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STRATEGIES AND RECOMMENDATIONS FOR THE CONSTRUCTION OF HEALTHCARE FACILITIES IN NYC

BY

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A thesis submitted in partial fulfillment

of the requirement for the degree of

Master of Engineering

May 2010

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The Cooper Union for the Advancement of Science and Art

THE COOPER UNION FOR THE ADVACEMENT OF SCIENCE AND ART

ALBERT NERKEN SCHOOL OF ENGINEERING

This thesis was prepared under the direction of Dr. Tzavelis and has received approval. It was submitted to the Dean of the School of Engineering and the full Faculty, and was approved as partial fulfillment of the requirement for the degree of Master of Engineering.

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May 2010

ACKNOWLEDGMENTS

This research would have not been completed without the help from industry participants and guidance of people who offered me support and knowledge in their respective fields. I would like to thank all who offered me the time in the interviews and help me in my data collection and data analysis. Thank You.

I would like to thank my advisors, Dr. Yapijakis and Dr. Tzavelis for their trust and encouragement throughout my studies at The Cooper Union and for supporting my endeavor to complete this study. I extend my gratitude to the Civil Engineering faculty and staff for helping me out throughout.

I also want to thank my friends for their love, motivation and understanding.

To my family, Gracias Papá y Mamá por estar siempre ahí, no me cabe la menor duda que fue el cariño y la confianza incondicional que me tienen lo que me permitió mantenerme en el trayecto del trabajo duro y arduo que una tesis requiere. A mi hermano menor, Michael, por ser tan paciente! Finally to my brother, Christian, Gracias por estar en las buenas y las malas, por las innumerables noches que pasamos estudiando, por la compañía, por la competencia, por darme fuerzas cuando no creía tenerlas y por ayudarme incondicionalmente en todos estos años de estudio juntos. ¡Lo logramos! ¡Gracias!

ABSTRACT

Hospitals are difficult buildings to operate, build and design. Their complex mechanical systems are strictly regulated for performance; design must be carefully planned in order to improve recovery rates in patients; and operation and maintenance is a non stop 24 hour and seven days a week all year long task. Besides these unique conditions, hospital facilities are considered to be among the top consumers of energy in the commercial sector. Hospital construction adds to the more than three billion tons of annually consumed raw materials and the 30 percent of CO_2 emissions that construction and use of buildings in all sectors produce in United States. Another conflict that has generated an interest in the health care sector is that an estimated $300 billion in the next 15 years will go towards new construction in an industry that is not quite ready to take on the task of sustainability. The industry itself has been facing many challenges in incorporating green strategies.

The objective of this research is to develop strategies and recommendations for sustainable hospital construction in the City of New York. Urban sustainability has become a pressing task on the city agenda already. This paper extracts sustainable technologies and practices for active systems and material selection for the urban hospital. Finally, in order to understand and propose changes, a comparative study case analysis on NYC hospitals was done. The findings allow recognition of areas where improvement is needed and initial steps could be taken. Among those steps: A more integrative and collaborative delivery system, smaller pilot projects and/or retrofit buildings where new technologies and ways of doing business could be tried; better familiarity with the soon to be released LEED for healthcare system; and more commitment and leadership by the owner in sustainable practices.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CH 1. INTRODUCTION

Healthcare facilities are complex building types, interaction between design, construction and operation need to be optimized to produce the best possible result for a healing environment. Constructions of these facilities cope with serious potential consequences to the lives and health of future patients if poor building design and construction were to occur. Additionally, there are insurmountable challenges of poor indoor air quality and extensive high energy consumption environment design concerns. Commonly hospitals are subject to additions and remodeling, and during construction activity existing areas of hospital remain functional; strict provisions must be made for these scenarios including a comprehensive infection-control technique to mitigate construction operations debris. Healthcare facilities are places where diseases can be spread easily through airborne particles, for this reason special consideration on materials and hazardous chemicals inside healing environments must be carefully selected so patients and staff don't get sick. These facilities operate 24 hours a day everyday and seven days per week all year long, which requires special care and provisions for ongoing maintenance, repair work, regular cleaning, and contribution to overall energy intensity and consumption. Finally, hospital facilities uniqueness becomes more complex when a new facility is built in an urban setting. Urban morphology on city climate has direct effects on energy consumption (Raydan and Steemers 2006). Location, density of building, land, solar access, location, pollution control, zoning regulations, etc. are few of the challenges to be considered when building a hospital in a city environment.

Healthcare industry, considered a largely nonprofit sector, represents almost 4 percent of all U.S construction or close to $47 billion of equivalent market share in the construction industry, including private and public sectors (USCB 2009). Projections estimate that in the next 15 years $300 billions will be spent on healthcare construction (Ulrich and Zimring 2004). These estimates are a response to the increasing population growth rates in the country as well as the aging population of baby boomers (USCB 2009). An urgent expansion of the healthcare infrastructure is eminent as the two above mentioned factors combined with the recent approved health reform, which extended the coverage to millions of U.S residents, will put a great amount of pressure to the industry to build more hospitals and other type of health care facilities. Under an unprecedented construction boom, the industry is presented with an opportunity to model green strategies in a time where public policy and advocacy organizations have already mandate legislation around the country in different cities and states. Goals and standards need to be expedited in pro of minimizing the negative impact that construction industry brings to the environment.

It is important that generations of new healthcare facilities develop a rather fast transformation into green strategies and the culture that goes with it so when construction starts taking full effect there can be a framework in place for sustainable building. The sector as a whole needs to engage in a commitment to do more and do better. “Brown hospitals” built in the past never fit healthcare’s acclaimed mission of “first do no harm”. New facilities must start addressing environmental areas forgotten in the past such as: reduction of carbon dioxide emissions, construction waste minimization, improvement on generation and transmission of energy; better water management and consumption techniques and more appropriate handling of natural resources allocation. Architects, engineers and construction industry (AEC) need to work, for all practical purposes, closely together so they can more effectively predict and avoid conditions that bring problems to future generations.

The opportunity that comes with a construction boom and the challenges associated with transitioning to sustainable practices become more difficult when construction takes place in an urban setting. Nevertheless, many metropolises of the world count with convenient factors for development of hospitals building types: density, efficient public transportation and extensive infrastructure are all desirable. The problem comes when comparing cons and pros of dense cities. Environmentally thinking, the cons are much bigger and significant. In cities, microclimate has significant effects on energy consumptions; urban heath island effects are common, sanitary and storm water management becomes more critical; limited water supply is a reality; limited land and hostile plant environments start to creep up as a major requirement; poorer air quality and less than optimal soils for vegetation becomes more important; and the congested underground utility infrastructure can also make the construction of buildings a nightmare (Steemers 2006).

Under the scenarios that healthcare construction is facing, this paper seeks to first: find out the current state-of-the practice in the health care construction building and second: to elaborate recommendations and strategies for sustainable practices applicable to the private builders of New York City hospitals.

Having said this, the city of New York (NYC) will be one more variable in the development of the thesis. NYC faces a growing population density and it is already a environmentally challenged city (CEQR 2008). In addition, studies have shown that sustainable construction of healthcare facilities is still in its infancy (Guenther and Vittori 2008). This paper is an effort in highlighting the importance of documenting good practices and developing sustainable strategies that can be applied to this sector in city environments.

New York City is chosen because it is one of the cultural and academic capitals of the world and tends to attract more sophisticated builders and architects. It was also chosen because the researcher of this thesis works in the industry and through his career in the sector has recognized the lack of documentation in green strategies tailored to the nonprofit sector in NYC.

The construction constrains and challenges that this city embraces are also a factor for creative and innovative characteristics for the AEC industry players. However, in an environment like NYC talent cannot be the only solution to the problem if communication and effective work platforms don't exist. Studies and professional organizations agree that current delivery methods have a structure that encourages adversarial and fragmented relationships as well as promoting non-collaborative processes (AIA CA Council 2007 ; Kiber 2004). Although some research have been done on recognizing successful key processes in delivering of green buildings, there is still a gap in the healthcare construction sector (Phelps et. al 2005; Pommer 2008).

Sustainable building is a relatively new concept for the healthcare industry(Guenther and Vittori 2008), and it requires early interaction and collaboration of all stakeholders during the full duration of the project. An integrated design approach that includes owners, architects, engineers and builders is crucial to build a green hospital in New York City.

Current literature has shown that there is negative trend in the construction industry towards adopting new technologies and ways of building (Autodesk White Paper 2004). Factors such as lack of experience, lack of data documenting success; fear of liabilities implications, risk allocation uncertainties; new responsibilities and greater expectations; negative perception of being more expensive; and passive behaviors based on the "no change is needed" are some of the common barriers that industry as a whole faces (Kent and Becerik 2010).

This paper finds that an integrated approach system hints to be the answer to successfully implement sustainable technologies. An integrated design defies the traditional delivery process by bringing together early in the project all key stakeholders (owner, designers, builders, users, operators, etc.) to empower and foster them into understanding and developing needs, goals, expectations and key elements of project design, construction and even operation. The process is fundamentally different from traditional delivery methods. It looks at augmenting performance in sustainable practices so operation cost can be reduced, first capital costs neutralized and environmental damage diminished so when a cost analysis is performed it favors it in the long run. The biggest challenges exposed in this paper include resistance to changing to a new culture, to a new definition of team and processes, to a new form of communication and tools, an to a new mindset. Opportunities to develop a more collaborative working platform will be discussed so sustainable water, energy and material selection sustainable techniques can be considered without skepticism.

This thesis will add knowledge, tools and hard data concerning integrative design, technologies and delivery process in hopes that the movement of change becomes less stringent and more accepted.

The following sections will discuss problem statement, objectives, purpose of this research and its justification.

1.1 Purpose of the Research

This research aims to investigate existing healthcare practices around the country implementing sustainable practices and integrated design techniques to achieve reductions in energy use, management of green materials and miscellaneous sustainable technologies that can be economically viable and life cycle cost effective for a city like New York. Analysis and extraction of data from literature and academic research in the sector; structure interviews with experts in the field; content analysis and qualitative survey of existing sustainable practices and a comparative study case approach will give professionals in the construction industry concise data on knowledge and experience levels on sustainability practices in the sector. Structure interviews and content analysis of procurement and design documents in under construction hospital in NYC will lead to a prescription of NYC state of the practice in the delivering of green hospital buildings. The comparative analysis will be performed between NYC sector and best documented practices in the sector, the result of data analysis will lead to recommendations. The research hopes to uncover barriers for adoption of integrated sustainable design practices as well as to develop fields for further research.

1.2 Scope of the Research

The limits of this thesis will try to expand on the literature gap of green healthcare construction in urban cities. Best Practices and sustainable strategies have not been documented or/and researched extensively (Harman et al. 2006) . The lack of documentation and knowledge on this field is one causes for sector's slow adoption (Kent and Becerik-Gerber 2010). It is important to emphasize that the healthcare sector is still in the midst of the green revolution (Guenther and Vittori 2008) and in essence it is this circumstance the main driving force for this paper. The scope of the paper will be limited to the nonprofit sector in New

York City; however, the recommendations and information can be used as a guide for other urban areas. Specific areas will be researched closer such as: Energy, HVAC, and water system sustainable technologies; delivery construction methods will be of great importance as they are the platforms allowing systems to get build and take green shapes. Life Cycle cost analysis and business case studies are not part of the thesis research either. They are only mentioned as a possible benefit.

1.3 Objectives of the Research

The goals for this thesis are several. One of them is to provide members and professionals of the construction industry in New York City with current available techniques and key ways to achieve sustainable performance in hospital buildings. Another goal is to obtain data from the nonprofit sector in NYC regarding current state-of-the practice so it can be analyzed and compared to best practices in the country. This exercise will lead to a methodology tool that can be revised and expanded as more data becomes available. Stakeholders in the industry can use this thesis as a first step to reconsider their role and opportunities in the green building movement. Finally, this paper seeks to provide a general understanding of key processes and current barriers in the delivery processes of sustainable healthcare facilities in NYC.

1.4 Research Justification

The general market has gone through a relatively rapid "green-thinking" transformation in the late years of the 20th century prompting a new level of recognition and acceptance of sustainable design during this new millennium (Yudelson 2008). Ironically, the healthcare sector, whose main mission of "first do no harm", fell through the cracks during the last construction boom in the early 20th Century, by no recognizing the damage of their buildings to the environment(Berkebile in Guenther 2008). Healthcare today is still in the midst of this transformation. In the last decade there has been an interest in the residential, commercial and municipal sectors on sustainable building. A clear example is the interest fueled by the leadership of the US green building council (USGBC) and its LEED point-based metric tool acceptance during these last 10 years. Exponential growths trend in application has been experienced these last five years (Yudelson 2008). Even today, with more buildings registering as LEED, public policy developing legislation; executive orders and mandates pointing LEED as the chosen benchmark for sustainable performance, Healthcare sector does not catch up to the movement. One reason can be the incompatibility of hospital nature with current version. To explain this conflict, it is fair to start by saying that LEED tools were developed to tailor the residential and commercial sector. When comparing a hospital operation and maintenance with a residential building the differences are infinite. Simply put, LEED was not custom made for healthcare buildings. As of today there is no an official LEED package customized for the sector. Although there is a LEED for Healthcare in the works of being revised and close to be released, hospitals are considering LEED unless it presents a business case opportunity or simply because it is the law.

This gap on benchmark metrics in the sector started to narrowed five years ago with the introduction of the *Green Guide for Health Care,* an excellent voluntary and self certifying tool kit customized for all types of healthcare facilities (GGHC 2009). Given that it was only five years ago when movement started it can be assumed that the movement is still in a process of evolution. In the guide, there is no really a define insight or set number of credits as to what is considered high, medium, platinum, gold or whatever denomination one might issue to benchmark a "sustainable practice." But it does provide a good guidance to important sustainable principles.

Conflicts of this type drove the writer to consider this topic. As a professional working in the industry for two years now, he believes that an initial step to consider sustainable practices in today's market is by documentation, data development, analysis and research that can produce "hard data" and concise results so owners can make something out of it when buying a designer and builder for their project.

Today, the barriers for a full sector transformation are numerous and very real. These will continue to creep up as more buildings get build under uneducated decisions on a market that soon will be mandated to be more resource conscious under pressuring city environmental agenda. Stakeholders need data soon and justified assurance that sustainability practices don't really cost more; and that there is more than costs and money behind sustainable buildings.

The opportunity to study the New York City market presents an interesting study case: As buildings become more complex, legislation and policies become stricter in order to regulate buildings and their impacts in the city. Mayor Bloomberg has already executed order legislations to city agencies for sustainable advocacy in new construction of city buildings, there is also a comprehensive plan to reduce 30 percent of carbon emissions below 2005 levels by 2030; the plan has specific goals in infrastructure and the energy sector. Some sectors, under the wave of LEED have moved towards the right direction, however, some sectors have not and some need to do more. The AEC industry faces enormous pressure to meet cities' needs and to preserve resources for future generations.

1.5 Problem Statement

New Hospitals replacing "brown" facilities or additions need to be developed in a different manner. They also need to be built fast given the population growth trends and the new major health reforms for expansion in the sector. Sooner than later, they need to make up for the negative impacts of existing facilities while meeting infrastructure demand ruled by the new health reform and construction estimates in the next decades.

In the sector of ecological and carbon footprint, methodologies have been developed to assign productive land and water acre areas to human population resources consumptions equivalences. The more resources consume the larger productive land and water areas are needed to counteract consumption. Results for Healthcare sector are rather negative, and more if taken into account the main mission of hospitals (GNF 2008). Hospitals in general have a bigger footprint than their communities they serve (National Health Service), European studies on the largest health care system in England concluded that both Energy usage and building mechanical system demand are the biggest contributors of CO_2 of this building type. Both energy and mechanical systems are also the crucial element for hospital operation. The intersection of these two priorities into an environmental issue is a major problem.

Environmental challenges are not the only roots driving the green movement; other pressuring factors are in the run as well. One of them is the estimated boom of construction in the sector, a$300 billion projections for the next decade is allocated to expand healthcare facilities. The other one is a 40 percent projected population growth in the U.S. for the year 2040. The scenario is set so in 30 years there will have to be more buildings handling demand of growing population. Along with an expansion of health infrastructure there is a potential to contaminate the surrounding ecosystems and consume earth's resources faster is those buildings are not built environmentally friendly. The Global Footprint Network (a leading organization on ecological footprint metrics) predicts that by 2040 there would be the need of having to two planet ecological services to keep up with the current rate of humanity consumption.

Under this scary scenario, it does not only make sense to distribute and dissipate these facts and problems to the unaware world; but to act in any way so that at the very least there is a change of mindset. This paper aims to document current state, pressuring problems, and strategies or recommendations for anyone interested in the field of discussion. As more frameworks and roadmaps get developed for selection of green technologies or processes in delivering buildings the bigger the momentum will be. Until these researches and validation of practices don't get published, challenged, enforced, documented, dissipated and analyzed the industry will always be reluctant to change.

CH 2. FRAME WORK METHODOLOGY

The methodology adopted in this study for achieving the objectives in this thesis consists in content analysis of related literature, academic research and documented best practices in order to extract sustainable technologies in three areas. A study case approach under a pattern matching and multi-attribute analysis was used to explore and predict the state of the practice in NYC market. Below there is an outline of methodology steps. Appendix F, figure 1.F depicts the below methodology as well.

1. Conduct background study → Literature review on sustainability Principles, Healthcare footprint and environmental Challenges.

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2. Sustainable areas are identified→ Chapters on active systems, Materials, integrated delivery methods

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3. Research on active sustainable technologies, sustainable materials Delivery methods.

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4. Extraction of Recommendations in each chapter based on urban and hospital criteria.

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5. NYC Study Case

↓

Content Analysis, Interviews, Academic Research, Observation

↓

Criteria for Green Hospitals developed

↓

Attributes and characteristics for each Criterion

↓

Multi-Attribute Matrix Developed→ Interviews, Content Analysis, Findings and Academic Research

↓

Data collection for each attribute (Pommer's Model)→Ranking

↓

Pattern Matching-Analysis

↓

Discussion

↓

6. Recommendations and Conclusions

CH 3. UNDERSTANDING THE CONCEPT OF SUSTAINABILITY

3.1 Sustainability Development

One of the most accepted definitions found in literature on sustainability falls inside the lines of the United Nations' 1987 *Brundtland Commission Report:*

> Sustainable development means to ". . . meet the needs of the present without compromising the ability of future generations to meet their needs."

The statement underlines the importance on responsibility of one generation with regard to their future generations; it also implies that future generations should have an automatic entitlement to a healthy environment. A responsibility today to entitle tomorrow's is how sustainability becomes a process. Sustainability is a process seeking to minimize negative impacts on earth's natural resources too. Three elements are bonded with natural resource preservation: Social, Economic and Environmental dimensions. Natural resources mishandling can liquidate any economic system, break down society and extinguish the environment. The fragility of compromising our resources is that all three dimensions are interconnected, so when one goes the other ones do too.

3.2 Economic, Social and Environmental Dimensions

At the current rate, Earth resources are being consumed 20 percent faster than their ability to support renewal (valentine 2004). Being this the case, today humanity is not taking one step forward but rather two backwards. In order to neutralize a dangerous counterproductive situation, global action is necessary much sooner than later. An irresponsible action today can later signify that our future generations will have to deal with food, water, climate, biodiversity and pollution crisis much sooner.

It is important that the connection among these three dimensions allows corporations; governments and institutions realize that economic policies or business strategies lacking the social and ecological integrity are not economically viable over long terms (Guenther and Vittori 2008). In the U.S some policies have realized that sustainability success is associated with satisfaction of basic economic, social and security parameters (EPA 2006) in such way that tomorrow's natural resources and environmental quality on which life depends does not get undermined. Furthermore, The US Environmental Protection Agency (EPA) defines successful business policies in its sustainable plan as those strategies that have the capability to adapt to variability so and anticipate and manage risk without compromising profit (EPA 2006).

Whatever the sector or circumstance might be, it seems that to develop sustainability performance both environmental protection and economic development must go hand on hand. Depending on that interaction, trade-offs between welfare of people today and the welfare of people tomorrow are determined. Another good example on the importance of the triple dimension is seen in EPA's 2006-2011 strategic plan, where it proposes to work on "[an] Improvement of understanding earth systems to better protect human health, manage natural resources, and design cost-effective and sustainable policies". The goal converges on the interaction among economics, social and environmental principles. EPA's *Strategic Plan* serves as the Agency's road map. It guides them into establishing the annual goals they need to meet along the way. It helps them to measure how far they have gone toward achieving their strategic goals and recognize where they need to adjust. The fact that one of the most important U.S environmental agencies like the EPA aligns its policies with a triple bottom approach shows that awareness and advocacy has already started.

3.3 Six Key Natural Resources

Water, air, land, energy, materials and ecosystems are earth's essential resources. All six resources are constantly affected by a host of externalities related to economic growth, demographic changes, and energy use and demand. For example, general economic policies are aligned with society quality of life so growth in one reflects the well being of the other.

Countries are learning that sustainable environmental polices are an essential component of sound economic growth. Some public agencies have agreed with this thought and included in their policies (EPA 2006). Natural resources are a priceless commodity. and as such, it should be considered of national priority. Countries that do not consider it as such will see how their profits will be going into resource acquisitions, pollution management; water and energy management and ecological damage restorations.

In the U.S,. Population growth trends for the next decades increase the pressure of allocating resources while preserving a reserve for future generations. With more people and more demand on resources renewable sources are of paramount importance. For example, energy demands will increase as water resources decrease, this logic of scarcity is a typical "effect-cause" across all other resources including energy and water.

The following must be true: Energy needs to be generated clean and used efficiently, air has to be kept clean and healthy, water must be sustained at potable quality and readily available all while making provisions for generation growth and capacity allocation; materials will need to continue shifting towards environmentally friendly; land and ecosystems need to conserve and protect sensitive areas as well as to restore ecosystem functions goods and services.

