great place to start. No matter what your project may involve, there are more environmentally sustainable ways to build and this book takes you step by step toward a better future for all....

— Ken Wilber, author of *A Theory of Everything*

David Johnston is such a good writer, readers will readily absorb the wealth of information offered in *Green Remodeling*.

— Katherine Salant, nationally syndicated newspaper and online columnist, and author of *The Brand New House Book*

Remodelers are the unsung heroes of the building industry — adding functionality and beauty to extend the life of existing buildings. Their work is much trickier than new construction because the rooms they start with are rarely square or plumb, and are often full of surprises. *Green Remodeling* shows how this inherently resource-efficient industry can become even more environmentally conscious, and it does so in a way that is both accessible and comprehensive. This book is a real treasure!

— Nadav Malin, editor, *Environmental Building News* and *BuildingGreen Suite*

Green Remodeling

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This book is dedicated to John Steiner and Margo King who have been a constant source of inspiration: one person can change the world. Without their support, evocation of and belief in a hopeful future, this book might never have been written.

Books for Wiser Living from Mother Earth News

Today, more than ever before, our society is seeking ways to live more conscientiously. To help bring you the very best inspiration and information about greener, more sustainable lifestyles, New Society Publishers has joined forces with *Mother Earth News*. For more than 30 years, Mother Earth has been North America's "Original Guide to Living Wisely," creating books and magazines for people with a passion for self-reliance and a desire to live in harmony with nature. Across the countryside and in our cities, New Society Publishers and *Mother Earth News* are leading the way to a wiser, more sustainable world.

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Acknowledgments

IT TAKES A VILLAGE TO WRITE A BOOK LIKE THIS. There are many people on whose shoulders I stand to have this work in print. Thanks to opportunities so many people have given me, my life has been enriched with experiences that have figuratively built the foundation of this book.

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To the "GEMS" group — Jim Turner, Richard Perl, John Steiner, Alisa Gravitz, Paul Ray, Ana Mika, Michael Ostrolenk and our circle of change agents: the world is a better place because each of you have such passion and commitment to healing the planet.

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Most of all I appreciate my collaboration with Kim Master, a brilliant and tenacious soul; her dedication and commitment made this book possible.

Foreword

by Marc Richmond

Fourteen years ago, I felt tired of building; I had been building for five years and needed to expand my horizons. So I left the industry to acquire additional education in graduate school, to pursue a career in a completely different sector — the environmental field — that would, I hoped, prove more meaningful to me and more valuable to others.

While researching the greatest causes of environmental damage, I read a statistic that changed my life forever: 40 percent of all the world's energy and material resources were used in only one industrial sector — the building industry. I was shocked. I had seen all of the dramatic photographs of air, water, and land pollution, as well as images of natural resources being used at an unprecedented rate, but I didn't understand that my previous work caused environmental ills greater than any other industry. I also felt removed from nature because I have always lived in cities or suburbs, oblivious to strip mines, oil fields, clear-cut forests, steel mills, refineries, and cement kilns. Like others, I was overwhelmed by environmental information and confused about how to make a dent in reducing the problem.

However, I did have a connection to buildings through my work experience, and like most other people, I lived in a building and worked in a building. I didn't need to go elsewhere to help the environment and follow my dream! I needed to wake up, look at where I already was, and fix things from the inside out. I was about to begin my new career in a new, little-known field called green building. To this day, that building industry statistic still inspires me more than anything else to continue to educate people about the benefits of green building.

Knowledge is power. We can't measure people's ideas in their heads or feelings

in their hearts, but we can measure what people do. If people have the education and training to understand their choices in life and how they can exercise them, then they will make the appropriate change for themselves and for society in general. I hope that you already have had or will shortly have an awakening of sorts as I did years ago, and that the education you get from this book will drive you to take action as well. Picking up this book is already a piece of that action. Reading it and then using its valuable information will be the measurable piece.

I met David Johnston about ten years ago when he interviewed me for a job opening with an exciting new green building products company. He was a tough interviewer, knew what kind of person he was seeking for this job, and told me directly that it wasn't going to be me. He did seem to like me, though, and asked me to visit him if I ever came to town. I stopped by a few months later and immediately found him to be a man of great character, vision, experience, curiosity, warmth, and balance. I have had the honor of coming to know David over the past ten years as a mentor, a brother, a collaborator, and a confidant. He is someone whom I, and many others who know him, respect as an experienced professional and as a deeply thoughtful human who holds a great passion for people and the planet. He has taught me the quality of being impatient in fighting for the need to educate people on how they could do things better for themselves and their world. He has also taught me to be patient with the world and the slow and nonlinear process of change. I truly admire his manner of always respecting people and trying to understand their perspective. This characteristic is most evident in this book, as he thoughtfully and comprehensively offers an educational pathway to empower readers to make simple, positive changes in their lives that affect them directly as well as all of the rest of us on this planet.

David's previous book, *Building Green in a Black and White World*, was aimed at professional builders — to educate and inspire them to build green for you, their customer. This book is aimed at you, the consumer and the true implementer of the movement. The subtitle, *Changing the World, One Room at a Time*, is truly appropriate because the book is intended to inspire you with the new-found knowledge that small room changes are indeed significant decisions, with ramifications not only in your home but also in your locality and in our global environment.

Whether you intend to hire a professional or do it yourself, this book offers hundreds of useful, doable ideas and steps. As one of the country's most

knowledgeable educators of green building, David has assembled all of his experience in this book. He shows that you have many choices in the types of products and services you can buy; that you can make definite choices in your remodeling work, allowing you to express your personal values as you build a healthy, affordable, and durable home.

Most of us feel helpless in a massive global economy that seems to be run by powerful, faceless corporations moving forever forward. In fact, we have a great deal of control, but we rarely exercise our power. We are the consumer of all products and services — those faceless corporations cannot move one inch without our daily purchases. We owe it to ourselves to become more educated consumers and ask for what we want. What do we want? We want our home to be our castle. To build such a castle, we want a good design and quality installation of products that work, that are durable, that are low maintenance, that save us money on utilities and maintenance, and that are healthy for our families. What we are seeking is a concept called green building. We also deserve to know the answers to questions regarding how a product is made, what type of pollution its manufacture creates outdoors and inside our homes, and what the real cost of this product will be over the long term. Many of us have exercised this power, as evidenced by the plethora of products now available versus ten years ago, and in the change in typical manufacturing processes. Today, most carpet manufacturers are actively battling to "out green" their competition by offering products with high recycled content, low emissions, plant-based fibers, and recyclability. The forest products industry has made great strides in implementing sustainable harvesting practices and in making engineered products that use half as much fiber as solid wood while being stronger, straighter, and more durable. Paint and adhesive manufacturers have moved from offering mainly highly volatile, dangerous products to offering numerous products that are completely solvent free.

I hope you will see the knowledge and power within this book. The action to make it happen lies with you. Please read this book carefully, consider its recommendations seriously, and allow yourself — and all of us — to benefit from your new education.

Marc Richmond
Austin Energy Green Building Program
Austin, Texas, 2003

Introduction

My entire childhood was spent in a suburb of Chicago. As far as I knew, June Cleaver was how everyone's mom behaved. I could ride my bike anywhere and be safe. Most of the houses looked alike and many of the people acted the same way. School was interesting and Little League was what boys did in the summer. But no matter what the planned activities were, I spent most of my time in the woods and prairies. I lived outdoors, catching insects, taming raccoons, and fishing in the local streams and ponds. I reveled in the way nature changed throughout the year from spring green to summer lush to fall leaves to winter silence.

Wooded areas are made for building "forts" and treehouses. Or so I believed when I was 13. The highlight of high school was building a three-story treehouse in a giant elm tree deep in the woods; two friends and I worked on it during summers after football practice and on cold fall afternoons. The gratification from building that tree house fulfilled me as nothing else did. My friends and I planned and improvised with materials neighbors had thrown away. Then we built like mad until the designs in our heads stood in physical reality before us. After a long weekend of work, I'd look back and feel great about what we had accomplished. Best of all, we could get away from the grown-ups at will! Thirty feet up and hidden in a dense forest, they couldn't find us, and if they did, they couldn't get to us.

When I arrived at the University of Colorado in 1968, I thought studying engineering would be the key to continuing my building experience. I bent my mind around calculus and physics and statistics and structures, but it was too abstract. I missed the practical experience of building; I missed nailing boards together. So in the summers I worked on construction sites, where my real learning took place.

College and I parted ways after three and a half years so that I could return full-time to building houses. I thought my treehouse and summer building projects would be all the experience I needed to become a carpenter in the "real"

world. Wrong! I had no idea there were such dues to be paid! Builders that I met were renegades; young bucks like me were minions to be ordered into servitude. "Boy, see that pile of two by fours over there? They need to be over here. Go move 'em and see me when you're done." After two long hours of hauling boards, I heard, "Boy, what are you doing? Those two by fours are in the way! Move 'em back to where they were, pronto!"

College days started to look sweeter and sweeter.

My savior was a great man named Bob Prentice. He was a third generation Colorado carpenter whose granddaddy had built bars in Cripple Creek during the gold rush days. Bob was a compassionate perfectionist. He taught me a lesson I had never learned in my twenty-something years: there is only one way to do things — right! If it went up, it was plumb. If it went across, it was level. When boards came together, they were square. Period.

I am grateful to Bob to this day because while the rest of the world was saying, "Good enough is good enough," Bob challenged me to build it right. What a concept! What if that philosophy of doing it right were applied to the rest of my life? What would that look like? My entire life I had been searching for black and white rules to follow that would always be true — Bob gave me the first chapter in the rule book.

I followed in Bob's bar-building family tradition and moved to Mississippi to build three bars in a college town. I jumped all over the chance to design and build commercial spaces without being a licensed architect or contractor. Each of the three buildings was unique. We used recycled stained glass, turned balusters, and wrought iron salvaged from torn-down antebellum mansions. Design was now in my blood. Drawing pictures and creating three-dimensional constructions, from paper to completion, was thrilling. I wanted more.

A client retained me to design and build a geodesic dome country retreat. I had never built one, but I knew that the inventor, Buckminster Fuller, fondly known as Bucky, was teaching at Southern Illinois University. The design school at the university taught classes in constructing geodesic domes, so I went to the source for the information I needed. When I arrived in Carbondale, Illinois, in 1974, I knew my life would be different from that point forward. In one geodesic dome that had been converted into a workshop, I saw an electric vehicle being built on a VW chassis. It was one of the first hybrid designs to get over sixty miles to the gallon. In another shop, carcasses of wind machines were being rebuilt using contemporary electrical technology. Site-built solar panels were everywhere.

I was home! I started school a month later. The Design Science program required that you create your own major so I invented what I called "Environmental Systems Design."

Life took on a new reference point for me: there was life before Bucky, and life after Bucky. From day one, my thinking was challenged and changed: we were taught to think in systems. Everything was connected, like nature. Nothing existed separately from anything else. A shift in one system affected the equilibrium of everything else. Any object, place, or thought was made up of subsystems and was a part of a metasystem, or larger context. All systems were created equally and followed the same rules. Smaller systems and larger systems dynamically interacted constantly. Nothing had meaning in isolation. It made so much sense!

Passive solar.

The building's structure (or an element of it) is designed to allow natural thermal energy flows such as radiation, conduction, and convection generated by the sun to create heat. The home relies solely or primarily on non-mechanical means of heating.

Systems thinking became part of my daily life. In order to study buildings, I had to learn about urban planning and forest ecology. And how could I understand heating and cooling systems without a solid background in human comfort conditions and climatology? (The term "passive solar" had not been coined yet. It was called "applied climatology.")

So many interrelationships became obvious to me. A building was an integral part of its surrounding ecosystem. If it respected the ecosystem and interacted with the natural flows, everything functioned better. When it was designed to capture solar heat in winter or prevailing breezes in summer it was more comfortable. Either it fit systemically or it was an irritant to the larger system. Buildings that interrupted animal habitats or changed water courses or microclimatic conditions had larger systemic impacts than just at the site itself. A building also had significant impact on the occupants, for good or ill. I learned that drafting an architectural wonder was unacceptable unless its existence was environmentally justified.

I graduated with my degree in Environmental Systems Design. Each word held a special significance for me. Designing environmental systems was a delightful challenge. Solar heating, wind-generated electrical energy, hybrid electric vehicles, and structures that danced with the elements all stimulated my thinking, my imagination, and my soul.

The horizons of my thinking said that systems were the basis of understanding everything. With systems thinking we could redevelop cities, eliminate environmental pollution, even cure cancer. I faced a design opportunity to take what works today and redesign the rest. It was so logical! I also developed a new appreciation for architects. I assumed architects understood good design because they had gone through similar training; architects had to synthesize an amazing amount of information to be able to design buildings that worked on many levels.

After graduation, my optimism led me to believe that it was just a matter of time until all design would be based on environmental systems. I wanted to be on the cutting edge of this exciting time; I was sure a new day was dawning that would shape how we built buildings from now on. Environmentally responsive, solar powered, human engineered, aesthetically integrated — the home of the twenty-first century had arrived 25 years ahead of schedule! Environmentalists had predicted that we would hit our limits to growth in the year 2000, but with this new vision we were going to make it! We had the tools, and the world would obviously understand its dilemma and transform itself for the sake of the future. Once again, I believed I had a clear view of the rules of the game.

Many years and many miles later, I realized how woefully inaccurate my naïve assumptions had been. What I had thought was inevitable — a world based on systems thinking, renewable energy, and human engineering — never truly came to pass. Solar had a short life in the late '70s and early '80s. Geodesic domes made great radar enclosures for the defense department, but they never made it to the suburbs. Bucky died in 1983, loved but not understood. His clear guiding principles seemed to get lost in the oil embargo and the subsequent recession.

Trying to recapture the enthusiasm of my early treehouse days, I designed homes, taught college, consulted for the government, and ran a construction industry trade association. But something was missing — something about looking over my shoulder at the end of the day and feeling gratified at seeing the frame of a new structure that wasn't there days ago. Building was still in my blood.

In 1983, I started Lightworks Construction in Washington, D.C. I wanted this company to combine the solar work I had done and the construction I loved. I was going to design and build solar homes that would embody all the principles I learned in school with the latest state-of-the-art passive solar design. I had been doing business by the book, following all the black-and-white rules of starting a construction company. But I realized I didn't want a black-and-white company — I wanted a "green" construction company! I didn't want to build typical houses

that looked like all the others on the block. I wanted to build houses that incorporated all I had learned about systems, energy efficiency, and quality construction that would last a hundred years. My hard work, marketing, and friendly customer relations paid off when Lightworks became the contractor of the year in Washington, D.C. and was named one of the top 50 contractors in the country by *Remodeling Magazine*. Building green in a black and white world paid off in spades!

My days as an official contractor ended ten years ago when I moved to Boulder, Colorado and began What's Working, an environmental construction consulting firm. I have had the pleasure of working with dozens of policy makers, developers, builders, architects, and homeowners to create thousands of healthy, environmentally friendly homes and buildings around the country. Still, I call myself a "recovering contractor" because I just can't leave my own house alone. Not only have I built a new office (the inspiration for this book), but I have replaced, repaired, upgraded, or added every major appliance in my home, not to mention the windows, doors, siding, roofing, insulation, the entire basement apartment, and a new solar system.

Green remodeling is the beginning of creating a lifestyle that is more in tune with the natural rhythms and flows of the planet. With all of the ecosystems on the planet in rapid and severe decline, the extinction of 27,000 species per year, and the onset of global climate change, we can no longer wait for "them" to fix it all. There is no "them" out there. *We* are the ones we have been waiting for to make the world a better place for our children and grandchildren. Each decision we make today regarding energy use, building materials, and water consumption will have a long-lasting impact on future generations. We have a responsibility today to make the wisest decisions possible to address the myriad environmental issues we face.

My work is based on the belief that each one of us makes a difference. Collectively, Americans spend $160 billion each year on remodeling. If just a fraction of this money was focused on greener construction, we could restore a significant portion of the world's ecosystems while immediately creating a healthier indoor environment for our families. Just think in terms of changing the world, one room at time.

David Johnson
Boulder, CO
July 2004

How to Use this Book

IT IS OUR INTENTION THAT THIS BOOK BE THE ONLY ONE you will need to start on the adventure of remodeling your home. It is divided into several sections so that you can readily find the information that is pertinent to your specific project. The first chapter is a journal of my own remodeling projects, complete with stories and details not covered elsewhere. But primarily the book is a "how-to" resource, including how to finance your remodeling project (Chapter 2); how to work with an architect, how to love your contractor, and how to stay sane during the remodeling process (Chapter 3); and how to understand building science basics (Chapter 4).

Given that buildings have such an enormous impact on the global environment, we have also developed a brief synthesis of the major environmental issues facing our planet (Chapter 5), particularly as they affect the choices you must make when remodeling. It is difficult to find a single source of environmental facts and figures that tell the real story instead of simply giving the media spin on our planetary conditions. This chapter is meant to stand alone as a reference, providing you with a basis to find out more about what is happening around the world — but it also contains information that relates specifically to the green building process.

The remaining chapters form a resource of green building materials and techniques — why you should use them, and how they provide benefits to your family and your checkbook. You can use Chapter 6 to look up individual rooms that you want to renovate, and then find information on stages of construction and categories of products in the following chapters (Chapters 7–19), to guide your remodeling team in selecting the green products that are most appropriate to your project.

The Resources section provides information for further research on a variety of subjects. The glossary will help you find terms commonly used in the green building world that may be unfamiliar to you, and which may help you to communicate clearly with your architect and contractor. In Appendix 2, you will

find conversion tables that will allow you to cross-reference between US measurements and metric equivalents.

The most important thing to us is to provide you with a smorgasbord of options on green building. You don't have to do everything! Pick and choose among the hundreds of options for the design features and green building products that serve your best interests. There is no such thing as the right or wrong set of products. This book was designed to give you as much information as you need in order to make informed decisions that will lead to your pleasure and comfort for years to come, when you are living in your remodeled home.

Part I

Getting Started

The Story of My Remodeling Project

GREEN REMODELING IS NEW TO MOST PEOPLE, so I want to share my experiences remodeling my 1973 vintage home and building a new office addition. They represent two entirely different approaches: first, working within the confines of an existing house with incremental improvements; and second, putting a second-floor addition over a detached garage that was designed to be as green as I could make it. My intention is to introduce you to some new building materials in the hope of easing their integration into mainstream construction, and to make green building standard building practice for you. What is unique about green remodeling is that each green material holds importance to your home; in a sense, each material has a story. You end up telling people about the retaining walls that were reclaimed from your dentist's yard or the structural beams that were compressed together from fast-growing aspen trees.

In my home renovations, I did many things that you will probably never consider. There is no need, unless you have a compelling desire, as I did, to do everything. Building green is a thinking process, not a contest to see how many green things you can incorporate into your home. Do what you can within your budget and motivation. By taking control of the project myself, I was able to get many products directly from the manufacturer. I also intervened with the trade contractors and instructed them on how to use the products. I was able to select my tradesmen by their willingness to try something different. In a typical remodeling project, you are somewhat at the mercy of a remodeler's relationship with subcontractors. In any case, here is my story; I hope it encourages you to create your own!

My 1973 Vintage Home

When I moved to Boulder, Colorado in 1993, I bought a "fixer upper" with a view. The house was built in 1973 and was rented for eight years before I bought it. Like

Fig. 1.1: My home in the hills. Credit: Kim Master.

any rental property, it showed the results of hard use and little maintenance. It needed everything, especially in the kitchen. All I could think about was getting rid of the avocado refrigerator and the lemon yellow countertops. I wanted to transform the kitchen from the '70s look-of-the-day to something modern and functional.

Several months later we were having our first dinner party. The house looked great, the table was set, and there were candles everywhere sparkling in the windows that overlooked the lights of Boulder. I didn't think the house could look any better, except with a new coat of paint. Just as friends were starting to arrive, our first November winter windstorm blew in. The windows were closed — yet all the candles blew out in the living room! The windows leaked air so badly that we had to wear jackets while we entertained. I realized that the kitchen renovations would have to wait; first, the single pane windows had to go.

Educated about window technology from my remodeling days, I called a local manufacturer that made Heat Mirror™ windows. These are often called "super windows" because they have a film of plastic suspended between two panes of glass that make them super energy-efficient — they're almost twice as effective as conventional windows. I started in the living room where most of the room was glass, by spring I had replaced all the fixed glass in the house. On the south side I wanted to enhance the passive solar gain, to heat my home naturally with the sun, so I installed high solar heat gain coefficient (SHGC) glass that lets lots of sunlight through the glass. On the east side I put in low SHGC windows that minimize sunlight through the windows, reducing overheating on hot summer mornings. The windows worked like a charm, making the house more comfortable and reducing our heating bill significantly.

Now I was ready to take on the avocado kitchen. Well — not quite. I came home one night to find water all over the basement floor. The water heater had rusted out and leaked. I talked to plumbers who suggested low-end models that would "serve the purpose," but I wanted better. I finally found a water heater that had twice the insulation around the tank. It included a valve that prevented hot water from rising up into colder pipes and returning to the tank as cold water, a phenomenon known as "thermosyphoning." Luckily, the model was also the "California code builder model," so the company manufactured a great many of them for builders to implement easily and inexpensively into their projects. My energy-efficient water heater ended up costing only slightly more than the low-end model the plumber suggested, due to transportation expenses from California. But more importantly, my monthly energy bills have been noticeably lower.

The upgraded windows and water heater were just the beginning of the improvements I've made to my home. I rebuilt the boiler and made it more efficient. I insulated all the hot water pipes and the crawlspace. I replaced the '70s washing machine when it died with a front-loading unit that used half as much water per load. I replaced burned-out light bulbs with compact fluorescent bulbs that are still burning ten years later. I repainted with low volatile organic compound (low-VOC) paint that contains fewer toxins that conventional paint. And I replaced the avocado refrigerator that finally died (thank God!) with the most energy efficient model on the market that uses 50 percent less electricity and comes in a lovely off-white color.

Even if it wasn't broken, I tried to replace old technology with new technology. Now, with the push of a button, my Metlund "on-demand hot water pump" circulates water in the pipes until it reaches a predetermined hot temperature at my bathroom faucet. I no longer waste water waiting for the shower to heat up; rather, the pump shuts off and the water is instantly hot.

Photovoltaic (PV) panels that generate electricity from the sun have been my best and biggest upgrade. Living in the mountains, we are at the end of the pipeline for everything, including electricity, water, gas, and cable. If anything went wrong somewhere below us we lost our service. At least once a month, especially in big snowstorms or thunderstorms, our power would go down, stopping my home-based business in its tracks. So in 1999, when the State of Colorado and the US Department of Energy had a rebate program for PV systems, I jumped on the opportunity. Interest rates had come down and I was able to refinance the house, allowing me to take enough money out of equity to pay for the PV system and simultaneously save money on my monthly payment.

The 1.2-kilowatt system is enough to power my office. In an emergency, the system also powers the hot water baseboard heating, lights, and the refrigerator. I

Solar Saves the Day

One day several months after installing my photovoltaic system, I was working frantically on a final report for a contract in Washington, D.C. The report had to be in that day by close of business, D.C. time — period. I was furiously writing, sending faxes and e-mails, and finalizing the report. At 3:00 p.m. mountain time, I hit send to deliver the report by e-mail to D.C. Only when I went into the kitchen to get a drink did I realized that all the digital clocks were flashing and that the power had been out for six hours! My computer never even blinked. The money I would have lost if I hadn't gotten the report in was more than the cost of the PV system. As far as I was concerned, the system paid for itself in three months.

don't believe in payback periods for energy equipment, but I do believe in never being powerless again.

Being powerless is not my only pet peeve — I also dislike the idea of my house on fire. We live in a mountain desert that is prone to drought and fire. The summer of 2002 was especially dry and it seemed as if the entire state was on fire. In every direction the smoke-filled sky looked like the Los Angeles basin. Just a quarter of a mile south of us a fire broke out. Fortunately a fire plane was just taking off after refilling its tanks in a nearby reservoir and it was able to put out the fire. A few weeks later another fire started just north of us and burned a couple of neighbors' houses. I panicked. I worked out the details to put one inch of rigid insulation over the existing plywood siding and under new James Hardie fiber-cement siding. That served two purposes: it increased the insulation all around the house and it fireproofed my home, reducing my home insurance rates by 15 percent. Needless to say, I slept better for the rest of the summer.

All this green retrofit work I did in the house was within the "footprint" of the existing foundation with very little cosmetic change (yes, I still have the canary yellow formica in the kitchen). I worked on mini projects one at a time, but the accumulation added up to reducing energy bills by 50 percent and water consumption by 30 percent. Yet these savings are just a small part of the gratification; peace of mind is priceless. The PV system has kicked in many times, allowing me to be productive in my office during down times. Fireproof roofing and siding are major contributors to my sense of safety. Reduced water usage protects the limited neighborhood water system. In general, greening my vintage home has been a fulfilling way to connect with my environment and to support my community.

My 2003 Office Addition

The following section details my office addition process, from planning and deconstruction through interior work and computer networking. I have written it in a journal format to give you a better sense of renovation time frames and chronology, as well as to prepare you for the feelings of elatedness and stress that tend to accompany specific remodeling stages. In sidebars, I've highlighted the green features in my office. This format reflects the way the green features were constantly on my mind, motivating the renovation process.

Planning

July 1, 2002

We are finally planning our office addition! When my wife and I first considered buying the house ten years ago, we climbed up on the garage roof and fantasized about working there. The view is breathtaking! And now it is really going to happen!

This is going to be the "world headquarters" of What's Working, my environmental construction consulting company, so it needs be the best example of what is working. I want to build a signature piece that will reflect what my company is all about — a prototype green building. I want unique architecture that will blend into my mountain neighborhood; a playful space in which to work and entertain; a room big enough for presentations and meetings. Additionally, it has to be energy efficient, it has to use all resources as efficiently as possible, and it has to have clean air without the toxic chemicals that are released from so many building products today.

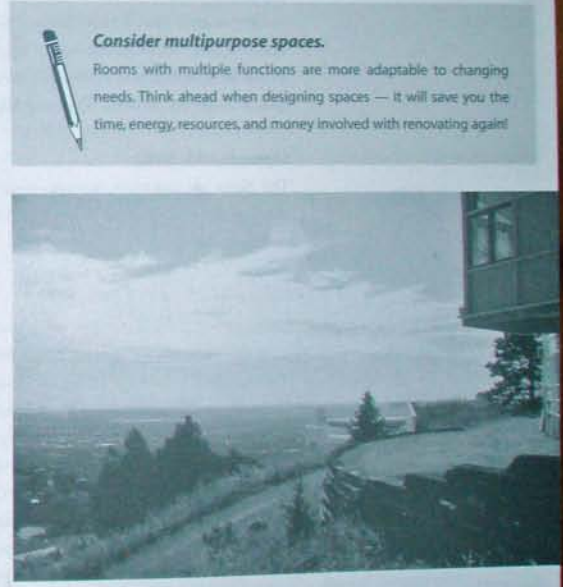


Fig. 1.2: View from garage. Credit: Kim Master.

Consider multipurpose spaces.

Rooms with multiple functions are more adaptable to changing needs. Think ahead when designing spaces — it will save you the time, energy, resources, and money involved with renovating again!

Consider "green" financing.
Contact a local professional who is familiar with financing green, energy efficient renovations. For further information, go to <www.DreamSourceFinancial.com>

I ruminate over what I want in my space and how it will work as a multi-purpose building. I need office space now, but what about the future? Will my company outgrow this building as I have outgrown the office in the house? What if I accept an assignment in another country (a fantasy that I hold dearly, especially after attending the World Summit on Sustainable Development in Johannesburg, South Africa, in 2002)? Could we rent out the house and convert the office into an apartment for our return visits?

At the same time, I have a limited budget to work with. My mortgage broker, who originally financed the house, calculates that refinancing my home in light of low interest rates and my home's appreciated value is equal to $100 per square foot of construction costs. This is enough to make my dream office a reality!

September 15, 2002
The plans are complete enough to start calling contractors for bids. I trained many of the remodelers in Boulder and figure I can get one of them to work with me on a project.

September 25, 2002
I am shocked when I get the contractors' figures back — $200 per square foot, twice my budget! The specifications freak out even those contractors I trained through the Boulder Green Remodeling program because they have never used materials such as structural insulated panels. The difference between my aspirations to "walk my talk" and reality have never been more dramatic.

I decide that it would be too expensive to use a contractor so I bite the bullet and choose to be my own general contractor. I haven't built anything significant for over a decade. Will I find good people to get the work done? Am I crazy? Despite the disconcerting voices in my head, I feel committed. Sometimes the voices of internal terror are just there to push us to reach higher and try new things.

October 23, 2002
My architect, George Watt, helps me flesh out my plans. After going through iterations of floor plans, elevations, and finish treatments, we arrive at a final design

that accomplishes all of our objectives. My motivations for using green products are twofold. First, I train builders, architects and remodelers how to build green. I have hands-on experience with many of the products I talk about, but not with all of them. Now is my chance to gain practical experience with even more of the materials, rather than simply relying on manufacturers' literature or word of mouth for information. Second, I developed the Boulder Green Points program and counsel many builders on how to comply with the program's energy efficient, resourceful, and healthy material requirements. Often I hear, "The products are too expensive," "I can't get my subs to use them," or "I can't find the products anywhere." Using green products in my own office addition will help me address these issues firsthand.

Focus on what's important to you.
Practicing what I preach — including energy conservation, saving old-growth trees, and healthy indoor air — is important to me, but different people will obviously have different concerns. Whether you feel passionate about reducing your dependence on foreign oil, saving old-growth forests, or creating a healthier environment for your partner and children, you can focus the time and money you spend on your remodel according to your specific motivations.

Deconstruction

January 1, 2003
We rent a U-Haul to empty out the garage in preparation for building. We recycle some of the stuff accumulated over two lifetimes stacked in the garage and put the rest in storage. It feels great to lighten the load — a symbolic beginning to getting rid of the old to make space for the new.

Fig. 1.3: Garage before construction.
Credit: David Johnston.

January 2, 2003
The 30-year-old siding is T-111 cedar plywood and the roof is cedar shakes — tinder waiting for a match. They reflect an architectural style of the '70s that today are a liability due to the high likelihood of fire in the mountains. Each fall I am grateful to have made it through another dry summer. So, as the roof of the garage is taken apart piece by piece to make way for the second floor we save the

One Person's Trash is Another's Treasure

The roof of the garage was deconstructed and donated to a non-profit reseller. One of the challenges I set out for myself was to keep the waste from deconstruction and the addition to a minimum. I have served on the board of directors for a local non-profit organization, The Center for Resource Conservation, for several years. In 1995, the group founded a business called ReSource 2000 (R2K) to sell used building materials. Builders and remodelers donate these building products from deconstructed buildings or leftover materials. Sometimes when a window order is messed up and the windows are returned, the window supplier donates them to R2K. I have supported the business and helped it to grow to a nearly $500,000 per year enterprise. The combination of being on the board and keeping my trash out of landfills inspired me to deconstruct whatever building materials I could for reuse. The roof was the beginning.

shingles as tinder for the wood stove in the winter. The least I can do is use the wood for its best purposes at this late stage of its life.

We deconstruct the plywood roof sheathing in a similar fashion and resell it at ReSource 2000 (a recycled building materials outlet) since it's still in great shape. (One forgets that 30 years ago they made plywood from big enough trees that there were almost no knots on the faces of the structural grade plywood. Today there are "footballs" — cutouts where the knots used to be — all over the faces of plywood.) We then remove the trusses one at a time and load them onto the truck. By the end of the day we are down to concrete walls and one wood frame wall. It is like the garage got a crewcut and is ready for boot camp.

Fig. 1.4: Roof deconstruction. Credit: David Johnston.

Job Site

January 3, 2003

Before you start digging, you never think there will be so much dirt! However, rather than trucking the dirt off site and having to import new dirt for the driveway, we have built a retaining wall for it onsite. The wall is made of old railroad ties graciously donated by my dentist and

Approximately 200 Railroad Ties were Reused for Retaining Walls

I love my dentist. She is not only a master of her trade, but she is interesting and fun. When I'm at her office, we always talk about trips, adventures, life in the abstract and in the pragmatic. (It doesn't get more pragmatic than a root canal.) She and her husband were about to remodel their house and asked if I would help them make it as green as possible.

I visited their lovely home, met with their architect, and we agreed on plans for an extensive addition/remodel that involved considerable deconstruction. I talked them into using ReSource 2000 (R2K). However, there were almost 100 old railroad ties retaining their back yard that would be excavated for their addition; I said I wanted first dibs on the ties. They agreed and R2K deconstructed the house and delivered the ties to my yard. There they sat for about six months; I knew I would figure out how to put them to good use. Eventually, they became retaining walls to support the new driveway.

her husband, who dug them up after renovating their own home. This structure also allows us to extend the driveway around the garage all the way up to the house — eliminating the need to hike up 50 steps to get to the house. Finally, we cover the red mud that has plagued us throughout the construction with 30 tons of recycled concrete. (Colorado red mud is much like concrete itself until it gets wet and then it is like walking through silly putty.)

When Denver International Airport (DIA) opened, Denver officials had the conundrum of what to do with all the infrastructure of the old Stapleton airport, including all the concrete from the old runways. As it turned out, one of the largest concrete recycling facilities in the country was built to take the runways and turn them into gravel that could either be used in new concrete or used for other purposes, like my driveway.

January 5, 2003

Building on a hillside requires extensive underground water drainage. I decide to use drain tile all around the building and in the retaining walls. It collects to central areas where it penetrates the retaining wall and out to the hillside. All of the gutters go into that drainage system so the area around the building stays dry.

Foundation

January 7, 2003

I have always been a closet pack rat. Well, perhaps not too "closet," since I'm admittedly building this addition to store ten years of old papers. Not only do I

Ensure quality construction, especially in the beginning of your renovations.

Any error in the foundation is compounded as you get higher up in the framing process, culminating in serious roof framing dilemmas. When building, there are certain things that always hold true:

- **Square means square.** That's ninety degrees; not eighty-nine, not ninety one.
- **Plumb is plumb, or perfectly perpendicular to the ground.**
- **Level is level.**

All these rules must be adhered to from the beginning or you will have ugly consequences later. For example, consider how a building starts from the ground up. That may seem obvious but it has major implications. If the foundation is out of square, then the rest of the building is difficult to square. Especially when working with structural insulated panels for framing, there is no margin of error for the foundation. The panels should come in pieces that fit together like a jigsaw puzzle; if the pieces don't fit, it's a building nightmare.

Fig. 1.5 (above right): It is important that the foundations are square, level and plumb. These men are making sure the concrete floor is level. Credit: David Johnston.

keep files on all past jobs, I probably still have copies of the first green building articles in magazines ten years ago. The same holds true for building materials. I use framing lumber I have been stacking in the back of the garage for years to reframe the new east wall that will serve as part of the foundation for the second floor. We save some of the plywood from the roof to sheath the new garage walls. In some cases we go to ReSource 2000, the local reused building materials lumberyard, to get framing material. This saves money and reuses materials that might have gone to waste otherwise.

January 13, 2003

We put a lot of faith in our concrete subcontractor for the foundation. I find a company that had been in Boulder for years; everyone in the building trades knew their company and loved working with them. Their reputation, combined with the relationship I am able to establish with the owner, sells me on doing business with them. To make a very long story short, Marvin Clyncke's company pours the foundation within a sixteenth of an inch of the required dimension, making it perfectly level for the structural insulated panel (SIP) floor. It is close to a miracle

to see so many laborers working with big concrete forms and a massive concrete pumping truck 50 feet away, with concrete pipes 40 feet in the air pumping high volumes of concrete. Neighbors are flocking to the end of the driveway to check it out. I know if something goes wrong I won't hear the end of it….

