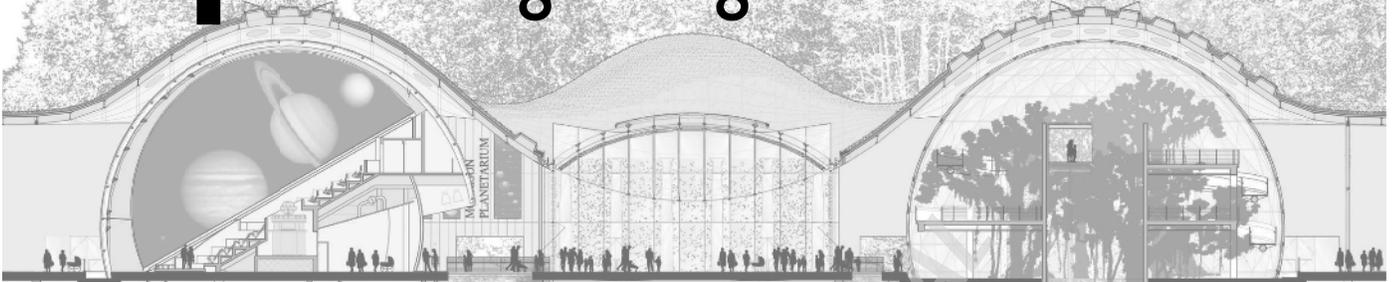


# 1 The Integrated Building Design Process



## ■ What Is Integrated Building Design?

Integrated building design is the practice of designing with sensitivity for sustainability. Not so long ago, the term “green design” was seen only in quotation marks, causing the meaning to seem infirm and of questionable viability. Today green design can be thought of as *integrated building design* when the process includes certain key elements: using the strengths of multiple team members, designing towards goals, and putting in place a method for accountability in design.

An evolution of the term, “integrative design,” is today gaining currency because of the nuanced difference: “Integrated” refers to a process that is complete; “integrative” is an ongoing process. Both address the work of imagining a green building and bringing it into operation. For purposes of this book, we refer to it as the integrated design process.

Integrated design concerns itself with energy, water and material resources, and indoor environmental quality decisions. These issues and strategies will be outlined in this chapter briefly and given in-depth treatment in the chapters that follow.

With integrated design, we treat design variables as interconnected and use them to develop and evaluate design solutions. As design students, and students of building science who study the built environment, you are learning to be problem solvers, which prompts you to imagine and anticipate the potential implications of even the most benign design decision. Learning integrated design will help you to use the knowledge of impacts in making design decisions. Every architectural design student should have a proficiency in these skills to be a productive and efficient team member.

Another key feature of *integrated design* is that *design decisions made earlier in the process do not compromise*

*the effectiveness of design decisions that need to be made later.*

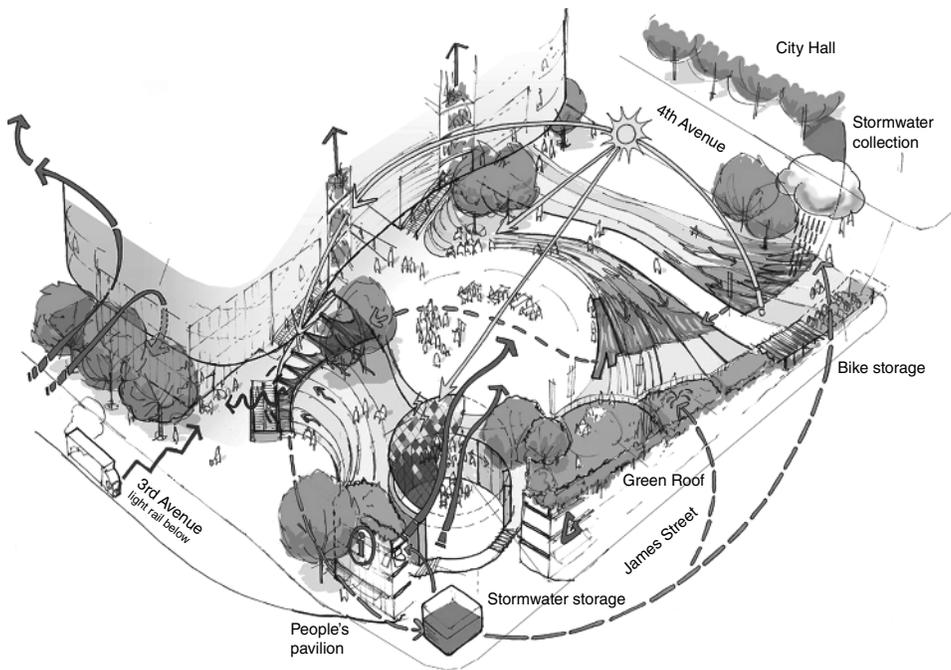
More than mainstream, conventional design, the integrated design process requires following a progression of setting goals and priorities, and evaluating the design choices honestly, to produce a successful green building. The process works because there is communication among team members, and because each team designer has an appreciation of the design challenges and responsibilities of the rest of the team.

Because every design decision produces a cascade of multiple effects, rather than an isolated impact, successful integrated design requires a necessary understanding of the interrelationship of each material, system, and spatial element (Figure 1-1). It requires all players to think holistically about the project rather than focus solely on an individual part.

## ■ The Process

The reality of professional practice can be mimicked in a studio on a student design project of any stripe by assigning different roles within a team and working collaboratively toward a solution. This can be applied to the design of a building, the development of a master plan, or even the creation of land-use policy or neighborhood development.

It is beneficial to learn the process of integrated design from the beginning of one’s design education so that it becomes the default approach. There is no script for the perfect integrated design process, but there are several key elements of the process that need to be incorporated into each design phase from conceptual design, design development, and during construction. These key elements are:



**Figure 1-1** Sketch showing site conditions and technologies in the Foster + Partners Civic Square project, Seattle, Washington. Every integrated design decision must be understood as having multiple impacts. Image courtesy of PHA Consult.

set goals; brainstorm ideas in a charrette setting; develop ideas; perform analysis to aid evaluation of ideas; evaluate ideas in a charrette setting; and make decisions and document them. At the completion of a project, during critique, it is valuable to evaluate the effectiveness of the integrated design process for each team.

