DEVELOPING A FRAMEWORK FOR SUSTAINABLE DESIGN/BUILD/OWN BUILDINGS

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DEVELOPING A FRAMEWORK FOR SUSTAINABLE

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

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ABSTRACT

Gore, Alexander Keith, M.S. Department of Construction Management and Engineering, College of Engineering and Architecture, North Dakota State University, June 2010. Developing a Framework for Sustainable Design/Build/Own Buildings.Major Professor: Dr. Eric Asa.

The objective of the research paper was to investigate the development of a workable framework for Sustainable Design/Build/Own buildings. Research from case studies, a literature review, and a design exercise was completed to form this framework. Currently certification programs have been slow to infiltrate small-to-medium markets. In this study, it was found that the current sustainability assessment guides can be improved by reorganizing information to reflect the driving factors of time and cost as well as by increasing access to information with the abundant sources of videos, online guides, and internet references in a more approachable manner.

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CHAPTER 1. INTRODUCTION

1.1. Problem Statement

The research investigated the barriers that restrict Design/Build/Own firms from building sustainably. An emerging construction strategy observes architects as the designers, the builders, and the owners in the building process. In the construction industry this phenomenon is not new and many companies perform this role. Architects have been slow to adopt this framework for two reasons. The first reason is a lack of capital and financing, and the second reason is a lack of construction knowledge. When architects move into this role, they begin to solve these problems. One of the most universal issues in the 21st century is sustainability. This research explored a framework that would be beneficial for producing sustainable designs.

Multiple sources in the literature review indicated a lack of cohesion in the architecture/engineering/construction (A/E/C) industry and a persistence of segmentation. Therefore, it is useful to investigate any system that would either increase the use of sustainable practices or help the unification of knowledge in the fields of the A/E/C industry.

Chapter 1 describes the significance of the research, the objectives of the project, and the methodology that was used to conduct the research. Chapter 2 provides a literature review covering project delivery systems, sustainability, and the work of three architects: Jonathan Segal, William Moore, and Sebastian Mariscal. Chapter 3 includes the Problem Statement and significance of the problem, and Chapter 4 contains a design exercise intended to illuminate the important factors for developing a sustainable framework.

1.2. Research Objectives

The objective of this research was to investigate the creation of a sustainable framework for small Design/Build/Own firms. This framework addresses the cost and sequencing factors of building sustainably in the form of a checklist that can link relative information to the user via the World Wide Web.

1.3. Research Methodology

Using existing data the literature review, and a design exercise the research investigated the problem of implementing sustainable designs and developed a method for increasing the use of sustainability. The research methodology used was as follows: One - conduct a literature review focused on understanding sustainability, its definition, and barriers to implementation. Two - create a hypothetical building design in order to view the framework in a more realistic setting. Three - create a framework shaped by the previous research. The methodology required the following steps.

Step One: Research. This stage included a synopsis of the literature, and it focused on identifying what is necessary for the development of a successful framework. The focus of the literature review was on becoming thoroughly knowledgeable about the definition of sustainability in the context of the construction industry from inception to operation. The purpose of this step was to develop a suitable framework in order to create a clear understanding of sustainability and to develop a design exercise.

Step Two: Design Exercise. The design-exercise stage was a simulated design test that helped refine the framework. This process required a mock project that assisted in the creation and editing of the final framework.

Step Three: Developing the Framework. The third and final stage involved the creation of an easily accessible framework that provided the steps and resources required in order to design a basic sustainable Design/Build/Own building.

1.4. Research Contributions

The result of the research investigation was the development of a framework upon which companies or individuals could start sustainable Design/Build/Own projects. The framework provided the base elements and resources necessary to embark on a sustainable construction model.

The contributions to the field are that the framework acts as a roadmap upon which future development can be made and transmitted (Graff, H. J., Noordervliet, M. W., Musters, C. M., & de Snoo, G. R., 2009). The benefits of this system include: a transitional way of thinking from a short-term profit perspective for the contractor to a long-term profit perspective, a mental switch of architects from an aesthetics-based design mentality to a product-based design, and a growth in owner knowledge about the design and construction phases of building.

1.5. Project Scope

In order for this project to be completed in a short period of time the objective of the research was to develop a framework for a Sustainable Design/Build/Own construction model as demonstrated though the work of Jonathan Segal, William Moore, and Sebastian Mariscal. Although framework could be applicable to a wider range of uses, this limitation is necessary in order to focus the paper on a productive and useful framework. The framework culminates in a checklist used to link sustainable knowlege to users in each phase of construction, design, building, and operate in order of relative cost. These sustainable strategies were then linked to manufacturers, references, and guides on the internet.

CHAPTER 2. BACKGROUND/LITERATURE REVIEW

2.1. Introduction

Current views about the state of the world range from an inescapable planet in peril doomed towards self-destruction to a denial that the effects of climate change are worth examining. All sectors of society have been encouraged to make changes. Automobiles, power-generation companies, and food production are being asked to be more efficient. In this complex and changing world it is necessary for the sustainment of the traditional way of life that barriers be broken down into solutions that could benefit society, as well as using lessons learned from others and applying them where they fit. The Background/Literature Review covers: Delivery Systems, current architects who practice the "Design/Build/Own" strategy, and frameworks for sustainability.

2.2. Delivery Systems

Interest rates in the 1970s required faster project delivery times and led to the division of a mainly one project delivery system into many systems. The 1980's liability crisis pushed architects further from the construction field and limited some of their jobsite responsibilities, and this crisis led to a greater loss of construction knowledge (Dimkin, 2002).

Current delivery systems can be broken down into three major categories: Design/ Bid/Build, Construction Management, and Design/Build. Each system has its own benefits and disadvantages, and selection is based on prevailing situations and needs.

The Design/Bid/Build system is the most recognized and widely used system. Its positive attributes are the simple, logical steps that are broken into isolated tasks. A project is designed by an architect then, and then that project is bid on by contractors:

and, finally, the project is awarded and constructed by the contractor.

The government sector is normally bound to select the lowest responsible bidder in the bidding phase of a project. This process keeps Design/Build companies or partnerships from participating. These limits are under review because the Design/Build strategy is sometime linked to better quality and efficiency. State governments are thus looking into whether this delivery system and the Build/Operate/Transfer method is a viable solution for public construction.

2.3. Design Build

The Design/Build method is where one entity performs both the architectural design, engineering and construction work under one contract. This construction method has become common in the last 20 years and lends itself to projects with time and schedule constraints (Ernzen J., & Schexnayder C., 10). The main reason owners choose to use a Design/Build contract is because it provides a shorter schedule, an early cost establishment, a single entity is responsible for design and construction, and the builder is involved in the design (Puerto, D. L., Gransberg, D., & Shane, J., 36, 2008). The benefits, as noted in "Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods," show that Design/Build methods have a lower cost and finish ahead of schedule compared to the Design/Bid/Build method (Hale, 2009).

In the article, "Company's Experience with Design/Build Labor Cost Risk and Profit Potential" states that Design/Build projects achieve lower labor costs but create more risk through greater fluctuations in quantities and productivity. The key factor found by the superintendents on two projects that increased productivity and decreased costs was cooperation of the owner's inspector and design engineer. "Change orders were implemented in a timely manner because approval authority was vested at the field level" (Ernzen J. & Schexnayder C., 2000).

Overall Design/Build total costs were 10% less than budgeted, and the Design/Bid/ Build costs were 5% greater than budgeted. This was because contractors would have the most opportunity to decrease labor costs during the design process when the design work is around 10-30% complete (Ernzen J. & Schexnayder C., 2000).

Each system has its potential benefits and disadvantages. Financial concerns might best be addressed by a guaranteed maximum price system which generally places a construction manager at risk, meaning cost overruns are the responsibility of the construction manager. Scheduling issues might best be addressed under the Design/ Build system because it creates one point of contact and responsibility for all construction services. Aesthetic issues might best be addressed by the traditional Design/Bid/Build method where the architect has a larger role.

2.4. Design/Build/Own

The construction industry, small developers, and major companies have the capabilities to design, build, and own the structures that they operate. Architects and architecture firms have largely but not entirely been out of this loop, but three architectural firms: Jonathan Segal, William Moore, and Sebastian Mariscal are examples of the Design/Build/Own construction method.

2.5. Jonathan Segal

Jonathan Segal is a well-respected architect who has won numerous awards. He has conducted a series of seminars called "Architect as Developer." He started his career working for two different firms for two years each. He credits his experience at these firms with giving him the foundation for which to start building his own practice (Segal. J 2007).

He became an owner of his own projects when he had a conversation with a developer who encouraged him to do take control of a project himself. Segal's idea was to introduce three bedroom condominiums into downtown San Diego. He saw downtown as a potential place for families and realized no one was catering to this demographic. With $5,000 downpayment, Segal started building his first self owned building: 7 on Kettner. Built in 1990 this $350,000 project took advantage of the low price of a "leftover" triangular lot in San Diego (Segal. J, 2007).

Mr. Segal's goal was to develop one project a year. This goal would later evolve into owning 300 units with $750,000 in profits per year. This means that this is about $200 profit on each one of his units (Segal. J 2007).

One of the points that Segal makes in his speeches is to understand the rules, the code, and the mentality, from the subcontractor to the bankers; to understand where they are coming from, and then to use that knowledge as an advantage. This knowledge allowed him to consistently build outstanding projects on a meager budget. For example, his 2001 Lusso project was built for an astonishing $72 per square foot and is valued at $7,500,000 (Segal J, 2007). Segal was able to accomplish this by investing himself in every phase of the project and gaining valuable knowledge.

2.6. William Moore - Sprocket Design Build Inc.

Mr. Moore received his master's degree in Architecture from Colorado State University in 1992 . His professional career in architecture began in Greensboro and Charlotte, North Carolina. Moore then moved to Spain and worked as a carpenter and architect before moving to San Francisco to work for Village Properties and William Wilson. There, he developed skills in managing construction projects for mixed-use developments (*Sprocketdesignbuild*, 2010).

Moore founded Sprocket Design Build, Inc., became its president; and opened the business in 2000 after working for Paragon Homes as a construction manager for a couple years in Denver. Sprocket Design Build, Inc. has completed architectural and/

or construction services for over 60 projects in Colorado, North Carolina, California, and Idaho, specializing in urban-infill projects. The website states the benefits of being well versed in both the design and the construction business model:

> Providing architecture and construction services as one unified company allows for a more efficient project delivery than the traditional development model. The complementary business and design goals as well as direct communication ultimately contribute to the successful execution of each project. (Sprocketdesignbuild, 2010)

2.7. Sebastian Mariscal

Sebastian Mariscal followed in his father's footsteps and was engaged in residential architecture at an early age. Mariscal skipped the traditional path of attending architecture school and, instead, took a four-year apprenticeship with his father. In 1995 Sebastian left Mexico City headed to Barcelona to work with the architect Tonet Sunyer. Eventually, he moved to San Diego to join Jonathan Segal (Sokol, 2007).

In 2000, Mariscal started his own firm and began working on State+Date, a two-family residence he created with an investor. With efficient project management and design, he was able to complete the building within four months. The strategies he used involved locating all the plumbing along one wall, ordering precut parts to minimize on-site labor, and skillfully organizing the construction crew. His firm now handles general contracting, architectural commissions, and his own development projects. By choosing infill or more difficult sites to work with, the purchase price of the lot is lowered while the challenge of creating an interesting architectural solution is enhanced (Sokol, 2007).

2.8. Design/Build/Own Conclusion

Firms and individuals can often handle the complexity of small-scale construction projects. From small remodels to additions the complexity of these projects can normally be handled by an ambitious undertaker, but if these projects expand to larger than the simplest of structures they can easily become more complicated and take more resources than a single person can handle.

Soon, an architect, engineer, and other specialty designers/skilled workers are needed, which makes profitability obtainable only by scaling up the project. The larger size normally increases the complexity and the resources required to complete projects. Specialization then increases. Some home builders have reduced the cost and complexity of the design for houses by simply repeating the design over and over, changing small items to create the appearance of variety. This process spreads the architecture and engineering work over many projects and makes it profitable. Architects also do this by creating a set style.

One of the secrets to success of the architects previously discussed is the apparent value of education outside of architecture. Business and construction skills are essential in order to complete a successful Design/Build/Own project. The combined characteristics of these buildings are smaller, multi-residential structures in infill lots. The structures are normally rented out and might have some commercial space attached to them.

Sustainability decisions are based on a cost-benefit-value perceived viewpoint. If the architect owns a building and technology, such as solar panels, long-term costs will be reduced as in Jonathan Segel's - The Union. This building uses high-tech strategies, such as photovoltaic solar panels, combined with low-tech solutions, such as cross ventilation and drought-tolerant landscaping, all of which lower costs (Segal, 2007).

One marketing strategy that all three of these case studies have in common is finding the niche opportunities where traditional delivery systems are too large to sufficiently satisfy demand. These projects typically have the characteristics of small, infill projects where a multitude of skills must be used in order to complete the project.

The common architectural denominator is a modern architecture theme. This theme is characterized by smooth planes, open volumes, spacious windows, and a limited variety of materials. This style helps reduce confusion in construction while also easing the amount of coordination and design work. The locations of these buildings are often in larger, more progressive cities which attract younger people. One potential problem is that this style of architecture may not always be associated with a home feel and, thus, might not be as well received in other areas of the country.

The techniques for completing Design/Build/Own projects are similar to lean construction principles (Howell, G. 1999). The main difference is the person responsible during the various phases. Traditional construction divides these responsibilities among the owner, the architect, and the general contractor. Because of the division of responsibility and knowledge, it is easy to see how the perception of success could differ. For example, an architect could consider aesthetics one aspect of success for a project, while a contractor might rank profitability as the highest priority. Because of this disparity, the concept of a successful project could be altered throughout the life cycle of a project -- changing with time and changing with who has the most responsibility at the moment -- resulting in incongruity and inaccuracies (Chan, A., Scott, D., & Lam, E. 2002).

