THE SOURCE OF SUSTAINABILITY:

INHERENT ENERGY SAVING FEATURES OF HISTORIC BUILDINGS

by

FRANCES LAUREN BRITTON

(Under the Direction of John Waters)

ABSTRACT

This thesis examines the need to reconnect with traditional construction methods in order to lessen our impact on the environment. A brief history of the green building movement is discussed, as well as the inherent energy saving features of historic buildings. Two case studies are presented as examples of these “green” features. As a result of this analysis, a number of recommendations have been developed. Finally, several examples of contemporary designs which implement these features are highlighted.

INDEX WORDS: Historic Preservation, Architecture, Climate Control, Waverly Mansion, Eleutherian Mills, Green building, Traditional architectural elements

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An Awakening

Recent Developments

In 1998, the *Wall Street Journal* featured a front page article about a new concept in commercial design.[1] The article describes a San Bruno, California building that allows employees to individually control the environment in which they work. Being aware of all of the technology that exists in today's "green" market, the reader envisions an advanced system for thermal comfort; one that reads internal body temperatures and adjusts each employee's office accordingly. Upon reading the headline, however, a much simpler innovation is revealed: "Windows that Open Are The Latest Office Amenity." The seemingly sophisticated report somehow becomes unimpressive. "When operable windows make news and set a design standard, we have reached an astonishingly low point in architecture," claims architect William McDonough. "Could we be any further from an architecture that sustains us and connects us with the natural world?"[2]

In recent years concern for the environment has taken hold at the forefront of American consciousness. The devastation of Hurricane Katrina in 2005 was recognized by many as a result, in part, of global warming. Former Vice President Al Gore released his Oscar winning documentary, *An Inconvenient Truth* the following year. According to a recent study, the United States is the leader in metric tons of carbon dioxide emissions per capita.[3] Efforts are being made to reduce that number. We are encouraged to switch from conventional incandescent light bulbs to the more energy efficient compact fluorescents. Grocery stores are offering a 10 per cent donation to local environmental organizations if shoppers carry reusable bags. Home appliances are plastered with bright labels to encourage the purchase of those which are Energy Star certified.

The conservation of energy has become a priority across a wide range of industries. In 1999, Honda released the first mass produced hybrid vehicle in the United States. The Insight, appropriately named, captured widespread media attention for its impressive EPA mileage ratings of 61 mpg city, 70 mpg highway.[4] The General Electric Company, which historically produces more greenhouse gases than most American cities, decided to adopt a new strategy of environmental responsibility. In 2006, the company launched an initiative to lessen its environmental footprint and expand its production of eco-friendly technologies—"from billion-dollar power plants to two-dollar compact fluorescent light bulbs."[5] One of the world's largest retailers, Wal-Mart, launched a $500 million program to adopt green business practices. Implemented in 2006, the plan proposed an increase in the efficiency of the company's vehicle fleet by 25 per cent over three years, with an added goal of reaching 50 percent efficiency within the decade. In addition, Wal-Mart proposed a 30 per cent decrease in operational energy usage in stores as well as a 25 per cent reduction in stores' production of solid waste within three years.[6]

The age-old farming industry is also going green. Dr. Carl Hodges has developed a system for converting desert terrain into arable farmland. The process, called seawater farming, begins with a single canal laid inland from the ocean. The salt water is moved inland through natural movement and a series of pumps. Once there, the water flows into “a secondary series of canals and lakes that become home to a flourishing aquaculture of fish, shrimp, and mollusks.”[7] Biological waste from the assorted marine life enriches the water with nutrients, effectively creating an excellent fertilizer for irrigating adjacent fields of salt-tolerant plants. In its final passage into “Earth's aquifers, it replenishes depleted wetlands, whose rejuvenated mangrove trees attract fish, birds, and other wildlife.”[8]

Clearly, a variety of industries are adopting cleaner, environmentally responsible practices. But perhaps the most significant and widely recognized sector of the movement is the building industry. According to a 2006 report by the Pew Center on Global Climate Change, buildings account for a staggering 43 per cent of U.S. carbon emissions.[9] Of that number, 76 per cent of total emissions are attributed to the generation and transmission of electricity used in buildings.[10]

What’s more, CO_2 emissions are expected to increase at an annual rate of 1.4 per cent through 2025.[11] These numbers are representative of the need for change in the building sector.

Modern technology has undoubtedly brought much progress in improving the energy efficiency of our built environment. But progress has come at the expense of our planet. Saws and axes have been replaced by machines, enabling lumber production to reach devastating highs. The damage is augmented by industries that process natural resources to manufacture materials such as steel and plastic, whose production releases harmful chemicals. A disconnect exists between building design and the larger ecosystem. Many modern buildings are conceptualized in terms of the efficiency of their operational systems instead of the environment in which they are placed. Technology and convenience have isolated builders from the environmental repercussions of their choices.

It has largely been believed that older buildings lack energy efficiency. They were constructed without the knowledge of modern technology and are therefore assumed to be obsolete. I would argue, however, that the opposite is true. Traditional builders were mindful of the environment. Historic architectural features were not merely decorative, as is often the case today. These buildings were designed with purpose: that they would work *with* the environment for the health and wellbeing of those who occupied them. Moreover, many of these structures served occupants with favorable air quality and thermal comfort without the use of electrical systems.

Another Perspective

The intent of this thesis is to reintroduce the innovations of historic structures, particularly those built before 1920, as part of the green building movement. The following chapters will explore the “greenness” of some long established building practices. The second chapter will outline the history of environmental awareness in the United States. Chapter three will address the various design elements that make historic buildings inherently green, such as siting, orientation, and architectural features. In addition, case studies of historic buildings will be utilized in order to demonstrate these ideas in practice. Finally, recommendations will be provided for green building professionals based upon long-established building practices that promote sustainable design.

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[10] *Ibid*.
[11] *Ibid*.

Chapter Two

The Modern Environmental Movement: A History

Early 1960s America experienced an awakening of the environmental conscience with the publication of a controversial book entitled *Silent Spring*. Marine biologist Rachel Carson accused the American people of the reckless use of synthetic chemicals to control insects. Widely used to kill malaria-causing insects in the South Pacific during World War II, DDT became available for civilian use in the United States in 1945. Carson referred to these chemicals as "elixirs of death" and described how they had infiltrated our environment: "For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals, from the moment of conception until death. In the less than two decades of their use, the synthetic pesticides have been so thoroughly distributed through the animate and inanimate world that they occur virtually everywhere."[1] She painted a bleak picture of a town in which springtime ceased to exist and all life—from birds, to trees, to humans themselves—had been "silenced" by the chemicals' damaging effects.[2]

The book was instantly successful in bringing environmental issues to the forefront of public discussion. It remained on the *New York Times* bestseller list for thirty-one consecutive weeks. It was included among such influential works as the Bible, *The Illiad*, and *Das Kapital* as one of the twenty-seven *Books that Changed the World*.[3] The book was met with widespread criticism from the chemical industry. Executives attacked Carson's credibility and even her sanity.[4] However, Carson's claims were well backed by fifty-five pages of notes and citations and a list of experts who had studied and accepted the manuscript.[5] The author maintained her position despite such powerful attacks. Shortly before her death in 1964, Carson appeared on a CBS documentary about *Silent Spring*. She remarked, "Man's attitude toward nature is today critically important simply because we have now acquired a fateful power to alter and destroy nature. But man is a part of nature, and his war against nature is inevitably a war against himself…[We are] challenged as mankind has never been challenged before to prove our maturity and our mastery, not of nature, but of ourselves."[6]

Silent Spring is widely recognized as the impetus for the modern environmental movement. The message was "that, at times, technological progress is so fundamentally at odds with natural processes that it must be curtailed."[7] The American public recognized the need to regulate industrial exploits in order to preserve the environment, and environmentalism was born.[8]

The uninhibited use of gasoline as a source for power in post-World War II America certainly exacerbated the environmental problems that the country was facing. But on October 16, 1973 the Arab-dominated Organization of Petroleum Exporting Countries (OPEC) froze the exportation of oil to the United States, Western Europe, and Japan. At the time, America did not realize how dependent it was on foreign oil.[9] But within a few weeks President Nixon asserted that the country was "heading toward the most acute shortage of energy since World War II."[10]

Energy efficiency became the top priority in America. The president called for air travel to be cut back by 10%, the lowering of speed limits on highways, the relaxation of environmental regulations affecting energy consumption, and executive authority to require special energy saving measures.[11] Nixon blamed the oil shortage on an era of extravagance after the war. He told a television audience, "We are running out of energy today because our economy has grown enormously and because in prosperity what were once considered luxuries are now considered necessities."[12] Oil usage had grown exponentially over the previous fifteen years. Americans consumed 9.7 million barrels of oil per day in 1960. By 1974, the figure reached 16.2 million barrels.[13]

The president's response to the problem was to endeavor to make the country completely independent of foreign oil by 1980. Nixon opposed conservation efforts and called for "the rapid development of coal production and the proliferation of nuclear reactors."[14] Conservationists were outraged, criticizing Nixon's disregard for the environment. The opposition warned of the destruction of the American countryside, the pollution of the air, and the dangers of exposure to radiation.[15]

In March of 1974, the Arab embargo was lifted and the issue of energy conservation faded from public view. The country promptly returned to their "high-consumption habits—relighting outdoor signs, avoiding mass transit, and violating the fifty-five mile per hour speed limits."[16]

Despite the lack of concern for dependence on foreign oil, Americans began to focus their attention on the vulnerability of the environment. It was a matter of great irony "that at the moment of [the country's] greatest achievement—the pinpoint landing of astronauts on the moon—human beings glimpsed just how unique and how vulnerable was the condition of the planet earth."[17] This concern launched a movement for the protection of the planet's non-renewable resources. The government responded with the passage of the National Environmental Policy Act of 1969.