Establish good relationships with contractors.

In the remodeling industry, relationships can determine the quality of your project. See Chapter 3 for more information about establishing good relations with your contractors.

Reuse onsite resources.

Reusing stone from a local resource saves the cost and energy of buying new patio materials.

Exterior Work

January 15, 2003

Each time the earth moving equipment unearths flat stones, I have the laborers pick them out of the pile and stack them for later reuse. We have reclaimed stone from all over the property that will become the flagstone patios around the house and the new office.

Fig. 1.6: Reusing stone from a local resource saves the cost and energy of buying new patio materials. Credit: Kim Master.

Framing

January 20, 2003

One of the reasons I am so committed to green building is to protect big trees. I love the big things on the planet including big animals and big trees. They stimulate my imagination to envision what the planet used to look like before the industrial revolution started reducing the absolute numbers of all of the above. The loss of large life forms on earth reduces humans to a lesser species by letting us believe that we can conquer nature. I believe that we are more human by preserving and protecting the ancient things. How can we remember our place in the larger ecosystem if all that is left is second growth forests and tigers in a zoo?

I've been in the construction industry long enough to know what a vice-grip the forest products industry has on wood production. Their approach is to cut the last of the big stuff as fast as possible before regulations get in their way. Once a forest is clearcut, it becomes a plantation, perhaps for corn. The ecosystem is fundamentally changed. The plants and berries, and animals that live on them, are gone. The very soil bacteria that support the forest ecosystem changes. It takes hundreds of years for an ecosystem to return to a stable state after it has been clearcut. The forest products industry likes to brag that there are more trees in the

Structural Insulated Panels (SIPs) Used for Floors, Walls, and Roofs.

SIPs are one of the building products of the future. SIPs are framing materials made by sandwiching expanded polystyrene (Styrofoam) insulation between two pieces of engineered wood (OSB) that are in turn made of small pieces of wood compressed together. Of all the foams, expanded polystyrene is the least toxic to the environment. It uses steam or pentane to expand the foam pellets rather than gases that eat the ozone, such as chlorofluorocarbons (CFCs) or hydrofluorocarbons (HCFCs).

SIPs are energy efficient because they have little wood that spans from the inside of the structure to the outside, a feature known thermal bridging. Without this unwanted transfer of heat through the wall, the SIPs create a structure that is better insulated and therefore more affordable to heat and cool than conventional framing. Making your home more efficient is one of the best investments you can make. I have been searching for the crystal ball that will tell me what the price of energy will be in five years: no one has a definite answer, but the outlook is not good. Natural gas prices increased in Colorado 75 percent in 2003 alone. I want my office to be affordable to heat and comfortable to work in 10–20 years from now when energy prices are high, so I'm building my office 40–50 percent better than the local energy code. If you are doing a major remodel, you have probably decided to stay where you are awhile. Building to the highest standards possible, in part by using efficient materials like structural insulated panels, will ensure that your comfort will be affordable in the future.

US than there were when the pilgrims landed but they are in tree farms. In reality, we have far fewer forests and animals than there were then.

One of the most upsetting things I've learned about forests versus tree farms is that the forest products industry managers shoot bears to protect their "agriculture." Last year in Oregon alone, big forest producers shot 110 bears and cubs and uncounted elk that were damaging the trees on the edge of their tree farms. I want to do my best to preserve what is left of our indigenous heritage.

And that's why I have chosen to use many of the engineered wood products and Forest Stewardship Council (FSC-certified lumber on the office instead of traditional wood framing. Structural Insulated Panels (SIPs) are the first step.

January 20, 2003

We've been moving dirt for weeks. It looks like a war zone, with foxholes everywhere.

While we're digging I am sending design plans to the SIP manufacturer in British Columbia who will precut the panels. I chose this SIP company because they "dry build" the entire structure inside their warehouse to make sure all the

panels perfectly fit my office's complex architectural form. One of the downsides of working with SIPs is that when they don't fit together, it is a real pain — you end up cutting the panels with a chain saw and Styrofoam dust flies everywhere, resulting in a less-than-perfect fit in the end.

To complicate matters, the panel installers only have one week to complete my job, or a little less than a month after the day we broke ground. It puts immense pressure on the architect, the panel salesman, and me to work out all the details in such a short time.

January 21, 2003

There is considerable drama around the arrival of the panels. We scramble around to make sure the top plates of the walls are perfect, that the steel beam over the garage door is secure, and that miscellaneous objects are out of the way. The road to the house is filled with big trucks and heavy equipment day after day, most charging by the hour. The crane that would unload the truck and move the panels to the driveway is $150 per hour. I feel pressure to get the job done quickly.

As the SIP truck arrives, I am amazed to think that there is an entire building stacked on the bed. The neighbors are already starting to collect on the next door lawn and film crews from the city of Boulder and the SIP manufacturer are set up to videotape the entire production. There is a crackle of excitement in the air.

The panels are all marked according to their order of assembly: floor-1, wall-6, roof-3. The crew segregates each set by the order they will be placed, and the crane operator keeps that boom moving for two hours without missing a beat. The first floor panel is in place before we know it. Floor-2, floor-3… they all fit perfectly! There isn't half an inch to spare in 35 feet. The first anxiety attack is over. The crew screws down the entire perimeter of the floor panels and lays down the bottom two-by-eight plates for the wall panels to stand upon. In two hours I have a new floor for the office and there is a ceiling on the garage for the first time in a month. Just as I was getting used to the "topless" garage experience…

Fig. 1.7: This temporary panel madness will transform into roof and walls. Credit: David Johnston.

Fig. 1.8: SIP walls can be erected faster than frame construction, saving labor costs. Credit: David Johnston.

January 22, 2003

This morning the wall erection goes even faster because the panels are smaller and it only takes two guys to install each one. By the end of the day we have walls — it is just amazing!

January 23, 2003

The large, open architecture of the addition requires many large beams both for support and for decorative purposes. The "prow" is able to overhang the driveway because of the large 7" × 14" beam that supports the weight of the structure. A similar 7" × 14" beam is required for the beam over the driveway to hold up the deck. Any beam that size, or for that matter down to 2" × 10" lumber, comes from old growth trees. To avoid cutting any old growth trees, we are using a variety of engineered wood called Parallam, or parallel laminated lumber. Parallam is made from cellulose that is stripped from aspen trees and then reassembled into wood beams. The final result is stronger than pine or fir beams cut from old trees. It is also stunning — with stain it adds a bold architectural accent.

January 24, 2003

Today we install the beams that hold up the roof panels. I am excited to get these beams up, but I'm also feeling stressed. Building is always a complex series of activities that must follow a critical path — something has to be in place before you can take the next step. This is particularly true with structural work. Excavation must be complete before concrete can be formed and poured. The concrete has to cure before you can put a load on top of it. All of the utilities must be installed before you can backfill the dirt against the concrete foundation. The structural wood has to be in place before you can put a roof on it — and so forth.

At 7:00 A.M. I go outside and count the beams to be sure they are all there. I measure each one and compare it to the plans. When I get to the major roof beam, the longest beam and the beam all the other beams attach to, I am horrified to realize that it is two feet too short! I feel like screaming and telling everyone to go home. It is the first thing to go in and it is the one that was custom manufactured for our job. I had asked my carpenter to double-check all the beams a week ago and I *assumed* that he did. He didn't. It's like the old joke, "Sorry boss, I cut it twice and it's still too short." I measured it again and it was still two feet too short.

Problem: The panel crew has today and tomorrow to finish the job before they leave the state. The beam took two weeks to special order. The roof panels

are the most complicated part of the job and only the panel crew has the special tools to do the assembly. It looks like the project is going to stop here for who knows how long.

Desperate, I know one person who can save my project: Jeff Booms from *County Line Lumber*. Between begging, praising his prowess at the impossible, and bribery, he finds the only beam this side of Idaho that fits my specifications. He delivers it just in time — the SIP crew doesn't even know it was missing.

Whew! I know now the angels are on my side!

The beam is lifted off the delivery truck and into place at the very top of the roof peak. The carpenters spend the rest of the day cutting and lifting the big beams into place. By dusk we are ready for the final roof panels.

Schedule extra time to do the job well.

Be aware that when working with a variety of trade contractors there will be times when you are beholden to other people's schedules. It can sometimes make the time allotted for your job unrealistic — and unattainable. Scheduling too much in too small a time frame will inevitably stress out you (and everyone around you)! Someone on the crew will likely make a mistake under pressure and the whole process (including fixing rash mistakes) will take longer than if you had allowed for extra time to do the job well.

Roofing

January 25, 2003

The clouds are rolling, the wind is kicking up, and it is starting to feel like January in the mountains. The first two roof panels go in without much difficulty and fit perfectly. Then, almost out of nowhere, the wind takes off and starts blowing dust devils all over the job site. We lift the next panel with a worker rope-attached to the bottom. Three of us hold on to the rope with two carpenters on the roof to catch the panel. With the panel in mid air, it is like a kite — and we are the tail. It blows out horizontally and almost lifts us off the ground. The crane is swaying and the panel is out of control. It slams into the building and crushes one of the edges. At that point the crane operator makes a unilateral decision and lowers it back down to the ground. We are all shaking from the effort.

By now it is late afternoon. The chilling wind continues to beat on us. The panel crew chief looks at the sky and says he is going to pull his guys off the job.

Fig. 1.9: Seeing the roof beams lifted into place seems magical. Now I remember why I love building! Credit: David Johnston.

Ice and Water Shield™ used on entire roof.

Most people misunderstand their roof and believe that it is the roofing material, or shingles, that keeps the underlying structure dry. That is only partially true. The real purpose of shingles is to protect the underlying roofing membrane from sunlight degradation. Ice and Water Shield™ is a quality roofing membrane that will protect the roof for 50 years.

Fig. 1.10: The roofing membrane (typically made of tar paper), keeps water out of the roof, the white flashing keeps moisture out of the roof valley, and 50-year composition shingles protect the roofing membrane from sunlight degradation. Credit: David Johnston.

I ask him if he will be back tomorrow, but apparently they are going to their next job so we would have to finish it ourselves. It's an extremely tense moment; everyone is exhausted, cold, and upset. There are two panels to go and it is getting darker by the minute.

After a few moments, some not-so-subtle extortion on my part, and intervention by the crane operator, the crew chief agrees to finish the last two panels. By now it is pitch black outside, so I pull out high intensity halogen work lights, stand up on the existing roof and shine the lights for the carpenters to set the next two panels. About an hour after dark the last panel is screwed down and the roof is intact. Although it was a trying, stressful ordeal, I am under roof after only four days.

January 26, 2003

Oriented strand board (OSB) is not the most water-resistant material; therefore, I want to make sure that the roof sheathing is totally protected. When OSB gets wet it can expand and lose its structural capacity. Typically, an elastomeric membrane like Ice and Water Shield™ is used only on valleys (where two roof planes come together) or on overhangs where ice dams may build up and allow water to get underneath the shingles in freeze-thaw cycles. But since structural insulated panels can be damaged by water, I need to cover the entire roof with the membrane. Well, we are under a roof and the Ice and Water Shield™ is on!

January 27, 2003

It's snowing! In construction this is not a good thing, but at least the roof is protected. Not only has it dropped 40 degrees in temperature, but it looks like it's going to continue to snow. The panels saved us at least a month of framing and

enclosure time — possibly even more time because we were able to build the structure before snow ground the project to a halt. As it is, the building is enclosed, waterproof, and insulated. With a heater, the carpenters and electricians can work inside in short sleeves while the winter snows are swirling outside.

Fig 1.11: After we had waterproofed the roof, it snowed for a month. Credit: David Johnston.

Electrical

February 1, 2003

The weather has slowed our momentum and the carpenters are so cold that their productivity seems like a crawl. Even though the walls and roof are up, the windows don't arrive for another few weeks. All we can do is cover the openings with plastic to try to keep out the cold winter winds. After everything moving so fast for the last month, it is now hard to see any progress.

Think ahead when planning the electrical infrastructure.

The primary challenge when configuring electrical infrastructures is to determine how much electricity you will need in the coming years, and to decide where the switches and outlets need to be. The key is to think in terms of future needs rather than current conditions.

I want to be able to operate lights from the house, have the computer network connect both places, maintain phone lines from one to the other, and so on. The buildings are about 40 feet apart and all of the utilities start at the house. We have to dig a four foot deep trench between the two buildings to get the gas line deep enough. The electrical line has to be one foot higher than the gas. Phone and CAT5 computer cable (CAT5 can carry phone as well as computer network), all run through the same trench. The last thing I want to do is dig the trench up again, especially after I make it a stone walkway! I put all the wiring in conduit and over-wire everything. I need two CAT5 cables for now, so I ran four, just to be confident I will have enough connectivity capability in the future. I put one size larger electrical line than I need in case the load in the office grows with new high-tech toys. The gas line is sufficient for twice the floor space, not even taking into account the energy efficiency of the building.

Work out contractual details in advance.

The job of the general contractor is to bring experience to the project. Part of what makes a job run smoothly is the contractor's relationships with his trade contractors. When serving as your own general contractor, it is vital to develop the working ground rules in advance of starting the work. When will they start? How long will it take them to finish? What happens when they uncover unforeseeable impediments? How much is their time and material work? The more detailed the contractual understanding, the less opportunity there will be for unpleasant negotiations at the end of their job.

Compact fluorescent bulbs used for exterior lighting.

Compact fluorescent bulbs are all over my house, both inside and outside. I was told not to use them outside because they might not work in cold weather. Well, never one to follow directions well, I put them in my outside lamps anyway, and five or six years later they have worked every time. This is one thing we can all do to reduce the demand on utilities. One compact fluorescent bulb can save an amount of energy over its lifetime equivalent to driving a car from New York to Los Angeles. I must have 40 of them around both buildings so I guess I have a great road trip coming up!

February 2, 2003

I am beginning to think the electricians are clueless as they run wire in the SIPs. When I sent architectural plans to the SIP manufacturer, we took exacting care to have them run holes (called "chases") in the Styrofoam for the electricians to run the wire through. It should be a relatively simple process to wire the outlets and switches.

February 12, 2003

Most of the electrical work happened while I was traveling for work. While I was gone, lack of experience and lack of supervision created a nightmare. The apprentice electrician started chopping away at the SIPs to run his wires, drilling holes everywhere. Now it looks like giant rats have eaten away the bottom 18 inches of the walls; all the wire is hanging down into the garage. The electrician has not used any of the chases that were formed into the walls for him. Just now he handed me a bill for $12,000 and he is not even finished roughing-in. He is over budget by 100 percent and the quality of his work is terrible. How did I get myself into this madness? I guess it serves me right for believing in a company named "Wisdom" electrical. The only wisdom in that transaction was how well he robbed me.

Exterior Siding

March 1, 2003

The weather has finally broken and we can move back outside. The first thing I want to do it to protect the oriented strand board (OSB), or the outside layer of the SIPs. I don't need a housewrap like Tyvek™ because the OSB doesn't leak air

Exterior wall moisture protection.

Use two-foot overhangs to protect siding

To protect the walls from water running off the roof, I design the roof with two-foot overhangs. This keeps the walls cooler in summer, protects the office from water, and, just as importantly, I like the look.

Wrap siding in 30-pound felt paper

Felt paper protects the oriented strand board (on the outside of the structural insulated panel frame) from moisture.

Flash all windows with Flex Wrap™

Flex Wrap™ is a special material used to "flash" a window — to divert water away from the window and prevent future problems associated with excess moisture.

Figure 1.12: Roof overhangs can be sized to suit the solar conditions in your region. Credit: Kim Master.

and the panels were caulked meticulously when they came together. Rather, I need to keep moisture away from the not-so-waterproof OSB. The roof overhangs in the original design protect the OSB siding to some extent, but in addition I wrap the walls in 30 pound felt paper, similar to how you would protect a roof. We tack the felt on at the bottom of the exterior wall and work up, just as a fish's scales are layered so that water runs off them. Extra precaution is taken at the corners and penetrations that are more vulnerable to water seeping through them. For example, windows are "flashed," or waterproofed with Flex Wrap™ that diverts water away. Felt paper then goes *over* the window-flashing wrap so all the drainage is to the outside (if the felt paper were installed under the window flashing, water could leak behind the window).

March 15, 2003

I want to stucco the building but I don't like synthetic stucco. Real stucco, or two layers of cement hand-troweled over wire mesh, turns out to be too expensive for my budget. I hire a siding company to install cement-based James Hardie Panel™ which is a fire-resistant siding made from fiber cement that comes in 4' × 8' sheets with a stucco pattern. Working with cement board takes a particular set of skills and tools. With the wrong saw blades, clouds of dust are created every time you make a cut. You also have to cut precisely because it is harder to work with than wood. The first contractor I hired said he knew how to work with the material but quickly

Protect wood on all sides to prevent warping.

Trim is one way to turn unsightly siding seams into an attractive architectural feature. Exterior trim is usually put up first and painted later, leaving the rear surface to absorb water. "Back priming," or painting all surfaces before it is installed, reduces the wood's ability to absorb water, thereby reducing its potential to warp or twist.

Fig 1.13: Hail the size of golf balls in Boulder, CO. Credit: Kim Master.

Consider using hail- and fire-resistant 50-year composition shingles.

Green roofing is a real dilemma for me. In order of importance I want my roof to be functional, aesthetically pleasing, and green. Why is "green" the last priority? Because there are few green options! Aside from expensive green roofing materials like faux-cedar shakes made from recycled garden hoses, most roofing is generally energy-intensive to produce and releases toxic contaminants when it's manufactured, installed, and landfilled. So it's best to find the longest-lasting roofing available so you don't have to waste energy, resources, and money to replace the roof. Like most green building materials, "green" roofing implies "durable" roofing.

proved otherwise. I replaced him with another crew that only worked with cement siding products.

March 17, 2003

We put two-by-fours over each of the seams in the James Hardie Panel™ siding, creating a wood trim pattern that echoes the overall building architecture. The top surface of each two-by-four is beveled like a windowsill so water will run off and away from the building. All the wood trim is "back primed."

Roofing

March 18, 2003

As evidenced by the month-long hiatus in my addition construction, Colorado often has severe weather. Not just snow, but wind over 125 miles per hour (hurricane strength is 75 mph), and hail bigger than golf balls at least once a year.

Given this weather, Colorado is the #1 roof replacement state for insurance companies in the country. Underwriter's Laboratory (UL) now has a hail rating for roofing products, and most roofing fails the test for Colorado, including cement tiles, clay tiles, and lightweight fiber-cement tiles. Fifty-year-rated composition asphalt/fiberglass shingles prove to have the best durability for the best price. These shingles resist hail and the uplift of strong winds; moreover, they are easily removed in case I decide to replace them with solar panels.

Interior Trim

March 20, 2003

For highlight trim, I install Forest Stewardship Council (FSC)-certified ipê, a tropical hardwood from South America. When oiled, ipê looks like a cross between teak and walnut — it's

beautiful as baseboards and, accents around the window and door casing, and as edging around the old reclaimed doors that I will use as desks and cabinets.

Exterior Finish

March 25, 2003

The architectural crowning glory is the deck and trellis on the south side of the office. It has the best view on the entire property. It also is the first thing you see as you drive up the driveway and acts like a picture frame announcing there is something special going on inside. It also serves to shade the south glass in the summer to keep the building cool.

It all hangs from three 6" × 6" beams on each front corner and is supported by a 7" × 14" Parallam beam. Decks are unusual in that the framing structure is also finish trim so this had to look great. It was the last day of having the crane in the driveway so we carefully raised the 6" × 6" beams into place and then hung the large beam from them. Once the beam was in place we could remove all the bracing that kept the posts plumb. After that, we placed the joists, decking, and rafters of the trellis, creating the "craftsman" look we wanted to achieve.

Green alternatives for interior trim.

Oriented Strand Board (OSB)

OSB is made from small pieces of wood that are pressed and glued together. It is a stable product that doesn't require lumber taken from old growth trees.

Highlight trim is Forest Stewardship Council (FSC)-certified ipê

FSC certification ensures the wood is managed and harvested sustainably, without damaging forest ecosystems.

Bona Kemi MEGA™, water-borne acrylic wood finish

Wood finishes are one of the most toxic finishes you can use in the home, affecting the respiratory, nervous, and immune systems. The so-called "Swedish floor finish" has been illegal in Sweden for over 20 years — don't let your floor finisher talk you into it. MEGA™ by Bona Kemi is a safer, durable finish for wood trim. It is a water-based urethane that has very little odor and dries to a satin sheen. MEGA™ protects the wood and highlights deep grain textures.

Fig. 1.14: The deck and trellis. Credit: Kim Master.

Windows

April 7, 2003

Window technology has advanced dramatically in the last 20 years. Today, average windows are twice as efficient as those in the '80s. That still isn't good enough for me. I want the addition to be as bright and energy-efficient as possible, therefore high-tech windows are my best option. I choose low emissivity (low-E) windows with specific solar heat gain coefficients (SHGC). I use low-SHGC window for the east and west windows that tend to be the hottest, so that I can enjoy the view overlooking the plains without cooking in the summer. I use high-SHGC on the south facing glass to maximize solar heat gain in the winter and keep my office

"Green" Wood for Your Exterior Trim

The decking material of choice is a composite of wood fiber and recycled plastic. It is my solution to the existential angst in the grocery line when I'm asked, "Paper or plastic?" Do I kill trees for a bag or do I use petrochemicals to carry my groceries to the kitchen? I still can't answer that question, but I used the bags—recycled along with wood fiber—for my decking.

Alkaline Copper Quaternary (ACQ) deck framing

Pressure-treated lumber using chromated copper arsenate (CCA) has been used for "ground contact" applications for years to keep wood from rotting or being eaten by termites. The chromium is hexavalent chromium, a known carcinogen that caused Pacific Gas and Electric (PG&E) to pay out one of the largest class action settlements in history (made famous in the movie Erin Brockovich). Arsenate or arsenic is used for rat poison. We have built decks and playgrounds for decades out of this material. It is so toxic that when it is burned, a tablespoon of the ash is potent enough to kill a cow. Finally, the EPA and the makers of CCA have come to an agreement to phase out CCA with several new replacements. Natural Select™ is another safe alternative wood treatment that uses alar, the coating used to protect apples from insects.

FSC-certified lumber used for trellis and three-by-twelve wood steps

FSC certification ensures that the wood comes from a sustainably managed forest.

Exterior trim is made from oriented strand board (OSB)

Wherever I can, I look for alternatives to old-growth wood. So for exterior trim I used exterior-grade OSB that is pre-finished at the factory to be waterproof. Without the pre-finish, moisture can seep into the OSB and damage the integrity of the structure.

Fig. 1.15: Low-E windows help keep us comfortable when it's 105 degrees outside.

warm; the sun is low enough in the sky that the overhangs that block unwanted sun in the summer will not obstruct this winter light.

I install Heat Mirror™ for all the fixed glass (see sidebar), or glass windows that do not move or open. The down side of heat mirror is that it requires a metal spacer between the panes of glass because of the tension of the plastic film; in turn, the spacer tends to lose heat through conduction. To counter the transfer of heat through the metal, I buried the spacer in the wood trim.

Interior Finishes

April 15, 2003

In an effort to avoid toxic paints, I use Kelly-Moore's Eco-Spec™ product line — a non volatile organic compound (VOC) paint that, unlike conventional paints, does not release toxic chemicals into the indoor air. It works as well as conventional paint for about the same price with no "new house smell" when it is applied.

Heating, Ventilation, and Air Conditioning (HVAC)

May 15, 2003

My heating options are limited by the open space design and the use of SIPs. Forced air won't work well because of minimal access for running ductwork. The office is so energy-efficient that it would be hard to find a small enough furnace to be efficient. Many contractors who looked at the job said to just use radiant electric resistance heaters. To me it was like telling me to drink hemlock! Electrical resistance heating is the least efficient source of heating next to having your own mini nuclear reactor for your heat source.

I decide to use radiant hot water in the floor — an easy decision but a challenge to execute. Radiant floors are created by laying tubing in serpentine coils with lightweight concrete (gypcrete) poured over them, and the concrete is then covered with wood, carpet, or tile. The problem is that I don't have enough room from the floor height to the bottom the doors and windows to pour the gypcrete. I also don't want to use baseboard radiators because filing cabinets and desks would cover many of the walls and reduce the heaters effectiveness. So I have found a product called Warm Board™ made of 0.875-inch-thick high-density OSB, which is specially grooved for the tubing to run through. I lay the Warm Board™ on top of the floor and fill in

High-tech windows.

All windows are low-emissivity (low-E), tuned by orientation

Low-E windows have a film "sputtered" onto the inside surfaces of a double paned window, which reflects heat out in the summer and into the space in the winter, increasing the insulation value of the window. Windows with specific solar heat gain coefficients further determine how much heat can enter through the windows.

Fixed glass is Heat Mirror™

This is a special type of low-E glazing made by suspending a thin plastic film like shrink wrap between two panes of glass with low-E coatings on all interior surfaces. The window is then filled with the inert gas, argon, to reduce the movement inside the window that leads to increased heat loss.

Climate-specific design.

Energy in your home has to be designed as a system. Whether or not you think about it, your home is always interacting with the environment. Hot sunny days create one response from your home's cooling system; cold snowy days create a totally different response from your heating system. When you consciously question your environment (When does the sun rise? What rooms does the sun shine into and when? In what direction does the wind blow in different seasons?), you create design requirements that are more efficient than automated systems because they are in tune with your specific environment.

the rest of the floor with two layers of 7/16-inch-thick OSB sheathing. It leaves just enough room to cover the floor with carpet and allows the doors to open. It also provides another layer of subfloor so the floor now is able to support 100 people dancing Greek style!

Water Heating

May 20, 2003

For a heat source, I first considered a tankless water heater that hangs on a wall and is plumbed like a typical water heater but doesn't store water in a tank. Unfortunately, they are expensive and aren't designed for space heating. As an alternative, I found an efficient A.O. Smith water heater with extra thick foam insulation around the tank and high efficiency combustion — it works great!

June 2003

All the contractors are gone; the rest is up to me. It's a mixed blessing. On one hand, all the disruption, noise, trucks, and muddy boots in the house are gone. On the other, it's all up to me to finish. I have been looking forward to this stage because I love to do finish work. The down side is that I travel all over the country training others in green building, so I'm gone much of the time. The process slows down dramatically.

Flooring

Early August 2003

My wife and I install the InterfaceFlor™ carpet tiles ourselves —which takes just a few hours since they incorporate a peel and stick process for attaching to the subfloor. Very satisfying! This is a brand new product on the market for residential applications. Not only is it 100 percent recycled content, but the 19-inch square tiles also come in many colors and patterns. The tiles also allow for flexibility in terms of how I want to use the space at a later time. In the future, the space may become an apartment, so I will have to run electrical lines and plumbing through the floor. Now I will be able to pick up only the tiles I need to get the work done. I will also change the flooring in both the bathroom and kitchen-to-be. The tiles allow me to remove just the pieces I don't want and replace them with, say, ceramic tile.

Fig. 1.16: InterfaceFlor recycled-content carpet tiles over radiant heat. Credit: Kim Master.

Natural Cooling

Late August

Thanks to natural cooling, the building works like a charm. The western sun is typically the hottest, and we are blessed to be on an east slope so the mountain blocks the late summer afternoon "furnace" sunlight. Large pine trees (that we took great care to design around) also provide plenty of shade. I open and close the awning and casement windows (placed strategically on each side of the building) as the wind patterns shift. Casement windows open like doors, hinged on the side so you can use them as wind scoops. Awning windows are hinged on the top and provide ventilation even when it's raining. When the wind isn't blowing, I use a centrally located ceiling fan for air movement. When it has been over 105 degrees Fahrenheit outside, the highest temperature in the addition was 84 degrees. No need for air conditioning with the building doing its job so well!

No need for air conditioning!

- Trees shade windows from the hot summer sun.
- Strategic placement of windows catches prevailing breezes.
- Ceiling fan helps with air distribution and destratification.

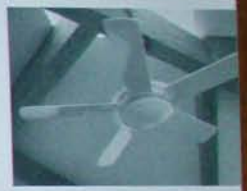


Fig. 1.17: Ceiling fan provides natural cooling while the skylight behind it provides natural light. Credit: Kim Master.

Wireless Networking

September

It is critical to keep the connection between the house and the new office, but I have wires everywhere in my life and I'm tired of tripping over all of them. So I install a wireless network, which is a real boon to civilization. I can now sit on the deck, barefoot, and check my e-mail on my laptop or I can work from the house and access the computers in the office. My commute has tripled from the den to the new addition fifty feet away, but the delight of working in the new space far outweighs the inconvenience of the additional travel!

Fig. 1.18: The new "world headquarters" of What's Working, September 2003. Credit: Kim Master.

Remodeling: An Emotional Rollercoaster

I love my new office, but I have to remind people that remodeling is a wild ride. It seems like it should be straightforward, but in reality, it is an emotional experience from start to finish. There is the excitement of the design process, the shock of the first cost estimates, the thrill of the initial construction, the frustration with the contractors, the elation of seeing the structure in form, the impatience of wanting it to be finished. All are part of the process. The more prepared you can be for the experience, the better you will handle the ride.

CHAPTER TWO

Affordable Green Dream

GREEN BUILDING IS FRAUGHT WITH MYTHOLOGY: "It is too expensive;" "I can't get the products where I live so why bother?" "I don't want to live in some weird strawbale house;" "Solar is ugly;" "Nobody I know has ever done it;" "I'm not an old hippie and don't want to live that way." Other people assume falsely that green building is too good to be true — that it is all greenwashing and a marketing ploy on the part of the industry to dupe us once again.

Yes, some building elements do cost more. But many cost less! More importantly, green building is the way buildings will be built in the next decade and this is just the tip of the iceberg. When we describe what we do at What's Working, we tell people that we consult in the growing field of applied common sense. Most of what green building brings to the construction industry is just a more systematic way of thinking about buildings. Looking at the big picture rather than just at the bricks and mortar adds a new perspective to how all the pieces fit together and the consequences, both near and far, of the decisions we make at the design stage of a project and the products we use to build it.

Green building need not be too expensive. When it is part of the initial process of setting goals for the remodeling project it becomes matter of fact — you, your architect, and your builder just make it happen. Many builders have found that the real cost is in the learning curve, not in the implementation of the building process. The products are becoming more available and more affordable all the time as major manufacturers develop new lines to meet the "green" demand. Paints are a classic case in point; paints that are low in volatile organic compounds (VOCs) are now featured in the product lines of all the major manufacturers. Keep in mind that green building doesn't have to look any different from conventional buildings: it is how it's built, not what it looks like. And most significantly, people from coast to coast and across the midlands are building and remodeling green.

> "Green building doesn't have to look any different from conventional building. It's how it's built, not what it looks like."
>
> David Johnston, What's Working, Boulder, CO

Green remodeling actually makes and saves money. And this is not just long-term energy saving costs; the cost to implement green features ("first costs") is often less than remodeling by conventional standards. In the long term, green renovations increase the resale value of your home. There are also financing options available for people who remodel with energy efficient features that can save hundreds of dollars. No matter how you look at it, green remodeling is a smart, moneymaking investment.

Be careful not to get caught in the "payback" trap for energy conservation features. Payback is an illusion for many reasons. If you save $2.50 per month on your energy bill will you even notice it? What is the payback of a night on the town? We don't think about payback for anything but energy conservation or solar products: the only things that do have a payback. There are two better ways of thinking about the energy you use. The first is to look at your mortgage payments plus your monthly energy bills as one collective cost. Most often, the increase in monthly payments for energy upgrades is less than the savings on your utility bills, so it is money in your pocket. Perhaps more important is how much will it cost you to five years to heat and cool your house; just look at the increase in energy costs over the last five years. Installing energy conserving products such as insulation or solar panels is a cheap insurance policy against rapidly rising costs for fossil fuels.

Another way to look at the cost of green is what it is worth to you to reduce the possibility that your children will develop asthma or other respiratory problems. How valuable is the health of your family? There are many subtle savings and preventative measures that can't be put into a bottom line cost/benefit analysis. How much do you value your Saturdays for family time rather than refinishing the deck? Is comfort on cold winter nights — thanks to energy efficient windows and increased insulation — important to you? All of these issues go into the "value proposition" of making green decisions.

For clarification, we've broken down how green remodeling saves money into five categories: general design strategies; landscaping; energy systems; products and materials; and job site considerations. Then we explain how you can fund your renovations in a way that maximizes the financial benefits of added energy-efficient features. Finally, we demonstrate the advantages of making investments in your dream — green.

How Green Remodeling Saves Money

Alex Wilson is president of BuildingGreen, Inc., the publisher (based in Brattleboro, Vermont) of *Environmental Building News (EBN)* and the *GreenSpec* directory of green building products. Alex has been the executive editor of EBN since the newsletter's founding in 1992 and is co-editor of GreenSpec. We value his concise, clear, and informative writing, which helps demystify green building concepts. The following section was adapted, with permission, from his article, "Building Green on a Budget," published in *Environmental Building News*, Volume 8, Number 5. It has been slightly altered so that it is most applicable for residential remodeling projects.

General Design Strategies

- Remodeling existing homes instead of building new saves significant quantities of materials and energy, in turn benefiting the environment. Project costs are reduced and there may be significant savings in time and money associated with not needing extensive regulatory review and approvals.
- Good design is the best way to make your project affordable. It is much less expensive to make changes on paper than after construction has started. A few extra hours of your architect's time can save hundreds if not thousands of dollars in construction changes.
- Integrated building design often results in first-cost savings, especially in the case of energy conservation (see Energy Systems below), but also in other areas of design. For example, including contractors in discussions with the architect and engineer can help identify ways to streamline the process and save on materials. Involving a landscape architect early may reduce the need for new costly plantings because he or she can protect existing plants from construction harm.
- Smaller renovations require fewer resources during construction, disturb less land during site work, and use less energy during operation.
- Paying attention to solar orientation by locating more windows on south-facing walls can reduce energy costs by 10 to 40 percent right off the bat. Using your home to respond to the natural energy flows of your micro-

climate means you reduce your need (and cost) for expensive mechanical systems.

- Minimize cooling loads (and costs) by reducing window area on east and west facades and, where there are windows, by incorporating shade plants to reduce the heat buildup.
- Leave floor slab exposed. Eliminating carpet will avoid mold and other biological pollutants, the environmental impacts of manufacturing the carpeting, and the cost of the carpet. Consider texturing and pigmenting concrete: it is beautiful and less expensive than carpet alternatives.
- Optimal Value Engineering (OVE) and advanced framing reduce waste without compromising structural performance. Some builders have found that they can reduce the framing materials by 20 percent and increase energy savings at the same time. You reduce overall material use, thereby benefiting natural resources and saving you money.
- Open layouts help distribute daylight, reduce ducting requirements for conditioned air distribution, simplify reconfiguration of space, and reduce material use.
- Optimize building dimensions to reduce cutoff waste. Anytime you reduce waste you save resources and money by buying less material, reducing onsite labor (for measuring and cutting), and paying less for disposal.

Landscaping

- Indigenous landscaping like prairies, woodlands, and desert gardens support wildlife and biodiversity better than conventional turf. Native landscaping does not require irrigation or chemical treatments, generally making native plantings less expensive to maintain. Moreover, native plantings reclaim weekend time for the family by eliminating the need to mow the lawn.
- In areas with low annual precipitation and areas that are prone to drought, provide xeriscaping (dry-adapted plantings) to obviate the need for irrigation systems and more expensive plantings.

