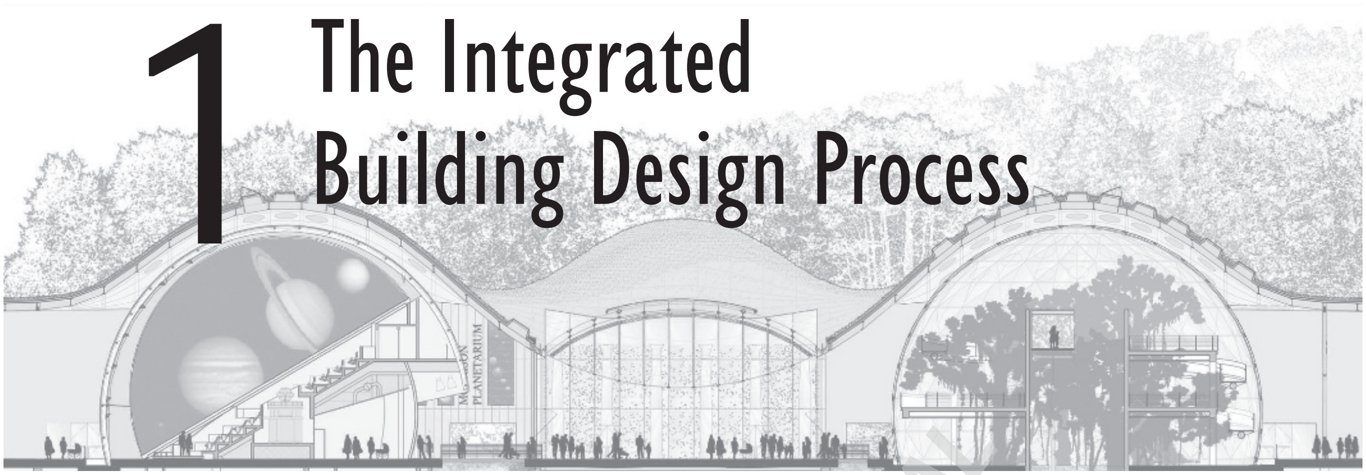
1 The Integrated Building Design Process



> The good news is we know what to do. The good news is we have everything we need now to respond to the challenge of global warming. We have all the technologies we need; more are being developed. And as they become available and become more affordable when produced in scale, they will make it easier to respond. But we should not wait, we cannot wait, we must not wait.
>
> *–Al Gore, former vice president of the United States, addressing the National Sierra Club Convention, 9 September 2005*

What Is the Process of Integrated Building Design?

Integrated building design is the practice of designing sustainably. *Green design* and *integrated building design* should be thought of as equivalent terms.

Not so long ago, the term "green design" was seen only in quotation marks, causing the meaning to seem infirm and of questionalble viability. Today, green, or sustainable, design is a well-established design-and-build model with a proven history—and integrated design is its natural evolutionary form. An integrated building is a green building.

Integrated design is the overarching theme that governs energy, resources, and environmental quality decisions. These decisions and strategies will be outlined in this chapter and given in-depth treatment in the chapters that follow.

With integrated design, it is necessary to consider design variables as a unified whole and use them as problem-solving tools. As architecture and design students, you are learning to be problem solvers, which should prompt you to imagine and anticipate the potential implications of even the most benign design decision. Learning integrated design will solidify these skills and improve a proficiency every architectural student should have—being a productive and efficient team member.

More than mainstream design, the integrated design process requires intense balance—and a path of priorities—to produce a successful green building. The process works because there is communication among team members, and because each team designer has a thorough understanding of each teammate's design challenges and responsibilities.

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 process of working collaboratively in studio as a team member on a student design project of any stripe mimics the reality of professional practice. It can be applied to a graphic design problem, such as a branding exercise, the development of a master plan, and even the creation of land-use policy or neighborhood development.

Because of this, it is beneficial to learn the process of integrated design from the beginning of one's architectural education. There is no script for the perfect integrated design process, but there are several levels of decision making that must take place at the start of conceptual design, while the design is being refined, during design development, and during construction. At the completion of a project, during critique, it is a valuable lesson to evaluate the effectiveness of the integrated design process for each team.