It is important that the healthcare sector foresees these challenges so future buildings can continue providing services to the aging population at lower resource consumption. United States has the biggest healthcare system in the world (Green Health Center 2004), and current trends show that it is embarked in a construction boom for the next couple of decades. In addition, over the next

30 years U.S. per capita GDP is expected to increase by 60 percent according to the US Census Bureau., the same agency expects U.S population to increase 40 percent by 2040 and 100 percent by 2100. The panorama outside U.S shows a growing trend too, with projections of fast growing developing economies such as Brazil, Russia, India and China (BRICs) to increase nearly tenfold in the same period (USBC). Population growth around the globe drives construction, and within the construction there will be hospitals and medical facilities to get built. Before major construction starts in the sector the industry needs to be in ready to affront a different mindset. Efforts in the U.S are heading to the right direction, but more and better needs to be done first locally and then in all sectors: both internationally and in all industries. Resource allocation must then be administered proportionally so it can be distributed in a balanced way to the world demands.

Unfortunately, healthcare has been slow in jumping to the green movement; it is a potentially large market that is still in its early stages. Healthcare facilities are by themselves a heavily regulated industry if not the most regulated sector in the U.S (CATO 2007), it is probably why these new waves of regulations and needs for higher performance buildings are slowly penetrating inside hospital's board rooms. Some hospitals are still try to comply with their traditional regulations before considering new ones.

3.4 Resource-Conscious Design and Construction

One question arises when society ask itself how to manage a problem if we can't measure the magnitude of it. To put a number or a quantitative benchmark method to inestimable benefits is a hard thing to do. Nonetheless, metrics of some kind need to be developed in order to guide action plans to act in pro of the biosphere. If metrics or frameworks are not in place is impossible to chart a sustainable plan in the construction industry (Guenther and Vittori 2008).

Governments, businesses and institutions have started to develop metrics so plans can be guide to the right direction. Footprint methodologies are one of those efforts. It is a comparative analysis as a way to establish tangible measurements in how much damage is created by humans' actions. The methodology was conceived in 1990 by Mathis Wackernagel and William Rees at the University of British Columbia, the methodology is now in wide use by scientists, businesses, governments, agencies, individuals, and institutions to monitor ecological resource use and advance on sustainable development (GNF 2008). It consist on ecological capacity metrics, that is, a determinate amount of biologically productive land and water area is set to be an equivalent unit to human population consumption rate. In 2001 this methodology estimated that the earth capacity yielded 2.2 hectares per person of biologically productive water and area. In that same year the rate at which human population was consuming resources yielded 1.8 hectares per person, already a deficit of .4 hectares had been seized. It is considered that in the 90s human population started to deplete resources faster than earth's renewal capacity. In the U.S, that same year of 2001, the per capita footprint was equivalent to 9.6 hectares. This means that Americans were creating a deficit of ecological services of five times earth's capacity (GNF 2008)Studies of these types allow to measure damage in a quantifiable approach allowing quantitative correction target goals through pollution prevention programs, and sustainable processes. .

An enormous pressure on the construction sector of the U.S exists, rising population and increasing depletion of resources are two areas of major concern. 40 percent of CO2 releases into the atmosphere are held against the construction industry (Worrell et al. 2001), a similar percentage is held for energy resources and a 16 percent of water consumption was allocated in 2006 (Seneviratne 2007). In a yearly basis, medical facilities will be building 70 to 75 million square feet starting 2005 (Vittori 2002), this trends need to often be revised against their environmental footprint impacts. Organizations such as the *Health Care Without Harm* and *the Center for Health Design*, two organizations representing hundreds of sustainable advocating hospitals are already making progress in this field. Their work is not documented in detail in this paper but significant progress and ideas can be read in their publications on the American Society of Healthcare Engineers journals or publications in their websites. As more hospitals move into this direction the task will be easier to manage, today however, the task at hand is overwhelming for the current advocating groups.

The following section outlines importance of Earth's resources and construction's negative impacts. Both, the urban context and construction of healthcare facilities drive this discussion.

3.4.1 Land Use

Sustainable land use is based upon the principle that land, especially undeveloped, natural, or agricultural land, is a precious finite resource, whose development should be controlled and minimized (Franklin and Durkin 2008). In an urban setting, planning land and green spaces is essential to minimize urban sprawl. Sprawl can lead to overdependence on automobiles for transportation, excessive fossil fuel consumption, and higher pollution levels (Raydan and Steemers 2006). Land has the advantage that can be recycled and can restore. Cities around the world have realized this and acted on. Development of disturbed land, such as industrial zones, has been re-planed and designed to promote economic and social development in areas that otherwise would have never enjoy development.

Traditional site development has led hospital to follow the same approach of commercial buildings: such as choosing locations near main traffic arteries at any cost and in lieu of advocating policies for smart growth or more responsible land planning and public transportation. Examples of traditional planning design can include the construction of impervious surfaces like roads and rooftops, these operations are responsible to the degradation of water quality, increasing of runoff volume, stream sedimentation, water acidity, and altering of regular stream flow and watershed hydrology. Better planning development for site selection is to locate building on areas with fragile or degraded ecosystems so they can have the opportunity to be restored.

3.4.2 Water

Potable water is one of the most precious resources. Its availability can be the limiting factor for development and construction in many areas of the world. Climate alterations produce changeable and unpredicted weather patterns that can threaten the further availability of water (Guenther and Vittori 2008). Water resource is mainly obtained from existing ground and surface water supplies, when water is contaminated at the source in can be economically and chemically unfeasible to reverse damage. Water as a natural resource faces challenges, the waste and misused of water adds to the degradation of aquatic water by disturbing the balance of water to nitrogen and phosphorous and further limiting the oxygen to aquatic life.

If the current global trend continues electric power plants and the energy sector will be impeded to expand and the supply for future generation in the next 20 years (DOE 2006). Water conservation and alternative techniques and research need to continue in development of sustainable and more efficient water usage. An example of innovation has been the strategies of water recycling and more effectively rainwater harvesting in office and residential buildings, the same needs to be done for hospital operations.. Innovations and "resource-conserving" thinking have started to penetrate sustainable techniques in buildings demonstrating savings in management and reduction of environmental impacts (USGBC 2009). The challenge for healthcare facilities is to take technologies from other sectors and customize it to its operation nature.

Healthcare sector is consistently within the top ten water users in the communities they serve (Guenther and Vittori 2008) estimates by *Applied Technologies* (One of North's America Largest distributors of energy components) and the *Hospital Corporation* (one of the largest private operators of health care facilities) estimated that 250,000 to 750,000 gallons of water are used in acute care setting hospitals every year. In those hospitals, breakdown of water use is mainly for process applications such as cooling towers, boilers and chillers, sterilization and sinks in bathrooms and kitchens. Harvest and recycling of water for this area can be streamlined and made possible at low cost so it can be an option for hospitals.

Healthcare's water consumption, however, is minor compared to that of power plants and other industrial applications. Nonetheless, a large healthcare facility can have thousand of drains representing an enormous flow of waste water to be treated. Luckily, commercial and industrial constructions have had good experiences developing sustainable practice in waste water treatments and the industry has started to adapt them. The key is that owners make the commitment and realize the importance of water conservation.

3.4.3Energy

Energy conservation in an urban setting is best addressed through an effective building design. Design integration of systems includes: (1) designing a building envelope that is highly resistant to conductive, convective, and radiate heat transfer; (2) employing renewable energy resources; and (3) fully implementing passive design (Karolides in Guenther 2008). Passive design employs the building's geometry, orientation, and mass to condition key parameters around natural and climatologically features such as the site's solar insulation, thermal chimney effects, prevailing winds, local topography, microclimate, and landscaping, all of importance in a city like New York. An integration of these elements can reduce energy consumption by lowering loads of artificial light and active mechanical systems for cooling, heating. Modeling software can be used to run parametric studies in order to determine input of best practices.

Since 30 percent of domestic primary energy is consumed by buildings in the United States, a search into renewable energy sources has emerged in the construction industry. Not only renewable sources can be more environmentally friendly but cheaper in the life cycle of a building (Medved in Santamouris 2006).

According to the National Energy policies estimates indicate that over the next 20 years, U.S. oil consumption will increase by 33 percent, natural gas consumption over 50 percent, and demand for electricity will rise by 45 percent. The consequences of the current practices will lead to increase demand to petroleum, natural gas and coal, all nonrenewable sources. If America's energy production grows at the same rate as it did in the 1990s, the planet will face an ever-increasing gap on demand and supply. Increases on this scale will require preparation and action today in all sectors of construction. Practices and current technology suggests that energy can be reduced substantially in the healthcare industry (NYC-DDC 2007). More renewable sources and their utilization need to continue their development so they are easily accessible and economically feasible to current power needs and technology.

Healthcare sector is a high energy consumer itself. Hospitals, surgery and other acute care facilities are among the most energy intensive commercial buildings in the U.S. (ASHE 2002) Energy generation and transmission of the overall system is relatively inefficient, the source energy is equivalent to 11 percent of all commercial energy consumption or an estimated 561 trillion Btu of combined site electricity, natural gas, fuel oil, and district steam or hot water (EIA 1995). The Commercial Building Energy Consumption Survey (CBECS) calculates energy usage per square foot area per year to be 250 thousand British thermal units of energy in hospitals. When compared to other building types in the same criteria, healthcare comes second to only food service type buildings (EIA 1995).

3.4.4Materials

In material selection and production, reciprocal action with the environment occurs in two distinct ways. The earth acts as the source of all material resources and at the same time it is the sink for resource consumption emissions, effluents, and solid wastes. This cycle of events has a significant negative impact on the environment. As a general rule, if the source is being depleted and contaminated, it is then overused and as a consequence its renewal capacity reduced. In addition, the process of extraction becomes more difficult and expensive due to scarcity of the resource.

Hospitals consume materials and resources during construction and related activities. Reconfiguration and expansions are common in healthcare facilities; the inclusion of new materials to built environment does too. Materials selection for healthcare should not only be based on its toxicity and impact on air quality but also on material's impact on natural resources and environmental degradation.

3.4.5 Ecosystems

The ecosystems have an important role to play in human survival. Humans and animals rely on them for food and water. Construction, manufacturing, waste and pollution all detrimentally impose extra loads to ecosystems. Ecosystems provide services on nutrient cycling, climate regulation, habitats, atmosphere gas balancing, pollination and water regulation. The services of ecological systems and the natural capital value they produce are priceless to the functioning of the Earth's life-support system. An estimate monetary economic value of 17 ecosystem services was monetized at $33 trillion worth (Costanza 1997). It is why is impossible to put a price to the thousand or millions of ecosystems that the world has.

On the good side, hospitals that have embarked into the green building movement see environmental stewardship as inescapable transformation from the traditional way of hospital buildings. Literature shows that organizations that engage in green building don't see it as optional but rather as the common wisdom (Vittori 2002). Healthcare has a specific mission of healing and curing people, their actions on building have already started to align toward environmental stewardship healing as well. That for the most part is a positive trend in the industry.

CH 4. HEALTHCARE'S ECOLOGICAL FOOTPRINT

All footprints — including carbon and ecological footprints — measure environmental impacts in relation to a set baseline. In the case of ecological footprint, there is a baseline set to biosphere productive land capacity. In the case of carbon footprint the metric refers to tons of CO_2 in the atmosphere. A comprehensive footprint assessment takes into account environmental impacts from both the supply chain and operations in various sectors. A widely-used indicator of an organization's environmental stewardship is its footprint. Because it is hard to put a value or quantity to pollution impact, the idea of foot printing seems daunting, but it is an essential and valuable tool in assessing an environmental problem. The Eco-health footprint is a footprint methodology initiative by the *Global Health and Safety Initiative* (a main partner of the Health Care Without Harm and the Center for the Health Design) released 10 months ago with a main the goal of measuring healthcare's impact on public health and the environment. Unfortunately during the research of this thesis it was found that the group opted to end all the initiatives arguing that current political climate might be a better opportunity to achieve "sector-wide leadership in environmental sustainability"(GHSI 2010)

4.1 Carbon Footprint

Carbon Footprint is 50 percent of humanity's overall Ecological Footprint and its most rapidly-growing component (GNF 2008). The term "carbon footprint" is often used as shorthand for the amount of carbon (usually in tons) emitted by an activity or organization. Currently, there is a great deal of focus on carbon footprints due to policy discussions on greenhouse gas reductions and targets on the next decades. However, it is important to remember that carbon footprint does not consider resource scarcity as their baseline; it only calculates tons of CO_2 in the atmosphere and sets a goal to be met with respect to a baseline yearly value.

4.2 Ecological Footprint

Ecological footprint methodology establishes an explicit benchmark that compares earth's available resources against consumed resources. It directly measures the amount of biologically productive land and water that it takes to meet the consumption demands of human population.

A major area of concern developed from ecological footprint studies is on cities. Although cities don't make part of a significant portion of land they still manage to contribute over 70 % of people's Ecological Footprint (GNF 2008). Urban environments, more than any other area in the world, have the biggest responsibility for environmental stewardship.

4.3 U.S Healthcare's Footprint

There has only been a comprehensive research on pollution metrics for the past 15 years (GHSI 2010). From it, ecological footprint analysis emerged and although some sectors have been more studied than others, there are studies for almost all the sectors. In the healthcare sector a handful of studies have gone through the methodology. An example is The Dartmouth-Hitchcock Medical Center (DHMC) in New Hampshire. The results revealed how disproportionate and large U.S. health care system's ecological footprint can be. DHMC currently reported that its ecological footprint is roughly 200 times its physical footprint (GHSI 2010). The studied showed that products, transportation and energy elements made up the 90 percent of physical hospital's footprint. *Kaiser Permanente* (the largest nonprofit organization in the country, serving almost nine million users) calculated that its direct energy carbon footprint in 2005 was 314,066 global acres, which equated to 0.049 global acres per member, 132 times smaller than the equivalent 6.6 global acres a person needs to compensate for his/her resource demands according to the latest footprint results by GNF.

One of the organizations that have engaged in footprinting methodologies to assist Healthcare organizations on improving overall stewardship is the coalition of eighteen of the largest, most influential system in the U.S the Global Health and Safety Initiative (GHSI). Their mission aims to move the healthcare sector towards making footprinting and standardize this practice in the sector. Their methodology consists of six major impact categories:

• Greenhouse gases including anesthetic and medical gases,

• Water including process and domestic (potable) and waste water,

• Waste (municipal solid waste, regulated medical waste, hazardous waste, electronic waste,

Construction & demolition waste, and recyclable waste),

- Toxic chemicals,
- Criteria air pollutants, and
- Built land.

The GHSI created the Eco-Health Footprint in 2009. Although it is still in its pilot state, the Eco-Health Footprint measurement standard addresses greenhouse gas (GHG) emissions, often using carbon dioxide as the proxy. Standards for energy and waste are also becoming harmonized within the healthcare sector. The GHSI and its Eco-Health Footprint Task Group have worked with Dartmouth-Hitchcock Medical Center to enhance and make their tool available as a standardized approach for the sector, reflecting current best practice in the field. Unfortunately during the research of this thesis it was found that the group opted to end all the initiatives arguing that current political climate might be a better opportunity to achieve "sector-wide leadership in environmental sustainability"(GHSI 2009)

CH 5. URBAN ENVIRONTMENTAL CHALLENGES

The earth's land converted to urban land according to 1991 statistics was calculated to be approximately a mere .2 percent (Oke 1991) that same year 45 percent of the world's population lived in those urban settings. Today close to half of the population must be living in cities. Concentration of population in small spaces conduces to higher demands for energy, lighting and HVAC requirements. Further studies estimate that out of the 70 percent global pollution created by urban cities, almost 45 percent is generated by buildings (Rogers and Stemmers 2006). These trends are one of the driven forces for advocates of sustainable movement. The idea of man and environment coexisting in an equally benefiting mode is stronger in an urban context.

Urban morphology has a direct effect on the urban microclimate and on energy consumption (Steemers 2006). Environmental issues can consequently inform a full range of building design decisions, from site planning to detail design. In general, urban climates are warmer and less windy than rural areas. Cities use more energy for air conditioning in summer, and more electricity for lighting in winter. Above all, there are physical parameters that have an effect on city microclimate and therefore in its design and energy consumption: City size, density of built-up area; land coverage and building height; orientation, street geometry, and site specific street layout; Ventilation conditions and solar access; the dispersion of pollutants in areas close to the building and common urban heat island effects are all examples of environmental problems that cities like New York or Chicago must face.

New York City planning must consider factors in the context of general topography and adjacent environment. Relations on climate data and orientation should be modeled first, land use impact to vicinity sites considered, and environmental conditions of the type traffic and noise pollution should be minimized.

Construction in NYC is believed to be less energy-efficient (NYC-DDC 2004.), its weather exposure and microclimate demand more on heating and cooling loads. "Town cramming" and the large amount of land demanded by private car usage in urban cities affects urban green spaces allocation (Owens 1998). Scarcity of land and growth of population in cities can explain the challenges in land use.

Next section outlines some of NYC Environmental challenges.

5.1 NYC Urban Setting and Its Unique Environmental Issues

New York City is a microcosm of the global challenge. As the largest city in the United States and as one of the largest cities in the world (in the basis of population and gross domestic product) it is also a global capital of finance, culture, arts, and the media. In addition, NYC is the biggest energy consumer in the state of NY (NYC-DDC 2004.) at almost $500 million annually on heat, light and power. As a metropolis, NYC must deal with growth in population and land size limitations; aging infrastructure and unique environmental issues giving its location and past developments.

A discussion on key environmental issues and future challenges follow below.

5.1.1Climate Change

Although climate change is a global matter, local environments such as NYC are experiencing warmer and more unpredictable weather. A report from the Inventory of New York City Greenhouse Gas Emissions estimated that temperatures in New York City were projected to increase as much as 8 F^o by 2100. Changes in temperature produce more incessant and severe storms, loss of coastal wetlands, beach and soil erosion and; increased localized flooding and water quality degradation have also being found to be effects of climate changes (NYC-DDC 2008). Although these problems cannot be mitigated by few good design buildings, designers should have on mind the importance of considering the effects of past practices and new practices that can avoid making the same mistake of the past and allowing them to deal with inclement weather in the future.

Commitment is important in owners and those that regulate environmental laws and principles. If provisions are not established towards environmental friendly practices, reduction of emissions can only be a wish and climate change will continue creating bigger struggles.

5.1.2 Urban Heat Island Effect (UHI)

The key effect of urbanization on air is the phenomenon known as the Urban Heat Island effect, where temperatures in cities can be 5°F to 10°F hotter than rural areas. The heat island effect is caused by a range of factors, including the relative dearth of vegetation in cities; the prevalence of heat-absorbing dark roofs and paving materials on roads and parking areas; and the accumulation of hot exhaust gases from; engine heat from cars, trucks and buses; surfaces and lack of vegetation. As a general principle, the altered energy balance near the ground leads to thermal discrepancies. Dark surfaces absorb heat and lack of vegetation cannot help to lessen the effect of reemitted heat back to the atmosphere. During dark nights the releases of heat are higher, that is, the difference of temperatures between rural and city environments is more during late hours. Although Heat Island can also be affected by meteorological effects, urban features such as city size, density of buildings and type of activities are decisive in Heat Island effects (Karatasou et, al. 2006)

Heat Island effect has a serious impact upon heating and air conditioning demands. Higher temperatures result in higher energy consumption and power plant emissions. Heat Island contributes to an increase smog production in the city atmosphere by granting ozone formation. This phenomenon traps heat and releases back to the city which becomes warmer. One of the consequences of warmer cities is reflected in more water use. Energy consumption and water are interconnected, if more energy is demand by inhabitants of a city, then energy infrastructure spends more and both landscaping and personal use water become scarcer (DDC 2008). More work by plants and by water management facilities leads to more emissions and therefore more pollution.

5.1.3 Combined Sanitary / Storm water Sewer System

New York City is a coastal city, and as such, there is water on all sides of the island. As more unpredicted weather results in inclement storms, billions of gallons can end up in waters boarding the city. Rainfalls can overwhelm sewer systems and cause flooding of the system. Approximately 70 percent of the City's 6,300 mile sewer system consists of combined sanitary and storm water sewers (NYC-DDC 2008).

According to Department of Design and Construction as many as 40 billion gallons of 'combined sewer overflows' (CSOs) – containing around 20% untreated sewage – are discharged in NYC's receiving waters each year. Overflows in combined sanitary and urban storm water runoff-including sewer runoff- are causes for site erosion, habitat damage, temperature increases, eutrophication, turbidity, and toxicity. NYC has established detention regulations in its sewers in order to prevent combine sewer overflows, nonetheless recent storms have topped the average precipitation levels at which they are designed.

5.1.4 Water Supply

New York City relies on over 1.1 billion gallons of water per day supplied from upstate reservoirs (NYC-DDC 2008). Water supply in NYC is of the highest quality urban water supplies in the world (EPA 2004), despite this fact, water is still a resource that needs to be preserve so potable water can still be accessible by population and ecosystem in the future. In NYC there is the need to develop new water filtration systems and to expand sewage infrastructure so water conservation can be prolonged and retained at reasonable quantities.

5.1.5 Hostile Plant Environment

In a city where there are cars, buildings and all the typical components of a metropolis the need for vegetation is essential to counteract effects. Traffic and transportation infrastructure, pollution of water and air, poor and compacted soils, people, dogs, cars; limiting sunlight and water contribute to a difficult habitat for plants to growth and flourish. Planning a site to encourage vegetation expansion should be a priority for any main city. DDC of New York is one of the city agencies that have established standard practices for sustainable planting techniques in all public building construction, these techniques are outlined in their Sustainable Urban Site Design Manual.[1]

Vegetation has an invaluable capacity of reducing urban heat island effects and lessen effects of carbon emissions; storm water management, runoff reduction and air quality improvement. Noise reduction from cars and construction and

[1] Reference to Appendix for manual source.

light pollution mitigation are all advantages for a city. Plants and trees provide oxygen to the city and help to cool urban settings, aesthetics and property values are improved by vegetation as well. Trees and green land is a precious source of aesthetics and better quality of life in a city where sprawl is a problem. As a renewable source they are very efficient techniques to provide shading and cooling during the summer. Investing in urban vegetation in cities has proven to be extremely cost-effective for infrastructure development (DDC 2008).

