

Green architecture design elements



Introduction

Since the Industrial Revolution, the world has witnessed incalculable technological achievements, population growth, and corresponding increases in resource use. As we enter a new century, we are recognizing the 'side effects' of our activities: pollution, landfills at capacity, toxic waste, global warming, resource and ozone depletion, and deforestation. These efforts are straining the limits of the Earth's 'carrying capacity' - its ability to provide the resources required to sustain life while retaining the capacity to regenerate and remain viable.

As the world's population continues to expand, implementation of resource-efficient measures in all areas of human activity is imperative. The built environment is one clear example of the impact of human activity on resources. Buildings have a significant impact on the environment, accounting for one-sixth of the world's freshwater withdrawals, one-quarter of its wood harvest, and two-fifths of its material and energy flows. Structures also impact areas beyond their immediate location, affecting the watersheds, air quality, and transportation patterns of communities.[1]

That recognition is leading to changes in the way the building industry and building owners approach the design, construction, and operation of structures. With the leadership of diverse groups in the public and private sectors, the building industry is moving toward a new value in its work: that of environmental performance.

The industry's growing sustainability ethic is based on the principles of resource efficiency, health, and productivity. Realization of these principles

involves an integrated, multidisciplinary approach - one in which a building project and its components are viewed on a full life-cycle basis. This 'cradle-to-cradle' approach, known as 'green' or 'sustainable' building, considers a building's total economic and environmental impact and performance, from material extraction and product manufacture to product transportation building design and construction, operations and maintenance, and building reuse or disposal. Ultimately, adoption of sustainable building practices will lead to a shift in the building industry, with sustainability thoroughly embedded in its practice, products, standards, codes, and regulations.

Understanding the specifics of sustainable building and determining effective sustainable practices can be confusing. Local governments and private industry often do not have the resources to perform the necessary research to assemble information on sustainable practices, assuming such information is readily available.

This thesis, by its parts, presents a full vision about green architecture, green buildings, and the opportunity to apply this architecture in Lebanon. In Addition, it includes a full conceptual design for a proposed project related to such architecture.

PART 1: Green Architecture / Green Buildings

1. 1 Definition

Sustainable development is the challenge of meeting growing human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future life and development. This concept recognizes that meeting long-term human

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needs will be impossible unless we also conserve the earth's natural physical, chemical, and biological systems.[2]

Sustainable development concepts, applied to the design, construction, and operation of buildings, can enhance both the economic well-being and environmental health of communities around the world. The Union Internationale des Architectes/American Institute of Architects (UIA/AIA) World Congress of Architects recognized that in its 1993 Declaration of Interdependence, which acknowledges that buildings and the built environment play a major role in the human impact on the natural environment and on the quality of life. If sustainable design principles are incorporated into building projects, benefits can include resource and energy efficiency, healthy buildings and materials, ecologically and socially sensitive land use, transportation efficiency, and strengthened local economies and communities.

Embracing sustainability concepts, the goals aim to reduce energy, operation, and maintenance costs; reduce building-related illnesses; increase the productivity and comfort of building occupants; reduce waste and pollution; and increase building and component durability and flexibility.[3]

In the developed countries, public and private leaders have realized the economic and environmental benefits of green building practices and are instituting policies, developing building guidelines, and manufacturing products and systems that will achieve sustainable development goals.

1. 2 Green buildings history

1. 2. 1 Historical Buildings

According to David Gissen, curator of architecture and design and the National Building Museum in Washington DC, structures such as London's Crystal Palace and Milan's Galleria Vittorio Emanuele II used methods that decreased the impact of the structure on the environment. Systems such as roof ventilators and underground air cooling chambers were used to regulate indoor air temperature.[4] In the early twentieth century, several skyscrapers such as the Flatiron Building and the New York Times

Building in New York utilized deep-set windows and the Carson Pirie Scott department store in Chicago had retractable awnings. Both of these techniques were effective in controlling interior temperature while lessening the buildings' impact on the environment.[5]

From the 1930's through the 1960's, the forward thinking cooling methods mentioned above gave way to some new building technologies that would change inner-city building construction dramatically.

The invention of air conditioning, reflective glass, and structural steel popularized the enclosed glass and steel buildings that litter the American city today. These buildings were able to be heated and cooled with massive HVAC systems that consumed huge amounts of cheap and readily available fossil fuels.[6] The massive consumption of energy required to inhabit these buildings made their viability tenable and entirely dependent upon energy availability and cost.

1. 2. 2 The Infancy

Around the time that the 'glass box' style high rise had become the icon of the American city (circa 1970), a forward thinking group of architects, environmentalists, and ecologists[7] were inspired by the growing environmental movement and the higher fuel costs that were prevalent during the 1970s.[8] The genesis of these two scenarios ultimately resulted in the modern build green movement.