The National Environmental Policy Act (NEPA) mandated that "all government agencies file environmental impact statements on virtually every public project and placed the burden of protecting the public interest on the government."[18] In 1970, a Council on Environmental Quality was created to oversee the fulfillment of NEPA's requirements. In addition, the council was required to prepare an annual report addressing and setting forth recommendations concerning the condition of the environment. Several pieces of legislation followed, including the Federal Water Pollution Control Act of 1972, the Resource Conservation and Recovery Act of 1976, and the strengthened Clean Air and Water Acts of 1977.[19]

After the passing of environmental initiatives crisis the green building movement was impeded by public complacency. While the environmental movement in many other countries progressed steadily, the eighties in America was a period of consumption and excess with little regard for environmental costs. Architecture responded to societal trends and design widely reflected a contemporary style—"a throwback to the idea that buildings could and should be built the same regardless of place, climate and culture."[20] In addition, it was discovered that the supposed energy conserving design experiments of the seventies also produced “sick buildings.”[21]

Nonetheless, the late eighties did experience one of the most significant advancements in the green building movement. In 1987, the United Nations World Commission on Environment and Development published *Our Common Future*, a report that discussed the environment and development as a single issue. Also known as the Brundtland Report, this document was the first to clearly define sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”[22] It also recognized that the “various global 'crises' that have seized public concern, particularly over the past decade...are not separate crises: an environmental crisis, a development crisis, an energy crisis. They are all one.”[23]

The Brundtland report laid the groundwork for change in the 1990s. In 1991, the American Institute of Architects formed its first Committee on the Environment. The Rio Earth Summit in 1992 compelled people from all over the world to reassess the condition of the environment. One of the movement’s most significant advances was the vision of two men, David Gottfried and Mike Italiano. They proposed a more inclusive committee of “representatives of all aspects of the profession, including engineers, builders, landscape architects, interior designers, academics, industry reps and architects.”[24]

United States Green Building Council and LEED

In 1993, the United States Green Building Council (USGBC) was created out of the American Institute of Architect's Committee on the Environment. This visionary group came together with the aim of transforming "the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life."[25] Its membership is comprised of a wide-ranging group of individuals as proposed by Gottfried and Italiano. The organization promotes buildings that embody the "Three Es:" ecology, economy, and equity; that is buildings that are "environmentally responsible, economically profitable, and healthy places to live and work."[26]

The USGBC's membership echoes the country's public awarness of environmentally friendly construction. In the years following its creation, membership experienced a slow and steady growth from sixty-one members in 1996 to 268 members in 1999. At the turn of the century, however, membership to the organization grew exponentially from 570 members in 2000 to nearly 12,000 in 2007.[27]

One of the primary goals of the USGBC was to develop a standard against which a building's level of sustainability could be measured. The organization wanted to be able to clearly measure and define "green buildings."[28] They began looking at existing building rating systems and eventually formed a committee exclusively dedicated to this end. The result of much research and discussion, the LEED (Leadership in Energy and Environmental Design) pilot program, version 1.0, was released at the USGBC Membership Summit in August of 1998.[29] The pilot program underwent several revisions and modifications until the organization was ready to take version 2.0 public in March of 2000.[30] The rating system, as defined by the USGBC "is a voluntary, consensus-based, market driven building rating system based on existing proven technology. It evaluates environmental performance from a whole building perspective over a building's life cycle, providing a definitive standard for what constitutes a 'green building.'"[31]

This first program focused on new construction and substantial rehabilitation projects; however, since its creation the LEED program has developed into several categories including homes, commercial interiors, core and shell, healthcare, retail, schools, existing buildings, and neighborhood development (currently in its pilot phase).[32]

Under LEED for New Construction (LEED-NC), buildings are given points based on performance in six categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation in design.[33] Buildings are certified if they earn a minimum 26 points. Ratings are awarded according to the number of points earned: certified (26-32 points), silver (33-58 points), gold (39-51 points), and platinum (52-69 points).[34]

The LEED Rating system has gained worldwide recognition as the standard in green building. Bob Berkebile, founding chairman of the AIA Committee on the Environment maintains that "no other tool has been as powerful in encouraging designers and builders to look at the environmental performance of buildings."[35] As of January 2008 there are 1,228 LEED certified projects worldwide.[36] There are over 9,000 projects that have been registered in each of the 50 states and in 41 countries.

The LEED system, however, is lacking in its application to historic properties. More than half of the existing building stock in the United States is older or historic.[37] Even so, as of August 2006, historic buildings accounted for a paltry 10% of LEED certified projects. Preservationists argue that LEED too narrowly defines sustainability. Many contend that today's green building standards "overlook the impact of projects on cultural value; do not effectively consider the performance, longer service lives, and embodied energy of historic materials and assemblies; and are overly focused on current or future technologies, neglecting how past experience helps to determine sustainable performance."[38]

From the onset it was recognized that LEED would be a process of evolution. In a 2007 statement to the Senate committee on environment and public works, the USGBC announced its intention to include Life Cycle Analysis (LCA) in its LEED version 3.0.[39] This system "evaluates the environmental impact of a product throughout its life cycle: from the extraction or harvesting of raw materials through processing, manufacture, installation, use, and ultimate disposal or recycling."[40] Although this would be a step in the right direction, LCA remains short sighted. Even the toughest LCA standards "ignore any after-use impacts other than demolition and disposal. What about restoration and renewal? Where is the work of preservation that gives buildings new life?" [41]

The idea of sustainability is understood to include three "pillars": Ecology, Economy, and *Equity*. While it is widely recognized that buildings should be environmentally responsible and economically profitable, it is equally important that they be socially equitable. This includes the "role that building construction and the buildings themselves play in fostering regional and local culture and traditions; supporting community life and the economy; and contributing to the texture and humanity of the built environment."[42] In the recent past, the focus of green building and sustainable architecture has been on new technology and innovative designs. It is the job of preservationists to bring historic buildings to the forefront of the discussion.

It has been said that "Man has no material other than his past out of which to make [his] future."[43] By studying the designs applied to historic buildings we make discoveries that are of practical use today. Historic buildings "represent not forms to be copied but principles to be understood." Traditional building methods and techniques have been refined over centuries of experience. Much mid to late twentieth century architecture represents a deterioration of architectural standards in terms of the environment. Many buildings of this period were designed with a disregard for the value of tradition and local climate--an "overestimation of the powers of technology."[44] The study of traditional design begins a process of education: understanding concepts that have been tested and proven by our ancestors; and using modern knowledge to refine those concepts for implementation in contemporary design.

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[2] *Ibid*.
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[11] *Ibid*.
[12] *Ibid*, 119.
[13] *Ibid*.
[14] *Ibid*, 122.
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[42] Andrew Powter and Susan Ross, "Integrating Environmental and Cultural Sustainability for Heritage Properties," APT *Bulletin: Special Issue on Sustainability and Preservation* 36, No. 4 (2005): 5.
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Chapter Three

The Inherent Sustainability of Historic Buildings

Embodied Energy and the Removal of Historic Material

Albeit cliché, it has been said that the greenest buildings are the ones already built. Over 200,000 buildings are being demolished each year, producing 124 million tons of trash. That amount of building waste could be used to construct a wall 30 feet wide and 30 feet thick around the entire coastline of the United States.[1] One major claim supporting the sustainability of historic structures is the value of embodied energy. The embodied energy of a building "is the energy used in its production and, eventually, its demolition. This includes the energy required to extract, process, manufacture, transport, and assemble materials, as well as the energy required for related equipment, services, and administration."[2] Many historic building materials have lower embodied energy levels than those of modern building materials. For example, the embodied energy levels of both lumber (5,229 Btu[3]/bd. ft.) and brick (13,570 Btu/each) are lower than the levels of more modern materials such as steel (21,711 Btu/lb.) and aluminum (90,852 Btu/lb.).[4] Still historic buildings embody great amounts of energy both in the initial effort to assemble them as well as the amount of energy it would take to replace them.

In 1976, the University of Illinois at Urbana produced a report called *Energy Use for Building Construction*. Based on construction data from 1967, the report reviewed the embodied energy of building materials, of some typical building assembles, and of new construction by various building types. The report was recognized by the Advisory Council on Historic Preservation as a research tool that could uphold its mission. However, the report raises some concerns for the preservation community. It is likely that these findings underestimate the corresponding embodied energy of older buildings. Two factors point to this conclusion: "older buildings often had more volume and greater amounts of materials" than newer ones.[5] In terms of volume, historic buildings often had greater ceiling heights than buildings of the mid-twentieth century. In terms of materials, historic construction utilized thick structural masonry walls rather than more modern masonry-veneer construction.[6] The report did not address the embodied energy of building processes used in the original period of construction. For example, the report claims that the typical embodied energy of a school building is 1,386,046 Btu/square foot. However, the differences between a school built in 1970 and 1910 are significant. In general, early 20th century schools were "multistory structure[s] with masonry load-bearing walls, terra-cotta tile floors, and wood roof framing."[7] A school building typical of 1970 would have more likely been a single story structure built of "concrete block with brick veneer, metal-bar joists, and concrete floor slabs."[8] A more recent study would more accurately demonstrate the importance of embodied energy.