Energy Systems

- An integrated design makes it possible to pay for increased energy conservation measures through savings in heating, ventilation, and air conditioning (HVAC) equipment. For example, a tight, well-insulated building envelope with high-performance glazing and shading strategies may enable you to downsize or eliminate conventional heating and/or cooling equipment. We have worked on many homes in the harsh Colorado climate that use only a typical water heater to heat the entire home.
- Using a water heater to satisfy heating loads saves first costs for an unnecessary furnace.
- Specifying specific glazings (windows) for different window orientations usually does not cost anything more than conventional windows. This allows the south windows to help heat your home and reduces heat gain from east and west windows that would otherwise drive up air conditioning costs. It almost always results in future savings from passive solar heating and cooling — reducing the need for mechanical equipment.
- Using ceiling fans increases air flow and occupant comfort in homes without mechanical cooling. This significantly reduces equipment costs.
- Keeping ducts away from exterior walls will improve energy performance and save money because less ducting is required.
- Reducing outdoor lighting by using motion sensors will save energy and reduce light pollution.

Products and Materials

- Salvaged materials can often be obtained at lower prices than new, virgin materials, depending on labor costs. This benefits the environment because fewer resources are used, thereby also saving landfill space. Salvaged materials include lumber, millwork, windows, cabinets, some plumbing fixtures, and hardware.
- Use more durable materials that require less maintenance. Brick facades may cost more up front but you never have to paint or repair your siding.
- Recycled content composite decking will outlast wood by two to three times, never requires paint or finishes, and will not burn or splinter bare feet in the summer.

- Using structural materials as finish materials eliminates a costly and resource-dependent building component. For example, use exposed beams or concrete floor slabs.
- Downsize the supply pipe diameter with water-conserving fixtures (such as low-flow showerheads and toilets) to deliver hot water faster, reduce standby losses from hot water pipes, and reduce water waste. Smaller diameter pipes are less expensive.

Job Site

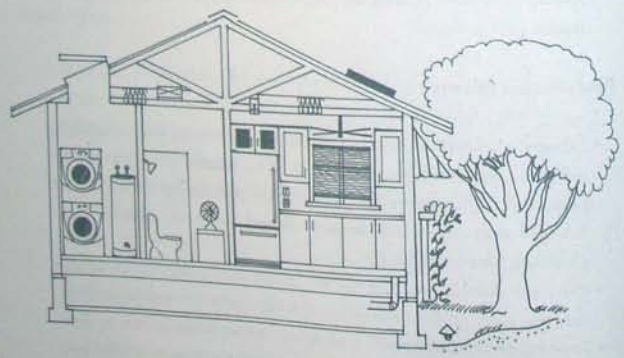
- Protect existing trees during remodeling. It may cost a bit more, but these costs are easily recouped by having to spend less on plantings when renovations are finished. Large trees also boost property value, and the shade and cooling effect they provide allows homeowners to downsize air conditioning equipment.
- Recycling job site waste avoids expensive landfill disposal costs.

Source: "Building Green on a Budget," *Environmental Building News*, 8(5): 11 to 14.

Fig. 2.1: How much does green cost: Green remodeling can be less expensive when you consider options in the context of the entire house. What you save in one area can be applied to another area.

KEY:
ø = no cost
¢ = low cost
$ = more costly

$ - energy-efficient washer & dryer
$ - light-colored, reflective roofing
$ - whole-house fan
$ - l.c. recessed lighting
$ - ridge vent
$ - radiant foil stapled to rafters
$ - PV panels
$ - check & seal ducts with mastic
$ - ceiling fan
$ - energy-efficient refrigerator
¢ - removable shade cloth
¢ - deciduous trees on south & west aspects of house
¢ - trellis with deciduous vines
¢ - permeable paving
¢ - low voltage landscape lights
¢ - portable fan
¢ - low-flow toilet & showerhead
ø - set water heater to 120°
¢ - compact flourescent floodlights
$ - low-E skylight & screen which opens
$ - R-38 attic insulation
¢ - drape or blind all sun-facing windows
¢ – awning to shade window



Credit: Jill Haras & Kim Master

Although this list is far from complete, it demonstrates just a few ways green remodeling is more affordable on the first cost side. The most important aspect is thinking in terms of building integration, or the house as a system. An overarching framework makes it possible to incorporate many strategies that, taken alone, might cost you more.

The following section on financing your renovation was written by our good friend and financial expert, Steven Schueth. Steven is President and Chief Marketing Officer of First Affirmative Financial Network, LLC. He lives in Boulder, Colorado, but his influence as a leader in socially responsible investments is recognized internationally.

Financing Your Renovation

There is a growing awareness and a deep yearning to understand how "greening up" a home can create a healthier living environment and save money. Financing healthy home upgrades and improvements can be easy, depending on your income, the equity you have in your home, and your credit scores.

If you have money in the bank or in an investment portfolio that, if liquidated, won't generate substantial capital gains taxes, the simplest way to finance your renovations might be to write a check. Once your renovations are complete, you can refinance the property at a higher market valuation, take out some or all of the additional equity invested, and put it back in the bank or into the stock market.

If you have good credit and a long-term low interest rate credit card and don't need extensive renovations (i.e., under $20,000), you might want to use your card (and maybe even get frequent flyer miles). Once the work is complete, you should refinance and pay off your credit card(s).

A local bank will often finance renovations. This should be a relatively painless process if you have substantial equity in your home; the bank will simply extend you a home equity loan. If you have good credit, solid, verifiable income, and/or substantial investment assets, the bank may be willing to lend you money for renovations as a personal loan, secured by your personal guarantee.

Construction-to-permanent one-time closing loan packages make a lot of sense if current interest rates are lower than your existing permanent loan. Essentially, you apply for a mortgage based on the "future completion value" of your home as determined by an appraisal. Loan amounts range up to 95 percent

of the future completion value and closing costs are rolled into the construction loan. Your existing mortgage is paid off, and additional payments are made to the contractor as the renovation work proceeds. Upon completion, the lender extends a permanent loan to you based on current market interest rates with no extra cost. Overall, closing costs are lower, especially when compared to paying for two separate loan transactions. This approach works best for higher cost renovations, say $50,000 or more. Only a few select lenders offer this type of product. You are not likely to find it at your local bank.

Another unique loan package that you won't find at local banks is generically called an Energy Efficient Mortgage (EEM). The Federal Fannie Mae, a financial products and services provider, is piloting a green mortgage product in a few states. A certified energy rater will analyze future energy savings you can expect from your renovation and calculate the present value of those savings. That dollar amount can be considered additional equity in your home, thus increasing the amount of money you can borrow, or reducing the amount of cash you need for a down payment. For some borrowers, the additional equity could mean hundreds of dollars saved annually by reducing or possibly eliminating private mortgage insurance.

Energy efficiency upgrades can help increase the value of your home and provide a resale advantage over other properties in your neighborhood. According to a study published in *The Appraisal Journal* in October 1999, the selling price of homes increased by $20.73 for every $1 decrease in energy bills. Think about it: if you could save $350 in utility costs annually, your home might increase in value by more than $7,000.

You can profit by investing in efficiency measures regardless of how long you live in your home. If the reduction in your monthly energy bills exceeds the after-tax mortgage interest paid to finance the energy efficiency upgrades, you will enjoy positive cash flow as long as you live in that home. And if energy prices spike as expected, energy efficiency may be one of the best investments you will ever make.

A healthy, energy efficient home often means you can borrow more or finance a higher percentage of the property value. Or you could use all of your energy savings to pay down your mortgage faster. If you make one extra payment per year, it is possible to pay off a 30-year loan in closer to 20 years — and save thousands of dollars in interest!

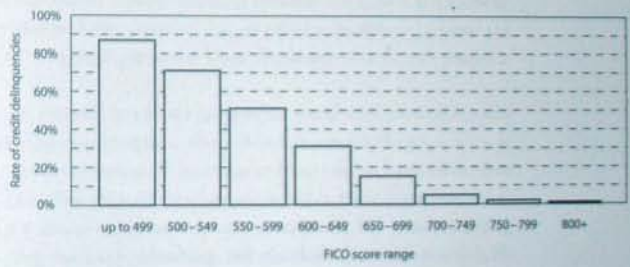
These are just a few of the financing options available to you; many solutions must be customized. Contact a local professional who is familiar with financing green, energy efficient renovations for help with these critical decisions.

The Mystery of FICO Scores Revealed

A majority of lenders use a credit score developed by Fair Isaac & Co., known as a FICO score, to determine the likelihood that credit users will pay their bills. People with high FICO scores are likely to repay loans and credit cards more consistently than people with low FICO scores. FICO scores are remarkably predictive, which is why lenders rely on them so heavily for credit decisions.

As a group, consumers in the 700–749 score range, example, have a delinquency rate of five percent illustrated below. This means that for every 100 borrowe this range, lenders expect that approximately five will de on a loan, file for bankruptcy, or fall 90 days past due o least one credit account in the next two years. Most len consider consumers in this score range as very low risk.

Delinquency Rates by FICO Score



Source: Steve Schueth and Teresa Lopez, personal conversation. Principals of DreamSource Financial LLC. Boulder and Rigway, CO; Santa Fe, NM.

This chart demonstrates the delinquency rate (or credit risk) associated with selected ranges of FICO scores. In this illustration, the delinquency rate is the percentage of borrowers who reach 90 days past due or worse (such as bankruptcy or account charge-off) on any credit account over a two-year period.

FICO scores are calculated based on information drawn your credit history. While knowing your actual score is a g start, understanding the key factors affecting your FICO s is much more important. For more information and direc on how you can increase or maintain your FICO score time, go to <www.myfico.com>.

Choose the Options You Can Afford

Our renovations are limited by what we can afford to finance, therefore we hope this chapter's overview of cost-effective green building options combined with expert financing tips will enable you to consider creative green remodeling options. Green remodeling is not about opening your wallet; it's about opening your mind!

CHAPTER 3

Working with Building Professionals

My construction company in Washington, D.C. was a design/build firm that specialized in remodeling. Lightworks Construction was intended to be a solar construction company, but by the mid-eighties solar had faded and we became a full service company specializing in large upper-end additions. We also built a "million" basement remodels and quite a few kitchens. By designing what we built, we found that we could streamline the process and avoid many of the pitfalls that occur when the design-construction process is linear.

For a typical remodeling job, the homeowner works with an architect who draws up a set of plans or blueprints. The architect then hands the plans off to an engineer, an interior designer, and a landscape architect who each contribute their respective insights. The plans are then put out to bid to three to ten remodeling contractors who dissect the plans into various trades for bid prices, including carpentry, roofing, insulation, plumbing, and electrical. The contractor puts his "head scratching" time into the plans and comes up with a bid. This whole procedure occurs in a vacuum with no interaction between the trades. When the bids come in, the homeowner looks at all the apples and oranges proposals with numbers everywhere and has to make an existential decision on which stranger to cohabit with for the next three to nine months. It can be a bit like throwing darts at a dart board to come up with a decision.

All too often the worst of all possible outcomes emerges: the homeowner chooses the lowest bid! Would you choose the cheapest heart surgeon? Probably not. Unfortunately, the conventional bidding process wastes time and costs more due to change orders and hidden costs. All too often, it doesn't accomplish the intention of building a great team to manifest your dream home, and is eventually brought to a close in a court of law — not what anyone ever intended.

> "We seek spaces that satisfy not only the basic requirements of size and function, but also our beliefs and philosophy. You, your architect, and your builders will define those beliefs in tangible terms that can be made real with wood, steel, glass, and stone. In other words, you have dreams for your home, your architect informs those dreams, and your builders materialize the informed dreams. However, the process is rarely this linear and straight-forward. For example, those who build, including carpenters, masons, electricians, and plumbers, are an incredible resource for ideas. Builders can significantly improve the look, feel, and efficiency of your home, especially when their ideas are considered early in the design process. Moreover, by including the builders from the start, you can create a team with a common understanding of the history of the project. This proves extremely helpful when a construction problem needs to be resolved along the way.
>
> **George Watt, Architect, Boulder, Colorado**"

A better outcome occurs when remodeling professionals collaborate as a design team from the first sales meeting. My architect, myself (as contractor), and often an interior designer would meet with our prospective client and brainstorm solutions to their design needs. The interaction was often stimulating and the clients loved it. Not only did these meetings help clarify the dreams of the customers, but all of us were able to ask questions at the beginning to further clarify the desires of the prospective client. It was much easier to get the client's ideas on paper with the designers present up front.

Once we got the job, we would all work iteratively on the design — costing different design solutions along the way, improving the design based on past experience — and come up with a better overall solution than any one of us would have developed on our own. By knowing the cost of construction we usually met the client's budget the first time out.

Today, the team approach, or collaborative design, is still an anomaly. The remodeling process is fraught with difficult decisions, conflicting information, and challenges right up to the very end. After years of remodeling we learned to prioritize client-architect-contractor relations. Ask yourselves, "Can we work with this remodeler? Does the architect share our values and worldview of what is important? Can we have deep discussions about our dreams and feel heard? Will the construction company protect our twenty thousand dollar landscaping? How will we solve problems and come to mutual understanding?" If you treat your relationships in the home remodeling process with the same care and consideration that you treat your friends and neighbors, the outcome is often much better than any contract can ensure.

Given the collaborative nature of remodeling a home, we thought it would be most informative to let you hear from the architects, contractors, and homeowners themselves. Together, our stories will help you find and work with the best professionals to remodel your dream home.

Working with an Architect

One of the most important relationships you will establish when remodeling is with your architect. He or she will capture your dreams and ideas and translate them into a language that the contractors can understand. We can't emphasize the importance of this process enough. Your architect helps you see what all the talk means on paper so that you can visualize the project before it starts and avoid disappointment later. It is a lot easier and less expensive to erase a line than to tear down a wall. For some, hiring an architect may seem like an unnecessary expense because you already have a design or plan in mind. However, even if you know the outcome you desire, an architect is like a lawyer who will help you write the brief that will lead to that outcome more smoothly than if you attempt a remodel design on your own. Hire an architect — your dream home is worth it!

Expert Advice from an Architect: Mercedes Corbell

We could think of no better person to explain the nuances of working with an architect during the remodeling process than our good friend and talented green architect, Mercedes Corbell. Mercedes Corbell Design and Architecture is located in Oakland, California, and her green designs can be viewed online at <www.mercedescorbelldesign.com>.

What kind of projects need an architect?

That depends on how one defines "need." For some projects, depending on their size and the requirements of the local jurisdiction, an architect is required to prepare the plans. For other projects an architect is not required by the local building department to prepare the plans. Basically, if there are design decisions to be made and drawn, you should strongly consider hiring an architect. Architects are the most broadly trained of the design professionals, and they look at a building in terms of its aesthetic qualities, the functionality of its spatial layout, and relationship between rooms, the building and planning code implications, construction feasibility (though contractors may dispute the architect's expertise here), and the compatibility of a design idea with the existing architecture. Investing dollars in the construction of a remodeling project without

investing the careful attention that an architect brings to a design problem seems like a big risk to take. That said, some projects are simple in terms of construction and design — these projects could benefit from a simple set of permit drawings, which can often be produced by the contractor.

What do architects do in a remodeling project?

An architect designs buildings, and this overall activity encompasses a series of smaller activities. An architect is also the legal agent of the owner as well as a "neutral arbiter" of disputes that might arise between the owner and the builder. The architect does not decide the result of the dispute but is the first mediator. The architect traditionally has been the lead in the process and one of three in the triangle of architect-owner-builder. In this capacity, the architect acts not only as a musician in the orchestra but also as the conductor, coordinating the work of consultants into the design, assisting the owner in choosing a contractor and in getting construction prices, applying for the building permit, and visiting the job site during construction to see that the results align with the design intent.

An architect can be involved once the owner has decided to remodel or add onto their house. The first tasks start during the "programming and predesign" phase and include establishing project constraints, drawing up a measured set of drawings of the existing building (called "as built" drawings), and identifying the owner's list of requirements and requests. This is the time to establish your list of green goals and expectations.

The second phase is referred to as the "schematic design" phase. This is akin to a brainstorming process. Your architect produces a series of schemes that the owner chooses to pursue. Actually, the accepted scheme often results from the combination of a series of schemes. The chosen design is expanded during the "design development" phase, resulting in more views of the design, material lists, and the preliminary work for consultants like the structural engineer or green consultant. If required by law, the architect then applies for design review or other planning department applications and navigates through that process. Sometimes redesign is required by the planning department. Once the design is well described and developed, the final construction drawings and specifications are prepared during the "construction documents" phase. At that point, it is time for the architect to apply for the building permit and for the contractor(s) to provide their final bid price during the "bidding/ negotiation" phase. Finally, it's time for construction, and the architect is available to visit the site and review the course of the work.

Table 3.1: Architectural Remodeling Phases

Phase I:	Programming and Predesign	• Establish project constraints • Sketch measured set of drawings • Identify owner's list of requirements and requests
Phase II:	Schematic Design	• Produce series of schemes that the owner chooses to pursue
Phase III:	Design Development	• Chosen design developed • More views of design • Materials list • Preliminary work for consultants • Planning Department applications
Phase IV:	Construction Documents	• Final construction drawings and specifications • Architect applies for building permit
Phase V:	Bidding and Negotiation	• Contractors provide final bid
Phase VI:	Construction	• Architect visits site and reviews course of work

Source: Mercedes Corbell, Personal Conversation. Mercedes Corbell Design + Architecture, Oakland, CA. <www.mercedescorbelldesign.com>

What kind of experience do architects have?

Since the job of an architect is technical, artistic, communicative, and regulatory, the education and training of an architect typically contains these elements as well.

The formal education of an architect, whether it takes place during undergraduate or graduate coursework (or both) varies between schools. Some schools emphasize theory and aesthetics, others construction technology, etc. At a minimum an architectural student will study the preparation of architectural drawings, architectural design, architectural history, structural design, and often calculus and physics (though in

> *"There is a sense of disconnect in the way that most of us live. It is very unsustainable and fairly toxic to the environment, generally speaking. If you want to live in a house that is less toxic and if you want to leave something for our great grandchildren, build green. Building green is exciting. And it is a challenge too. Anyone can build a house. But can you build a green house?"*
>
> **Cate Leger, Architect, Berkeley, California**

architectural practice these are rarely if ever used). Ideally, the architectural student will also study freehand drawing, color, sculpture, the sociology of design, construction methods, environmentally sustainable building practices, design theory, and professional practice.

The architectural profession is regulated by each state and so the architect must meet the requirements of that state. Each state requires that an architect perform a certain number of years working for a licensed architect as an intern.

Following the internship period are the licensing exams. The exams are extensive and cover the areas of architectural, structural, mechanical, building technology, construction administration, site planning and design, architectural layout and design, and professional practice. They are rigorous exams and in some states there is the additional requirement of an oral exam.

Builders often criticize an architect's training because it rarely includes doing construction or spending many hours on a construction site. This is a drawback and it's up to the architect to spend as much time on job sites as possible. It is a great question to ask your architect, "How much actual hands-on construction experience have you had?"

Lastly, an architect is always learning. Given the complexity of the profession there is no way to know it all. Just choosing to grow and learn in the aesthetic area is the work of a lifetime. Some architects continue their growth solely on their own, and others take part in continuing education courses offered by trade groups such as the American Institute of Architects (AIA).

How do I find the right architect for my project?

While interviewing architects, it makes sense to use some of the typical interviewing guidelines: check their references, meet the architect and see examples of their work (often just photos work, but you can visit the buildings as well), get a feeling for the rapport between you and the architect.

When looking at the work of the architect, keep in mind that an architect is the servant of the homeowner to a large extent, and must translate their goals and aesthetic rather than providing their own aesthetic. So if you don't see the style you are looking for in their portfolio, do not decide too quickly that it is not a fit. Instead, look for well executed examples of the style they are working in and for interesting ideas (aesthetically or practically) that show a creative spirit. The other element to look for is the architect's ability to listen to you and to communicate

Questions to Consider When Choosing an Architect

- What do the owner and architect each want to accomplish with the project?
- What would the owner and architect each need from the experience to feel successful?
- Are there any fears about the project?
- Are the owner's goals for their home and the philosophy of design that informs the architect's practice consistent? (e.g., if the owner wants to build their project green, is sustainability a foundation of the architect's practice?) If so, can they go beyond a systems approach to environmental building based on resource conservation to weave in ideas of lifestyle, quality of light and space, and relationship to the landscape?
- How will decisions be made as you progress through the design process?
- Are there others that will round out the design team, including the builder, landscape architects, structural engineers, civil engineers, mechanical engineers, financiers?

In general, is there a fit between the owner and the architect? The answer is part intellectual (what can be understood quantitatively) and part emotional (what can only be felt intuitively).

Source: George Watt, Architect, Boulder, CO

clearly, since so much of the process will involve listening to your ideas and concerns and translating them into the project design.

What is the best way to work with an architect?

Have fun!

Although the architectural design process can be tedious, and it involves large sums of money (both in terms of design fee and construction costs), it can also be fun. After all, you are investing in making your home reflect your life and dreams, and the things and experiences that bring you pleasure. Also, it's a chance to learn about what may be an entirely new area — that of design.

Keep an open mind

Hiring an architect means that you should end up with ideas that are better than the ones you've arrived at on your own. So the first rule of thumb is to let the architect look at your project with fresh eyes; do not dictate how you want the design to turn out. Instead, let him/her know what things you want to accomplish (and this can be very specific: I want a master bedroom of about 14 by 15 feet which extends off of the back of the house). It's fine to let him or her know what solutions you've thought of so far, and it could be that it is the best solution. But the architect needs to get their head around the problem before arriving at that conclusion.

> "Design is iterative. It is the architect's task to create a working record of the process of design, influenced by the opportunities and constraints brought to the project over time. It is the owner's responsibility to engage in the discussion inspired by the drawings and models created in order for the architect to evolve the design in the next set of drawings and models.
>
> **George Watt, Architect, Boulder, CO**"

Ideally you'll get at least three design solutions, even if some of them don't contain all the items on your list and if some are completely different than you discussed or expected.

During the design process homeowners typically become clearer about the details of what they care about. At the beginning of the project, it's difficult — if not impossible — for the homeowner to put in writing all the likes and dislikes they experience in their home. It is while reviewing the schematic designs that the architect and the homeowner refine their understanding of each other and of the project requirements. It may not be until one of the schemes does not allow a view of the neighbor's canary island date palm that the owner realizes the importantance of that view, and should be included.

Expose yourself to architectural and interior design

Expand your view of what's possible in home design in terms of room types, spaces, and materials. Go on home tours, check out books from the library on both domestic and international design, subscribe to design magazines, and start to notice buildings around you. The more exposure you have to interiors, buildings, and gardens the easier the design process will be, because you will have a context in which to place the design ideas that your architect is proposing. Most schools in the United States have a dismal record of educating students in visual and aesthetic literacy, and so the gap between the training of an architect and that of a typical homeowner is often great.

Communicate what you like and don't like to the architect

At the start of the project it's important to communicate as best you can your design preferences. The best way, since an architect is a visual person, is to show pictures and tour local buildings together that strike your fancy.

If you don't understanding the drawings, get help from the architect

It's not uncommon for a homeowner to have difficulty understanding the plans, and it's also not uncommon for the architect to forget that this happens. The architect has become so accustomed to speaking the language of lines within an architectural project that he/she forgets that the owner does not speak this language. Add the fact that often one of the most used drawings is a floor plan,

which by its nature is abstract (rather than an illustrated perspective drawing), and the opportunity for homeowner confusion is great. Ask the architect for an "acting out" of the idea. Get out the tape measure together and map out where things will go, using masking tape to mark important spots on the floor or wall. Use stakes or sticks at the exterior to map out the extent of an addition. You can also ask for perspective sketches or additional drawings to illustrate an idea.

The other part of this is — pay attention during the design process. All too often an owner will coast along during the design process and wake up during construction deciding that they in fact want something different. Changes made during construction are expensive, and can cause frustration for all parties involved.

Get cost estimates at each design phase

One of the biggest complaints about architects is that they don't meet construction budgets. The fact is, architects are not cost estimators and cannot guarantee what price a contractor will be willing to work within. The architect can refer to both square foot figures and recent projects as a benchmark, but the nuts and bolts of an estimate should be left to those who produce them all the time; namely, a cost estimator or a general contractor. It is both possible and wise to ask a contractor to perform this service from the schematic design phase onward. If you make your selection early enough, your contractor can become part of your design team, estimating costs and recommending practical construction details through the rest of the design process.

In turn, the architect faces the challenge of gently curbing the owner's enthusiasm for things they may not be able to afford. It can be difficult to dissuade a homeowner from an element or space that their heart desires until there are some cold hard facts (the cost estimate) to review and process.

Lastly, a good architect will be naturally excited about design and materials and all that is possible, and can get carried away. The key is that the architect responds to cost information and scales back the plan in an attempt to meet the budget.

How do I manage construction costs?

No matter how much cost estimating is done or how carefully it is done, there will always be changes and unexpected conditions that result in cost increases. There are many factors influencing the design and construction of a project; additionally, remodeling involves the integration of a new project into or attached onto an existing structure. The foibles and intricacies of the old structure are not

entirely visible even during the demolition stage. Homeowners change their mind and want a different material. Architects come up with a new idea that is wonderful but costs more. Surprises keep happening. Instead of being totally shocked, the better strategy is to plan to be surprised and set aside at least 15 percent of the estimated construction cost as a contingency amount. This means that if your budget is, for example, $100,000, then you'll want to actually aim for a construction cost of $85,000 so that you have $15,000 set aside.

What are the architectural design fees?

There are several ways that architects charge for their services. Hourly, fixed fee, a fixed fee based on a percentage of the cost of construction, and/or hourly for some phases with fixed fees for others. Reimbursable expenses are added to the fee (printing costs, etc.). Consultant costs are either included or charged for separately.

What products does the architect produce for this fee?

After all of the design phases are complete, the architect provides the owner with a set of architectural plans and often a written specification of products and materials to be used on the project. These "contract documents" form the basis of the contract between the owner and the builder. The builder's contract with the owner to provide construction services references the architect's name and the date of the plans and specifications. Note that often there are different "editions" of the design, with the first set often being that used to obtain the building permit. *It is crucial to the success of the project that everyone uses the same dated prints and that old versions are thrown away.*

It's tempting for some homeowners to try to save architectural fees during construction by not having the architect visit the site or by diminishing the services during construction. Unfortunately, the end result almost always suffers. The design continues to evolve during construction, with a number of factors influencing the project's design at this stage: unexpected conditions popping up and having design ramifications, code issues that the site inspector interprets differently than the plan checker did during the review process, and new ideas about how to handle something now that the plans are in three dimensions. In general, having the skills of an architect through only part of the process short-changes your dream home; imagine using the skills of a surgeon for only part of the surgery!

Choices, choices, choices!

> *"There are so many resources that go into new houses and so much of it is built without thinking about it carefully. The house is going to be there for a long time; don't let it be a missed opportunity.*
>
> **Cate Leger, Architect, Berkeley, CA"**

The number of choices to make during the process can be staggering. It's important to start looking at materials, finishes, appliances, hardware, and so on as early on as possible, so that you aren't faced with a huge list at the end. In fact, the architect typically does at least a preliminary selection of most of these, since they are integral to the design, but at some point the owner must at least review and approve or disapprove the suggestions. Many times the architect leaves specific decisions up to the contractor. Unless you pay attention, you may get substitutions that compromise the integrity of your green design. Another way choices are presented to an owner is as "allowances." The builder has set aside a budget for items that the homeowner must select. Be careful that the allowance reflects the true cost of items you may want. An allowance for $12.00 per yard of carpet may be a builder price but you probably wouldn't want to live with carpet that cheap.

How do I collaborate with my architect and builder?

Traditionally an architect worked on the design and the drawings and then provided them to the contractors during the bidding process. The problem with this model is that beautiful buildings were designed in somewhat of a cost vacuum, and all the effort and money and falling in love with the design were wasted once it was discovered that the project exceeded the budget. Working with a contractor during construction for cost estimating is the first step in collaboration, and the other is to have the contractor present during design (whether at part of the architect/client meetings or just with the architect) to suggest efficient construction details, bring up possible conflicts with other parts of the building such as the plumbing system, and in general bring their extensive experience in construction to bear on the project. Typically contractors need to be paid for these services, just as any project consultant is paid. Some contractors are willing to credit some of these fees if they are hired to do the job.

Another benefit to working with a contractor during design is that it gives the homeowner a chance to get to know a contractor before working with one. And working with one contractor during design does not preclude the homeowner

from working with another during construction, although it is often best to maintain continuity if the relationship goes smoothly.

In general, an architectural project has so many bits of information to manage that no architect will do it perfectly. It's everyone's job to manage the flow of information and it's advisable for at least one person to prepare meeting notes and distribute them. *At the very least, the homeowner should keep their own dated notes of meetings and decisions and review them with the architect on a regular basis. The same habit should extend to the homeowner's communication with the builder.*

Working with Remodeling Contractors

If anyone knows how to find, hire, and establish a relationship with remodeling contractors, it's Dave Lupberger. We met years ago when we were both designing and remodeling homes in the Washington, D.C. area. He is now an industry consultant, and author of the *Turn-Key System for Remodelers* program and *The Emotional Homeowner*. Through his company, Remodelers Advantage, Dave works with remodeling contractors across the country.

Expert Advice from a Contractor: David Lupberger

Finding the Perfect Remodeler

Here are some simple steps to take to find the right remodeler for your home:

- Drive around your neighborhood. Most remodelers will post signs promoting their services in front of homes they are working on. Knock on the door and speak with the homeowner. I know of no better source of high-quality referrals than a happy homeowner, so the better remodeler will work hard to leave a legacy of satisfied customers. And you'll find that visiting remodeling projects is an excellent source of design ideas.
- Talk to friends, or friends of friends. Be bold! The more people you ask, including colleagues at work, clubs, professional organizations, charities, or service organ-izations, the more names you'll be able to gather. Be sure the people have personal experience with the remodeler they recommend. Six to twelve months after a job has been completed on their home is the best time to ask questions. During that interval their remodelers will have responded to some warranty item claims — an excellent test of their reliability and professionalism. Many folks are overflowing with information from this once-in-a-lifetime experience and are full of stories they want to share.
- Yellow Pages. You can use the phone book, but are you willing to spend thousands of dollars based on a random lead you get?
- Contact the National Association of Home Builders (NAHB) Remodelers Council at 800-368-5242, ext. 216. The NAHB has published three consumer information brochures in a series: *Remodeling Your Home: How to Find a Professional Remodeler; Understanding Your Remodeling Agreement; and How to Live With Your Remodeling Project.* These can all be purchased from the NAHB bookstore for $3 each. The purpose of NAHB is to promote professionalism and image within the remodeling industry, therefore association members are more reliable than remodelers who are not members.
- Call the local National Association of the Remodeling Industry (NARI), 800-611-NARI (6274) or e-mail info@ nari.org. Ask for the most recent NARI Home Remodeling Guide that will list industry members in your area. Like NAHB, this association can provide you with more dependable, qualified "green" remodelers than the Yellow Pages; in fact, NARI members must attend a training seminar a pass a final exam to qualify as a NARI-certified green builder.
- Get a copy of Green Spec, <www.buildinggreen.com>. If you live in a remote community, you may have difficulty finding a green building remodeler. However, this book details specifications for building green, like using only certified wood, using solar energy, or recycling at least 50 to 80 percent of construction waste. Include in the contract that renovation plans will adhere to these specifications.

Now you know where to begin — *but*, before you sign that remodeling contract, learn the difference between a good remodeler and the telltale signs of a *bad* remodeler!

Table 3.2 Signs of a Good (or Bad) Remodeler

Signs of Good Remodeler...	*Signs of a BAD Remodeler...*
Returns your first or second calls.	Does not return your second call. They might just be too popular, but imagine how stressful that could be after work on your house begins.
Shows up promptly at your first meeting.	Fails to show up to your first meeting and does not call to reschedule.
A well-organized work site with workers moving like they know what they are doing.	A messy and chaotic work site.
A licensed, bonded, or registered business, when law requires it.*	An unlawful business.
Proof of insurance. The remodeler supplies you with a certificate of insurance indicating the company has sufficient general liability and workers' compensation insurance. The remodeler also has coverage against theft of any materials delivered to the jobsite but not yet installed.	No insurance.
A business address to confirm their permanance. It could be an office, or, as often is the case, a home office.	Works out of the back of a truck.
Does not mind you asking for a credit report, that you can obtain easily from your local banker.	Does not want to give you their name, address, and social security number to secure a credit report.
After contacting a list of suppliers and trade contractors the remodeler has worked with, you determine he or she manages business responsibly, pays trade contractors and suppliers on time, and that the business has a good reputation in the building community.	Poor reputation in the community increasing the risk that you might get a construction lien placed on your property by an unpaid trade contractor or supplier.

Note: *Call the building department in your local jurisdiction to find out the exact city, county, and state requirements and verify the appropriate licensing of your candidates.

Signs of Good Remodeler...	*Signs of a BAD Remodeler...*
After calling the Better Business Bureau and your local consumer affairs office to check the company for consumer complaints, you determine the remodelers are honest advertisers and sellers with few complaints. If your favorite remodeler has a complaint, it was addressed quickly and to the client's satisfaction — a sign of professionalism.	Complaints recorded by the Better Business Bureau and local consumer affairs office. Keep in mind unreasonable homeowners also exist, so if your favorite candidate has a complaint, ask for information about its resolution.
Committed to fulfilling your desires.	Does not seem to prioritize your concerns.
The homeowners he or she has worked for in the past testify this remodeler provided excellent value and delivered high quality work.	Past homeowners fail to praise the remodeler's craftsmanship.
Provides a contract price you can afford. Remodeling team making an effort to keep prices down by "engineering" certain features in your home in a cost-effective way.	Does not provide price checks and value engineering to help you stay within your preliminary design budget. This suggests a remodeler may not be interested in keeping you within budget.
Provides peace of mind and security.	Makes you stressed.
Progress on design.	Lack of progress on design.
Design-revisions contain the exact changes you asked for, and the revisions come back to you within a time frame the remodeler agrees to.	Shows general inattentiveness and lack of attention to detail.
Communication clear and easy, like when you're talking with a good friend.	Difficult or uncomfortable discussions. Dismissive.
Contractor comments, "This is your house, we do it the way you say."	Contractor comments, "Lady, I've been building 25 years, don't tell me how to build."
When you ask if he is a green builder, contractor replies, "Why yes! If it's not VOC-free, it was not meant to be!"	When you ask if he is a green builder, contractor replies, "What do you mean by that?"

Source: David Lupberger, Personal Conversation, Remodelers Guild, Olney, MD.

Working with Your Emotions

We used to laugh about calling Lightworks a design, build, and family therapy firm because we were in the middle of so many relationship issues that surfaced between couples during remodeling. It really helped develop my interpersonal communication skills. Remodeling is stressful and when it is over, all you remember is that is took longer than you thought but mainly that you love the new space. Nonetheless, understanding before you start that you will have moments of "buyer's regret," cost overruns, friction with some of the workers, more dust in your life than you ever imagined, and times when no one on the job seems to see eye-to-eye. For those times here are some tools to help get you through.

John Brockett is an unusual combination of trained psychologist and builder; he has eased homeowners through the remodeling process for over twenty years. Given John's sense of humor and insight, he is the perfect person to forewarn you of the emotions you may feel as you remodel your home.

Expert Advice from a "recovering" psychologist and builder: John Brockett

Remodeling and Love: There Really Is a Connection

Dating

In this initial stage, you call up some prospective contractors. If they fail to call you back, you call someone else. You meet with them, ask your friends what they think of them, and make sure they are not in trouble with the law or have a history of troubled homeowner relationships. Finally, you narrow down your search to someone you listens to your needs, communicates well, and is committed to fulfilling your needs.

Honeymoon

The beginning of your relationship with your contractor is the "honeymoon period." This is when the other can do nothing wrong and you usually overlook any faults the other may have because you are so enamored. This is natural and inspiring. With a little help the ecstatic feeling can be transferred throughout the project.