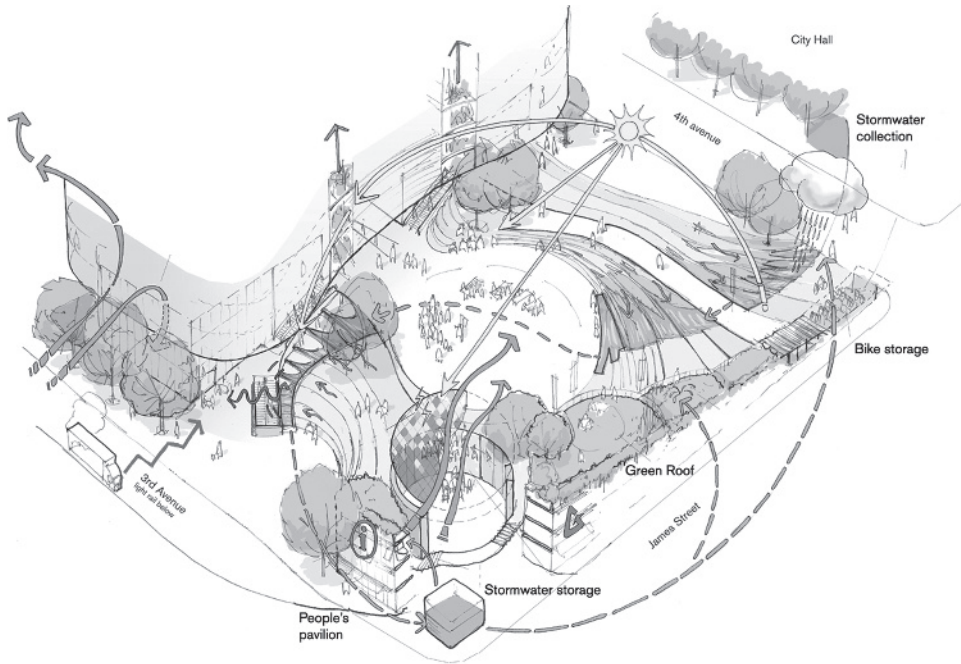


Figure 1-1 Sketch showing site conditions and green site technologies in the Civic Square project, Seattle, Washington. Foster + Partners. The square provides a series of linked permeable urban rooms.

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

Understand the Scope of the Project

It is helpful to develop a schedule of team meetings around project milestones or class deadlines, the first of which should be a discussion that encompasses the following questions:

- 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?
- Is the project an urban infill or an open space development?
- 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?
- What are the geographical and project site constraints?
- What are the population densities and land-use regulations of the project site?
- Where is the money coming from to fund the project? Is the source of funding a government agency or municipality, or is it a private developer or homeowner?
- How will the involvement of each team player and *stakeholder*[1] affect the integrated design process?

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

[1]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.

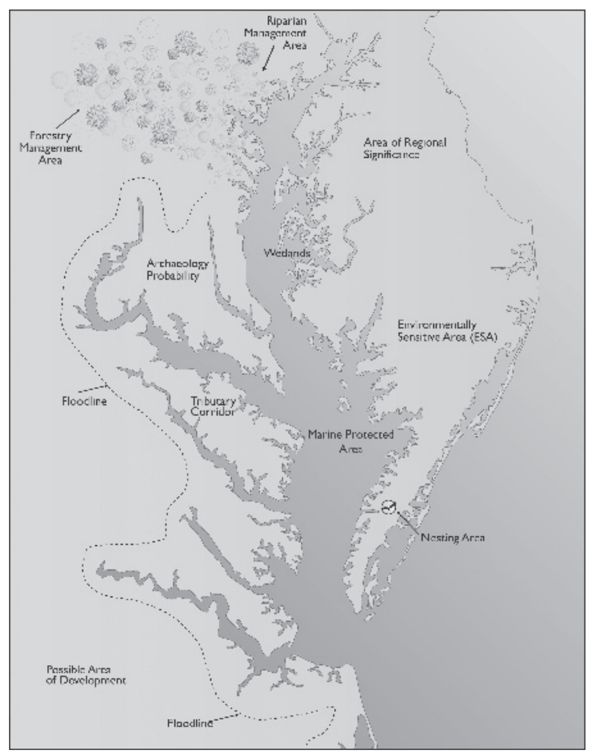


Figure 1-2 An example of a resource map.

What Environmental Impacts of Your Project Will the Team Consider?

Before you can design responsibly, you need to understand the potential vulnerabilities of the site and community. Figure 1-2 is an example of a resource map, the kind of graphic exercise that would help discover environmental impacts on the site. Many 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. Some questions to consider include the following:

- 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 storm water runoff?
- Does storm water 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?

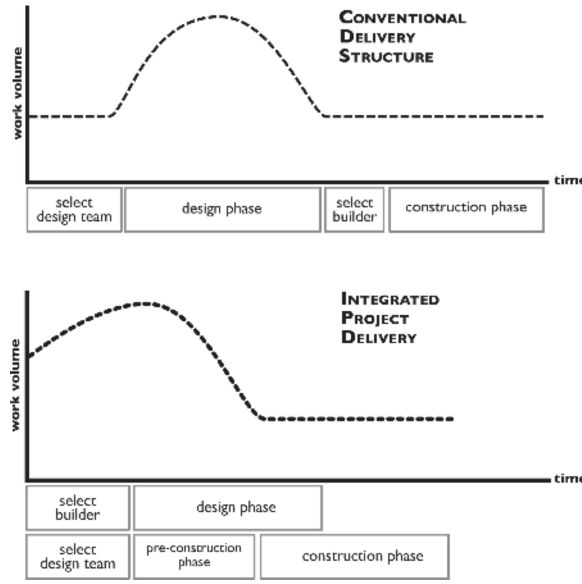


Figure 1-3 Integrated project delivery requires involving the builder early and front-loading design work.