In 1998, the University of Michigan performed a study that compared the total energy consumption of a new 2,300 square foot house with that of another hypothetical house that integrated energy saving design features. The study assumed a fifty year life cycle for both houses. It found that the energy-efficient house consumed only 37 percent of the energy consumed by the standard house, saving 1,598 barrels of oil over its lifetime.[9] Although the construction of the two homes involved roughly equal amounts of embodied energy (about 900-950 gigajoules), the embodied energy of the energy efficient house amounted to a much larger percentage of its lifecycle total energy use—16 percent compared to 6 percent in the standard house.[10] This finding is significant because it indicates that there is an opportunity for considerable energy savings by lowering a structure's embodied energy, even once it becomes occupied. A simple way to lower the embodied energy of a structure is to remodel an old house rather than build a new one. The cycle of the American housing market is far shorter than 50 years. Because people are not taking them to term, the average lifetime of a typical home mortgage in America is just 7 ½ years. In using the results of the study to asses embodied energy levels according to this cycle, "the embodied energy in an energy-efficient house built in 2007 will amount to about 60 percent of its total energy consumption by the time its owner is likely to move in 2014."[11] By 2027, it will still be 1/3 of the total energy use.[12]

Many environmental-benefit studies concentrate on operating-efficiency upgrades because they build up over time. The average ratio between total embodied energy and annual operating energy ranges between 5:1 and 30:1.[13] Because historic buildings typically use strong, resilient materials in large volumes, they will more often fall towards the higher end of the ratio. In the long term, improving operational efficiency by 10 percent will increase energy savings more than by lowering embodied energy by the same amount. Nonetheless, the equation changes when a building is renovated and its embodied energy is saved.[14]

Table 3.1 shows a comparison between new energy efficient construction and an existing building in three situations. Scenario one illustrates the energy required to construct a new building. Even when no energy is spent tearing down an old building, it will take over thirty years before any cumulative energy savings is realized. The second scenario shows the energy required to demolish an old building. Despite the fact that some of the materials were reused, the energy spent by tearing down and building anew will not be offset for fifty-seven years. The third scenario shows that it would take over fifty years to realize energy savings in a new building compared with an existing building which was renovated. In each scenario, the comparison shows that even highly efficient new construction has a significant payback period before any energy savings is realized. The practice of tearing down buildings and building anew is in direct contradiction with the principles of sustainability.

TABLE 3.1: LIFE CYCLE ANALYSIS COMPARING EMBODIED ENERGY AND OPERATING ENERGY BETWEEN REUSE OF AN EXISTING BUILDING AND CONSTRUCTION OF A NEW BUILDING, ILLUSTRATING THE TIME IT TAKES BEFORE A NET ENERGY SAVINGS IS ACHIEVED

These three scenarios all point to the fact that reusing an existing building and making it more energy efficient results in an immediate savings of total energy use. If building new, no net savings of total energy are achieved until a future date that can be greater than the life expectancy of many new buildings.

Scenario 1: Do nothing to the existing building and build a new building. The existing building will remain and be used by a different user. The new building will be designed to meet Energy Star standards of operating efficiency.

- Embodied energy 1,200 MBtu/sq.ft. for the new building (mid-range value)
- Existing building operating energy at 70,000 Btu/sq. ft.
- New building operating energy at 35,000 Btu/sq. ft.

34.2 years before any life-cycle energy savings is achieved

Scenario 2: Demolish the existing building with partial salvage. Construct new office building to meet Energy Star standards.

- Embodied energy: 1,200 MBtu/sq. ft. (existing)
- Embodied energy: 1,200 MBtu/sq. ft. (new)
- Embodied energy: - 400 MBtu/sq. ft. (salvage)
- Total Embodied energy: 2,000 MBtu/sq. ft.
- New building operating energy at 35,000 Btu/sq. ft.

57 years before any life-cycle energy savings is achieved

Scenario 3: Renovate existing building, improving its efficiency by 30 percent, although not meeting Energy Star performance standards. Construct new building to meet Energy Star Standards.

- Embodied energy: 400 MBtu (rehab)
- Operating energy: 50,000 Btu (rehab)
- Embodied energy: 1,200 MBtu/sq. ft. (new)
- Operating energy: 35,000 Btu/sq. ft. (new)

53.3 years before any life-cycle energy savings is achieved

Source: Mike Jackson, “Embodied Energy and Historic Preservation: A Needed Reassessment,” APT Bulletin Vol. 36, No. 4: Special Issues on Sustainability and Preservation (2005).

Inherently "Green" Historic Architectural Features

Before the introduction of mechanized climate control and electrical systems, buildings were built with the intention of maintaining a level of comfort for those who lived and worked within them. In the past, builders and craftsmen integrated climate-appropriate architectural features into buildings. Largely until World War II, "working in sync with the environment was the norm, including siting, local materials, natural ventilation, shading, clean energy (e.g., mills), reflective roofing, cisterns, indigenous plantings…the list becomes long. . ."[15] The Energy Research and Development Administration has undertaken numerous studies which indicate that "the buildings with the poorest energy efficiency are actually those built between 1940 and 1975."[16]

By taking advantage of traditional building techniques we are able to decrease our dependence on systems powered by fossil fuels and make a lasting impact on the environment.

Siting and Orientation

Traditional builders considered a structure's orientation at the onset of construction. They considered nature and population density when choosing a site. Historic buildings utilize the natural features of their sites in order to control daylighting and shade, heat and coolness. Vitruvius wrote of the importance of this in his *De Architectura*: "There will also be *décor* of nature in using eastern light for bedrooms and libraries, light from the southwest setting of the sun for baths and winter apartments, and northern light for picture galleries and other places in which a steady light is needed."[17] In the Northern hemisphere, southern sunlight can be available over an entire day during the winter and can be shaded without difficulty during the summer.[18]

Historic landscape features helped maintain a comfortable climate. Trees were planted so that they provided shade in the summer while allowing heat from the sun's rays during the winter. According to some studies, planting trees around buildings offers enough shade to reduce cooling requirements by up to 30 per cent.[19] Also, permeable materials were used for historic paths and driveways. This is beneficial in terms of storm water runoff. Impermeable surfaces allow pollutant-carrying runoff to enter surface waters. On the contrary, porous surfaces permit water to infiltrate gradually, with little runoff.[20] Some examples of porous materials used historically include crushed oyster shells, cinders, paving bricks, and gravel.[21]

Sprawl

In the recent past, our communities have been hurt by the negative effects of sprawl. Sprawl encroaches upon farmland and open space. During the 1990s, the Atlanta metropolitan area grew from 65 miles north to south in 1990 to over 110 miles by the end of the decade. In some estimates, 50 acres of Atlanta area forests per day were lost to development. This loss of open space is a national phenomenon. According to one Department of Agriculture official, an estimated 2,000,000 acres of farmland are developed every year.[22]

Sprawl also increases our dependence on vehicular transportation. Sprawl causes homes and jobs to be long distances from one another. This type of anti-pedestrian development leads to a sedentary lifestyle. According to a Department of Transportation study, the average American spends 72 minutes behind the wheel each day. With one of the lowest population densities in the country, Atlanta residents drive an average of 34 miles every day- the highest per capita rate in the United States.[23] Older historic districts are walkable and decrease reliance on automotive transportation. Historic areas typically mix uses, with lower building floors designated for commercial and retail use and upper floors for residential. Furthermore, historic buildings tend to be closer to one another than in sprawling developments. Limited distances between home and the places where we work, shop, and play encourage transportation by foot. In addition, historic districts often have sidewalks lined with street trees, separating pedestrians from automotive traffic. This creates a safer, more pedestrian friendly environment.[24] The result is a decreased reliance on vehicular transportation and decrease in needless air pollution from automobiles.

Sprawl increases energy expenditures. Sprawl requires new streets, street lights, schools, and water and sewer lines. When we create new development, we pay higher taxes in order to provide these things for sprawling communities, abandoning the infrastructure within the city that we have already paid for. Historic preservation encourages the use of *existing* infrastructure, thus reducing the need for new public utilities.[25]

By maintaining and rehabilitating historic downtowns and village centers, communities can develop civic facilities and cultivate engaging environments. Density increases the opportunity for multiple methods of transportation. By reusing existing historic buildings, communities not only preserve local character, they also conserve energy that would be put into the erection of new buildings. Infill development also avoids the cost, both socially and environmentally, of development on local farmland.[26]

Building Materials and Thermal Mass

For the most part, traditional builders utilized natural and local materials in construction. Modern transportation allows today's builders to use materials from all over the world. Technology has introduced materials that are made of synthetic chemicals, some of which emit toxic fumes. The excessiveness with which today's building materials are selected is illustrated by a well known resource, the *Sweet's Catalog*. This annual "compilation of building-material manufacturers' literature occupies three feet of shelf space and summarizes a virtually infinite number of materials, colors, finishes, devices, and pieces of equipment in all sizes and scales. [Most] of these products are unnecessary, are poorly constructed, differ only in surface treatment, or are designed to perform a specialized function that never should have been used in the first place."[27]

Many modern metals and plastics have an enormous impact on the planet because of the methods used to process them. For instance, polyvinyl chloride (popularly known as PVC) is a modern material that is widely used for piping, siding, and windows. Although it is durable, recycling PVC is problematic. Also, its “production and incineration generate carcinogenic dioxins, vinyl chloride monomers, and other pollutants.” [28] Another problem with modern materials is their effect on indoor air quality. Many “bonding and drying agents in carpets, veneers, particle board, plywood, and petroleum based paints emit health-threatening volatile organic compounds.” [29]

Historic buildings are constructed of natural materials, such as wood, stone, and brick. These materials are renewable, easily found locally, and usually less expensive than synthetic ones. Of course, there are environmental costs with using these materials. Brick must be fired, stone quarried, and wood harvested. Still, the durability of these materials allows them to last longer, increasing the amortization period. They are also organic, and do not release any harmful chemicals. Perhaps most importantly, natural materials are easily recycled. Traditional builders had an “understanding of material behavior that has been lost and supplanted by construction techniques that are faster and require less skill.”[30]