5.1.6 Poor Quality Soils

All plants require space for root and crown development; some plants need deep soil for their long roots, proper sunlight, and specific climate and drainage conditions. The space where trees have to develop their roots is taken many times by utilities running underground or other systems such as subway or buildings foundations. Under these conditions, trees and plants can simply stop growing and become more susceptible to drought, pests and diseases. Compacted soil created by the weight of pavement, cars and daily urban traffic can cause lower infiltration rates resulting in erosion and sedimentation (DDC 2008). Landscape architectural is out of the scope of this thesis but an excellent guide on landscaping design is listed under Urban landscape design[2]

5.1.7 Underground Infrastructure

New York City at any given time of the year is likely to have a crane building skyscrapers, commercial building, offices, residential complexes of all sizes and

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[2] Reference to Appendix for manual source.

mass types. At the same time erection of steel and concrete structures takes shape from the ground up, there is also an entire underground world of construction from the ground down. Utilities, transportation systems, sewers and tunnels reside under the streets of NYC. Complex subsurface conditions during construction create significant site planning and design constraints for architects and landscape architects: from rerouting utilities to making up space for new building footings, drainage, and transportation opportunities or disturbances. The world of construction underground provides a hidden place for those things that either don't fit above ground or simply pollutes the sight of inhabitants. It is imperative for designers and builders to know what's under the surface of future sites in order to avoid damaging critical infrastructure. Vegetation and drainage techniques should be developed at the inception of project and their value maintained to the end of project. Many times through value engineering some values of design might get eliminated.

5.1.8 Reduced Noise Pollution

During construction, noise pollution can become a serious public health hazard. Noise pollution causes hearing and can also pose higher risks of hypertension and even provoke certain types of heart disease. Construction regulating agencies such as DOB, sets regulation on noise-control techniques when construction occurs. Community input on large projects is necessary since they will be the most affected by construction noises related. Contractors must submit a noise and mitigation control plan as part of their application for construction permit. In the construction plans, means and methods need to be explained for noise mitigation program. In noise and mitigation plans, special equipment and provision need to be made when exceeding noise levels of more than 10 decibels when readings are taken 15 feet from source (NYC Building code). The U.S. Department of Energy estimates that street trees can absorb 50% of urban noise when plants are properly arrange to the side of walkways. Special considerations have been established when excavation and foundation phases occur. Starting July 1 of 2007 a new noise code was enacted in NYC, the need to update decibel levels and address new technology drove agencies to replace the old 30 year old noise code. More on the specific regulation and guidelines are stated in DOB and NYC codes[3]

In order to mitigate the environmental issues described above some chapter below explore sustainable technologies and practices in areas of concern.

[3] References for NYC Codes in appendix

CH 6. ACTIVE SUSTAINABLE SYSTEMS

Energy conservation techniques must be developed by considering possible negative impacts to local ecosystems and by forecasting how the environment and climate conditions can improve the optimization of active techniques. These criteria should also anticipate possible improvements on patients and staff built-environment. Urban settings and the complexity of hospital systems exhibit considerable number of challenges. Urban context is composed of very diverse environmental conditions such as neighboring buildings with low to high densities; fixed orientations of streets and different building heights and shapes; and different microclimates within the city boundaries. Conditions of these types, combined with site specific location circumstances can bring constraints and fewer opportunities for development of active sustainable systems. In addition to the urban complexity, hospitals are unique in design; the services they provide have special requirements that are dissimilar in nature to other type buildings, for instance, hospital air conditioning plays a more important role in a hospital than just boosting of comfort. Patient therapies in many cases depend of proper air conditioning, in some cases conditioning can the most important factor for the health of a patient. With these two criterions of location setting and hospital design some approaches are preferred. Literature review has showed that for new buildings in urban settings an integrated design approach is the most effective and efficient way to reduce energy consumption (Karolides 2008; DOE 2009; Kiber 2004; AIA 2007: Autodesk White Paper 2008).

6.1 Heat and Mass Transfer

The principles of heat and thermal mass transfer are paramount principles to mechanical system design. Heat in buildings is transferred by conduction, convection and radiation modes. Thermal mass of a building is measured by its capacity to store heat and regulate heat. Construction of new hospitals in NYC is not the exception to heat and mass transfer principles. Sustainable techniques should be design to optimize conduction modes by carefully designing walls, floors and roofs since those are the areas where heat transfers through. Convection modes need to look into airflow optimization as well as infiltration and ventilation technologies. Radiation heat transfer principle is important for hospitals since solar radiation and sun movement pose opportunities for renewable sustainable opportunities. Glazing can trap heat resulting from sun rays passing through windows and as long as the inside temperature is higher the heat loss can be reduced.

The following principle of thermal balance will be used as a starting point to understand that energy needs of a building.[4]

I. Heat Conduction through walls, roof and other elements

II. Heat conduction into the ground from slab-on-grade elements

↓

III. Solar radiation gains through glazing elements by transmission through, and/or absorption by, the glass

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[4] The heat transfer process explanation was excerpted from Geros on Heat and mass transfer phenomena in urban buildings. *Environmental Design of Urban Buildings*

IV. Internal heat gain from people, lighting and equipment

↓

V. Latent internal heat gains (losses) through evaporation(condensation) of water involving the latent heat of humidity

↓

VI. Convective heat transfer from the building envelope to the air and long-wave radiative heat transfer to the upper atmosphere (sky) clouds

↓

VII. Convective heat transfer from internal surfaces of building elements to indoor air, and radiative heat transfer between the internal surfaces of building elements, or absorption of solar radiation and light radiation by internal surfaces

↓

VIII. Heat transfer by convection due to infiltration through cracks to natural ventilation through openings and forced ventilation using fans

↓

IX. Storage in different building elements, both external (walls, roofs, floors) and internal (structures and internal walls), resulting in the attenuation of internal temperature swing

↓

X. Artificial heating and cooling by HVAC equipment

6.2 Distributed Resources NYC

Findings in a report prepared by the New York City Energy Policy Task Force (NYC-EPTF), an agency appointed by Mayor Bloomberg which coordinates and addresses energy policy issues on behalf of the city, were analyzed in order to make informed recommendations based on current energy infrastructure status of NYC.

In the report, which comprehensively assessed the City's energy needs in 2005, it was found that as of 2005 NYC had an adequate electricity resources but only by a slim margin. The projections in the report indicated that by 2010 NYC would already be in the position to expand on generation and transmission facilities, and it would need to start looking into expanding distributed resources. It also recommended that all the old power plants would need to start being retired and/or replaced for cleaner and more efficient facilities. The idea of distributed resource expansion will be discussed within the scope of this section.

Unlike central stations and generation plans which can take many years to plan and design in a city like NYC, distributed resources can be implemented within a short term. Distributed resources refer to cogeneration, peak load management (encouragement to curtail energy consumption during peak hours), renewable energy, and energy efficient techniques (high-efficiency energy buildings by design in HVAC and water management).

Three criterions will be considered to developed practices and technologies in this chapter: Basic principles of heat and mass transfer phenomena, current status of distributed resource in NYC infrastructure; and the Healthcare sector unique design, construction and operation nature.

6.3 Sustainable Energy Systems

Energy needs for cooling and heating are determined by energy balancing. This in turn requires and understanding of how heat transfer works between outdoor, indoor environments, and building components. Another important concept to emphasize is that not always the most energy efficient and most technical systems are the most optimal for patients. Some special rooms within hospitals are heavily regulated either by code provisions, environmental condition or therapy conditioning. In these cases a new equipment or mechanical system may not be ideal due to regulations not allowing it to operate or technology performance not being able to guarantee success in therapy due to lack of data of equipment in that specific environment. Another example that highlights the difficulty of selecting best practices for a hospital can be witnessed in the case of room lay out design. Multiple-occupancy rooms, although optimal for reducing square footage per patient and for energy reduction on mechanical systems might not be, in the other hand, recommended for controlling infection rates due to bacteria like hood of spreading and reach patients. Multiple occupancy rooms also limit the effectiveness of radiation and evaporation when crucial for patient therapy (ASHRAE 2007).

Having said this, some opportunities are however a win-win. They can be reliable, cleaner and cheaper than the available today. Below some of those practices and technologies will be discussed next. A criterion of hospital building type and urban setting type are considered in the choosing of technologies. Current NYC energy infrastructure also drives the discussion. A summary of all technologies and recommendations noted in this section can be found in Appendix F, figure 3F-5F.

6.3.1 Renewable and Environmentally Energy Sources

Healthcare sector can promote energy efficiency and environmental health by relying on renewable energy sources and technologies. One environmentally friendly technique is Cogeneration. Cogeneration processes use wasted heat from electrical generation processes to generate electricity or useful heat for cooling and heating. On site generation systems are excellent opportunities for energy conservation in hospital facilities. Hospitals are an excellent representative building type for distributed resource integration, especially those in urban areas. Hospital's need for emergency power in case of electricity shortage, the complexity mechanical system optimization; the importance of uninterrupted demand for both heat and power; their 24 hours and seven day operations; and the implications of building relative big buildings in tight city spaces make them perfect candidates for sustainable opportunities

6.3.1.1 Fuel cells

This system is the cleanest and quietest form of power generation technology. Fuel cells can be powered by renewable sources, but currently their most popular fuel is natural gas (ASHRAE 2008). The system generates electricity inside a cell through reactions between a fuel and an oxidant, the heat produced from this reaction process goes through a heat recovery mechanism so it can be reused to meet loads on conventional heating or specialized processes within the hospital.

6.3.1.2 Combined Cooling, Heating, and Power (CCHP) systems

On site combined cooling, heating and power plants (CCHP) is a cogeneration system ideal for hospitals application. On site plants of this type eliminate transmission and distribution losses that are typical in centralized district power plants mainly because transportation from source to end user is longer than when having a plant on site. Wasted heat from on site plant is used for space heating or hot water heating. Reusing of heat and reduction on transmission and distribution losses increases fuel efficiency as high as 75 percent (ASHRAE Greenguide 2008). Power quality and reliability are two essential components for the stringent requirements of 24/7 healthcare facilities. Bringing the power generation closer to the point of application reduces the dependency to utility grid and it reduces emissions of CO_2 as a byproduct of fuel efficiency and transportation through trucks.

6.3.1.3 Biomass, Solar Heating, Photovoltaic, daylight and Wind Energy

Today three-quarters of the world's energy is produced from fossil fuels -coal, petroleum, and gas (Santamouris 2006).- Combustion of fossil fuels produce the greatest threats to the environment in the form of CO_2 , CO, NO_x, SO_x, and suspended particles. (EPA-Air Act 2004)

Renewable energy can be incorporated to replace fossil fuels if properly designed within building orientation and characteristic features. Daylight, passive cooling and natural ventilation are strategies to reduce energy in heating, cooling and lighting of buildings. Other techniques that have resulted in environmental results and efficient energy delivery include: biomass fuels, wind systems, photovoltaic and solar systems. The integration of these other techniques requires an extra first-cost capital investment so “free energy” collected can be extracted into a useful operation. For example, wind systems might need proper infrastructure for turbines.

Solar energy can by converted to heat using solar collectors, the most efficient way to take advantage of these technique is to mount collector on the roof or façade of building, depending on building orientation, large area is needed to achieve higher temperatures; preheating of water and air are the two most common uses. Photovoltaic is another for of solar energy. It uses sunlight to produce electricity. A hospital building can use it as a substitute of building envelope and reduce system installation costs. One of the major drawbacks for PV systems is the high initial costs (Borenstein 2008). With all solar renewable energy techniques interruptions to sunshine exist as taller building might get developed next to systems. Hospitals built in Manhattan should study the possibility of taller buildings being built next to facility before considering solar renewable energies.

6.3.1.4 Green Power Contracts

Another way of environmentally and responsible way of consume energy production is to engage into green power contracts, if the possibility is feasible, renewable power suppliers will provide kilowatt hour price and sometimes at lower prices than fossil fuel. Providence Newberg Medical Center in Portland negotiated to buy 100 percent of their energy through one of these contracts, because fossil fuel price volatility can be high, this technique can work better when infrastructure for renewable energy is more developed, it will be cheaper and much cleaner. (Guenther and Vittori 2008)

6.3.2 Lighting

Daylighting: Evidence-based research has demonstrated that patient recovery outcomes can be improved. Literature review shows studies that associate daylight environments as a possible cause to reduce depression, agitation and drug use (Pradinuk in Zimring 2004). The same studies make a connection between productivity loss and lack of proper lighting. Daylight is a cheap way of lighting a space because it reduces the need for electrically artificial lights. Daylighting requires an optimum exhaustive analytical and modeling work. Modeling can simulate the amount and quality of available daylight by setting parametric criteria such as seasons, time of day and weather considerations. Synergies among those parameters should be the objective of the model.

Glare discomfort and eventual problems related to high construction density and taller buildings need to also be considered when designing for naturally lit spaces.

Light Controls: They are appropriate to be used in conjunction with daylighting. An integration of artificial and natural light can save life of lamps and energy can be reduced if controls allow turning artificial light whenever a room has sufficient natural light. Controls and dimming options add flexibility to comfort as well as patient visibility and environment satisfaction. For hospital type buildings timers and sensors need to be used in non-medical areas and medical spaces that are not used regularly.

6.3.3 Energy Modeling

Computer energy modeling software can improve parametric analysis by running simulations on parameters that affect the energy balance of a building: façade, passive solar heating, daylight, orientation, size, glass type, external shading, artificial lighting and other internal loads such as equipment and population profiles. A comparative analysis can then be performed to screen the best results. A full scale modeling (mock-up) should then be built so specifications dictated by software can be followed and modeled in a full scale (ASHRAE 2009).

6.3.4Medical Equipment/Systems Efficiency

Major diagnostic equipment typically consumes considerate amounts of energy. A recommendation on medical equipment management is to demand manufacturing companies to start creating more efficient equipment. Medical equipment is assumed to be a substantial and increasing fraction of hospital electrical loads (Schinger and Tschudi 2009). Energy use by medical equipment is currently not covered under any regulations or voluntary standards for energy efficiency. Information on medical equipment and process loads specific to hospitals is important to ensure accurate energy modeling and efficient hospital system designs (both electrically and thermally). Residential and many other commercial types of equipment follow the EPA energy star label as a certification of their efficiency and stewardship designs. Specialized equipment does not have a system similar to that.

Rating systems should help to create a market with more efficient products by providing purchasers with information so they can make more informed decisions on buying equipment.

6.4 Sustainable Heating, Ventilation, and Air Conditioning Systems

A great amount of energy in hospitals goes into the heating, ventilation and air-conditioning systems in hospital facilities. The requirements for HVAC designing go above comfort, in effect, health care designed indoor environments many times is part of the healing and curing techniques. Additionally, healthcare is a heavily regulated type building in this area due to the high potential of disease, bacteria and virus spreading through airborne movement.

6.4.1 District Energy Systems

District Systems provide cooling or heating by transporting chilled water or refrigerants for the former and steam or hot water for the latter. A central distribution system for a typical hospital considers three main components: A central plant, a distribution network and an end-user heating system. Central plants can make use of co-generation techniques (as discussed in previous section of this paper) heat from the plant can be from high efficient boilers or high performance chillers which can be fueled by either renewable energy or fossil fuel. Conventional piping system acts as distribution system between source and end-user. The last component is the hospital's heating and cooling systems within building. A heat exchanger separates district system from hospital systems. A common hospital system for heating and cooling is an Air Handling Unit (AHUs). AHU is an integrated piece of equipment consisting of fans, heating and cooling coils, air-control dampers, filters and silencers. The purpose of this equipment is to collect and mix outdoor air with returning air from inside the building space. The air mixture is then cooled or heated and discharged into the building space through a duct system.

A study case by a hospital in the College of Dublin found that efficient direct drive motors equipped with variable speed control, energy efficient bag filters, and a thermal wheel recovering heat from extracted air can be very efficient and reduce electrical load and reductions of energy consumption of up to 40 percent (SEI 2007)

An advantage of becoming a user of direct supply systems is the elimination of boilers and the use of chiller plants. Without those two components hospital don't have to deal with chemical handling of waste from boiler and chiller plants. When Hospitals have their own chillers and boilers in the building a waste management program needs to include boiler and chiller maintenance. In general central systems are more efficient than multiple and dispersed multiple small boilers and chiller plants (ASHRAE, 2009). Some of the advantages of larger plants include higher thermal efficiency; they also allow for more space in mechanical rooms at end-user facilities bigger equipment can be adopted to use different kind of fuel more efficiently. The following discussions of systems are guided to those hospitals that don't count with district systems. General technologies for heating and cooling systems will be outlined as well as air quality criteria and good practice techniques.

6.4.2 Displacement Ventilation System

Displacement works by supplying air near floor level at low velocities; the temperature of supplied air is slightly lower than the desired room temperature. The mixing of supplied air with warmer air in room creates a displacement of warm air to higher section of room where return exhausts are located. Displacement of warmer air results in a cooler room with an improved air quality by essentially carrying pollutants out of the breathing zone and to exhaust. This technique is desirable if noise control is important.

6.4.3 Mixed-Mode Ventilation

Mixed-mode ventilation refers to a space conditioning approach that combines passive ventilation techniques with mechanical heat and cooling. Concurrent mixed-mode is the most prevalent design of this system. A typical example include an open-plan office space customized with standard variable air volume (VAV) air-conditioning systems and operable windows, where perimeter VAV zones may go to minimum supply air when sensor indicates that a window has been opened (CBE 2005). Depending on the area of the hospital, the air conditioning, quality of air required for a room, and season of the year. This technique can save energy by reducing energy consumed by mechanical systems while introducing fresh air into the space.

6.4.4 Radiant Heat Technique

It involves supplying heat directly to the floor or to panels in the wall or ceiling of a room space. Peak loads are reduced as a result of thermal energy storage in the panel structure, exposed walls, and partitions inside rooms. Radiant heating has a number of advantages in hospital environment: it can be more efficient than forced-air heating because no energy is lost through duct supply. When infection control and strict air conditioning and quality are required heat can be a preferred technique since it does not deal with moving air (DOE 2009).

6.4.5 Ground/ Water Couple Heat Pumps

Water-couple heat pump systems: are made up of multiple water-source heat pumps delivering heat or cooling to local areas within the building, the key characteristic consists of pumps tied into a central water loop with a neutral-temperature serving as source and sink. (ASHRAE Green Guide 2009). Water loop is connected to a boiler and a central heat dissipation device, this to ensure that operation of looped pumps operate within the temperature range of water loop. Loop systems of this kind are ideal for hospitals because heat pumps provide both heating and cooling simultaneously, that is, one heat pump can set to work as a heater while another one in the system can be set to cool.

Ground Source Heat Pump with closed loop: For closed loop systems, water or antifreeze solution is circulated through pipes buried beneath the earth's surface.

During the winter, the fluid collects heat from the earth and carries it through the system and into the building. During the summer, heat pump pulls heat from the building and carries it through the system and uses underground as sink. This process creates free hot water in the summer and delivers substantial hot water savings in the winter. Because thermal energy from the earth is used, this technology can be cost effective. In NYC this practices can be useful since the winter and summer seasons are very predictable.

6.4.6 Absorption Chillers

Chilled-water systems are usually fueled by electricity in traditional systems. Absorption chillers can use thermal energy to generate chilled water; fuel flexibility is one of the pros of absorption chiller technology. Natural gas, propane, and wasted steam are all available fuels to supply thermal energy to chiller. Another advantage is that power supply does not have to come from hospital electrical grid. This fact allows a load expansion without taking a toll in hospital electric grid allocation.

6.4.7 VAV

Variable air volume systems (VAVs) have being replacing constant air volume systems. VAV work under thermostatically controlled variable-volume boxes that regulate the quantity of conditioned air supplied to each zone. VAV systems can simplify provisions for operations and conservation of energy in areas where natural ventilation provides for, recirculation of air is minimized in areas that can be thermostatically controlled by other means of building orientation or daylighting.

6.4.8 Desiccant Cooling and dehumidification Systems

There are two basic types of desiccant process: Solid and liquid. Depending on facility system loads an analysis can determine what application works better. The general concept consists of the following steps:

1. Warm and humid air enters and makes contact with a slowly rotating desiccant wheel and is dehumidified by adsorption of water, as this happens the desiccant temperature risers and its useful absorption capability lessens.

2. Since the air is heated up by dehumidification process, adsorption heat is giving up to a recovery system that takes it and uses it for pre-cooling of building air stream, subsequent dehumidified air can be humidified by a controlled humidifier that set-values of supply air temperature and humidity to facility. The result is that possible VOCs and contaminants are absorbed by the desiccant.

3. The exhaust air stream of the rooms is recovered and humidified close to the saturation point so it can be cycled back into the system. Prior of circulating exhaust air, desiccant needs to be regenerated. A heating reactivation by desiccant contact is used or re-concentration process, the former for solid desiccant and the latter for liquid desiccant.

6.4.9 Chilled Beam Cooling

Chilled Beam differs from typical ventilation systems. In Most buildings the air that travel ducts is already cooled before reaching room destination. In contrast, chilled beam systems, use chilled water pipes in modular units mounted to ceilings to cool or heat air before supplying it. They differ from radiant chilled ceilings in that they transfer heat primarily via convection instead of radiation. Chilled beams can save energy by eliminating fan consumption. Fan energy is reduced because system is off the duct loop.