Labor of Love

Nothing stays the same, so the "honeymoon" will naturally become a "labor of love" given the chance. Again, your feelings, emotions, and thoughts, when clearly named, will become a natural corrective device when the ship gets off course. Naming them allows for necessary shifts, whereas harboring them is equal to constipation (and that is always uncomfortable for everyone).

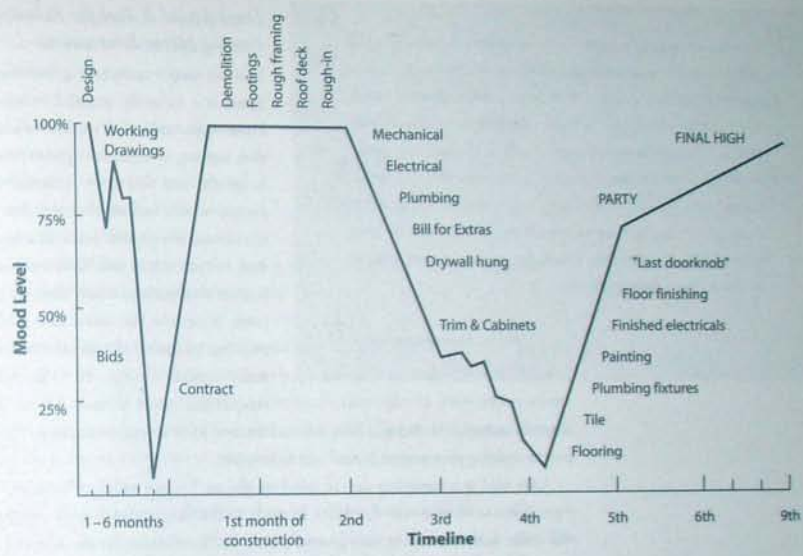


Fig. 3.3: Relationship between mood and remodeling. Credit: David Lupberger, redrawn by Jeremy Drought.

Mediation

When trouble arises, it is best not to try to negotiate the really difficult problems of communication with your contractor by yourself. At the first signs of trouble, get some help. Call in your architect. You have hired experts to build your dream home, therefore you should consult an expert to ensure that your participation is in support of that dream in every way possible.

Growing Stronger from the Relationship

Building a new home is synonymous with building a new life. It is an emotional experience and a wonderful opportunity to manage a major undertaking through to completion. With diligence and commitment you will step back and smile, wanting everyone on the planet to see.

> *I have been reading about the California Native Americans and how they built their own structures just out of materials that were available to them. It was a community effort ... such a different kind of process from how we live now, where there are people who build, and then there is everyone else who just goes into these structures and doesn't really know what they are all about. But when I remodeled my home, I learned how it works. When my husband says, "The plug is not working," I can usually figure out the problem, whereas in all the other houses I've lived in it's been a complete mystery. It feels good to understand the building you are living in.*
>
> **Susan Jones, Homeowner**

Don't Stress! A Tool for Relaxing During Home Renovations

Like any major undertaking, building a home is a naturally stressful endeavor. From major university studies we know that moving or remodeling your home is in the top five most stressful life events, which include divorce, loss of job, severe illness and death of a loved one. Are you scared yet? Well, if you are, you are absolutely normal! What we call stress is simply the mind and body's response to fear of the unknown. Even really good things in life, like remodeling your dream home, are naturally stressful. However, a little information and a few special tools can go a long way to making your project a pure and lasting joy.

One tool is a centering device, kind of like an Eastern religion "mantra." A mantra is a word or words that when brought to the foreground of your attention will calm and focus your energy and poise. So, here's what to do when your emotions and thoughts are running wild after a construction worker accidentally installed a hot tub where the kitchen should be:

- Control your instinct to pick up a hammer and do something with it other than drive nails!
- Find a pen and three pieces of paper.
- Find a quiet, relaxing place to be by yourself. Try to rid yourself of the day's trials and tribulations, empty your mind, get quiet and relaxed.
- Ask yourself, "What are the three most important aspects of my new home?" They can be actual parts of the physical structure, feelings about having the project, reasons why you are building, relationships with others involved, etc. Don't force it; remain quiet until what comes, comes. Try not to second guess what comes usually comes from a deeper place than normal everyday functioning.
- Write one on each piece of paper as they appear.

- Place the three pieces of paper in front of you. Look for feelings or emotions that arise as you read each one.
- Discard one of the three. Notice what you feel.
- Again, do the same until there remains only one. Notice how you feel, notice what this remaining value means to you, notice that above all else this can represent the most important aspect of your new home.

> *When you start paying attention, you start to realize the impact we have. That is one of the things about this project that has been a life-changing experience for me. I started to ask, "What's in that? Where did it come from? What's its impact?" I began to see the world differently.*
>
> **Susan Jones, Homeowner**

There is a method to this madness and if you use it, some magic can happen. Believe it or not, this value has come to you through your uncon-scious and you can depend on it. If you are willing to maintain that value in every aspect of the building process, the power of that dedication will fill your new home. The gift of this process is to stay true to yourself in the face of adversity.

Helpful Tip: Maintain Positive Energy (Your house will show it!)

Remember, this home is a reflection of you. No one will see it as you do, including your contractor, however competent she may be. The difference between satisfaction and disappointment rests in one's ability to navigate the territory between the inner truth and outer reality. In this gray area, conflict and stress can arise. Either the contractor can be engaged to do her best work or discouraged to their worst. In other words, like the law of attraction, good energy produces more of the same; a stress-filled job site can produce a comedy of errors. This doesn't mean the homeowner must take a Pollyanna approach to the project. Rather, it means that when there is a problem, communication is clear, concise, and free of blame. Trust that the overall larger project will succeed even if certain smaller concessions must be made, and your home will radiate the caring energy that went into it.

Tools for Change

The bottom line for this chapter is to develop healthy relationships with your team. Take the time to find just the right architect, designer, contractor, and their workers. The best insurance policy you can provide for a successful remodeling project is to spend time interviewing and "dating" several of each type of professional. Do your homework. Everyone who has gone through the process of remodeling their home will tell you that this is the most important step. With the right teammates, you can make your remodeling dreams come true.

Working with building professionals can be exciting and fulfilling. We hope we have given you some tools to help you choose your professionals wisely and to remain calm when something doesn't work out exactly as you planned. Remember, this is your bathroom, kitchen, bedroom, or addition we're talking about — and while our goal is to *change* the world, a quarrel with a #$!@-ing electrician is not the *end* of the world.

CHAPTER 4

Building Science Basics: The physics you never wanted to know in high school

BUILDINGS ARE ESSENTIALLY A MANIFESTATION of the basic laws of physics. What holds them up, what keeps them dry, and what makes them comfortable are all just applied physics. Buildings fail when we ignore these laws. My childhood was filled with mops and buckets and backed up sewer drains, but this could have been avoided if our home had been built in accordance with physics. This brief overview will help you understand how your house works and when to be concerned if your contractor or his subcontractors start to ignore the basics.

Heat Movement: Thermodynamics

Energy is basically the "go" of things. Without energy the planet would be at rest, and nothing would ever happen. It takes energy for everything we know to exist. We rarely think about energy because it is the mainly invisible: only the results of energy in action are apparent to us. Energy has two basic laws that determine its behavior and the results we can achieve by using it.

The First Law of Thermodynamics

The first law of thermodynamics says that energy can neither be created nor destroyed, only changed from one form to another. We are familiar with various forms of energy on a daily basis. *Atomic or nuclear energy* is what powers the sun and nuclear power plants, and is the basis of nuclear bombs. Basically the energy that holds atoms together is broken and energy is released, called *radioactivity*.

Electrical energy occurs when electrons are released from an atom and they flow from a higher concentration to a lower concentration. A battery has more electrons on one end than the other, and when a light bulb or a motor connects

them, the electrons flow from one end to the other. That is why a light switch works: we connect the concentrated electrons in the power lines to the "ground" and the light bulb is in the middle of the flow, creating resistance — which causes it to glow. When we flip the switch, the flow stops and the bulb goes out.

Chemical energy is released every time we eat. Digestion breaks the chemical bonds in food and releases energy. Petroleum is stored chemical energy. The energy is stored in the bonding of molecules and released when those bonds are broken by refining the oil or by burning it.

Mechanical energy is the energy of anything in motion. The chemical energy in petroleum is burned and released to create the mechanical energy of our cars going from place to place.

Potential energy is stored in differences in altitude. Hydropower is based on gravity pulling water down from higher elevations to lower elevations spinning a generator to produce electricity in the process.

We constantly change energy from one form to another every day.

The Second Law of Thermodynamics

The second law of thermodynamics says that energy can be changed from one form to another, but something is always lost in the process. In other words, there is no such thing as a free lunch when we convert energy — just as when you translate from one language to another, something is lost in the process. When you burn petroleum, you lose some of the chemical potential energy in the form of heat.

Heat is the final or lowest form of energy. At the end of the day, all the energy we use turns into heat that is radiated from the earth to the universe, an infinite heat sink. The more times energy is converted from one form to another, the more heat is lost in the process. The difference between what we started with and what we have to work with in the end is called "entropy." Entropy measures how much is lost in conversion. The higher the entropy, the less efficient the energy conversion process was. The lower the entropy, the more efficient the process. Understanding energy use requires an understanding of how entropy works.

Different forms of energy have different concentrations, or the ability to do more or less work. Uranium has many times more potential for doing work than a hot rock. Electricity is a much higher form of energy than the heater in your car. You can do some things with one that you cannot do with another, so we change it back and forth to do the work we want to accomplish.

Sunlight is the only form of incoming energy we have on the planet. Everything else comes from stored energy like oil, coal, or natural gas. When we use solar energy to heat our homes, there is very low entropy because we are going from the energy source to a direct application, making us comfortable. Very little is lost in the process of sunlight coming through our windows and heating our homes in the winter.

On the other extreme, if we use electricity generated by an oil burning power plant then there is a whole string of high entropy processes that take place. Oil exploration is often in remote places, like Alaska or under water. It takes energy to do the exploring. When it is found, it then takes energy to manufacture massive equipment to extract the oil. The equipment must then be transported to the site, using more energy. It takes more energy to run the pumps to extract the oil. Once the oil is extracted it must be transported to another location for conversion to useable products like diesel oil. It takes a lot of energy to reconfigure the chemical bonds in petroleum to make other products at refineries. The oil is then transported to a power plant that burns the oil to create steam to turn the big generators that create electricity. The electricity is then distributed through power lines that lose energy in the process, until it is converted by a transformer from high voltage to a form that you can use in your house. At the outlet, you can plug in a computer that uses electricity very efficiently and does amazing work, or you can plug in an electric baseboard heater that converts electricity to heat to make you comfortable for a few minutes. Energy, or entropy, is lost at every step of the process. The final usable energy available is called net energy.

Fig. 4.1: Direct passive solar heating is a good example of low entropy energy use, because there's only one step from sunlight to indoor heat. Credit: Reid Yalom, Leger Wanasekja Architecture, San Francisco, CA.

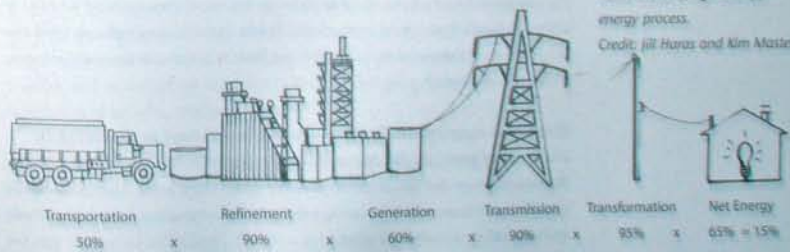


Fig. 4.2: Multiplying the efficiency losses at each stage in the process of delivering electricity to your home shows a high entropy energy process. Credit: Jill Huras and Kim Master.

Efficiencies multiply. Net energy from a coal or oil-fired power plant is only 25 percent by the time it reaches your home! This is an example of high entropy energy use.

All energy moves from higher concentration to lower concentration. So that means that warm air always moves from hot to cold. The difference is called the temperature differential. The higher the differential the more heat moves from hot to cold. In the winter, your house is warmer than outdoors so heat moves from your house to the universe. The only thing that stops it is your insulation or reducing the *conduction* of heat through the walls and ceilings.

Hot air is also lighter than cold air so hot air rises like a hot air balloon. Often, the second floor is warmer than the first floor or the basement. That is from the process of *convection*, warm air rising and cooler air falling.

Also, warmer objects radiate heat to cooler objects. That is the experience of standing in the sun on a hot day. We feel warmer in the sunlight because of the *radiant* heat from the sun. That is why you feel the heat from a teapot even though your hand may be several inches away.

So heat transfer has three characteristics:

Conduction is the process whereby heat flows through a material

Thermal conduction is analogous to electrical currents; if it conducts electricity, it will conduct heat. Insulation slows the rate of conduction and is a better insulator than wood. Wood is a better insulator than metal. Would you rather pick up a hot frying pan with a cast iron handle or a wood handle?

Convection is the heat transfer in a gas (air) or liquid by the circulation of currents

Convection is based on the fact that warm air (or water) rises and cold air falls. A chimney works because of convection. Drafts form at single-glazed windows because the windows cool the air, which gets heavier and moves down the window and across the floor.

Radiation is energy radiated or transmitted as rays or waves (or in the form of particles for the subatomic physicists in the family)

Radiation is how the sun works to heat the earth. On a warm day it is hotter in the direct sun than in the shade, even though the temperature is the same. Warm surfaces radiate toward cold objects.

Our homes use these principles all the time to keep us comfortable — or not. The intention with green building is to use all of the laws of thermodynamics to our best advantage. We can incorporate as much insulation as possible to reduce the conduction of heat to the environment; reduce drafts by sealing the house well and incorporating ventilation where and when we want it, by directing and controlling convection; and we can take advantage of the radiant energy from the sun in winter through passive solar design.

Conventional approaches often don't take full advantage of the natural laws. Homes are oriented any which way, regardless of where the sun's heat is; they incorporate only as much insulation as they are required to by building codes, and too often they are drafty or hotter in some areas than others because natural convection has been ignored. We overpower the natural laws of thermodynamics by using more energy in heating and cooling equipment than we need to, resulting in unnecessary energy costs.

Air Movement

Ventilation

Ventilation is the way we manage the air inside the house. In bathrooms or kitchens we have exhaust fans to eliminate the humid air at the point of highest concentration. In other parts of the house, we typically move air around with the furnace fan. Ultimately, what we want is to control how much air enters the house, where it enters the house, and what we do with it once it is there.

Grandma's house never had ventilation problems because it probably wasn't insulated and it exchanged air with the outdoors all the time. Air sealing houses was never even a consideration. If water got into the wall cavities, it dried right out because there was nothing to keep it from evaporating. In today's homes, the intention is to make them as airtight as possible with as much insulation as possible and to control air movement either by designing for natural convective ventilation or by using mechanical means.

If the house is very tight, it is important to bring in fresh air, especially if there are gas appliances such as furnaces, water heaters, gas ovens, or clothes dryers. A fireplace makes it even more critical to bring in "make-up" air to replace the air that is used in combustion. There are many ways to address this issue, using varying degrees of technology. The first is to keep a window open in the area

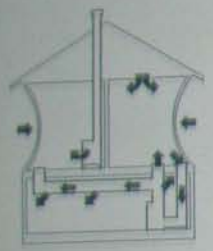


Fig. 4.3a: Depressurized house: supply ducts leak air outside living space; return take more air from inside than leaky supply ducts can replace; and air leaks in through holes in house air barrier.

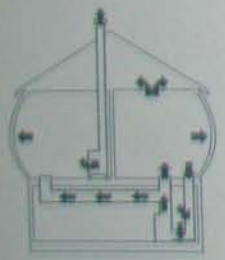


Fig. 4.3b: Pressurized house: return duct leaks take air from basement instead of from house; supply ducts add more air than leaky return ducts remove; and air leaks out through holes in house air barrier.
Credit: Jill Hamm, redrawn by Jeremy Drought.

where fuel is burning, for instance, in a room with a fireplace (although it is not so romantic to have a cold draft wafting over the bearskin rug while you are lying there with a glass of wine). The second is to have ventilation built into the combustion appliance, such as a vent that supplies combustion air right to the fireplace. Sealed combustion furnaces and water heaters are designed that way.

Other ways to bring in fresh air are to have a fresh air vent into the return air duct in a forced air system. Many commercial buildings use this approach. On the high end, heat recovery ventilation systems are tied into exhaust fans in the bathroom and kitchen. When these fans are used or when a timer activates the equipment, fresh air is drawn in as air is exhausted. The air streams pass through an air-to-air heat exchanger that transfers the heat from the out going air stream to the incoming fresh air. This allows you to have fresh air without paying the energy penalty for exhausting conditioned air and reheating incoming cold air.

Air Pressurization

Good heating, ventilation, and air conditioning design creates balanced supply and return ducts so that there is no positive or negative pressurization in the home. Just as a balloon expands because you pressurize the air inside it, a home can be pressurized one way or the other. When you turn on an exhaust fan, you pull air out of the house creating a slight negative pressure.

Air always wants to be the same pressure everywhere, so when you turn on the fan, air comes in through leaks around doors, windows, or other penetrations in the envelope. This is called *infiltration*, but we experience it as a draft.

When the house is tight and we turn on a fan or the dryer, there are few leaks around the penetrations so air must come from somewhere else. Air will always follow the path of least resistance so the furnace, water heater, or fireplace flue becomes a likely candidate for make-up air. The problem is that it can backdraft carbon monoxide (CO) from the combustion gas into the house. This then becomes dangerous because you can't smell or see carbon monoxide — and it can be deadly.

The ideal situation is to have the house slightly pressurized. This helps keep out drafts, it creates resistance to external gas such as radon from entering the house and it reduces the risk of backdrafting. Heat recovery ventilators often create a positive pressure indoors.

Water Movement

Hydrodynamics covers the laws of water movement. Water and air both act according to fluid dynamics, but with different densities or viscosities. Water always wants to move or change states. Changing states means that it is converted from ice to water to steam depending on temperature. What we are most concerned about are the movements of water and humid air.

Moisture, like energy, moves from higher concentrations to lower concentration. Any porous material will act like a sponge. The drier sponge will absorb moisture until it is as moist as it can get. The same is true with building materials; wood is porous and will absorb moisture, which is why we protect our buildings with materials that don't absorb water such as shingles or siding.

Water is very insistent, and will migrate through any material or flow through any cracks it can whenever it has the opportunity. So if your foundation is not waterproofed sufficiently, water will always find a way to migrate through the porous concrete and into your basement. Once it is inside it is a pain to deal with, so keeping it out in the first place is the most important thing.

A roof either works or it leaks. The same is true for your siding material, although we are much more aware of leaky roofs than leaky siding. Roofs have two membranes, roofing felt or tar paper and a protective covering such as shingles or roof tiles; the main waterproofing layer is the felt paper, while the shingles are secondary, to protect the felt paper from degrading in the weather or from ultraviolet sunlight.

Siding should have the same consideration as roofing for keeping water out. Siding has more penetrations in it such as windows and doors and every one has the potential for leakage. The problem with leakage around windows is that the water gets into the wall framing and often never gets inside the drywall, so we don't see it. If the water has no way to evaporate and dry out, it causes rot or mold. Once it does become visible, it is often far too late, and the whole wall may need to be replaced. So once again, it is very important to keep the water out in the first place with good flashing around doors and windows and some form of house wrap to direct the water flow down and out away from the walls. This is called a drainage plane.

Moisture can also come from the soil around the house. If you live with a high water table, water can push its way up through the basement floor. If you live with

a crawlspace, the moist soil can release moisture that is then trapped in the floor framing or distributed through the house by the ducts running through the crawlspace. The dirt floor of the crawl space should be sealed with sheet plastic, taped at the seams and around the perimeter, and the ducts should be sealed with mastic.

Although it is easier to visualize how water flows than how moist air moves, humid air is another way moisture gets into walls. In most climates, air inside the house contains more moisture than outside air. This is because people have the bad habit of breathing! We also water plants, boil water for dinner, and take showers. All these activities put moisture into the air. If the walls and ceiling are not protected with a vapor barrier, then the moisture can migrate through electrical outlets, recessed ceiling fixtures, or through the paint into the drywall, and ultimately get trapped inside the walls. Once there it can cause the same rot or mold problems.

Alternatively, in a hot, humid climate, there is more moisture outdoors than indoors. In these situations, a vapor barrier does not make sense; you need to ensure the walls can "breathe," or allow moisture to evaporate.

Still, we want some moisture in the air. Believe me, living in the high desert of Colorado, indoor moisture is a great thing — just not too much of it. Relative humidity is the measure of how much water is in the air at a given temperature. Warm air can hold more water than cold air. Most people are comfortable with a relative humidity of 30–50 percent. Above that, moisture problems can develop. Below 30 percent, hard wood floors or wood trim may shrink and crack (to say nothing of your nasal passages!).

This is just an overview of the wonderful world of building science. By having a basic understanding, you can make your home much more comfortable, have a better idea of what is going on when it isn't, and be able to have constructive conversations with your design team and contractors to assure that you are getting the most for your money. Living with nature starts by obeying the laws of nature. Green building is derived from living more closely with the natural processes that surround us, and making our homes a natural part of the larger ecosystem.

Part II

Changing the World One Room at a Time

MILLIONS OF AMERICANS ARE RENOVATING their homes every year. Whether because of changing lifestyles or simply because houses are getting old and outdated, more money is spent each year on renovation than on new home construction. Buildings are responsible for 40 percent of energy flow and 40 percent of material use worldwide. The US Environmental Protection Agency (EPA) has stated that "indoor air pollution in residences, offices, schools, and other buildings is widely recognized as one of the most serious potential environmental risks to human health."

From another perspective, remodeling is an opportunity to make a difference in the world. As increasing numbers of people upgrade furnaces, cabinets, and toilets, they can have a positive impact on the world, including less fossil fuel pollution, less resources depletion, and lower health risks. Reusing existing buildings may be one of the "greenest" things we can do.

We are not suggesting that installing solar hot water heaters will stop greenhouse gas emissions from reaching what some experts predict will be levels higher than at any time in the last 50 million years. Remodeling your kitchen with certified sustainable wood will not stop the annual destruction of an area of biodiverse, old growth forest equal to the size of Nepal (*Time* magazine, November 1997, page 13). And installing a low-flow toilet will not replenish our dwindling water supply (*Time* magazine, November 1997, page 19). But green remodeling is energy-efficient, resource-efficient, healthy for occupants, and affordable to create, operate and maintain. Room by room, it is a way you can make a positive difference in your home.

If more and more people renovating use green remodeling strategies, the remodeling industry would have a significant role in saving the air, land, and waters we are degrading at unprecedented rates.

CHAPTER 5

Changing the World ...

Energy

NO MATTER WHAT KIND OF REMODELING YOU ARE DOING, whether it is a kitchen, bathroom, or guest room, you should first think about reducing energy use. Over the past 60 years, our access to inexpensive energy has allowed building design to ignore location and orientation. Unfortunately, this tradeoff of historical design wisdom for standardized building comes at great cost to the environment. We are using our natural resources at an unsustainable rate. According to Paul Hawken, author of *The Ecology of Commerce*, "Today's population uses in one day what it took nature 10,000 days to create." To say it in another way, we are living on our energy capital (stored petroleum and coal) and squandering our income (solar energy). If you ran your company on your capital savings and ignored current income, you wouldn't be in business very long. Green building is a step toward reversing that trend.

Based on 1998 figures, the heating, cooling, and lighting of buildings consumes 36 percent of the energy consumption in the US. A significant portion of this energy is in the form of electricity: residential buildings alone consume 35 percent of all electricity in the US.[1] However, the energy that buildings require starts accumulating long before the buildings and homes are even in existence. The energy required to extract, transport, manufacture, and then re-transport materials to the point of use requires a substantial amount of energy at a significant cost to the environment. The sum of all the energy required by all the materials and services (including the costs of upkeep and maintenance) that go into constructing a building is called the *embodied energy*. The unit of measure for embodied energy is British thermal unit per pound (Btu/lb.). It is highly dependent on factors such as geographical location and the technology used during the manufacturing process. For example, stones excavated from a nearby hillside for a new patio have lower embodied energy than stones that must be transported from another state. Embodied energy figures give us a realistic base

Table 5.1: Energy Required to Produce from Virgin vs. Recycled Materials

	Energy required to produce from virgin material (million Btu/ton)	Energy saved by using recycled materials (percentage)
Aluminum	250	95
Plastics	98	88
Newsprint	29.8	34
Corrugated Cardboard	26.5	24
Glass	15.6	5

Source: Roberta Forsell Stauffer, "Energy Savings from Recycling." Resource Recycling Magazine. *January/February, 1989.*

for comparison as we assess different products or technologies for use in our homes.

To better understand embodied energy, let's consider a brick in your exterior wall. Where did it come from? First, clay had to be extracted from the earth. Then it was transported to the brickworks where the clay was molded into a brick form and fired in a kiln. Eventually the brick was again transported twice more — to a retailer and then again to your building site — before the brick was put into place. But this is only the direct embodied energy of the brick. Embodied energy also includes indirect energy, including mining equipment to extract the clay, trucks to transport the clay, and kilns — anything that had a proportion of its energy invested in that brick.

The embodied energy in recycled building materials is generally much less than the embodied energy in materials produced from raw, or new, materials. Although using recycled materials can involve transporting, cleaning, and sorting, the total energy requirements are still far less than the energy used in extracting and refining a virgin resource.

This section will help you assess the embodied energy that goes into your home, the products you use, and the way you live. In this way you can understand and appreciate the complexity of construction, and its profound affect on everything around us. Our goal is to help you make appropriate choices when planning your remodeling project.

Effects of Fossil Fuel Use

Green building will help wean us off our dependence on fossil fuels. Currently, the US relies on fossil fuels — oil, coal, and natural gas — for 86 percent of its energy needs,[3] despite their polluting effects. Burning these fuels spews tons of fine particles, sulfur dioxide, toxic metals, and other pollutants into the air. The Union of Concerned Scientists (UCS) estimates that fine particles alone may cause 64,000 deaths a year, or more deaths than result from auto accidents. In addition, drilling for oil and natural gas and mining for coal harms the environment by polluting natural surroundings and disrupting local wildlife populations.[4] Given that the building sector is the second largest user of energy, changes in current building behavior are critical to reducing fossil fuel emissions and environmental damage, including the larger international issue of global climate change.

"Is Global Climate Change Really Happening?

Have you stepped outside of your air-conditioned homes lately? The fact of the matter is that we have had the hottest temperatures in decades over the last ten years. We have also seen erratic weather patterns, where we have had extreme cold, flooding in eastern Europe, severe drought in the western United States for at least five years, and major tropical storms. In Nicaragua, 40,000 people died as a result of mudslides and extreme weather; 10,000 people died during heat waves in France. These extreme weather patterns are characteristic of global climate change.

Claudine Schneider, former Congresswoman"

Global Climate Change

Green building directly addresses the single most significant challenge of our generation — global climate change. The greenhouse effect is primarily a function of the concentration of water vapor, carbon dioxide, and other trace gases in the atmosphere that absorb the terrestrial radiation leaving the surface of the earth. Atmospheric concentration changes in these gases can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. With everything else constant, when greenhouse gas concentrations in the atmosphere increase, there is a net increase in the absorption of energy on the earth.[5] This causes a rise in surface, ocean and air temperature as more heat is transferred to the ground.

Water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3) are all naturally occurring greenhouse gases, but can increase to destructive levels as a result of human activities, such as construction. Over the last 250 years, carbon dioxide concentrations have increased by 31 percent, methane by

131 percent, and nitrous oxide by 17 percent. Moreover, each greenhouse gas differs in the way it absorbs heat in the atmosphere: methane traps over 21 times more heat per molecule than carbon dioxide, and nitrous oxide absorbs 270 times more heat per molecule than carbon dioxide.[4] That said, the global mean surface temperatures have increased between 0.5 and 1 degree Fahrenheit since the late 19th century, which further correlates to a four- to eight-inch rise in global sea level. This current trend will likely accelerate the rate of climate change over the next centuries. Some climatologists expect the average global surface temperature to increase between 2.2 and 10°F (1.4 and 5.8°C) in the next 100 years.[5]

Scientists explain that some of the heat due to the greenhouse effect raises the air temperature a bit, but more of it causes increased evaporation of water. As a result, the extra moisture may disrupt weather patterns, producing stronger, longer-lasting, more frequent storms in some areas and droughts in others. Even in the short term we can expect to see these more extreme weather patterns directly caused by global climate change.

"Great!" you may be thinking. "If we keep burning fossil fuels to build homes and provide for our energy, maybe I can wear my swim suit in December!" Think again. Even in the short term, global warming is predicted to destroy coastal wetlands. It will cause unusually frequent but long-lasting bouts of severe weather: flooding in central Europe, vicious cyclones in South Asia, and freak spring snowstorms on the American plains. Global warming may also stress crop production, increase the frequency of diseases like malaria carried by airborne insects, threaten wildlife species, and disrupt entire ecosystems around the world. Low-income communities have the fewest resources to cope with climatic changes, and unfortunately, those communities are often situated near toxic, greenhouse-gas emitting facilities.[7]

In the eyes of most of the world, US leadership and integrity on issues of global climate change have disappeared. Concern with only those issues that are of specifically American interest has replaced historical global concerns, and that is costing the United States an enormous amount of good will. Former US Congresswoman Claudine Schneider thinks that this will result in higher tariffs on some American goods. In other words, the average American will have to pay more for various goods and services because the Europeans, Japanese, and others may eventually say, "All right, we are going to levy a tax on these goods coming from the U.S. because they are using more resources and more energy, and that is creating more of a problem for all of us."

In addition to the cost of political goodwill, there are bottom-line economic costs related to climate change. The US is spending billions of dollars on insurance to cover increasingly devastating weather damage, and also spending more on health care costs related to pollution-induced ailments such as asthma and allergies. As climate change increases, so too will virus-based diseases (such as West Nile disease), for which we have no remedy and which migrate north as a result of weather and habitat changes. Given all the negative ramifications of global warming, even the chief executive of British Petroleum has admitted it would be "unwise and potentially dangerous to ignore" the threat of global climate change.[8]

Green building helps us take personal responsibility for global climate change by clarifying the link between our actions and rises in temperature. Today, confusion masks the problem. For example, the term "global warming" can be misleading because we may still have record low temperature days while the earth is steadily warming. Adding to the confusion, high atmospheric winds carry air pollution long distances: how is someone who lives in the northeastern US supposed to identify their air pollution with Midwestern factories exhausting gases into their air from thousands of miles away? Perhaps even folks next door to coal-fired power plants don't make the connection: the Environmental Protection Agency estimates that we spend 90 percent of our lives in temperature-controlled buildings that shelter us from the elements. Furthermore, global climate change is the combined effect of human activities around the world: what difference does remodeling a house with inefficient incandescent lights make if factories are spewing out tons greenhouse gases in Europe?

Keep in mind the warming is global — and therefore everyone needs to take responsibility. This book helps you to understand the connection between your actions (how you remodel) and their consequences (global climate change). Each person who is remodeling *can* change the world for the better! In the following chapters, you will learn how to remodel your home to save you money and minimize its detrimental energy impact on the environment in two fundamentally "green" ways: use less energy and use renewable resources for energy.

Using Less Energy

In addition to investing in renew-able energy sources, as homeowners we can make simple changes to our homes that save energy — always the cheapest and most environmental solution! It is estimated that a whopping 43 percent of

The US Department of Energy estimates that buildings annually consume $20 billion more energy than would be necessary if the buildings were improved.

Source: Stephen Andros, "Green Buildings Help Cut Huge Energy Consumption," The Phoenix Business Journal, November 4, 2002.

American energy use is wasted.[9] The US Department of Energy estimates that we could save anywhere from 50 to 94 percent of our home energy consumption by making energy-saving changes.[10]

Green building reduces energy consumption in many ways. First, we can decrease the embodied energy of the building through efficient design, by using recycled and local materials, and by recycling construction waste. Second, green building design reduces a building's energy consumption over its lifetime. Installing ceiling insulation and double-glazed windows in every US home can save more oil than the Arctic National Wildlife Refuge can produce at its most optimistic projections, at about 1/20 the cost.[11] Strategically placing windows and skylights can eliminate the need for electrical lighting during the day, which is often when electricity is in highest demand from utilities. A whole house fan can cool the house over night, rather than relying on air conditioning. Additionally, houses can maximize passive heating and cooling. South facing windows with overhangs can reduce heating costs by 20 to 30 percent, and prevailing breezes, shading, and natural plantings can keep houses cool in the summer using the same physics that cause global warming. This list only scratches the surface of the possibilities for reducing a building's energy requirements. The financial benefits are obvious: less energy leads to a lower energy bill. Additionally, decreasing energy consumption, and thus reducing alterations in the global climate, could help prevent further environmental degradation. Keep in mind that it is the impacts of energy use that we are trying to avoid — not the energy itself. In other words, reducing the use of specific non-renewable, polluting energy sources (for example, coal or oil), should be a higher priority than increasing the use of renewable energies such as solar-generated electricity.

Use Renewable Sources of Energy

Conventional Sources of Energy

When we discuss "renewables," we are referring to solar, wind, geothermal and biomass energy. Like renewables, nuclear power plants do not burn fossil fuels

Energy Efficient Design Savings

The study, *Greening the Building and the Bottom Line* by Joseph Romm of the US Department of Energy and William Browning of the Rocky Mountain Institute (RMI), highlights case studies of several companies that invested in energy-efficient designs and thereby experienced significant savings.[12] Further justifying the investment in retrofitting, they found compelling evidence that daylighting (a design feature which allows the use of natural light, rather than artificial light during daytime hours), improved the effectiveness of heating, ventilation, and air conditioning (HVAC), as well as the quality of indoor air. This resulted in increased productivity, fewer worker errors, and less absenteeism in many cases studies. For example:

- Boeing's "Green Lights" effort reduced its lighting electricity use by up to 90 percent, with a two-year payback and reduced defects.
- Lockheed's engineering development and design facility saved nearly $500,000 per year on energy bills and gained 15 percent in productivity, with a 15 percent drop in absenteeism.
- West Bend Mutual Insurance's new building yielded a 40 percent reduction in energy consumption per square foot and a 16 percent increase in claim-processing productivity.

Because labor costs are such a large share of total costs (workforce accounts for approximately $130 per square foot, 72 times more than energy), a one-percent increase in worker productivity can result in savings to a company that exceed their total energy costs. There are more and more cases similar to those documented by RMI, and as a result, companies are starting to invest in energy efficiency for the reasons suggested above: reduced energy expenditures and increased worker productivity.

and therefore do not emit substances that harm air quality or cause climate change. In fact, substituting nuclear energy for fossil fuel energy has significantly reduced US and global emissions of carbon dioxide, the chief greenhouse gas, and other pollutants. Moreover, radiation from nuclear plants is not an issue — nuclear plants produce only a small fraction of the radiation experienced by the US population. One report estimates that New York's six nuclear power plants cause approximately 0.5 to 1.5 statistical cancer deaths per year. Extrapolated to the US as a whole, this data implies 8 to 30 annual statistical deaths related to nuclear radiation that are concentrated among individuals who work in the power plants.[13]

The primary concern with nuclear energy is disposal. State and federal documents indicate that every dump ever used to store low-level nuclear waste — a total of six — has leaked.[14] In addition, the Congressional Research Service (CRS) reports that transporting nuclear waste to the proposed Yucca Mountain storage

facility in Nevada could result in 154 truck and 18 rail accidents per year, a small number of which might release radioactivity.[11] Given that plutonium is radioactive for 250,000 years, one spill could stay on this earth and cause harm to people for longer than our species has inhabited the planet! Although nuclear power itself does not harm air quality, cause climate change, or emit harmful radiation from power plants, the waste from nuclear power is a serious hazard to human and environmental health — a risk not worth taking, given cleaner alternatives.