Historic wood is an infinitely greater resource than modern wood. First of all, historic wood is typically old growth wood. Its annual rings are closer together making it much denser than modern wood. It is more rot and insect resistant and by extension more durable. Modern wood is often treated to make up for its lack of natural resistance to external threats; however, preservatives used on wood are often "laden with heavy metals" and vary in toxicity.[31]

The building materials used in historic structures played a role in the passive heating and cooling of those structures. A green building should be "carefully balanced to reduce excessive solar heat when the weather is hot, whilst fully utilizing solar radiation when the weather is cold."[32] Traditional builders considered this principle in material selection. The measurement of a material's ability to hold heat or coolness is called thermal mass.[33] Materials with an ideal thermal mass have "a high heat capacity, a moderate conductance, a moderate density, and a high emissivity. It is also important that the material serve a functional (structural or decorative) purpose in the building."[34]

Modern construction techniques do not generate much thermal mass. Building lightness was considered a desirable quality in industrial-era designs by designers such as Buckminster Fuller and Mies van der Rohe.[35] Although it has an ostensibly high potential for heat storage, steel does not have good thermal mass. This is because of its low emissivity which shows that "a large majority of the incident radiation is reflected, rather than absorbed and stored."[36] Because steel is a highly conductive material, it has "an ability to quickly transfer heat stored in the material's core to the surface for release to the environment."[37] This cuts the storage from hours to minutes. Glass has a low thermal mass because it "is relatively transparent to near infrared radiation and reflective of far infrared radiation."[38]

Masonry materials such as brick, stone, stucco, adobe, and earth all have a great capability for heat storage. Masonry walls of one to three feet in width were often used in the construction of historic buildings. This type of construction mitigates large fluctuations in temperature from day to night. In hot or humid climates, materials with a high thermal mass will store "internal heat gains which are flushed out at night by using natural ventilation or fans."[39] In cooler climates, high-mass materials absorb and maintain heat within the structure and release it at nighttime, thus mitigating lower temperatures. A high thermal mass improves insulation, decreasing our reliance on mechanical heating and cooling systems.

Roofing Materials

Historic roofing materials also have environmental advantages to modern ones. Historic materials such as slate and tile typically last longer than those used in today's buildings. Furthermore, historic roofing materials do not readily absorb heat as modern materials do. Many homes are roofed with dark asphalt shingles that absorb the sun's heat and reduce energy efficiency. Wood shingles, used historically, are poor conductors of heat and therefore do not create heat gain through absorption. The reflective quality of metal roofs, used on many late nineteenth century commercial buildings, also helps in the reduction of heat gain. The durability of historic roofing materials is also significant. Tile and slate roofs generally last three times as long as contemporary asphalt shingles. Durable materials increase the amount of time to offset initial environmental and economic costs.

Historic Windows

Traditional builders were very thoughtful in determining the nature of openings in the building envelope. Window size, design, and orientation were all considered in determining how to best take advantage of environmental conditions for thermal comfort. It is common in modern construction to use fenestration decoratively. Today, windows are often inoperable and situated according to aesthetics instead of functional utility.

The size of windows has much to do with energy efficiency. Even the most technologically advanced windows are "many times less effective as insulators than walls."[40] In northern climates, windows are generally smaller. They were built only large enough to allow adequate day lighting and ventilation. By decreasing the size of windows the builder increases the area of insulating wall space in cooler climates. Historic buildings often have a ratio of glass to wall below 20 per cent while some modern buildings' ratio is almost 100 per cent.[41] On the contrary, windows were made larger in warmer climates, especially when shaded by deep overhangs or porches. Larger windows in southern buildings allow maximum ventilation, cooling interior rooms while increasing indoor air quality.[42]

Window placement and construction were both major considerations in historic buildings. Windows were oriented to take advantage of the sun and wind, used for heating, day lighting, and ventilation. Window type was also thoughtfully considered in traditional buildings. Often windows with operable sashes were used historically to ventilate buildings.

Figure 3.1 *The historic window on the left . (Source: John Leeke, National Park Service) has operable sashes that enable building occupants to passively ventilate the building. The modern window on the right(Source: Glengrove Windows) is fixed, meaning it cannot be opened. Building occupants are forced to rely on electricity for ventilation and cooling*

Ventilation in historic buildings was important both for the improvement of air quality and for heating and cooling internal environments. Windows were situated to maximize the use of wind. The greatest results are achieved when the wind hits from a perpendicular or oblique angle. "As air flows around a building, it causes higher pressure zones on the windward side and lower pressure zones on the leeward side. The most effective cross ventilation occurs when the inlets are placed in the higher pressure area and the outlets in the lower pressure zones."[43] Window openings in opposite walls create higher wind speeds. Window openings in adjacent walls encourage both turbulence and air mixing. As a result, a more even velocity distribution and cooling effect exists throughout the room. Operable sash windows offer control over wind movement through the building. When some openings are high and some are low then higher wind speeds will occur in the "occupied zone" (usually one to six feet from the floor).[44]

Another feature aimed at taking advantage of the wind is the transom window. Transom windows were placed over both interior and exterior doors in order to stimulate wind movement for cooling and air quality. A 1912 magazine article emphasizes the importance of such a feature: "Bedrooms should have transoms over the doors opening into the halls so as to permit of cross-ventilation. With the doors of the first floor rooms generally open and the transoms just referred to from the bedrooms opening into the second and third story halls, we secure an important ventilating factor if the well of the stairway is heated and carried to a vent at the roof. Transoms over the doors on the first floor opening to the outside make excellent inlets for fresh air."[45]

Some traditional buildings implemented splayed window openings to take advantage of daylight. This feature is commonly found in early masonry structures because of the thickness of the walls. Artificial light expends around 25 per cent of a building's operational energy.[46] Many studies have revealed that "natural light is the best type of light for the human eye, and that proximity to windows improves well being."[47] Splayed window reveals allow more light to enter than square cut openings.[48] This is not only because the effective opening is larger than in a square window, but also because it allows "reflecting light striking at an angle into the interior."[49] Splayed window reveals are more efficient because they take advantage of daylight without experiencing the thermal loss of a larger window opening.[50]

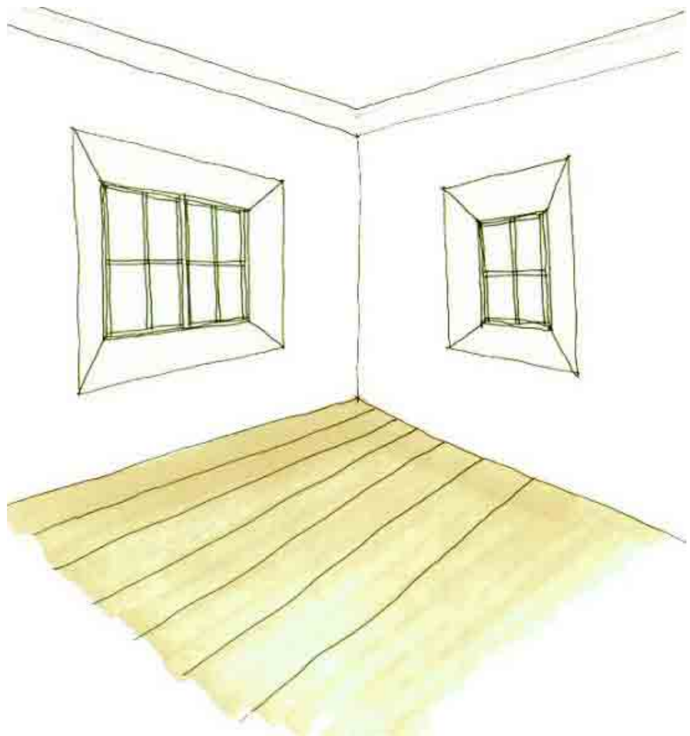

Figure 3.2 *Splayed window opening*
(Source: Sustainable Housing Design Guide for Scotland).

The Removal of Historic Windows

Many "green" builders maintain that historic windows account for significant energy loss; however, the opposite is true: Replacement windows are often installed when original windows become drafty or broken. These problems can easily be fixed by installing internal or external storm sashes. This fix retains the original fabric while improving the U-value of the windows.

Often original windows are unnecessarily replaced with modern ones, destroying the building's historic character and adding refuse to ever-growing landfills. In assessing the embodied energy and life cycle analysis of historic windows, we find that replacement windows are not as environmentally sound as some would have us think.

A homeowner in Boulder, Colorado applied for a certificate of appropriateness to paint his window sash and trim. The landmarks commission granted approval the same day. Two weeks later the commission learned that he had violated the local ordinance by replacing his historic windows with new ones. The process was carried out by a contractor who claimed to be "Boulder's greenest contractor." He maintained that he used ecologically sensitive techniques to complete the project.[51]

The commission ordered that the original windows be saved and that their condition should be documented. Boulder's greenest contractor argued that "the greater energy efficiency of the new windows should outweigh the regulations that apply to houses within the historic district."[52] The commission's ruling garnered support by the city council. Sadly, a local reporter decided to take on the issue himself. He "went to the house, picked up the historic windows, took a sledgehammer to them, hauled them to the dump, and arranged to have a bulldozer run over them."[53]

In this case, the diesel fuel used to run the bulldozer that destroyed the windows consumed more fossil fuel than would be saved over the lifetime of the replacement windows.[54] Such shortsighted actions undoubtedly stall the progress of the green building movement. For a number of reasons, the removal and destruction of historic windows counters the values of a sustainable community.