6.4.10 Air Indoor Quality Considerations

Medical evidence has shown that proper air conditioning can help to prevent and treat medical conditions (AIA 2006). Hospitals are required to provide infection control assessment and mitigation to American Institute of Architects for code compliance. ASHRAE dictates in the code that assessment and mitigations in infection controls must also be included in contract documents for all new construction design. As hospital facilities, they have a responsibility for healing and many times proper air conditioning becomes a crucial factor in patient's therapy. In addition to being critical for healing, literature review in this topic yielded couple of results on studies about controlled environments. The findings revealed a more rapid physical patient improvement than areas with uncontrolled environments (Center for Health Design 2006).

Air conditioning code regulated by ASHRAE, calls for restricted air movement criteria as well as for specific requirements on ventilation, filtration and dilution rates. In hospitals, these parameters need to be controlled for appropriate removal of contamination and accurate thermal control on room environments. Mishandling of these principles can result in transportation of bacteria from one are to another and virus spreading, such as Varicella can happen through propagation of air particles. Temperature and humidity in the air are factors regulated based on service provided by area in the facility (ASHRAE 2007).

Ventilation systems must provide air virtually free of dirt, dust, chemical and radioactive pollutants. Patients with pulmonary and respiratory conditions are very sensible to outside air. Provisions in those areas and rooms can consider high-efficiency particulate air (HEPA) and ultra low penetration filters-both can achieve filtering efficiencies of up to 99.97%- When using filters to protect clinical environment, safe removal, disposal and replacement should followed a strict protocol as to avoid future propagation of bacteria or viruses due to mishandling and incorrect installation of filters in critical areas. Air movement must also be designed to minimize the spread of contamination in hospital settings. At minimum, air movement should always be from cleaner to dirtier areas. Negative pressure in rooms with potential contamination opportunities must be designed to mitigate supply of dirty air. ASHRAE suggests that VAV system can be considered in noncritical areas, but in operation rooms or protective isolation areas, constant volume systems should ensure that ventilation criteria is always met.

Smoke control ventilation design needs should be design to create areas with positive and negative pressure so smoke contamination is limited. Ventilation design for smoking should be less of a concern starting 2010 due to a NYC new law that prohibits smoking inside hospitals campus property at least 15 feet from properly line.

Zoning, as discussed above, is important to isolate different departments within the same building. Supplies, returns and exhaust systems should be separated from special rooms where air conditioning, temperature and humidity require more strict parameters.

6.5 Sustainable Water Systems

Water efficient designs applications look into balancing water quality and quantity while maintaining aquifer and water sources undisturbed. Healthcare facilities are among the most intensively water users, mainly because; the potential for disease spreading dictates a constant washing of hands and sterilization of equipment (Warshall in Vittori 2008). Process water reduction techniques are identical to commercial and residential buildings. Some sterilization water conservation techniques are discussed below.

An audit by the Water Resource Authority in Boston on seven major metropolitan hospitals yielded that HVAC (23%), sanitary (40%), Cafeteria/kitchen (9%) and medical processes (14%) are the major consuming areas in hospitals. There are several key strategies for water reduction in health care facilities.

6.5.1 Steam Recycling from Heating and Cooling Systems

Steam is used extensively in the heating and cooling systems of hospitals, sterilization of medical equipment, absorption chillers and food preparation. Condensate water from these processes can be reused and recycled back into cooling towers or other cooling purposes.

6.5.2 Faucet Black-water

Replacing flush and fill urinals with water efficient models have proven cost effective by some hospitals. The Oregon Health and Sciences University Center Hospital, in a city with similar municipal combined storm water/sewage system of NYC, opted to change to dual flush toilets and waterless urinals to avoid overwhelming sewage capacity. In a year they saw reductions of 20 percent in domestic water use (Guenther and Vittori 2008)

6.5.3 Medical Equipment Water Conservation

X-Rays: Medical facilities have x-ray processing equipment running all year long. Film washing uses considerable amount of water in a yearly basis. The rinsing water used in the film is rarely captured. A device to recycle the rinse water can reduce the operating cost of these machines; in San Juan Regional Medical Center such devise lowered processing water of that equipment by 97 percent (Warshall in Vittori 2008). New Hospitals should also look into replacing X-rays altogether. Digital imaging processors produce sharper images at lower operating costs (Cioata and Iacob 2000).

Steam sterilizers: They are used in hospitals for cleaning and total destruction of microorganisms. The most common type is the steam sterilizer. It consists in a putting the medical equipment inside a sterilizer chamber in which air creates a vacuum seal. Low-pressure steam is then injected at 273 °F and in 15-30 minutes when chamber is opened the equipment is clean. After sterilization and subsequent clean up of chamber, cool potable water is mixed with steam condensate resulted from low steam process so it can be disposed of at cooler regulatory temperature. In the process, potable water used to cool condensate is wasted. Since no attempt is made to save potable water used, some sort of holding tank should be designed to contain steam condensate let ambient air cool it rather than potable water. If this is not feasible, other type of water source can be used to cool condensate, an example previously used can be wasted chilled water from pumps.

6.5.4 Rain Water Harvesting

Water demand can be reduced by rainwater harvesting. Recycling of rainwater can be incorporated into hospital distribution plumbing piping to supply toilets, or used for other specific uses such as: site irrigation, HVAC systems and mop sinks.

6.5.5 Floor Cleaning:

A study by the University of California concluded that microfiber mops can be up to 10 percent cheaper that cotton mops and can reach up to 95 percent reduction of water and chemicals usage (Seneviratne 2007).

CH 7. SUSTAINABLE MATERIALS

When it comes to healthcare, material's selections on performance, environmental degradation, and embodied energy are very important criterions. However, the "green story" does not end there. Of viral importance is material's toxicity and indoor quality. Both parameters can have negative consequences on human health and safety.

Designer of hospitals play an important role when specifying green materials. It is their job to find synergies among the parameters mentioned above so an optimum point can be set. However, knowledge on what makes a material sustainable is still a challenging field (Rossi 2007). In addition, finding an optimum point that can meet all parameters can be a very hard thing to do.

A definition of green material based on literature consensus is provided below.

7.1 Green Material Properties in the Health Care Context

The definition below is the most accepted in the available literature, consensus among Green Guide Health Care organization, LEED and the biggest sustainable Health Care advocate groups such as *Kaiser Permanente group, Hackensack University Medical Center, and the Health Care Without Harm, and the Center for Health Care and Design* (Rossi 2007) seem to be in the same grounds.

Green Material Properties in the Health Care Context:

- No toxic chemistry: Uses only green chemicals in production, use, and disposal. Green chemicals are those that are healthy to humans and the environment and are produced in accordance with the twelve principles of green .
- Bio-based or recycled content: Is manufactured from sustainably grown and harvested plant resources or postconsumer recycled content.
- Reusable, recyclable, or compostable: Avoids disposal at the end of its useful life through refurbishment, reuse, recycling into an equivalent product (closed-loop recycling), or composting into soil.

With definition on hand, an important remark must be made: today, there is no a ready-made evaluation tool that one can easily use to choose environmentally or sustainable building materials. One of the major obstacles resides in the fact that green chemistry is practiced by few companies and few materials on the market come close to fully meeting the definition of green material. Arriving to the green material per se requires patience and close work between user and manufacturers.

7.2 Criteria for Green Material Selection

The major advocacy players in the health care sector have developed criterion to fill the gap and lessen the difficulty of evaluation techniques on material selection and specification. An initiative by the Health Care Without Harm organization, a coalition of 440 hospitals in 44 countries and pioneers of green movement in the health care sector, reached a consensus on green material properties among the sector. These criterions are outline below.

Criterion 1: Do not use materials that contribute to the formation of persistent organic pollutants (POPs) as defined by the Stockholm Convention.

Criterion 2: Do not use materials that contain or emit highly hazardous chemicals, including:

a. Do not use materials that contain
   1. Persistent, bioaccumulative, toxics (PBTs) or
   2. Very persistent, very bioaccumulative (vPvB) chemicals

b. Avoid materials that contain
   1. Carcinogens
   2. Mutagens
   3. Reproductive or developmental toxicants
   4. Neurotoxicants
   5. Endocrine disruptors

c. Avoid materials that emit criteria levels of VOCs.

Criterion 3: Use sustainably sourced biobased or recycled and recyclable materials.

a. Prefer sustainably produced biobased materials that are:
   1. Grown without the use of genetically modified organisms (GMOs).
   2. Grown without the use of pesticides containing carcinogens, mutagens, reproductive toxicants, or endocrine disruptors.
   3. Certified as sustainable for the soil and ecosystems.
   4. Compostable into healthy and safe nutrients for food crops.

b. Prefer materials with the highest postconsumer recycled content.

c. Prefer materials that can be readily reused or recycled into a similar or higher value product and where an infrastructure exists to take the materials back.

Criterion 4: Do not use materials manufactured with highly hazardous chemicals, including those described in criterion 2.

Figure 7.1. Criterions of Green Material Selection in the HealthCare Industry
Source :Center for Health Design

Dr. Rossi the principal of HWH explains that each criterion represents healthcare's values of prevention, precaution, and concerns for environmental health in today's world. (Rossi and Lent 2006). Although a definition and criteria are a valuable tool to spec green materials in reality sustainable and truly green materials are hard to get all the times. Guidelines do not ensure that an organization will stop using harmful materials. Criterion is only a reference and initial step in an organization's objective to preserve natural resources and enhance patients built environment. The major barriers is that manufactures cannot provide materials all the time under the guideline established, either because it is a new movement or products cannot flood the market right away or simply because the current technology and resources don't allow for sufficient supply of green products. Nonetheless, the effort to demand new products needs to become the rule.

Other more general principles that make green material greener include: (1.) ensuring that manufacturing practices comply with concerning labor and human right practices. (2) Use of local manufactures is preferred over foreign or non local makers so transportation is minimized and energy and pollution cost associated with materials reduced. (3) Setting contractual incentives to contractors that would go the extra mile to use and/or develop environmentally friendly materials.

7.3 Material Selection Process

When an organization decides to make the run for green selection and maintenance those products, couple of barriers will have to be overcome. For example, it is still difficult to know with exactitude the chemicals contained in each material, this information needs to be provided by manufacturers and many times either they are not even aware of what chemicals are preferable. In other cases, some products cannot be replaced for alternates, simply because there is no enough research in an area of that product. Since green material development is entering a new wave of change, a close relationship between specifiers and manufacturing companies should be developed. There has been couple of cases where through relationship and agreements between manufacturers and users open communication allows a clear understanding on code compliance, performance, aesthetics and cost target of materials desired. Such was the case of Kaiser Permanente. In 2002, the organization challenged manufacturers to produce a sustainable carpet title under strict criteria with the assurance of a multimillion contract to the manufacturer that could produce a durable, low-emissive and PVC-free carpet. Collins and Aikman met the challenged and earned sole-source contract with Kaiser Permanente.

In selection of materials a typical green selection protocol is described below. A material process selection starts by:

1. Assessing all chemical constituents of a material/product (if possible).
2. Understanding the hazards posed by that chemical. Unfortunately, the majority of chemicals on the market has not been comprehensively tested for

their hazardous effect (HCWH) .Comprehensive hazard data requires government action through chemical policies and mandates or market driven incentives such as purchasing agreements by hospital organization.

3. Commitment, conviction and championship is necessary to come from owners to go with green materials in most cases.

4. After commitment is reaffirmed, the next challenge is finding products that meet criteria. If the product does not exist it is recommended to find the next best alternative. Efforts on alternative products that might have other sustainable characteristics can be used in lieu. Vendors need to be engaged in the search for solutions and be rewarded with contracts when they deliver the product. Of course, as new green materials are developed, it is critical that no standards of performance or patient c are be sacrificed.

5. Finally, once a new material is in place, workers need to be engaged to maximize the benefits of the greener material. Organizations have to carry out in place training and monitoring program when using materials that change the common way of doing things. An example can be required training to maintenance staff to understand the new ways of working and handling new products.

7.3 Material Selection Mission

A mission and goal for health care is to provide safe environment for patients and staff. Owners might be discouraged to advocate green materials due to higher first costs. Although it is logic that scarcity of products and new market yields higher initial costs it is also truth that life cost analysis can result in more cost-effective products. Life cycle costs take into consideration manufacturer practices; quantifies the amount of energy consumed during all stages of production into a monetary value when possible; maintenance implications and possible health impacts. Ultimately demolition and recycling values are estimated to a monetary quantity. From the above description is it obvious that material selection goes beyond initial costs. An understanding of pros and cons of material life cycle are crucial when considering green materials. Specifying a material based on environmental issues in not the ultimate metrics, embody energy and health implications need also be considered and weighted against alternative materials.

CH 8. ASSESSMENT TOOLS AND SUSTAINABLE METRICS

U.S healthcare sector started its transition to sustainability stewardship in 2000 after setting the Health Care's Environmental Agenda conference in late October of that year. During such conference healthcare leaders began advocacy towards environmental awareness for construction and design of facilities. The initiative has led to an impressive awareness rate when compared to 20 years ago (Yudelson 2008). Shortly after the first conference back in 2000, the industry and in specific the American Society of Healthcare Engineers, published for the first time a green building guidance tool in January of 2002. The guidance was called the *Green Healthcare Construction Guidance Statement*. Soon after the release of this guidance it became apparent that a performance metric tool was missing for new construction of health care facilities. In 2003 with the permission of the U.S Green Building Council's Leadership in Energy and Environmental Design rating system (LEED) a group of architects and engineers realized that the time was right to launch the next phase of sustainable building tool for the sector. A joint effort of *Health Care Without Harm* and the *Center for Maximum Potential Building Systems* with funding by the Merck family fund, developed the *Green Guide for Health Care (GGHC)*. The guide was developed from industry's first best practices and in principle a voluntary green building tool with an emphasis on integrated design from construction to operations. GGHC was developed following credit structure from LEED system but many of the principles on sustainability were modified and customized to fit the uniqueness nature of healthcare facilities. Late in 2007, a LEED-Healthcare was developed by the USBGC. To this date it has not been released officially as a third-party green building certification tool. LEED for Healthcare had already gone through its first public comment period in November 2007, since then it has gone through anticipated revisions and a second public comment period in early 2008, a balloted version is yet to be available.

A discussion on two sustainable rating systems used by the sector is presented below.

8.1 Health Care Sustainable Assessment and Rating Systems

LEED rating system and the Green Guidelines for Healthcare construction are the only two opportunities for hospital facilities. LEED is a voluntary, consensus-based national standard for high performance sustainable buildings. LEED standards are currently available for new construction, existing building operations, commercial, core and shell, and homes. A healthcare section is in the making. The emphasis of LEED has always been mainly for new construction of commercial and office buildings. LEED current version for New Construction does not include operation and maintenance categories: two of the major concerns for healthcare facility. It is why in today's market there is no a legit certifying system for green performance in the Healthcare sector.

The Figure 8.1 presents a breakdown on LEED categories, prerequisites and optional credits.

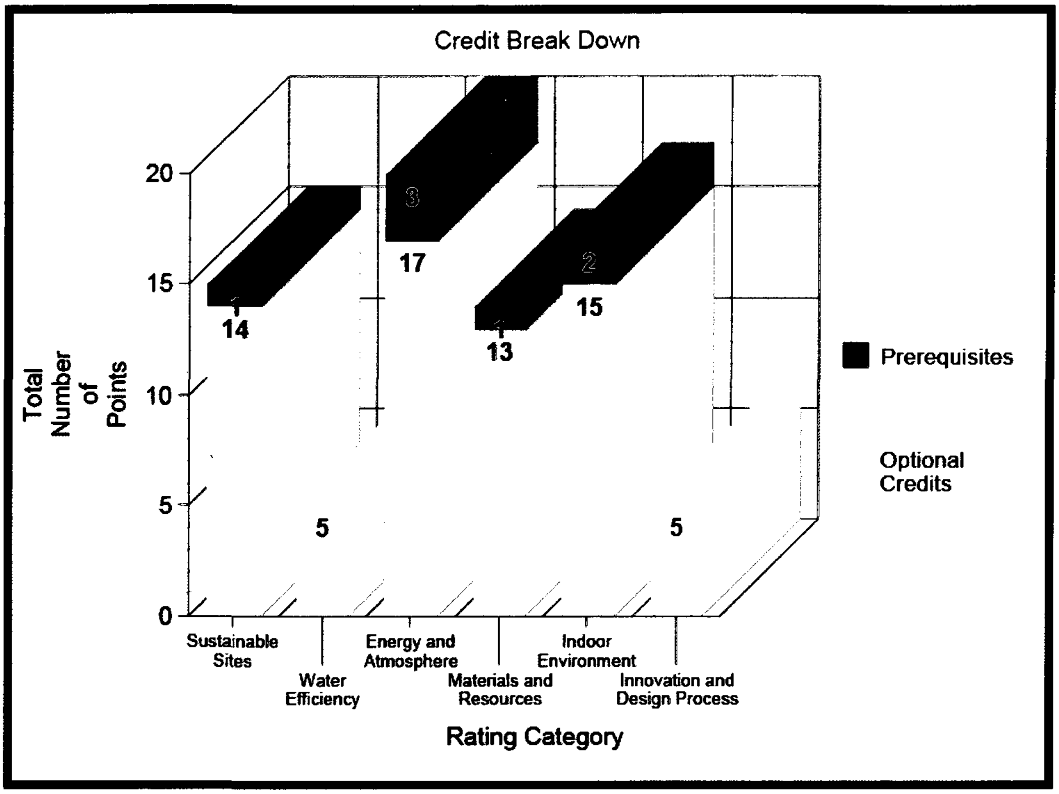

Figure 8.1. LEED categories.

In order to consider a path in the certification process by LEED at least 7 prerequisites must meet criteria. Once that criterion is met project can file for optional credits. The more credits obtained the higher the rating and the "more sustainable" the building is. Figure 3 below summarizes rating level against credits required.

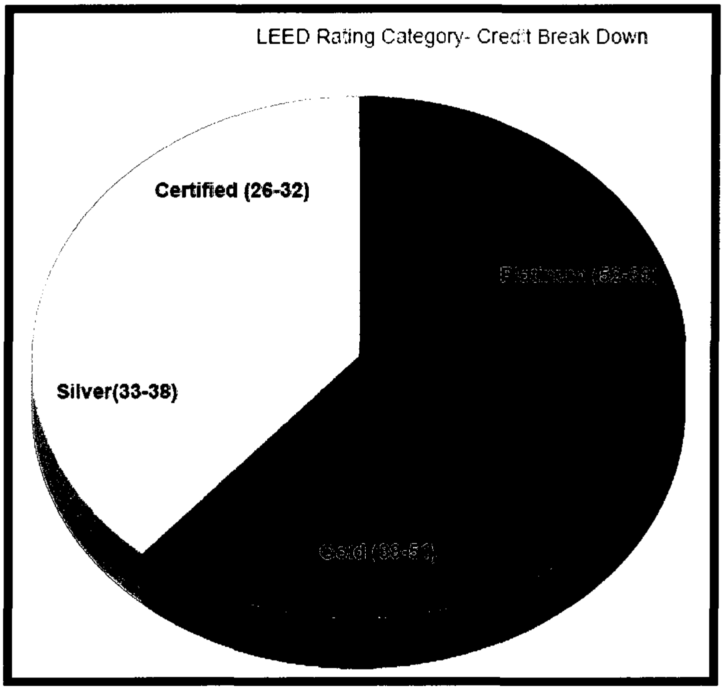

Figure 8.2. LEED Rating Vs Credit Points

On the other hand the GGHC guide bases the structure around LEED credit systems but it does not establish minimum achievement thresholds. It instead suggests a user self certification methodology. The current version of GGHC distinguishes from LEED in three main criteria:

1.) GGHC includes a comprehensive approach to both construction and operation. Because operations and maintenance in hospitals presents a big window of opportunities to reduce costs and environmental impacts, a separate category was included to account for it. A development of 10 credit points was set as prerequisites out of the 72 possible.

2.) It included the importance of integrated design. Out of the 8 possible credit points, half are set up as prerequisites. Although it is imperative to work in an integrated approach when considering sustainable principles, this category supports the importance of engineers, owners, architects and construction managers into collaborating together from inception of project.

3.) Finally the last major distinction is that each credit highlights specific connections between built environment and health consequences. Figures 4 and 5 below summarize the breakdown credits for GGHC current version.

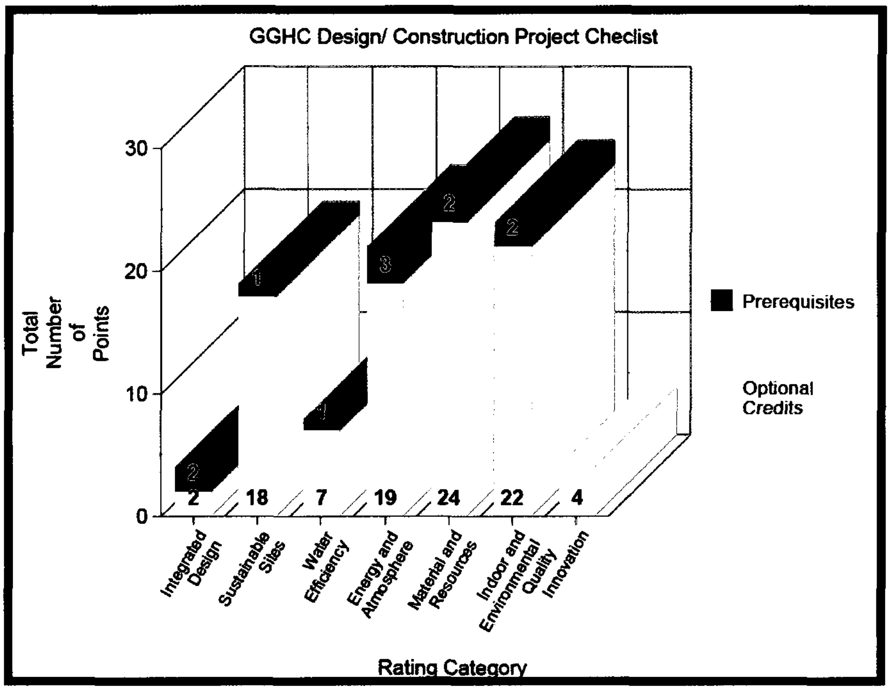

Figure 8.3. Construction Section GGHC

The major cons of GGHC reside in that it does not provide third-party certification. Its lack of formal recognition might not be desirable if public perception of hospital's mission is not immediately recognized, this effect reduces a possible business case for hospital's intentions. Another con is that it is in its infancy of sustainable movement. In the last 1 .5 years GGHC registered 115 projects (GGCH 2007), this alone indicates that not enough data is readily available to formulate a greening formula. Therefore, the fact that the guide is not yet widely causes it to have a limited acceptance when compared to LEED popularity (Holtz 2006).