In the Design/Build/Own delivery system, the owner/architect/contractor is the same person. The potential benefits of this system could clearly be seen as more focused goals, less knowledge loss due to handing the project off through phases, an increased internalization of knowledge about all phases of construction, and the owner/architect/contractor involved with all of the stages of the building process (Ballard, G., Gil, N., Kirkendall, R. L, & Tommelein, I. D., 2001).

2.9. Sustainability

While today's green movement was popularized by Al Gore and a long list of other promoters, the breakthrough book *Silent Spring* by Rachel Carson created intense interest in the environment in the 1970s. This movement is hardly new in America. The United States has been rooted in ecological intellectual thought since the 1830s. Juggernauts such as Henry Thoreau and Teddy Roosevelt supported this train of thought and contributing significantly to the field of sustainability.

Today, this movement has been complemented by the evolution of technology. Sun analysis, energy efficiency, and full 3D modeling of buildings can now be an integrated part of the process. The industry's most prominent strides are in the Cradle to Cradle movement, the 2030 challenge, and the development of LEED (Leadership in Energy Efficient Design) certification process.

Cradle to Cradle was coined by Bill McDonough. This notion is that all buildings and products should contribute no waste, meaning that the product life cycle should be circular, rather than lineal, with no toxic emission or waste. Sustainability has also made large strides in sustainable accounting which would include life-cycle analysis and the criteria method which would include the LEED movement.

The generaly agreed-upon building principle is to address the "triple bottom line." This phrase means that projects are successful when they positively benefit the economic, social, and environmental needs of an area or people (Azapagic, 2003).

The problem in sustainability boils down to what achieves this end, and how a society or an individual should take on these challenges. To answer these questions, methods have been produced to guide the process. Life-cycle analysis is an attempt to measure the impact that choices have on the planet, and the criteria method/guide method is the culmination of experts' best thoughts and science about what produces the major categories or keyword definitions stated in the organizations guides. Figure 2.1 demonstrates their compatibility.

The major players in the sustainable market, the United States Green Building Council, Leadership in Energy Efficient Design (USGBC-LEED); the National Resource Defense Council (NRDC); Green Globes; the National Association of Home Builders (NAHB), the American Institute of Architects (AIA), and Tool Base, all lay out different categories which cover sustainability. Figure 2.1 shows their similarities. The top seven categories are as follows:

Sustainability: The most popular definition of sustainability comes from the 1987 United Nation conference and states, "Meeting present needs without compromising the ability of future generations to meet their needs" (*Report of the World Commission on Environment and Development: Our Common Future,* 1987). Robert Gillman, editor of *In Context* magazine, extends this goal-oriented definition by stating, "Sustainability refers to a very old and simple concept (The Golden Rule)...do onto future generations as you would have them do onto you" (Michael, 2009).

Energy: Energy usage is one of the main pillars of sustainability. The most effective approach is an integrated energy approach that utilizes proper sizing of heating and cooling equipment; efficient day-lighting controls, including correct orientation and efficient windows; appliances; highly insulated walls and attics; and utilizing energy sources either on site or off site that do not pollute (Top Strategies, 2010).

Water: Fresh water is a precious commodity. Simple steps, such as using drought-tolerant grass, low-water plans, capturing rain water, recycling grey water, and installing low flow faucets could dramatically reduce the use of this ever-important resource (Top Strategies, 2010).

Materials: Recyclable, reusable, renewable materials are key to sustainable buildings. Specially certified wood from the Forest Stewardship, recycled steel, and

	1	2	3	4	5	6	7	8	Percent Similar
Orientation	☑				☑		☑		37.50%
Windows and Daylighting									
Site Selection and Location	☑	☑	☑	☑	☑	☑	☑	☑	100%
Locations & Linkages		☑			☑				
Site Design and Selection									
Sustainable Sites		☑			☑				
Energy	☑	☑	☑	☑	☑	☑	☑	☑	100%
Atmosphere		☑		☑	☑				
Water	☑	☑	☑	☑	☑	☑	☑	☑	100%
Water Efficency					☑				
Materials	☑	☑	☑	☑	☑	☑	☑	☑	100%
Materials and Resources		☑			☑				
Air Quality	☑	☑	☑	☑	☑	☑	☑	☑	100%
Indoor environment quality		☑							
Emissions									
HVAC and Air quality									
Occupany comfort									
Waste	☑			☑	☑		☑	☑	62.50%
Longevity						☑	☑	☑	37.50%
Durability						☑			
Quality									
Project Management		☑				☑			25%
Preplanning- identifly goals									
Deconstruction/Recyclability						☑			12.50%
Emissions									
Awarness and Education		☑	☑						25%
Innovation and Design Process		☑							
Operation, Maintenance,		☑	☑						25%

1) National resource Defense Council (Building green from principle to practice, 2009).
2) Leadership in Energy Efficient Design (Leadership in Energy Efficient Design, 2010).
3) National Green Building Standards (National Green Building Standards, 2010).
4) AIA Checklist (AIA Checklist, 2010).
5) Tool Base (Tool Base, 2010).
6) Green Globes (Green Globes, 2010).
7) Whole Building Design Guide (Whole Building Design Guide, 2010).
8) Minnesota Sustainable Building Guideline (Minnesota Sustainable Building Guideline, 2010).

Figure 2.1. Sustainability Concept Comparison.

agriboard are all examples of cost effective sustainable alternatives that could help preserve the landscape from being exploited, while limiting the embodied energy it takes to create new materials (Top Strategies, 2010).

Location: Location has a greater impact than just the site where the building is. Locations away from city development could require more roads and utilities, further isolating society and taking away precious crop and grazing land (Top Strategies, 2010).

Air Quality: Having poor air quality can lead to: respiratory problems, sick building syndrome, a poor work environment, and an unhealthy setting. By not properly ventilating a building and using low volatile organic chemicals (V.O.C.) material people's health could be in danger (Top Strategies, 2010).

Waste: Minimizing waste helps minimize emissions. Building smaller, building using standardized material sizes and increments of two feet, and having an onsite means for recycling waste are all easy ways to reduce waste (Top Strategies, 2010).

Quality: Most importantly, sustainability is about life and the quality of life that people can achieve. Quality covers a broad spectrum from materials and finishes, to the care taken during the design and execution phases. Quality is also synonymous with durability, which means the building could last longer thus saving resources. These seven factors define the makeup of sustainable building design and become the basis for which sustainability can be sought.

2.10. Life Cycle Analysis

Sustainable-cost and full-cost accounting are based on the principle that one should maintain natural capital for future generations' use. Sustainable costs are the amount it would take to replace/replenish the natural capital taken (Heijungs, R., Huppes, G., & Guinée, J. B., 2009). Natural capital inventory accounting relies on recording the stock of natural-capital over time, and using those stock levels as an indicator of the versions which encourage the transition of life-cycle thinking may be more cost effective (Heijungs, Huppes, & Guinee, 29).

The methods and sources used to capture environmental data are broad, varied, and potentially unreliable, therefore the Global Reporting Initiative set up the framework and guidelines for reporting. Two commonly used programs are ATHENA, and BEES 4.0.

> BEES 4.0 software is extremely useful to designers interested in finding out the LCA impact of products they may select, but the learning curve is steep and a considerable amount of data collection and analysis is required for custom LCA analysis (*Life Cycle Assessment: Building for Environmental and Economic Sustainability*, 2010).

2.11. Criteria Method/Indicators

The criteria-method assessment is used by Non-governmental originations (NGOs), corporations, the United Nations, the European Union, and numerous others. It is often subdivided into groups covering the economic, environmental, and social dimensions of sustainability (Heijungs, Huppes, & Guinee, 2009). The criteria-method systems range from a simple checklist, such as the AIA Checklist, to entire organizations having accreditation criteria. Other popular assessments come from reputable sources such as the the National Resource Defense Council (NRDC) (Building green from principle to practice, 2009) and the National Association of Home Builders (NAHB).

The most widely used certification systems are the LEED system (Leadership in Energy Efficient Design) and Green Globes. In order to obtain certification a building has to be inspected by a third party. This inspection requires additional time and money, thus limiting its acceptance and practice. The learning curve and requirements of LEED also limit its widespread use. In a comparison conducted by the University of Minnesota between the internet-based Green Globes and LEED's paper-based format, it was found that Green Globes is easier to administer and cheaper to conduct, and the methods have an 80% comparability in their categories used to judge sustainability (Smith, 2006). The LEED rating system is a comprehensive, in-depth assessment of the environmental aspects of a building.

2.12. Frameworks

Frameworks are normally a combination of tools, resources, tasks, and objectives presented graphically to represent how processes and pieces fit together. They are usually specific to a project and provide a guide about how to achieve a certain goal. The structure of a framework is normally hierarchical, and the major categories are listed at the top and then broken down into subsequent tasks or subcategories. Frameworks attempt to model the complexity of decision making and reformat it into more manageable and explainable tasks.

For example, in "Sustainable Transport: Analysis Frameworks", Barbara C. Richardson graphically represents the forces affecting the sustainability of the transportation systems. Her article has nine different figures ranging from passenger factors to freight factors with each graph acknowledging approximately 30 figures (Richardson, 2005).

Articles such as, "Framework of Success Criteria for Design/Build Projects", (Chan, Scott, and Lam, 2002) take a more graphical approach -- laying out stages and tasks -- comparing factors and processes in their figures. Frameworks are very different depending on the specific project and time frame they are in. Frameworks are both extremely useful because of this fact and extremely irrelevant by the same fact.

2.13. Construction Advancement

Research conducted in the construction industry is fragmented into its respected fields which excludes a full analysis of the industry. Implementation of new advances is hampered by fears that bidding prices will rise or by an uncooperative, fractured structure of individuals who have a different understanding of what success means.

These criticisms, along with the desire for improvement, have led individuals in this industry on a search for solutions outside the field. Corbusier laid out the modern rendition of this pursuit through his book, *Towards a New Architecture,* where he urged architecture to imitate advances from shipbuilding as well as the aerospace and automotive industries.

This same appreciation was echoed by architects Stephen Kieran and James Timberlake in their book, *Refabricating Architecture.* Today, these thoughts are still relevant, but what is necessary to proceed is not a blanket adoption of other industries' processes, but a change in the E/A/C industry. Cross industry comparisons do not always work because of the difference in owner, labor, production methods, profit structure, purpose, and goals. So, unless the underlining structure of an industry is changed, solutions adopted from other industries will be hard to implement.

2.14. Design/Build/Own Advantages and Disadvantages

The Design/Build/Own construction method has a great potential for sustainability for two reasons. First, developers who own their buildings on a longer-term basis rather than quickly selling their buildings have an interest in choosing long-lasting materials that will not need excess repairs. Secondly, the Design/Build/Own construction model lends itself towards a more informed leadership that would be able to make informed sustainable decisions. This process could foster a larger knowledge base when starting the next building.

Smart building owners who plan to own and operate their buildings for a longer time period would tend to favor products that have less maintenance and a longer life span. The awareness of thinking in terms of 20 to 50 years plus decreases the incentive for poor workmanship in the construction phase and choosing low-quality materials that do not last long. These sorts of products decrease the amount of energy used to maintain the product and use less materials because they last longer, creating a more sustainable building.

The Design/Build/Own construction model lends itself to a very involved leadership structure. This construction model is defined by the ability of one person or group assuming responsibility for all phases of a building's life cycle, thus the Design/Build/Own name. The article "Master Builder Project Delivery System and Designer Construction Knowledge" points out that architects and designers could increase their knowledge by receiving construction training (Yates & Battersby, 2003). Therefore, sustainable solutions could be implemented more easily if the owner/designer knew how to implement the solution. Design/Build/Owners have a competitive advantage for building small-scale buildings (because large-scale buildings involve a more specialist role rather than a generalist) on infill lots because they do not need to have other designers or construction supervisors on staff. Building on infill sites reduces the demand of virgin soil thus increasing land used for farming or animal/plant life. A sustained interest by leadership is also crucial for a sustainable agenda to proceed successfully, so an interested Design/Build/Owner would have a greater impact in each phase of development if that leader was driven towards a sustainable building. For these reasons, the Design/Build/Own construction model has a great potential to produce extremely sustainable buildings. A framework that would help guide this construction model towards greater a sustainable outcome would help increase would increase the affectness of implementing a green strategy.

The disadvantages to the Design/Build/Own role are its limitations in size, scope, and ability to produce specialized knowledge to the extent that other construction models can. Because the roles of designing, constructing, and operating are concentrated in one person or group, this construction model limits itself to smaller-scaled projects. This model also has a limit about how much specialized knowledge can be acquired due to the fact that its leader has to understand every phase of the project. Meaning that the practice can only go so far in size and scope but that it is still appropriate for smaller scaled projects.

2.15. Chapter Summary

The definition of insanity from Einstein is "doing the same thing over and over and expecting different results." Similar systems will lead to similar results. For progressive change to happen, the industry must change the way the product is owned, conceived, made, operated, maintained, and updated.

It is necessary to develop a roadmap of the hard and soft developments required to implement successful change including guidelines for design, engineering, and production. A framework that changes the way sustainability is viewed in the construction industry is discussed in the paper.