Figure 1-4 Porous paving allows rainwater to percolate rather than run off.

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 project team in integrated design will have a clearly defined role and area of expertise for which he or she will be responsible and from which he or she will inform the project design. Adopting these roles can create advocacy for certain design solutions. Again, this exercise mimics the practice of integrated design in real life.

In integrated design practice, the range of stakeholders includes the owner, the various designers and engineers (structural; civil; heating, ventilation, air-conditioning, and refrigeration [HVAC&R]; plumbing; electrical; and energy engineers), the builder and contractor, specialty consultants (daylighting, energy, sustainable design, and commissioning consultants), building users and operators (Figure 1-3).

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

In a studio project, each team member should be assigned to traditional and basic roles, and each member should be responsible for documenting strategies and decisions.

Consider How Your Team's Design Project Will Address the Issues of the Site and Community

View the solutions to the project site, materials, energy, and air quality challenges as potential design elements, and set specific measurable goals.

For example, 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.

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 efficiency. Figure 1-4 shows a porous surface area that functions as a durable hardscape, but it also allows 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

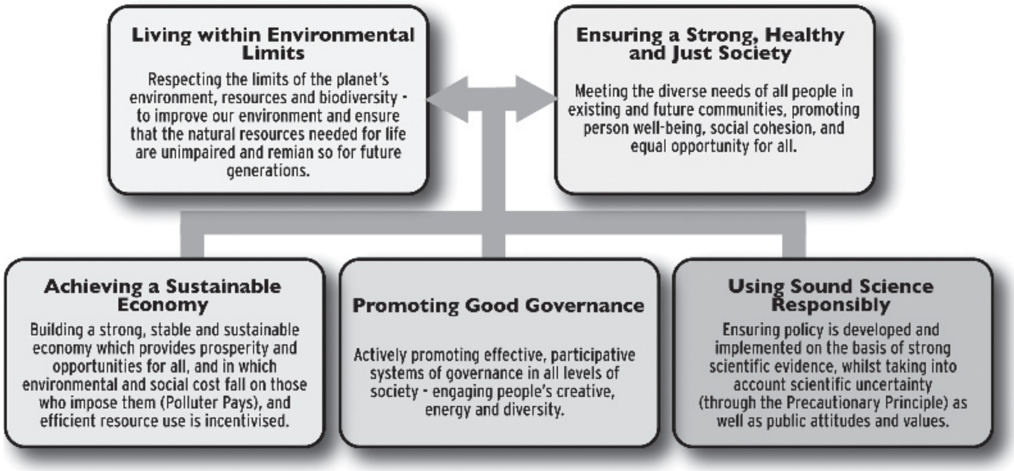


Figure 1-5 Three of five key points in the British sustainability plan concern social issues.

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 preserved 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 most recent sustainability plan, "Securing the Future—UK Government Sustainable Development Strategy,"[2] highlights social justice and inclusion as one of several key sustainable development themes (Figure 1-5).

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

Weigh Interrelated Impacts of Proposed Solutions

At this particular point in the process, it is typical 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.

For example, the team member responsible for energy analysis can point out that a building with daylight efficiency and harvesting technology, such as light shelves, could also have the potential for unwanted glare or heat gain.

[2] Available at the United Kingdom Department for Environment, Food, and Rural Affairs, http://www.defra.gov.uk/environment/sustainable.

The interior designer will recommend interior finishes, and this work will have a major impact on the quality of the indoor air. 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.

The project client may argue that some sustainable strategies carry with them a higher cost impact than others. A traditional design approach, which usually treats green design as an add-on, leads to higher costs. The integrated design approach typically requires higher design fees, but it can also lead to lower first costs and reduced operating costs. In professional practice, a life-cycle-costing analysis or pricing exercise may be conducted to weigh these strategies and assess their long- and short-term economic viability. Figure 1-6 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.

The client may say that unproven technology is not a risk they wish to pursue because of liability and the potentially unpredictable nature of innovative systems. What are the effects on design aesthetic? The green designer will argue that high-technology systems can lead to good design, but the views of the owner occupants and the community as to what constitutes good design need to be included as part of the integrated design process.

Establish Priorities

A troubling reality about the integrated design process is that there are no perfect solutions and that no project can achieve complete greenness, as we are defining the term in this book. But we can come close 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 a certain approach and direction, such as those identified earlier.