In this chapter we will see how the practice of integrated design plays out in professional practice.

### Understand the Scope and Set Goals

It is helpful to develop a schedule of team meetings around project milestones or class deadlines, the first of which should be a discussion with the project *stakeholders*<sup>1</sup> that encompasses the following questions:

- **Size and Type:** What is the project type? What is the size and scale of the project? Is the project a large commercial high-rise tower; a sustainable neighborhood development; or a small, private school on five acres?
- **Regulations and Codes:** Is there a master plan governing new construction for the site that describes the project scope and construction phasing? Are there legislated guidelines for envelope design? Are there municipal, regional, state, or federal regulations governing sustainable design? Will green building codes or mandatory green building certifications be required

for permitting? If so, what is the pace of code revisions? What are the population densities and land-use regulations of the project site?

- **Geography:** Is the project an urban infill or an open space development? What are the geographical and project site constraints? What is the climate zone, and what are the opportunities for passive energy design? What is the rainfall or precipitation on site? What environmental resources or constraints does the site provide? What are the public or low impact transport options available to the site?
- **Environmental Performance Goals:** Does the project location or client brief suggest performance goals for energy use, water use, material resource use? Does the client brief include certification for an environmental standard or a green rating system? Are these goals, and any additional ones, acceptable to the entire team?
- **Project Budget:** Where is the money coming from to fund the project? Is the source of funding a government agency, a municipality, a private developer, or a homeowner? Does the project budget anticipate and support the Environmental Performance Goals?

Answers to these questions will help integrated design teams map out their process.

### Consider the Environmental Impacts

Before you can design responsibly, you need to understand the potential vulnerabilities of, and the opportunities available in the site and community. Figure 1-2 is an example of a resource map, showing an example of a

<sup>1</sup>A stakeholder is a person, entity, or agency that has some investment—either as an owner, funder, occupant, or designer—in the design, construction, and ultimate outcome of the building project.



**Figure 1-2** An example of a resource map showing biological and hydrological resources around a site. Illustration by Killer Banshee Studios.

graphic exercise that would help identify environmental impacts resulting from a project. Many additional issues can be mapped, from demographics to noise levels. For the integrated green building design process, your team will devote considerable time to scrutinizing the details of the site. Questions to consider that are related to biological or hydrological impacts include:

- Will endangered species or wildlife be affected?
- Are there wetlands nearby?
- Should the project restore wetlands or green fields, if it has an impact on these?
- Is there a *riparian corridor* on the site?
- How will potable water quality be affected?
- What is the current pattern of stormwater runoff?
- Does stormwater percolate and drain into the water table or a body of water nearby?
- Are there impervious surfaces on the undeveloped site?
- How will impervious surfaces affect the loss of water through the sewer system or through the evaporation process?
- Will construction cause soil erosion or soil loss due to wind?

## Understand Team Responsibilities and Define Roles

Which team members should be responsible for researching, presenting, and advocating for the issues identified in the questions above?

Ideally, each member of the integrated design project team will have a clearly defined role and area of expertise that will inform the project design for which he or she will be responsible. Adopting these roles can create advocacy for certain design solutions. Again, such an exercise in a studio setting mimics the practice of integrated design in professional practice.

In integrated design practice, the range of stakeholders includes the owner, building users and operators, the various designers and engineers (architectural, landscape, structural, civil, HVAC&R<sup>2</sup>, plumbing; electrical), specialty consultants (daylighting, energy, building certification consultants, and commissioning consultants), the builder and contractor, and could include community members who have a stake in the project (Figure 1-3).

Additional team members will be responsible for more focused issues, such as green roofs, on-site wind-generation, or in-building wastewater treatment. It may be that manufacturers or specialists for some systems, such as building-integrated waste-water treatment technology and photovoltaic systems, are present at least during some phases of the project.

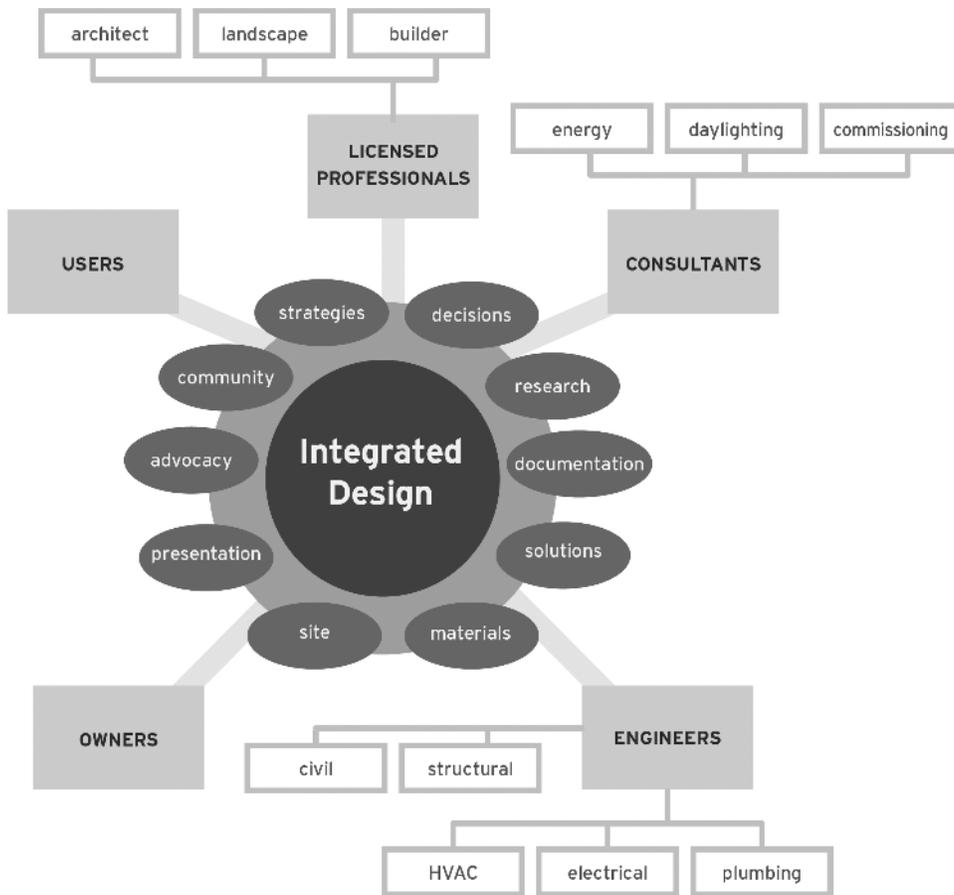
In a design studio setting, a team member should be assigned to traditional and basic roles, and each member should be responsible for documenting strategies and decisions relevant to their role.