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CHAPTER 3. PROBLEM STATEMENT

3.1. Significance of the Research

The National Science Foundation, in collaboration with the United Sates Department of Energy and the Environmental Protection Agency, has issued its *Emerging Frontiers in Research and Innovation 2010* guidelines (Emerging Frontiers, 2011). These guidelines make note of the fact that, currently, U.S. citizens spend 90% of their time indoors; buildings use 71% of the total electrical consumption and produce 38% of carbon dioxide emissions (Emerging Frontiers, 2011). It is for these reasons that the National Science Foundation, the United States Department of Energy, and the Environmental Protection Agency have seen fit to focus on engineering sustainable buildings. The paper states:

> While the green building movement has motivated research in materials, sensing and control, and occupant behavior, it has not yet matured to encompass system-level considerations in a broad-based way. Researchers are encouraged to engage in compelling and challenging system-level problems, arriving at new approaches, frameworks, and enabling technologies by learning from other advanced mechanical and social systems and then taking a step back to integrate and generalize the knowledge gained before assessing and optimizing the path to an engineered solution (Emerging Frontiers, 2010).

Element two of the guideline states "Provide a unique framework through which components of diverse disciplines can connect and relate to each other" (Emerging Frontiers, 2011).

The S2 objective listed above seeks to cross pollinate different disciplines in order to achieve a more "fruitful result" (Emerging Frontiers, 2011). This research seeks to take the diverse disciplines and allow them to directly apply their knowledge in a constructive, engaging manner.

In shaping the world people must first come to an understanding about what social, environmental, and economic effects a system has on how the world operates . Undoubtedly the environment influences the would in which we live, the business models under which we work, and the social lives we live; therefore, if we deem it necessary for change to happen, we must take a look at the structures in which we operate.

3.2. Problem Definition

The construction process is plagued by barriers and segmentation. The umbrella of the construction industry covers the fields of business, real estate, banking, politics, architecture, engineering, construction and more. It is because of this complexity that multiple parities are often necessary to complete a project, but it is also because of this complexity that these parties could disagree and, in general, lack a unified vision or goal. It is difficult in this situation to ensure unified principles, priorities, or incentives.

Current research tends to dissect large problems and divide them into smaller parts which are then more manageably solved. This research looked at the problem with the notion that, "the whole is more important than the sum of its parts."

Scale, mass production, location, and implementation are all causes for concern in this industry. Specialization has set barriers among owners, designers, builders, and material producers that have retarded innovation and growth.

> Fear of introducing new technology. To provide the owners' maximum benefits from contractors' price competition, the developer usually considers the prevailing construction practices in the design and avoids setting specific methods that may benefit particular contractors. The obvious consequences of these practices are that the designer is reluctant to introduce new construction materials and

methods, fearing that the contractors will either refrain from bidding or bid high prices (Cassimatis, 1969). Thus the prevailing construction process technology is one of the forces that oftentimes restrict product innovation by the designer. He cannot easily exert his influence to change process technology and support product innovation. (Nam, 1988)

At least two of the problems, limited use of mass production and separation of design from production, offer important opportunities for practical applications and competitive advantage. Specialization, which sets barriers among owners, designers, builders, material producers, and others, is responsible for paralyzing many types of technological innovation.

> Construction itself cannot induce the demand for its products... However, much of the technology literature indicates the either existing or anticipated marked demand ... as well as supply-side mechanisms.... are a prerequisite for technological innovations. Thus, the inability of construction to create demand may be a barrier to the rapid advancement of construction technology (Nam, Pg 134).

3.3. Problem Statement

There are four constraints that indicate that the construction industry warrants an investment in a possible perspective shift that might hopefully result in connecting this diffused complicated industry together. They are:

1) Fear of introducing new technology.

2) Separation of design from production.

3) Specialization sets barriers among owners, designers, builders, materials producers, and others.

4) Construction itself cannot induce the demand for its products.

But producing change in a large non-homogeneous field is difficult to do.

> An assumption of diffusion theories is if the adopter is not an individual or a group, but rather a system in which every actor acknowledges that others have heterogeneous goals, this system may regard an innovation as a force that upsets the equilibrium state. Change in this system through the rapid diffusion of innovations are difficult. The system is locked. (Nam, Pg 136)

This research revised the equation and looked at the necessary ingredients that facilitate a successful sustainable Design/Build/Own building process. In "Barriers and Commitment of Facilities Management Profession to the Sustainability Agenda" (Elmualim, Shockley, and Valle, 2010) it was found that, without the direct support and knowledge of leadership, sustainability could be a hard avenue to pursue, and that the diffused, sometimes uncorroborated, nature of the A/E/C industry warrants the research question: What factors could aid Design/Build/Owners in addressing the time, cost, and accessibility/bureaucracy barriers to sustainable design?

CHAPTER 4. FRAMEWORK

4.1. Introduction

To determine a solution for a suitable sustainable framework for the Design/ Build/Own construction method, it was necessary to engage in a design exercise for the following three reasons:

1) To reduce the volume of information that was considered during the literature review. There are thousands upon thousands of papers in the construction industry and all of them are relevant in their own right. But inorder to find out which ideas, thoughts, and conclusions are applicable, it is necessary to simulate a situation where the researcher would use this information.

2) Incorporating the existing parameters of financing, marketing, design, and construction was necessary in order to provide the perspective needed to be relevant to the field. Experience is one of the best teachers. The design process helped to organize information in a manner that was deemed most beneficial / most practical.

3) A wide range of programs and skills are necessary to complete such a task. Revit; Dreamweaver; Maxwell Render; cost estimating; and becoming familiar with sustainable design rating systems such as LEED, Green Globes, the National Green Building Standard, and Energy Star are beneficial to future employment and success in the field.

The scope of this project was limited to pre-designed planning and financial analysis, web development marking mock-ups, and schematic design layout. For convenience some of the mock-ups are presented in the body of the work rather than in the Appendix.

4.2. Project General Summary

Two real-estate trends could lead to financial success in the Fargo/Moorhead market: 1) The rise in enrollment at North Dakota State University (NDSU) and 2) the maturing of the echo-boomers. NDSU could grow to have over 16,000 students. This increase would lead to a greater need for student housing and recent graduate housing. The second area of growth is the development of the echo-boomers (people generally under 30) into home buyers. This statistical block is now beginning to reach home buying age.

In a couple years, this age block will be looking for starter houses. Married couples without children and empty-nesters will be the fastest-growing type of household, followed closely by single-person households. This generation might be more likely to start families later and live in cities longer. Within about three years, a large portion of the echo-boomer generation should start to buy houses.

This project proposes to briefly model the design and construction of six townhouses in the downtown region of Fargo. The items covered in the design exercise were as follows: project overview, market analysis, project schedule, finance, project cost.

4.3. Project Overview

The project includes six residential units in the form of modern/craftsmen row houses titled Fusion. They are located on the corner of Roberts and 4th Ave. N. (Figure 4.1). The market will be heavily geared towards young professionals and professors. The units will be comprised of two-story living spaces with a third bedroom attached to the garage. Units are approximately 2,000 square feet.

Figure 4.1. Project Site.

Source: *Fargo*.46° 52′ 38″ N / 96° 47′ 21″ W. Google Earth. December. 15, 2009.

4.4. Marketing

The marketing plan would consist of an analysis of the target market groups; the existing competition; and a strength, weakness, opportunity, and threat (SWOT) analysis.

1) Strengths:

- The market is prime for the lifestyles of each target market.
- There are numerous rental and entertainment options for residents.
- There is a low volume of new, middle-income residences downtown.

2) Weaknesses:

- Downtown is perceived as less family friendly.
- There are no substantial private yards.

3) Opportunities:

- Could partner with local medical, banking, and university systems to promote a vibrant, livable downtown.
- Could make connections with local downtown businesses.

4) Threats:

- Housing price could stay low enough to make the new building unaffordable.
- Lagging economy could produce a limited demand for new housing.
- There is less expensive housing on city outskirts.
- The cost of current housing is low.

4.5. Target Market

The target market is young professionals, professors, and hospital workers. With a spousal combined income above $90,000 ($45,000 each), these units are affordable, especially considering the fact that one of the rooms could be rented out. While there seems to be at least 4,000 households with a combined income of $80,000-$120,000 in this category, there is a shortage of affordable, newly constructed housing downtown (*Fargo: population profile, 2009*). NDSU also predicts that the Downtown campus will have a capacity of over 4,000 students. This project relies on the assumption that young graduates will seek to continue to live in a downtown residence and to pursue the nightlife and atmosphere that the downtown has to offer. In the near future, these students will come into the range of being able to afford these units.

4.6. Advertising

Marketing this project will rely on three things: 1) Partnership with the local medical, banking, and university systems to help attract potential buyers to a vibrant downtown, 2) Savvy internet advertising campaign, along with print advertising, that utilizes current website development skills and social networking sites such as Facebook and Craigslist, and 3) A marketing campaign that sells downtown as an experience and as affordable as compared to other options. Prices per unit will range from $259,000 to $289,000.

Figure 4.2 to Figure 4.5 show a mock-up of the website created using Sketchup, Mental Ray, Photoshop, and Dreamweaver. The figures can also be viewed by visiting, http://f9productions.com/Fusion.html (website terminated Summer 2010). Figure 4.6 to Figure 4.10 show in more detail the design and site of the project.

4.7. Project Schedule

The mock schedule for this project is set during the summer of 2010. This timeframe was chosen because it corresponded to the time in which writing this thesis took place. The mock project duration is approximately 7 months and is as follows; land development July 7th, building construction July 15th, and estimated project completion December 15th.

Figure 4.2. Downtown Website Marking Page.

Created by author *Source*: Images from Top of page: 1) *Fargo Theatre.* (2008) Retrieved from http://www.jerry-reynolds.com/. Courtesy of Jerry Reynolds. 2) *The Great Northern Clock Tower.* (2008) Retrieved from http://www.jerry-reynolds.com/. Courtesy of Jerry Reynolds.

Figure 4.3. Main Page Website Marking Page.

Created by author. *Source*: Images from left to right. 1) *Fargo Theatre.* (2008) Retrieved from http://www.jerry-reynolds.com/. Courtesy of Jerry Reynolds. 2) *Fargo.* 46° 52′ 38″ N / 96° 47′ 21″ W. Google Earth. December. 15, 2009.

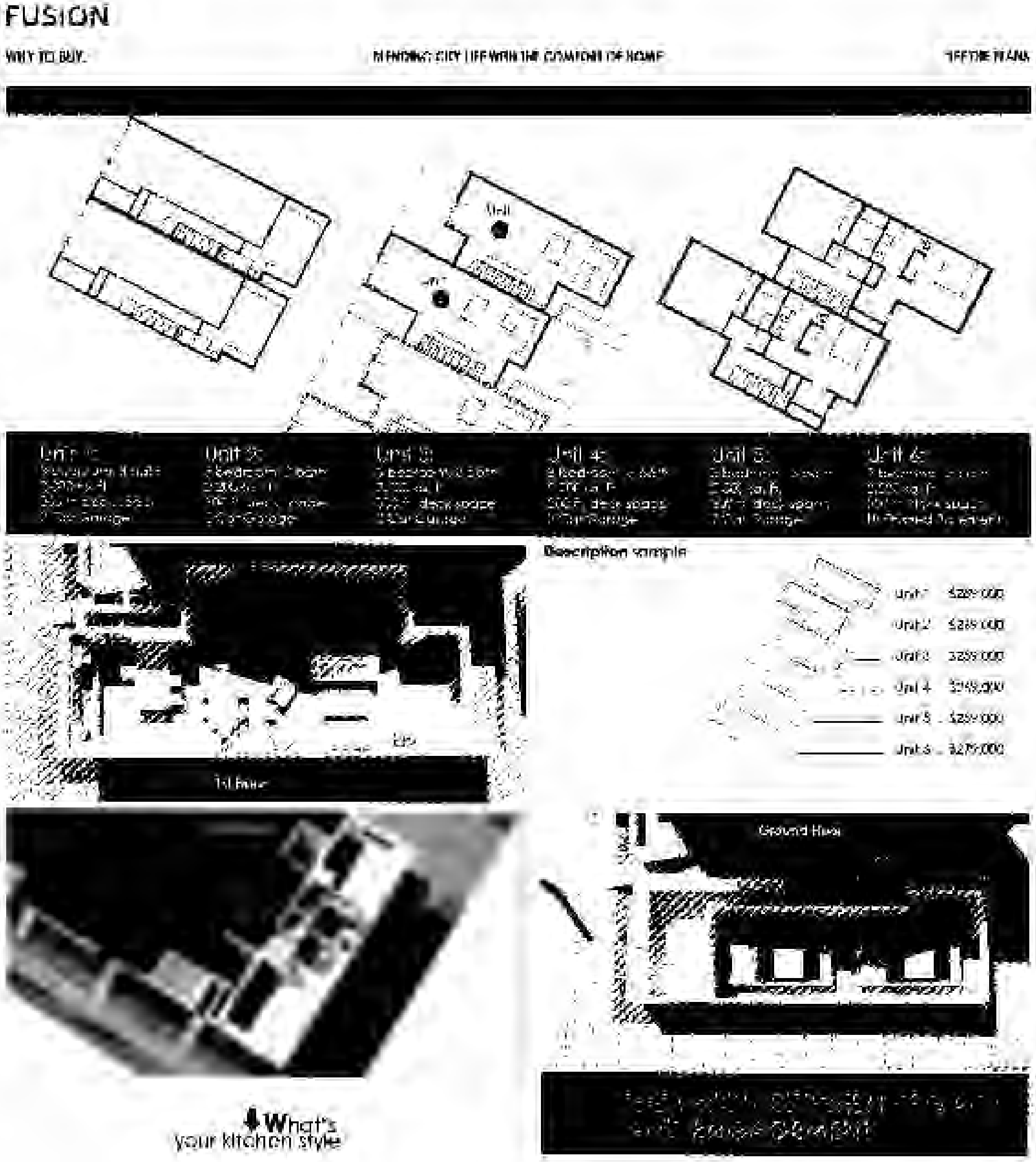


Figure 4.4. Floor Plan Website Marking Page.

Created by author.