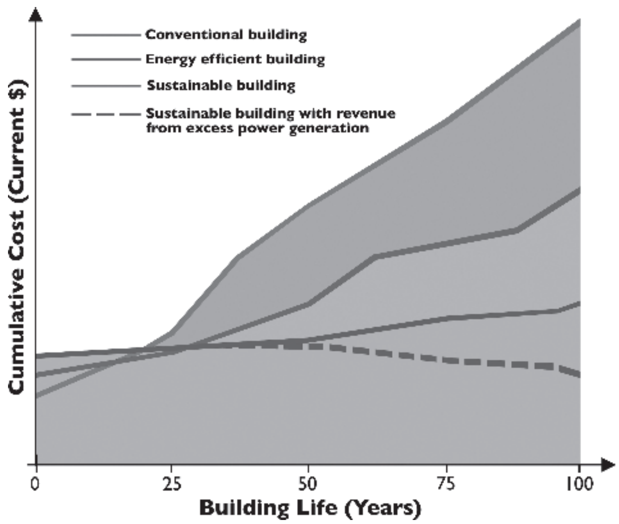


Figure 1-6 A life-cycle cost comparison of four building types: a conventional building, an energy-efficient building, a sustainable building, and a sustainable building with revenue from excess power generation. Cumulative costs of a building with energy-efficiency strategies and energy revenue are significantly lower, while a conventional building's costs rise steeply over time.

This is another area where team roles and the integrated design process come into play. Needless to say, at the end of all this, a final decision must be made. It is in this area that project design can fully benefit from an integrated design process and can reap the benefits of the various team members' shared expertise.

Take a Step Beyond

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 Building Design: Energy, Resources, and Air

Methodology and Tools of the Integrated Design Process for Energy

As discussed earlier in the chapter, integrated design is a process that recognizes the relationships among the many decisions made when designing a building. Early design decisions regarding the site and building orientation, building plan and section, and size and location of windows have a great effect on building aesthetics (Figure 1-7).

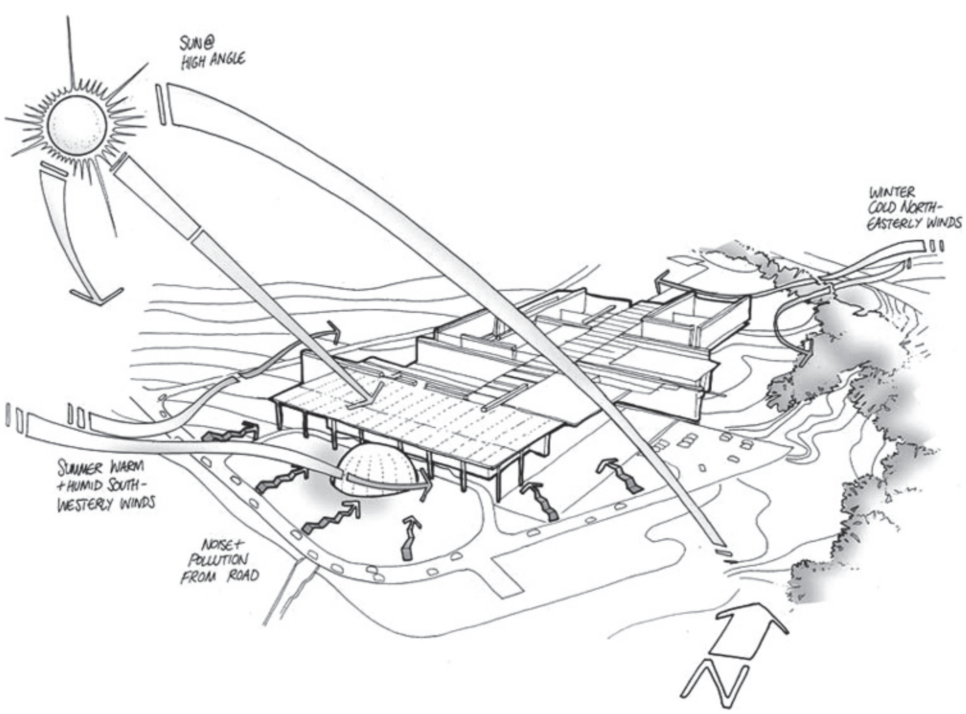


Figure 1-7 A sketch of the Istanbul Science Centre helps designers understand the site's wind patterns and the sun's path, which will then inform design decisions.

In many cases, the interrelationships of design decisions also determine how much energy a building will require to operate. In the integrated design process, a designer is conscious of a more complete set of impacts, including aesthetics, energy, environment, and occupant experience.

In the real world of architecture and design, integrated practice usually requires additional design time in the schematic phase. This is so that the architect, mechanical and electrical engineers, and other members of the team can ask questions, discuss options and their impacts, and model the energy and cost implications of the choices under consideration. (See Figure 1-3.)

Fundamental sustainability goals should be established early in design to set meaningful targets against which to assess options and level of achievement. The goals should specify a measurable and easily understood target for building performance rather than prescribe specific solutions.