Hydropower has both positive and negative aspects associated with energy production, but in general is not a viable alternative. Dams needed to generate the power severely alter physical and chemical characteristics of the water and disrupt ecosystems both upstream and downstream. Scientists at Oak Ridge National Lab hold federal hydroelectric dams primarily responsible for reducing Northwest salmon from 16 million to 300,000 wild fish per year. Furthermore, dams are disruptive to human communities: one million people had to be relocated from an area inundated by the Three Gorges Dam in China.[12] Even though the US Department of Energy (DOE) defines hydropower as representing 42 percent of renewable energy production,[13] we do not recommend hydropower as an alternative to fossil fuels.

For building green, we do not need fossil fuels or hydroelectric or nuclear power — we need the services they provide. Most often we want heating, lighting, energy, and fuel, and this we can obtain from other renewable sources — such as wind, sun, and biomass. As Amory Lovins, president of the Rocky Mountain Institute, has said for many years, "People want hot showers and cold beer; they don't care where the energy came from." Renewable energy just needs to prove better or cheaper…

Wind Energy

Wind power is a realistic economic alternative today. Since 1983, prices for wind energy have dropped by an extraordinary 85 percent,[14] exceeding the most optimistic expectations from renewable proponents. Current state-of-the-art wind power plants are generating electricity at less than five cents per kilowatt hour and costs are continuing to decline as more and larger plants are built and advanced technology is introduced. According to Stanford University researchers in a 2001 *Science* article, the direct cost per kilowatt hour of power generated by winds of at least 14 miles per hour is 2.9 to 3.9 cents per kilowatt hour; one quarter of wind monitoring sites are capable of these wind gusts. This price is cost-competitive with new coal plants

Wind Energy Facts

- Denmark, Germany, and some regions of Spain now have 10 to 25 percent of electricity generated from wind power.
- A single one-megawatt wind turbine displaces 2,000 tons of CO_2 each year — equivalent to planting a square mile of forest — based on the current average US utility fuel mix.
- To generate the same amount of electricity as a single one-megawatt wind turbine using the average US utility fuel mix would mean emissions of ten tons of sulfur dioxide and six tons of nitrogen each year.
- To generate the same amount of electricity as a single one-megawatt wind turbine for 20 years would require burning 26,000 tons of coal (a line of ten-ton trucks ten miles long) or 87,000 barrels of oil.
- To generate the same amount of electricity as today's US wind turbine fleet (4,685 MW) would require burning 6.1 million tons of coal (a line of 10-ton trucks 2,300 miles long) or 20 million barrels of oil each year.
- 100,000 megawatts of wind energy will reduce CO_2 production by nearly 200 million tons annually — the amount of wind energy the European Wind Energy Association (EWEA) claims can be installed in Europe by 2010.

producing power at 3.5 to 4 cents per kilowatt hour and new natural gas plants producing power at 3.3 to 3.6 cents per kilowatt hour.

Wind is the world's fastest growing energy source on a percentage basis, growing 32 percent annually for the last five years[15] and on track to grow more than 25 percent in 2003.[16] A modern windmill can produce the energy used for its own production within just three months.[17] Three wind-rich states — North Dakota, Kansas, and Texas — have enough harnessable wind to meet our national electricity needs.[18] Globally, windmills can cover more than half of all energy consumption[19] without adding to air pollution, greenhouse gases, or other types of pollution or environmental damage such as that produced by strip mining or oil spills.

Fig. 5.1: America's wind production is doubling every two years. Credit: David Johnston.

Wind has myriad benefits beyond its ability to supply large amounts clean electricity cheaply, including national security, new wildlife-friendly models,

> **The Future of Wind Turbines**
>
> *Once wind turbines are in wide use, there will be a large, unused capacity during the night when electricity use drops. Turbine owners can turn on the hydrogen generators, converting wind power into hydrogen, ideal for fuel cell engines. John Deere & Company is working on wind turbines that generate hydrogen to use in hydrogen-consuming farm equipment.*
>
> **Sandy Butterfield, Chief Engineer, Renewable Energy Lab, Golden, CO**

pleasing aesthetics, fast installation, job creation, reliability, and predictability. In terms of national security, wind turbines are widely distributed, unlike a nuclear or coal plant where a single location can be targeted. Many people argue that a more distributed power structure such as one relying on wind power might have avoided blackouts in New York and New England caused by an outdated, centralized system. If 30 percent of America's electric power needs were met by wind, the US would be able to get rid of 60 percent of its coal dependence.[14] Today's larger, slower-turning blades are also less of a hazard for birds, that can be killed while attempting to circumnavigate the smaller, faster turning blades of older models. Turbines are being placed offshore, thereby reducing aesthetic objections (although inland they look and smell better than any power plant).[15] Wind power is the fastest of all technologies to install. The turbines can be built quickly to respond to electricity shortages and are a feasible option for developing countries or rural areas where fossil fuel power plants prove too expensive.

The European Wind Energy Association (EWEA) estimates that every megawatt (MW) of installed wind capacity creates about 60 person-years of employment and 15 to 19 jobs, directly and indirectly. A typical 50-megawatt wind farm, therefore, creates some 3,000 person-years of employment. The wind industry is likely to be one of the largest sources for manufacturing jobs in the 21st century. This is especially relevant for rural areas where it can provide a source of skilled-work income for sometimes hard-pressed farmers.[16] In addition, wind offers a "double cropping" benefit for rural communities. In other words, a farmer can grow crops while leasing his wind rights and earn $2,000 to $4,000 per year or more for housing a single utility-scale turbine on his property. The income-generating wind turbine is essentially a second, or double, crop.[17] Reliability has also increased — the availability of utility-scale machines is typically greater than 98 percent.[18] Wind is also inflation-proof, meaning that once a wind plant is built, the cost of energy is known and is not affected by shifting fuel market prices.[19]

Forecasting is expected to dramatically reduce the impact of wind's variability on utility operations, making integration into the grid easier.[20] It seems the answer to our energy problems may indeed be blowing in the wind.

Solar Energy

By far the largest part of the energy on Earth comes from the sun. The sun gives off so much energy that it is equivalent to a 180-watt bulb perpetually burning for every square meter (nine square feet) on Earth. This solar energy influx is equivalent to about 7,000 times our present global energy consumption. In other words, there is tremendous potential in solar energy to provide a significant portion of our heating, lighting, electrical, and mechanical power needs — 7,000 times our energy needs. Just by covering an area 291 by 291 miles square with solar cells, this 0.15 percent of the Earth's land mass could supply all our current energy requirements.[21]

But you don't need solar cells to take advantage of the sun's energy for your home. *Passive solar heating and cooling* represent an important strategy for displacing traditional energy sources in buildings. Anyone who has sat by a sunny, south-facing window on a winter day has felt the effects of passive solar energy. Passive solar techniques make use of the steady supply of solar energy by means of building designs that carefully balance their energy requirements with the building's site and window orientation. The term "passive" indicates that no additional mechanical equipment is used, other than the normal building elements. All solar gains are brought in through windows, with some use of fans to distribute heat or effect cooling.

Fig. 5.2: Designing to use natural light can eliminate the need for mechanical heat.
Credit: David Johnston.

All passive techniques use building elements such as windows, walls, floors, and roofs, in addition to exterior building elements and landscaping, to control heat generated by solar radiation. Solar heating designs collect and store thermal energy from direct sunlight. Passive cooling minimizes the effects of solar radiation through shading or generating air flows with convection ventilation.

Passive Solar Case Study

Susan Jones is a homeowner in California who has noticed a substantial improvement in comfort and a decrease in energy bills since she incorporated passive solar design into her home renovations. Before, "It would get to be 110 degrees in the house; it was amazing. Our energy bill was about $100 a month." Susan superinsulated her home, replaced leaky, single-pane windows with double-pane windows, and added a reflective roof. Now, "It can be 30 degrees outside and it stays 60 degrees inside; it is really nice. Our energy bill is only about $10 a month."

Beyond her comfort and financial gains, Susan feels emotionally fulfilled knowing that she thoroughly researched all the materials in her home to insure that every detail minimally impacted the environment and the health of the products' manufacturers.

"I feel a new sense of connectivity with nature....When I started to research conventional building materials and looked at where they came from, who made them, how they were made, I started to look at everything differently."

Another solar concept is daylighting design, which uses natural light to illuminate rooms during the day and contributes greatly to energy efficiency by eliminating the need to turn on lights. The benefits of using passive solar techniques include simplicity, low price, and the design elegance of fulfilling one's needs with materials at hand.

Photovoltaic (PV) cells convert sunlight into electricity for your home. They are usually made of silicon; they contain no liquids, corrosive chemicals or moving parts. Moreover, PV cells require little maintenance, do not pollute, and operate silently. Photovoltaic cells come in many sizes, but most are ten centimeters by ten centimeters (3.94 square inches), and generate about half a volt of electricity. A bundle of PV cells that produce higher voltages and increased power is referred to as a PV module, solar collector, or array. A module producing 50 watts of power measures approximately 40 centimeters by 100 centimeters (15.75 inches by 39.37 inches). PV modules can be retrofitted on to a pitched roof above the existing roofing, or the tiles replaced by specially designed PV roof-tiles or roof-tiling systems.

PV modules, like flashlights or cars, generate direct current (DC), but most home electric devices require 120-volt alternating current (AC). A device known as an inverter converts DC to AC current. Inverters vary in size and in the quality of electricity they supply. Less expensive inverters are suitable for simple loads, such as lights and water pumps, but models with good quality waveform output are

Photovoltaic Facts

- Worldwide photovoltaic installations increased to 340 megawatts in 2001, up from 254 megawatts in 2000. In 1985, annual solar installation demand was only 21 megawatts. The total on-grid market segment grew to almost twice the size of the off-grid market in 2001. That is the equivalent of one small conventional energy power plant.
- Of the global demand for solar photovoltaics, over 30 percent is accounted for by Japan, 20 percent by European countries, and less than 10 percent by the US.
- Nearly 45 percent of the world's solar cell production is manufactured in Japan. The US is second with 24 percent (of which 70 percent is exported), with Europe third, at 22 percent.
- Two billion people in the world have no access to electricity. For most of them, solar photovoltaics would be their cheapest electricity source — but they cannot afford it.

Source: Solarbuzz, "Fast Solar Energy Facts," cited September 26, 2003, <www.solarbuzz.com>.

needed to power electronic devices such as TVs, stereos, microwave ovens, and computers. In grid-connected systems, PV supplies electricity to the building and any daytime excess may be exported to the grid. Batteries are not required because the grid supplies any extra demand. However, if you want to be independent of the grid supply you will need battery storage to provide power outside daylight hours.

Between 1987 and 1998, the annual number of US PV shipments in the US grew 640 percent, with a 20.5 percent average annual increase.[5] The cheapest photovoltaic cells have become three times as effective since 1978.[6] Back in the 1970s the cost of PV cells was $70 per watt of production;[7] today, residential solar energy system typically costs about $8 to $10 dollars per watt. In some areas, government incentive programs, together with lower prices secured through volume purchases, can bring installed costs as low as $3 to $4 dollars per watt (10–12 cents per kilowatt hour). Without incentive programs, solar energy costs (in an average sunny climate) range from 22 to 40 cents per kilowatt hour.[8] Scarcely a month goes by without another advance in either PV cell design or manufacturing technology — by 2030, the price is expected to drop to 5.1 cents per kilowatt hour.[9] PV demand has been stimulated in part by government subsidy programs (especially in Japan and Germany), and by equipment rebate policies and tax credits for utilities or electricity service providers (e.g., in Switzerland and California). The central driving force, however, comes from the desire of individuals or companies to obtain their electricity from a clean, non-

polluting renewable source, for which they are prepared to pay a small premium. The greater the demand for PV, the faster the price will come down.

PV systems are appropriate for electric devices, but water heating or other heating is most efficiently produced by *solar water heaters*. They convert up to 60 per cent of the sun's energy into heat used for domestic hot water, pool heating and space heating needs.[37] There are two types of systems: passive and forced circulation. A passive water heater consists of a water tank located above a solar collector. As water in the collector warms, water flows by natural convection through the collector to the storage tank. A forced circulation system requires a pump to move water from the storage tank to the collector. Most solar water heaters in the United States are the forced circulation type.

There are several types of solar collectors. Most consist of a flat copper plate with water tubes attached to the absorber plate. As solar energy falls on the copper plate and is absorbed, the energy is transferred to the water flowing in the tubes. Integral collector and storage systems combine the function of hot water storage and solar energy collection into one unit. Solar collectors are typically roof-mounted, with hot water storage tanks inside the house. They are often connected to a conventional water heater for back-up.

Solar water heating systems are efficient, clean, easy to install, and virtually maintenance-free. And since hot water counts for as much as 40 percent of the energy requirements of an average house, solar water heating systems can cut the costs for heating hot water by 40 to 60 percent.[38] An active, flat-plate solar collector system will cost approximately $2,500 to $3,500 installed, and will produce about 80 to 100 gallons of hot water per day. A passive system, typically used in climates that don't freeze, will cost about $1,000 to $2,000 installed, but will have a lower capacity. If the monthly cost of financing the system is less than the net savings, a solar water heating system may result in immediate positive cash flow.[39]

Overall, solar energy has a bright future. Passive heating obviously makes economic and environmental sense today, and solar systems are cheaper, simpler, and more reliable than ever for homes. All types of solar applications are expected to become commonplace when and if the true costs of fossil fuel use — including external costs like pollution, health risks, and military protection for foreign oil sources — become reflected in its price.

Biomass Energy

After hydroelectricity, biomass is the most widely used renewable source of energy, representing three percent of energy consumption in the US.[40] In contrast to other sources of renewable energy that rely directly or indirectly on sunlight and its effects on weather patterns — such as wind power, solar cells and hydro-power — biomass energy comes from stored solar energy in plants. Electricity from burning biomass (crops and crop waste) is also predicted to have substantial growth. Unfortunately, biomass can cause respiratory infections and various pollution problems, including sulfur, nickel, cadmium, and lead pollution. For some places in the world, however, growing biomass may turn out to be sensible since production can take place on poor soils, help prevent erosion, and even help restore more productive soil. Others argue it is not likely biomass will provide a major part of global consumption because the total agricultural biomass production from stalks and straw, constituting half the world's harvest in mass, only makes up about 16 percent of the current agricultural production. Still, Shell Oil, the most successful company in the oil industry, expects that biomass will provide between 5 and 10 percent of the world's energy within 25 years, possibly rising to 50 percent by 2050.[41]

Geothermal Energy

Like biomass energy, geothermal energy can be used at all times. Produced by the earth's natural subterranean heat, it is a vast resource, most of which is deep within the earth. Geothermal energy can be economically tapped when it is relatively close to the surface, as evidenced by hot springs, geysers, and volcanic activity. (The "Old Faithful" geyser in Yellowstone National Park is an example of geothermal energy.) In contrast to oil fields, which are eventually depleted, properly managed geothermal fields keep producing indefinitely.[42]

In the home, geothermal energy is used for heat pumps. Pipes are drilled into ground water that stays a relatively constant temperature. That is then used as the heat source for a pump that extracts the heat and blows it into the building or dumps excess heat in summer and cools the home. The cost of geothermal energy is currently priced

> "Just as the Stone Age did not end for lack of stone, the oil age will not end for lack of oil. Rather, it will be the end because of the eventual availability of superior alternatives."
>
> **Bjorn Lomborg, *The Skeptical Environmentalist: Measuring the Real State of the World.***

Table 5.2: Major Life-Cycle Environmental Impacts of Energy Sources for Electricity Generation

	Air Pollution	*Climate*	*Land Use/ Degradation*	*Water Use & Quality*	*Wildlife*	*Radiation*
Coal	Very High	Very High	High	Very High	High	Low
Oil	High	High	Moderate	Moderate – High	Moderate – High	Near 0
Natural Gas	Very Low – High	Moderate – High	Low – Moderate	Near 0 – Low	Low	Near 0
Biomass	Near 0 – Moderate	Very Low – High	Near 0 – High	Very low – High	Low – Moderate	Near 0
Wind	Near 0	Very Low	High	Near 0	Near 0 – High	Near 0
PV	Near 0	Low	Very High	Near 0 – High	Near 0	Near 0
Geothermal	Near 0 – Very Low	Very Low – Low	Very Low	Near 0	Near 0	Near 0
Hydroelectric	Near 0	Low	Very Low – High	High	Very High – High	Near 0
Nuclear	Near 0	Very Low	Very Low	High – Low	High	High

This table is qualitative, labeling impacts in order from worst to best as high, moderate, low, or near zero. It should be read vertically; it does not attempt to compare the severity of different categories of environmental effects (e.g., air and water pollution). Finally, the life cycle impacts are not only based on power plant operation, but but also fuel production and transport, waste disposal, and other operations. Therefore, no cell in the table is empty, because even very clean energy sources like solar and wind require energy at some point in their cycle — for instance, for manufacturing — and this energy itself has environmental impacts.

Source: Adam Serchuk. The Environmental Imperative for Renewable Energy: An Update. *Renewable Energy Policy Project.* REPP-CREST. *April, 2000.*

at five to eight cents per kilowatt hour, and is expected to drop to four to six cents per kilowatt hour with more industry experience and improved drilling technology.[39]

Renewable Energy Outlook

Compare the $50 billion the US spends on safeguarding oil supplies in the Persian Gulf with the $150 billion Americans could save annually by switching just 20 percent of our energy production to renewables.[41] A study by the Economic

Research Associates found that by switching to renewables, Colorado residents alone would gain 8,400 jobs and enjoy a $1.2 billion energy savings. Co-op America's Solar Catalyst Group found that California could create up to 15,000 new full-time jobs by producing up to 500 megawatts of new solar photovoltaics (PVs) per year by 2008.

Given this potential savings, why do fossil fuels still supply 85 percent of US energy needs, and renewable energy sources less than 3 percent?[40] Importantly, there exist powerful economic incentives to "disinvest" in renewables. We don't have to pay for resource depletion or air pollution, to say nothing about the tax incentives and corporate welfare the fossil fuel industry enjoys; therefore, the true price of fossil fuels is not reflected on our energy bills.

Additionally, the price of fossil fuels does not reflect the heath treatment costs, higher insurance rates, missed work, and lost life resulting from air pollution. Studies by the American Lung Association indicate that annual US health costs from all air pollutants may amount to hundreds of billions of dollars.[42] Until we pay for pollution, waste, carbon fuels, and resource exploitation (all of which are presently subsidized), there is little to encourage us to install unfairly expensive solar panels or other renewables.

Despite economic obstacles, the global wind industry is growing by 25 percent annually while the markets for oil and coal are expanding only 1 to 2 percent per year. Although the oil and coal markets are a significantly larger percentage of our energy use, meaning that, statistically, a one percent growth reflects a significant increase, a 25 percent growth in wind is still substantial growth. People are realizing that if we are going to approach our future with environmental and economic foresight, it would be wise to reduce our consumption of fossil fuels and invest in renewable energy production.

There are great advantages to using renewable energy: It pollutes less, makes a country less dependent on imported fuel, requires less foreign currency, and has almost no carbon dioxide emissions. Many of the renewable technologies are cheap and easy to repair. Renewable energies can be the most cost-effective method of bringing electricity to developing countries or remote villages that do not have reliable or wide-reaching energy infrastructure. Surpluses of

> *"Oil scarcity may be the weakest reason for making the transition away from oil. Profit, climate protection, security, and quality of life are all more relevant and defensible."*
>
> **Amory Lovins, co-founder of the Rocky Mountain Institute**

Ozone Depletion from Construction

In 2000:

- 60 percent of ozone-depleting substances, including chlorofluorocarbon (CFC) and less-destructive hydrochloro-fluorocarbon (HCFC), were used for building and construction systems in the US.
- 7,000 tons of CFCs were used to replace leaking or otherwise emitted refrigerants from older equipment in buildings.
- 120,000 tons of HCFC were used for new and existing building equipment.
- 75,000 tons of HCFC were used for foam building insulation.

Source: US Green Building Council, "Industry Statistics," cited September 25, 2003, <www.usgvc.org>.

wind, solar, and geothermal electricity on long-term contracts can guarantee the price, something those relying on oil or natural gas cannot do. And, once we get cheap electricity from these renewables, we can use it to electrolyze water, splitting the water molecule into its component elements of hydrogen and oxygen. Hydrogen, an exceedingly environmentally friendly energy-carrier that leaves behind only water, can later be used in electricity production.[47] Although renewables were once referred to in *The Economist* as "alternative" pet projects for "bearded vegetarians in sandals,"[48] these energy sources are quickly becoming recognized as economically competitive, more socially just, and environmentally sustainable energy solutions.

Natural Resources

Green building not only saves energy, but helps reduce the three billion tons of raw materials that are turned into foundations, walls, pipes, and panels every year. In fact, the building construction industry is the biggest user of materials, including steel and cement.[49]

Reducing the need for raw coal minimizes one of the most environmentally-destructive processes of the entire energy sector — mining. Mining often involves mountaintop removal and produces acid mine drainage caused by exposing iron- and coal-bearing rocks to water. Waste from uranium mines and milling operations constitutes the largest source of low-level radiation in the US; moreover, a disproportionately large fraction of this waste resides on Native American lands.[50] According to the Worldwatch Institute, mining for building materials such as copper and steel is responsible for 50 percent of CFC (chlorofluorocarbon) production in the U.S., thereby destroying the ozone layer that protects us from the sun's harmful radiation. Mining also generates 33 percent of the carbon dioxide (CO_2) emissions that contribute to global warming.[51]

Table 5.3: Remodeling Project Comparisons

Type of Remodeling Project	Geographic Location	Size of Project (Sq. ft)	Total Waste (lbs)	Generation Rate (lb/sq. ft.)	Average Generation (lb/sq. ft)
Kitchen and Room	Maryland	560	11,020	19.68	
Bathroom	North Carolina	40	2,883	72.10	
Totals		**600**	**13,903**	**23.17**	
Kitchen	Oregon	150	9,600	64.00	
House	Oregon	1,330	26,000	19.55	
Totals		**1,480**	**35,600**	**24.05**	
New Roof	Maryland	1,400	4,464	3.31	3.31

Source: Environmental Protection Agency, Characterization of Building-Related Construction and Demolition Debris in the United States. Report No. EPA530-R-98-010. Municipal and Industrial Solid Waste Division. Franklin Associates, June 1998. Chapter 2.

These disheartening facts do not even consider building waste. Alex Wilson, editor of *Environmental Building News*, describes construction and demolition (C&D) waste as "one of the most daunting challenges we face in the construction industry." Disposal costs are high, resources are needlessly wasted, and we are running out of landfill space. Even though there has been considerable media attention given to the solid waste crisis, Wilson comments that "it is remarkable how little we really know about C&D waste."[52] There are few reliable statistics on quantities of C&D waste generated nationally, and just a few studies of the composition of this waste.

It is especially difficult to assess total waste generation for renovations because of the wide variation in the types of remodeling jobs. Table 5.3 above, shows the results of five waste assessments that have been made at residential sites in the US, showing a wide variety of generation rates on a square-foot basis.

The National Association of Home Builders (NAHB) avoided this discrepancy by estimating the amount of material produced by the type of remodeling project. In the US, the major waste generated during remodeling activities stems from kitchens, bathrooms, and room additions. Annually, there are approximately 1.25 million major kitchen remodeling jobs (complete tear-

out), with average waste generation of 4.5 tons per job. Americans perform 1.5 million minor kitchen remodeling jobs (facelift, cabinet replacement, etc.), that generate 0.75 tons of waste per job. Major bath remodeling (1.2 million per year) produces on average 1 ton of waste material each, and 1.8 million minor bath remodeling jobs produce on average 0.25 tons of waste each. Room additions, estimated at 1.25 million per year, produce about 0.75 waste tons apiece. From these calculations, NAHB estimated total residential renovation waste generation, from improvements or replacement projects, to be 31.9 million tons per year.[13]

In the US, construction and demolition debris account for 20 percent of all landfill waste; 43 percent (58 million tons) of this total is from residential construction, demolition, and renovation projects.[14] The number of landfills in the United States is steadily decreasing — from 8,000 in 1988 to 2,300 in 1999.[15] Creating new landfills is limited due to the protests of area residents near proposed sites. As a result of landfill limitations, the disposal costs are soaring to an average of 2 to 5 percent of the overall budget costs,[16] or $511 per house for construction disposal.[17] These costs drive more and more people to illegally dump construction and demolition waste.

Reduce, Reuse, Recycle

Green building provides myriad ways to dramatically reduce your waste and the costs associated with disposing it. Did you know that 85 to 90 percent of construction disposal is recyclable? If you plan with the 3 R's of waste reduction (reduce, reuse, and recycle) in mind, you will definitely see economic benefits. To this end, green remodeling encourages three key steps: planning ahead of time; reusing materials wisely; and recycling building waste.

The first step is planning. For minimizing the amount of waste generated, the following main areas should be focused upon: dimensional planning and design, material use and recycling, and use of modular/pre-constructed elements along with other resourceful building techniques. Since you may need to outsource this work, it is essential that the design team establish the waste reduction goals in contractual form with the subcontractors. Since contracts are often sidestepped (either purposely or inadvertently), it is the job of the construction manager to oversee all work and verify its successful completion.

Poor planning and design results in insulation leaks, moisture, rot, insect infestation and added waste — leading to added costs ranging from higher energy and waste removal bills to the worst-case expense of evacuating and demolishing

Case Study: One Moldy, Rotten House

In 1999, Melinda Ballard paid a plumber to repair a leak. A few months later, the hardwood floors began to warp and buckle. Soon mold grew and started to destroy their furniture and walls. Melinda and her family began coughing up blood and suffering memory loss. Finally, they had to evict themselves from their "dream home." Melinda's insurance company had to pay $32 million for material damage to the house. Still, the lawsuit verdict did not pay for the health damage to her husband, who lost his job and now goes to cognitive therapy four times a week as a result of their moldy home. Although this is a particularly extreme case, it clearly shows how cheap repairs and renovations can end up costing consumers and the environment more than do well-made homes.

Source: Lisa Belkin, "Haunted by Mold," *The New York Times Magazine*, August 12, 2001.

a mold-infested house. The extra energy and resources needed for repairing poorly planned buildings also contribute to the deterioration of the quality of our water, air and land.

Second, as you will read, green remodeling helps you use resources more wisely. We can build structures durably out of energy-efficient materials, including reused and recycled products. Some examples are engineered lumber, which reduces the amount of material needed by as much as 50 percent without sacrificing strength; walls built from insulation sandwiched between panels of oriented strand board; and recycled-content building products such as carpet, decking, cellulose, and fiberglass insulation.

Third, recycling waste helps to keep resources out of landfills. As an incentive to builders, many local municipalities are beginning to collect used construction materials at solid waste transfer stations with little or no tipping fee. Some non-profit recycling or reuse organizations will come to the site and load waste materials, often offering the builder a tax receipt for the donation.

Although there would seem to be no reason not to reduce, reuse, and recycle, the construction industry is a conservative one. New green technologies, products, and procedures typically take time to establish their stronghold. However, in our capitalist society the construction industry will adapt more quickly to a change in demand for green products. Homeowners who choose to make a difference and embrace green remodeling, therefore, have a huge potential to green the building industry and save precious natural resources.

Fig. 5.3: Weeping tree. Credit: David Johnston.

Wood Resources

Residential construction accounts for more than 50 percent of the wood consumed in the United States;[59] 30 percent of softwood lumber (pine) consumption is accounted for by remodeling and repair alone.[60] Wood is durable, beautiful, and renewable. Compared to steel and concrete, wood also uses less energy; creates less air, water, solid waste, and greenhouse gas pollution; and uses fewer ecological resources.[61] However, we still waste wood unnecessarily and we need to be more reflective about the types of wood that we use. In particular, wood harvested from virgin, endangered, or old-growth forests should be avoided.

Old-growth forests take hundreds and even thousands of years to reach maturity and are home to innumerable plants and animals found nowhere else. To date, we have harvested over 97 percent of North American old growth forests.[62] Of that, one third goes into lumber, plywood, particleboard, and other structural building material.

Although the extraction process for wood is less polluting than that for many other building materials, we must consider the quantity of wood extracted compared to steel and plastics. Global consumption of industrial timber (approximately 1.66 billion tons per year) exceeds the use of steel and plastics combined. The average US home requires about 15,000 board feet of lumber,[63] the equivalent of harvesting an acre of trees. Humans are deforesting the world at a rate of 37 million acres a year (approximately the land area of Finland).[64] As a result of this high rate of timber consumption globally, forests are not just declining in area, but also in quality. As recently as 20 years ago, the average old-growth tree harvested from US national forests was 24 inches in diameter. Today the average is 13 inches! Globally, we also lose an estimated 27,000 species annually because of habitat loss, and the building industry is largely responsible.[65]

Although the US is home to only 4.5 percent of the global population, it is responsible for over 15 percent of the world's consumption of wood.

Source: "World Primary Energy Consumption and Populations by Country/Region." US Department of Energy, August 7, 2000.

Use Less Wood

In recent years, there has been a strong movement towards using wood more efficiently in construction in order to minimize wood consumption and the cost of wasted materials, as well as to optimize energy savings. By understanding the common dimensions available for building materials, we can quickly see what dimensions can be incorporated into design to reduce waste. Plywood, oriented strand board (OSB), and rigid insulating sheathing all come in four-foot by eight-foot dimensions. If you build in two-foot increments (outside dimension to outside dimension), there will be less wood sheet waste because the two-foot dimension is divisible by both the four-foot and eight-foot factors. This is applicable for wall construction, roofs, and overhangs.

For maximum framing efficiency, 24 inches on center (o.c.) spacing between framing members should be used instead of the standard 16 inches o.c. In other words, if you have studs (vertical pieces of wood) spaced 24 inches apart as opposed to spacing them 16 inches apart, you use less wood along the length of any given wall. If your wall is 12 feet long, you can build 24 inches o.c. with seven studs (144 divided by 24 +1). If you build 16 inches o.c., then you have to use ten studs. When you're adding on multiple walls, you can see how the wood savings from building 24 inches o.c. quickly add up.

When you construct with 24 inches o.c., you typically use two-by-six pieces of lumber for framing. These are usually more expensive than two-by-fours used with 16 inches o.c., and the volume of material is roughly the same. However, the 24 inches o.c. two-by-six method uses about 30 percent fewer pieces of wood, translating into labor savings and greater wall cavity space for more insulation. And more insulation equates to more energy savings. The typical R value (rate of heat loss through a material) for two-by-fours is 13, whereas for two-by-sixes, the R value is 19. This difference can save a significant amount of energy!

Additionally, you can also couple the 24-inch frame spacing with other efficient measures, including two-stud corners. Often builders use up to four studs at a corner, but this method merely wastes material, since you only need two. Also, the entire corner is wood with four studs — a "thermal bridge," or area with minimal insulation resulting in greater heat loss. Using two studs enables you to install more consistent insulation. In turn, the two-stud corner lends a higher R value and can save you money on lower energy bills.

Certified Wood

Not all timber is created equal: some is harvested with care and knowledge of valuable ecosystems, while some is the product of clearcuts and deforestation. A forest is very different from a tree farm or a plantation forest. Once a forest has been clearcut, the fundamental ecology is changed, from the micro-organisms in the soil to the diversity of fauna and flora. In other words, a tree farm is much like

Small is Beautiful: 14 Ways to Optimize Space

1. Provide an open plan for the kitchen/dining and living areas. Family members often prefer to spend time in the kitchen, so provide for that in the design. In many cases it also makes sense to extend this open layout to the living area, so that one space serves all three.
2. Avoid single-use hallways. Design houses so that circulation areas serve additional functions — circulation through the living/dining area, or hallways that also serve other functions — library space, for example, or (with adequate separation) laundry.
3. Combine functions in other spaces. By combining functions in certain rooms, space can be optimized. For example, combine a guest bedroom with a home office.
4. Provide built-in furnishings and storage to areas to better utilize space. For example: storage cabinets and drawers built into the triangular space beneath stairways; bench seats built into deep windowsills; library shelves along stairway or hallway walls; and display cases built into wall cavities. Small windows in walk-in closets can make those spaces more inviting and better used.
5. Make use of attic space. A tremendous volume in most houses is lost to unheated/uncooled attic space. Instead, insulate the roof and turn attic spaces into living area — making use of skylights and dormers to bring in light and extend the space. Having some rooms extend right up to the ceiling often makes sense, because variations in ceiling height make the room feel larger. If a standard uninsulated attic can't be avoided, at least design easy access and provide convenient storage areas so that the space can be used.
6. Don't turn bedrooms into living rooms. These are actually primarily used for sleeping and dressing. Keep them relatively small to avoid wasted space.
7. Provide acoustic separation between rooms. A small house will be more acceptable if there are no common walls between bedrooms. Closets can help provide this separation. Also consider insulating interior walls and providing staggered wall studs for acoustic isolation.
8. Provide connections to the outdoors, especially from the master bedroom. This will create a more pleasant house and make a compact house feel significantly larger. Careful placement of windows and glazed patio doors, as well as tall windows that extend down close to the floor help extend spaces to the outdoors.
9. Provide daylighting and carefully placed artificial lighting. Try to provide natural light on at least two sides of every room to provide a feeling of spaciousness and an opportunity for natural cross-ventilation. Incorporate some natural and artificial lighting where the light source is not readily visible to make compact spaces feel larger. Uplighting onto ceilings also makes a space feel larger.

Fig. 5.4: Credit: Kim Master.

Small is Beautiful: 14 Ways to Optimize Space

10. Provide visual, spatial, and textural contrasts. Contrasting colors, orientations, degrees of privacy, ceiling heights, light intensities, detailing, and surface textures can be an important design strategy for creating spaces that feel larger than they really are.
11. Use light colors for large areas. Most walls and ceilings should be light in color to make spaces feel larger. Use dark colors only for contrast and accent.
12. Keep some structural elements exposed. Structural beams, posts, and timber joists can be left exposed, creating visual focal points and texture. Be careful not to let these elements overwhelm the space; too many exposed timbers can make a space feel smaller.
13. Design spaces for visual flow. Careful building design can make small spaces feel larger by causing the eye to wander through a space. A continuous molding line that extends throughout a house somewhat below the ceiling can assist with this visual flow. Continuity of flooring and wall coverings can also tie spaces together visually. With very small spaces, provide diagonal sight lines that maximize the distance and feeling of scale.
14. Provide quality detailing and finishes. By limiting the overall square footage of a house, more budget can be allocated to green building materials and products that cost more (natural granite countertops, linoleum, certified wood flooring, top-efficiency appliances, etc.).

Source: Alex Wilson, "Small is Beautiful: House Size, Resource Use, and the Environment," Environmental Building News, January, 1999, p.11.

a cornfield: it is not a native habitat for the original species that once inhabited the area. Therefore, when we do use virgin wood, we should buy wood that is certified as being sustainably harvested, thus supporting environmentally appropriate, socially beneficial, and economically viable management of the world's forests and encouraging lumber companies to adhere to sustainable forestry guidelines. Certified wood is becoming increasingly commonplace; you can even find it in places such as Home Depot.

Keep in mind there are numerous certification programs, and some are more reputable and reliable than others. The Forest Stewardship Council (FSC) was launched in 1993 by indigenous groups, timber companies and environmental organizations in an effort to standardize the emerging programs. FSC is an international nonprofit organization established for the purpose of creating a verifiable international standard for well-managed forests and a process for tracking and certifying products derived from those forests. Significantly, certification is a third-party process — in other words, the people certifying the forest operations are not forest owners or managers, whose biases may cause them to overlook forest

FSC ©

Fig. 5.5: The FSC logo identifies products which contain wood from well-managed forests certified in accordance with the rules of the Forest Stewardship Council. © 1996 Forest Stewardship Council A.C.