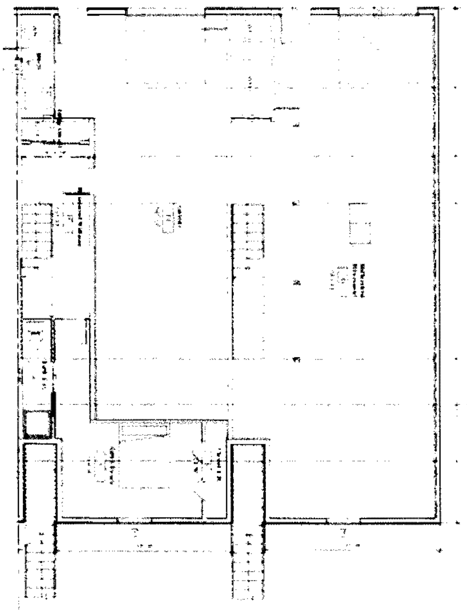


Figure 4.5. Unit A and B Ground Floor. Created by author.

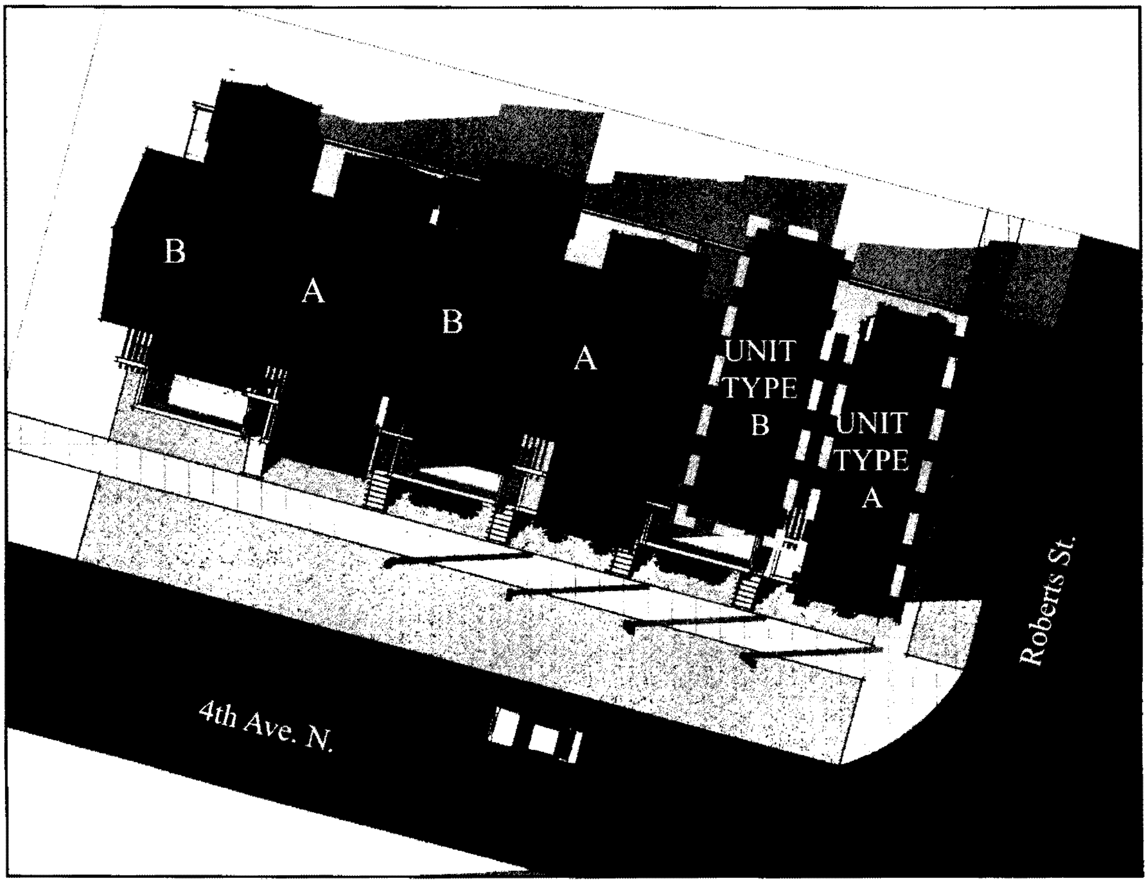


Figure 4.6. Ground Floor. Created by author.

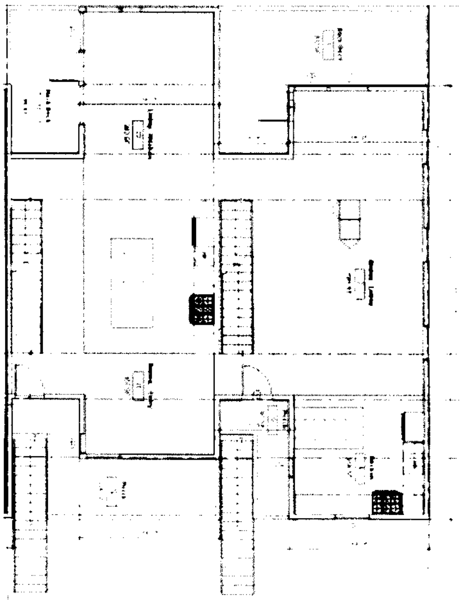


Figure 4.7. Main Floor. Created by author.

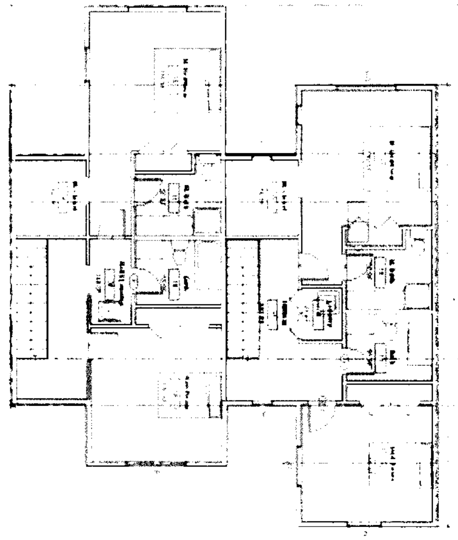


Figure 4.8. Second Floor. Created by author.

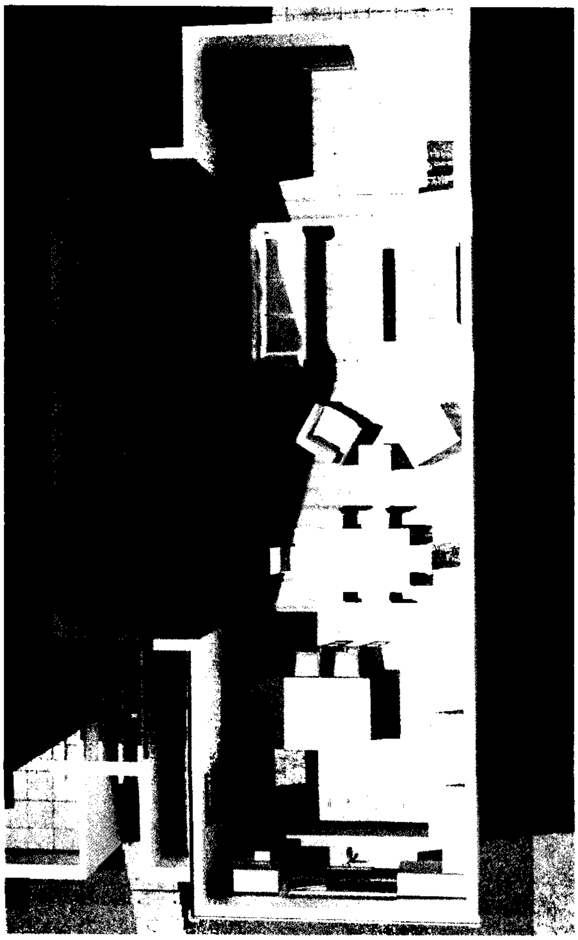


Figure 4.9. Unit A Main Floor. Created by author.

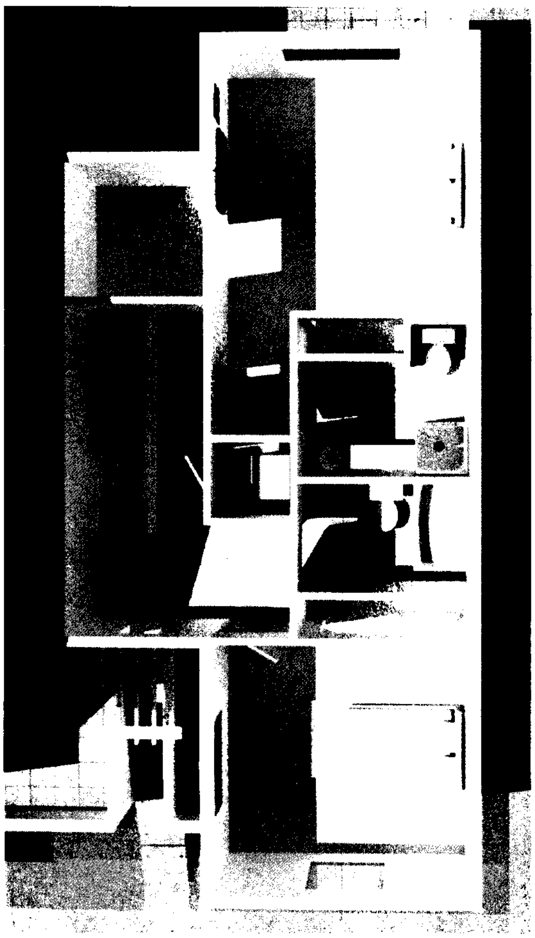


Figure 4.10. Unit A Second Floor. Created by author.

4.8. Finance and Project Cost

The project is built on a solid financial footing in order to ensure a safe investment for all parties involved in the project. All calculations were performed in Excel and are shown in the Appendix.

Project costs were derived by using the square-foot conceptual cost estimation method. The cost per square foot came from RS Means Assemblies Cost Data 2010 (Balboni, B. 2010). Each unit is approximately 2,000 square feet of air-conditioned space, and 560 feet of garage. For upper end for low rise apartments buildings the cost per square foot is $111. That number was then multiplied by the location factor to produce a square foot cost of $91. The square foot project size modifier was approximately 1. An amount of $30 per square foot was allotted for the garage space (Balboni, B. 2010). The financial information for this project is follows:

Total Cost: $1,392,800

Interest: 6% = $52,568

Total Expenses: $1,446,368

Gross Revenue: $1,629,994*

Net Profit: $183,626

Profit: 12.70%

IRR (Internal Rate of Return): 26%

NPV (Net Present Value): $122,822

*See the Appendix for Excel calculations.

The selling prices for the six units are as follows: $279,999; $259,999; $269,999;

$259,999; $269,999; and $289,999. To achieve sufficient financing, the project aims to presell half the units before construction. Examples of the project were shown in Figures.

4.9. Addressing Sustainability

The exercise provided the perspective needed to narrow relevant information as it pertained to sustainable building. The NAHB Green Guide was the easiest to use and understand in this scenario; LEED was the second easiest to use; and with Green Globes was the most difficult due to its vagueness of language and direction. Each one of these systems failed in the author's eyes by hiding behind too many restrictive layers. In the case of LEED, it was the monetary aspect and the unclear navigation of its website. Green Globes also had this barrier. The NAHB downfall was the guide's inability to deal with any project that was not a home. Leaning this particular system is cumbersome for architects who cross over into commercial, or industrial design. Also information was not available in video format.

4.10. Part Two Framework Introduction

It was found through the design process that a framework that is free, easy to use, breaks down the barrier between design and construction information, and acknowledges the pressures of cost and time is needed. These thoughts are echoed by the papers presented previously. What is now known is the significance of these issues and better ways to address them.

It is clear that there are three main obstacles to generating a suitable, sustainable framework:

1) Premium: a cost to participate
2) Organization: not organized in driving factors of cost and time
3) Uncontrollable: user cannot create or change the information or presentation

Solutions to these obstacles are as follows:

1) Reorganize so that green techniques acknowledge cost factors and the time in which they are done.
2) Free up content to allow everyone to access the information, download, manipulate, upload, share, link, grow, respond, criticize, and correct.
3) Redesign the format so that it is pleasant, printable, and easy for everyone to access.

In order to complete this framework thoroughly, this chapter will answer three questions: 1) What is sustainability? 2) How can sustainability be reorganized to be applicable to the field? and 3) What would this framework look like?

4.11. Framework

There are a plethora of sustainable frameworks, guidelines, and standards available. Books, journals, and websites are devoted to this subject, and one of the hardest things to do is determine the relevance of all the information.

The sustainability framework is broken down into three parts: planning, implementation, and evaluation and improvement (Figure 4.11). Each part comes with its own tasks. The stages will be discussed here briefly and explained more fully later in the paper.

Planning stage: During this stage, sustainability is discussed with all parties. There are two major goals: 1) a demystification of sustainability and 2) the direction and support of leadership, i.e., the Designer/Builder/Owner, which as stated in "*Barriers and Commitment of Facilities Management Profession to the Sustainability Agenda*", could be a major cause for setbacks, are sought here (Elmualim, Shockley, Valle,Ludlow, and Shah, 2010).

The implementation stage: This stage is where the major critique of current practices occurs. This research seeks to address the two main concerns when building--time and money in a more efficient, effective, and open way.