As a student considering energy performance, you might establish a goal of reducing building energy use by 50 percent compared to the average energy use for buildings of that type in your region. Demonstrating achievement of your goal could vary from a simple list of low-energy design strategies you have incorporated to a simple energy model of your design made with easy-to-use software, such as Energy-10 or eQUEST (Figures 1-8A, B, and C). Getting some experience with computer tools that assess building energy performance prior to graduating should be a goal of all architecture and engineering students.

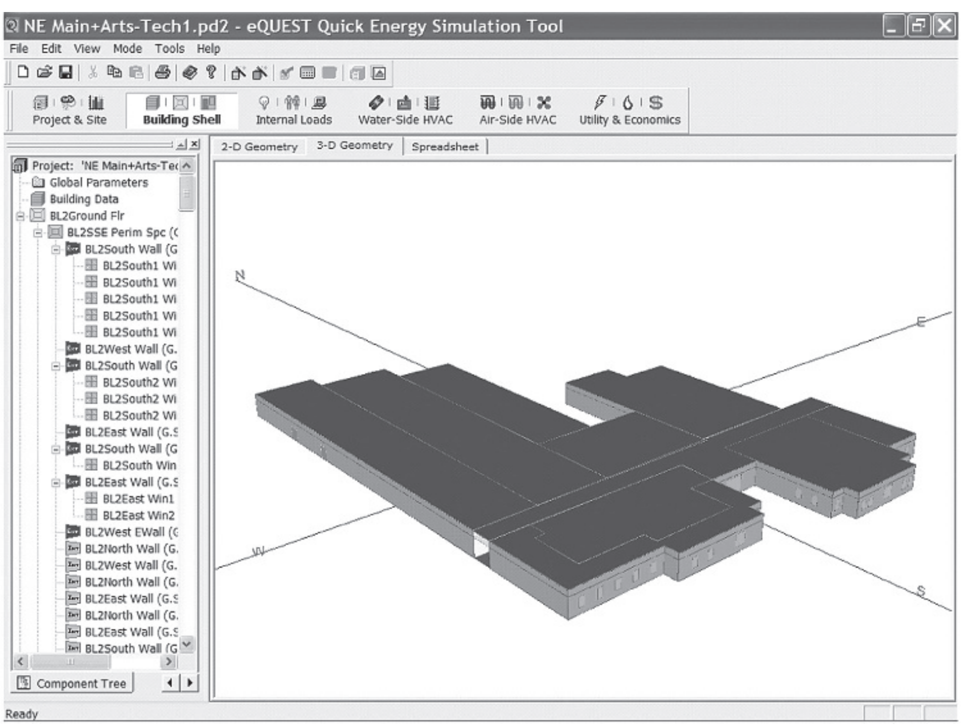
At the professional level, setting performance targets and assessing your design must be a more rigorous process. Many professional societies in the design professions have established standards for recommended practice.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has created an energy use standard known as ASHRAE 90.1, which is updated periodically; the most recent update is from 2007.

The State of California's *Title 24 Building Energy Standards*[3] set requirements for new construction and renovation projects in the state. Both ASHRAE 90.1 and California Title 24 requirements vary by region. Overall energy goals should reference such existing standards, for example, calling for energy performance 50 percent better than ASHRAE 90.1-2005 or California Title 24-2008.

At the professional level, it is important to model the options for informed decision making. This makes it possible to better understand interactions between building systems and between the other elements of sustainable design, such as material resource use and indoor air quality.

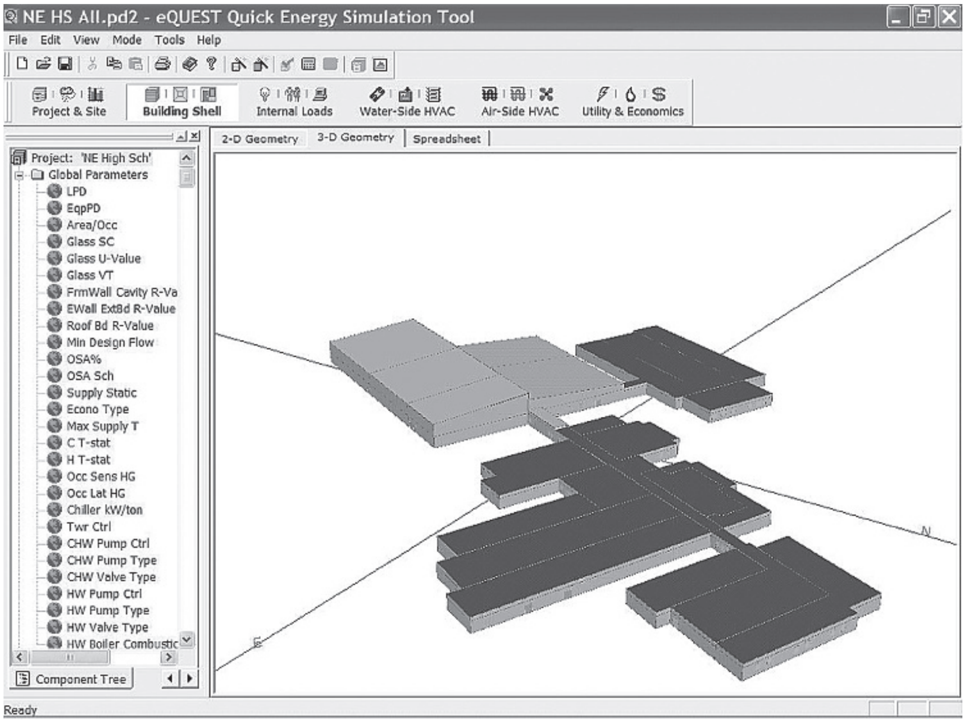
Whether student or professional, the goal should be to maximize efficiency of building systems, looking for complementary interactions that reduce waste—for example, using waste heat from one system to preheat inputs for another. At the professional level, this involves using high-efficiency equipment, sizing systems properly, and incorporating renewable energy once other systems have been optimized.