For many reasons, removing historic windows does not make sense. For starters, the overwhelming majority of heat loss in homes is through the attic or uninsulated walls, not windows. Putting up "3 ½ inches of fiberglass insulation in the attic has three times the R factor impact of replacing a single pane unit with no storm window with the most energy efficient window."[55] Despite claims of longevity, 30 per cent of the windows being replaced each year are less than ten years old.[56] According to a study conducted by a professional engineer, a low-e glass double pane thermal replacement window has a payback period of over 220 years.[57] Many historic windows are made of old growth timber, a scarce resource in modern society. To dispose of this fabric is the same as cutting down trees in old growth forests.[58]

Energy conservation is a key motivation for keeping original windows in place. To retain the original windows in a structure is to avoid wasting their embodied energy. Furthermore, it eradicates the energy expenditures required in new window production. Materials commonly used in replacement windows, such as aluminum, vinyl, and new glass, contain high levels of embodied energy.[59] Figure 3.2 illustrates the fact that replacement windows actually have a lower U-value than would a historic window with a storm window. In addition, it shows that the payback period of replacements can extend beyond the life of the window.

TABLE 3.2: COMPARISON OF WINDOW-IMPROVEMENT STRATEGIES IN ANNUAL ENERGY SAVINGS AND PAYBACK PERIOD

Window Improvement Strategy	U-Value	Cost	Annual Energy Savings	Payback Period
Storm window over a single-pane original window	0.50	$50	722,218 Btu	4.5 yrs.
Double-pane thermal replacement of single pane window	0.58	$450*	625,922 Btu	40.5 yrs.
Low-e glass double-pane thermal replacement of single-pane window	0.35	$550*	902,772 Btu	34 yrs.
Low-e glass double-pane thermal replacement of single-pane window with storm window	0.35	$550*	132,407 Btu	240 yrs.

* Cost of 3' x 5' window, installed
(Source: Keith Haberern, P.E., R.A. Collingswood Historic District Commission)

Environmentally, the costs of replacement windows are great. The removal of historic windows and the manufacture and transportation of new ones require unnecessary energy expenditures.[60] Furthermore, many replacement units are made of vinyl and PVC, whose production is known to generate dioxin and several other toxic chemicals.[61] Also, the disposal of the original units adds refuse to our ever growing landfills. Finally, repairing historic windows is economically sustainable. The work required to restore windows creates strong, vibrant local economies. Almost twice as labor intensive as new construction, restoration projects put more money into the workforce instead of building materials.[62] The money goes back into the local economy instead of going to a remote manufacturer.[63]

Shading Devices

Historic buildings use working shutters, awnings, and deep overhangs to maintain thermal comfort. Shading devices were traditionally used both for cooling and insulation. They also protect the interior from the elements while allowing ventilating breezes to pass through.

Deep overhangs were used historically in order to shade buildings from the sun's rays. In the Northern hemisphere, a horizontal overhang above a southward facing window can provide complete shading from April to August while permitting solar penetration from October to February. Deep overhangs also provide partial shading for eastern and western facing windows. In fact, fixed horizontal overhangs are more effective on eastern and western windows than vertical shading devices, such as shutters.[64]

Unlike modern shutters that have been reduced to aesthetic elements, working shutters are environmentally-sensitive devices that were historically used to cool buildings. Shutters can be operated to either keep out or give access to solar radiation. When closed, they capture the sun's rays before the rays hit the window glazing. Louvered shutters closed over an open window allow fresh, cool air to enter, cooling the interior while improving indoor air quality. Proper daylighting is maintained as the interior collects "the striped light of louvers."[65] They can also absorb solar radiation that is being reflected from the ground. Operable external shading devices can lessen "solar heat gain through windows. . . down to about 10 to 15 [per cent] of the radiation impinging on the wall."[66] Shutters can also considerably lower heat loss through windows. Solid or plank shutters, when closed, create insulating airspace between the shutter and the window. Furthermore, they close off the building envelope maintaining internal temperatures.[67] Although simple in design, working shutters "do almost everything with the sun, the wind, and the rain that we could hope for in sophisticated electronic technology."[68]

Figure 3.3 *The historic window on the left .*
(Source: Newport Preservation) has operable louvered shutters.
The modern shutters on the right(Source: Shawnee
Shutters) are bolted to the house.

Porches, Courtyards, and Verandas

Porches, courtyards, and verandas were used historically for shade and increased air circulation. Furthermore, they offer habitable outdoor spaces; an extension of the home into the outdoors. They also can increase the surface area of a building to allow room for more openings such as windows and doors.

Porches work to maintain comfortable temperatures during both the summer and winter months. They were designed to open up the indoors to the outdoors. The principal benefit of porches is "shading the high summer sun from the walls of a house while allowing the lower winter sun to penetrate to the walls."[69] Porches also allow windows to remain open regardless of weather conditions. Building occupants could maintain systems of passive cooling and ventilation even when it was raining. Finally, they offer a cooler place to carry out normal household activities.

Similarly, courtyards serve as outdoor living spaces where building occupants can enjoy sunlight and fresh air. But courtyards were also traditionally used for both daylighting and thermal comfort. Courtyards allow greater surface area to place window and door openings. The purpose of this is twofold: daylighting and ventilation. Buildings that have a central courtyard take advantage of the sun's natural light rather than relying on artificial light sources. Courtyards or light wells are often implemented into office buildings for this purpose. Furthermore, by increasing the number of window and door openings, building occupants increase wind velocities and improve the cooling effects of cross ventilation.[70] Courtyards can also stimulate air movement by the "stack effect." This occurs when hot air rises through the courtyard and is replaced by cooler air below. The courtyard serves as a ventilator shaft, allowing "hot air to be expelled as it is warmed by the sun during the day, and to allow cooler night air to sink and pass into surrounding rooms after dark."[71] Courtyards are used optimally in warm climates with low humidity. Dry climates experience cooler nighttime temperatures optimal for the stack effect. Such advantages can also be achieved when other historic elements are employed. Traditional features such as "cupolas, skylights and clerestory windows helped to dissipate heat and provide healthy ventilation."[72]

Our culture has become obsessed with the "new and now," showing a complete disregard for the legacy of our forbearers. Much of the focus of the green building movement has been on new innovations and technologies rather than the simple but effective strategies of the past. Contemporary architects should look to the past and implement historic building features in green design.

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CHAPTER FOUR

HISTORIC GREEN BUILDINGS

The following examples aim to demonstrate the responsiveness of historic buildings to environmental conditions. Both examples are historic buildings in which climate control features are implemented into the design. Both structures were built prior to the invention of modern HVAC systems, causing them to rely on architectural features for thermal comfort. It has been estimated that climate-sensitive design could decrease heating and cooling energy use by "70 per cent in residential buildings, and total energy use by 60 per cent in commercial buildings."[1] The following case studies illustrate ways in which elements of historic architecture could be used to lessen the environmental impact of buildings.

The Waverly Mansion: West Point, Mississippi

The Waverly Mansion is located in the hot, humid climate of West Point, Mississippi. Constructed in 1852 by Colonel George Hampton Young, this building utilizes a four story central atrium and cupola to passively cool the interior. In 1996, two students in the School of Architecture at Mississippi State University tested the effectiveness of this system. They performed extensive tests on temperature changes and air movement under various situations.[2]

The Waverly Mansion was designed to respond to environmental conditions. Because of the humid climate, residents of Mississippi had to take advantage of building techniques that work to lower internal temperatures. One way to provide thermal comfort in such an environment was to increase air movement. In order to promote passive cooling, early builders designed a house plan that was responsive to the humid environment. First recognized in the late eighteenth century, the dog trot form employed a natural method of cooling.

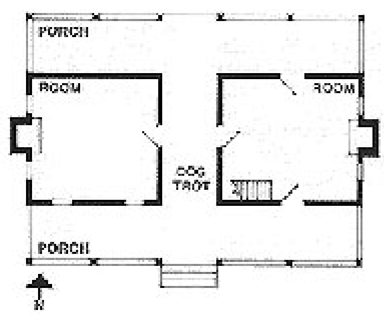

Figure 4.1 *Typical dog trot plan.*
(Source "Waverly Mansion Passive Cooling: Past and Present")

Traditionally, the dog trot house is characterized by two houses connected by a central passageway. The central passageway provided adequate shade and ventilation from summer sun. When situated to the south, "the dog trot house maximizes its potential by taking advantage of the prevailing southerly winds."[3] Improved ventilation and thermal comfort were achieved when winds hit the house, "creating a pressure differential and increasing air speed between the two rooms."[4] Waverly's plan shows the influence of the dog trot in Mississippi.