## Consider Issues of the Site and Community

A project can address site and community issues such as: provision of and access to community resources, open spaces, solid waste management, growing of food, parks or waterbodies managed by the community, solar access for neighbors, and so on. The solutions being developed relative to the project site (materials, energy, and air quality) as potential design elements must consider the impact on the community.

For example, in the Northern Hemisphere, a flat roof on a longitudinally oriented building, with its longer facade facing south and whose floor is a thick concrete surface, will have the potential for heat gain and retention, while a building in a hot climate with deep overhangs will protect occupants from glare and unwanted heat gain. Another example: a school project can provide community access to the grounds for urban vegetable gardens to increase local food supply and educate the students about the benefits of organic farming. Or the shade created by a new building may have an

<sup>2</sup>HVAC&R: Heating, ventilation, air-conditioning, and refrigeration.



**Figure 1-3** There are numerous project stakeholders involved in the collaborative integrated design process. Illustration by Killer Banshee Studios.

adverse impact on a neighboring site by cutting off its solar access.

A project with an asphalt parking lot will shed water to the storm sewer that could be captured for other uses, while a project with a pervious paved surface handles recharge to the water table and contributes to the overall water cycle. In addition, a porous surface area functions as a durable hardscape, while allowing water to percolate through.

Because sustainable design involves social justice, designing for community is considered a part of the integrated design process and thus takes on a deeper nuance. In terms of community, any project has the potential to enhance or displace existing communities. The team for an integrated project will examine the history of the site and its ethnographies and determine optimal solutions for enhancing quality of life for existing communities.

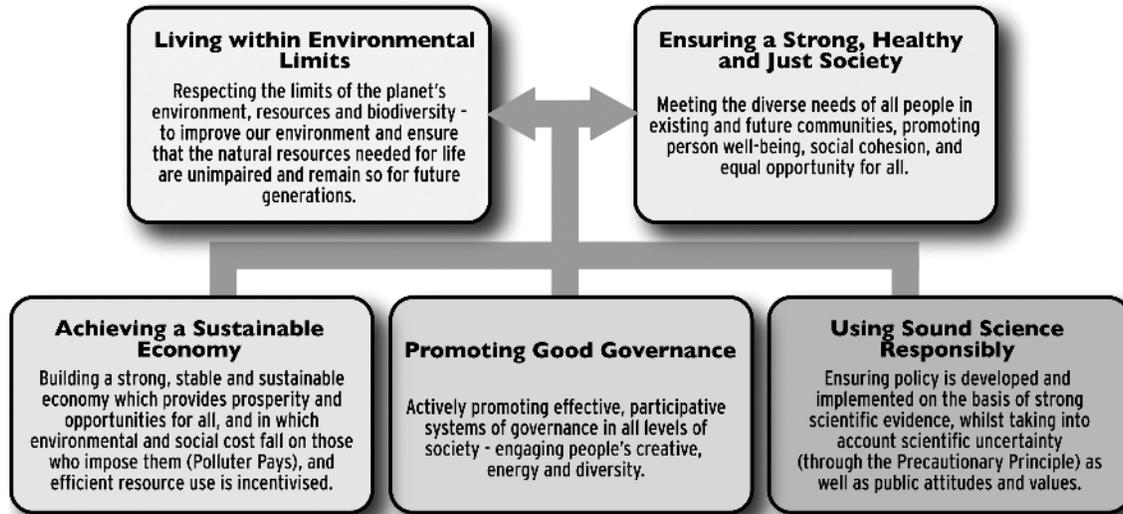
At the same time, a project has the potential for *creating* community, a concept that is part of a complete and traditional architectural education. Using integrated design, creating community takes on a new dimension.

For example, a team must consider future tenants in a multifamily housing project as more than simply an element of programming. The team must also ensure that

social structure is addressed and must provide opportunities for inhabitants to engage or retreat from their environment and to participate in the planning of their living environment and its future incarnations. The United Kingdom's sustainability plan "Securing the Future—UK Government Sustainable Development Strategy,"<sup>3</sup> highlights social justice and inclusion as one of several key sustainable development themes (Figure 1-4). Further recommendations for sustainability policy changes are stressed as key to the socio-economic impacts of climate change: Christophe Degryse and Philippe Pochet published a working paper in 2009 for the European Trade Union Institute, "Paradigm Shift: Social Justice as a Prerequisite for Sustainable Development," whose thesis states, "the behavioral changes made necessary by the ecological crisis will be untenable without concern for social justice."<sup>4</sup> As we will understand in a future chapter,

<sup>3</sup>Available at the United Kingdom Department for Environment, Food, and Rural Affairs, <https://www.gov.uk/government/publications/securing-the-future-delivering-uk-sustainable-development-strategy>.

<sup>4</sup>Christophe Degryse and Philippe Pochet, working paper for the European Trade Union Institute, "Paradigm Shift: Social Justice as a Prerequisite for Sustainable Development," 2009. <http://www.etui.org/Publications2/Working-Papers/Paradigm-shift-social-justice-as-a-prerequisite-for-sustainable-development>.



**Figure 1-4** Three of five key points in the British sustainability plan concern social issues. Image courtesy of Torbay Council, Devon, UK.

with deepening environmental emergencies attributable to climate change, vulnerable populations suffer. This makes social justice an essential indicator of sustainable design.

A responsible project will educate inhabitants on their green building, as well as on the relationship of their building to the surrounding community and landscape. Teaching future inhabitants about the unique maintenance and cleaning practices necessitated by a green building is part of the integrated design process.

### Evaluate Interrelated Impacts of Proposed Solutions

Use a design charrette setting for the various team members to contribute their expertise and offer for discussion the relative merits and downsides of the solutions identified. Team members should communicate and interact with each other.