(a)

Figure 1-8 a–c Screenshots of the energy software eQUEST, available online at http://www.doe2.com/equest/.

[3] California Energy Commission, *2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings,* CEC-400-2008-001-CMF (Sacramento, CA: California Energy Commission, December 2008).



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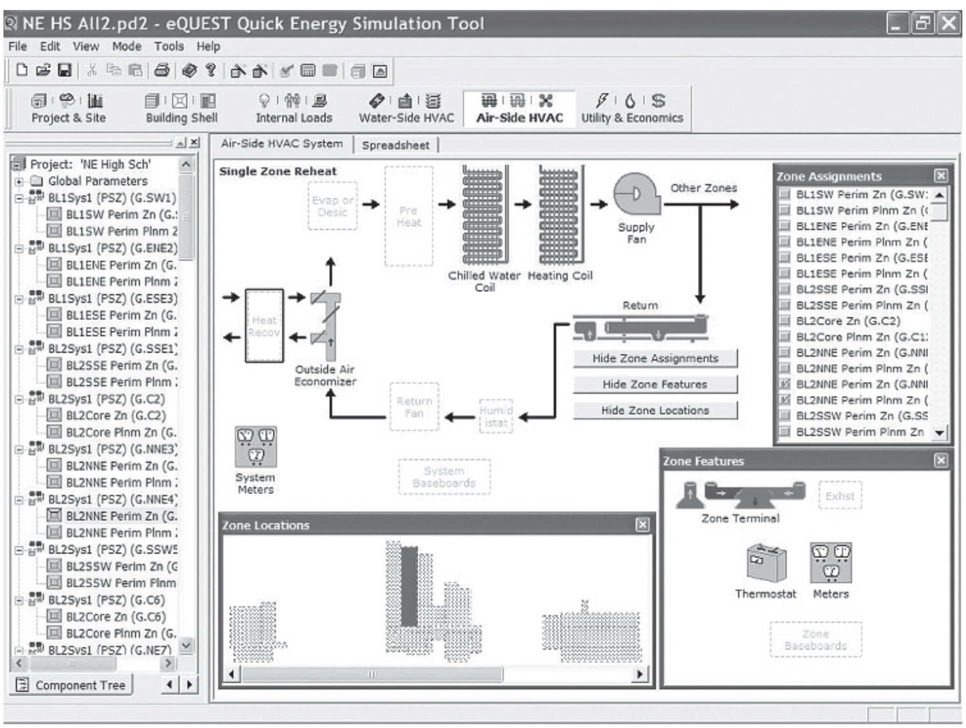

(c)

Figure 1-8 a–c *Cont'd*

Resources: Water and Raw Building Materials

As with all green 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).[4] So conscientious use of water and soils, as well as mined and harvested resources, is critical.

[4]N. Lenssen and D. M. Roodman, "Paper 124: A Building Revolution: How Ecology and Health Concerns are Transforming Construction," *Worldwatch* (1995),Worldwatch Institute.

Two keys to wise resource management require that you maximize their potential to increase effectiveness and efficiency and to reduce or entirely to "eliminate the concept of waste," as William McDonough and Michael Braungart proposed in *The Hannover Principles*.[5] 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, judiciously using their full potential.

The flip side of resource management is to understand natural balance and to avoid damaging interventions while extracting these resources. This is the moment that the troubling reality of integrated design becomes the opportunity to determine priorities, balance, and options. Figures 1-9 and 1-10 show the results of sustainable versus nonsustainable forestry practices.

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

On the local scale, as architects and designers, we can address these issues with a much smaller order of magnitude by designing sustainable buildings; this task is not only manageable but also meaningful in its cumulative effect.