The first Earth Day, celebrated in April 1970, gave some credence to this new building concept, but the OPEC oil embargo of 1973 gave the burgeoning environmental movement, and subsequently the green build effort, the kick start it needed. With gas lines stretching for blocks, some Americans began to question the conventional wisdom that we should be so independently reliant upon fossil fuels for our energy.[9]

As a result of the oil embargo, amongst other energy concerns, the American Institute of Architects (AIA) formed a Committee on Energy that was broken into two camps. 'One group looked toward passive, such as reflective roofing materials and environmentally beneficial siting of buildings, to achieve energy savings, while the other concentrated more on technological solutions, such as the use of triple-glazed windows.'[10]

As energy concerns subsided, momentum for green building and the environment, in general, slowed down, but a dedicated core-group of architects continued to push their green building concept forward.

A couple of notable buildings constructed during the seventies which utilized concepts of green design are: The Willis Faber and Dumas Headquarters in

England, which utilized a grass roof, day-lighted atrium, and mirrored windows; the Gregory Bateson Building in California, which used energy-sensitive photovoltaic (solar cells)[11], under-floor rock store cooling systems, and area climate control devices.[12]

Through the late seventies, throughout the eighties, and into the early nineties, much research was commissioned on energy efficient processes. This research resulted in more effective solar panels, prefabricated efficient wall systems, water reclamations systems, modular construction units, and direct usage of light through windows in order to decrease day-time energy consumption.[13]

1. 3 Green Organizations

1. 4 Green effect on buildings & cities

1. 4. 1 Energy Efficiency

Approximately 50 percent of the energy use in buildings is devoted to producing an artificial indoor climate through heating, cooling, ventilation, and lighting.[14] A typical building's energy bill constitutes approximately 25 percent of the building's total operating costs. Estimates indicate that climate-sensitive design using available technologies could cut heating and cooling energy consumption by 60 percent and lighting energy requirements by at least 50 percent in U. S. buildings.[15]

1. 4. 2 Water Efficiency

Water conservation and efficiency programs have begun to lead to substantial decreases in the use of water within buildings.

Water-efficient appliances and fixtures, behavioral changes, and changes in irrigation methods can reduce consumption by up to 30 percent or more.[16]

As demand on water increases with urban growth, the economic impact of water conservation and efficiency will increase proportionately. Water efficiency not only can lead to substantial water savings, it also can reduce the requirement for expansion of water treatment facilities. Non-residential water customers account for a small percentage of the total number of water customers, but use approximately 35 percent or more of the total water.[17]

1. 4. 3 Waste Reduction

Green architecture also seeks to reduce waste of energy, water and materials used during construction. For example, in California nearly 60% of the state's waste comes from commercial buildings.[18] During the construction phase, one goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter going to landfills.

To reduce the impact on wells or water treatment plants, several options exist. " Greywater", wastewater from sources such as dishwashing or washing machines, can be used for subsurface irrigation, or if treated, for non-potable purposes, e. g., to flush toilets and wash cars. Rainwater collectors are used for similar purposes.

Centralized wastewater treatment systems can be costly and use a lot of energy. An alternative to this process is converting waste and wastewater into fertilizer, which avoids these costs and shows other benefits. By

collecting human waste at the source and running it to a semi-centralized biogas plant with other biological waste, liquid fertilizer can be produced. This concept was demonstrated by a settlement in Lubeck Germany in the late 1990s. Practices like these provide soil with organic nutrients and create carbon sinks that remove carbon dioxide from the atmosphere, offsetting greenhouse gas emission. Producing artificial fertilizer is also more costly in energy than this process.[19]

1. 4. 4 Construction Cost Reduction

Application of green building concepts can yield for savings during the construction process. Measures that are relatively easy to implement can result in savings to the contractor in the following areas:

- Lower energy costs, by monitoring usage, installing energy-efficient lamps and fixtures, and using occupancy sensors to control lighting fixtures;
- Lower water costs, by monitoring consumption and reusing storm water and/or construction wastewater where possible;
- Lower site-clearing costs, by minimizing site disruption and movement of earth and installation of artificial systems;
- Lower landfill dumping fees and associated hauling charges, through reuse and recycling of construction and demolition debris;
- Lower materials costs, with more careful purchase and reuse of resources and materials;
- Possible earnings from sales of reusable items removed during building demolition; and
- Fewer employee health problems resulting from poor indoor air quality.