For example, the team member responsible for energy analysis can point out that strategies for daylighting a space, such as high windows and light shelves, also have the potential to reduce glare and improve the productivity in the building.

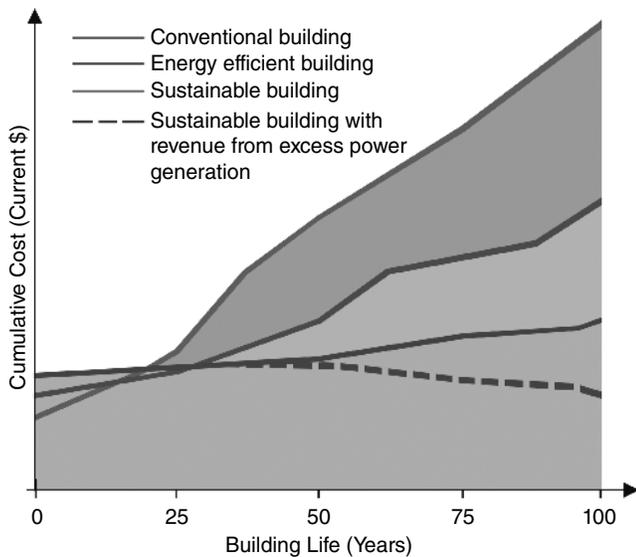
Designers will recommend interior finishes, and this work will have a major impact on the quality of the indoor air and the light distribution in the space. The designer may propose that a particular floor surfacing material with 100-percent-recycled rubber be considered; however, though the material uses resources wisely, it presents a stronger odor for several months after installation, unlike rubber flooring manufactured from virgin rubber. Materials with light colors effectively reflect light, and can help to reduce the number of light

fixtures required, resulting in lower construction costs as well as lower energy use.

Models and calculations assist the design team in quantifying the impact of the design strategies. Several “what-if” scenarios can be modeled to understand how changes in design variables can impact the results. These can be evaluated for incremental costs. For example, increasing roof, wall, and window insulation values in a cold climate reduces energy consumption and operating cost but results in additional cost of construction. When insulation values are increased sufficiently it is possible to eliminate a heating system in a nonresidential building, which not only reduces the operating costs but also reduces the construction cost.

It is commonly thought that most sustainable strategies carry with them a higher cost impact than others. However, traditional design approaches, which usually treat green design as an add-on, lead to higher costs. The integrated design approach may require additional design fees, but it can also lead to lower first costs and reduced operating costs. In professional practice, a *life-cycle-costing analysis* or an integrated cost estimation exercise may be conducted to evaluate these strategies and assess their long- and short-term economic viability. Figure 1-5 compares building-life costs across building alternatives, illustrating that a sustainably constructed building that generates its own power provides the best cost-to-life relationship.

New or cutting-edge technology is often perceived as risky and is avoided because of liability and the potentially unpredictable nature of innovative systems. The responsible designer will contend that high-technology systems can lead to good design, and in an integrated



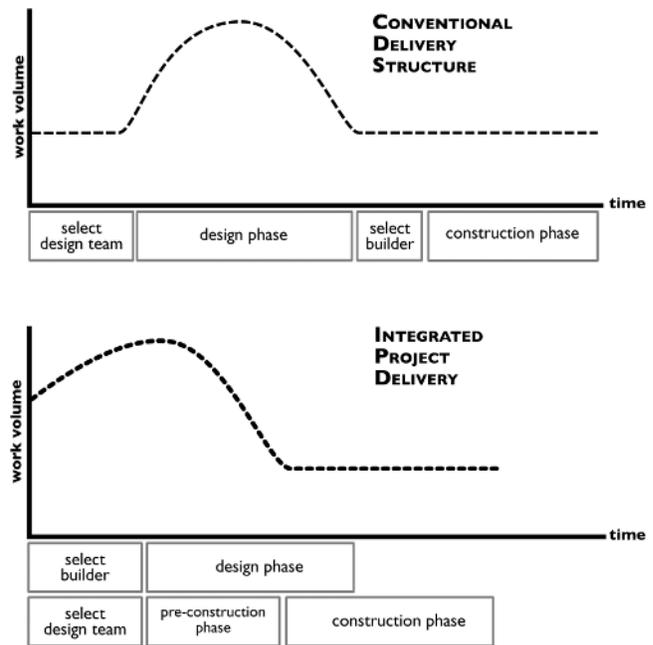
**Figure 1-5** A life-cycle cost comparison of four building types: a conventional building, an energy-efficient building, a sustainable building, and a sustainable building with revenue from excess power generation. Cumulative costs of a building with energy-efficiency strategies and energy revenue are significantly lower, while a conventional building's costs rise steeply over time. Source: Ted Kesik, University of Toronto; illustration by Killer Banshee Studios.

design setting that includes the commissioning agents, building operators, and users, systems performance and operation can be discussed to reduce unpredictability, and thus reduce risk.

### Resolve Competing Approaches

Very few projects are able to achieve environmental performance where adverse impacts of a building on the environment are eliminated, and the building assists the natural ecosystems in regenerating the environment. However, most projects can make considerable progress toward such goals by weighing the merits and complementary effects identified above and testing their solutions and impacts.

For each project, there are frequently several optimal design solutions that are uniquely connected to project constraints. Team leadership becomes crucial during the discussion and winnowing process, because, ultimately, to be efficient, the team must commit to one approach and direction. Needless to say, at the end of all this, a final decision must be made. This is another area where team roles and the integrated design process come into play. Team leadership that is experienced with the integrated design process can help the project reap the benefits of the various team members' shared expertise.



**Figure 1-6** Integrated project delivery requires involving the builder early and front-loading design work. Illustration by Killer Banshee Studios.

### Beyond Design and Construction

In professional practice, the integrated design process does not end with construction. Operators, occupants, tenants, lessors, and facilities managers need training to understand how every interrelated green decision should behave. Tenant and operator manuals amplify this understanding and improve the likelihood of a successful integrated green building. Commissioning, a process defined and outlined below, is assurance of a healthy and functioning building and is the mechanism to confirm that design intent is met. Integrated design takes inputs from these stakeholders as early as possible in the process, and involves them in the decision making to get buy-in and ensure successful performance (Figure 1-6).