Water

Buildings use 12.2 percent of all potable water, or 15 trillion gallons per year.[6]

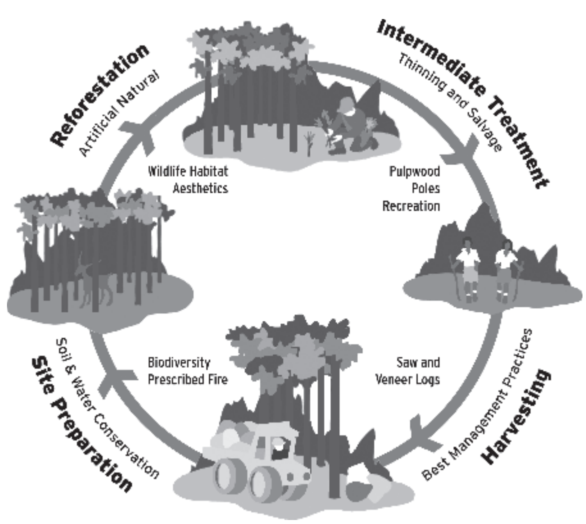

Figure 1-9 Responsible resource extraction techniques.

Figure 1-10 Destructive resource extraction techniques.

In the chapters that follow we will discuss specific strategies 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 1-11.

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. For purposes of integrated design, water conservation strategies revolve around *sewage conveyance, landscape concerns*, and *water sources*.

Sewage Conveyance. A green building can affect integrated design around water issues in a major way by reducing the potable water needed to manage human waste. Recycling gray water and black water are two potable water-conserving strategies (Figure 1-12).

Plumbing design, according to occupant demand, is another way to reduce potable water use. The approach 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 Concerns. 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:

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[5]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.
[6]United States Geological Service data (1995).

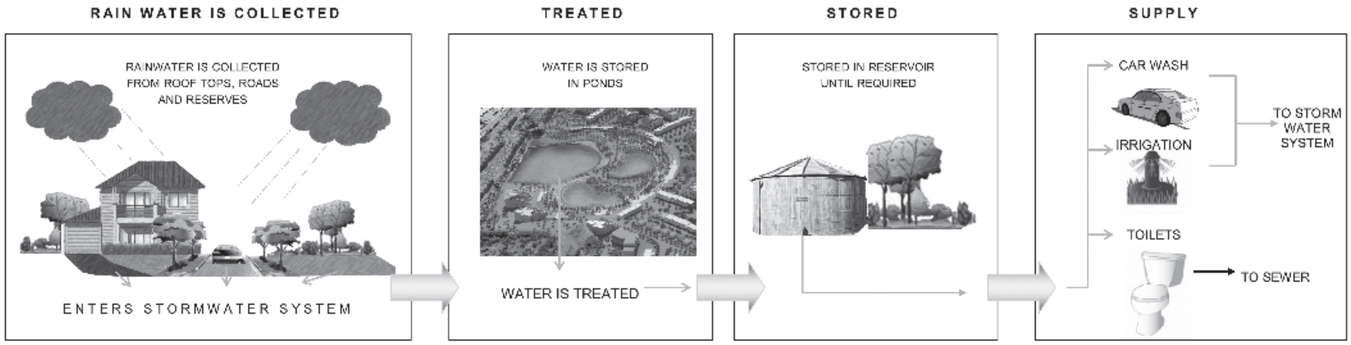

Figure 1-11 Rainwater collection system at the community level in New Zealand.