This listing suggests some possible areas for cost savings; the project team can identify other possibilities through a cooperative and integrated team approach. The contractor can also improve relations with the community and building owner by viewing them as part of the team effort to implement environmentally sound construction measures.

1. 4. 5 Building Operation and Maintenance

The green building measures discussed in this manual can lead not only to lower building operating expenses through reduced utility and waste disposal costs, but also to lower on-going building maintenance costs, ranging from salaries to supplies. For example, in many buildings, maintenance staff collects recycled materials on each floor - or even at every employee's desk - and carry the materials down to the basement for hand sorting. Recycling chutes, a viable green alternative, allow direct discarding of materials from any floor in the building to the basement. The chute system, which ideally is installed during initial construction or renovation, can sort materials automatically, saving labor costs by eliminating the need to collect, transport, and sort recyclables. Other savings come in the form of lower waste hauling fees; reduced workers' compensation insurance premiums due to lower claims for accidents from sharp glass and cans; reduced elevator maintenance; less frequent cleaning of spills on carpets and floors; and less need for pest control.

Environmentally friendly housekeeping products can also have financial advantages. For example, cleaning products that are purchased as concentrates and use minimal packaging not only promote waste reduction, but also can reduce product usage by 30 to 60 percent with dispensers that

more accurately measure and dilute the cleaning products for optimum effectiveness.[20]

Building owners need to view the building manager and staff as vital participants in environmentally sound and cost-effective operations. Building managers, charged with the efficient operation and maintenance of multi-million-dollar assets, have experience in all areas of operations and maintenance over the life of a building. Once a building is operational, training of management and maintenance staff - including education on effective green building measures such as building energy management systems, new cleaning products, and new building codes and standards - can help them to maintain the building in a resource-efficient and economically favorable manner.

1. 4. 6 Insurance and Liability

The past decades' conventional office design, construction, and operational practices have decreased the quality of the indoor office environment, resulting in new health concerns and associated economic costs and liability. The introduction of a multitude of new contaminant pollution sources into the workplace, combined with tighter building construction, has intensified air-quality problems. For example, poor indoor air quality can result from such factors as faulty air-conditioning systems, occupant related pollutants, construction materials that emit high levels of volatile organic compounds, and poor maintenance practices. The U. S. EPA ranks indoor air pollution among the top five environmental risks to public health. Unhealthy indoor air is found in up to 30 percent of new and renovated buildings.[21]

Sick Building Syndrome (SBS) and Building Related Illness (BRI) have become more common in the workplace, increasing building owner and employer costs due to sickness, absenteeism, and increased liability claims. It has been estimated that SBS and BRI cost roughly \$60 billion each year in medical expenses and lost worker productivity in the United States.[22]

Legal actions related to Sick Building Syndrome and other building-related problems have increased. These actions against building designers, owners, or employers may be initiated by occupants who have short- or long-term problems, ranging from headaches and burning eyes to more serious ailments. Initial economic impact may come in the forms of higher health insurance premiums, increased workers' compensation claims, and decreased productivity. Expensive remediation projects and environmental cleanups may follow, and building owners may try to recover losses from the original project contractors and architects through litigation.

By ensuring better indoor air quality, building owners, employers, and design professionals can lower their risk of future litigation by building occupants. Professional liability insurance companies have indicated a willingness to offer design professionals lower insurance premiums for higher operating-procedure standards that lead to improved indoor air quality. Some national architectural firms are attempting to rate building products according to the levels of volatile organic compounds they emit after installation, and to educate building owners and managers about healthier product choices.

1. 4. 7 Occupant Health and Productivity

The purpose of a building is not only to provide shelter for its occupants, but also to provide an environment conducive to high performance of all intended occupant activities. Recent studies have shown that buildings with good overall environmental quality, including effective ventilation, natural or proper levels of lighting, indoor air quality, and good acoustics, can increase worker productivity by six to 16 percent.[23]

An organization's most significant financial commitment is usually to its employees. Many employers spend at least as much on salary-related expenditures as they do on constructing an entire company building. In many organizations, salaries and associated benefits consume the majority of the annual operating budget.[24] For example; based on the sample calculations in 2, a typical employer could spend \$233 per square foot annually for an employee. Building construction costs generally fall below this level, often by 50 percent. In addition, annual employee salary-related expenditures, using the numbers in 2, are approximately 130 times greater than energy costs. A productivity increase of six percent equates to savings to the employer of \$14 per square foot - eight times the cost of the building's annual energy bill.

Given this information, an employer can decide to maximize the performance and efficiency of personnel resources through assessment of, and improvement to, the indoor environmental quality of its building. The following account of a recent renovation project illustrates this approach.