### ■ The Focus Areas: Energy, Resources, and Indoor Environment

#### Energy

Buildings consume 32 percent of the energy across the world. In the United States, 48 percent of the energy goes into buildings, 28 percent into transportation, and 24 percent into industry. Halving the energy consumption in new buildings compared to average existing buildings is now considered routine with an integrated

design approach; the number of projects that aspire to consume zero energy continues to increase.

As discussed earlier in the chapter, integrated design is a process where *design decisions made earlier in the process do not compromise the effectiveness of design decisions that need to be made later*. This is exemplified in the focus on low energy design, where the early design decisions for site selection, siting the building, massing, and fenestration design serve to reduce heating and cooling loads and bring in daylight. Passive design strategies take this approach further by increasing the time when a building can operate independent of lighting, heating, cooling, or ventilation systems (Figure 1-7).

The interrelationships between design decisions determine how much energy a building will consume in operation. In the integrated design process, the designers are conscious of a more complete set of impacts, including aesthetics, energy, operations, and occupant experience.

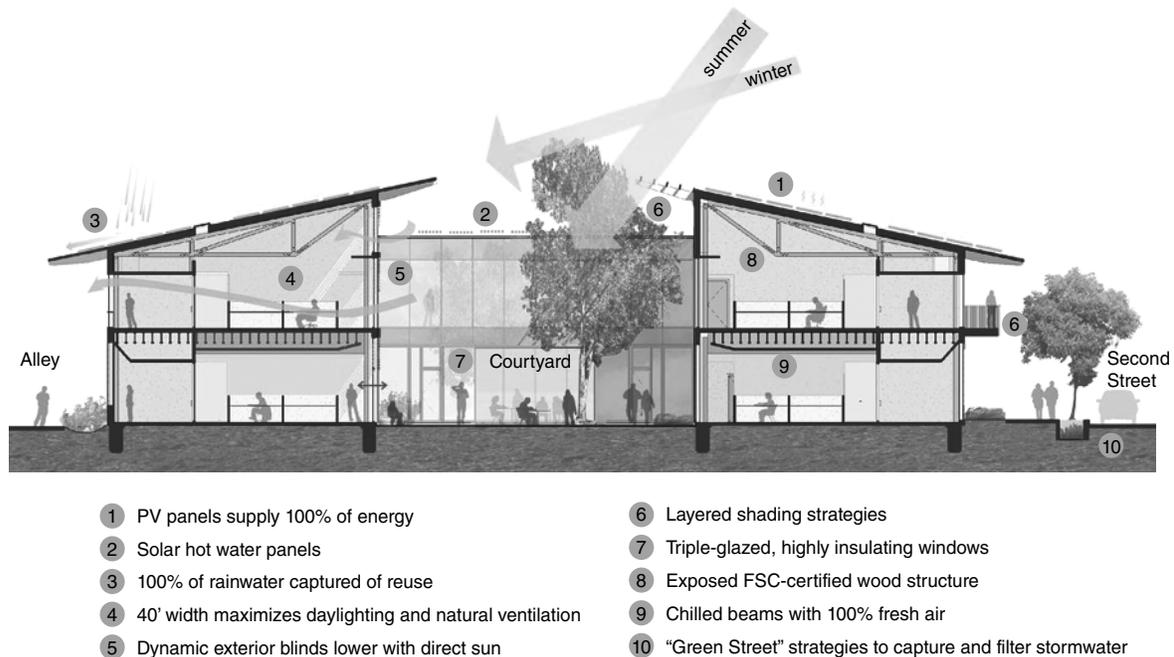
In the real world of architecture and design, the integrated design process uses energy models to measure the difference between design approaches.

Energy performance goals should be established early in the process to set meaningful targets and assess options for the level of achievement. In chapters 8 through 10, we cover background on how buildings use energy, and the approach to low energy design, with an introduction to building systems that help in reducing

energy consumption. Chapter 11 introduces the concepts of measurement and modeling to set up accountability during the design, construction, and operation process. Chapter 12 introduces the current best practice of low energy design: net zero energy buildings.

As students focusing on energy performance, you will need to establish a goal of reducing building energy use compared to a standard practice building (also referred to as a “code-minimum” building) in your region. You will need to learn the concepts, technologies, and passive design approaches that help reduce loads in a building. You should learn about lighting and HVAC systems and conduct field trips to see these systems in real life. Learning about energy modeling, and the dynamics of how energy is consumed in a building can help you guide an energy modeler who can then give you valuable feedback to evaluate design options. You can learn early design energy modeling tools described in Chapter 11 to test design scenarios in predesign and conceptual design. Getting some experience with computer tools that assess building energy performance prior to graduating should be a goal of all architecture and engineering students.

Energy codes and prescriptive guides such as Advanced Energy Design Guides by ASHRAE can help you understand the basic performance requirements for building systems. An optimized solution that uses energy models



**Figure 1-7** The Packard Foundation Headquarters is a net zero building using building form, shading, operable windows, and Load reduction and a low-energy cooling system uses free cooling for most of the year. Image courtesy of EHDD

to evaluate an integrated design approach can easily surpass these prescriptive approaches in reducing energy consumption. It is common practice to set performance targets as a percent reduction compared to such a prescriptive guideline or code, for example, 30 percent better than ASHRAE Standard 90.1 2010. However, increasingly, owners find design teams responding more creatively to absolute energy consumption targets, for example, a target of 25 kBtu/SF per year.

Whether student or professional, the approach to low energy building consists of:

- Design of appropriate building form and envelope to harvest free energies at the site in the form of daylight, passive solar heat, and passive cooling approaches
- Design of building envelope, lighting, appliances, and equipment to reduce the building loads
- Design of HVAC systems that minimize energy consumption
- Design of systems to generate on-site renewable energy

All the above design efforts need to be underpinned by modeling exercises to evaluate options, and be further supported in building operation through an energy monitoring system.

## Resources

As with all green building decisions, an early start to thinking about resource management is essential to meaningful design. The building industry accounts for 40 percent of all raw material use in the United States (3 billion tons annually).<sup>5</sup> The EPA estimates the percentage to be as high as 60 percent.<sup>6</sup> A host of environmental impacts are associated with mining and harvesting or raw materials, processing and transportation, and the extraction and supply of freshwater. An efficient use of water and soils, as well as mined and harvested resources, helps to reduce these environmental impacts.