Until LEED makes its final appearance, GGHC should be the building tool to measure achievement on sustainable principles. The structure of the guide can be used for all size projects, including renovations and addition projects.

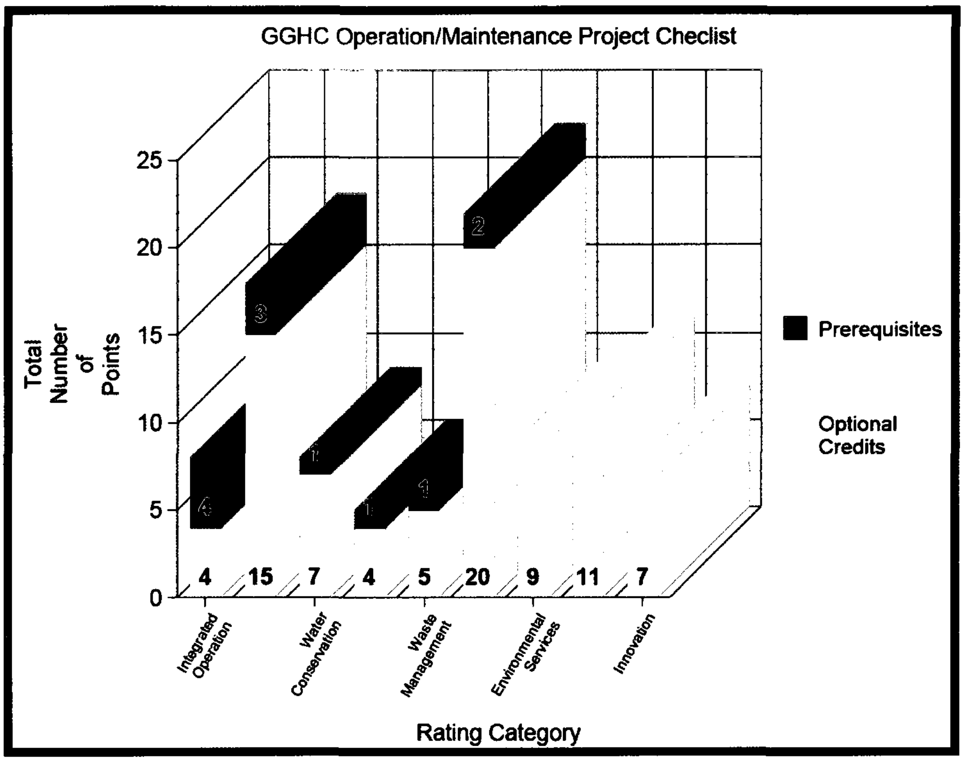

Figure 8.4 . Operations Section GGHC

CH 9. INTEGRATED DESIGN DELIVERY METHODS

Since the late 40s public policy procurement developed a framework of the type Design then Bid then Build. Since then it has been the norm for the majority of public and private construction delivery methods.(Kent 2010). As the buildings grew into more complex forms so did all AEC components. Industry became more specialized in order to respond to the new generation of buildings, from one master builder at the beginning to the separation of the industry into specialization sectors. Construction industry grew into separate cultures and fragmentation and inefficiency were now common during project management (Kiber 2004) . In order to deal with problems of interoperability and inefficiency Construction Management was introduced in the 60s. Today CM delivery method is a popular choice for delivery method, but it still has not changed the fundamental problem of fragmentation among industry stakeholders. In the last couple of decades Design and Build companies have emerged to deal with fragmentation problems between contractors and designers, until now Design and Build has performed relatively at lower costs and less fragmented than CM and DBB (Kent 2010). In this last decade sustainable building ideas demand a great deal of interaction and communication among industry team members to ensure success of high performance buildings (Kiber 2004). Project Alliance, a delivery method that today is commonly referred as Integrated Project Delivery, was developed to improve outcomes through more collaborative and integrated project (AIA 2007).

9.1 Project Delivery Definitions

A project delivery method is the process by which designers, constructors and stakeholders such as consultants comprehensively design and build a specific project. Three are three main delivery methods in the construction industry: Design-Bid-Build (DBB), Construction Manager at Risk (CM), and Design-Build (DB).

9.1.1 Design-Bid-Build (DBB)

This method is characterized by a clear separation between design phase and construction phase. The architect and engineers are hired by the owner to produce functional requirements into a set of detail drawings and specifications. Drawings, specification and schedule requirements become the basis of a request proposal. General Contractors bid and a fixed price or lump sum contract is awarded. Usually the lowest qualified bidder receives the job. In a similar fashion the general contractor selects subcontractors based on competitive bidding. The process offers "checks and balances" through the separation of design and construction contract, but the separation yields a linear process that is the most lengthy of the three methods.

Because the owner sets the budget, many times owner's budget may not reflect the correct cost of the construction project. Unrealistic prices set by the owner will cause the processes to be redesign and then rebid so it can fit within owners program. It is why some people refer to design-bid-build as design-bid-redesign-rebid. Figure 6 below outlines an organizational chart of the delivery system.

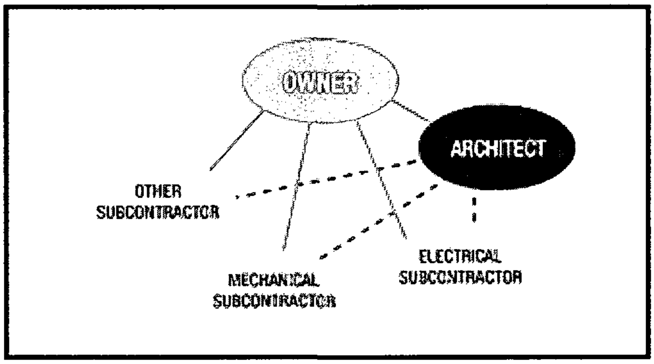

Figure 9.1. DBB Schematic

9.1. 2 Design-Build

Design-build is a method in which one entity is contracted by the owner to take on both the design and construction of the facility. The contractual relationship between owner and entity becomes a single item. Entities possess in-house design and construction capabilities or might just subcontract the phase of design and engineering to an A&E firm. In general, this delivery system is more likely to reduce typical design-construction conflicts given the fact that in-house processes can reduce change order requests, claims and litigation due to errors, omissions, or ambiguities in plans and specifications. This advantage can be seen in a lower price for the owner, improve quality, speed the project to completion, and facilitate improved communication among the project team members. One of the withdraws with the system is that the owner looses the opportunity to deal with the architect and designers directly; this can be result in the owner loosing control. In design-build the designer is under the contractor's payroll. Design-

Build requires the owner to be experienced and have a detailed plan so the contractor can manage the job from the owner's standpoint.

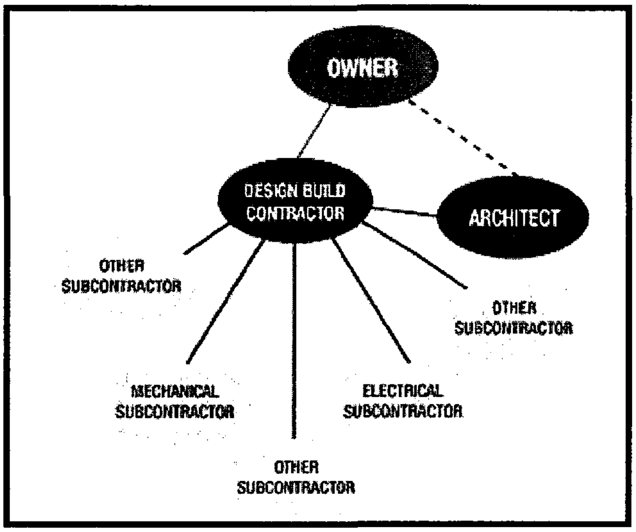

Figure 9.2. D-B Schematic

<u>9.1.3 Construction Manager at Risk</u>.

Construction manager at risk project delivery is a method in which an owner retains a designer to furnish design services and also retains a construction manager to build the project – guaranteeing the cost and schedule. The CM will then schedule, managed and award the bids of the project to subcontractors. It will coordinate and direct the day to day work for each subcontractor. In theory the overall schedule is reduced by the implementation of a fast track approach. Before all drawings are completed the job starts, the advantage is that if planned correctly the schedule could be reduced, however, in case a subcontractors is catching up with uncoordinated area then disputes between CM/Subs and owner can be a common thing. If this is the case the project will be characterized by continuous change orders and claims for additional compensation.

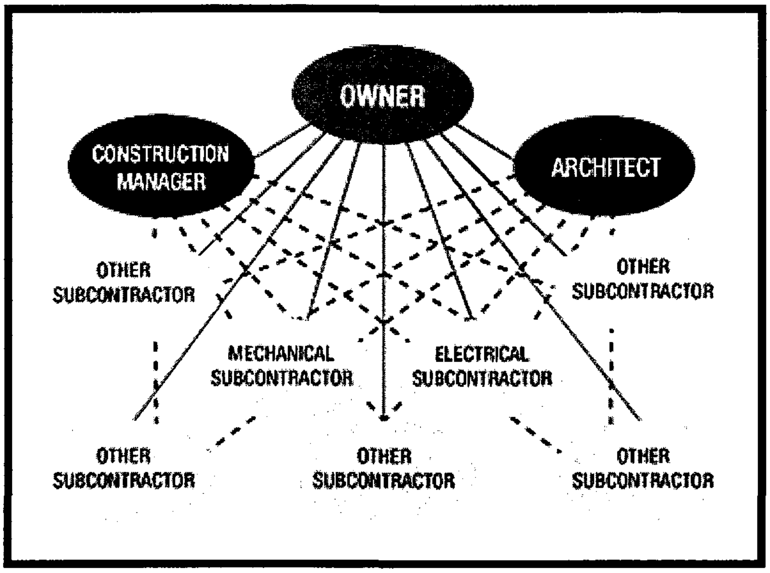

Figure 9.3. CMr Schematic

9.2 Sustainability vs. Traditional Delivery Methods

The linear separation and nature of traditional methods does not facilitate input on sustainability ideas early in the project. In DBB the separation of designer and constructor allows the constructor to input on sustainable ideas only until the design is already finished and construction is ready to start. In CMR the constructor comes in earlier, and unlike DBB, it has the opportunity to input before actual construction starts, however, knowledge gather in a "just-as-need" basis promotes fragmentation (AIA 2007). Finally in DB, builder also has the same approach as in CMR. The drawback is that owner in essence does not own design detail once the criteria is passed to DB contractor. A "minimum-necessary" relationship does not contribute to integration and risk sharing (Molenaar 2009).

In a traditional delivery method a linear and non-collaborative process occurs. The general processes consist of the following steps:

a. The owner and architect come to an agreement on a design concept where basic appearance, size and height are determined; orientation and basic materials are set too.
b. Mechanical engineers take design and based on location, orientation and related parameters design systems of electric and HVAC. Civil engineers, transportation and landscape architects and consultants develop the surrounding concept including parking and infrastructure based on owner's design concept.
c. In essence, a schematic is created in step (a) then a design developed and from it the construction documents. The flow of tasks is employed in a rather lineal and with minimum interaction between disciplines (AIA 2007).

This non-collaborative process and strongly hierarchical controlled process, results in minimal interdisciplinary communications and purely random performance results. Handoff from one silo to other yields inefficiencies (AIA 2007). Optimization is done at each specialty disciplines in a linear form. A suboptimal building is attained at the end of the process as a consequence. (Kiber 2007).

9.3 Integrated Project Delivery

In contrast to traditional processes approach, there is a need to optimize a project in a different and more efficient way. The department of Energy (DOE) defines Integrated Building designs as

> "a process in which multiple disciplines and seemingly unrelated aspects of design are integrated in a manner that permits synergistic benefits to be realized. The goal is to achieve high performance and multiple benefits at a lower cost than the total for all the components combined. This process often includes integrating green design strategies into conventional design criteria for building form, function, performance, and cost. A key to successful integrated building design is the participation of people from different specialties of design: general architecture, HVAC, lighting and electrical, interior design, and landscape design. By working together at key points in the design process, these participants can often identify highly attractive solutions to design needs that would otherwise not be found." (DOE)

One of the main characteristics of IPD is the early integration of project members. High levels of interaction and communication are needed to ensure a high performance building. (Kibert 2004) In a hospital environment this is more so due to their complexity of mechanical systems and unique characteristics as a 24/7 facility.

9.3.1 IPD Principles

In the context of this thesis, three main principles will be highlighted as the major difference between IPD and traditional processes[5]:

a. Early Involvement: Participants are involved at the earliest possible moment, their knowledge and expertise is the most powerful at the beginning when the most important decisions are made. Informed

[5] Principles and definitions of IPD process are synthesized here from multiple industry documents.

decisions are only possible is all members that related to an issue offer an input.

b. Multi-Party Agreement: The primary participants (Owner, architects, general contractor and any other party who may have a primary role) execute a single contract specifying their respective roles, rights, obligations and liabilities. Compensation structures are often-open book. Trust and collaboration are major principles for this kind of contracts. Individual success is tied to overall project success, and individual success depends on the contribution of the other primary participants.

c. Shared Risk and Reward: IPD contracts are designed to encourage compensation reward structures based on team performance rather than specific team. Unlike traditional methods where minimization of risk is approached by individual primary members looking only to preserve their own financial interest, business risks such as costs overruns, failure to meet project goals and market uncertainties is combined among team members.

9.3.2 Building Information Modeling Technology

As mentioned before, open communication is also a key of IPD. Cutting edge technology can enhance a development of a communication protocol platform that can facilitate the transfer of project data. Building information technology is software packages are one of the most powerful tools supporting IPD. (AIA 2007). BIM is projected to revolutionize the construction industry (Autodesk White paper 2008). Because this software can combine design, fabrication information, erecting instructions, cost and schedule logistics; and modeling can either act as a shop drawing or reproduce 2D drawings for fabrication and field use. Interoperability, risks of moving to a new technology and lack of standard BIM contract documents are the main barriers for its adoption (Autodesk White Paper 2007; Kent and Burcin 2010) Nevertheless several projects have demonstrated its powerful benefits (AIA 2007 ; AIA 2010: ; Autodesk White Paper 2008).

Recommendation for Construction Managers

Given the principles of IPD, it is important that the earlier the inception of participant in the process the more meaningful their input will be. Already this process has some IPD principles; Construction Managers tend to be introduced before construction starts. However, the silos of responsibility specified in the scope still are present. To break that adversarial behavior it can be useful to use construction manager as and advisor during schematic design, since it is in this phase where the most important decision are made.

A construction manager can also make use Building Information Technology as a tool to coordinate mechanical trades and administration of RFIs for example. Modeling can help reduce errors by field personnel when sketchers missed or neglect a comment in a 2-d drawing coordination. Visual 3-D modeling can be a great tool for clash detention.

Recommendations for Design-Build

Design and Build is also a partially integrated process similar to construction manager at risk. Since designer and builder, by default, engage in a collaborative and integrative fashion since the beginning of project the integration fall through when owner hands in building criteria and design to the company. All the risk is transfer to design and build company and owner involvement is limited. It is recommended that provisions to let owner be involved are developed as well as provisions to diminish risk to design-build Company. By deferring the GMP to later in the project, the owner can be more involve and the risk is diminished, more collaboration will happen in optimizing GMP and monitoring of costs between key participants.

For a summary table on this recommendations refer to Appendix F, Figure 6F.

CH 10. NEW YORK CITY STUDY CASE

In addition to best practices and recommendations presented for sustainable Hospital construction in the City of New York in the previous sections, this part of the thesis is an initial step in determining and understanding important key aspects for green construction. A study case approach will be used because there is a lack of empirical data that does not allow statistical analysis and/or validation through those means.

Two hospitals under construction in Queens, New York are the center of this study. Both hospitals will go through a comparative analysis against a "Hybrid" case model. The Hybrid case hospital is a combination of two extensively documented "best practice" hospitals. Couple of academic research papers has feature findings in these two hospitals. Because of the principles outlined in literature review above and academic research findings on green attributes for hospital buildings it can be assumed that practices of one can be applied or could have been applied easily to the other. For this study an Integrative Project Delivery approach will be assumed to have been implemented. The other two hospitals make part of the current expansion on nonprofit health infrastructure that the City is starting to witness. Those two hospitals make part of the North Shore Long Island Jewish systems campus and combined approximately $400 millions for the construction sector.

Study case analysis approach allows for the understanding of important factors on sustainable construction by observation. This understanding will open door to formulate valid recommendations. List below shows key criteria found to be key in a delivery of high performance hospitals buildings (Lapinski 2008; AIA 2010; Pommer and Horman 2009; Bilec at, el. 2009; Kiber 2004):

1. Early Evaluation and Adoption of Green Principles.
2. Integrated Delivery/ Partnering and Trust
3. Design Integration of Systems
4. Early Selection of experienced member with Green
5. Business Case for green building.

10.1 Case Study Background

The Dell Children's Hospital of Austin[6]

Dell's Children Hospital in Central Texas is located in a 32 acres lot where the existing Robert Mueller Airport Runway used to sit. The hospital is a complex of four stories with an average square footage of 120,000 square feet per floor. It has an outdoor Healing Garden designed as a giant playground where children can play, run and heal. The project was built in 27 months under a Design-Bid type of delivery. Upon completion of construction, documentation for LEED was filed with USGBC for platinum rating. In 2007 the hospital became the first LEED Hospital under the LEED for commercial buildings version to be giving that certification. One of the highlights of design and construction was the

[6] A background narrative was synthesized from previous research on children's hospitals. (Pommer and Hormann 2009)

recycling of the old airport runway to build hospital's parking lots. The hospital also opted to build a combined cooling and heating plant to reduce dependency on Austin's electrical grid.

Encircle Health Ambulatory Center[7] in Appleton, Wisconsin

The hospital houses three floors for physician practices, ancillary diagnostic services including diagnostic services, imaging, radiology, endoscopy and a pharmacy. The project itself was managed by a larger regional health care group, ThedaCare, which has had construction experienced in the area of Wisconsin where the medical facility is located. Encircle Center was delivered under an Integrated project delivery scheme. An integrated form of agreement contract was signed by owner, architect and builder. MEP trades also made part of a multiparty agreement with mutual shared risk and reward scheme. The project was delivered successfully in 18 months; it achieved a gold rating under the LEED rating system for commercial buildings. One of the highlights of the project was the use of Building Information Modeling software to canalize all the information between stakeholders and predict the typical "if" scenarios of construction. The programming and schematic design phase take longer under IPD schemes and include more planning than typical traditional methods. This practice allowed them to spend more money at the beginning but spend less during construction due to smoother coordination efforts and faster delivery time.

[7] A narrative of Encircle Health Ambulatory Center was synthesized from extensive academic research by AIA council of California in buildings delivered under Integrated Project processeses Scheme. (AIA 2010)

Women's Hospital in Queens New York

Currently under construction and half way its target schedule, the hospital will house new spaces for the delivery healthcare to expectant mothers; it will also serve as a connection to existing Long Island Jewish Medical Center Hospital Building. The building is approximately 250,000 square feet and comprised of 9 floors. The project will provide postpartum single occupancy beds, medical/surgical patient rooms, women's diagnostic and treatment services, women's inpatient ante-partum testing and it also includes delivery room and education and conference spaces. The project is being delivery under a construction manager at risk on a 218 week schedule. The campus itself had just finished an energy center that provides heat and cooling to various buildings in campus. A $ 250 million is the budget for the first phase of hospital. The building was designed to accept an additional four floors of patient room and support areas including a mechanical penthouse to support new floors. Phase two is to start in 2013 depending on philanthropic funding. Hospital did not file for LEED.

Zucker Hillside Hospital in Queens New York

The building is currently in the design development phase. The proposed building will be a two story facility with a full basement. Three specific population groups will be treated in this Psychiatric facility: Adolescent, adult and geriatric. The building itself will be a steel frame construction concrete on metal deck floors. The building will comprise 105,000 square feet of treatment space. First floor will have a courtyard and family waiting area, the second floor will house dining area and the adolescent wing, and third floor will house adult wing. The building will be served by the campus chilled water and steam system. At $ 100 million budgeted and 15 month schedule, the hospital will be the last one to be built in campus for phase one expansion. Currently four projects are simultaneously being built. Phase two will consist of façade renovation of main building, a new six story children's hospital and various additions to the house distribution energy and oxygen facilities for new buildings. None of the current four projects filed for LEED certification under the commercial and residential version.

Children's Hospital of Pittsburg

Located in Pittsburg on a 10 acre campus, the campus opened less than a year ago. With a budget of $555 million and 900,000 square feet the hospital houses 262 beds. Upon completion building filed for Certified LEED rating with USGBC and successfully granted. The hospital it is also registered as a Green Guide For Health Care Pilot Program. It has 9 floors of inpatient and outpatient care areas; 41-bed emergency room and trauma center; and it houses a 10-story research facility; 2 office center and atrium.