Both building owners and building tenant/employers can benefit in other ways by improving indoor environmental quality. For owners, these improvements can result in higher property values, longer tenant occupancy and lease renewals, reduced insurance and operating costs, reduced liability risks, extended equipment life, and good publicity. For tenants, benefits include reduced absenteeism and better employee morale, reduced insurance and operating costs, reduced liability risks, and community recognition. If the building owner is also the employer, an organization can offset initial construction design and systems costs with the reduction of long-term organizational and operational expenses over the building's life cycle.

1. 4. 8 Building Value

Green buildings' high efficiency and performance can result in higher property values and potentially lower lenders' credit risk. Lower operating costs associated with more efficient systems can lead to higher building net income.

In addition to increasing a building's net operating income or value, green building measures may allow building owners to charge higher rents or achieve higher rates of building occupancy, if tenants view green properties as more desirable. Currently, voluntary building rating programs are under development for commercial buildings in the United States. As these programs are introduced into the marketplace and gain the acceptance of building owners and tenants, they could impact the value of properties. Prospective tenants will be able to rate buildings based on such measurable features as natural daylight, better indoor air quality, and lower energy,

water, and waste costs. If enough buildings are rated for environmental performance, those that perform better will start to realize market advantages.

1. 4. 9 Local Economic Development Opportunities

Promotion and implementation of green building practices within a community can generate new economic development opportunities. These opportunities can take a variety of forms, including new business development to meet the demand for green products and services; resource-efficiency improvement programs that enable existing businesses to lower operating costs; development of environmentally oriented business districts; and job training related to new green businesses and products.

1. 5 Appliance & Ways of applying

1. 5. 1 Appliances

1. 5. 1. 1 Selecting environmentally and economically balanced building materials.

Buildings significantly alter the environment. According to Worldwatch Institute¹, building construction consumes 40 percent of the raw stone, gravel, and sand used globally each year, and 25 percent of the virgin wood. Buildings also account for 40 percent of the energy and 16 percent of the water used annually worldwide. In the United States, about as much construction and demolition waste is produced as municipal garbage. Finally, unhealthy indoor air is found in 30 percent of new and renovated buildings worldwide.

Negative environmental impacts flow from these activities. For example, raw materials extraction can lead to resource depletion and biological diversity

losses. Building materials manufacture and transport consumes energy, which generates emissions linked to global warming and acid rain. Landfill problems, such as leaching of heavy metals, may arise from waste generation. All these activities can lead to air and water pollution.

Unhealthy indoor air may cause increased morbidity and mortality. Selecting environmentally preferable building materials is one way to improve a building's environmental performance. To be practical, however, environmental performance must be balanced against economic performance. Even the most environmentally conscious building designer or building materials manufacturer will ultimately want to weigh environmental benefits against economic costs. They want to identify building materials that improve environmental performance with little or no increase in cost.

The building community is making decisions today that have environmental and economic consequences. Its decisions are plagued by incomplete and uncertain data as well as the lack of a standardized methodology for evaluating the data. The NIST/EPA team seeks to support these decisions by gathering environmental and economic performance data and by structuring and computerizing the decision-making process. The resulting BEES tool will be publicly available over the Internet.

In the mean while, the USGBC has published a list of materials - certified from LEED - containing several green materials including: flooring, interior construction, paints & film, fabrics, draperies, tack surfaces, ceiling systems, lighting, appliances, millwork, furniture and plumbing fixtures.

1. 6 Education of green architecture

Since 1993, UIA released the 'Declaration of Interdependence for a Sustainable Future' suggesting that the architectural profession should seek 'to achieve ecological sustainability within the limited time that is likely to be available'. And it's been 14 years after the release of UIA / UNESCO 'Charter For Architectural Education' that registers among educational goals 'an ecologically balanced and sustainable development of the built environment'.

Since then, many architecture schools have introduced or upgraded courses on technical aspects of sustainability, like 'Energy Conscious Design', 'Sustainable Architecture', 'Beyond Green' or 'Bioclimatic Architecture' and others more.

The integration of sustainability in design schools up to now has been reviewed by several surveys. Most of them share two conclusions:

- first, that not many schools have embraced the subject in a thorough manner, pointing at 'the low level at which sustainable design concepts have been incorporated into the regular curriculum' and noticing that 'environmental education in architecture has been done on an ad-hoc basis, 'fragmented and insufficient'[25];
- second, that sustainable design requires teaching methods quite different than the long-established ones[26].

Environmental crisis and its foreseeable effects are still a marginal issue in the academic discourse at schools supposedly dealing with the environment,

perhaps because crises are not an attractive subject in our 'feel-good' era. As a result, those who will have to tackle the looming crisis in the near future are not adequately prepared.