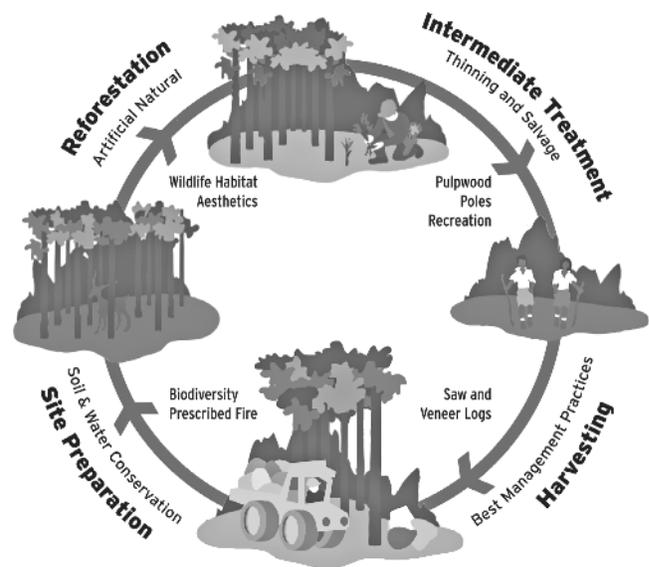
We are confronting a crisis in climate change and the linked impacts of extreme weather, crop failure, and soil and water depletion. The effort to balance energy, emissions, and water flows is the monumental planetary task we face. Resources, materials, products, and systems, including their life cycles, need to be examined to implement integrated design thoroughly. When

architects and designers address these issues on the local scale, we create pockets of sustainability that have a deeper reach with the resources they consume, and we make this task not only manageable but also meaningful in its cumulative effect.

Two key approaches to wise resource management are to maximize the potential of resources to increase effectiveness and efficiency, and to reduce or entirely “eliminate the concept of waste,” as William McDonough and Michael Braungart proposed in *The Hannover Principles*.<sup>7</sup> Just as some cultures use the entire animal—nose to tail, beak to claw—for both sustenance and warmth, we must do the same with trees, granite, threatened and overharvested resources, always employing judicious use of their potential. The complement to resource management is to understand natural balance and avoid damaging interventions during the extraction and processing of these resources. The power of integrated design is magnified with the opportunity to determine and specify the source of building materials so as to avoid these adverse impacts. Figures 1-8 and 1-9 show the results of sustainable versus nonsustainable forestry practices.

## Water

Buildings in the United States use 12.2 percent of all potable water, or 15 trillion gallons per year.<sup>8</sup> In the chapters that follow we will discuss specific strategies



**Figure 1-8** Responsible resource extraction techniques. *Reforestation: Growing Tomorrow's Forests Today*, ©1998, 2000. American Forest & Paper Association, Inc.

<sup>5</sup>N. Lenssen and D. M. Roodman, “Paper 124: A Building Revolution: How Ecology and Health Concerns Are Transforming Construction,” *Worldwatch* (1995), Worldwatch Institute.

<sup>6</sup>“In fact, construction activities use 60 percent of the raw materials, other than food and fuel, used in the entire U.S. economy,” [www.epa.gov/greenhomes/SmarterMaterialChoices.htm](http://www.epa.gov/greenhomes/SmarterMaterialChoices.htm).

<sup>7</sup>William McDonough and Michael Braungart, *The Hannover Principles, Design for Sustainability*, 10th Anniversary Edition, commissioned as the official design guide for the EXPO 2000 World's Fair, William McDonough + Partners, McDonough Braungart Design Chemistry, 2003.

<sup>8</sup>United States Geological Service data (1995).



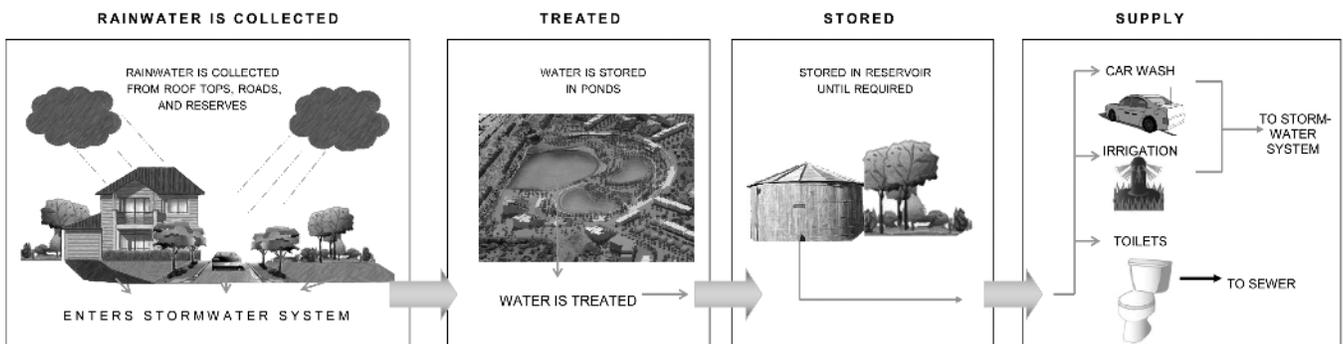
**Figure 1-9** Destructive resource extraction techniques. ECAHINE: Energy Wood Production Chains in Europe.

to reduce consumption of water during construction and occupancy and to use nonpotable and harvested water for uses other than human consumption. Harvested rainwater needs to be managed, as described in Figure 1-10.