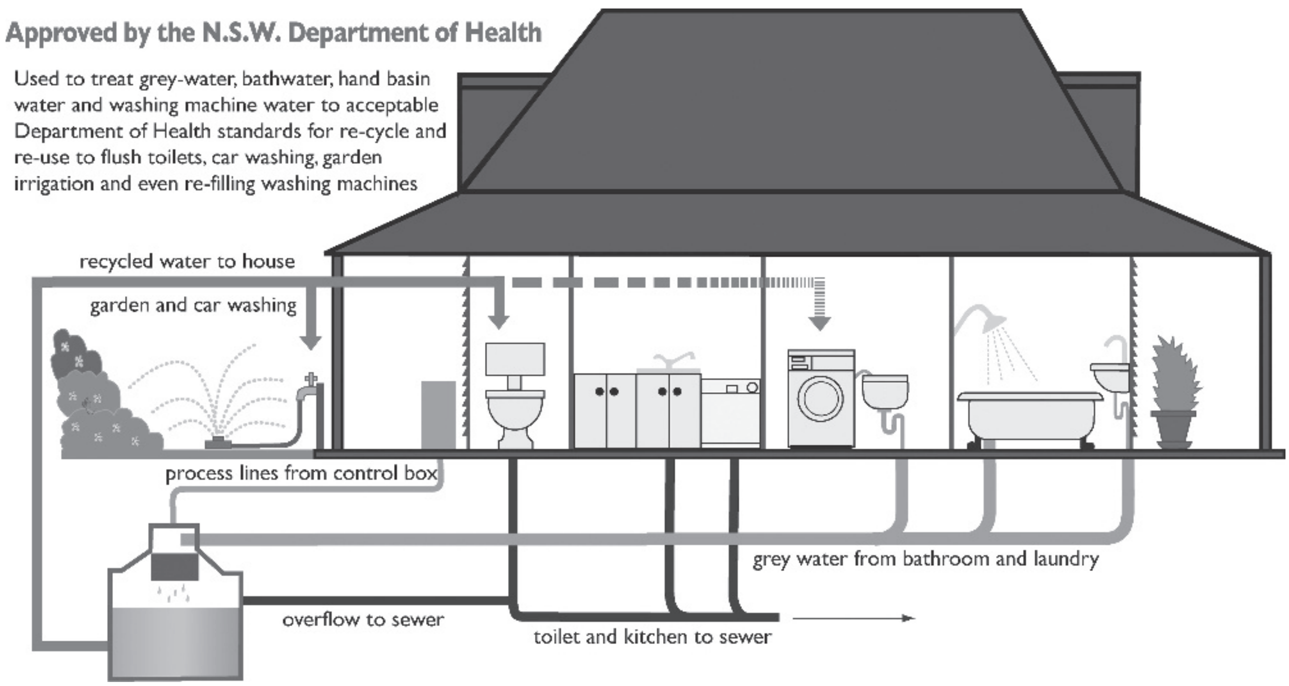

Figure 1-12 Gray water captured from bathtubs, showers, sinks, and laundering can be treated and reused to flush toilets and irrigate landscape.

- Planting types (climate adaptive, native species, xeriscape, monoculture avoidance)
- Irrigation systems
- Erosion control
- Storm-water management

Water Sources. 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 desalinization. Water control methods in use include the following.

- Rainwater harvesting and storage
- Black-water treatment, on-site and integrated into buildings
- Municipal gray water use
- Future technologies include desalinization and water recycling for potable use

Other 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 the chapters that follow, 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 yourself 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;
- embodied energy;
- recycled content;
- recyclability, reuse, and salvageability;
- waste production;
- closed-loop manufacturing process;
- durability and lifespan; and
- renewable or nonrenewable resource composition.

A materials assessment database and system like Pharos (Figure 1-13), which will be discussed in the green materials chapter, makes the job of researching the best environmental choices much easier.

Indoor Air and Environmental Quality

Indoor environmental quality refers to an abundance of issues relating to occupant comfort and quality of work or living space: temperature, humidity, glare, acoustics, access to daylight, the efficiency of air movement through occupied spaces, and the quality of the indoor air itself. Building occupants themselves can address many of these concerns, provided that building systems are creative enough to give people an 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. Bad IAQ is a problem on many levels, as described in Figure 1-14. 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 green janitorial program—are other ways of attempting to ensure ongoing improved air quality.

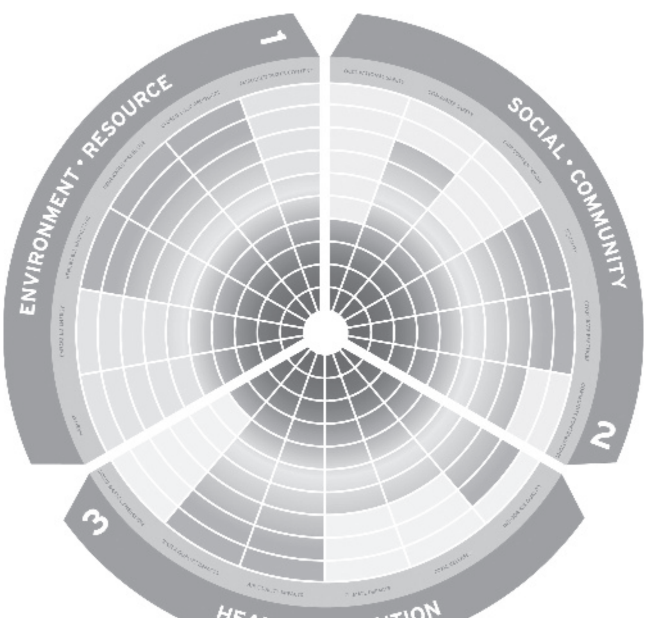

Figure 1-13 The Pharos "wheel" or "lens" illustrates three cores of sustainability: environment and resources; social and community; and health and pollution. It ranks materials along a visual scale within the lens.

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 1-14 Poor indoor air quality can have a number of negative effects.

After reading this chapter, you may come away with the feeling that integrated building design is all work and no play. But if you approach this unique design process as 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. Create a simple energy model with Energy-10, using a short list of energy-use assumptions.
4. 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?
5. How would the integrated design process differ for a high-rise tower and a private elementary school? What consultants would be involved for each?
6. Develop a schedule of regular team meetings around project milestones for your current studio project.