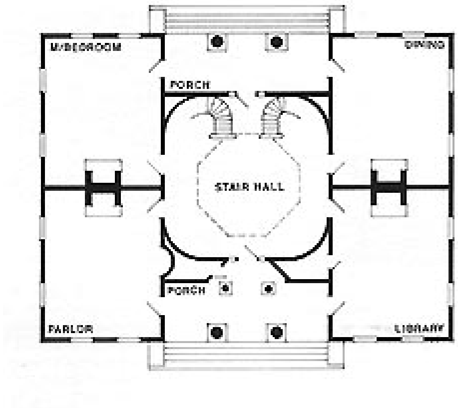

Figure 4.2 *Plan of the Waverly Mansion*
(Source "Waverly Mansion Passive Cooling: Past and Present")

Waverly has several features that are used to passively cool its interior. Because it is raised off the ground, the mansion promotes convective cooling. The use of porches allows residents a habitable outdoor space that is protected by shade. Shutters allow breezes to pass through while protecting the interior from both the sun's heat and rain. Great ceiling heights permit hot air to rise above the home's living space. Finally, the architect applied elevated openings on interior walls. As hot air rises, these vents allow escape, pulling cooler air inside.[5]

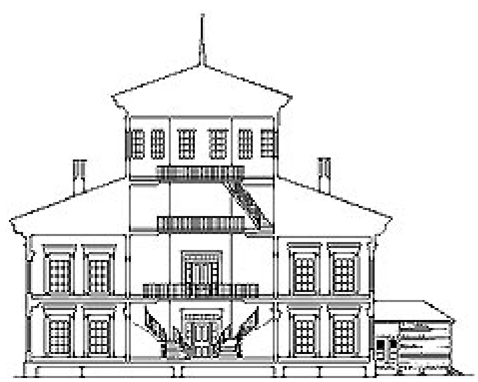

Figure 4.3 *Waverly Mansion, Section.*
(Source "Waverly Mansion Passive Cooling: Past and Present")

While each of these techniques aid in the cooling process, perhaps the most important is the ceiling height of the central atrium: an astounding 52 feet. This design feature allowed hot air to rise to the top of the cupola by way of a natural process known as thermal buoyancy. The cupola was designed with 16 operable windows so that, when opened, the hot air could escape. This allowed cool air from the outside to be drawn into the living spaces on lower floors. All of the living spaces were oriented to the east or west of the central atrium. Each was equipped with operable windows or doors on three sides, creating a system of cross ventilation throughout the building. Interior doors also contained transom windows which permitted air flow even when doors were closed.[6]

Since its original date of construction, several modifications have been made to Waverly's passive cooling system that could affect its efficiency. A concrete wall has been constructed on the building's south side, disrupting the convective cooling that would occur in its absence. The transom windows throughout the house have been painted shut and are therefore inoperable. A number of shutters have been lost, leaving some windows exposed to direct sunlight. One northern exterior door is inoperable. Seventeen of the forty-eight original windows have been either painted or nailed shut. The students constructed a ½" = 1' scale model of the home so that they could test the system in its original form, with operable transoms, windows and doors. The material used for the Waverley model was 1/8 inch thick foam core board. Plexiglass was used for the cupola roof so that activity within the model's atrium could be observed. In order to provide access to interior doors and transoms, the model was built in three pieces. Hot glue and tape were used to seal all of the joints. The students compared results taken from the model with tests conducted under the mansion's current conditions.[7]

The students measured indoor and outdoor temperature away from direct sunlight. They also measured relative humidity. These measurements were taken every half hour from 12:30 p.m. to 4:30 p.m. They also constructed paper pinwheels and hung them on each floor in order to determine air movement. Air movement was monitored in the mansion under four conditions: (1) all exterior openings closed, all interior doors open; (2) southern exterior door opened, all other exterior openings closed, all interior doors open; (3) all operable windows, doors, and transoms open; (4) only operable cupola windows open, all interior doors closed.[8]

In testing the model, the students used ¼" x 2" streamers made out of tracing paper throughout, with a box fan set on low to simulate wind. Streamers were placed outside of all exterior doors and windows and inside on each floor of the atrium. The model was tested under five conditions: (1) all exterior openings closed, all interior doors open; (2) southern exterior door opened, all other exterior openings closed, all interior doors open; (3) all openings which are currently operable on the actual building were opened; (4) all interior and exterior openings were opened; (5) only cupola windows were opened.

The study concluded that hot air did rise to the cupola. The results were similar in both the actual building and the model: when the building envelope is closed off, there was little to no air movement. However, by opening all operable openings in the building, air movement greatly increased proving that cross ventilation played a role in passively cooling the mansion. Similar results were found when all windows, doors, and transoms were opened in the model.[9]

Eleutherian Mills: Wilmington, Deleware

Named for Eleutherèe Irenèe DuPont, Eleutherian Mills were constructed on the west bank of Brandywine Creek just north of Wilimington, Deleware in 1802-1803. The buildings were successfully used as gunpowder mills through the nineteenth and early twentieth centuries. The original house, built in 1803, was modest in size and ornament. The building had only a few Federal design features such as a central elliptical staircase. Its simple Georgian central hall plan followed the tradition of many eighteenth century American country houses.[10]

The home's eastern façade, however, was remarkable. Situated on the highest elevation of the property, the three story façade is in full view from the river. The design implemented a two story classical portico, likely designed by Peter Bauduy. Bauduy was a Santo Domingan shareholder in the company who was "influenced by the West-Indian practice of providing breeze-catching verandahs and deeply shadowed cellar arches."[11] This façade illustrates the building's initial response to climate and site. The kitchen and work areas were placed on the lowest floor which was built into the cool earth of the cliff and shaded on its exterior wall by the lower porch. Combined with the breezes moving up the creek, these conditions kept the area cool. At the same time, its eastern orientation let in the illumination of the morning sun.[12]

The original design also featured louvered exterior shutters which allowed the passage of wind while protecting from the heat of the sun. It is assumed, although not documented, that louvered doors were also implemented into the design. The plan is suggestive of this because it is formed around a "central entrance hall terminating on the piazza, providing a perfect breezeway from front to back."[13] Although these features were fashionable, their use in lessening "heat gain and promoting cooling ventilation" is significant.[14]

The house was in a state of consistent renewal for much of the early nineteenth century. It was damaged by explosions in the powder yards in 1817, 1818, 1821, 1834, and 1837. In 1847 significant damage was caused by a particularly large explosion. Subsequent plans to enlarge and rework the entire house were put into place in 1853. The new design included a new roof deck and attic, an increase in size of 40 per cent on the first and second floors and 100 per cent on the lower floor area and the third floor [15]

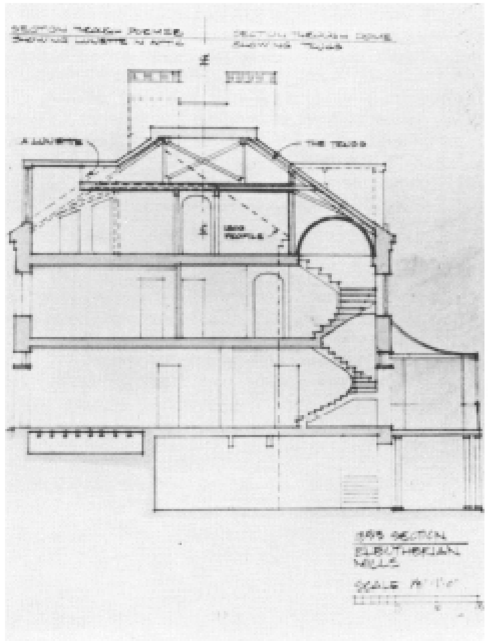

Figure 4.4 *1853 Improvements; the dotted line represents the original house. (Source "An Early Victorian Passive Solar System")*

Like the original, this design was climate responsive. Windows, shutters, and doors were manipulated to take advantage of cross ventilation and the "stack effect" throughout the day. For example, convection currents "were created from low on the cool side of the house across and up to high on the warm side in the morning and then reversed in the evening."[16] The warm air of the attic and cooler air of the basement were also utilized for thermal comfort.

Figure 4.5 *Lunette windows installed in the attic. (Source "An Early Victorian Passive Solar System")*

One particularly innovative feature of the 1853 design was included to promote ventilation in the attic. Small semi-circular windows, glazed and screened, were placed behind each of the third floor's six dormer windows. Each was installed about 6 feet in and just above ceiling height. The lunettes serve several purposes. First, they provide borrowed light for the attic. They also served to ventilate the attic. They were likely "closed during the winter nights to retain the heat accumulated below the roof during the day," while the dormer windows were left partially open to promote the circulation of fresh air.[17] During the summer "they would probably remain open to prevent the building up of hot air in the attic."[18] Perhaps most important is the likelihood that the lunettes actually stimulated ventilation throughout the rest of the house. The process is as follows:

> "A siphon effect [is] created by the movement of air up from the river valley, over the roof and simultaneously through the attic. Room partitions on the third floor would prevent the free flow of air from the front to the back, but in the attic there were no such obstructions. The warmest air on the upper floor would have been drawn off from each room at the dormers, and an updraft would be created at the top of the stair well, thereby serving the rest of the house as well."[19]

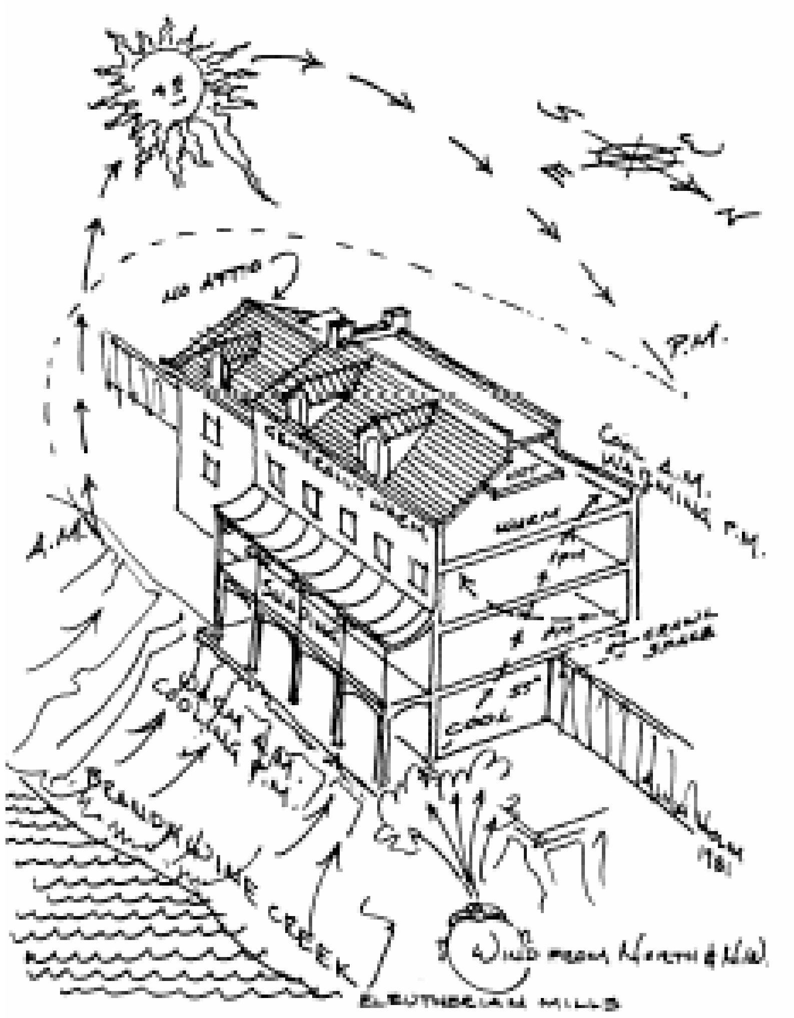

Figure 4.6 *Schematic drawing of air movements.*
(Source "An Early Victorian Passive Solar System")