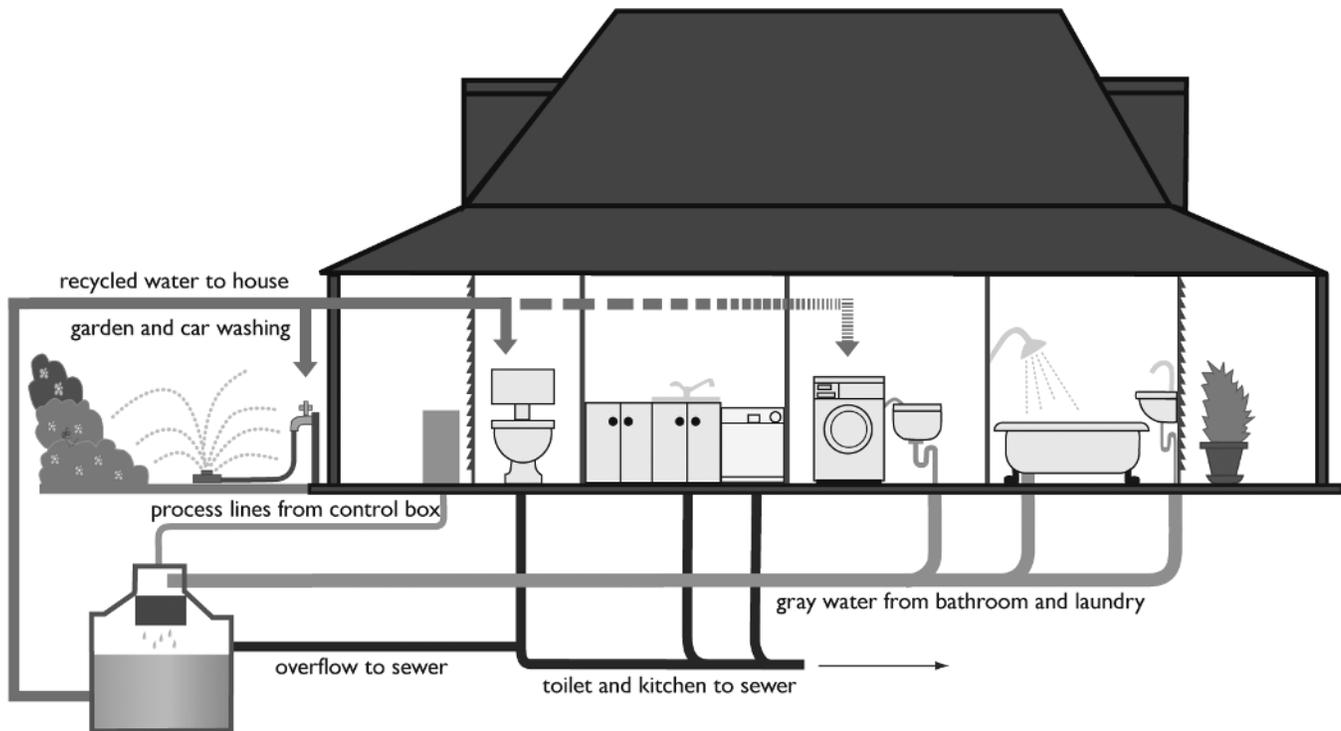
As architects and designers, our job is to think of built solutions, such as water storage systems, both natural and human made, and treatment solutions on the site

and in the building. A good preparation for studying options for water conservation strategies includes *building water use reduction*, *landscape water use reduction*, and *on-site water recycling*.

**Building water use reduction.** A green building can affect integrated design around water issues in a major way by reducing the potable water needed to manage



**Figure 1-10** Rainwater collection system at the community level in New Zealand. Image courtesy of Landco Land Developments.



**Figure 1-11** Gray water captured from bathtubs, showers, sinks, and laundering can be treated and reused to flush toilets and irrigate landscape. Image courtesy of Tanked Australia, Rainwater Storage Solutions.

human waste. Recycling water, concepts known as *gray water* and *black water*, are two potable water-conserving strategies (Figure 1-11).

Careful design and specification of water using fixtures, aligned with occupant demand, is another way to reduce potable water use. Reeducation of occupant behavior around water use may be necessary. Using water-efficient equipment and becoming accustomed to different types of water sources requires new behavior. The approach to water use reduction involves calculating several factors by using a baseline or standard design scenario and proposing a design case with which to compare it. This is a modeling exercise and, therefore, can be used as a design tool. Factors to consider when modeling for a reduction in potable water use in sewage conveyance include the following:

- Occupancy, or the number of people using the building and times of day they are present
- Frequency of use
- Types of plumbing fixtures

**Landscape water use reduction.** Design teams have the opportunity to design meaningful water use reductions in the outdoor landscape in concert with potable water use reductions inside the building. Again, a simple scenario comparison modeled using consistent assumptions about

climate and landscape area is a recommended way to approach irrigation efficiency. Some factors to consider when modeling landscape concerns include the following:

- Planting types (climate adaptive, native species, *xeriscape*, *monoculture* avoidance)
- Elimination of lawns
- Irrigation systems
- Erosion control
- Stormwater management

**On-site water recycling.** Controlling water consumption, of course, is only one aspect of maximizing water effectiveness; others are wise management of water sources and even the potential to produce usable water, through treatment technologies or desalination. Examples include the following:

- Rainwater harvesting and storage
- Black-water treatment, on-site and integrated into buildings
- Municipal scale gray water reclamation
- Desalination
- Blow-down water<sup>9</sup> and condensate water from HVAC systems
- Reverse osmosis filter discharge water

<sup>9</sup>Blow-Down Water: Introduction, Alliance for Water Efficiency, [www.allianceforwaterefficiency.org/blow\\_down\\_water\\_introduction.aspx](http://www.allianceforwaterefficiency.org/blow_down_water_introduction.aspx).

Ultimately, opportunities to protect and manage water resources exist in developing water conservation education programs for building occupants. Historical methods of managing water supply, community water, and diversion will need to be reimagined.

### Raw Building Materials

In Chapter 14, we will discuss examples of resources. There are many types of resources, for example, *living and nonliving*, such as metals, minerals, oil, and timber; *flow (or energy) resources*, such as tide, wind, and solar; as well as *other renewable and nonrenewable resources*.

Raw materials for building are most directly addressed by the living and nonliving category of resources, but flow resources figure into their life cycles.

Building material specification is an absolutely critical element of green building design. Asking questions about a product's life cycle is a good way to educate oneself as to the materials' variability, utility, and contribution to environmental degradation. (Materials selection will be discussed in a later chapter.)