Dell's Hospital and Encircle are assumed to be one hospital for this study case. By themselves they have many of the best practices discussed in this paper and literature review. Because the two hospitals seemed to showed similar characteristics in team selection and goals it can be assumed that some practices would have not affected their real performance in their search for sustainability goals. For example the biggest inclusion or assumption here is to adopt the integrated project delivery structure to the already highly collaborative Dell's Children Hospital project team. So in essence when referring to Hybrid hospital, the reference is made to Dell's team working under an integrated project delivery scheme instead of their design-build scheme.

The UPMC study is included here to add validity of data tool collection. Both DELL and UPMC were already filtrated through similar data collection tools in researches by (Pommer and Horman 2008). UPMC hospital won't be described comprehensively; it is only mentioned for reader's acknowledgment.

10.2 Data Collection Tool

After literature was reviewed on sustainable factors, academic research on high performance hospitals and input given by expert in the field, it was determined that the following criterions in table 1 below are vital for sustainable Hospital building delivery.

Key Criteria	Characteristics/Attributes	Cross Case Analysis/Validated by Interviews/Procurement Documents/Design Intent Documentation.	Sample Questions
Early Adoption of Environmental Considerations	Enabling of clear understanding of sustainable objectives from the beginning when decision matter the most.	3 (100-90 % Compliance) ▾ Select A Ranking (0-3) 3 (100-90 % Compliance) 2 (60-80 % Compliance) 1 (30-50% Compliance) 0 (No Compliance)	were sustainable considerations considered early in the project? Was sustainable criteria discussed and defined early as well?Yes (Explain)
	It enables management support		
	It enables Budget to account for this considerations		
		Avera	
Integrated Delivery/Partnering &Trust	Integration of key players include incentive structures on value added by organization.		is there a structure of alliance or incentive for project members based on value added to project? During programming phase, how many stakeholders were present?
	Risk is allocated equally among primary stakeholders in order to enhance collaboration. Responsibilities are define in a no-blame culture	Select A Ranking (0-3)	
	Collectivity capacities are more powerful and meaningful when key participants are involved as early as possible	Select A Ranking (0-3)	
	it enables appropriate technology to enhance functionality, generality and interoperability		
		Average Ranking:	
Design Integration	Mechanical and Natural systems in the building are integrated to minimized heating and Cooling loads	Select A Ranking (0-3)	Design decisions, were they made for on a best for project basis? Was there an incentive or interest in LEED or GGHC as a quantitative metric? Energy or lighting simulations, were they performed?
	Process and disciplines which seemingly appear unrelated are integrated to allow synergistic benefits.	Select A Ranking (0-3)	
		Average Ranking:	
Early Selection of team members with sustainable experience.	Bringing the team together early in schematic design allows team to develop preliminary targets to reach goals. It empowers the team to make more informed decisions when searching for optimization of systems.	Select A Ranking (0-3)	Is there a consultant or team member with experience on green buildings? How many LEED professionals in the team? Is there anybody familiar with GGHC guide?
		Average Ranking:	
Business Case Imperatives-Aligning Sustainability with possible triple bottom	Life cycle cost analysis is performed to justify operational savings.	Select A Ranking (0-3)	Is Life cycle analysis data available? Is there a triple bottom consideration for sustainability in this project? Through integration of systems, were savings in those areas used to cover first cost of possible sustainable practices?
	Sustainability is important to show commitment to community and to improve patients' environment and healing.	Select A Ranking (0-3)	
	Reduction of operating cost neutralizes first costs.	Select A Ranking (0-3)	
		Average Ranking:	

Table 10.1. Pommer Modified Data Collection Tool.

This five point criteria is a consensus among researchers and literature review in delivering a high performance building. Above in the second column specific attributes and characteristics of each criterion are noted. A ranking system by comparing studies is also developed. Finally a data collection questionnaire type questions is displayed for the structure interviews with project team members held at each project. A content analysis of procurement documents and reports of intent on design were revised in order to validate collected data.

The following table charts collected information on each project. For Dell project data was extracted from previous research (Pommer and Horman 2008). Encircle Data comes from AIA study case (AIA 2010). Tables (2 To 7) Summarize key project delivery processes during construction and provide relevant project data collected during observation and visits to project sites.

Hybrid Hospital Project Chart

Hybrid Hospital	*Project Data (Pommer et. al 2008; Guenther and Vittori 2008)*
Building Type	New Acute Care Hospital
Delivery Process	IPD
Stake Holders	N/A
Conceptualization (Programming)	It hires consultants, Engineers and Architect for initial budget and programming phase. Owner makes LEED one of the main priorities. Architect, Engineer and Builder attend Eco-Charette to start thinking on site selection. LEED workshops. BIM Workshops. Platinum becomes the goal. Cost Structure is developed. Energy Plant concept derives during this phase. $150 million is the budget. And $18 million for plant.
Criteria Design(Schematic Design)	Modeling starts for if scenarios. It is established that 27 months is required to deliver building. Orientation and landscaping features developed. Energy Modeling performed. Final hospital layout agreed. Life Cost by owner.
Detailed Design (Design Development)	Development of all building elements coordinated and fully engineered. In this phase decisions are finalized. Specifications developed. BIM is used to complete 3d models of systems and detailing complete. Quality levels are established. 35 percent improvement in energy used thanks to CCHP facility. View to gardens from patient room becomes paramount. Navisworks software is used to detect clashes in MEP equipment.
Implementation Documents(Construction Documents)	Because most of the project is fully defined, subs finish their cost by using BIM software.
Construction Administration	Construction Starts
Cost	Design, Construction Cost, Plant, Misc $ 200 million
Sustainability Features	30 % potable water reduction by dual flush toilets, Roof is shape to accommodate photovoltaic, 92 percent of demolition recycled, Extensive access to daylight for patients and staff, site went through Brownfield remediation, CCHP plant. LEED platinum

Table 10.2. Hybrid Hospital Information Chart

Data Collected Hybrid Hospital

Key Criteria	*Hybrid Hospital(Pommer 2008 ; AIA 2010; Guenther and Vittori 2008)*
Early Adoption of Environmental Considerations	The notion of green was introduced during the programming stages -it was there from the beginning. The owner proposed that this hospital be LEED Platinum and took a "do whatever it takes approach" without sacrificing it or backing out. The green objectives were discussed periodically in relationship to the project goals and objectives and the team trained on the LEED certification process. (Dell Project)
Integrated Delivery/Partnering &Trust*	Each of the selected major subcontractors entered into a "lean partner" relationship with the core team through the use of joining agreements, and all were in place at the start of schematic design. An integrated form of agreement (IFOA) was signed by owner, architect, and builder. Prior to the start of schematic design, four of the major sub trades--mechanical, electrical, plumbing/fire protection and exterior glazing--signed joining agreements and participated in the financial incentives scheme. Project goals, developed collaboratively by the core team, included budget, schedule, and a requirement to attain LEED rating.
Design Integration	The team selected green features that aligned with the project goals and encouraged patient healing (daylighting, low VOCs). Therapy Garden, Trees are positioned to reduced heat island effects, drip landscaping is provided by reclaimed water system. Rooms provide views to even eco-gardens, organic paving. CCHP facility for cooling and heating. Roof shaped to receive photovoltaic panels.
Early Selection of team members with sustainable experience.	The team was brought together through a LEED workshop in the beginning. The workshop was organized by Greg Franta from Ensara (now part of the Rocky Mountain Institute) All the teams were represented at this meeting. None of the teams had previous experience with LEED certified projects. The architect does a lot of work on healthcare facilities. The team does not have previous experience as a unit.
Business Case Imperatives-Aligning Sustainability with possible triple bottom	The project budget has been aligned with the environmental project goals and the corporate mission from the start. Life-cycle analysis studies were performed and found out that the facility will have \$6-8 million savings in energy costs the first 20 years and that every dollar a non-profit healthcare organization saves on energy is equivalent to generating new revenues of \$20 for hospitals and \$10 for medical offices. The payback period is 6-7 years.

Table 10.3. Hybrid Hospital Data Collected

Women's Hospital Project Chart

Women's Hospital	*Project Data*
Project Name	Kartz Women's Hospital
Building Type	Inpatient(LDR, Diagnostic and treatment, Intermediate Care
Delivery Process	Construction Manager-Construction Advisor
Stake Holders	LIJ North Shore, BLL, SOM
Programming	Women's Hospital design process started in 2006. SOM and Cantor Seinuk were hired to assist LIJ with site selection. Granite Associates(an Stantec company) along with Bovis Lend Lease were brought up to assist in managing and as advisory parties for programming phase. LEED following Core and Shell was recommended but later in the programming phase it was dropped.
Criteria Design(Schematic Design)	Schematic design started in march of 2008. Davis Langdon finished pricing the job 3 months later. The estimated cost was established at $239 million.
Design Development and Construction Documents	Giving the market conditions and philanthropic donation issues the job had a three month stop. Construction Manager was kept in campus and excavation and foundation packages were revised. GMP documents preparation started. An opportunity for more scrutinizing in documents was given during three months. VE alternatives for saving in design were established.
Construction Documents Period	Superstructure package was also revised and the opportunity to buy a more sustainable concrete and without the need of reinforcement appeared. Fiber glass reinforced concrete was cheaper because it did not need reinforcement steel. Labor will be reduced and a saving of 10% in concrete contract was obtained. A final GMP of $ 250 million was reached.
Construction Administration	Construction Started in May of 2008.
Cost	$250 million (Phase 1) Phase 2 of three floors on top is expected to start in 2013.
Sustainability Features	A major redevelopment of landscaping outside hospital entrance. Replacing 27,000 square feet of impervious paved surface with landscape. Emergency power will be obtain from emergency co-gen power plant. Chilled Beams installed at all non-critical spaces. Adhesives and Sealants were specified using limits stipulated in LEED for Core and Shell Version 2.0

Table 10.4. Women's Hospital Information Chart

Data Collected Women's Hospital

Key Criteria	*Kartz Women's Hospital LIJ*
Early Adoption of Environmental Considerations	The idea of sustainability is not included as a possibility. Although there was a possibility discussed at the beginning for core and shell it was only done as a good practice. There was never a solid directive to for LEED certification. GGHC guide was not well known in the building and owner representative sides, the only one that had a basic idea was the architect. It was said that given the "low fruit hanging" the project could have been registered as a pilot hospital for GGHC program.
Integrated Delivery/Partnering &Trust	In a Different approach than Encircle Ambulatory medical center, the project was delivered under a construction managing at risk. The CM was brought up as early as the schematic design and it was invited to act as an advisory many times. The CM had been in campus before construction documents phase started due to the close relationship with ownership and the construction of another facility in the campus during programming-Schematic phase of women's hospital. Even thought the collaboration and mutual respect between owner and Manager was established there wasn't a structure of mutual reward and risk.
Design Integration	The building aimed to follow up principles of LEED for CORE and Shell Version 2.0. Using aluminum extrusions with a minimum 20% recycled content. Framing material at least 25% . In procurement documents it was stipulated that materials should be extracted within a maximum of 500 miles. Steam and Heating obtained from on site plant.
Early Selection of team members with sustainable experience.	There is only one AP LEED. Upon interviews team was not aware of Green Guiide for Healthcare. Architects worked before with LEED buildings
Business Case Imperatives-Aligning Sustainability with possible triple bottom	A landscape garden in front of the hospital will take great part of the entrance of main campus. Owner believes that providing an outdoor space back to the community will foster the mission of hospital of health, welfare, comfort and service for the community they serve.

Table 10.5. Women's Hospital Data Collected

Zucker Hill Chart

Zucker Hill Hospital	*Project Data*
Project Name	Psychiatric Zucker Hill
Building Type	Inpatient
Delivery Process	Construction Advisory/ Manager at Risk
Stake Holders	North Shore, BLL, Polshek Partners, Stantec, Cantor Seinuk
Programming	An existing area which includes trees, walking paths and other vegetation south of existing therapy building is the proposed site location. This location is optimum because relocation of utilities is minimized.
Criteria Design(Schematic Design)	Modeling starts for if scenarios. It is established that 27 months is required to deliver building. Orientation and landscaping features developed. Energy Modeling performed. Final hospital layout agreed. Life Cost by owner.
Design Development	Currently going into this face. Relocation of utilities starting summer 2010.
Implementation Documents(Construction Documents)	N/a
Construction Administration	Summer 2010
Cost	Estimates by Langdon Consulting at $100 million
Sustainability Features	Minimum Code compliance. Energy modeling not performed. District Cooling and heating. VAV and air handling units.

Table 10.6. Zucker Hill's Hospital Information Chart

Data Collected Zucker Hill

Key Criteria	*Zucker Hill Medical Center*
Early Adoption of Environmental Considerations	Owner did not mandate green, and it is not seeking certification. There is a storm water prevention program and the notion of sustainability is not embedded in the mission of the project.
Integrated Delivery/Partnering &Trust	The construction manager was brought up early in the process, input on preconstruction. Although planning has been increased the owner, architect and Construction company still keep their traditional service scopes. BIM will not be used either. Granite Associates are acting as the advisors. Because that group is the same group that acted for Women's Hospital it is expected to work well in terms of agreement and collaboration ethics.
Design Integration	Besides making use of chilled water and steam off co-gen power there is no indications of sustainable techniques that exceed code.
Early Selection of team members with sustainable experience.	The project does not need an AP LEED associate. Individuals currently in project have limited experienced.
Business Case Imperatives-Aligning Sustainability with possible triple bottom	Schematic Design has been based on minimum requirements based on building codes. Redevelopment of area with proposed new roads, landscaping forecast a better circulation of pedestrians. No higher costs were reported by the senior project manager.

Table 10.7. Zucker Hill's Hospital Data Collected

A series of interviews, observation and content analysis on the projects are used to rank the commitment of each project on each attribute. All projects are compared through a multi-attribute analysis in order to rank who is more committed and who is engaging more actively in the principles of criteria in of design and construction. The ranking consist in assigning a numerical value of "3" if attribute is clearly defined in project goals and in fact there is a commitment to that attribute. A ranking of "0" or no ranking is giving to attributes that are non existent in the project and/or non feasible for adoption later in the project for those where construction has not started. A computer program in excel was developed using Boolean logic in order to tabulate ranking data. A simple spreadsheet with conditioning of numerical average range values was set up. For example, if ranking in a specific category averages more than 2.5 for a specific criterion, then program will round value to three and stored value as such in the attribute cell. That cell value will be link a graphing function. For example, if value in cell is three then a red colored cell will be assigned; if cell is two a blue color assigned and if cell is one a gray colored value cell will be assigned (refer to figures 8-10). The assignation of colored red, blue and gray will play an important role when graphical representation of pattern matching analysis is presented.

10.3 Data Analysis

To demonstrate the ranking and color denomination a screen shot of spreadsheet using Boolean logic is shown below for each of the study cases.

Key Criteria	Characteristics/ Attributes	Cross Case Analysis/Validated by Interviews/Content Analysis	Questions
Early Adoption of Environmental Considerations	Enabling of clear understanding of sustainable *objectives from the beginning when decision matter the* most.	3	were sustainable considerations considered early in the project? Was sustainable criteria discussed and defined early as well?
	It enables management support	3	
	It enables Budget to account for this considerations	2	
	Average Ranking:	3	
Integrated Delivery/Partnering &Trust	Integration of key players include incentive structures on value added by organization.	3	is there a structure of alliance or incentive for project members based on value added to project? During programming phase, how many stakeholders were present?
	Risk is allocated equally among primary stakeholders in order to enhance collaboration. Responsibilities are define in a no-blame culture	2	
	Collectivity capacities are more powerful and meaningful when key participants are involved as early as possible	3	
	it enables appropriate technology to enhance functionality, generality and interoperability	3	
	Average Ranking:	3	
Design Integration	Mechanical and Natural systems in the building are integrated to minimized heating and Cooling loads	3	Design decisions, were they made for on a best for project basis? Was there an incentive or interest in LEED or GGHC as a quantitative metric? Energy or lighting simulations, were they performed?
	Process and disciplines which seemingly appear unrelated are integrated to allow synergistic benefits.	3	
	Average Ranking:	3	
Early Selection of team members with sustainable experience.	Bringing the team together early in schematic design allows team to develop preliminary targets to reach goals. It empowers the team to make more informed decisions when searching for optimization of systems.	2	Is there a consultant or team member with experience on green buildings? How many LEED professionals in the team? Is there anybody familiar with GGHC guide?
	Average Ranking:	2	
Business Case Imperatives-Aligning Sustainability with possible triple bottom	Life cycle cost analysis is performed to justify operational savings.	3	Is Life cycle analysis data available? Is there a triple bottom consideration for sustainability in this project? Through integration of systems, were savings in those areas used to cover first cost of possible sustainable practices?
	Sustainability is important to show commitment to *community and to improve patients' environment* and healing.	3	
	Reduction of operating cost neutralizes first costs.	3	
	Average Ranking:	3	
	Total Ranking:	92	

	HIGH COMMITMENT(Multiple sources of Evidence)
	SOMEWHAT EXISTENT(Not an Expertise Area)
	INTENT IS MINIMUM (It has been discussed)

Table 10.8. Excel Software- **Multi-attribute and Ranking Analysis for Hybrid Hospital**

Key Criteria	Characteristics/ Attributes	Cross Case Analysis/Validated by Interviews/Content Analysis	Questions
Early Adoption of Environmental Considerations	Enabling of clear understanding of sustainable objectives from the beginning when decision matter the most.	1	were sustainable considerations considered early in the project? Was sustainable criteria discussed and defined early as well?
	It enables management support	1	
	It enables Budget to account for this considerations	1	
	Average Ranking:		
Integrated Delivery/Partnering &Trust	Integration of key players include incentive structures on value added by organization.	2	is there a structure of alliance or incentive for project members based on value added to project? During programming phase, how many stakeholders were present?
	Risk is allocated equally among primary stakeholders in order to enhance collaboration. Responsibilities are define in a no-blame culture	2	
	Collectivity capacities are more powerful and meaningful when key participants are involved as early as possible	3	
	it enables appropriate technology to enhance functionality, generality and interoperability	2	
	Average Ranking:		
Design Integration	Mechanical and Natural systems in the building are integrated to minimized heating and Cooling loads	3	Design decisions, were they made for on a best for project basis? Was there an incentive or interest in LEED or GGHC as a quantitative metric? Energy or lighting simulations, were they performed?
	Process and disciplines which seemingly appear unrelated are integrated to allow synergistic benefits.	2	
	Average Ranking:		
Early Selection of team members with sustainable experience.	Bringing the team together early in schematic design allows team to develop preliminary targets to reach goals. It empowers the team to make more informed decisions when searching for optimization of systems.	1	Is there a consultant or team member with experience on green buildings? How many LEED professionals in the team? Is there anybody familiar with GGHC guide?
	Average Ranking:		
Business Case Imperatives-Aligning Sustainability with possible triple bottom	Life cycle cost analysis is performed to justify operational savings.	1	Is Life cycle analysis data available? Is there a triple bottom consideration for sustainability in this project? Through integration of systems, were savings in those areas used to cover first cost of possible sustainable practices?
	Sustainability is important to show commitment to community and to improve patients' environment and healing.	1	
	Reduction of operating cost neutralizes first costs.	1	
	Average Ranking:		
	Total Ranking:	54	

	HIGH COMMITMENT(Multiple sources of Evidence)
	SOMEWHAT EXISTENT(Not an Expertise Area)
	INTENT IS MINIMUM (It has been discussed)

Table 10.9. Excel Software- Multi-attribute and Ranking Analysis for Women's Hospital

Key Criteria	Characteristics/ Attributes	Cross Case Analysis/Validated by Interviews/Content Analysis	Questions
Early Adoption of Environmental Considerations	Enabling of clear understanding of sustainable objectives from the beginning when decision matter the most.	1	were sustainable considerations considered early in the project? Was sustainable criteria discussed and defined early as well?
	It enables management support	1	
	It enables Budget to account for this considerations	1	
	Average Ranking:		
Integrated Delivery/Partnering &Trust	Integration of key players include incentive structures on value added by organization.	2	is there a structure of alliance or incentive for project members based on value added to project? During programming phase, how many stakeholders were present?
	Risk is allocated equally among primary stakeholders in order to enhance collaboration. Responsibilities are define in a no-blame culture	2	
	Collectivity capacities are more powerful and meaningful when key participants are involved as early as possible	3	
	it enables appropriate technology to enhance functionality, generality and interoperability	2	
	Average Ranking:		
Design Integration	Mechanical and Natural systems in the building are integrated to minimized heating and Cooling loads	1	Design decisions, were they made for on a best for project basis? Was there an incentive or interest in LEED or GGHC as a quantitative metric? Energy or lighting simulations, were they performed?
	Process and disciplines which seemingly appear unrelated are integrated to allow synergistic benefits.	1	
	Average Ranking:		
Early Selection of team members with sustainable experience.	Bringing the team together early in schematic design allows team to develop preliminary targets to reach goals. It empowers the team to make more informed decisions when searching for optimization of systems.	2	Is there a consultant or team member with experience on green buildings? How many LEED professionals in the team? Is there anybody familiar with GGHC guide?
	Average Ranking:		
Business Case Imperatives-Aligning Sustainability with possible triple bottom	Life cycle cost analysis is performed to justify operational savings.	1	Is Life cycle analysis data available? Is there a triple bottom consideration for sustainability in this project? Through integration of systems, were savings in those areas used to cover first cost of possible sustainable practices?
	Sustainability is important to show commitment to community and to improve patients' environment and healing.	1	
	Reduction of operating cost neutralizes first costs.	1	
	Average Ranking:		
	Total Ranking:	49	

	HIGH COMMITMENT(Multiple sources of Evidence)
	SOMEWHAT EXISTENT(Not an Expertise Area)
	INTENT IS MINIMUM (It has been discussed)

Table 10.10. Excel Software- Multi-attribute and Ranking Analysis for Zucker Hill Hospital

Multi-attribute analysis sheet tool was developed as described above, each attribute is giving a ranking and values are stored in cells that are conditioned to ranges between “3” and “0”. As the values as stored, another worksheet takes values into graphical representation (refer to figures 8 to 10) Following section will explain in detail the pattern matching section of study case approach.