Over the past ten years, 104 million acres in more than 40 countries have been certified according to FSC standards.

Source: Forest Stewardship Council, "About FSC" [online], cited July 20, 2004, <www.fsc.org>.

management inadequacies. Most environmental groups, the U.S. Green Building Council, and progressive businesses recognize FSC as the only environmentally and socially credible certification program in existence at this time.[45]

Rapidly Renewable Wood

All wood is renewable to a degree — which is one reason why wood is such a sought-after material for green construction. However, just as there are more efficient appliances for the home than others, there are also more renewable species of trees than others. Fast-growing trees offer the general benefits of plants (helping replenish oxygen in the air, and removing harmful CO_2), but also offer a consistent supply of material for construction.

There are many different species of wood used in construction that are highly renewable, with varying uses and applications based on geography, building codes, and availability. For instance, bamboo reaches up to a height of 60 feet in the first several months, making it extremely fast growing and renewable. Its strength is unmatched relative to its weight as compared to other construction materials. Although it is rarely used as frame construction in North America, it is commonly used in other areas of the world. Bamboo has successfully been adopted as a green flooring material due to its quick regrowth, and resulting consistent supply. Aspen is another rapidly renewable tree, but its uses are limited to engineered lumber products such as oriented strand board (OSB), because of its limited strength.

Alternate, Under-Utilized Tree Species

In Table 5.4 opposite, the left-hand column lists examples of endangered, vulnerable and rare tree species that you should avoid purchasing. For example, ipê, like many other trees in the tropical rainforests, only occurs in densities of one or two individuals per acre throughout most of its natural range. To meet the orders for hundreds of thousands of board feet of FAS ("fine and select" or "four-side-clear," meaning no knots or defects on all four sides of the board for its entire length), loggers have to log thousands of trees. That means punching roads and skid trails into thousands of mostly pristine acres of old-growth rainforests, as well

Table 5.4: What Trees are OK to Use?

***Trees to Avoid*[1]**	***Alternate Species*[2]**
Temperate:	
Alaskan Cedar	Angico—outdoor applications
Douglas Fir	Arariba—furniture, cabinetry, flooring, interior
Giant Sequoia	Cancharana—interior and exterior, joinery, furniture
Sitka Spruce	Chakte Kok—variety of applications
Western Hemlock	Chechen—furniture and variety of applications
Western Red Cedar	Curupau—heavy construction, outdoor, flooring, turnings
	Granadillo—substitute for Cocobolo or Rosewood; furniture
	Katalox—substitute for Ebony
Tropical:	Peroba—furniture, cabinet, flooring, trim, sashes, doors, turnery
Mahogany	T'zalam—furniture, interior finish work
Rosewood	
Okoume	
Ramin	
Ipê	
Cocobolo	
Ebony	

[1] Prior to specifying any tropical wood, reference the CITES listing of endangered species.

[2] Harvested from forests that have been certified as "well managed" according to standards endorsed by the Forest Stewardship Council.

Source: Rainforest Relief. Woods to Avoid and Alternatives *[online]. [Cited October 28, 2003]. Rainforest Relief, 2003. <www.rainforestrelief.org/>.*

as damaging or destroying up to 28 trees for every one they target. The canopy is reduced by about 50 percent after loggers take the mahogany, ipê, jatoba, and a few other high-value species for export.[46] The right-hand column in Table 5.4 will help you identify and specify alternative, under-utilized species to expand your design options and extend the forest resource. By using lesser-known species in lieu of the handful of "standards" we now depend so heavily upon, we can

alleviate pressure on species that are threatened with extinction from over harvesting. We can also dramatically improve the economics of sustainable forest management by demonstrating the value of the full panoply of forest resources. This, in turn, will provide an incentive to maintain the wide diversity of species in natural forests.

Engineered Wood

In addition to rapidly renewable certified wood, homeowners should consider engineered wood as they remodel their home. Today's building industry is limited to younger, smaller trees that yield little sizable lumber. Much of this new wood tends to be weaker and wetter, with more natural defects and less tensile strength. However, unlike these smaller trees, engineered wood can utilize the strongest fibers. New technologies can take a tree apart and put its fibers back together to take advantage of its natural strengths wherever they are found on the tree. Using trees too small for sawn lumber, they can produce engineered lumber that's bigger and stronger than anything cut from a tree today. The result is a structural system of high quality lumber that's superior to the original log in size, strength, and dimensional stability.

Not only does this process avoid the use of old-growth trees, but the manufacturing process converts as much as 75 percent of a log into structural lumber compared to less than 50 percent by conventional methods — using fewer trees to do the same job. Making the most of under-used fiber, they produce cost-effective, readily available lumber that maximizes underused resources and minimizes environmental impact. In addition, engineered woods are able to use wood from readily available and quick-growing trees such as yellow poplar and aspen.

Significantly, engineered wood should still be certified. Most wood utilized for engineered wood is extracted using clearcut logging practices. Approximately 1.2 million acres are cleared annually to operate 140 chip mills in the Pacific Northwest. According to the US Forest Service, the removal of softwoods is currently exceeding the growth rate in southeastern US states.[87] FSC-certified wood — whether virgin or engineered — ensures proper management and longevity of our precious forests.

Reclaimed/Salvaged Wood

Non-forest sources of wood are another alternative to virgin or old-growth lumber. Reclaimed wood is salvaged from buildings and structures that are being remodeled or torn down. Sometimes logs that sank decades ago during river log drives can even be salvaged. Reclaimed wood is desirable from an environmental perspective because it is not associated with recent timber harvesting, it reuses materials, and it can reduce the construction and demolition load on landfills. Additionally, reclaimed wood is often available in species, coloration, and wood quality not found in today's forests. But, as with other resources, the supply of reclaimed wood is limited, therefore efficient and appropriate use of reclaimed wood is important for its long-term availability.[88]

Wood Treatments

Overall, whether you choose certified rapidly renewable, engineered, or reclaimed/salvaged wood, avoid selecting wood that has been treated with chromated copper arsenic (CCA) or ammoniacal copper arsenate (ACA). Arsenic is a rat poison. Treating wood increases its durability in locations where degradation by rot or insects might occur. However, leaching of chemicals out of the wood into the surrounding environment may occur to a limited extent. Handling the wood can also pose a risk to human health, especially if the chemical treatment is not fully dry. This is particularly a problem for young children who might be playing on a treated wood deck or playground equipment. Roughly 17 percent of all softwood lumber is pressure-treated today, including about 40 percent of all softwood from the southeastern US.[89] From 1985–97, approximately 48 billion board feet of wood products have been treated with CCA. The Environmental Protection Agency classifies wood treated with these substances as hazardous waste.

The most significant environmental concern associated with preservative-treated wood is disposal by incineration. Currently, an estimated 2.5 billion board feet of preservative-treated wood is disposed of annually; as much as 16 percent may be incinerated. Toxins, such as arsenic, may become airborne to a limited extent, but most toxins end up as ash where they are highly leachable.[90] One tablespoon of ash from CCA lumber is enough to kill a cow. Unfortunately, the only environmentally acceptable disposal option for CCA-treated wood is to send it the landfill, and these are filling up.

Although CCA was phased out of production for residential use in December 2003, it will remain an issue for existing homes. To avoid problems with CCA-

treated wood, try to ensure that treated wood is disposed of in lined landfills only, so that it does not pollute the soil and water. Better yet, try to reuse treated wood so it does not end up in a landfill in the first place. Use construction details that minimize the use of wood in locations where rot or insect infestation is likely. If wood must be used, a healthier alternative is Alkaline Copper Quarternary (ACQ), which does not contain arsenic or chromium.[77] Borate preservatives are also much less toxic, but can somewhat leach out of wood in wet conditions. You might also consider naturally rot-resistant species like cedar or redwood, but only if they are from a certified forest.

Recycled Plastic "Wood"

Plastic lumber, a newer and increasingly popular replacement for CCA pressure-treated lumber, is most effective because it protects timber resources and prevents the use of highly toxic lumber treatments.[78] It also provides a use for the millions of tons of annual plastic waste.[79] Plastic lumber will not rot, absorb water, splinter, or crack; it is also resilient to shock, making it an extremely durable component in exterior applications. Plastic lumber is most cost-effective in large-dimensions where wood is most expensive,[80] but should not be considered a suitable replacement for load-bearing structural components.[81]

Composite lumber incorporates some of the characteristics of wood with those of plastic lumber. Recycled wood waste fiber is combined with recycled plastic resins to create a product that has some improved strength and aesthetic characteristics. Like plastic lumber, it will not rot, crack, or splinter. Furthermore, wood composite materials generally have a more natural coloring and appearance, although they may still be stained or painted. In general, plastic and composite lumber are great options to consider for decks or other exterior applications.[82]

Water Resources

When remodeling we must also consider another increasingly valuable resource — fresh water. According to the Worldwatch Institute, buildings in the United States use 17 percent of the total freshwater flows.[83] Large quantities of water are required to produce many construction materials: during manufacturing, steel uses 25 times more water than wood.[84] More generally, our water consumption has almost quadrupled since 1940.[85] US indoor residential water use is estimated to average 80 gallons per day in homes without efficient fixtures. Outdoor use varies tremendously, but obviously adds significantly to this number.[86]

Washed Down the Drain

- Older toilets use between 3.5–7 gallons of drinking-quality water per flush.[87]
- Most dishwashers use between 8 and 14 gallons of water for a complete wash cycle.[88]
- Clothes washing in a typical top-loading machine require about 45 gallons of water.[89] Front loading machines can reduce this figure by a third to a half.
- Nationally, lawn care accounts for 50 to 75 percent of outdoor residential water use.[90]
- A typical family of four on public water supply uses about 350 gallons per day at home.[91]
- Each day, US water users withdraw over 300 billion gallons of water from the earth, enough to fill a line of Olympic-size swimming pools reaching around the world.[92]
- Hand washing dishes with the tap running half open uses 25 gallons. Washing and rinsing in a sink or dishpan uses only 6 gallons.[93]
- A dripping faucet wastes 15 to 21 gallons per day.[94]
- Taking a bath uses 36 gallons for a full tub.[95]
- Showering uses 12 gallons per minute, or three gallons per minute with a flow restrictor. (Try a shower with a friend).[96]

In the Middle East, China, India, and the United States, groundwater is being pumped faster than it is being replenished, and rivers such as the Colorado and Yellow River no longer reach the sea year round. Fresh water in groundwater often takes centuries or millennia to build up — it has been estimated that it would require 150 years to recharge all of the groundwater in the United States to a depth of almost 2,500 feet if it were all removed.[97] Issues over water rights create conflict between neighbors, counties, states and countries. Water issues also force us to dam rivers and irrevocably damage countless ecosystems: "In the northern hemisphere, three-quarters of the flow from the world's major rivers has been tamed to quench our thirst."[98] Bjorn Lomborg, author of *The Skeptical Environmentalist: Measuring the Real State of the World*, reasons that our water wells are not going to run dry; in fact, even projected "overestimates" of total water use for 2025 require just 22 percent of the readily accessible, annually renewed water.[99] But when we consider its uneven distribution and the environmental degradation caused by pollution and damming, it becomes clear that better water management practices are essential to providing clean water for everyone while preserving fresh water ecosystems.

Fig. 5.6: Xeriscaping minimizes water use and maintenance, saving time and money. Credit: B.F. Norwood.

Water Quantity

Better water management can begin in the home. While domestic use only accounts for a small fraction (12 percent) of total water use,[54] it is still problematic. For example, rapid urban growth has resulted in depleted groundwater sources in Los Angeles, San Diego, and Tucson, forcing these cities to siphon water from far-reaching places. However, with minimal impact on our current lifestyles, we can reduce our domestic water use by as much as half. Today's water-saving showerheads and faucet aerators save water by creating a more forceful spray, sometimes mixed with air, using less water. Low-flush toilets, required by code in the US for new construction use, use 1.6 gallons of water or less per flush. Composting toilets are also an option; they can save a typical family of four 47,028 gallons of water per year.[55] Additionally, modern dishwashers can fit on a countertop and use only 4.75 gallons of water per wash cycle. Newer front loading washing machines are initially more expensive, but use only 20 to 28 gallons per load as opposed to 45 gallons and save $60 to $100 per year in water and energy costs.[56]

Outside, we can take steps to lower the water needs of our lawns. One solution is to use wildflowers, low-water native plants, and attractive xeriscape designs. Not only do these plants lower water use, they also save time and money because of fewer maintenance requirements. If giving up a traditional grassy lawn is unappealing, simply plant buffalo grass, which requires less water than traditional lawn grasses. Finally, instead of installing a conventional sprinkler system, use drip irrigation. Drip irrigation delivers water directly to the plants' roots rather than wastefully spraying water over a large area, where much of it evaporates.

Water Quality

Although our planet is 71 percent water, humans depend on a mere 0.65 percent of this water for survival — much of which is polluted. In a recent article in *The Washington Post*, it was reported that "about a quarter of the nation's largest industrial plants and water treatment facilities are in serious violation of pollution standards at

What's in Your Water?

- **Arsenic**: An element that gets into the water supply through natural soil deposits or industrial and agricultural pollution. Arsenic causes bladder, lung, and skin cancer; heart and nervous system damage; and skin problems. Very low levels of arsenic have also been found to disrupt hormone functions.
- **Trihalomethanes (THMs)**: These chemicals are formed when chlorine used to disinfect water reacts with organic matter, such as animal waste, treated sewage, or leaves and soil. They can increase the risk of cancer and may damage the liver, kidneys, and nervous system, and increase rates of miscarriage and birth defects.
- **Trazine**: A weed killer used on most corn crops, atrazine can cause organ and cardiovascular damage and is a suspected hormone disruptor.
- **Coliform bacteria**: These indicate the presence of dangerous microbes such as cryptosporidium, which can be life-threatening to people with weak immune systems.
- **Lead**: A toxic heavy metal that can damage developing brains and nervous systems. While lead may not be present at the source, it can leach into your water from lead-containing pipes in your home and in public water mains.

Source: The Green Guide Institute, "Water Filters," cited September 29, 2003, <www.thegreenguide.com>.

any one time."[57] Moreover, half the serious offenders exceeded pollution limits for toxic substances by more than 100 percent.

According to the Natural Resources Defense Council, an estimated 7 million Americans are made sick annually by contaminated tap water; in some rare cases, this results in death.[58]

Many Americans worry about drinking tap water: we spend over $4 billion per year on bottled water and over $2 billion per year on in-home water filtration systems.[59] We do not recommend bottled water for several reasons:

- **It's wasteful**. According to a Los Angeles' *Times* report, "If the [plastic water bottle waste] problem continues, enough water bottles will be thrown in the state's trash dumps over the next five years to create a two-lane, six-inch-deep highway of plastic along the entire California coast."[60] In an April 2001 report by the World Wildlife Fund, an estimated 1.5 million tons of plastic is manufactured from petrochemicals each year to package water. The EPA estimates that in 1999 alone, about one million tons of plastic bottles ended up in US trash bins.

- **It's just tap water.** National Resources Defense Council and *Consumer Reports* have found that some bottled water is simply tap water. In can be worse for you, in fact: tests by *Consumer Reports* in August 2000 showed that plastic water containers can leach phthalates and other chemicals into the water, and bottles that are left open for long periods are subject to bacterial growth and contamination. Unlike tap water, regulations allow bottled water to contain E. coli or fecal coliform and don't require disinfection for cryptosporidium or giardia.
- **It's expensive.** Bottled water can cost from 240 to 10,000 times more per gallon than water from the faucet, according to calculations by the Natural Resources Defense Council. In the US, we pay more for bottled water than we pay for gasoline.

Water filters are the best option for contaminated water. First, you need to figure out what's in your water. In a May 2002 study of the nation's stream water by the US Geological Survey, scientists discovered chemicals found in drugs, detergents, disinfectants, insect repellants, plastics, and personal care products, including 33 suspected hormone disruptors. If your water source is "good," the easiest and least expensive option is to select a charcoal filter that removes the chlorine taste and smell, as well as excess minerals and possibly some heavy metals. For water that is contaminated with pollutants such as pesticides and harmful chemicals, consider systems for reverse osmosis and distillation. The Environmental Protection Agency (EPA) estimates that the cost of providing state-of-the-art drinking water via water filtration systems would cost the average household only $30 per year. (Learn more about water filtration in the Plumbing section of Chapter 7.)

Aside from using water filters, there are several other options. You can boil water for a minute to kill bacteria and parasites. You can drink and cook with only cold water and let the water run for one minute in the morning to decrease lead from pipes in old homes (although this option wastes water). Or you can leave tap water in an open container in the refrigerator for few hours to dissipate chlorine and trihalomethanes (THMs).

Ultimately, the best defense against water pollution is to protect the rivers, streams and wetlands that are the source of your drinking water. Campaign to limit development around reservoir watersheds. Refuse to use yard pesticides and fertilizers that can run off or seep into groundwater. Dispose of leftover paints and other household chemicals through your community's hazardous waste collection program — don't pour them down the drain. Use biodegradable cleansers and detergents, and buy organic food that is grown in accordance with watershed-protecting farming practices. Small actions add up to a big difference!

Health and Indoor Air Quality

It is estimated that we now spend more than 90 percent of our time indoors.[103] Our health and well-being are notably affected by the large amount of time we spend indoors. In part because of dust, mold, lead, and asbestos in the home, more than 38 percent of Americans suffer from allergies,[104] resulting in a variety of symptoms ranging from runny noses and fatigue to learning problems and epilepsy.[104] Moreover, asthma, which is linked to animal dander, paint fumes, dust mites, cockroaches, molds, pollens, and indoor secondhand smoke,[105] is on the rise. From 1980 to 1994, the number of asthma cases grew 75 percent[106] to over 17 million.[107] We are just beginning to understand the connections between many more ailments — some life threatening — and your home.

Indoor air quality represents a considerable challenge for several reasons. First, the current method of determining IAQ is not related to any health or productivity measure. Rather, it is simply a function of the percentage of people who are dissatisfied with a space: if 20 percent are dissatisfied, the building has poor indoor air quality. Not only does this measure ignore health care costs, productivity, and crippling law suits, but it is technically inaccurate.[108]

Second, pollution laws in general focus more on the sources of the greatest amounts of pollution, rather than on the sources of the greatest amount of exposure to pollutants. Smoke stacks emit large amounts of pollution, but most of us do not live next door to one. Our homes, on the other hand, emit relatively small amounts of pollution, and yet they are often the places where we face the greatest exposure to health-threatening pollutants.

Third, in recent years we have become more concerned with energy efficiency and sealed up our homes more tightly without consideration for proper ventilation. In effect, as cabinets, carpets, furniture, stoves, and many other common household items contribute to indoor air, they build up to unhealthy concentrations because they can not escape from the house as they might in a leakier home.

By remodeling green, you can prevent serious health issues related to indoor air. It is important to understand the sources of your exposure to toxic pollutants

Indoor Air Pollution

- The US EPA ranks indoor air pollution among the top five environmental risks to public health. Unhealthy air is found in up to 30 percent of new and renovated buildings.[108]
- According to the World Health Organization (WHO), indoor air pollution causes about 14 times more deaths than outdoor air pollution, or about 2.8 million lives each year.[109]
- Of all the hundreds of chemicals regulated by the Environmental Protection Agency (EPA), only ozone and sulfur dioxide are more prevalent outdoors than indoors.
- According to the US EPA, the medical and lost-productivity costs of workers breathing poor air amounts to tens of billions of dollars each year in the United States alone.
- The National Contractors Study indicated an average indoor air quality (IAQ) productivity loss of 10 percent from IAQ on its review of 500 studies.[110]
- A study at Cornell University showed that poor lighting results in a 10 percent worker productivity loss.[111]
- Green designs resulting in productivity gains of 1 percent can provide savings to a company greater than the savings from reduced energy consumption.

in your home, including showers (chloroform), stoves (carbon dioxide, respirable particles), and carpets (lead, pesticides). Additionally, there exist many often-unrecognized indoor pollutants that you should be aware of as you remodel. We have organized all these pollutants into six overarching categories to clarify the indoor air quality issues in your home and allow you to make simple, healthy remodeling choices:

1. Particulates (lead, asbestos, fiberglass, dust)
2. Combustion gases (carbon monoxide, nitrogen oxide, hydrocarbons)
3. Volatile Organic Compounds (VOCs — formaldehyde, pesticides, vinyl chloride, soil gases)
4. Radioactive contaminants (radon gas)
5. Environmental tobacco smoke
6. Moisture and mold

Particulates

Particles, sometimes called particulates, are small specks of solid matter. Common household dust can include microscopic particles from fabrics, soil, plants,

Sick Building Syndrome

When I was working as an independent contractor, I got a call from a homeowner who was at his wit's end. He recounted that for several months his kids had been constantly sick with headaches, fever, coughs, and other flu-like symptoms. The doctors didn't seem to be able to help the kids and they were missing a lot of school. During the same period, his wife had two or three migraine headaches a week, and was losing a lot of sleep. All of them were exasperated. He asked me if these conditions could possibly be from something in his home.

I asked him many questions about their home and lifestyle and if they had done any remodeling. Nothing seemed relevant to their situation. Finally, he told me he had gotten a bonus at work and had bought built-in shelves and desks for his kids and their master bedroom. He hadn't mentioned it because he couldn't see how that made any difference. I asked him to go to the rooms and pull out a shelf and describe to me what he saw. It turned out to be particleboard with a melamine veneer.

I suggested that he try an experiment: take everything off the shelves and remove them for the weekend since all the shelf edges were not sealed and I suspected they were offgassing formaldehyde. I asked him to call me a week later to report if there was any difference. He called and said that the kids' symptoms had decreased and he was encouraged. The next weekend he removed all of the built-in cabinetry. He called me two weeks later and said all of their symptoms were gone. The kids felt great and his wife hadn't had a headache since he took the shelves out.

insulation, human and animal dander, food, dirt, paint, plastic, soot and cigarette smoke. The particles themselves can carry harmful chemicals, such as lead. In addition, particles can carry dust mites, or tiny insects that live on the dust itself. Many of these are biological allergens that can cause reactions ranging from sneezing and running eyes to heart palpitations, internal pains, and loss of muscle control.[112]

Particulates are especially dangerous to small children, who play on floors, crawl on carpets, and regularly place their hands in their mouths. Infants are particularly susceptible: their rapidly developing organs are more prone to damage, they have a small fraction of the body weight of an adult, and they may ingest 5 times more dust — 100 milligrams a day on average. Carpets act as a reservoir for particulates, especially plush and shag carpets. Vacuuming hard-surface floors will remove almost 100 percent of dust, while vacuuming a carpet typically removes only 30 to 60 percent of the dust. However, wiping one's feet on a commercial grade doormat appears to reduce the amount of lead in a typical carpet by a factor of 6.[113] A central vacuum that vents outdoors and a vacuum with a high-efficiency filter are the best options to keep particles to a minimum.

Lead paint.

Twenty million lead-painted houses have too much lead dust or chippings — about 20 percent of all housing in the US. Homes in the Northeast, Midwest, and Western states have more lead than those in the South.

Source: Debra L. Dadd, The Nontoxic Home and Office, Jeremy Tarcher, 1992, p. 165.

Lead

Lead has long been recognized as an especially dangerous particulate. It impairs mental and physical development in fetuses and young children and decreases coordination and mental abilities. Additionally, lead damages the kidneys and red blood cells, and may increase high blood pressure.[17] The margin of safety between measured blood levels and the levels causing clinical symptoms is remarkably small; only a slight increase in lead concentration in children's blood levels is necessary to cause anemia and the onset of mental losses.[18] Low exposures can be even more dangerous than higher exposures because there are no visible symptoms, but the subtle learning and behavior problems can go on untreated for years.[19]

Children, especially between the ages of six months and six years, are at high risk because they are more likely to ingest lead particles, and because harmful effects begin at lower blood levels. Lead enters the body when an individual breathes or swallows lead particles or dust once it has settled. There are many ways that humans can be exposed to lead: through air, food, contaminated soil, deteriorating paint, and dust. Additionally, pipes, solder in pipe joints, and home plumbing can release lead into your drinking water; in some instances, this may account for up to 40 percent of your family's lead exposure.[20]

If your house was built before 1950, you almost certainly have some paint with high lead content — the most significant source of lead exposure in the US today.[21] According to a 1990 study by the US Department of Housing and Urban Development (HUD), 75 percent of all private housing built before 1980 has some lead paint.[22] If the house has been repainted, the old paint has been sealed in. However, if the new paint deteriorates or is improperly stripped, it can create a new hazard.

It is especially important for children and pregnant women to avoid drinking, eating, or breathing lead because growing children and developing fetuses are the most vulnerable to lead poisoning which can cause irreversible brain damage and behavior and learning problems, and delay mental and physical growth. Kids tend to get lead on their hands and then put their fingers and lead-ridden objects in their mouths, so they are likely to have higher exposure. The US Centers for Disease Control (CDC) estimates 890,000 children in the US between the ages of 1 and 5 have elevated lead levels in their blood.

To avoid lead in your home, have old paint lab-tested for high lead content before major renovations. Leave paint undisturbed if it is not accessible to children and if it is in good condition. Replace doors, windows, or trim covered with lead paint, or strip and repaint them away from the house. If you want the paint removed on-site, have it done by a trained contractor. The work will be dusty, so you should move the family out the house during the work, and clean up thoroughly before moving back in. Also, have your water tested for lead content. If the results show high lead levels, replace old plumbing or install a point-of-use water purification device, such as a reverse osmosis system or distiller.

Asbestos

Asbestos is a naturally occurring particulate with long, flexible fibers that can lodge in your lungs. There are no immediate symptoms, but prolonged exposure can cause asbestosis (severe impairment of lung function), or cancer of the lung or lung cavity. Asbestos can also cause cancer in the digestive tract if fibers are inadvertently swallowed. Smokers are at a higher risk of developing asbestos-induced lung cancer.

In 1974, after the elevated risk to asbestos workers was documented, asbestos was banned for interior use in the US. It still exists in many homes today and is difficult to remove, given that if any of the products mentioned above are damaged, improperly removed, or get disrupted in any number of ways (like sanding), it is likely that the asbestos will become airborne. However, most asbestos is embedded in other materials, such as ceiling tiles or pipes, and is not as dangerous in that form.

Combustion Gases

Appliances that burn fuel, such as furnaces and fireplaces, commonly leak at least small amounts of the gases created during combustion. They will emit larger amounts when the appliances are not working properly, or when another appliance or system, such as a bathroom fan or range hood, draws air from the house and causes normal chimney flow to be reversed, known as backdrafting. This negative pressure causes gases to be drawn back down the chimney or exhaust duct, and into the house. For example, leaky return-air ductwork, fireplaces, down-draft kitchen

Asbestos Alert

Asbestos is only detectable under the lens of a microscope and is only problematic when the mineral fibers become airborne. Because asbestos is cheap, fireproof, and a good insulator, it was used in a multitude of products, including:

- **Vinyl floor tiles and vinyl sheet flooring**. French scientists found that heavily trafficked floors released significant amounts of fibers. Fibers can also be released if the tiles are sanded, cut, dry scraped, cleaned abrasively with a broom or vacuum, or otherwise damaged.
- **Patching compounds and textured paints**. Asbestos has not been allowed in textured paints since the Consumer Product Safety Commission banned the use of asbestos in patching compounds in 1977. Still, scraping or sanding these materials in older homes will release asbestos fibers.
- **Ceilings**. A home built between 1945 and 1978 may have had asbestos-containing material sprayed or troweled onto the ceilings or walls.
- **Pipe and Duct Insulation**. If your home was built or repaired between 1920 and 1972, the hot water pipes and furnace ducts may be covered or wrapped in asbestos-containing material, such as asbestos paper tape.
- **Wall and ceiling insulation**. Asbestos insulation is typically "sandwiched" between plaster walls in homes constructed between 1930 and 1950.
- **Fireproofing**.
- **Acoustical Materials**.
- **Wood Stove Door Gaskets**.

Backdrafting

Rob deKieffer and Rich Moore, working with Sun Power, Inc., tested the whole-house pressure of 100 homes in Colorado. They found that negative pressure is common in homes with forced-air systems, especially in basements whenever the furnace is operating.

Source: Steve Andrews, "A House Under Pressure," Home Builder, January 1997, pp. 13–14

exhaust fans, undersized cutouts through floor plates for return-air drops, normal exhaust fans (kitchen range hoods and bath fans), dryers, central vacuum systems, large combustion air ducts located on the sheltered side of a home, and large penetrations into attics, such as whole-house fans,[10] can all cause backdrafting.

Carbon Monoxide

Although you can't see, taste, or smell carbon monoxide (CO), this combustion gas is responsible for a larger number of severe chemical poisonings than any other single agent.[11] When breathed, carbon monoxide preferentially binds to blood hemoglobin, displacing oxygen at the binding site and thereby depriving the body of oxygen. Early symptoms of carbon monoxide poisoning include persistent

Tips to Avoid Carbon Monoxide Poisoning

- Never burn charcoal inside a home, garage, vehicle, or tent.
- Never use unvented fuel-burning camping equipment inside a home, garage, vehicle, or tent.
- Never leave a vehicle running in an attached garage, and minimize the amount of time the vehicle is in the garage when you start it each morning, even with the garage door open. Move the vehicle out as soon as possible after starting.
- Have your fuel-fired appliances serviced every one to two years.
- Never use gas appliances such as ranges, ovens, or clothes dryers for heating your home.
- Never operate unvented fuel-burning appliances in any room without adequate ventilation or in any room where people are sleeping.
- Do not use, or service, gasoline-powered tools, and engines indoors or in attached garages.

Source: American Lung Association of Minnesota, <www.healthhouse.org>, cited October 1, 2003.

headaches, nausea, fatigue, blurred vision, rapid heartbeat, loss of muscle control, and flu-like symptoms that clear up upon leaving the house. More severe exposures cause vomiting, collapse, coma, and death, depending on the degree of oxygen deprivation. Suicidal or accidental death from running a car in an enclosed garage or from using an unvented, poorly tuned combustion appliance indoors results from depression of the central nervous system to the point where breathing is stopped. The Consumer Products Safety Commission reports that more than 200 people in the United States die from CO poisoning every year.[12]

In addition to carbon monoxide, fuel-fired appliances also emit other combustion by-product pollutants, including formaldehyde, nitrogen dioxide, sulfur dioxide, carbon dioxide, hydrogen cyanide, nitric oxide, benzo(a)pyrene, and vapors from various organic chemicals. At low levels produced from average use from combustion appliances, possible symptoms from exposure to these by-products include eye, nose, and throat irritation; headaches; dizziness; fatigue; decreased hearing; slight impairment of vision or brain functioning; personality changes; seizures; psychosis; heart palpitations; loss of appetite; nausea and vomiting; bronchitis; asthma attacks; and breathing problems.

The most effective way to avoid combustion by-products is to use all-electric appliances — range, heaters, water heaters, and clothes dryers. Self-cleaning electric ovens are one exception because they produce carcinogenic polynuclear aromatics that are on the EPA list of priority pollutants. In general, however,

indoor air pollution studies show that all-electric homes have significantly lower concentrations of combustion by-products than do homes with gas appliances.

You can still use gas appliances and protect yourself somewhat by ensuring that fuel-burning appliances like furnaces, hot water heaters, stovetops, and fireplaces are properly ventilated. If you are replacing your furnace or water heater, consider using a sealed combustion unit that isolates the appliance from the indoor space. During cooking, for example, a hood fan can remove up to 70 percent of pollutants produced.[14] If possible, put your gas appliances in a space outside of the living area, venting the fumes to the outside and placing a tight seal between the appliance and the living space to prevent gases from spreading throughout the home. Use a new-model gas stove with low-heat-input gas pilot light and non-gas ignition systems, which produce significantly lower pollutants than do older stoves with pilot lights.

For wood stoves and fireplaces, make sure they are installed and fitted properly. Have your chimney inspected for creosote buildup when the weather starts getting cold, or periodically throughout the year if you frequently use your fireplace. Fix cracks or leaks in the stovepipe and keep a regular maintenance schedule to keep the chimney and stovepipe clean and unblocked. Have your fireplace retrofitted with an insert that draws air from the outside and has airtight doors that can be closed when you leave the room.

Finally, beware of negative air pressure and downdrafts indoors that can pull pollutants into your living space instead of up the flue. Eliminate the problem by installing only sealed combustion appliances. If this proves too expensive, reduce the backdrafting by selecting only fan-driven, draft-induced water heaters and eliminating any wood or gas fireplace that isn't sealed combustion. Other alternatives include carefully sealing all ductwork with mastic, installing a return-air duct in all the bedrooms, and selecting a standard kitchen range hood rather than an excessively powerful downdraft exhaust cooktop, which can suck too much air out of the house too fast, causing negative air pressure. Keep in mind that "leakier" homes are *not* a solution; this merely makes the home uncomfortable and more expensive to heat and cool. Moreover, if leaks are located in the wrong places, they can add to unbalanced pressure and introduce combustion gas issues in the home.

Tighter Buildings and Formaldehyde Risk

In past decades, energy-conserving airtight buildings that use urea-formaldehyde foam insulation (UFFI) have become common. The Consumer Product Safety Commission (CPSC) banned use of UFFI in residences and schools in 1982, after receiving numerous complaints that exposure to this insulation caused respiratory problems, dizziness, nausea, and eye and throat irritations, ranging from short-term discomfort to serious adverse health effects and hospitalization. The ban was later overturned by the US Court of Appeals, but the CPSC continues to warn consumers that evidence exists to indicate the substantial risk associated with UFFI.

Volatile Organic Compounds (VOCs)

Many of the hazardous chemicals in modern houses are members of a large family called volatile organic compounds, or VOCs. The distinctive smell of a newly remodeled house is primarily composed of offgasing toxic volatile organic compounds. They are commonly found in plywood, particle board, wood paneling, carpets and carpet padding, insulation, paints, finishes, adhesives, heating fuels, solvents, waxes, polishes, and many other household products.

VOCs found in the home include formaldehyde, benzene, xylenes, toluene, and ethanol. There are several main concerns with VOCs. First, VOCs contribute to pollution outside by reacting with sunlight to form ground-level ozone, a major component of smog. Second, VOCs' effect on indoor pollution is even worse — the Environmental Protection Agency's total exposure assessment methodology (TEAM) studies have found indoor levels of common organic compounds to be two to five times higher than those found outside. Third, producing many of the binders and solvents in wood finishes creates significant amounts of hazardous wastes. If leftovers are discarded into the trash, they contribute to air pollution. When poured down the drain, they contribute to water pollution and clog your sinks and water pipes in the process. And finally, petroleum-based finishes (like most wood finishes) contribute to the depletion of this non-renewable resource and increase our nation's dependence on imported oil.

While some building products now report the parts per million of VOCs on labels, this information can be misleading. Fewer parts per million is certainly better, but chemicals like dioxin are not safe in any detectable amount.

VOCs and Offgasing

VOCs are characterized by the fact that they release vapors at room temperature. The easiest example to understand would be the application of interior house paint. When you open the can of paint and get out the brush to begin, the paint is wet and in a liquid form. You apply the wet paint and several hours later, the paint is dry. During the drying period, the volatile solvent in the paint vaporizes to a gas, known as "offgasing," leaving the non-volatile portion of the paint on the wall, and dry. Most VOCs are released into the air during this offgasing period. You should open windows and use fans to move the VOCs out of your indoor air as quickly as possible. Turning up the heat also makes the paint dry and offgas faster. The rate of offgasing dissipates dramatically within a few days. However, the paint may continue to offgas small amounts for the lifetime of the paint, especially as the paint begins to age and chip small flecks of paint that can become trapped in your rug. It is best to avoid VOCs altogether when you are buying paints or any other products for your home.