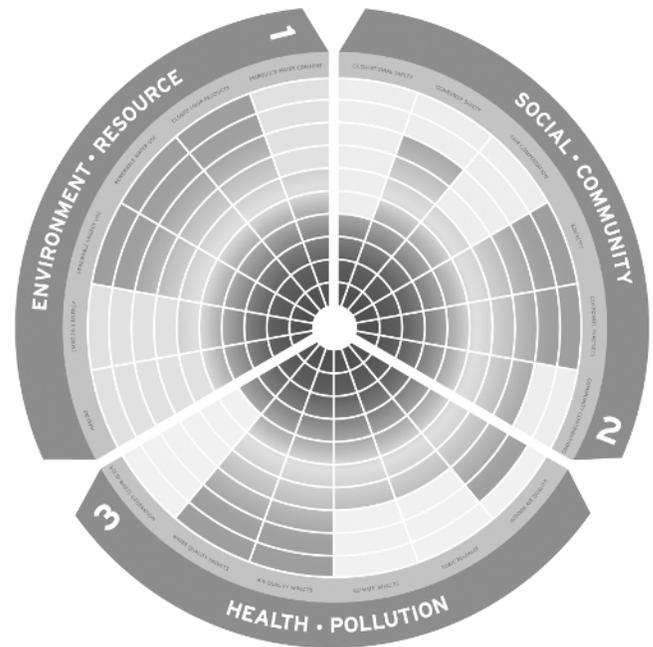
As part of the integrated design process, architects and designers must gather data on the materials and products they wish to specify in order to design a resource—efficient building that uses mined and harvested materials wisely. Among other considerations, the designer should know about product:

- Packaging
- Recycled content
- Recyclability, reuse, and salvageability
- Waste production
- Closed-loop manufacturing process
- Durability and lifespan
- Renewable or nonrenewable resource composition
- Embodied energy of total life cycle

Various building materials databases and systems like Pharos (Figure 1-12) assist specifiers in researching the benefits and downsides of materials selection. These, along with product certifications (discussed in Chapter 15), ease the job of making the best environmental choices.

### Indoor Environment

Indoor environmental quality (IEQ) is important to address because, at least in the developed world, we spend about 98 percent of our time indoors. It is therefore imperative that we consider IEQ a key element of integrated design. As we shall review in Chapter 7, IEQ refers to an abundance of issues relating to occupant comfort and quality of work or living space: temperature, humidity, glare, acoustics, access to daylight and views, the efficiency of air movement through occupied spaces, and the quality of the indoor air itself. Building occupants themselves



**Figure 1-12** The Pharos “wheel” or “lens” illustrates three cores of sustainability: environment and resources, social and community, and health and pollution. It ranks materials along a visual scale within the lens. The Pharos Project™ is a project of the Healthy Building Network.

can address many of these concerns, provided that building systems give them the opportunity to control their own environment.

Indoor air quality (IAQ) should be the foremost concern for designers of integrated buildings, as indoor air correlates directly to long-term occupant health, as we shall learn in Chapter 6. Bad IAQ is a problem on many levels, as described in Figure 1-13. Achieving good IAQ involves reducing the building occupants' exposure to chemicals of concern (e.g., carcinogens, reproductive toxicants, and other potentially harmful chemicals) by considering the following four elements of good IAQ design throughout the project:

- *Source control* through wise selection of building materials, finishes, and furnishings, while screening them for their volatile organic compounds (VOCs) emissions and not simply content.
- *Ventilation control* through carefully designed systems that adequately filter outside air and circulate it such that guideline rates of air exchanges are surpassed.
- *Building and IAQ commissioning*, by which engineers and builders determine if a building's systems are functioning as designed.
- *Building maintenance* involves the introduction of new chemicals that often create synergistic effects and generate new chemicals of concern. Using benign cleaning and maintenance products and establishing a

SYMPTOMS RELATED TO INDOOR AIR POLLUTANTS										
	Particles			Bioaerosols				Gases		
	Dust, Soil, Ash...	Tobacco Smoke	Pollen	Molds, Mildew, Fungus	Bacteria, Virus	Pet Dander	Dust Mites	Carbon Monoxide	Formaldehyde	VOCs
Headaches		✓	✓					✓	✓	✓
Dizziness	✓			✓		✓	✓			
Fatigue			✓					✓		✓
Nausea								✓	✓	
Vomiting									✓	
Skin Rash					✓					✓
Eye Irritation	✓	✓	✓	✓	✓	✓			✓	✓
Nose Irritation	✓	✓	✓	✓	✓	✓	✓		✓	✓
Throat Irritation	✓	✓							✓	
Respiratory Irritation		✓		✓	✓		✓		✓	✓
Cough	✓	✓	✓	✓	✓	✓	✓		✓	
Chest Tightness				✓	✓	✓	✓		✓	
Respiratory Infections	✓	✓		✓	✓	✓	✓			✓
Asthma (exacerbation of)	✓	✓	✓	✓	✓	✓	✓		✓	✓
Allergic Reactions	✓		✓	✓	✓	✓	✓			
Lung Cancer		✓								

**Figure 1-13** Poor indoor air quality can have a number of negative effects. Source: DTR Corporation; illustration by Killer Banshee Studios.

green janitorial program are other ways of attempting to ensure ongoing improved air quality.

Another factor affecting the indoor environment involves an area of research quickly gaining scrutiny: material chemistry affecting human health. We will examine this issue in greater detail in Chapter 5; it is noted here because it should be included as a component in the integrated design process, specifically related to IEQ and IAQ.

After reading this chapter, you may come away with the feeling that integrated building design is all work and no play. But if integrated design is approached an innovative yet grounded way to solve design challenges, in concert with injecting sustainable thinking, both your practice and the results of your efforts will benefit. This book is intended to guide students “toward a new sustainable architecture,” an architecture that designs and produces efficient and healthful built environments.

**EXERCISES**

1. Memorize three key statistics identified in the chapter that illustrate the resource depletion effects of mainstream construction.
2. Create an environmental resources map for a hypothetical building project and determine which location would have the least environmental impact on surrounding resources.
3. Plan an integrated design studio charrette. How would team roles be divided? At what level and phases of design would each team member be involved?
4. How would the integrated design process differ for a high-rise tower and a private elementary school? What consultants would be involved for each?
5. Develop a schedule of regular team meetings around project milestones for your current studio project.

## ■ Resources

- AIA Knowledge Net, AIA Center for Integrated Practice, <http://network.aia.org/centerforintegratedpractice/home/>.
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