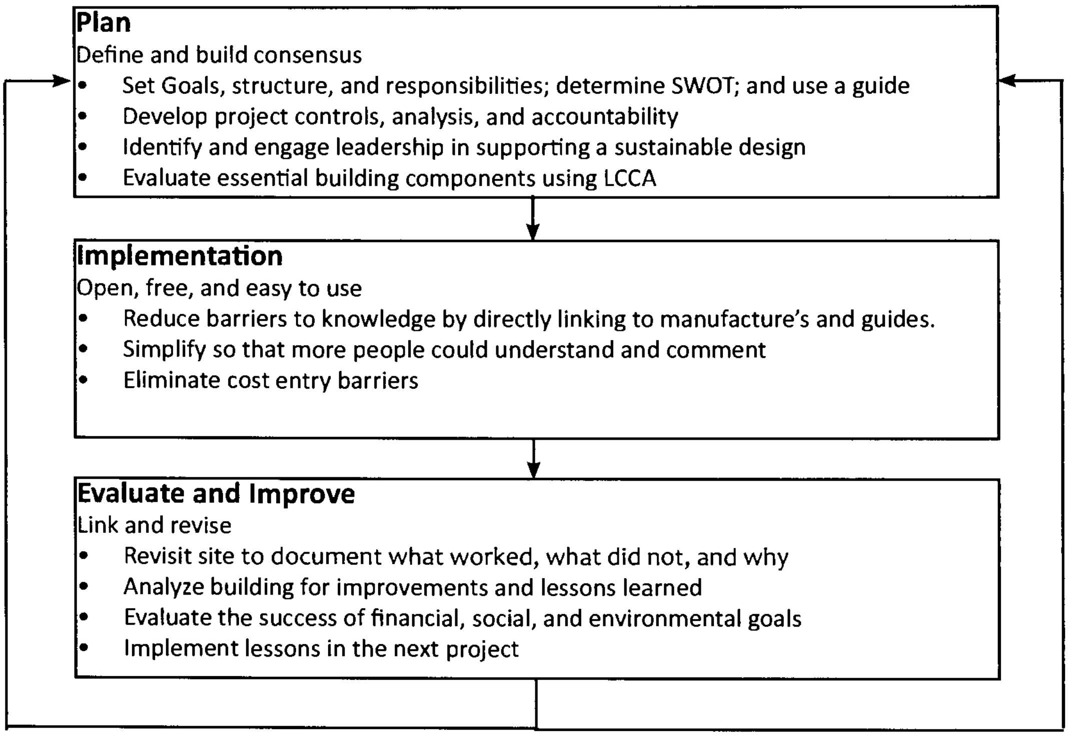


Figure 4.11. Sustainable Framework.

The evaluation/improvement stage - This stage has two purposes: 1) assess the effectiveness of the green framework on a continual basis and 2) provide a vehicle for continually reviewing and changing the information and techniques available.

4.12. Stage 1: Plan, What is sustainability?

This first step is a guide for the architect, the developer, and the contractor to have a consistent understanding of goals, objectives, and assessment criteria. Figure 4.12 lays out the planning stage.

Plan
Define and build consensus
- Set Goals, structure and responsibilities, determine SWOT, and use a guide
- Develop project controls, analysis, and accountability
- Identify and engage leadership in supporting sustainable design
- Evaluate essential building components using LCCA

Figure 4.12. Sustainable Framework: Planning Stage.

4.13. Sustainability Defined

From examining eight different green guidelines, the definitions of what elements make up sustainable building are quite similar. What is contested is how much of these elements are needed to be fully sustainable.

The major players in the sustainable market, the United States Green Building Council, Leadership in Energy Efficient Design (USGBC-LEED), the National Resource Defense Council (NRDC), Green Globes, the National Association of Home Builders (NAHB), the American Institute of Architects (AIA), and Tool Base, all lay out different categories which cover sustainability. The definitions of the major categories are presented in Figure 4.13 in a more presentable format. Summed up on one page is a definition of sustainability, the central pillars to sustainable building, and the questions that sustainable solutions should seek to answer to spark discussion and debate. This page can be used as an information sheet for owners or participants in a building process.

ENERGY: Does the energy solution reduce use of non-polluting sources of energy? WATER: Does the building capture, reduce, or reuse water? MATERIAL: Are the materials easy to maintain and do they come from a renewable source? LOCATION: Does the site reduce car trips, or does it increase infrastructure? AIR QUALITY: Are the rooms properly ventilated? Does the energy come from non-polluting sources? Are low V.O.C. materials being used? WASTE: Are there easy ways to recycle? Is the building designed in standard material sizes? QUALITY: Does the design promote social interaction, durability, and longevity?

Sustainability Summary

Energy, Water, Air Quality, Waste, Location, Materials, Quality

SUSTAINABILITY - [illegible]

ENERGY - [illegible]

[illegible]

WATER - [illegible]

[illegible]

AIR QUALITY - [illegible]

[illegible]

WASTE - [illegible]

[illegible]

LOCATION - [illegible]

[illegible]

MATERIALS - [illegible]

[illegible]

QUALITY - [illegible]

[illegible]

STAGES:

[illegible]

[illegible]

[illegible]

[illegible]

Figure 4.13. Sustainability Summary

After defining sustainability and clearly communicating it the next three goals are as follows:

1) Set goals, structure, and responsibilities; determine SWOT; and use a guide.
2) Develop project controls, analysis, and accountability.
3) Identify and engage leadership in supporting a sustainable design.

Setting goals; structuring responsibility; and determining the strengths, weaknesses, opportunities, and threats to green design are not only prudent, but are common business skills that can be applied to sustainable thought.

The paper "Barriers and Commitment of Facilities Management Profession to the Sustainability Agenda" points out that "time constraints, lack of knowledge, and lack of senior management commitment are the main barriers for the implementations of consistent and comprehensive sustainable FM policy and practice"
(Elmualim, Shockley, Valle, Ludlow, and Shah, Pg. 5).

When the designer takes on the role of the architect, general contractor, and owner, goals are easily understood across the varying project stages. The direction of the leadership is now singular, and the challenges and rewards of each phase of construction are now more aptly understood. Knowledge of every stage of the project is now centralized.

An engaging, informed leadership is key in making sustainability a recurring practice in a business. The next step is to take this understanding of sustainability and arrange it in a way that is useful.

4.14. Evaluate Essential Building Components

In small building projects, this type of analysis is often not done due to complacency, habit, or a fear of the learning curve in an analysis system. A notion that is pervasive in academia is that a system, guideline, or tool must fully consider all options or account for all offshoots before it could be deemed credible or used. While this constant pursuit of perfection is welcomed, its unintended consequences are an exponential growth of complexity that limits the possible benefactors because of the users' lack of understanding which impedes implementation. To combat this complexity, builders and owners must see a clear correlation between time spent on analysis and value/money gained from the analysis.

Therefore, the strategy is to decrease investment time and increase investment returns. Decreasing time could be done by limiting the analysis to only the major aspects of the building: foundations, walls, roofs, large materials, and energy; and by implementing this step in the planning stage. Thus, dramatically reduce costs by allowing the design portion of the project to be guided by the systems selected in the analysis phase. Thus, solar panels, wind systems, or wall systems could be accounted for in the beginning of the design rather than applied later.

Life-cycle cost analysis is one approach to weighing the cost benefits of competing products. It consists of seven steps (Velado, 2007):

1) Establish alternatives
2) Determine analysis periods
3) Determine maintenance and rehabilitation frequencies
4) Estimate cost
5) Calculate life-cycle cost
6) Analyze and compare alternatives

Steps one and two are self explanatory to any professional in the construction field. This information could be found through a basic internet search and with inquiries to manufactur's. Step three could also be found the same ways. Step five, estimating cost, can be determined by combining maintenance costs and initial costs. Note that the maintenance costs are in the future, so they have to be converted into a present value.

The life-cycle cost is a direct comparison of the cost of each alternative. This comparison is done by bringing all the costs associated with a choice into the present value, or using an estimate for the cost savings per year if provided. The easiest way of doing this comparison is by using the present value (PV) equation to bring these costs to one point in time – now. This could be done by using the financial formulas in Excel.

$PV = F\ 1/(1+i)^n$ where

F= future cost at the end of n years

I = discount rate

^{n} = number of years

Determining the present value of the options is considered finding the "discount rate." Simply means finding the interest rate at which future dollars could be converted to present dollars. A typical discount rate is between 3% and 5%, according to the current U.S. government 10-year Treasury Note (Velado, 2007). In some cases bringing the cost into present value does not need to be determined because other factors in the process has already eliminated or selected certain options.

Figure 4.14 shows the major elements of construction: energy, framing, walls and roofs, paving, and HVAC equipment. Initially, solar power is the most viable solution, but meetings with each industry representative would need to occur to determine proper feasibility, payback, and a more accurate cost.

Step six, analyzing and comparing alternatives, is the process of weighing the cost versus the sustainable benefits of health, comfort, or happiness. These values cannot always be quantified, so an informed judgment by the owner, architect, or other involved parties has to be made. An example of the analysis is shown in Figure 4.15.

LCCA

ENERGY
On-site
Solar
Wind
Geo-thermal

Offsite
From Power Company

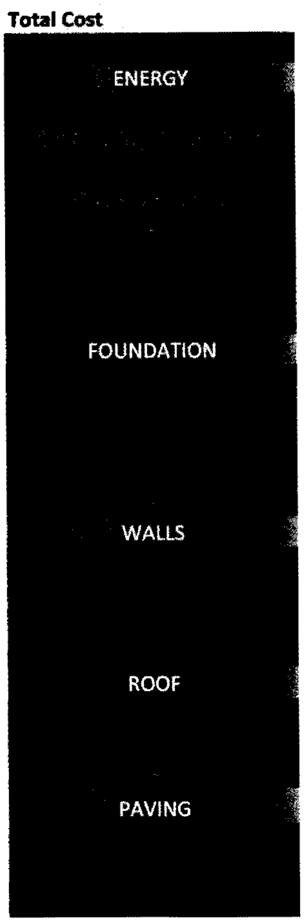
FRAMING/WALLS
Foundation*
Use a frost-protected shallow foundation
Superiorwalls
Concrete wall with footing

Walls
Advance Framing Techniques
Agriboard panels
2x4 Wall

Roofs
Corrugated roofing (metal) recycled and light colored
Asphalt roofing

PAVING/HEATING AND COOLING
Asphalt
Light Paving (concrete)
Permeable Paving

HVAC LCCA done by sub.



While the Life Cycle cost might be lower on a Metal roof, in this senerio a judgment call that the upfront cost is too high.

* According to Ducker's 2004 research study, the life cycle cost of a metal roof is significantly less than an asphalt or single-ply roof. The expected life cycle cost of metal roofs reported in this study is 30 cents per square foot per year, asphalt is 37 cents per square foot per year, and single-ply roofs is 57 cents per square foot per year. (Life Cycle Cost Analysis, 2005)

Figure 4.14. Life Cycle Cost Analysis Summary

Using a shallow foundation system would produce a cost savings by reducing the amount of concrete used. The savings would easily offset the estimated engineering time

Figure 4.15. Life Cycle Analysis Summary Continued

LCCA	ıtion factor if any	Instalation Cost (step 5)	Maintance Cost (step 6)	Time Span	PV (Present Value)	SOURCE
ENERGY						
On-site						
Solar	might be too much snow	111 monthy payment	$0	15 years	-	
Wind	cost and site prohibitive	$43,645 min	-	-	-	10 kW GridTek Package
Geo-thermal	initial investment barrier	$10,000	$0	16 years	-	https://www.dmr.nd.gov/
Offsite						
From Power Company	not available	-	-	-	-	-
FRAMING/WALLS						
Foundation*						
Use a frost-protected shallow foundation		$11,899	$0	100 years	no need to determine	
Superiorwalls	not cost effective for crawl space		-	100 years	no need to determine	
Concrete wall with footing		$22,595	$0	100 years	no need to determine	RSMeans Residential Cost Data Pg. 118
						RSMeans Residential Cost Data Pg. 122
Walls						
Advance Framing Techniques		$2.67 per Sq. Ft. Wal	same	50 years	no need to determine	RSMeans Residential Cost Data Pg. 136
Agriboard panels		$5.42 per Sq. Ft. Wal	same	50 years	no need to determine	
2x4 Wall		$2.65 per Sq. Ft. Wal	same	50 years	no need to determine	RSMeans Residential Cost Data Pg. 136
Roofs						
Corrugated roofing (metal) recycled and light colored		$3.21 S.F.		40 Years	*	RSMeans Residential Cost Data Pg. 212
Asphalt roofing	upfront cost determined to high	$1.87 S.F.		23 Years	*	RSMeans Residential Cost Data Pg. 214
PAVING/HEATING AND COOLING						
Asphalt	asphalt needs to be resealed	$3.64 S.F.	eliminated due to maintance cost		-	RSMeans Residential Cost Data Pg. 110
Light Paving (concrete)		$5.86 S.F.		25 years	-	RSMeans Residential Cost Data Pg. 110
Permeable Paving						

HVAC LCCA done by sub.

needed to implement such as system. Advance framing techniques for the walls cost the same as using conventional 2 x 4 framing while reducing wood and adding more space for insulation. While it is noted that a metal roof might have a lower life-cycle cost, it was determined that, to keep a proper profit margin, an asphalt roof would be installed. The cheaper asphalt paving option was not chosen because of the frequency of repairs needed; it was deemed appropriate to choose a higher cost but lower maintenance material such as concrete for the pavement. The HVAC LCCA would be done in collaboration with the HVAC subcontractor this is the specialty knowledge in this complex field is vital for a successful system.

None of these systems added significantly to the overall budget, so no adjustment to the budget was necessary because the budget is just a preliminary estimate. Especially the since the solar option has no installation cost (which normally can be very high) because it is spread over the life span of the system.

4.15. Stage 2: Implementation

This stage was about transforming the way green assessments and guides interact with designers. Simple checklists have been successfully implemented in the aerospace industry to help reduce accidents and in hospitals to reduce infections by 66%, and have also sharply reduced mortality rates. Dr. Peter Pronovost, who won a MacArthur "genius" award for popularizing and creating this concept, believes that this procedure saves lives because there are small, simple steps that are forgotten but can make a huge difference (Szalavitz, 2010). These steps can be seen in Figure 4. 16.