Formaldehyde

Another one of the more lethal VOCs in the home is formaldehyde. It comes primarily from the adhesives in pressed wood products, such as particleboard, hardwood paneling, and medium density fiberboard. It is also found in urea formaldehyde foam insulation (UFFI), combustion sources, environmental tobacco smoke, durable press drapes, some other textiles, and glues. Building materials can offgas formaldehyde for five or more years following manufacture. The amount of formaldehyde released from building materials increases as temperature increases — for example, during the winter when indoor heaters are on and there is little ventilation from windows.

Several studies have shown that a significant portion of the public is exposed to formaldehyde at levels high enough to produce symptoms such as eye, throat, and nose irritation; wheezing and coughing; fatigue; skin rash; and severe allergic reactions. Symptoms have occurred at levels as low as 0.05 parts per million — the level that has been proposed as the California indoor air quality standard.[115] Over time, some people develop heightened sensitivities to formaldehyde — in other words, once a person is exposed, even minute exposures to formaldehyde can induce health problems.

The long-term effects of prolonged exposure to low levels of formaldehyde — levels typically found in mobile homes or energy-conserving buildings — are controversial. Still, the EPA has concluded that formaldehyde is a probable human carcinogen on the basis of experimental studies and human epidemiological studies and laboratory tests. In the human epidemiological studies, they found increased incidence of brain tumors, leukemia, and cirrhosis of the liver among workers exposed to formaldehyde. Laboratory studies indicate that formaldehyde causes nasal cancer in rats and that it appears to cause mutations in bacteria, yeasts, fruit flies, and mammalian and human cells.[116]

To reduce your exposure in the home, keep in mind that medium-density fiberboard emits about three times more formaldehyde than particleboard. And plywood, although made with a formaldehyde resin, is preferable to particleboard. Also, exterior grade plywood emits less than interior grade. "Swedish" hardwood floor finish is notorious for high formaldehyde emissions: it is banned in Sweden and many other areas.[117] The best option is to choose pre-finished solid wood flooring or use water-based finishes.

In addition, use air conditioning and dehumidifiers to maintain a moderate temperature and reduce humidity levels. Insist on carpet or carpet pad with little or no formaldehyde content. Also, apply surface barriers (such as low-VOC latex paints and primers) to particleboard or plywood to reduce offgassing. These vapor barriers can reduce formaldehyde emissions by up to 95 percent, but tend to break down after several years and require reapplication. Foil tape can seal the edges and keep fumes from escaping.

Finally, open the windows! This is particularly important after bringing new sources of formaldehyde into the home. Consumer advocate Debra Dadd also recommends spider plants to absorb formaldehyde: "You'll need about 70 Chlorophytum elatum (spider plants) in one-gallon containers to purify the air in an average 1,800-square-foot energy-efficient home (a veritable jungle!), but don't be overwhelmed."

Pesticides

Although some pesticides may technically be considered VOCs, these often odorless and invisible substances have become such a health threat that they warrant a separate discussion. According to the World Health Organization, more than 3 million people get sick, and 220,000 die worldwide from pesticides each year. In the United States alone, pesticides poison 110,000 people each year. More than one-third of calls to animal poison control centers result from pets exposed to pesticides.

Pesticide Facts

- The pesticides and VOCs found indoors are believed to cause 3,000 cases of cancer a year in the US, making these substances just as threatening to nonsmokers as radon or second-hand tobacco smoke.[11]
- A National Cancer Institute study indicated that the likelihood of a child contracting leukemia was more than six times greater in households where herbicides were used for lawn care.[12]
- According to a report in *The American Journal of Epidemiology*, more children with brain tumors and other cancers were found to have had exposure to insecticides than were children without cancer.[13]
- According to the New York State Attorney General's office, 95 percent of the pesticides used on residential lawns are considered probable carcinogens by the EPA.[14]
- 2,4-D — a component of Agent Orange — is used in about 1,500 lawn care products.[15]
- Pesticides have been linked to the alarming rise in the rate of breast cancer.[16]
- Besides causing cancer, pesticides have the potential to cause infertility, birth defects, learning disorders, neurological disorders, allergies, and multiple chemical sensitivities, among other disorders of the immune system.

Pesticides, or biocides, are poisons designed to kill a variety of plants and animals such as insects (insecticides), weeds (herbicides), and mold or fungus (fungicides). Although pesticides were first developed as offshoots of nerve gas during World War II, many people falsely assume pesticide ingredients are now safe for humans. Would pesticides be on the market if they were unsafe? *Yes*. The US EPA approves pesticides based on efficacy, not safety. Out of the hundreds of active ingredients registered with the EPA, less than a dozen have been adequately tested for safety.[17] In two studies of indoor air quality conducted during the late 1980s, investigators found that indoor air contained at least five (but typically ten or more) times higher concentrations of pesticides than outside air.[18]

Pesticides can be absorbed through the skin, inhaled, or swallowed. Many building products and household furnishings such as paints, wood products, and carpets are treated with biocides. Carpets are especially hazardous; if you have kids, you know that infants and small children are likely to touch and crawl around on them. Also, people and pets may track pesticides into the house from the lawn or even the neighbor's lawn, allowing the toxins to become trapped in carpets. Pesticides that break down within days outdoors may last for years in carpets, where they are protected from the degradation caused by sunlight and bacteria. For example, the pesticide DDT (dichlorodiphenyltrichloroethane), was

Understanding Product Labeling

The following are important areas of a product's label:

- **EPA Registration Number**: This number is your assurance that the product has been approved by the US Environmental Protection Agency.
- **Directions**: Follow these carefully!
- **Precautions**: There are three types. "Danger — Poison" is extremely toxic in the form found in the container. "Warning" is less toxic to humans, but you should use extreme care when applying. Finally, "Caution" is the least harmful when you use it as directed.
- **Statement of Practical Treatment**: This includes information about first aid.
- **Classification Statement**: Tells the customer if the product needs a license to be used.
- **Storage Tips**: Always keep products in the original container; do not stockpile. Keep out of reach of children. Store flammable liquids outside your living area; do not store near food or medical supplies, where flooding is possible, or in places where spills could leak into your water supply. It is best to store products in an outside, locked cabinet.

outlawed in the US in 1972 because of its toxicity, yet researchers found that 90 of 362 homes they examined in the Midwest between 1992 and 1993 had DDT in the carpets.[19]

To avoid being exposed to harmful pesticides while remodeling your home, learn to understand the labels on products you buy. You can also reduce pesticide exposure by not treating the soil under the building, and by eliminating standard building products that contain biocides. A well-renovated home will be pest-resistant if it incorporates features like weather tightness; appropriate grading and drainage; ventilation fans and windows that allow cross ventilation to prevent excess moisture buildup from within; dry wood without rot or infestation; exterior wood treated appropriately for prevailing climatic conditions; screens on windows; and ground cover, leaves, chips, wood piles, and other potential insect habitats kept at a distance from the building. If a pest must be eliminated, first see if its current access to nourishment and habitat can be limited. For example, if you have ants, you might clean up crumbs from the floor and counters and caulk the cracks. Second, consider the most benign trapping or killing methods — use the least toxic chemicals you can find, and then only as a last resort!

> *"My father had built an office for himself in the basement of our house that was totally enclosed, without any windows or venting. So I put the radon detecting canister in his office and found that it was off the charts. My father died of small cell carcinoma, the type caused by radon. And I remembered that after working a whole day in the office, he would come home and go to his little office in the basement and do his bookkeeping for many hours, day after day. So the radon exposure was a contributing factor to his ultimate death. Even though I was not able to save my dad, I can hopefully save other lives through promoting awareness of how we live in the midst of all different types of health dangers."*
>
> **Claudine Schneider, former Congresswoman**

Vinyl Chloride

Vinyl chloride is a widely produced chemical VOC used to make polyvinyl chloride resin, which is the raw ingredient of polyvinyl chloride (PVC) plastic. Vinyl chloride is a colorless gas with a characteristic "plastic" odor. It is widely distributed throughout the industrialized world and can be found in municipal drinking waters, #3 plastics, PVC pipes, vinyl flooring, adhesives, swimming pools, upholstery, and wall coverings in your home.

As dramatized in the movie "Blue Vinyl," acute exposure to vinyl chloride can induce the feelings of intoxication, dizziness, weakness, and lightheadedness that many kids are drawn to for the same reasons people are enticed by alcohol and other drugs. These symptoms rapidly disappear when exposure is stopped. However, long-term exposure to vinyl chloride can cause cancer, birth defects, genetic changes, indigestion, chronic bronchitis, ulcers, skin diseases, deafness, vision failure, circulatory changes, and liver dysfunction.[47]

Although many plastics are potentially dangerous, some seem to be relatively safe alternatives to vinyl chloride. For example, melamine formaldehyde plastics, such as Formica™ countertops, are relatively inert. You can also avoid PVC in plastics; instead, use natural materials, like wood and glass.

Radioactive Contaminants

The EPA estimates that 15,000 lung cancer deaths each year in the United States are due to radon exposure, which makes it the second leading cause of lung cancer in the United States after smoking. Smokers have an even higher risk of developing radon-induced cancer; in fact, many smoking statistics may be caused by the combination of

The Environmental Protection Agency estimates that one of every 15 homes in the United States has indoor radon levels at or above the EPA's recommended action guideline level of four picocuries per liter (pCi/L) of air.

Table 5.5: Know Your Plastics

Not all plastics are equal — some are safer than others. Plastics are typically classified by one of seven recycling codes (found on the bottom of containers), indicating the type of resin used.

#	Name	Where It's Found	Good or Bad?
1	**Polyethylene terephthalate (PET or PETE)**	Used to make soft drink, water, sports drink, ketchup, and salad dressing bottles, and peanut butter, pickle, jelly, and jam jars.	**Good** • Not known to leach any chemicals that are suspected of causing cancer or disrupting hormones. • Widely recycled.
2	**High density polyethylene (HDPE)**	Milk, water and juice bottles, yogurt and margarine tubs, cereal box liners, and grocery, trash, and retail bags.	**Good** • Not known to leach any chemicals that are suspected of causing cancer or disrupting hormones. • Widely recycled.
3	**Polyvinyl chloride (V or PVC)**	Most cling-wrapped meats, cheeses, and other foods sold in delicatessens and groceries are wrapped in PVC.	**Bad** • To soften into its flexible form, manufacturers add "plasticizers" during production. Traces of these chemicals can leach out of PVC when in contact with foods. • According to National Institutes of Health, di-2-ehtylhexyl phthalate (DEHP), commonly found in PVC, is a suspected human carcinogen. • Not recyclable.
4	**Low density polyethylene (LDPE)**	Some bread and frozen food bags and squeezable bottles.	**OK** • Not known to leach any chemicals that are suspected of causing cancer or disrupting hormones. • Not as widely recycled as #1 or #2.
5	**Polypropylene (PP)**	Some ketchup bottles and yogurt and margarine tubs.	**OK** • Hazardous during production, but not known to leach any chemicals that are suspected of causing cancer or disrupting hormones. • Not as widely recycled as #1 or #2.

continued

Table 5.5: Know Your Plastics – continued:

Not all plastics are equal—some are safer than others. Plastics are typically classified by one of seven recycling codes (found on the bottom of containers), indicating the type of resin used:

#	Name	Where It's Found	Good or Bad?
6	Polystyrene (PS)	Foam insulation and also for hard applications (e.g., cups, some toys).	**Bad** • Benzene (material used in production) is a known human carcinogen. • Butadiene and styrene (the basic building block of the plastic) are suspected carcinogens. • Energy-intensive. • Poor recycling.
7	Other (usually polycarbonate)	Baby bottles, microwave ovenware, eating utensils, plastic coating for metal cans.	**Bad** • Made with bisphenol-A, a chemical invented in the 1930s in search for synthetic estrogens. A hormone distruptor. Simulates the action of estrogen when tested in human breast cancer studies. • Can leach into food as product ages.

Source: The Green Guide. Plastics for Kitchen Use [online]. [Cited October 29, 2003]. The Green Guide Institute, 2003. <www.thegreenguide.com/reports/product.mhtml?id=44&sec=2>.

exposure to radon and smoking. The main risk is not from the radon itself, but from radon's "progency," or "decay products," which directly or by attaching to airborne particles may be inhaled into the lungs.

This invisible radioactive gas seeps up into homes through the earth. Its points of entry include floor drains and sumps, joints where the basement wall and floor come together, cracks in the basement walls and floors, holes in the foundation wall for piping or wiring, exposed earth or rock surfaces in the basement, or well water. It is a breakdown product from uranium-238, which occurs naturally in the subsoil. Although it is harmless when it is outside, inside our homes the gas and its decay products can build up to high levels and when inhaled can cause lung cancer. Energy-efficient, tightly sealed homes are especially vulnerable to this

accumulation of radon. And because it takes 1,602 years for only half of the radon atoms to disintegrate, radon concentrations tend to become higher as time goes by.

The EPA and the Surgeon General recommend that all homes test their radon levels below the third floor. In the US, the average indoor radon level is 1.3 picocuries per liter (pCi/L), while average outdoor levels are only 0.4 picocuries per liter. The EPA suggests that action be taken to increase ventilation if tests result in a radon level above 4 picocuries per liter. When looking for a radon test kit or mitigation professional, make sure you choose one that is certified by either the National Environmental Health Association (NEHA) or the National Radon Safety Board (NRSB).

If you are adding on to your home, ask your remodeler about methods of radon mitigation that can be incorporated into the construction. For example, you might place an airtight membrane under carpets, or provide some form of under-slab ventilation. Additionally, consider covering any exposed earth with a polyethylene air barrier, and seal all cracks and joints in the foundation wall and floor slab with caulking or foam. You can also install a self-priming drain or gas trap in the floor drains leading to a sump or to drainage tiles, and remove radon from well water using activated charcoal filters or aeration units. Radon-resistant construction features usually keep radon levels in new homes below 2 picocuries per liter.

Environmental Tobacco Smoke

Environmental tobacco smoke (ETS), also known as secondhand or passive smoke, is the smoke that comes from a burning cigarette, pipe, or cigar, as well as smoke exhaled from the lungs of smokers. ETS is a mixture of over 4,000 chemicals, 200 of which are known poisons, and more than 50 known cancer-causing agents. There is no safe level of exposure to ETS; every year, smoking-related diseases claim approxi-mately 430,700 lives in the U.S.[19]

The best way to deal with ETS is to stop smoking in the house. Otherwise, you can create a separate smoking room, with its own ventilation and air seals to keep the smoke from spreading

In the United States alone, secondhand smoke has been esti
to cause about 35,000 deaths per year from heart dise
nonsmokers, and about 3,000 deaths each year from lung can
nonsmokers. Secondhand smoke is responsible for 150,
300,000 lower respiratory tract infections (i.e., bronchitis
pneumonia) in children under 18 months of age. This result
7,500–15,000 hospitalizations each year.

Source: American Lung Association. "When You Smoke, Your Fa
Smokes!" <www.lungusa.org>, October 1, 20

Table 5.6: Signs of Too Much or Too Little Humidity

	Too Much Humidity	*Too Little Humidity*
Typical Symptoms	Condensation on windows Wet stains on walls and ceilings Moldy bathroom Musty smells Allergic reactions	Chapped skin and lips Scratchy nose and throat Breathing problems Static and sparks Problems with electronic equipment
Long-Term Effects	Damage to house and contents Ongoing allergies	Continuing discomfort Damage to furniture and other items

through the house. An effective ventilation system should supply outside air and incorporate a particulate filter.

Moisture and Mold

Moisture may not be a pollutant, but high or low humidity in a house can make you feel uncomfortable, and can even cause health problems. High moisture levels create a welcoming environment for bacteria, viruses, molds, and dust mites, increases offgassing, and can cause a room to feel stuffy. On the other hand, low moisture levels can cause high dust levels and respiratory infections.

One of the most dangerous effects of high moisture in the home is mold. Molds and mildew (two words for the same thing), are simple plants of the group known as fungi. They grow on the surfaces of objects when the relative humidity, or degree of moisture contained in the air, is high. Mold is commonly assumed to be found only in older homes, but it can be found wherever moisture accumulates, such as basements, kitchens, bathrooms, window sills, carpets, furniture against outside walls, wall cavities, unventilated storage areas, laundry rooms, or wherever leaks and flooding occur. One study showed 16 different kinds of mold in one finished basement.[19] As a general rule of thumb, if you can see it or smell it, you have mold.

And mold spreads! Microbes commonly grow within the ductwork of forced air heating systems, which can result in the spreading of mold and dust

What is Relative Humidity?

Relative humidity is a measure of the amount of water in the air compared with the amount of water the air can hold at the temperature it happens to be when you measure it. (We typically measure relative humidity in metric.) For example, at 30 degrees Celsius, the air can hold 30 grams of water vapor per cubic meter of air. At 10 degrees C, the air can hold 9 grams of water vapor per cubic meter of air. These are basic physical facts at sea level pressure. Let's say at 3 P.M. the air's temperature is 30 degrees and the air has 9 grams of water vapor per cubic meter of air (you can measure water vapor in your home using a device called a hygrometer). To calculate relative humidity, we divide 9 (water vapor in air) by 30 (temperature) and multiply by 100 (percentage rate) to get 30 percent relative humidity. If it were 9 degrees outside, we'd get a relative humidity of 100 percent, because 9 (water vapor in air) divided by 9 (temperature) multiplied by 100 is 100 — the air now has as much vapor as it can hold without condensing into liquid water. In your home, it is best to keep relative humidity below 50 percent.

throughout the house. Unless kept spotlessly clean, toilets and many modern appliances that use water reservoirs, such as vaporizers and humidifiers, can breed microbes. Many standard construction materials are susceptible to water damage and fungal growth: they can become breeding grounds for mold and bacteria within a few days. Even when molds are contained inside walls or other building cavities such as attics or crawlspaces, the slightest air current can send fungal spores swirling through the air where they are easily inhaled.

Once inhaled, mold produces allergic reactions, hypersensitivity, and infectious diseases. Certain fungi found indoors produce mycotoxins, which can be carcinogenic, teratogenic (induces birth defects), immuno-suppressive (reduces immune system performance) or oxygenic (poisons tissues). In addition to health issues, mold discolors surfaces, causes odor problems, deterioration of building materials, and homeowners can incur large bills for structural damage caused by water or water vapor trapped behind walls.

You may have mold if...

- You see mold or discoloration, ranging from white to orange and from green to brown or black.
- You smell a musty odor.
- There is condensation on your windows.
- Building materials, such as drywall and plaster or plywood, look cracked or discolored in areas where previous water damage occurred.
- You see loosened drywall tape.
- You see rotting material, such as warping wood.

Getting Rid of Mold

Once you have identified mold, you can get rid of it by following these steps:

- Wash the area with soap and water.
- Disinfect the area with a solution made up of ten percent household bleach and a little detergent (the detergent will help with the dirt and oil on the surface and act as a surfactant to help thoroughly wet all surfaces).
- Clean and disinfect area quickly — mold grows within one to two days.
- Let cleaned area dry overnight.
- Remove materials affected by mold, especially porous materials such as sheetrock, carpeting, and plywood.
- Bag and discard the materials at the work area rather than potentially spreading contaminants throughout the home.
- Wear gloves and high quality respiratory protection when cleaning areas affected by mold growth and when removing damaged materials.
- Provide continuous and controlled ventilation in the work area, with slightly more negative pressure in the contaminated area so that air flows from clean to dirty areas

Although the above cleaning methods will temporarily get rid of mold of your home, there are two ways to prevent mold from forming again. First, keep the interior surfaces of exterior walls and other building assemblies from becoming too cold (think of condensation on a cold soda can). Air conditioners tend to cool particular spots on a wall, resulting in mold growth where humid air enters the wall cavity. Impermeable wall surfaces, such as vinyl wallpaper, can exacerbate the problem by further trapping natural moisture flow. Therefore, you should prevent the overcooling of rooms, increase the permeability of interior finish materials in humid climates, and relocate ducts and diffusers to elevate the temperature of the surface. Adding insulation to walls, ceilings, ducts, or cold water pipes also raises the temperature of the interior surface and prevents condensation. Air-vapor barriers can be used to keep wall cavities warmer and drier, and two-stud corners reduce heat loss and condensation at corners.

The other way to control mold growth is by limiting interior moisture levels. Install a balanced, whole-house ventilation system that controls moisture by bringing in drier outside air where and when possible. Controlled ventilation, such as venting moist air from bathrooms, clothes dryers, and kitchen stoves, and space heaters to the outside can significantly reduce mold issues in these areas. Also, it helps to store firewood outdoors — storage of one cord of green firewood

indoors over the winter can produce the same amount of moisture as does a family of four through respiration!

Your air conditioner acts as a dehumidifier after it runs for about eight minutes. Use this to control relative humidity on an ongoing basis, Install your hygrometer right next to your thermostat to constantly monitor your home.

Some people use dehumidification to remove moisture from a space; the dehumidifier warms the moisture-laden air to reduce its ability to hold moisture, thereby forcing moisture to condense. This can be helpful in the short term, but you should also control moisture sources to limit interior moisture levels. In other words, fix basement plumbing and leaks, avoid porous absorbent material like cardboard or newspaper in the basement, use and remove carpets and rugs from cold floors, and remove obstacles obstructing air flow in damp areas that can give molds a place to grow.

Consider using a hygrometer to monitor humidity levels, to help you maintain a healthy 30 to 55 percent humidity. If you find moisture levels are too low, you can counter the low humidity by reducing ventilation or you can use a humidifier, cleaning it often and monitoring the humidity level.

Now that you understand how your home's renovation impacts world energy, world resources, and the health of you and your family, you have a solid background for changing the world, one room at a time....

... One Room at a Time

SO YOU WANT AN EFFICIENT, resourceful, healthy kitchen that will change the world? We'll help you. We've divided this chapter into a room-by-room survey to give you an overview of the stages of the building process for each particular remodeling project — so you can make connections to our more in-depth coverage of specific green features in later chapters.

Keep in mind that, underlying this simple format, we are still considering the house as a whole. In other words, the addition of a large bathtub might add 1,200 pounds to the load capacity of the floor, which will require additional structural support — and this in turn will have an effect on such things as adjoining walls or pipes that service the entire house.

The descriptions of remodeling for each room are by no means complete: there are always more innovative ideas that can be applied to specific situations and, as technology improves, new ways to save energy and resources, improve air quality, and so on. Use the room descriptions as a guide for discussion with your architect and contractor, and refer to the checklist at the end of each description to locate more information on specific features. Always keep an open mind to new ideas — and choose whatever works best for your renovation project.

The Bathroom

Most people renovate their bathroom to upgrade old fixtures and, in the course of remodeling, find they need to repair water damage. As discussed in Chapter 5, excess moisture not only causes house materials to rot, but can also result in serious health issues. We'll show you ways to control bathroom moisture that will result in improved comfort, better air quality, and lower utility bills. We will also discuss other important bathroom remodeling issues, including low-impact construction and water- and electricity-saving strategies.

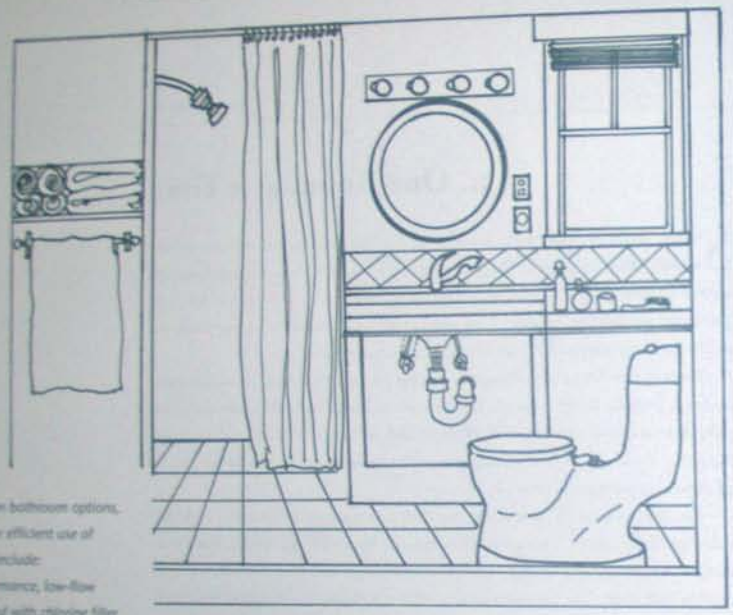


Fig. 6.1: Green bathroom options, remodeled for efficient use of space could include:
- high-performance, low-flow shower head with chlorine filter
- compact fluorescent bulbs
- lighting controls
- windows that open
- landscaping for shade
- greater natural daylight
- upgraded single pane windows
- water filters
- low-flow faucets
- insulated plumbing & pipes
- solvent free adhesives
- low-flow or greywater flushing toilet

Credit: Jill Harris & Kim Master

Job Site and Landscaping

As you plan for your bathroom remodel, try to build with as little impact as possible. This means recycling job site waste and salvaging reusable materials. That avocado green sink may look hideous to you, but could be someone else's treasure. In fact, maybe you want an avocado green sink that someone donated or could use the sink you are replacing in a second bathroom — be resourceful when looking for replacement bathroom features! Old lumber, door and window casings, and baseboards can all be reused when they are removed carefully. When reusing old materials is not possible, some companies can recycle them. For example, porcelain toilets and other ceramics can be recycled into concrete, and metal bathtubs can be used for making steel. Contact your local waste management authority for recycling information specific to your neighborhood.

Structural Framing

If you want to change the size or shape of your bathroom, this will probably entail taking down walls. Some walls you can demolish yourself, depending on the type of wall. Load-bearing walls — the walls that literally hold up the house — can be altered, but this requires new structural support in the form of a beam supported by posts on either side of the room. In addition, temporary wood frame walls will be needed to support the structure above until the new wall is in place. This work can be intensive, and is best completed by a professional. However, you can easily cut into or tear down non-bearing walls yourself without damaging the adjacent structures. You still need to be on the lookout for plumbing leaks — even if you have a professional work on the project, he could inadvertently break a pipe and cause a leak, or cut live electrical wires. Look for obstacles ahead of time to avoid unnecessary expenses and hardship.

Opening walls in your bathroom is a great opportunity to redo bad wiring or plumbing. You can also replace any rotted or damaged wood, repair leaks that have gone unnoticed, check to see if you have adequate insulation in the exterior walls, and caulk cracks in the structure so that air doesn't leak through.

Plumbing

First, look at what kind of pipes you have. If your home was built before 1950, you may have lead pipes that should be replaced! Otherwise, cast iron, steel or plastic drainpipes are adequate, as are copper, brass, and steel. Polyvinyl chloride (PVC) pipes can also be used; although the PVC manufacturing process produces toxins, the pipes are durable and affordable, and won't need to be replaced for a long time. Second, if you've opened up bathroom walls, consider moving the plumbing from outside walls to interior walls where heat from your home will keep the pipes warmer. Insulating the hot water pipes will further reduce heat loss through the piping.

To save water, add an "on-demand" hot water circulation pump that can send hot water to fixtures in seconds without wasting water while you wait for it to get hot. Some jurisdictions allow households to use greywater (all waste water except toilet water) for outdoor watering use or as toilet-flushing water. Although you need to be especially careful what you put down the drains, this will dramatically reduce water use around your home. If this is not currently allowed in your neighborhood or is too costly, you may consider "pre-plumbing" while the walls

are open during renovation — installing the plumbing necessary for later greywater use to make this retrofit easier and less costly in the future.

When buying a new toilet, look for models with less than 1.6 gpf (gallons per flush). Likewise, look for low-flow bathroom faucets and showerheads that produce an adequate flow but use 60 percent less water by combining the water with air pressure. This not only decreases your water consumption, but also lowers your water bill and reduces your impact on the local water treatment system. If you buy a large whirlpool tub, make sure you have it installed before new framing makes it difficult to fit the tub in the bathroom. You may have to add an additional water heater to fill the tub entirely. This is a great time to install a tankless unit. (See Chapter 17 for more on tankless water heaters.)

Additionally, faucets and showers can be equipped with filters to make your water safer to drink and less irritating for sensitive individuals to bathe in. Carbon filters are an inexpensive option for most people who desire cleaner-tasting water. Chlorine can be an issue if you suffer from eczema or have sensitive skin, in which case you may want to purchase an additional carbon filter for your showerhead.

Electrical

Bathrooms may be small, but they need good overall lighting and task lighting for washing, shaving, and applying makeup. Incandescent bulbs are standard for home lighting but they waste a lot of energy. Fluorescent tubes and compact fluorescent bulbs are significantly more energy-efficient for general and vanity lighting. Fluorescent lighting has improved vastly over the past decade — it is now available in flattering light (as opposed to the older cool, bluish color), and with dimming options that enable you reduce the light energy output. Compact fluorescent bulbs are similarly effective for task lighting. Although fluorescent bulbs cost more initially, you'll definitely save money on your electric bills and replacement bulb costs over time.

Another option for recessed or indirect lights is halogen lighting. These produce as much light as incandescent lights but use half the power. Use halogens for mood lighting and to light specific features, like glass block. While you are in the walls it is a good opportunity to wire for music for that perfect night with candles and bubble bath....

Keep in mind that lights over showers or other wet areas need a waterproof housing. Also, it saves energy to wire different lights to different switches so that you can turn on only the lights you need in the bathroom at a given time.

Radiant electrical panels are wonderful for when you're sitting in the tub or while you're drying off. They can be mounted on a wall or ceiling, and they heat you rather than the air. They can be put on a timer or controlled with a switch (see "Install Zoned, Hydronic, Radiant Heating" in Chapter 16).

If you are doing serious rewiring, put in a separate circuit for electrical devices. A hair dryer alone can use up most of a circuit's capacity. Add extra "his and hers" plugs.

Insulation

As we mentioned briefly in the above framing section, renovating your bathroom is a great time to upgrade your insulation, because the walls are already open. The bathroom is where you want to stay the warmest. If possible, add new insulation in the form of rigid foam board on the inside of the framing. Insulating just to code doesn't mean that it will keep you comfortable when you are wet in cold winter months; how much insulation you need also depends on your climate. Check the existing insulation to see how thick it is, and if it is evenly distributed so that heat does not escape through gaps. Also check for water damage or compaction, which can reduce the effectiveness of insulation. (Water damage can take the form of blackened wood — a sign of mold or rot — or obvious water marks.) When installing new insulation, fill the area around the tub: this helps keep drafts down and the tub warm. The most efficient, resourceful, and safe types of insulation include recycled-content fiberglass, and cellulose insulation. Make sure the insulation stays dry after it is installed; water vapor inside the wall can condense when it meets cool outer layers, causing rot and harmful mold growth. A vapor barrier installed on the warm side of the insulation can also prevent moisture from getting into the floor, ceiling, or walls.

Always use advanced infiltration reduction practices to further save energy in leak-prone areas. This includes using a low-toxic sealant around plumbing fixtures, such as the hole in the subfloor around the tub drain, and use rubber gaskets behind electrical outlets. The trap under the tub should be sealed well too, since the plumbing pipes go all the way down to the ground, and it is a typical place for drafts to occur.

Take precautions when removing paint from windows!

According to the EPA, painted window sashes and frames in homes built before 1978 may contain lead-based paint. This is a special concern because the friction of opening and closing windows can release lead dust into the home. (See "Lead" in Appendix 1.)

Energy

Windows in bathrooms are important for many reasons. First, bathrooms without any windows at all are illegal in many jurisdictions because the windows provide necessary ventilation. Second, a large window can make the room brighter, resulting in proven mood-uplifting effects.[1] Third, leaky windows can waste a lot of energy, therefore efficient double-paned windows with reflective or low-emissivity film can effectively keep unwanted heat or cold outside your bathroom. Try not to put the window directly over the bath or in the shower area. This can can cause condensation problems when the steam hits the cool window surface. Vinyl or fiberglass window frames will also minimize the potential for condensation damage, and are a better option than wood or aluminum. Other options include well-insulated skylights or a smaller, more efficient solar tube that effectively brings light in through a reflective pipe.

Heating, Ventilation, and Air Conditioning (HVAC)

Fixing up an existing bathroom generally does not require changing air registers, radiators, or baseboard heaters — usually it can simply be "retuned" by a heating contractor. A new bathroom, however, will require an extra heat register or radiator installed by a professional, usually with no extra strain on the heating system. Make sure the workers use duct mastic on duct joints rather than less-effective duct tape. The new ductwork should be installed in conditioned (or insulated) walls rather than in walls facing the outside of your home, where energy can more easily escape from the pipes.

Ventilation requirements are usually stipulated in the building code for each jurisdiction. Often the code will state that you need to have either an operable window or a fan to get rid of unwanted moisture caused by showering and bathing. We recommend that a fan be installed in any case — you don't want to open a window in the winter! The fan should be energy-efficient and should be vented to the outside. Most people prefer quiet fans under two "sones" — when they are quiet they tend to get used more often. If extensive HVAC work is being considered, keep in mind that a heat recovery ventilator (HRV) can transfer heat from outgoing bathroom exhaust air to warm the incoming fresh air for the entire house.

Water Heating

If the current water heater is old or if you'll be using a lot more water because of a new whirlpool bath, you'll need an upgrade, such as a more efficient water heater with an energy factor (EF) of .60 or higher. Tankless water heaters are a more expensive option, but they save water, energy, and petroleum resources by heating water as it is needed. Installing a heat trap will help minimize water heat loss by preventing thermosiphoning. (See "Upgrading Your Water Heater" in Chapter 17.) If you decide to keep your existing water heater, consider an insulating jacket that works like a winter coat to keep heat in. It costs only about $10 to $20 and reduces heat lost through the tank by 25 to 40 percent.[2]

Interior Materials/Finishes

Bathroom finishes should be attractive, water-resistant, and healthy. Some people use wallpaper, but we do not recommend this option because moisture can get behind the paper (especially vinyl wallpaper), and cause mold growth. Also, avoid using particleboard and medium-density fiberboard (MDF) in cabinets and substrates under counter tops. Choose exterior-grade plywood or a formaldehyde-free alternative (see "Formaldehyde" in Chapter 5). If you do use particleboard or MDF, use a low-toxic sealant, such as water-based, low-VOC paint to keep the unwanted vapors trapped in the material.

Solid wood can be a healthy alternative. The best woods to use are Forest Stewardship Council (FSC)-certified with a low-VOC, water-based wood finish. Sustainably harvested FSC wood is also available for trim material. If you decide to paint the finish, use a hard wearing, washable, low- or no-VOC and formaldehyde-free paint that minimizes indoor air pollution.

Ceramic tiles are a popular finish because they are water-resistant, washable, and don't need a painted finish. Look for a low-toxic grout to fill the areas between the tiles. Natural stone, like marble or slate, is a more expensive option, but is extremely water-resistant and is a healthy, beautiful element to add around showers, tubs, or other areas of the room. Like ceramic tile, stone is a durable material that will save resources and energy because it will rarely need replacing. For all bathroom materials, select low-VOC adhesives and sealers when they are required to minimize toxins in your indoor environment.

Flooring, like other bathroom finishes, should be durable, water-resistant, and washable. We do not recommend carpeting — it traps dirt and moisture that leads

Volatile Organic Compounds (VOCs)

VOCs are a class of chemical compounds that can cause nausea, tremors, headaches, and, some doctors believe, longer-lasting harm. VOCs can be emitted by oil-based paints, solvent-based finishes, and other products on or in construction materials.

to unhealthy mold growth. Use small, washable rugs for softer surfaces in specific areas of the bathroom. The best flooring options are hard or smooth surfaces, recycled-content ceramic tile, and natural linoleum. Ceramic floor tiles, larger and thicker than walls tiles, are easily cleaned and long-lived. Some floor tiles are made from stone. Dense or vitreous tiles are the most moisture-resistant. Tiles should be installed with low-toxic grout and adhesive when possible.