10.4 Pattern Matching

As discussed above, a comparison of attributes among the study cases was performed with the objective of developing a quantifiable performance ranking. The ranking developed in the spreadsheet program will determine which patterns are most applicable and stronger in commitment in the projects.

Pattern Matching has been used to allow a fairly direct assessment of how convincingly the evidence of conclusions on study cases are related to expected results (Yin 1994). In this study there is a situation where is important to develop an assessment that can positively prove that criteria presented in the study cases is key for sustainable performance.

Pattern Matching requires the use of past experience, logic of theory before the “job” begins to specify what is expected. In essence it compares actual findings to expected findings. When actual meets expected then pattern criteria is validated. The pattern study here is that five criteria are key factors for building high performance hospitals.

Hybrid hospital attributes presented here represent the platform to test actual findings (Cross case analysis, validation of processes and attributes through interviews, LEED assessment and qualifications, observation noted by researchers, etc.) against statistical and empirical studies that demonstrate correlation of green success with the following criteria:

1.) Early Evaluation and adoption of policies.

2) An integrated delivery structure that promotes team collaboration and mutual benefit.

3.) A Design Integration approach that can benefit from architectural, natural and active systems.

4.) An early selection of experienced personnel in sustainable systems.

5.) A business case that aligns with sustainable goals.

Hybrid Hospital pattern matching results are shown below after being filtered through the data collection tool and validation processes (Interviews, procurement documents, observation etc.) Women's and Zucker Hill hospitals are also shown below. A conformed pattern match analysis is also depicted in Appendix F.

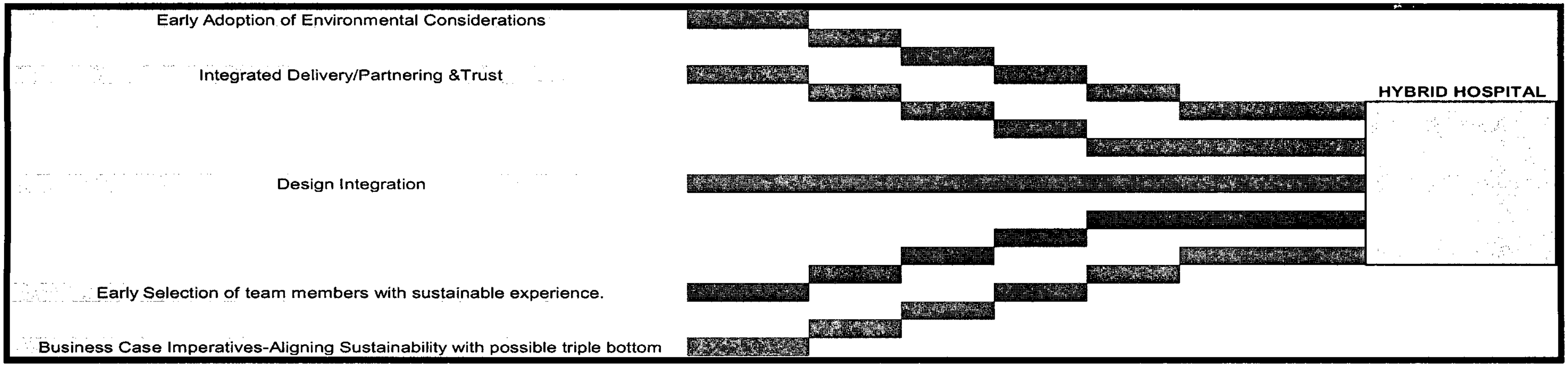

Figure 10.1. Graphical Patter matching for Hybrid Hospital

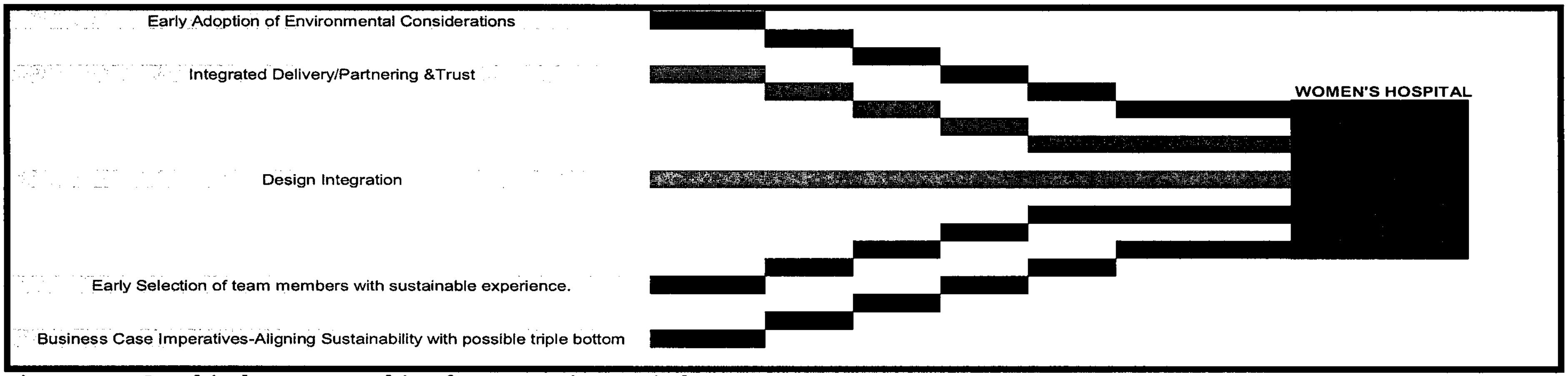

Figure 10.2 Graphical Patter matching for Women's Hospital

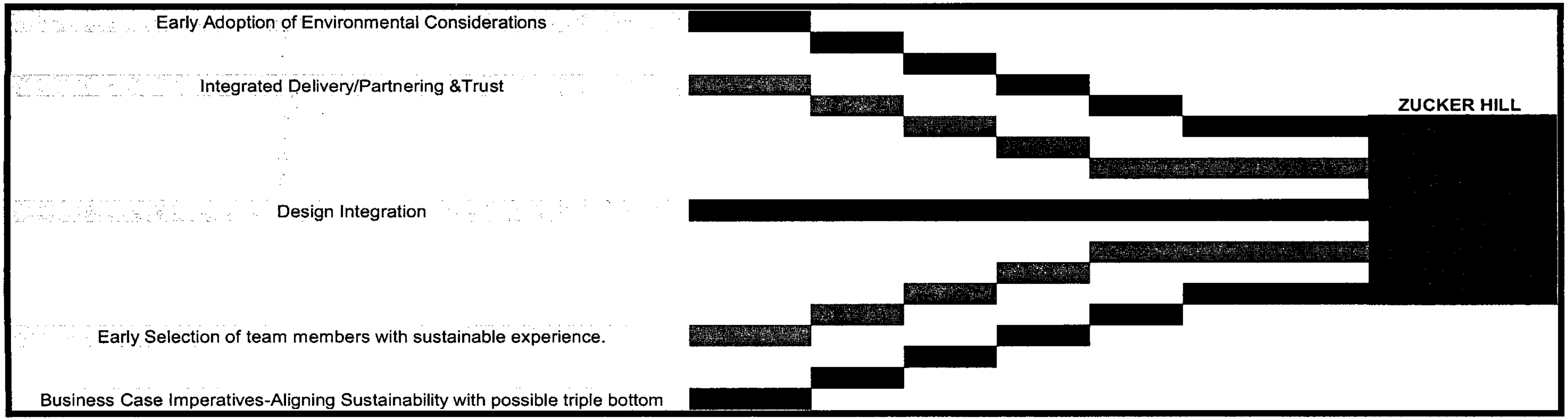

Figure 10.3. Graphical Patter matching for Zucker Hill Hospital

The program is set up so when data collection tool is populated a graph representing results is generated based on ranking results and comparison analysis. The logic is that as one building is filtered through the data instrument a patter matching model is created in real time. The hybrid hospital shows that actual findings are in fact equal to the expected values. The result is important because it leads to convincingly propose alternatives and recommendations in areas where red paths were not recorded.

Results show that there are different levels of commitment among the hospitals featured here. The higher the commitment on criteria the higher it is the performance on sustainable principles.

CH 11. CONCLUSIONS AND FUTURE RESEARCH

The collection of data during literature review and content analysis of academic research allowed the formation of the hybrid hospital model in chapter 10. Dell's Children Hospital was a project that from programming phase was highly committed to green principles and from inception. Its key stakeholders were part of a collaborative team from the start of project too. In the other hand Encircle Ambulatory Center team executed their project under an integrated project delivery where open communication and collaboration among key participants was paramount. This idea and the contractual scheme were assumed to be part of the delivery process of Dell's Hospital. With these assumptions in hand it was determined that Dell's team functioned more integrated, and efficiently by using BIM as communication and a coordination platform in the same way that Encircle Center team did. From there on, this thesis referred to that combination of projects as the Hybrid hospital. Traditional Responsibility silos in a team under IPD scheme are challenged; the commitment to sustainability with all the team from the beginning proposes a different model as well. In the matching of patterns above in figures 9 -11(Also refer to appendix figure 2.F for conformed pattern), it can be seen that NYC still experiences typical fragmentation of tasks between architect, owner and builder, the commitment towards integration was not observed to be in the "highly committed area" and that made it more difficult to include green strategies.

The results above in chapter 10 are a representation of filtering study cases that through observation were subjected to a modified data collection tool(Pommer and Horman 2009) on five criterions found to be crucial for sustainable buildings (Lapinski 2008; AIA 2010; Pommer and Horman 2009; Bilec at, el. 2009; Kiber 2004). The analysis of data collected is used to validate predicted criteria of success. Pattern matching logic allowed a comparison of empirical based pattern with a predicted pattern. If observation of patterns coincided with predict ones then a validation is generated for study case approach. The prediction in chapter 10 was that if a hospital executes a 100 percent commitment in the five main criterions then it was considered to be a high performance building. Figure 9 of hybrid hospital validates theory after filtration of that hospital data. Although there was no a 100 percent commitment in all areas, especially in the expertise and experience on sustainable practices, it was observed that overall there was a higher commitment in all areas. During the process at Dell's Hospital the owner had to hire a consultant to help on LEED compliance and time had to be adjusted to let the team become more knowledgeable, as a consequence, both time and money were compromised. Besides that, it was observed that all across the board the hospital needed the commitment to deliver a highly sustainable hospital. In the hybrid hospital the commitment was observed to be high and that matched the performance obtained.

Another highlight from results can be made from the NYC study cases. In some areas where pattern showed stronger commitment there was no a relationship with LEED alignment or sustainable expertise in team members. To explain why the pattern was matched to be existent it is necessary to look into design integration criterion. That area matched a ranking of "2" for the most part and it was mainly because both Hospitals (Women's and Zucker Hill) had an efficient infrastructure of utilities distribution. District systems are considered a good practice for sustainable energy systems (refer to chapter 6.3). It is important to mention that although the owner did not champion green principles in these specific projects, in the past there had to be a directive from ownership in aligning business case and design integration as an important hospital mission, these can be assumed because an energy center with co-generation had recently been built (2006) in campus. Nevertheless, results showed that some areas do not necessarily fail if attributes on five criterions don't exist for the most part, that is, if infrastructure is given some areas can be green even if commitment is not there in the team. Other results indicated that there is potential for a higher commitment in studied cases, especially after it was learned that economical problems were resolved and put behind. The potential and opportunity is even better after project executive in the CM company revealed in interview that at least $300 million in building is approved for campus expansion for the next five years. It is here where owner and team need to capitalize in the opportunity to build a truly green facility. To do that is critical to invest and commit more to five criteria presented in CH 10.

Additionally, the industry in NYC can make use of the following recommendations, observations and findings presented through this thesis:

1. Owner is a key participant to promote green alternatives solutions at the beginning of project. There was no connection between hospital missions on community based hospital and "do no harm" with environmental friendly practices. Alternatives and best practices technologies can be considered in future projects at Queens campus. A better understanding of owner priority should be research in the future. If patient recovery rate is more important that say an efficient chiller then maybe sustainable ideas can be approached by explaining the owner that evidence-base study cases have showed materials selection and system integrations with daylighting to improve patient recovery rates while saving energy during the day. A study or research on nonprofit ownership triggering factors on deciding to build a new facility can be developed so the AEC industry learns about what is important during the process of funding, philanthropic search, and healthcare executive planning. Findings in this type of research would allow the industry to approach the idea of sustainability through a more informed approach.
2. The field of building truly green hospital is a new idea in the city. Currently in a $1 billion market of the construction company studied here there is only one project filing for LEED certification. The trend is the same in the industry as there are only a handful of builders of new hospitals in the city. It is therefore normal that owners and industry professionals become skeptical to try new things in a market that has not shown enough product to develop strong business case on green hospital. However better times are projected to come for healthcare and the opportunity is at hand now.

Risk continues to be a major concern in the sustainable sector. It is recommended that more collaborative and integrative schemes are tried in other to counteract the fear of losing or getting into something unknown. In the study cases it was found that there was a strong partnering and collaborative relation between owner and construction manager already. This advantage can be capitalized by moving into an integrated project delivery scheme. If the risk of making the move to green strategies exists, it is recommended to be tried in a smaller project. Building information modeling technology should also be included in this try out as it has proven to be a good practice in other projects. Controlled environments should be set up to analyzed interactions and reactions of the team to new practices. Collaboration and structures of reward and shared risk should also be implemented. Experiences of this type have led builders in the west coast to enjoy success in bigger projects very successfully (AIA 2010).

3. The industry, including outside NYC, needs a recognized sustainable metric that adjust more to hospital nature. Only two percent of hospitals are certified by LEED, but the LEED they are certified by is the commercial version which in nature is not compatible with hospital operations. Industry in NYC should start training their teams to the "soon to be released" LEED for Health Care version. A starting point in this effort is to become familiar with the Green Guide for Healthcare tool since it is the platform under which USBGC created LEED for Healthcare. Because LEED for Healthcare is a much stricter version than the popular LEED for commercial and residential buildings, an expertise and

knowledge of this tool is highly recommended. The revised version that went for public review is very similar to the GGHC guide. In the past, a recognized third party certifying tool fueled the change towards green strategies in the residential sector. A similar scenario is set up for the healthcare sector. Given the estimates for construction projections in healthcare, a race to build the first LEED hospitals under the healthcare version is open to anybody in the industry.

4. Strategies outlined in chapters 6-10 in this thesis should be reviewed for anyone interested in looking into active system, material selection or alternative delivery methods systems. It is recommended that owners and professional industry consider alternative technologies presented here as a first step in green practices.

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Appendix A

ASHE-GGHC Project Checklist

Appendix A: Construction Section Checklists of GGCH

Construction

For provisional strategy assessment in DoN applications, applicants are encouraged to estimate the percent likelihood of adoption on credits for which there is significant uncertainty. Such provisional estimates will be used strictly as indicators of intent and/or areas requiring additional design work. If such an estimate is not practical, insert "U" for "Unknown" in the second column. For certifiable plan review approval, the "Percent Likely or Unknown" column cannot be used.

Integrated Design

Achievable	Percent Likely or Unknown*	Not Achievable	Not Applicable		
				Prereq 1	Integrated Design Process
				Prereq 2	Health Mission Statement & Program

Sustainable Sites

Achievable	Percent Likely or Unknown*	Not Achievable	Not Applicable		
				Prereq 1	Construction Activity Pollution Prevention
				Credit 1	Site Selection
				Credit 2	Development Density & Community Connectivity
				Credit 3.1	Brownfield Redevelopment: Basic Remediation Level
				Credit 3.2	Brownfield Redevelopment: Residential Remediation Level
				Credit 3.3	Brownfield Redevelopment: Minimizing Future Hazards
				Credit 4.1	Alternative Transportation: Public Transportation Access
				Credit 4.2	Alternative Transportation: Bicycle Storage & Changing Rooms
				Credit 4.3	Alternative Transportation: Low-Emitting & Fuel Efficient Vehicles
				Credit 4.4	Alternative Transportation: Parking Capacity
				Credit 5.1	Site Development: Protect or Restore Open Space or Habitat
				Credit 5.2	Site Development: Reduce Development Footprint
				Credit 5.3	Site Development: Structured Parking
				Credit 6.1	Stormwater Design: Quantity Control
				Credit 6.2	Stormwater Design: Quality Control
				Credit 7.1	Heat Island Effect: Non-Roof
				Credit 7.2	Heat Island Effect: Roof
				Credit 8	Light Pollution Reduction
				Credit 9.1	Connection to the Natural World: Outdoor Places of Respite
				Credit 9.2	Connection to the Natural World: Exterior Access for Patients
				Credit 10.1	Community Contaminant Prevention: Airborne Releases
				Credit 10.2	Community Contaminant Prevention: Leaks & Spills

Water Efficiency

Achievable	Percent Likely or Unknown*	Not Achievable	Not Applicable		
				Prereq 1	Potable Water Use for Medical Equipment Cooling

Y	?	N	NA	Credit 1	Water Efficient Landscaping: No Potable Water Use or No Irrigation
Y	?	N	NA	Credit 2.1	Potable Water Use Reduction: Measurement & Verification
Y	?	N	NA	Credit 2.2	Potable Water Use Reduction: Domestic Water
	?	N	NA	Credit 2.3	Potable Water Use Reduction: Domestic Water
Y	?	N	NA	Credit 2.4	Potable Water Use Reduction: Process Water & Building System Equipment
Y	?	N	NA	Credit 2.5	Potable Water Use Reduction: Process Water & Building System Equipment

Energy & Atmosphere

Y				Prereq 1	Fundamental Commissioning of the Building Energy Systems
Y				Prereq 2	Minimum Energy Performance
Y				Prereq 3	Fundamental Refrigerant Management

Y	?	N	NA	Credit 1.1	Optimize Energy Performance: 3.5%/10.5%
Y	?	N	NA	Credit 1.2	Optimize Energy Performance: 7%/14%
Y	?	N	NA	Credit 1.3	Optimize Energy Performance: 10.5%/17.5%
Y	?	N	NA	Credit 1.4	Optimize Energy Performance: 14%/21%
Y	?	N	NA	Credit 1.5	Optimize Energy Performance: 17.5%/24.5%
Y	?	N	NA	Credit 1.6	Optimize Energy Performance: 21%/28%
Y	?	N	NA	Credit 1.7	Optimize Energy Performance: 24.5%/31.5%
Y	?	N	NA	Credit 1.8	Optimize Energy Performance: 28%/35%
Y	?	N	NA	Credit 1.9	Optimize Energy Performance: 31.5%/50.5%
Y	?	N	NA	Credit 1.10	Optimize Energy Performance: 35%/42%
Y	?	N	NA	Credit 2.1	
Y	?	N	NA	Credit 2.2	
Y	?	N	NA	Credit 2.3	
Y	?	N	NA	Credit 3	Enhanced Commissioning
Y	?	N	NA	Credit 4	Enhanced Refrigerant Management
Y	?	N	NA	Credit 5	Measurement & Verification
Y	?	N	NA	Credit 6.1	Green Power: 20%
Y	?	N	NA	Credit 6.2	Green Power: 50%
Y	?	N	NA	Credit 6.3	Green Power: 80%
Y	?	N	NA	Credit 6.4	Green Power: 100%
Y	?	N	NA	Credit 7	Equipment Efficiency

Materials & Resources

Y				Prereq 1	Storage & Collection of Recyclables
Y				Prereq 2	Mercury Elimination

Y	?	N	NA	Credit 1.1	Building Reuse: Maintain 40% of Existing Walls, Floors & Roof
Y	?	N	NA	Credit 1.2	Building Reuse: Maintain 80% of Existing Walls, Floors & Roof
Y	?	N	NA	Credit 1.3	Building Reuse: Maintain 50% of Interior Non-Structural Elements
Y	?	N	NA	Credit 2.1	Construction Waste Management: Divert 50% from Disposal

				Credit 2.2	Construction Waste Management: Divert 75% from Disposal
				Credit 2.3	Construction Practices: Site & Materials Management
				Credit 2.4	*Construction Practices: Utility & Emissions Control*
				Credit 3.1	Sustainably Sourced Materials: 10%
				Credit 3.2	Sustainably Sourced Materials: 20%
				Credit 3.3	Sustainably Sourced Materials: 30%
				Credit 3.4	Sustainably Sourced Materials: 40%
				Credit 3.5	Sustainably Sourced Materials: 50%
				Credit 4.1	PBT Elimination: Dioxins
				Credit 4.2	PBT Elimination: Mercury
				Credit 4.3	PBT Elimination: Lead & Cadmium
				Credit 5.1	Furniture & Medical Furnishings: Resource Reuse
				Credit 5.2	Furniture & Medical Furnishings: Materials
				Credit 5.3	Furniture & Medical Furnishings: Manufacturing, Transportation & Recycling
				Credit 6	Copper Reduction
				Credit 7.1	Resource Use: Design for Flexibility
				Credit 7.2	Resource Use: Design for Durability