Implementation

Open, free, and easy to use

- Reduce barriers to knowledge by directly linking to manufacture's, and guides.
- Simplify so more people can understand and comment
- Eliminate cost entry barrier

Figure 4.16. Sustainable Framework: Implementation Stage.

The title of the head website page can be seen here in Figure 4.17.

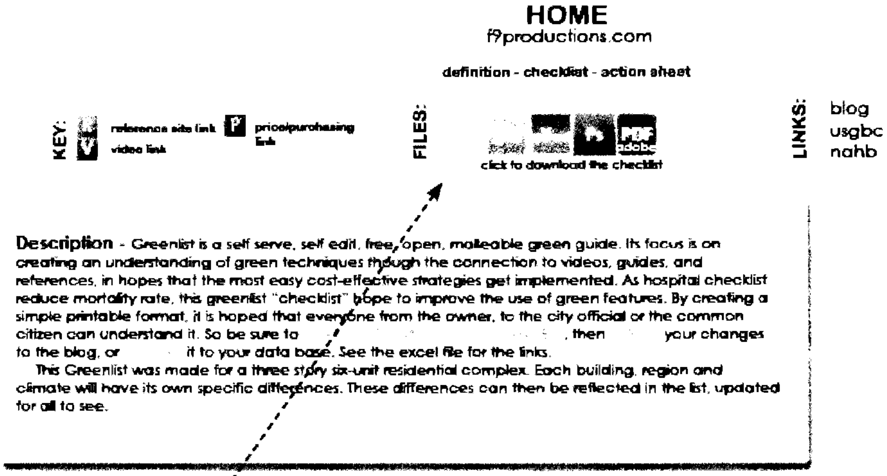


Figure 4.17. Framework Website Header.

The icons to the left of "Files" are the location where the checklist and definition could be downloaded as a Photoshop file, a pdf, a Dreamweaver file, or in the Excel file format that has all of the links. The Excel file is shown in the Appendix, and the website mockup was at www.f9productions.com/easygreen, (accessible March 2010 - June 2010).

The purpose of this checklist - Figure 4.18. - is to amend the "sustainability process" to fit the driving decision factors of time, money, and know how; and to plainly list the simple, affordable solutions that could make a difference. This simple format allows architects, builders, owners, and city officials to address sustainable issues in an open and honest way.

Figure 4.18 shows an example of this form. The checklist, definition and action plan are located under the website header.

The left-hand side of the form is the order in the time frame in which decisions are now made; planning/design, construction, and operation. From left to right the top of the form is organized in the cost determining factors (see appendix). First, low to no additional cost; second, pay now, save later; and third, added value, added cost. Each item is referenced to an source that indicated loosely what category it should be placed in.

PLANNING / DESIGN

LOW TO NO ADDITIONAL COST

- Design building in units of 2'
- Orient Building on E/W Axis for Solar Gain [V] [V]
- Orient the building to benefit from passive cooling [V]
- Install low flow water fixtures [P]
- Install energy-star windows, lighting, appliances [V] [P]
- Use native plants and xeriscape landscape design [V]
- Build Closer to Utilities, choose an infill lot next to mass transit
- Use underfloor HVAC system

Foundation

- Use a frost-protected shallow foundation [V] [P]
- Incorporate Flyash in Concrete up to 15%

Framing/Walls

- Use Advance Framing Techniques or [V]
- Agriboard pannels [V]

Roofing

On Site Power

PAY NOW SAVE LATER

- Capture and recycle water, use greywater system
- Install Dual Flush Toilets [P]
- Install Heat Recovery Ventilation Unit (HRV) [P]
- Plant Deciduous Trees on the West and South Sides
- High-efficiency water heater [P]
- Use Serious Windows [P]
- Use plants to clean air

Foundation

- Superiorwalls [P]

Framing/Walls

- Increase attic insulation to R60 and Wall insulation to R20 [V] [V]

Roofing

- Use a Raised Heel Roof Truss [V]
- Use cool roof materials

On Site Power

- Install Solar /Wind/Geothermal Power [V] [P]

ADDED VALUE, ADDED COST

- Build within already developed areas
- Use Low/No-VOC Paints, and Wood Finishes, carpets. [V] [P]
- Provide Daylight and Views to 75% of Spaces, better 90%
- Collect and reuse rain water. [V]
- Select FSC Certified Wood Flooring, and Framing
- Use Permiable paveing, or light colored paving. [V]
- Keep Storm water on site [V]

Foundation

Framing/Walls

- Specify Eco-rock drywall [P]

Roofing

- Install a green roof or a cool roof
- Roofing materials with at least 33% recycled content
- Tankless water heater [P]

Energy Power

- Purchace sustainable energy from utility company

CONSTRUCTION

LOW TO NO ADDITIONAL COST

- Dedicate an area on site for recycle-reuse bins [V]
- Centralize wood-cutting operations
- Save and Replace Excavated Topsoil
- Protect trees and topsoil during site work. [V]
- Protect stored on-site or in-stalled absorptive materials from moisture damage
- Caulk and seal common air leak areas [P] [V] [V]

ADDED VALUE, ADDED COST

- Flush out HVAC for two weeks after construction
- Have a IAQ Management Plan
- Conduct baseline IAQ testing prior to occupancy

EXAMPLES

- Drywall scrap: Ground up for use as soil amendment by local farmers.
- Vinyl siding scrap: Recovered and used to produce more vinyl.
- Asphalt shingle scrap: Ground up for path and walkway mate-rial.
- Excess concrete: Ground up and reused as aggregate to make more concrete.

OPERATION

LOW TO NO ADDITIONAL COST

- Use Energy Star® programmable thermostat [V] [P]
- Measure energy and water usageage
- Raise the indoor temperature, in hot summer months, to 74°F to 78°F.
- Replace HVAC Filter on Schedule and with High-Performance Filters

PAY NOW, SAVE LATER

- Make provisions for storage and processing of recyclables: recycling bins near the kitchen, compost, ect...
- Utilize double sided printing

- Energy Star
- HGTV Pro
- Home Depot
- ARCAT
- Harvard
- ToolBase
- USGBC
- NAHB
- Green Globes
- NRDC

Figure 4.18. Sustainable Checklist.

The colored boxes are links to guides/references (R), videos (V), and pricing/ purchasing (P). The right-hand side has links to, NAHB, USGBC, and other checklists that individuals can upload.

By allowing the checklist to be downloaded and free to manipulation, it allows the power of the internet, which is the ability of the masses, to update and create content faster than that of any institution to be unleashed. An example of how this checklist works is demonstrated in the Appendix.

The process of choosing specific items on the checklist involved comparing the National Association of Home Builder's Green Standards, the Leadership in Energy Efficient Design Checklist, Green Globes, and other sources as seen in the Appendix. From that comparison, items were included that, to the best of my knowledge, were most applicable to the specific design project or that could have the biggest sustainable impact on the design.

4.16. Stage 3: Evaluate and Improve

The last stage seeks to include review and revision into the process. The Army has a procedure that is done after almost every large task is completed. It is called an After Actions Review (AAR). See Figure 4.19.

Evaluate and Improve
Link and revise
- Revisit site to document what worked, what did not , and why.
- Analyze building for improvements and lessons learned.
- Evaluate the success of financial, social, and environmental goals.
- Implement lessens in the next project.

Figure 4.19. Sustainable Framework: Evaluate and Improve Stage.

This is a meeting that includes all personnel who were involved in the operation. They meet and review five basic things: what was meant to happen, what actually happened, what went well, what did not go well, and some suggestions for future improvements (Fisher, 2000, 10). "Design professionals talk a lot about improving the quality of life, but we rarely attempt to prove our case by returning to the design environment to document what worked, what didn't, and why." Once this precedent is set and implemented, constant improvement can become a vehicle for change, and that change can transform the checklist to remain current and be constantly updated by a vast number of people.

4.17. Checklist Evaluation

After creating the checklist, it was used to evaluate what changes would be made to the building. Through this diagnosis, areas of improvement for the checklist were determined. Future projects could implement the flowing sustainable features or procedures from the beginning into the design using the the checklist: capture and recycle rainwater, use plants to clean the air, orient the roof for better access to solar power, find space to replace excavated topsoil, find ways to recycle on-site construction scrap, orient the building to benefit from passive cooling, examine a grey water system, use a xeriscape landscape design, keep storm water on-site, design the building using a raised heel roof truss, and create a building user guide for occupants. These strategies would aid in creating a more sustainable and cohesive design from the begining.

Adding these 10 strategies would cut down on fossil fuel usage, save on water consumption, clean the air, and help reduce the amount of natural resources wasted. The building would have clearly benefited from having a simple checklist reminder of sustainable strategies to implement.

Five of the above-mentioned strategies were in the "Low to no additional cost" category of the checklist; four were in the "Pay now, save later" category; and one was in the "Added value, added cost" category, signifying that the sustainability strategies that were missed without using the checklist would not add significant cost to the building.

Areas that were missed, or that the framework could improve upon, were the social and educational aspects of sustainability. The checklist could have added social strategies such as allocating a certain percentage of the development to affordable housing and adding design guidelines (Bowen, P., & Hill, R.,1997). Addressing how aging affects a person's ability to live in the building throughout a life span is another issue that could be investigated and studied.

4.18. LEED Evaluation

A preliminary comparison to LEED was done in order to quickly assess the sustainable potential of this framework. LEED was used because of its popularity and ease of use as a preliminary assessment tool. While this system is bureaucratic and time consuming in practice and documentation, its checklist is simple and straight forward for a general overview. Project points were only awarded to corresponding items on the green list or to items commonly done in construction. The author purchased and read though the study guide before doing the assessment to gain a better understanding of the system.

The main points received were in sustainable sites, energy and atmosphere, location and linkages, and water-efficiency categories. These points were mainly attributed to using xeriscaping techniques such as drought-tolerant plants, using Energy Star appliances with a high-efficiency HVAC system, building close to community transit on previously developed land, and using high efficiency fixtures.

The project's preliminary estimate is 55.5 points. This point level achieves the certified level by surpassing the 45 points needed and coming 5 points short of the silver certification level. Note that this is just a preliminary estimate, but shows the possibility that a checklist based not on points or verification, but on options and cost effectiveness, could produce sustainable results of a considerable degree. If a simple checklist, even as simple as a hand-written one, could be implemented in such a way that it quadruples the number of sustainable buildings being built, the impact would be tremendous. The LEED checklist can be seen in the Appendix.

CHAPTER 5. CONCLUSION

5.1. Conclusion Summary

This research investigated a sustainable framework for small Design/Build/Own projects that do not use a current rating system. The literature review researched project delivery systems; sustainability; and the work of three architects: Jonathan Segal, William Moore, and Sebastian Mariscal. The paper then simulated a building project for the purpose of mimicking how the author would use the information that was researched in a design. Through this exercise, it was determined that sustainability guides suffer from barriers because of the cost associated with completing such guides and a lack of using the full potential of the internet's capabilities.

It was determined that a framework could benefit small firms if the information ware free, assessable in different media such as video, and open to manipulation. The author then set up a proposal for how this framework might look. The framework included a web-based checklist, a definition of sustainability, and an outline of a framework to follow. The checklist contained sustainable strategies that were organized in two separate ways: first, by the order in which a building is built and, second, by cost categories from low to medium to high prices. Each strategy was accompanied by links to videos, guides, or places in which to purchase an item.

The building that was used to help create the checklist was then evaluated to see what sustainable strategies could be added if the checklist were used from the beginning. In this exercise, it was found that 10 sustainable strategies that could have been implemented without significant cost were overlooked. This reinforces the notion that an easy to use and accessible sustainable checklist could help in advancing sustainable practices.

A new way of thinking must be adopted in order to meet the goal of reducing carbon emissions associated with buildings. What is important to know is that true sustainable design deals with a whole system mentality. Every building should, in some way or shape, address the heat gain from the sun, the cooling effects and quality of the air, water efficiency and recycling, material longevity, embodied energy and longevity, the size and quality of the building, the location of the project, and the energy used to power the building. These important decisions should not be left to a select few who dictate what sustainable is and what achieves it. This research critique is to offer a framework for getting more people involved and giving them the knowledge and skills necessary for implementing green design.

The criticisms of this sort of framework are valid. Credibility is low or questionable without a certification process or strict professional oversight, and the checklist could be manipulated to serve the company's goals and not the client's. But manipulation could happen in most any case. The benefits of this solution outweigh its potential pitfalls. Having a free, open, and clear framework watched over by the masses might help in stemming too many bastardizations and hopefully improve some of the criticisms of other performance standards, such as the criticism of LEED that the process sometimes focuses on searching for points rather than true sustainability.

What is most important is not that these buildings are LEED certified, but to make sure that the simple solutions and the most cost effective solutions that can make a big difference are implemented as often as possible, and that this framework/checklist can be a catalyst for people to aspire to even higher standards or higher forms of sustainability than the framework is itself.

5.2. Suggestions for Further Research

Application to other delivery methods has not been made; and could be studied further Areas for future research include:

1) An in-depth analysis of the real-world application of this framework.

2) An advanced study about the sustainability level achieved with this sort of framework.

3) A broadening of the checklist to include more social sustainability practices.

Further research could explore the relationship between the owner and the designer in small building projects. It would be beneficial to explore how the issue of sustainability is dealt with and brought up in the beginning stages of design. Further research could also narrow down the strategies that could have the biggest impact on the sustainability of a building.