The stack effect that exists to a certain extent in any stair well is enhanced at Eleutherian Mills. One reason is the placement of a dormer window "near the half-dome at the top of the stairs."[20] This feature allows "rising warm air to be directly vented."[21] Comparable to the Victorian practice of installing an operable skylight above the stair well, this promotes the chimney effect. Another reason is that "any breeze through the lunettes creates the siphon effect at the top of the stairs."[22] Finally, the "contribution of solar heated air from the attic to the top of the stack" produced a great disparity in temperature that subsequently generates the rising air current and the "concomitant intake of cooler air from the lower levels."[23] Various rooms may be included or left out of the system simply by opening or closing interior doors. It must be noted that rooms included in the system must also keep windows open in order to provide supply air; otherwise there will be no draft.[24]

The E.I. DuPont House benefited from a system of cross ventilation as well. Double hung sash windows permitted control over the speed of air movement. Greater wind velocity reduces humidity and augments the cooling effect. Wind speeds may be increased by maintaining a smaller input opening than output area. The 1853 renovations left the building plan more open to a system of cross ventilation than did the original. While both plans are two rooms deep, the earlier design featured solid partitions. In contrast, the 1853 plan promoted airflow between rooms by installing operable doors. This allowed "cross draft from east to west and vice versa."[25]

Some features help maintain a comfortable temperature year round. The 1853 design included the addition of a vestibule in the main hallway. This feature was "intended to reduce the heat loss and draftiness during the cool months."[26] Likewise, this element also served to keep cool air in during the warmer seasons. The building, made of stone, has a high thermal mass which holds the heat gained from sunlight during the day and slowly releases it by night. During the warmer months, this material is slow to heat up.

High retaining walls surround the ground floor terraces, creating "reservoirs for exterior air."[27] The northern terrace remains cool. Not only is it exposed to the wind, it is shaded by trees, the retaining wall, and the house itself. The southern terrace remains warm. The retaining wall shields it from the wind while it receives more intense sunlight. These two areas of warm and cool can be drawn into the house, serving the previously mentioned systems of ventilation.[28]

The orientation of the building is also climate responsive. It is sited in such a way as to receive "the cool updrafts from the river to penetrate the house along its long dimension and through its narrowest width."[29] The home's smallest elevations are situated to the extremes of hot and cold. The northern façade faces the winter winds while the southern façade fronts the heat of the midday sun. The building is surrounded by large deciduous trees which offer shade during the summer and permit necessary sunlight during the winter.

This historic home presents a fine example of how early Americans designed *with* climate. They implemented passive systems of thermal comfort. The early technology seen in the E.I. DuPont house serves as a lesson to modern builders and architects: that historic buildings address our future as well as our past.

What these examples reveal, in summary, is the simplicity with which designers can build green. By thoughtfully considering placement and size of openings, relationship to the site, and implementation of functional design elements, we can lessen our impact on the planet. Both the Waverly Mansion and the E.I. Dupont House at Eleutherian Mills are models for sustainable development. This section is limited in that only residential structures are examined. Further research on historic climate responsive features in commercial buildings would present a more thorough analysis.

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CHAPTER FIVE

BACK TO THE FUTURE

Today, architects are looking to the past to design for the future. Le Corbusier once said that "the house is a machine for living in."[1] But perhaps the visionary architect was misguided in his approach to design. Many modern designs disregard the relationship between the building and the environmental system that it occupies, while focusing instead on the energy efficiency of operational systems. Our culture has "adopted a design stratagem that essentially says that if brute force or massive amounts of energy don't work, you're not using enough of it."[2] A leader in the green building movement, William McDonough contends that modern glass buildings "are more about the building than they are about people. [These designs] used the glass ironically. The hope that glass would connect us to the outdoors was completely stultified by making the buildings sealed."[3]

One problem is the demand for structures that are "bigger and better." The average middle class home jumped from 1,710 square feet in 1982 to over 2,100 square feet in 1993; this despite the fact that the size of the average family decreased.[4] The modern market values appearance and form; luxury is mistaken for necessity. As Gopal Ahluwalia of the National Association of Home Builders explains, "everybody wants a media room, a home office, and exercise room, three bathrooms, a family room, a living room, and a huge, beautiful, eat-in kitchen that nobody cooks in."[5] Those qualities that remain unseen are largely ignored. This encourages the industry to take shortcuts on important features such as energy efficiency and durability.

As a result of this analysis, a number of recommendations have been developed. The building industry should adapt methods from the past to contemporary green design. Table 5.1 addresses these recommendations.

As buildings have become more complex, the industry has become more specialized. Where traditional structures were typically built by a few workers with generalized knowledge, modern construction employs a virtual army of laborers; each with their own area of expertise. Today's jobsite is teeming with architects, engineers, contractors, subcontractors, building inspectors, plumbers, electricians, and roofers (to name a few). Each individual fills a role; each is integral to the success of the project. But among the seemingly countless workers exists a separation. It is often the case that each individual is concerned solely with the task at hand, showing little regard for how his duty may affect the next. This affects the tasks of those workers that come after. Work is performed in reaction to the jobs previously carried out. Designers often "set key parameters—such as shape, location of windows, and amount of lighting—without concern for how their decisions can substantially affect energy use down the road."[6] This lack of foresight is not without consequences. In order to compensate, the engineer will recommend the installation of a larger heating, ventilating, and air conditioning (HVAC) system, and "the opportunity for savings is lost."[7]

TABLE 5.1: RECOMMENDATIONS	
1. Participate in an integrative design process.	Employ a skilled workforce that understands the building as a complex network of individual systems. Promote communication among various members of the building team. This results in a more efficient use of building materials and decreases dependency on modern HVAC systems.
2. Forego mass produced building materials for more durable, natural materials.	Use natural building products and employ skilled craftsman. This results in the long-term amortization of environmental and economic costs. In addition, using natural building products reduces the emission of harmful chemicals and volatile organic compounds.
3. Create climate responsive designs that relate to their surroundings.	Consider orientation, placement of openings, and historic architectural features in building design. This reduces reliance on electricity and climate control systems.
4. Consider rehabilitating existing historic buildings.	These buildings were made to work for those who occupied them. They were designed to maintain a comfortable indoor environment without the use of HVAC systems. With rehabilitation, the amount of construction waste is drastically reduced and the building's embodied energy is retained.
5. USGBC should design a LEED rating system for historic buildings.	LEED(HB) would encourage contemporary designers to draw inspiration from traditional designs. Furthermore, it would promote the re-use of old buildings.

Historically, building construction was viewed in terms of the building as a whole. Builders approached design as an arrangement of interrelated systems, each one affecting the next. They also considered how to best take advantage of site and climate conditions. Because fewer workers were present, communication over such issues was facilitated. It would be unreasonable to suggest that fewer people should be present on a construction site. The complexity of modern design necessitates a workforce of many. A more unified design process should be implemented; a method that recognizes the building as a whole and its relationship to its surroundings. An "integrative design" process fosters open communication and promotes awareness of the connections between the various phases of construction. This would help each individual on the project team recognize the building as a system, as traditional builders did.

To a great extent, new construction lacks the quality and durability once valued by traditional builders. Traditional craftsmen had a profound understanding of the behavior of materials, and this knowledge is manifested in historic buildings. In an effort to lower costs and increase production, modern industry has sacrificed quality by using shoddy materials and unskilled labor. Although it is difficult to prove that modern buildings are of a lesser quality than historic ones, one analysis of post-storm damage suggests that modern workmanship must be re-examined. In 1992, the southeastern region of Florida was devastated by Hurricane Andrew. Over 100,000 homes were damaged and another 25,000 were completely destroyed.[8] Upon surveying the damage, a curious finding was revealed: older homes suffered less damage than those more recently built. Researchers concluded that "low quality construction, faulty designs, and flimsy materials . . . all played a role in the severity of the damage."[9] Analysis of post-Katrina damage in 2005 produced similar findings. A majority of roofers in the Gulf Coast region were found to be unlicensed and unregulated. In a report by the National Institute of Standards and Technology, poor installation was cited as a principal cause of roof damage. Even more exasperating, it was discovered that roofers making repairs after the storm were doing so in the same substandard manner.[10]

One of the key components of sustainable building is durability. The longer a building lasts, the more time it has to amortize the economic and environmental costs incurred in construction. New construction in the United States is often found to be of a lesser quality than is found in historic buildings. It is integral that the construction industry reintroduce high quality craftsmanship as essential to building durability. Technology has "largely replaced craft with a zeal for speed and an assembly-line mentality."[11] By some reports, 95 per cent of new homes in the United States include some factory assembled components. Such elements are typically manufactured in "high-volume assembly lines, staffed by low-wage, unskilled workers."[12] Rarely do such materials meet the "exacting dimensional standards" required to make homes "airtight and energy efficient."[13]

This is not to suggest that the industry should discount technology in the name of craftsmanship. However, machines should be used more carefully, enabling skilled workers to increase production of quality building components. The building industry in Sweden has struck a balance between technology and tradition. Known as “factory crafting,” the Swedes have established a system that places “high-technology equipment” in the hands of skilled craftsman. In essence, “they are hand building a house, but doing in with high technology in a factory so they can do it quickly.”[14] Utilizing semiautomatic tilt tables to suspend wall panels in place, building craftsmen can quickly and effectively add features such as framing and insulation. This enables workers to focus on “doing what they do best and bring craft back into their work—painstakingly making parts fit well—without raising costs.”[15] In this way, the Swedish building industry has appropriately fused modern convenience with longstanding craftsmanship.