Natural linoleum is the preferred alternative to vinyl. Although similar in appearance to vinyl, natural linoleum is made from natural materials including linseed oil, jute, and wood dust. It is durable, available in a variety of patterns and colors, and can be installed without toxic adhesives.

The Kitchen

Redoing the kitchen is the number one renovation project. We spend a lot time there, cooking, eating, or just lounging around, so it might as well be the best room in the house. Fixing up the kitchen also has a tremendous impact on the resale value of your home, and can be a great investment. Like the other rooms in this chapter, we will divide our discussion of the kitchen into the generic categories basic to remodeling projects (site, plumbing, electrical, etc.) and emphasize an important upgrade for the kitchen when considering energy use — appliances.

Job Site and Landscaping

It is always a good idea to try to reuse materials in the kitchen, from countertops and ceramic dishware to flooring and appliances. Check your regional waste management authority to find out who can use the materials you don't want. If a material can be reused, look into recycling it; construction materials, glass, fluorescent light bulbs, telephones, sinks, and appliances can all be recycled.

As you're designing your kitchen, think about creating a space that won't have to be remodeled again, thereby saving energy and resources in the future. You should be able to move around three key cooking areas — the stove, the sink, and the refrigerator — easily. Consider adding features that allow you to do more than

Bathroom Checklist

Job Site and Landscaping (see Chapter 7)
- ❑ Reuse construction and deconstruction waste.
- ❑ Recycle job site waste.

Structural Framing (See Chapter 9)
- ❑ Use advanced framing techniques (AFT).

Plumbing (See Chapter 12)
- ❑ Insulate pipes.
- ❑ Remove plumbing from outside walls.
- ❑ Install on-demand hot water circulation pump.
- ❑ Install low-flush toilets.
- ❑ Consider greywater flushing.
- ❑ Install high-performance showerheads.
- ❑ Install low-flow faucets.
- ❑ Investigate your water supply.
- ❑ Install chlorine filters on shower heads
- ❑ Install activated carbon filters.
- ❑ Install water distillers.
- ❑ Install a reverse osmosis system.

Electrical (See Chapter 13)
- ❑ Install compact fluorescent light (CFL) bulbs.
- ❑ Install halogen lighting.
- ❑ Install lighting controls.
- ❑ Install sealed or airtight IC recessed lighting.

Insulation (See Chapter 14)
- ❑ Use formaldehyde-free, recycled-content fiberglass insulation.
- ❑ Use cellulose insulation.
- ❑ Caulk, seal, and weatherstrip.
- ❑ Increase insulation thickness.

Solar Energy (See Chapter 15)
- ❑ Install double-paned windows.
- ❑ Install low-e (low-emissivity) windows.
- ❑ Incorporate natural light.

Heating, Ventilation, and Air Conditioning (HVAC) (See Chapter 16)
- ❑ Use duct mastic or Aeroseal™ instead of duct tape.
- ❑ Install ductwork within the conditioned space.
- ❑ Install operable windows for natural ventilation.
- ❑ Install a bathroom exhaust fan.
- ❑ Install a heat recovery ventilator (HRV).

Water Heating (See Chapter 17)
- ❑ Consider a tankless water heater.
- ❑ Use the smallest water heater possible.
- ❑ Install hot water jacket insulation.
- ❑ Install heat traps.

Interior Materials/Finishes (See Chapter 19)
- ❑ Use formaldehyde-free materials.
- ❑ Seal all exposed particleboard or MDF.
- ❑ Use rapidly renewable flooring materials.
- ❑ Use recycled-content tile.
- ❑ Replace vinyl flooring with natural linoleum.
- ❑ Use low- or no-VOC and formaldehyde-free paint.
- ❑ Use solvent-free adhesives.

Fig. 6.2. Green kitchen options, remodeled for efficient use of space could include:

- *upgrade single-pane windows*
- *windows that open*
- *window coverings for shade*
- *landscaping for shade*
- *light pipes*
- *range hood venting to outside*
- *water filters*
- *low VOC, water-based finishes*
- *formaldehyde-free materials*
- *sealed particleboard & MDF*
- *Energy Star® appliances*
- *low water-use dishwasher*
- *best-available technology refrigeration*
- *recycled-content tiles*

Credit: Jill Harris & Kim Master

just cook and eat — like adding a small desk in an unused space or creating an area for entertaining. Also, installing a recycling center into the cabinetry makes recycling kitchen waste more convenient.

Structural Framing

For information regarding structural changes you may need to make to the kitchen, please refer to Chapter 9, Structural Framing.

Plumbing

As long as you do not move or add plumbing fixtures, you can use existing hookups for a new sink or dishwasher. More drastic changes may require new plumbing. Try to avoid moving your sink, because this can significantly increase the cost of the job. Again, if your house was built before 1950, the pipes may be lead, in which case they need to be replaced to protect your health (see "Lead" in Chapter 5, and "Lead" in Appendix 1.)

For minimal cost, you can insulate your hot water pipes so that energy does not escape as you are running water. To further save water, install a low-flow faucet that uses less water but with seemingly no effect on water pressure because the spray is mixed with air.

Water quality can be improved simply by adding a carbon filter to your tap. Each water filtration method filters distinct pollutants from the water, so you should find out what's in your water from your regional water authority before you purchase a filter. (See "Water Quality" in Chapter 5).

Electrical

In general, people prefer bright kitchens. While light colors and big windows help, good general lighting and task lighting will provide for the best cooking, eating, and socializing environment, any time of day or night. The most energy-efficient lights are fluorescent and halogen lights. Energy-efficient dimmers are available that can create an intimate dining area. You can also save energy by wiring lights to different switches, allowing you to illuminate specific areas of the kitchen. For safety and energy-saving purposes, recessed lights should be labeled "IC-AT," meaning they're designed for direct insulation contact and an airtight housing.

In terms of circuitry, new appliances may require new circuits and/or upgrading of existing circuitry. Many old kitchens can overload existing circuits, causing a fire hazard. Stoves need a heavy-duty circuit, and other appliances also need their own circuits. New circuits in the kitchen are a good investment since there will always be a new gadget to plug in.

Insulation

If you've opened up walls in your kitchen for the renovation, this is a cost-effective time to upgrade your insulation. Uneven insulation distribution and blackened wood or other signs of moisture damage are indications that your insulation needs to be replaced. Otherwise, you might just consider adding more insulation to improve the comfort and overall energy-efficiency of your home. Green insulation options include recycled

Kitchen lingo.

Backsplash: The part of the wall surface behind the sink or countertop. As it is splashed frequently, it should be finished with a waterproof surface.

Kickspace: The recessed space at the bottom of a base cabinet. The kickspace allows you to stand close to the cabinet without stubbing your toes.

Soffit: The space above the upper cabinets. This can be left open for storage or display, covered with molding, or boxed in with drywall. Sometimes it is used to hide the vent duct running from your range hood.

Vinyl Windows: A Green Product?

We have discussed how "bad" vinyl and PVC are for your health (see Vinyl Chloride in Chapter 5). So why do we recommend it for windows? There are pros and cons to almost every material. Wood is expensive and uses wood resources. Vinyl is a low-cost option that has good temperature and sound insulation qualities, thereby helping you to save energy that would otherwise have to come from polluting, non-renewable energy sources. Many people are concerned about health risks associated with vinyl, but hard vinyl used in windows does not offgas vinyl chloride as much as soft vinyl (such as the kind in vinyl flooring).

content cellulose, cotton batts made from trimmings in jeans factories, and recycled-content fiberglass. Advanced infiltration reduction practices will also help you save energy. This involves looking out for leaks in doors, windows, plumbing, ducting, and electrical wire, and penetrations through exterior walls, floors, ceilings, and soffits over cabinets. Leaks should be sealed with a low-toxic caulk, sealant, or expansive foam.

Solar Energy

Windows can make the kitchen significantly brighter and will help to open the room up. Purchase the most energy-efficient windows you can afford for optimum energy-savings and comfort. At a minimum, they should be low-emissivity (low-E) windows that block out unwanted heat during the summer, while allowing in plenty of sunlight, and should have low-conductivity frames like vinyl or wood. You may want to shade windows with overhangs or landscape features to prevent your kitchen from overheating in the summer.

Heating, Ventilation, and Air Conditioning (HVAC)

Unless you are adding major space to the kitchen, you won't need extra heating for this room. However, you may want to relocate a register in the kickspace under your kitchen counter to fit a new design. If you are putting in new flooring or there is an unfinished basement below, you might also consider radiant floor heating, which uses water in tubes under the floor to deliver heat to the room. Not only does this make typically cold kitchen floors warmer, but it heats objects instead of air — efficiently making you more comfortable. As with all rooms in the house, ducts should be sealed with duct mastic for greatest efficiency, because duct tape deteriorates over time.

Given all the moisture created while cooking, ventilation should be a top priority in the kitchen to avoid mold, odors, and harmful combustion gases caused by cooking. Operable windows are always a good idea, but an impractical solution for many homeowners in the winter. A range hood directly over the stove effectively carries pollutions and odors outside through an air duct to the outside. Vent hoods are mounted on a cabinet above the stove, while canopy hoods hang down from the ceiling over stoves on an island. The noise of fans is measured in sones: the lower the sone (typically below 4.5) the better.

Appliances

The major appliances in your kitchen are the stove or range, the refrigerator, and the dishwasher. Stoves and ranges do not have great variations in efficiency, which is why there is no EnergyStar® rating for them; however, another major issue with them is indoor air quality. Cooking releases particulates, odors and moisture. (Gas stoves can also emit harmful combustion gases; see "Combustion Gases" in Chapter 5.) To keep these things to a minimum, be sure to ventilate properly. The basic "recirculating" range hood does little more than blow everything back into the house; instead, install the hood close to the cooktop (25-30"), and vent it to the outside with as short a duct as possible to reduce the amount of fan power needed. A basic 190-360 cfm range hood fan should be adequate.

Refrigerator efficiency has improved significantly over the past decade, but it is still the biggest energy user in the kitchen. Don't buy a bigger fridge than you need, as this will only increase its energy consumption. Likewise, keeping your old one for extra food storage will only increase your energy bills unnecessarily — it is best to buy a slightly larger new refrigerator that accommodates all your needs. Keep in mind that extra features, like water and ice dispensers, will make your refrigerator less efficient. Likewise, refrigerators with the freezer compartment to the side of the refrigerator are less efficient than models with the freezer door above or below the refrigerator door. Avoid locating your refrigerator close to heat sources like the stove or microwave that will reduce its cooling efficiency.

Most of the energy required for dishwashers is used to heat the water. Therefore, look for models that heat less water or include a booster heater that allows you to turn your main water heater down to save energy. A heat "on/off" setting allows you to turn off the heat and air-dry dishes to further save energy.

Also look for water saving features. Extra-insulated models will operate more quietly.

Interior Materials/Finishes

Although many materials and finishes in a renovated kitchen can potentially cause serious health problems, there are ways to avoid this. For example, the particleboard and medium density fiberboard (MDF) used to make kitchen cabinets and counters contain urea formaldehyde glue which can cause a range of health issues (see "Formaldehyde" in Chapter 5). The toxins can be sealed into the materials with several coats of a water-based sealant, preferably at the factory, before the material gets into your home. Better, you can purchase exterior-grade plywood that contains less toxic phenol formaldehyde, or formaldehyde-free medium density fiberboard (MDF).

Your best — but likely most expensive — option is custom cabinets made from solid wood, and solid surface countertops, which are durable and healthy. Finger-jointed wood is an excellent option for trim because it uses smaller diameter wood by joining the pieces like intertwined fingers, creating a stronger piece of wood which might otherwise have been cut from a larger tree. Also, use low- or no-VOC, formaldehyde-free paints, low-VOC wood finishes, and solvent-free adhesives where they are applicable. In general, paints are better for indoor air quality than wood finishes, but remember that the shinier and darker the paint, the more likely it is to offgas toxins into your living space. Calculate finish needs beforehand to avoid wasted leftovers; store, donate, or recycle finishes when leftovers are unavoidable.

Kitchen floors should be durable and washable, because chances are things will spill on the floor while people are cooking or eating. (My dogs also do a good job of making their own mud artwork on the kitchen floor.) The best options are wood, ceramic tile, exposed concrete, or natural linoleum. Wood should be FSC-certified or come from a natural, rapidly-renewable resources like bamboo, to avoid cutting down old-growth forests that take hundreds of years to regenerate. Wood is relatively soft and comfortable, but may be damaged with long-term exposure to water; for example, oak turns black with repeated exposure to water. Always use low-toxic adhesives and water-based wood finishes to minimize indoor air pollution.

Recycled-content ceramic tile, stone tile, or exposed concrete are durable surfaces. Concrete can be mixed with various pigments to create beautiful, warm

Kitchen Checklist

Job Site and Landscaping (See Chapter 7)
- ❑ Remodel for efficient use of space.
- ❑ Reuse construction and deconstruction waste.
- ❑ Recycle job site waste.

Plumbing (See Chapter 12)
- ❑ Insulate pipes.
- ❑ Install on-demand hot water circulation pump.
- ❑ Investigate your water supply.
- ❑ Install a whole-house water filtration system.
- ❑ Install activated carbon filters.
- ❑ Install water distillers.
- ❑ Install a reverse osmosis system.

Electrical (See Chapter 13)
- ❑ Install light pipes.
- ❑ Install compact fluorescent light (CFL) bulbs.
- ❑ Install halogen lighting.
- ❑ Install lighting controls.
- ❑ Install sealed or airtight IC recessed lighting.

Insulation (See Chapter 14)
- ❑ Use formaldehyde-free, recycled-content fiberglass insulation.
- ❑ Use cellulose insulation.
- ❑ Caulk, seal, and weatherstrip.

Solar Energy (See Chapter 15)
- ❑ Install double-paned windows.
- ❑ Install low-e (low-emissivity) windows.
- ❑ Install low-conductivity frames.
- ❑ Install window coverings and overhangs.
- ❑ Use landscaping to shade windows.

Heating, Ventilation, and Air Conditioning (HVAC) (See Chapter 16)
- ❑ Install zoned, hydronic, radiant heating.
- ❑ Use duct mastic or Aeroseal™ instead of duct tape.
- ❑ Install operable windows for natural ventilation.
- ❑ Vent kitchen range hood to the outside.

Appliances (See Chapter 18)
- ❑ Replace your standard dishwasher with a low water-use model.
- ❑ Look for EnergyStar® label on gas appliances.
- ❑ Buy best available technology refrigerator.

Interior Materials/Finishes (See Chapter 19)
- ❑ Use formaldehyde-free materials.
- ❑ Seal all exposed particleboard or MDF.
- ❑ Use FSC-certified wood flooring.
- ❑ Use rapidly renewable flooring materials.
- ❑ Use recycled-content tile.
- ❑ Replace vinyl flooring with natural linoleum.
- ❑ Use exposed concrete as finish floor.
- ❑ Calculate paint needs beforehand.
- ❑ Use low- or no-VOC and formaldehyde-free paint.
- ❑ Use low-VOC, water-based wood finishes.
- ❑ Deal properly with finish leftovers.
- ❑ Use solvent-free adhesives.

patterns. Although pigment adds to the cost of the concrete, it does not require any finishes or maintenance and therefore is a cost-effective option.

Natural linoleum — not to be mistaken with vinyl flooring — is made from natural materials like linseed oil, jute, cork dust, and wood dust. Unlike vinyl flooring, which offgases toxic vinyl components, this surface is relatively non-irritating (unless you are affected by linseed oil). Natural linoleum is durable, can be finished in solid colors or patterns, and can be installed without the need for adhesives.

Keep in mind that even though carpeting can be warm and cozy on your feet, it is not a recommended kitchen floor option because it traps dirt and moisture. Small, washable mats should be used instead.

Room Additions

The purpose of adding on an addition is to provide more space in you home. Often, it is to take that little box they called the master suite in the '70s and create a contemporary master suite and bath. Perhaps it is a new den so you can all be together after dinner. Whatever drives the project, aesthetics, comfort, health, and functionality are all part of the plan.

It is important that the addition work well with the existing house. There is nothing worse at the end of the job than to look at the house and see a strange protrusion sticking out of one side. Keeping the architecture consistent is important both from an aesthetic standpoint and to the value at the time of resale. Adding a room is an opportunity to improve the comfort and remedy many of the existing problems of the entire house.

Designing an addition is like designing a whole house, and it's an opportunity to think about your house as a system, with the addition a smaller system itself. Virtually everything involved in new construction is encountered in building an addition, especially if you are including a kitchen or a bathroom.

Beginning with the site of the addition and ending with its flooring, we'll show you how to make your additional room as energy-efficient, resourceful, and healthy as possible.

Job Site and Landscaping

If possible, when you first think about adding a room, consider exactly where it will go to optimize sunlight and wind exposure, and to minimize disruption to

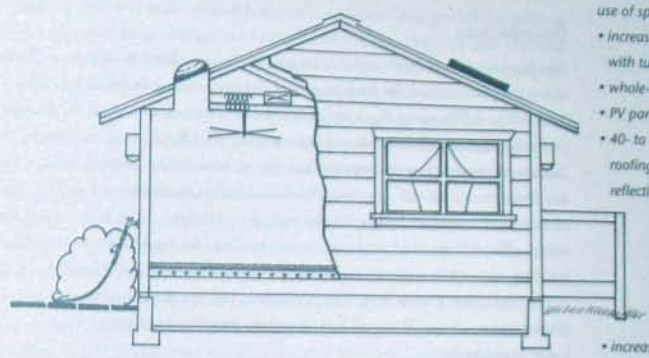


Fig. 6.3: Green room addition options, remodeled for efficient use of space could include:
- *increased natural daylighting with tubular skylights*
- *whole-house and ceiling fans*
- *PV panels*
- *40- to 50-year composition roofing in a light-colored or reflective material*
- *increased insulation*
- *compact fluorescent bulbs*
- *siding made from materials other than wood*
- *finger-jointed studs*
- *recycled-content decking*
- *FSC-certified wood*
- *limited use of wood treated with unsafe chemicals*
- *rapidly-renewable flooring*
- *recycled-content carpet & underlay*
- *zoned, hydronic radiant heating*
- *outside drip irrigation*
- *protect native topsoil with native plants*

Credit: Jill Haras & Kim Master.

existing landscaping. You will likely need to demolish a wall or tear down part of a roof. Often contractors will reuse many of the deconstructed materials, or you may be able to utilize them yourself for the new space. If not, choose a contractor who is willing to make an effort to recycle construction materials. These days, everything from windows to wheelchair ramps can find a happy home outside of our overflowing landfills.

Protect native soil by removing it carefully and storing it until renovations are complete — this will save you the cost of buying new soil later. Avoid digging utilities in root zones, or try hand-digging utilities to protect existing vegetation. Mark fragile site features so that vehicles do not inadvertently run over delicate plantings or tree roots. Try to limit traffic in general, because cars and trucks tend to contaminate indoor air quality and compact the soil to a point where existing plant roots are damaged irreversibly. Remember, your yard is a micro-ecosystem, and damaging one tree could disrupt the stability of what you have nurtured over years.

To re-landscape disturbed areas, use native plants that require minimal water or fertilizers. If you do water, consider a drip-irrigation system that directly waters plant roots, wasting significantly less water than a sprinkler system, where most water evaporates. Also consider permeable surfaces, like gravel driveways and

walkways, that prevent drainage problems caused by impermeable surfaces such as conventional asphalt.

Foundation

The foundation will be there for as long as the house is lived in. It pays to think about the permanence, the perfection, and the protection a foundation provides. You will probably never dig it up again, so do what you can from the start. A perfectly dimensional foundation layout (square, plumb, and level) is essential so that the above structure fits together and functions well. Use recycled-content fly ash concrete — it will improve the foundation's durability and reduce the potential for moisture migration through the concrete. In addition, consider energy-efficient insulated concrete forms. Insulate the foundation at this early building stage while it is easy with foam panels on the outside of the walls or slab so you don't have to deal with cold floors later. Perhaps most importantly, install drainage around the footing to keep moisture away from the house and prevent future mold problems.

Structural Framing

Use Forest Stewardship Council (FSC)-certified, engineered, or reclaimed wood to reduce the need to cut down old-growth forests. Consider structural insulated panels (SIPs) for the exterior walls, floors, and the roof. These are constructed of a rigid foam core sandwiched between two panels of oriented strand board (OSB). SIPs are more energy-efficient, provide excellent sound-proofing, reduce infiltration, are erected quickly (saving labor costs), and save wood relative to conventional frame construction.

Advanced framing techniques, such as using two-stud corners instead of conventional four-stud corners (studs are vertical framing members) will save wood studs and allow for extra insulation to improve your home's energy efficiency. Finger-jointed studs also enable you to save wood material, as they are constructed by joining smaller pieces of wood (that would otherwise be wasted), in a manner that resembles interlocking fingers.

Whatever choice you make, do it intentionally. Each step of construction determines how comfortable you will be, how much you pay in future energy bills, and how you personally steward the larger environment. The structure of the addition makes an indelible impact on the rest of the building, and you will only make these decisions once.

Exterior Siding

Obviously you will want to match the new addition's siding with the existing siding, but sometimes you can use a material (like stone), that will look stunning and blend well with an existing wood structure. Or you may consider redoing the siding of the entire house to make it more durable and attractive. There are numerous options for exterior siding that eliminate the need for old-growth wood, including regionally produced brick, indigenous stone, natural stucco, or cementitious siding. These materials are also low-maintenance, impact-resistant, and fireproof. Additionally, fiber-cement siding is more durable than wood (warranted to last 50 years). It looks like wood but won't warp, twist, melt, or burn. It is also moisture- and termite-resistant, inhibits fungal growth, holds paint very well, and is easy to install and finish.

While you are working on the exterior of your home, consider building a deck — an easy way to add enjoyable living space. Locate it on the south side if possible. You will gain extra months of use by letting the sun temper the space and melt the snow. (North decks are cold and icy in winter.) Use sustainable decking materials, such as FSC-certified or reclaimed wood for the structural components. Ensure that treated wood is not CCA-treated lumber that contains chromium or arsenic. Also consider recycled composite wood and plastic decking for the surface. Building a patio made of indigenous stone or brick will last a lifetime and add value. It is important to slope the earth away from the house to keep water from pooling beside the foundation wall or under the deck. Plant trees for a bit of shade, and if there is a tree exactly where you want your patio or deck, build around it to keep the house cooler in summer.

Roofing

The main function of a roof is to keep the house dry and protected from the elements. All too often people compromise on roofing materials. This is where you want the best you can afford and you want a roofer that really understands how the existing roof and the addition roof intersect. Make sure that the roofs provide positive drainage, and be sure to install flashing carefully to avoid future leaks.

All roofing shingles require significant amounts of energy during manufacture, so look for 40- to 50-year composition roofing you won't have to replace. Recycled-content asphalt, slate, concrete tile, lead-free metal, recycled-content plastic, and photovoltaic roofing tiles are other options worth looking into. For

all roofing materials, avoid adhesives and calculate how much material you'll need, in order to be able to assess contractors' estimates accurately. Light-colored roofing and radiant roof barriers installed on the underside of your roof sheathing are recommended to reflect unwanted heat away from your home.

Plumbing

For information regarding plumbing changes you may make to the addition, please refer to Chapter 12, Plumbing.

Electrical

Design electrical lighting with natural light in mind. For example, if you incorporate clerestories or light shelves into your addition, you'll likely need only minimal task lighting during the day. Compact fluorescent lights are the best option for electrical lighting, including task lighting. They last 10 times as long as incandescent lights, and a 15-watt fluorescent light can give off as much light as a 60-watt incandescent. The light is more flattering than older fluorescent lights, and they're now available with dimming options so that you can change the mood of your room while reducing energy output. Compact fluorescent bulbs are also available for outdoor lighting fixtures. It is important that outdoor lighting fixtures do not create light pollution that disrupts wildlife, neighbors, and possibly even your health. To this end, avoid use of floodlights, specify "full-cutoff" luminaries, and focus lights downward. Also consider timers, motion detectors, or photocells to ensure lights are on only when needed.

Insulation

The building code for your jurisdiction determines the *minimum* required level of insulation, but you really want as much insulation as you can get into the walls and ceiling. We have had artificially low energy prices for decades, and that is about to come to an end. Insulation will reduce your need for heating and air conditioning, making your home more comfortable and affordable. In general, framing determines how well the house will be insulated — if you build with 2" × 4" walls, you can wrap one inch of rigid foam around the exterior to improve your comfort level; if you frame with 2" × 6" walls, you can get even more insulation into the walls. The ceiling is the least expensive place to install additional insulation.

It is important to seal and insulate exterior walls with advanced infiltration reduction practices. This entails paying close attention to where the new addition joins the existing house. Often, this area isn't sealed properly, so it is open to the attic at the top and filled with wires and pipes that were shoved in during remodeling. Advanced sealing entails using spray foam or caulking at all intersections and penetrations so no air can enter the house. Even though it is standard practice to seal around doors and windows, make sure you can't see daylight around the framing and the window. Gaps like these are small details that all too often get overlooked and covered over; they will then create drafts for all the years you live there.

During the renovation, when walls are already open and trucks with insulation materials are on your property, is the best time to insulate the other walls of the house. Blow loose fill into attic or walls cavities. Consider recycled-content fiberglass, rock wool, or cellulose. Dense pack fiberglass or cellulose provides air sealing as well as insulation benefits. There will be small holes in either the exterior siding or in the drywall inside that you will have to fill, patch, and paint.

Solar Energy

Purchase the most energy-efficient windows you can afford for optimum energy-savings and comfort. At a minimum, use low-emissivity (low-E) windows in low-conductivity frames like wood or vinyl to save energy. A skylight is another option that significantly brightens a room; make sure it is well-insulated and low-E if possible so that it doesn't become an energy-wasting feature. Skylights on the south side gain heat in the winter, while skylights on the north side lose heat; all skylights have the potential for overheating in the summer when the sun is high in the sky. A solar tube, essentially a pipe lined with a reflective surface, is a more efficient option — it lights a room more effectively with less heat loss.

Passive solar heating and natural cooling help create a comfortable temperature in your home, reducing the need for mechanical heating or cooling. Orienting the addition to maximize sunlight and prevailing breezes, as well as installing reflective or low solar heat gain windows on east and west windows can help maximize comfort inside your home. You might also consider constructing some form of "thermal mass." A thermal mass is a wall made of stone, brick, or other dense material in south-facing rooms. It can be an attractive feature while soaking up sunlight from windows to store the heat in your home when the sun has set. Window awnings and trees, conversely, can block unwanted sunlight in the summer. One homeowner I worked for wondered why the new furnace never went on in his new addition — it simply wasn't needed because good insulation and the energy-efficient windows provided enough passive solar heat for the space!

Active solar energy uses sunlight to generate heat in solar panels to heat water. Photovoltaic panels generate electricity. Solar energy is a great investment, but for those who can't afford the upfront cost, pre-plumbing the new addition for solar water heating or installing easily removable roofing material to make way for PV later are options that minimize the cost and labor required when adding solar to your home in the future.

Heating, Ventilation, and Air Conditioning (HVAC)

Whether you replace your existing HVAC system with a larger one or put a separate system in the new space depends on other changes you have made to the house. If you have insulated the entire house, you may be able to use the existing system. Even if you must replace an old and inefficient system, you will likely be able to buy a smaller, less expensive system because your home is better able to keep heat in or out. Similarly, you may be able to purchase a separate split system heat pump that will suffice for an efficient addition. Installing new ductwork in the conditioned space (rather than on outside walls) and applying duct mastic to duct joints will also improve furnace efficiency.

If you are going to replace the system, at a minimum, install a forced air furnace or sealed combustion furnace with a 90 percent or greater AFUE (Annual Fuel Utilization Efficiency). Another option is radiant floor heating which uses water in tubes under the floor to deliver heat to the room. Zoned radiant heating enables you to heat certain rooms more than others, helping you save energy if other rooms in the house tend to be colder than your new, efficient addition.

For cooling the new addition, first consider operable windows and ceiling fans. Fans run on 98 percent less electricity than air conditioners, and substantially reduce energy costs. Also consider evaporative coolers that work by blowing house air over a damp pad or by spraying a mist of water into the house air. The dry air evaporates moisture and cools off. This is the same process as a breeze that makes you feel cooler when you get out of a swimming pool, and it works best in dry, hot climates. Since it is often hard to duct a single space, these coolers can be perfect. The wicks (moisture absorbing element in the cooler) must be inspected several times a year for mold. If you must use air conditioning, room air conditioners use less energy than central air conditioning. For more ways to avoid air conditioning or to use your AC unit more efficiently, refer to Chapter 16.

Nursery Percolation

Chemical Cleaners + Volatile Organic Compounds + Polyvinyl Chloride + Phthalates + Formaldehyde = Toxic Chamber

As parents, we want to provide a healthy, safe and secure environment for our children. However, we may not be able to provide a 100 percent chemical-free environment: since World War II, at least 75,000 new synthetic compounds have been developed and released into the environment; fewer than half of these have been tested for potential toxicity to humans, and still fewer have been assessed for their particular toxicity to children. However, with a little care, a lot of label-reading and an awareness of what we are putting into our children's spaces, we can offer them a healthier future.

Table 6.1 on pages 156 and 157 shows the effect of toxins that carry a high-exposure burden and which are often released during a typical nursery renovation. It includes some of the things you can do to make this room healthy for your new child.

Connie Menuey McCullah, Odin's Hammer Construction, Berkley, CA

Interior Materials/Finishes

You can make your home healthier by using no-VOC, formaldehyde-free paint; low-VOC water-based wood finishes; solvent-free adhesives; and formaldehyde-free materials in place of more toxic materials like particleboard and medium density fiberboard (see "Health" in Chapter 5).

One of the most popular flooring options for bedrooms is carpeting, but this can also be the least healthy. Not only do the fibers trap pollutants, which a vacuum cannot pick up, but the carpet also often offgases formaldehyde and toxins from the adhesive backings. If you must use carpeting, ensure that it carries the Carpet and Rug Institute Green Label. That will ensure that it has minimal offgasing. Consider recycled-content carpet tiles that you can replace individually, if they are damaged.

A better option is wood that has not harmed old-growth forests; such as FSC-certified wood, reclaimed wood, or rapidly renewable wood like bamboo or cork. Wood is highly durable, washable and attractive in any room.

My friend Connie McCullah is a green building professional and co-owner of Odin's Hammer, a residential remodeling company in Berkley, California. As a woman concerned about her children and the planet, she specializes in implementing safer alternative materials and methods of design and building to improve indoor air quality and energy efficiency. She has compiled the

Table 6.1: Nursery Room Toxins

Activity or Product	*Product Ingredients*	*Exposure Type*	*Exposure Burden*	*Notes*	*Safer Alternatives*
Cleaners	Blue Cleaners – ammonia Bleaches – chlorine	Offgasing[1]	High	May cause eye, nose, throat, or skin irritation. Use gloves during application.	Lemon juice, white vinegar, baking soda. Never mix different conventional products — you end up producing a more toxic brew!
Paints	Washable or enamel paints; - VOCs[2]	Offgasing	High	Eye, nose, and throat irritation; headaches and nausea.	Use no- or low-VOC paint.
Floor or wall coverings	Vinyl floor, wall paper, PVC[3], chemically treated carpets	Offgasing	High	May cause kidney or liver damage.	Use no- or low-VOC paint and solid wood flooring.

Notes:

[1] *Offgasing:* The release of gases or vapors into the air.

[2] *VOCs (volatile organic compounds):* A class of chemical compounds that can cause nausea, tremors, headaches, and, some doctors believe, longer-lasting harm. VOCs can be emitted by oil-based paints, solvent-based finishes, and other products on or in construction materials.

[3] *Polyvinyl chloride (PVC):* Thermoplastic polymer of vinyl chloride. Rigid material with good electrical properties and flame and chemical resistance. PVC is a known human carcinogen. Due to the environmental releases during manufacture and during fires, it is banned in many parts of Europe. Used in soft flexible films, including flooring, and in molded rigid products like pipes, fibers, upholstery, and siding. Identified by a "1" inside a recycling triangle found on packaging. Greenpeace has developed an online resource listing PVC alternatives.

information in Table 6.1, above and opposite, on the kind of toxins that may be released when remodeling a room that is intended to serve as nursery.

Activity or Product	*Product Ingredients*	*Exposure Type*	*Exposure Burden*	*Notes*	*Safer Alternatives*
Mattresses, crib bumpers	PVCs, formaldehyde	Offgasing	High	EPA classifies formaldehyde as a Class B carcinogen.	Unbleached cotton or fabric with padding.
Cribs, dressers, etc.	Particleboard, formaldehyde, plastic, PVC	Offgasing	Very high to High	PVC often has a pungent, disagreeable odor; often a masking agent is used to cover this smell	Formaldehyed-free medium density fiberboard or exterior grade plywood, or used furniture that has had time to offgas.
Clothing, linens, curtains	Flame retarding or fire resistant chemicals	Offgasing, absorption	High	Eye, nose, and skin irritations.	Unbleached, chemical-free cotton clothing, like linen, hemp, silk wool, cotton. Wash new clothes in 4–5 washings with a nonphosphorus soap to break down chemicals. Purchase used clothing that has had time to offgas.
Toys, soft and flexible	PVC, phthalates	Ingestion, offgasing	Very high	May cause cancer, alterations in sexual development.	Wooden toys or toys stuffed with natural fibers. If using pacifiers, nipples, or plastic bottles and bags, do not heat over a flame or in the microwave. The plastic will breakdown and leach into the liquid. Liquids should be warmed before filling containers.

Source: Connie McCullah, personal conversation. Oden's Hammer Construction, Berkley, CA.

Imagine having factually accurate *and* emotionally calming info at your fingertips when you remodel your home. Now, add energy-conscious, durable, healthy, and environmentally responsible. Sound implausible? In *Green Remodeling*, David Johnston uses rich language, anecdotes and anec-don'ts to help homeowners translate their needs and desires into refreshed spaces that are gorgeous, great, and green.

— Helen English, Executive Director, Sustainable Buildings Industry Council

At a time when every American is feeling helpless about affecting change and seeking ways to make a difference, along comes *Green Remodeling* — one of the most empowering, comprehensive how-to books ever! Yes, we *can* change the world for the better by the way we remodel our home.

— Honorable Claudine Schneider, former US congresswoman, and author of energy efficiency and renewable energy legislation

MILLIONS OF NORTH AMERICANS renovate their homes each year, and many want to remodel in ways that are as healthy and environmentally friendly as possible. But there are so many decisions to consider that making wise, green choices is not easy.

This book changes all that. An encyclopedic how-to of all you need to make your home green, *Green Remodeling* is a comprehensive guide. It first points out the energy, cost and health advantages of remodeling, taking the reader through the author's recent renovation in detail. It then discusses some general building principles before dealing with specific details room-by-room. Next, the book outlines simple green renovation solutions for homeowners, focusing on key aspects of the building including:

- foundations, framing, and roofing
- windows, interior and exterior finishes
- plumbing, electrical and insulation
- heating, ventilation and air conditioning
- water heating, appliances and solar energy.

In addition, a detailed appendix lists common sources of indoor air pollutants to avoid.

Easy-to-read and well-illustrated, *Green Remodeling* comes complete with checklists, personal stories, expert insights and an extensive resource list that will guide a homeowner through any remodeling project. Addressing all climates, this is a perfect resource for conventional homeowners, as well as architects and remodeling contractors.

DAVID JOHNSTON was named one of the top 50 remodelers in the U.S. in 1990. He developed the first green remodeling program in the U.S. and is creating a national green certification program for the National Association of the Remodeling Industry. KIM MASTER, LEED AP, is a green building consultant. Both are from Boulder, Colorado.

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