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APPENDIX

A.1. Site Selection: Excel Document

CONSTRUCTION COST

Estimate

2000 x 91sq ft =	182,000	Location Factor Fargo 83.2	
560 x 30sq ft =	16,800		
Total:	**198,800**	x 6 house=	**1192800**
		Land*	200,000
		TOTAL	**1,392,800**
		Less Contractor overhead and profit turned into Arch Fee	
		Interest 6%	53568
			1,446,368
		per house	241061.3333

PRICING: per units

						Total	Profit
$279,999	$259,999	$269,999	$259,999	$269,999	$289,999	**$1,629,994**	**$183,626**
					Profit %	**12.70%**	

IRR

Capital rate 6%

	Rate	Year 0	Year 1	Year 2	
Revenue		-500000	407,627	275,999	8279.97

IRR **26%**

NPV

Data

6%	Annual Discount Rate	cost of borrowing
-500,000	Initial Cost of Investment	
407,627	Return from First Year	
275,999		
$122,822.55	Net Present Value	

Appropriately risked projects with a positive NPV could be accepted.

if there is a choice between two mutually exclusive alternatives, the one yielding the higher NPV should be selected

A.2. Checklist Links Page 1: Excel Document

TASK : Planning/ Design Stage - No to Low additional Cost
No to Low additional Cost
Design building in units of 2'
Price Reference - Wilson, Your Green Home, pg. 12C

Orient Building on E/W Axis for Solar Gain
Price Reference - Wilson, Your Green Home (pg. 120)
Guide Link - http://energetechs.com/wp-content/uploads/2009/10/Passive-Solar-Design.pdf
Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_63755,00.htm
Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_55073,00.html?c=486&videoid=6695Z

Orient the building to benefit from passive cooling
Guide Link - http://www.house-energy.com/Landscape/Passive-Cooling.htm
Guide Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_55073,00.html?c=486&videoid=6695Z

Install energy-star windows, lighting, appliances
Price Reference - The Added Cost of Greening a New Home, pg. 14
Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_63755,00.htm
Guide Link - http://www.energystar.gov/index.cfm?c=products.pr_find_es_products

Use native plants and xeriscape landscape design
Price Reference - Wilson, Your Green Home, pg. 12C
Guide Link - http://pubs.caes.uga.edu/caespubs/pubcd/B1073/B1073.htm#Tables
Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_63755,00.htm

Build smaller / compare your buildings footprint to industry averages
Price Reference - Wilson, Your Green Home, pg. 12C

Use underfloor HVAC system

Use a guide such as LEED, Green Globes, or NAHB Guide
Guide Link - http://www.nahbgreen.org/
Guide Link - http://www.usgbc.org/DisplayPage.aspx?CategoryID=19

Use a frost-protected shallow foundation
Price Reference - The Added Cost of Greening a New Home, 1C
Guide Link - http://www.toolbase.org/PDF/DesignGuides/revisedFPSFguide.pdf
Guide Link - http://www.toolbase.org/PDF/DesignGuides/revisedFPSFguide.pdf
Guide Link - http://www.nahbgreen.org/Guidelines/nahbguidelines.aspx

Incorporate Flyash in Concrete up to 15%
Price Reference - The Added Cost of Greening a New Home, pg. 9 -1C
Guide Link - http://flyash.sustainablesources.com/

Use Advance Framing Techniques or Agriboard pannels
Price Reference - The Added Cost of Greening a New Home, pg. 1C
Guide Link - http://www.nahbgreen.org/Guidelines/nahbguidelines.aspx
Guide Link - http://www.toolbase.org/PDF/DesignGuides/advancedwallframing1.pdf
Guide Link - http://www.buildingscience.com/documents/insights/bsi-030-advanced-framing/?topic=/doctypes/building-sc
Guide Link - http://www.toolbase.org/TechInventory/TechDetails.aspx?ContentDetailID=2761
Guide Link - http://www.agriboard.com/

A.3. Checklist Links Page 2: Excel Document

TASK : Planning/ Design Stage

Pay Now: Save Later

Capture and recycle water, use greywater system

Price Reference - The Added Cost of Greening a New Home, pg. 6

Guide Link - http://www.toolbase.org/TechInventory/TechDetails.aspx?ContentDetailID=907

Install Dual Flush Toilets or low flow water fixtures

Price Reference - The Added Cost of Greening a New Home, pg. 6

Guide Link - http://www.americanstandard-us.com/products/productDetail.aspx?id=2055

Install Heat Recovery Ventilation Unit (HRV)

Guide Link - http://www.hometips.com/buying-guides/heat-recovery-ventilator-hrv.htm

Plant Deciduous Trees on the West and South Sides

Price Reference - Azerbegi, pg. 2, and 8

Guide Link - http://www.builditsolar.com/Projects/Cooling/Shading/EB%20Landscaping%20for%20energy%20efficiency.pdf

High-efficiency water heater

Guide Link - http://www.energystar.gov/ia/new_homes/features/WaterHtrs_062906.pdf

Use Serious Windows

Guide Link - http://www.seriouswindows.com/

Use Superiorwalls

Guide Link - http://www.superiorwalls.com/

Increase attic insulation to R60 and Wall insulation to R20

Guide Link - http://insulation.sustainablesources.com/

Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_63755,00.htm

Guide Link - http://insulation.sustainablesources.com/

Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_55073,00.html?c=486&videoid=66952

Use a Raised Heel Roof Truss

Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_55073,00.html?c=486&videoid=66952

Install Solar /Wind/Geothermal Power

Price Reference - Morris, pg. 17

Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_63755,00.htm

Guide Link - http://solarlease.solarcity.com/solarbidlite/estimator.aspx?leadsource=FirstSolar

Use plants to clean air

Guide Link - http://greenspaces.in/blog/ted09/

A.4. Checklist Links Page 3: Excel Document

TASK : Construction - No to Low additional Cost

No to Low Additional Cost

Dedicate an area on site for recycle-reuse bins
Price Reference - Wilson, Your Green Home (pg. 120)
Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_55073,00.html?c=486&videoid=66952

Centralize wood-cutting operations
Price Reference - Wilson, Your Green Home (pg. 120)

Save and Replace Excivated Topsoil
Guide Link - http://www.toolbase.org/PDF/CaseStudies/LCCTC_Added_Cost_Greening_New_Home.pdf

Protect trees and topsoil during sitework
Price Reference - Wilson, Your Green Home (pg. 120)
Video Link - http://www.youtube.com/watch?v=67M_E8UgaUs

Protect stored on-site or installed absorptive materials from moisture damage
Guide Link - LEEDs credit: EQ 3.2

Caulk and seal common air leak areas
Price Reference - The Added Cost of Greening a New Home, pg. 12-13
Guide Link - http://www.energystar.gov/ia/partners/publications/pubdocs/DIY_Guide_May_2008.pdf
Video Link - http://www.hgtvpro.com/hpro/pac_ctnt/text/0,2595,HPRO_20196_63755,00.htm
Guide Link - http://www6.homedepot.com/ecooptions/index.html?

Pay Now: Save Later
Flush out HVAC for two weeks after construction
Price Reference - Morris, pg. 20
Guide Link - http://www.wbdg.org/design/ieq.php

Have a IAQ Management Plan
Price Reference - Morris, pg. 20
Guide Link - http://www.wbdg.org/design/ieq.php

Conduct baseline IAQ testing, after construction ends and prior to occupancy, using testing protocols consistent with the United States Environmental Protection Agency Compendium of Methods for the Determination of Air Pollutants in Indoor Air
Price Reference - Morris, pg. 20
Guide Link - http://www.wbdg.org/design/ieq.php
Added Value: Added Cost
Drywall scrap: Ground up for use as soil amendment by local farmers
Price Reference - Morris, pg. 18
Guide Link - www.drywallrecycling.org
Guide Link - http://constructionwaste.sustainablesources.com/

Vinyl siding scrap: Recovered and used to produce more vinyl
Price Reference - Morris, pg. 18
Guide Link - http://www.aboutbluevinyl.org/recycling.asp
Guide Link - http://constructionwaste.sustainablesources.com/

Asphalt shingle scrap: Ground up for path and walkway material.
Price Reference - Morris, pg. 18

A.5. Checklist Links Page 4: Excel Document

TASK : Operation - No to Low additional Cost
No to Low Additional Cost
Use Energy Star® programmable thermostat
Price Reference - Energy Savings and Performance Gains, pg. 4
Guide Link - http://www.wbdg.org/research/energyefficiency.php?a=11

Measure energy and water usageage
Price Reference - The Added Cost of Greening a New Home, pg. 9
Guide Link - http://www.wbdg.org/design/optimize_om.php

Raise the indoor temperature, in hot summer months, to 74°F to 78°F
Price Reference - Energy Savings and Performance Gains, pg. 4
Guide Link - http://www.gsa.gov/graphics/pbs/GSA_SevenStrategies_090327screen.pdf

Replace HVAC Filter on Schedule and with High-Performance Filters
Price Reference - Energy Savings and Performance Gains, pg. 6
Guide Link - http://www.gsa.gov/graphics/pbs/GSA_SevenStrategies_090327screen.pdf

Pay Now: Save Later

Make provisions for storage and processing of recyclables: recycling bins near the kitchen, compost, ect...
Price Reference - Wilson, Your Green Home (pg. 120)

Utilize double sided printing
Price Reference - Energy Savings and Performance Gains, pg. 8
Guide Link - http://www.wbdg.org/research/energyefficiency.php?a=11

Create a Builders Owners Manual
Price Reference - The Added Cost of Greening a New Home, pg. 19

A.6. LEED Checklist Comparison Page 1

LEED for Homes Simplified Project Checklist

for Homes

Builder Name:	*Alex Gore*
Project Team Leader (if different):	
Home Address (Street/City/State):	

Project Description:

Building type: ***Single attached*** Project type: ***Custom***

\# of bedrooms: ***0*** Floor area: ***0***

Adjusted Certification Thresholds

Certified: ***45.0*** Gold: ***75.0***

Silver: ***60.0*** Platinum: ***90.0***

Project Point Total

Prelim: 0 + 6 Maybe pts ***Final: 55.5***

Certification Level

Prelim: Not Certified ***Final: Not Certified***

Final Credit Category Total Points

ID: 3 ***SS: 13*** ***EA: 13*** ***EQ: 5***

LL: 7 ***WE: 7*** ***MR: 7.5*** ***AE: 0***

Min. Point Thresholds Not Met for Prelim. OR Final Rating

date last updated :

last updated by :

				Max Points	Project Points Preliminary			Final
Innovation and Design Process (ID)		(No Minimum Points Required)		Max	Y/Pts	Maybe	No	Y/Pts
1. Integrated Project Planning	1.1	Preliminary Rating		Prereq				*Y*
	1.2	Integrated Project Team		1	*0*	*0*		*1*
	1.3	Professional Credentialed with Respect to LEED for Homes		1	*0*	*0*		*0*
	1.4	Design Charrette		1	*0*	*0*		*1*
	1.5	Building Orientation for Solar Design		1	*0*	*0*		*1*
2. Durability Management Process	2.1	Durability Planning		Prereq				*Y*
	2.2	Durability Management		Prereq				*Y*
	2.3	Third-Party Durability Management Verification		3	*0*	*0*		*0*
3.Innovative or Regional Design	3.1	Innovation #1		1	*0*	*0*		*0*
	3.2	Innovation #2		1	*0*	*0*		*0*
	3.3	Innovation #3		1	*0*	*0*		*0*
	3.4	Innovation #4		1	*0*	*0*		*0*
		Sub-Total for ID Category:		***11***	*0*	*0*		***3***
Location and Linkages (LL)		(No Minimum Points Required)	OR	Max	Y/Pts	Maybe	No	Y/Pts
1. LEED ND	1	LEED for Neighborhood Development	LL2-6	10	*0*	*0*		*0*
2. Site Selection	2	Site Selection		2	*0*	*0*		*0*
3. Preferred Locations	3.1	Edge Development	LL 3.2	1	*0*	*0*		*0*
	3.2	Infill		2	*0*	*0*		*2*
	3.3	Previously Developed		1	*0*	*0*		*1*
4. Infrastructure	4	Existing Infrastructure		1	*0*	*0*		*1*
5. Community Resources/ Transit	5.1	Basic Community Resources / Transit	LL 5.2, 5.3	1	*0*	*0*		*0*
	5.2	Extensive Community Resources / Transit	LL 5.3	2	*0*	*0*		*0*
	5.3	Outstanding Community Resources / Transit		3	*0*	*0*		*3*
6. Access to Open Space	6	Access to Open Space		1	*0*	*0*		*0*
		Sub-Total for LL Category:		***10***	*0*	*0*		*7*
Sustainable Sites (SS)		(Minimum of 5 SS Points Required)	OR	Max	Y/Pts	Maybe	No	Y/Pts
1. Site Stewardship	1.1	Erosion Controls During Construction		Prereq				*Y*
	1.2	Minimize Disturbed Area of Site		1	*0*	*0*		*1*
2. Landscaping	2.1	No Invasive Plants		Prereq				*Y*
	2.2	Basic Landscape Design	SS 2.5	2	*0*	*0*		*0*
	2.3	Limit Conventional Turf	SS 2.5	3	*0*	*0*		*3*
	2.4	Drought Tolerant Plants	SS 2.5	2	*0*	*0*		*2*
	2.5	Reduce Overall Irrigation Demand by at Least 20%		6	*0*	*0*		*0*
3. Local Heat Island Effects	3	Reduce Local Heat Island Effects		1	*0*	*0*		*1*
4. Surface Water Management	4.1	Permeable Lot		4	*0*	*0*		*0*
	4.2	Permanent Erosion Controls		1	*0*	*0*		*0*
	4.3	Management of Run-off from Roof		2	*0*	*0*		*0*
5. Nontoxic Pest Control	5	Pest Control Alternatives		2	*0*	*0*		*2*
6. Compact Development	6.1	Moderate Density	SS 6.2, 6.3	2	*0*	*0*		*0*
	6.2	High Density	SS 6.3	3	*0*	*0*		*0*
	6.3	Very High Density		4	*0*	*0*		*4*
		Sub-Total for SS Category:		***22***	*0*	*0*		***13***