Still, the need to implement sustainable design is widely recognized by the educational community, at least in principle. A telling example is a survey among architectural educators in more than 30 European countries in 2001[27], where 'nearly 90% of the respondents are voting for a rather dramatic shift from a currently rather low to a high consideration of 'Sustainable Development' in future architectural education'. According to the survey, 'only 19% of those said that this concept is currently receiving a very/quite high level of consideration, and 83% said it should receive a very/quite high level of consideration in architectural education', identifying as an 'aspect of leading importance' the " integration of sustainability-issues into all studio design".

In spite of such consensus, there is still a long road until sustainable design is firmly rooted in architectural learning. There are a number of reasons for this, within and outside the academic perimeter:

1. 6. 1 Academic obstacles

In most schools that show environmental concern, related issues are usually confined in elective classes, detached from design studios. This creates a 'fringe' reputation for sustainability, shunning its principles from the main design projects to the periphery of architectural learning. As a result, no

practical experience is gained in how to introduce sustainable qualities in the 'core' design agenda.

In many cases the emphasis is on quantitative rather than qualitative matters. As a result number crunching eclipses design, and students tend to associate sustainable concerns with numerical performance only, detached from issues like comfort, resources, or societal ethics. In that manner, sustainability-related courses are considered similar to those on technical fields like structural or mechanical design, but not 'real' architecture.

Sustainable design is a rather recent theme, not very familiar to the old guard that administers schools. Most tutors have had limited or even nonexistent training in their past, and practical experience is even more rare. Consequently, 'a lack of importance placed on sustainable design by many architectural educators'[28] is no surprise. As a result, it is difficult to introduce 'obscure', 'uninteresting' or 'useless' new topics to the curriculum, especially in view of the fact that sustainable design challenges the predominantly artistic stance of architecture.

Sustainable design is a complex architectural approach, encompassing diverse fields of knowledge and requiring multi-discipline teamwork. Therefore its teaching cannot fit with the conventional linear approach where different technical skills are segregated in different departments, with rare

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opportunities to bring them all together through joint projects in a holistic manner. Furthermore, 'sustainable architecture is a complex subject that should be covered throughout the curriculum'[29], not just in sporadic projects.

Furthermore, design projects are frequently detached from earthly reality as if they refer to a space station, hardly interrelated with nature or society. Societal ethics or environmental awareness are not embedded in the agenda, confining training in merely technical skills with major focus on the aesthetic. 'An architectural student suddenly transported to many of our architecture schools from 1900 Paris would feel right at home'.[30]

Environmental crisis is repeatedly under the limelight of the media but, remarkably, it is seldom included in the academic discourse. There is little systematic awareness of the relationship of building and urban design with vital environmental issues like energy & water shortages, air & ground pollution, urban heat island & ecological footprint, or resources depletion. And certainly such topics are not included in project briefs or ordinary student work.

Furthermore, there is insufficient supplementary input through technical classes like building physics or environmental technology that could support sustainable design projects. When students do not understand the dynamic

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linkage between structures, environmental conditions and users, it is not easy to differentiate, say, between 'building in the landscape' and 'building in interaction with the landscape'.[31]

1. 6. 2 Outside the classroom

The introduction of sustainability in architecture schools encounters further difficulties stemming from the outer side of the academic walls:

Sustainable design has yet to find a clear identity:

- Is it a building technique, a blend of architecture and engineering that can be applied on any architectural variety just like, say, fire safety or seismic proofing?
- Is it just one more architectural fashion, perhaps with extra consideration to the environment than the rest, with its own stylistic trademarks like solar collectors, conservatories, or green labels?
- Or is it a novel design mindset, where nature & society, today & tomorrow are equal partners in the design framework?

The sustainable design family includes variations like 'energy conscious', 'bioclimatic', 'solar', 'ecological', or 'green', any of which could be applied in a non-sustainable manner. For instance, an energy-saving scheme could employ non-ecological materials; bioclimatic skyscrapers use more resources than low rise, and the sustainability of a huge 'green' mansion with just two

occupants is questionable. It is clear that sustainable design in full scale is a complex endeavor that requires a holistic alertness on a broad array of subjects, technical as much as social: 'Although there is much interest and curiosity about the subject, no one would say it's easy to learn or apply in practice'.[32]

The architectural 'haut couture' of our era markets themes rather far from sustainability. As a result prudence and 'ἡμετέριον μέτρον' (metron = Greek for measure) are ostracized from the main architectural values[33]. Given that architecture is always learned by example, many students - and many grownups too - clone the glamorous paradigms of the grand maitres,