Today, buildings are often constructed without consideration for context. Historic buildings were planned in response to the availability of local materials and the inconsistency of local climate. Neither seems to be a consideration in new construction. In 1937, Le Corbusier proclaimed, “I propose one single building for all nations and climates.”[16] It seems that the industry has followed. Buildings are no longer constructed one at a time; instead, uninspired designs of entire neighborhoods or shopping centers are built quickly in order to maximize profit. These types of developments often bear no relationship to their site and are unresponsive to local climate. No environmental consideration is given to orientation or regional style. The industry is driven instead by property lines and construction costs. Such impractical designs require the installation of high energy mechanical systems to maintain comfortable temperatures and adequate ventilation.

Perhaps the most significant way to lessen the environmental impact of buildings is to implement climate-sensitive designs. It has been estimated that approximately half of the energy used in building construction and operation is used for creating artificial indoor climate. This includes systems of heating, cooling, ventilation, and lighting.[17] There is great potential for energy savings in designs that use natural forces to create similar comforts. Contemporary designers should place value in the designs of the past. Studying historic buildings enables industry professionals to gain an understanding of concepts that have been tested and proven over thousands of years. Using modern knowledge to refine those concepts, we can lessen the damage that buildings cause our planet.

Furthermore, developers are encouraged to take advantage of such inherently sustainable features by rehabilitating historic buildings. By reusing these resources, construction energy and refuse are diminished significantly. Buildings constructed before the invention of air conditioning and electricity lessen dependence on modern energy systems. Finally, rehabilitation promotes the retention of a building's embodied energy.

These recommendations would enhance the built environment by lessening its impact on the planet. This is not to say that the industry should regress into a world without electricity or modern amenities, but appropriate technology should be integrated with historic building forms. Designs from the past should be used not as templates to be copied, but as examples to learn from. Industry professionals should take from them the established principles of green design and use them in a modern framework.

Finally, the USGBC should work to create a LEED rating system for historic buildings. LEED is extraordinary in its "ability to remind us of what we have forgotten, as builders and communities."[18] Its very origins are found in traditional building practices. But the relationship between historic buildings and sustainability is often overlooked. A LEED system for historic buildings would give traditional architecture more attention, and perhaps encourage contemporary designers to take notice of the precedents set forth by traditional buildings. A LEED-HB certified project would serve as an example for contemporary green designs. It would make contemporary designers aware of the building techniques and innovations from the past.

Today, many architects are building green by taking a traditional approach to contemporary design. One example is the firm Weber + Thompson of Seattle, Washington. This firm finished construction in 2007 on a new building that uses a system of passive cooling. Among other things, the design features operable windows and no air conditioning.

The building plan is square with a central courtyard, ensuring proper airflow. Each of the four floors is narrow, only about 35 feet wide. During the warmer months, hot air "will collect in the courtyard and rise, pulling air out of the building's courtyard windows and creating cross-breezes inside."[19]

In addition, courtyard windows have operable external shading devices which absorb the sun's rays and retain heat outside of the building. The roof of the building is painted with a reflective light-colored compound. Windows on the east and west facades, which receive the most sunlight, are also equipped with external shading devices that "filter out heat and ultraviolet radiation outside."[20] Finally, the building itself is constructed of poured concrete instead of steel. Poured concrete has a greater thermal mass than that of steel.[21]

Figure 5.1 *Weber + Thompson Building, Seattle, Washington, 2007. A central courtyard stimulates the "stack effect" to increase ventilation. (Source:Weber + Thompson Architects)*[22]

Architect Frank Harmon also draws on the past in his modern residential and commercial designs. Harmon realizes that much of the green building movement is focused on new technologies, such as "systems with photovoltaic [cells], geothermal systems, and control and management systems."[23] Nonetheless, he maintains that "the most fundamental sustainable practices are basic and free."[24] Harmon says the most important decision in planning an environmentally-friendly project is orientation. The results of proper orientation, he says, "are more effective than all other energy-savers combined." [25]

Harmon's environmental sensibility is evident in one project located in the coastal low-country. The client approached Harmon to create a small residence that would take advantage of the breathtaking views of Shem Creek in Mount Pleasant, South Carolina. But the project was not without challenges. In order to capture the panorama, Harmon would have to orient the house to the west, where the sun would virtually bake the house during summer afternoons.[26]

Figure 5.2. *External Shading Devices reminiscent of Charleston's historic shutters (Source: Beth Broome,* Architectural Record Magazine*)*

Taking a cue from Charleston's historic shutters, Harmon designed an external shading device for the southwest façade. When raised, "the system opens the house onto the landscape and allows daylight to flood inside." [27] During the warmer months, the devices can be lowered, "shading the residence while allowing cooling breezes to enter through doors and narrow operable windows that appear again on the front of the building."[28] These windows also enable passive systems of cross ventilation and lighting for the home.[29] A reflective standing seam roof and broad overhangs add to the energy efficiency of the home.[30]

Figure 5.3. *When closed, external shading devices create a shady breezeway. (Source: Beth Broome,* Architectural Record Magazine*)*

Historical antecedents are also dictating the form of some American communities. Perhaps the best known example of this is the planned community of Seaside, Florida. Founded in 1979, this New Urbanist community was designed by Andres Duany and Elizabeth Plater-Zyberk.[31] Seaside was planned with regard to "the notion of reviving Northwest

Florida's building tradition, which had produced wood-frame cottages so well adapted to the climate that they enhanced the sensual pleasure of life by the sea."[32] The team traveled all over the South researching old communities such as Charleston, Savannah, and Apalachicola. From their analysis, "the idea evolved that the small town was the appropriate model to use in thinking about laying out streets and squares and locating the various elements of the community."[33] Seaside was developed in reaction to the sprawling post-World War II suburbs that came to dominate the 20th century American landscape. This town effectively blends examples of "house forms and street layouts from a variety of well-known historic towns" to create a sustainable community in which residents can live, work, and play. [34]

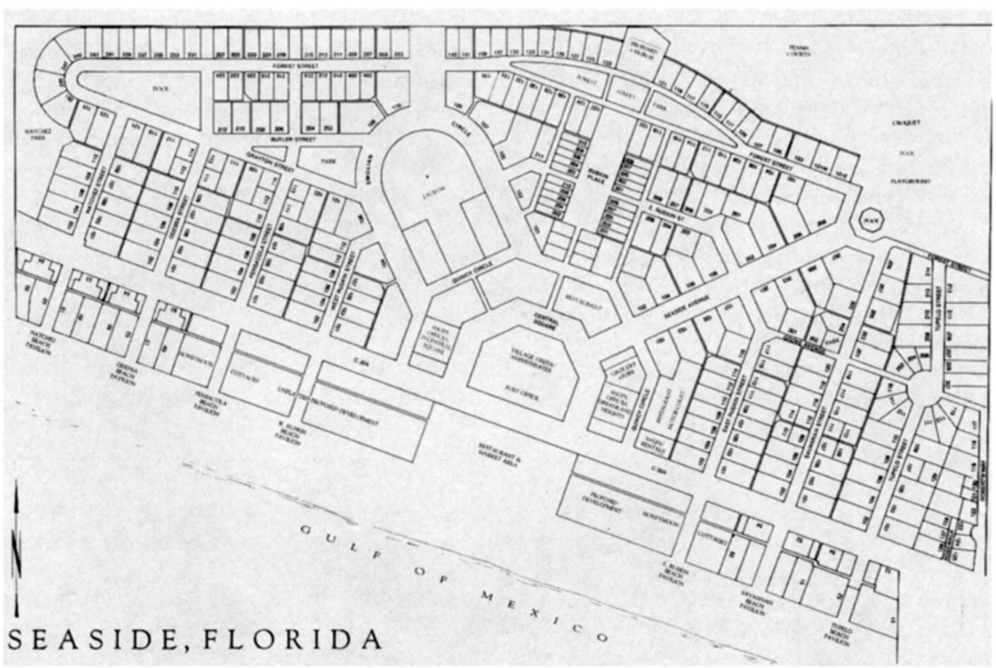

Figure 5.4. *Town Plan of Seaside, Florida.*
(Source: Kathleen LaFrank, "Seaside, Florida: 'The New Town: The Old Ways'"[35])

New Urbanist communities like Seaside share many characteristics with traditional historic districts. Seaside's town green, located at the town center, was inspired by the common placement of central squares, greens, or parks in historic neighborhoods.[36] The size of the town was also considered in a historic context. There is an emphasis on walking in Seaside, expressed by the close proximity of residential, commercial, and retail areas. One of Seaside's sub-districts even combined places of work and residence near the town center, a feature common in historic downtowns.[37]

These are just a few examples of modern buildings that use historic precedents for eco-friendly design. While some architects are using lessons from the past in order to build green, historic buildings must be preserved in order to demonstrate these principles to contemporary designers. Traditional principles must be refined and utilized as part of an environmentally sound design strategy. By protecting historic buildings we document green strategies implemented by our forefathers. The influence of these buildings will continue to spread to contemporary designs and, as a result, the building industry can lessen its impact on our planet.

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