A.7. LEED Checklist Comparison Page 2

LEED for Homes Simplified Project Checklist (continued)

				Max Points	Project Points Preliminary Y/Pts	Maybe	No	Final Y/Pts
Water Efficiency (WE)		(Minimum of 3 WE Points Required)	OR	Max	Y/Pts	Maybe	No	Y/Pts
1. Water Reuse	1.1	Rainwater Harvesting System	WE 1.3	4	0	0		3
	1.2	Graywater Reuse System	WE 1.3	1	0	0		1
	1.3	Use of Municipal Recycled Water System		3	0	0		0
2. Irrigation System	↘ 2.1	High Efficiency Irrigation System	WE 2.3	3	0	0		0
	2.2	Third Party Inspection	WE 2.3	1	0	0		0
	↘ 2.3	Reduce Overall Irrigation Demand by at Least 45%		4	0	0		0
3. Indoor Water Use	3.1	High-Efficiency Fixtures and Fittings		3	0	0		3
	3.2	Very High Efficiency Fixtures and Fittings		6	0	0		0
		Sub-Total for WE Category:		15	0	0		7
Energy and Atmosphere (EA)		(Minimum of 0 EA Points Required)	OR	Max	Y/Pts	Maybe	No	Y/Pts
1. Optimize Energy Performance	1.1	Performance of ENERGY STAR for Homes		Prereq				Y
	1.2	Exceptional Energy Performance		34	0	0		0
7. Water Heating	↘ 7.1	Efficient Hot Water Distribution		2	0	0		0
	7.2	Pipe Insulation		1	0	0		1
11. Residential Refrigerant Management	11.1	Refrigerant Charge Test		Prereq				
	11.2	Appropriate HVAC Refrigerants		1	0	0		1
		Sub-Total for EA Category:		38	0	0		13
Materials and Resources (MR)		(Minimum of 2 MR Points Required)	OR	Max	Y/Pts	Maybe	No	Y/Pts
1. Material-Efficient Framing	1.1	Framing Order Waste Factor Limit		Prereq				Y
	1.2	Detailed Framing Documents	MR 1.5	1	0	0		1
	1.3	Detailed Cut List and Lumber Order	MR 1.5	1	0	0		1
	1.4	Framing Efficiencies	MR 1.5	3	0	0		3
	1.5	Off-site Fabrication		4	0	0		0
2. Environmentally Preferable Products	↘ 2.1	FSC Certified Tropical Wood		Prereq				
	↘ 2.2	Environmentally Preferable Products		8	0	0		0
3. Waste Management	3.1	Construction Waste Management Planning		Prereq				Y
	3.2	Construction Waste Reduction		3	0	0		2.5
		Sub-Total for MR Category:		16	0	0		7.5
Indoor Environmental Quality (EQ)		(Minimum of 6 EQ Points Required)	OR	Max	Y/Pts	Maybe	No	Y/Pts
1. ENERGY STAR with IAP	1	ENERGY STAR with Indoor Air Package		13	0	0		0
2. Combustion Venting	2.1	Basic Combustion Venting Measures	EQ 1	Prereq				Y
	2.2	Enhanced Combustion Venting Measures	EQ 1	2	0	0		0
3. Moisture Control	3	Moisture Load Control	EQ 1	1	0	0		0
4. Outdoor Air Ventilation	↘ 4.1	Basic Outdoor Air Ventilation	EQ 1	Prereq				Y
	↘ 4.2	Enhanced Outdoor Air Ventilation		2	0	0		2
	4.3	Third-Party Performance Testing	EQ 1	1	0	0		0
5. Local Exhaust	↘ 5.1	Basic Local Exhaust	EQ 1	Prereq				
	5.2	Enhanced Local Exhaust		1	0	0		0
	5.3	Third-Party Performance Testing		1	0	0		0
6. Distribution of Space Heating and Cooling	↘ 6.1	Room-by-Room Load Calculations	EQ 1	Prereq				Y
	6.2	Return Air Flow / Room by Room Controls	EQ 1	1	0	0		0
	6.3	Third-Party Performance Test / Multiple Zones	EQ 1	2	0	0		0
7. Air Filtering	7.1	Good Filters	EQ 1	Prereq				Y
	7.2	Better Filters	EQ 7.3	1	0	0		0
	7.3	Best Filters		2	0	0		0
8. Contaminant Control	↘ 8.1	Indoor Contaminant Control during Construction	EQ 1	1	0	0		0
	8.2	Indoor Contaminant Control		2	0	0		1
	↘ 8.3	Preoccupancy Flush	EQ 1	1	0	0		1
9. Radon Protection	↘ 9.1	Radon-Resistant Construction in High-Risk Areas	EQ 1	Prereq				
	↘ 9.2	Radon-Resistant Construction in Moderate-Risk Areas	EQ 1	1	0	0		0
10. Garage Pollutant Protection	10.1	No HVAC in Garage	EQ 1	Prereq				Y
	10.2	Minimize Pollutants from Garage	EQ 1, 10.4	2	0	0		0
	10.3	Exhaust Fan in Garage	EQ 1, 10.4	1	0	0		1
	10.4	Detached Garage or No Garage	EQ 1	3	0	0		0
		Sub-Total for EQ Category:		21	0	0		5
Awareness and Education (AE)		(Minimum of 0 AE Points Required)		Max	Y/Pts	Maybe	No	Y/Pts
1. Education of the Homeowner or Tenant	↘ 1.1	Basic Operations Training		Prereq				Y
	↘ 1.2	Enhanced Training		1	0	0		0
	1.3	Public Awareness		1	0	0		0
2. Education of Building Manager	↘ 2	Education of Building Manager		1	0	0		0
		Sub-Total for AE Category:		3	0	0		0

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A.8. LEED Checklist Comparison Page 3

LEED for Homes Simplified Project Checklist

Addendum: Prescriptive Approach for Energy and Atmosphere (EA) Credits

Points cannot be earned in both the Prescriptive (below) and the Performance Approach (pg 2) of the EA section.

Energy and Atmosphere (EA)		(No Minimum Points Required)	OR	Max Points (Max)	Project Points Preliminary (Y/Pts)	Maybe	No	Final (Y/Pts)
2. Insulation	2.1	Basic Insulation		Prereq				Y
	2.2	Enhanced Insulation		2	0	0		0
3. Air Infiltration	3.1	Reduced Envelope Leakage		Prereq				
	3.2	Greatly Reduced Envelope Leakage		2	0	0		0
	3.3	Minimal Envelope Leakage	EA 3.2	3	0	0		0
4. Windows	4.1	Good Windows		Prereq				
	4.2	Enhanced Windows		2	0	0		2
	4.3	Exceptional Windows	EA 4.2	3	0	0		0
5. Heating and Cooling Distribution System	5.1	Reduced Distribution Losses		Prereq				Y
	5.2	Greatly Reduced Distribution Losses		2	0	0		2
	5.3	Minimal Distribution Losses	EA 5.2	3	0	0		0
6. Space Heating and Cooling Equipment	6.1	Good HVAC Design and Installation		Prereq				Y
	6.2	High-Efficiency HVAC		2	0	0		2
	6.3	Very High Efficiency HVAC	EA 6.2	4	0	0		0
7. Water Heating	7.1	Efficient Hot Water Distribution		2	0	0		0
	7.2	Pipe Insulation		1	0	0		1
	7.3	Efficient Domestic Hot Water Equipment		3	0	0		0
8. Lighting	8.1	ENERGY STAR Lights		Prereq				Y
	8.2	Improved Lighting		2	0	0		0
	8.3	Advanced Lighting Package	EA 8.2	3	0	0		3
9. Appliances	9.1	High-Efficiency Appliances		2	0	0		2
	9.2	Water-Efficient Clothes Washer		1	0	0		0
10. Renewable Energy	10	Renewable Energy System		10	0	0		0
11. Residential Refrigerant Management	11.1	Refrigerant Charge Test		Prereq				Y
	11.2	Appropriate HVAC Refrigerants		1	0	0		1
			Sub-Total for EA Category:	**38**	0	0		**13**

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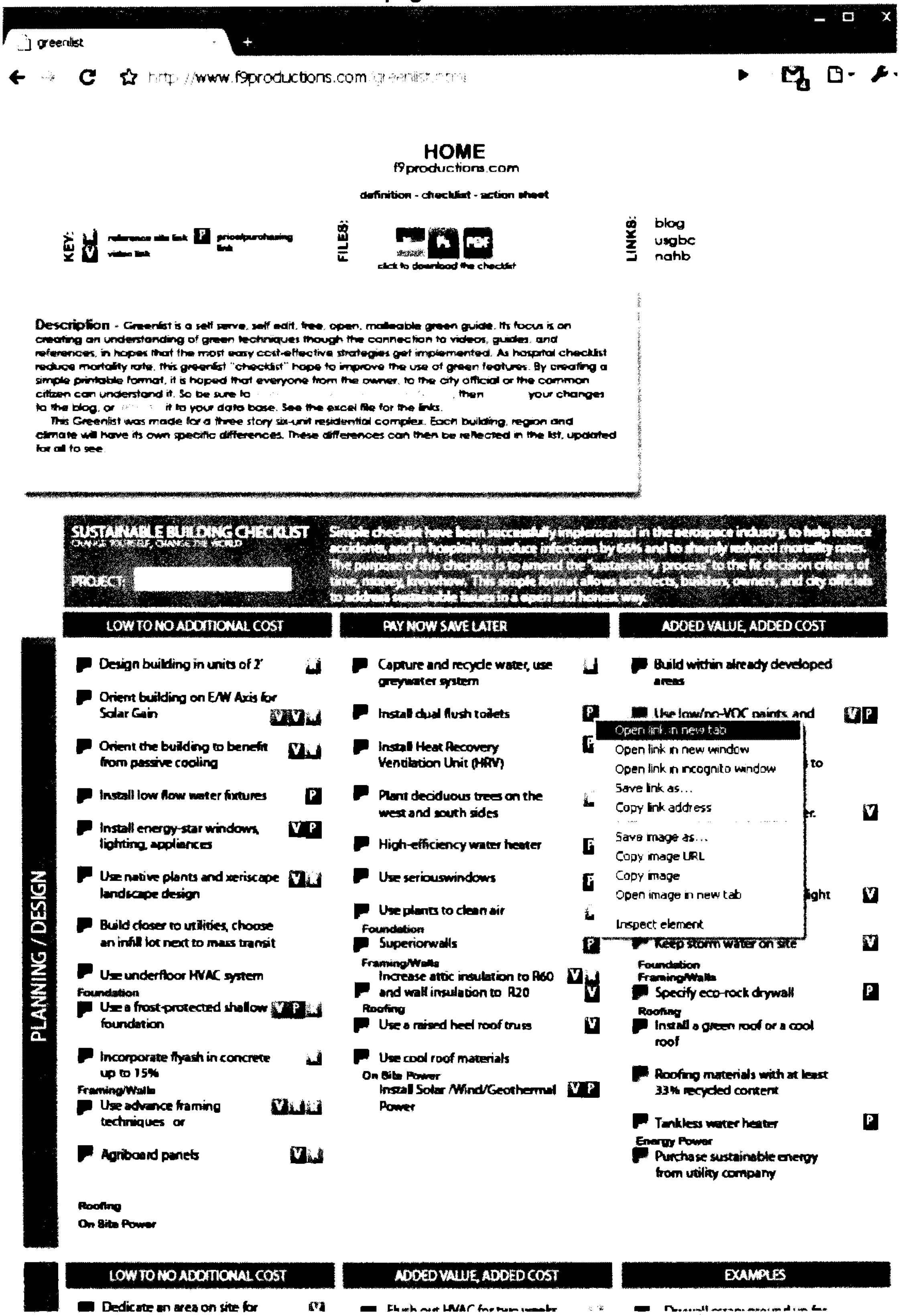
FOUNDATION WALLS						
Footing	272 Ln Feet		$5,051		Footing: $18.57 L.F.	RSMeans Residential Cost Data Pg. 118
Wall					Wall: $10.75 S.F.	RSMeans Residential Cost Data Pg. 122
Shallow foundation at 24"	544 Sq. Ft.		$5,848			
Normal foundation at 72"	1632 Sq. Ft.		$17,544			
Engineering work for shallow foundation estimate:			$1,000			
WALLS					Time savings	
Advance Framing Techniques	$2.67 per Sq. Ft. Wall space	$.73 sq ft R19 Ins.				RSMeans Residential Cost Data Pg. 136, 386
Agriboard pannels	$5.42 per Sq. Ft. Wall space*				25 days	Installed Cost Comparisons PDF
2x4 Wall	$2.65 per Sq. Ft. Wall space	$.10 sq ft for 2" thick Rigid In		$.63 sq ft R11 Ins.		RSMeans Residential Cost Data Pg. 136, 384, 386
						356ln ft.
Wall Perimeter	187 ln ft. per two units (one one floor)					
	17,952 sq ft. for level one and two					
	2,848 sq ft. for level one and two					126 x 52
	Total			20,800		
Agriboard pannels	Interest payment		$53,000	$210 per day		
	Framing time 3 1/2 months	120 days		$25,200		
	25 days			$5,250		
	Difference			$19,950		
	Cost savings Per Sq. Ft. Breakdown			$1.04	* - cost savings of $1.04 sq. ft.	

A.10. Greenlist Demonstration Homepage



A.11. Example Links

By right-clicking "open in a new tab" as demonstrated on page 71 to reveal: guides, videos, and products will be presented in new tabs like the example screenshots below.