Environmental Quality

				Prereq 1	Minimum IAQ Performance
				Prereq 2	Environmental Tobacco Smoke Control (ETS)
				Prereq 3	Hazardous Material Removal or Encapsulation
				Credit 1	Outdoor Air Delivery Monitoring
				Credit 2	Natural Ventilation
				Credit 3.1	Construction EQ Management Plan: During Construction
				Credit 3.2	Construction EQ Management Plan: Before Occupancy
				Credit 4.1	Low-Emitting Materials: Interior Adhesives & Sealants
				Credit 4.2	Low-Emitting Materials: Wall & Ceiling Finishes
				Credit 4.3	Low-Emitting Materials: Flooring Systems
				Credit 4.4	Low-Emitting Materials: Composite Wood & Insulation
				Credit 4.5	Low-Emitting Materials: Furniture & Medical Furnishings
				Credit 4.6	Low-Emitting Materials: Exterior Applied Products
				Credit 5.1	Chemical & Pollutant Source Control: Outdoor
				Credit 5.2	Chemical & Pollutant Source Control: Indoor
				Credit 6.1	Controllability of Systems: Lighting
				Credit 6.2	Controllability of Systems: Thermal Comfort
				Credit 7	Thermal Comfort
				Credit 8.1a	Daylight & Views: Daylight for Occupied Spaces: 6% above 'square-root base' daylit area
				Credit 8.1b	Daylight & Views: Daylight for Occupied Spaces: 12% above 'square-root base' daylit area
				Credit 8.1c	Daylight & Views: Daylight for Occupied Spaces: 18% above 'square-root base' daylit area
				Credit 8.1d	Daylight & Views: Daylight for Occupied Spaces: 75% of regularly occupied spaces
				Credit 8.1e	Daylight & Views: Daylight for Occupied Spaces: 90% of regularly occupied spaces
				Credit 8.2	Daylight & Views: Connection to the Natural World: Indoor Places of Respite

Y	?	N	NA	Credit 8.3	Daylight & Views: Lighting & Circadian Rhythm
Y	?	N	NA	Credit 9.1	Acoustic Environment: Exterior Noise, Acoustical Finishes, & Room Noise Levels
Y	?	N	NA	Credit 9.2	Acoustic Environment: Sound Isolation, Paging & Call System, & Building Vibration

Innovation & Design Process

Y	?	N	Credit 1.1	Innovation in Design:
Y	?	N	Credit 1.2	Innovation in Design
Y	?	N	Credit 1.3	Innovation in Design
Y	?	N	Credit 2	Documenting Health, Quality of Care & Productivity Performance Impacts: Research Initiatives

Appendix A: Operations Section Checklists of GGCH

Operations

Integrated Operations

Y				Prereq 1	Ongoing Self-Certification
Y				Prereq 2	Integrated Operations & Maintenance Process
Y				Prereq 3	Environmental Tobacco Smoke Control
Y				Prereq 4	Outside Air Introduction & Exhaust Systems
Y	?	N	NA	Credit 1.1	Building Operations & Maintenance: Staff Education
Y	?	N	NA	Credit 1.2	Building Operations & Maintenance: Building Systems Maintenance
Y	?	N	NA	Credit 1.3	Building Operations & Maintenance: Building Systems Monitoring
Y	?	N	NA	Credit 2.1	IAQ Management: Maintaining Indoor Air Quality
Y	?	N	NA	Credit 2.2	IAQ Management: Reduce Particulates in Air Distribution

Transportation Operations

Y	?	N	NA	Credit 1.1	Alternative Transportation: Public Transportation Access
Y	?	N	NA	Credit 1.2	Alternative Transportation: Low Emitting & Fuel Efficient Vehicles
Y	?	N	NA	Credit 1.3	Alternative Transportation: Carpool Programs

Energy Efficiency

Y				Prereq 1	Existing Building Commissioning
Y				Prereq 2	Minimum Building Energy Performance
Y				Prereq 3	Ozone Protection
Y	?	N	NA	Credit 1.1	Optimize Energy Performance: Energy Star score of 63
Y	?	N	NA	Credit 1.2	Optimize Energy Performance: Energy Star score of 67
Y	?	N	NA	Credit 1.3	Optimize Energy Performance: Energy Star score of 71
Y	?	N	NA	Credit 1.4	Optimize Energy Performance: Energy Star score of 75
Y	?	N	NA	Credit 1.5	Optimize Energy Performance: Energy Star score of 79
Y	?	N	NA	Credit 1.6	Optimize Energy Performance: Energy Star score of 83
Y	?	N	NA	Credit 1.7	Optimize Energy Performance: Energy Star score of 87
Y	?	N	NA	Credit 1.8	Optimize Energy Performance: Energy Star score of 91
Y	?	N	NA	Credit 1.9	Optimize Energy Performance: Energy Star score of 95
Y	?	N	NA	Credit 1.10	Optimize Energy Performance: Energy Star score of 99
Y	?	N	NA	Credit 2.1	On-Site & Off-Site Renewable Energy: 1% on or 5% off
Y	?	N	NA	Credit 2.2	On-Site & Off-Site Renewable Energy: 2% on or 10% off
Y	?	N	NA	Credit 2.3	On-Site & Off-Site Renewable Energy: 5% on or 25% off
Y	?	N	NA	Credit 2.4	On-Site & Off-Site Renewable Energy: 10% on or 50% off
Y	?	N	NA	Credit 3	Energy Efficient Equipment
Y	?	N	NA	Credit 4	Refrigerant Selection

Credit 5.1	Performance Measurement: Enhanced Metering
Credit 5.2	Performance Measurement: Emission Reduction Reporting

Water Conservation

Prereq 1	Minimum Water Efficiency
Credit 1.1	Water Efficient Landscaping: Reduce potable water use by 50%
Credit 1.2	Water Efficient Landscaping: Eliminate potable water use
Credit 2.1	Building Water Use Reduction: Reduce 10%
Credit 2.2	Building Water Use Reduction: Reduce 20%
Credit 2.3	Building Water Use Reduction: Reduce 30%
Credit 2.4	Building Water Use Reduction: Reduce 40%
Credit 2.5	Building Water Use Reduction: Reduce 50%
Credit 3	Performance Measurement: Enhanced Metering

Chemical Management

Prereq 1	Polychlorinated Biphenyl (PCB) Removal
Credit 1.1	Community Contaminant Prevention: Airborne Releases
Credit 1.2	Community Contaminant Prevention: Leaks & Spills
Credit 2.1	Indoor Pollutant Source Control & Other Occupational Exposures: Chemical Management & Minimization
Credit 2.2	Indoor Pollutant Source Control & Other Occupational Exposures: High Hazard Chemicals
Credit 3	Chemical Discharge: Pharmaceutical Management & Disposal

Waste Management

Prereq 1	Waste Stream Audit
Credit 1.1	Total Waste Reduction: 15%
Credit 1.2	Total Waste Reduction: 25%
Credit 1.3	Total Waste Reduction: 35%
Credit 2.1	Regulated Medical Waste Reduction: <10%
Credit 2.2	Regulated Medical Waste Reduction: Minimize incineration
Credit 3	Food Waste Reduction

Environmental Services

Credit 1.1	Outdoor Grounds & Building Exterior Management : Implement 4 strategies
Credit 1.2	Outdoor Grounds & Building Exterior Management : Implement 8 strategies
Credit 2	Indoor Integrated Pest Management

				Credit 3	Environmentally Preferable Cleaning Policy
				Credit 4.1	Sustainable Cleaning Products & Materials: 30% of annual purchases
				Credit 4.2	Sustainable Cleaning Products & Materials: 60% of annual purchases
				Credit 4.3	Sustainable Cleaning Products & Materials: 90% of annual purchases
				Credit 5	Environmentally Preferable Janitorial Equipment

Environmentally Preferable Purchasing

				Credit 1.1	Food: Organic or Sustainable
				Credit 1.2	Food: Antibiotics
				Credit 1.3	Food: Local Production / Food Security
				Credit 2	Janitorial Paper & Other Disposable Products
				Credit 3	Electronics Purchasing & End of Life Management
				Credit 4.1	Toxic Reduction: Mercury
				Credit 4.2	Toxic Reduction: DEHP
				Credit 4.3	Toxic Reduction: Natural Rubber Latex
				Credit 5	Furniture & Medical Furnishings
				Credit 6.1	IAQ Compliant Products: 45% of annual purchases
				Credit 6.2	IAQ Compliant Products: 90% of annual purchases

Innovation in Operation

			Credit 1.1	Innovation in Operations
			Credit 1.2	Innovation in Operations
			Credit 1.3	Innovation in Operations
			Credit 1.4	Innovation in Operations
			Credit 2	Documenting Sustainable Operations: Business Case Impacts
			Credit 3.1	Documenting Productivity Impacts: Absenteeism & Health Care Cost Impacts
			Credit 3.2	Documenting Productivity Impacts: Research Initiatives

Appendix B

LEED for New Construction v2.2.

LEED for New Construction v2.2
Registered Project Checklist

Project Name:
Project Address:

Yes	?	No		Sustainable Sites		14 Points
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required	Required
			Credit 1	**Site Selection**	1	1
			Credit 2	**Development Density & Community Connectivity**	1	5
			Credit 3	**Brownfield Redevelopment**	1	1
			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1	6
			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1	1
			Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel-Efficient Vehicles	1	3
			Credit 4.4	**Alternative Transportation**, Parking Capacity	1	2
			Credit 5.1	**Site Development,** Protect or Restore Habitat	1	1
			Credit 5.2	**Site Development,** Maximize Open Space	1	1
			Credit 6.1	**Stormwater Design,** Quantity Control	1	1
			Credit 6.2	**Stormwater Design,** Quality Control	1	1
			Credit 7.1	**Heat Island Effect,** Non-Roof	1	1
			Credit 7.2	**Heat Island Effect,** Roof	1	1
			Credit 8	**Light Pollution Reduction**	1	1

Yes	?	No		Water Efficiency		5 Points
						Required
			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1	2
			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1	2
			Credit 2	**Innovative Wastewater Technologies**	1	2
			Credit 3.1	**Water Use Reduction**, 20% Reduction	1	2
			Credit 3.2	**Water Use Reduction**, 30% Reduction	1	2

				Energy & Atmosphere	17 Points
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required

***Note for EAc1**: All LEED for New Construction projects registered after June 26th, 2007 are required to achieve at least two (2) points under EAc1.

			Credit 1	**Optimize Energy Performance**	1 to 10
			☐	10.5% New Buildings or 3.5% Existing Building Renovations	1
			☐	14% New Buildings or 7% Existing Building Renovations	2

Yes	?	No			Points
				17.5% New Buildings or 10.5% Existing Building Renovations	3
				21% New Buildings or 14% Existing Building Renovations	4
				24.5% New Buildings or 17.5% Existing Building Renovations	5
				28% New Buildings or 21% Existing Building Renovations	6
				31.5% New Buildings or 24.5% Existing Building Renovations	7
				35% New Buildings or 28% Existing Building Renovations	8
				38.5% New Buildings or 31.5% Existing Building Renovations	9
				42% New Buildings or 35% Existing Building Renovations	10
			Credit 2	**On-Site Renewable Energy**	1 to 3
				2.5% Renewable Energy	1
				7.5% Renewable Energy	2
				12.5% Renewable Energy	3
			Credit 3	**Enhanced Commissioning**	1
			Credit 4	**Enhanced Refrigerant Management**	1
			Credit 5	**Measurement & Verification**	1
			Credit 6	**Green Power**	1

continued...

Yes	?	No	Materials & Resources		13 Points
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
			Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
			Credit 1.2	**Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
			Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
			Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
			Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
			Credit 3.1	**Materials Reuse**, 5%	1
			Credit 3.2	**Materials Reuse**,10%	1
			Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
			Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regionally	1
			Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regionally	1
			Credit 6	**Rapidly Renewable Materials**	1
			Credit 7	**Certified Wood**	1

Yes	?	No	Indoor Environmental Quality		15 Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
			Credit 1	**Outdoor Air Delivery Monitoring**	1
			Credit 2	**Increased Ventilation**	1
			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1

Yes	?	No	Credit	Description	Points
			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
			Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
			Credit 6.1	**Controllability of Systems**, Lighting	1
			Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
			Credit 7.1	**Thermal Comfort**, Design	1
			Credit 7.2	**Thermal Comfort**, Verification	1
			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
			Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Yes	?	No			
			Innovation & Design Process		5 Points
			Credit 1.1	**Innovation in Design**: Provide Specific Title	1
			Credit 1.2	**Innovation in Design**: Provide Specific Title	1
			Credit 1.3	**Innovation in Design**: Provide Specific Title	1
			Credit 1.4	**Innovation in Design**: Provide Specific Title	1
			Credit 2	**LEED® Accredited Professional**	1

Yes	?	No		
			Project Totals (pre-certification estimates)	**69** Points

Certified: 26-32 points, **Silver:** 33-38 points, **Gold:** 39-51 points, **Platinum:** 52-69 points

Appendix C

Case Study Interviewed Personnel/Data Collection Tool and Related Questions.

Name/Company	*Company*	*Sector*	*Interview Type*	*Date*
Ian T.	BLL	MEP/ Women's and Zucker's/Central Plant NSLIJ	In person	3/9/10
Richard B.	BLL	Executive Project Manager/ Women's Hospital, Decanting, Garage Parking.	In Person	4/2/10
Robert P.	SOM	Junior Architect/ Women's	Phone	3/10/10 and 4/3/10
Cerino A	BLL	MEP/ Womens	In Person	3/2/10
Michael B.	BLL	Senior Project/ Zucker Hill	In Person	3/9/10
John O.	BLL	Project Manager/ Children Hospital, Zucker's	In Person	4/3/10
Anthony C.	BLL	I.T /BIM Mount Sinai	Phone	3/15/10
Jeff F.	NS LIJ	Owner Rep/ Womens, Zucker	Phone	3/16/10
Dorien. M	Polshek Partnership Architects	Architect	Phone	3/12/10 and 3/19
Peter M.	BLL	AP and Project Manager/ Women's	In Person	3
Greg T.	Five Star/ Electric	Local 3. Green Energy Instructor	In person	4/10/10

Related Questions/Miscellaneous/Complementary and Validation to Data Tool Collection.

1. Involvement with Company?
2. Experience with LEED?
3. Team Experience with LEED, GGHC?

4. Green Initiatives
5. Eco-Charettes Discussions
6. Owner Involvement
7. Number of Staff Owner, level of involvement
8. Level of Owner input, Architect Input
9. Priorities and Goals
10. Decision Makers
11. Guarantee Maximum Price and Green Initiatives Connection
12. Builder Experience/Green Experience/Support from Main Office
13. Qualifications of staff Members
14. Outside Consultants/Construction Managers and Planners
15. Indoor Environmental Quality Implications
16. Commitment to Green/ Architect Role/Owner role/Builder Role
17. BIM technology/ Staff qualifications
18. Communication among team members/ Frequency of Meeting/ Green Agenda during planning/schematic design
19. Risk Allocation/ Key areas identified/
20. Selection of Architect/Relation with builder
21. Commissioning/ Energy Modeling
22. Future Plans/ North Shore and Future Green Initiatives
23. Construction Management at Risk as Agency/ Design Build/
24. Value Engineering
25. Integrated Processes and Lessons Learned
26. Company/Institution Vision.

27. Performance/ Safety/Quality/Budget/Owner Satisfaction

Appendix D. The City of New York Design and Construction Manual and Guidelines reference Matrix.

Publication	*Topic*	*Reference*
Design Consultant Guide	The *Design Consultant Guide* describes all the design phases of a DDC structures project, as well as all of the services and deliverables that may be required in those phases. It also includes a description of expectations in the Design Criteria section, and guidance on the approvals that consultants may be required to obtain in the regulatory approvals section.	http://www.nyc.gov/html/ddc/downloads/pdf/ desguide/designguide.pdf
Universal Design New York 2	Universal Design 2 reviews values important to the design of public facilities, including equitable use, flexibility in use, perceptible information, and low physical effort.	http://www.nyc.gov/html/ddc/downloads/pdf/ udny/udny2.pdf
High Performance Infrastructure Guidelines	"A best management practices," to be used in road, site and water management projects. Called right–of-way infrastructure projects, they affect environmental, social, and economic factors in the city.	http://www.nyc.gov/html/ddc/downloads/pdf/ hpig.pdf
High Performance Building Guidelines	the most recognized first step taken in what is now a heralded sustainable program for buildings in New York City. These guidelines review sustainable strategies in the indoor environment, in site design, in water management, in material and product selection, and much more.	http://www.nyc.gov/html/ddc/downloads/pdf/ high_build_guide/BuildGuide.pdf

Local Law 77 DDC Ultra-Low Sulfur Diesel Manual	This document is an introduction and resource handbook for understanding New York City Local Law 77. This law requires the use of ultra-low sulfur diesel (ULSD) and "best available technology" (BAT) for reducing emissions from non-road equipment used on City construction projects.	http://www.nyc.gov/html/ddc/downloads/pdf/lowsulfur.pdf
Manual for Quality, Energy Efficient Lighting	An introduction and resource handbook about quality lighting and energy efficient solutions for New York City projects. Its basic goal is to assist designers and project manager personnel to understand the current energy codes and meet or exceed them with appropriate and creative designs	http://www.nyc.gov/html/ddc/downloads/pdf/lightman.pdf
Construction & Demolition Waste Manual	An introduction and resource handbook for construction and demolition (C&D) waste reduction, reuse and recycling on New York City Projects.	http://www.nyc.gov/html/ddc/downloads/pdf/waste.pdf
Geothermal Heat Pump Manual	An introduction and 'hands on' manual for project managers and consulting engineers working for the City of New York who are considering the use of geothermal systems to reduce energy costs on their building projects	http://www.nyc.gov/html/ddc/downloads/pdf/geotherm.pdf
DDC Cool & Green Roofing Manual	An introduction to environmental roof strategies, both reflective and planted roofs. Its basic goal is to evaluated the effectiveness of these strategies for New York City projects.	http://www.nyc.gov/html/ddc/downloads/pdf/cool_green_roof_man.pdf
Sustainable Urban Site Design Manual	An introduction to more environmentally, economically, and socially responsible urban site design practices for New York City capital projects.	http://www.nyc.gov/html/ddc/downloads/pdf/ddc_sd-sitedesignmanual.pdf

Appendix E: Boolean Logic used in the comparative data analysis and pattern matching using Excel as platform.

Data Collection Tool Sheet Logic. (Tables 10.8 to 10.10)

Heading: Cross Case Analysis Validated by Interviews and Content Analysis

Attributes Cells for Criterion 1 “Early Adoption of Environmental Considerations”

{

If value >= 2.5 assign red and round value to 3 ; //cell 1

if value between 1.5 and 2.4 assign blue and round value to 2 ; //cell 2

if Value < 1.5 assign gray and round value to 1; // cell 3

else do nothing and assign zero to value.

}

Criterion Cell Average Ranking. “Early Adoption of Environmental Considerations”

{

Average Ranking_Criteria 1= cell 1+ cell 2 + cell 3 / 3

If Average Ranking >= 2.5 assign red and round value to 3 ; //cell 1

if Average Ranking between 1.5 and 2.4 assign blue and round value to 2 ; //cell 2

if Average Ranking < 1.5 assign gray and round value to 1; // cell 3

else do nothing and assign zero to value.

}

// Note: The Same logic is applied to criterions 2-4 and their respective attribute cells

Pattern Matching (Figures 10.1 to 10.3)

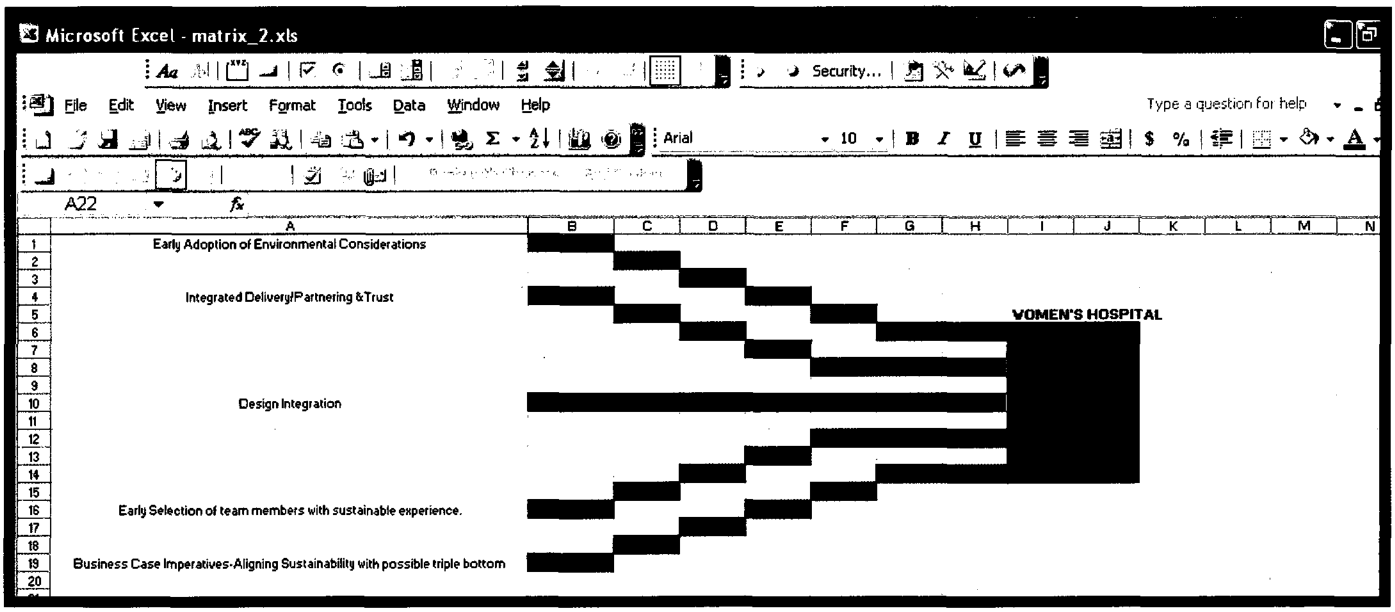
{

Obtain value from Average Ranking_Criteria_1 and assign to B1, C2, D3, E4, F5, G6 and H6 // refer to snapshot of excel sheet below.

In that example. Average Ranking _Criteria is= 1 (gray) therefore B1=C2= D3 =E4 =F5 =G6 =H6 = Average Ranking _Criteria = 1 (gray).

Average Ranking Criteria _2 = 2 (blue) therefore B4=C5=D6=E7=F8=G8 = Average Ranking Criteria_2 = 2 (Blue).

The same is done with criterions 3, 4, and 5 until the pattern is completed.



Snapshot of Women's Hospital Pattern Matching.

Appendix F: Miscellaneous Material Included in Presentation.

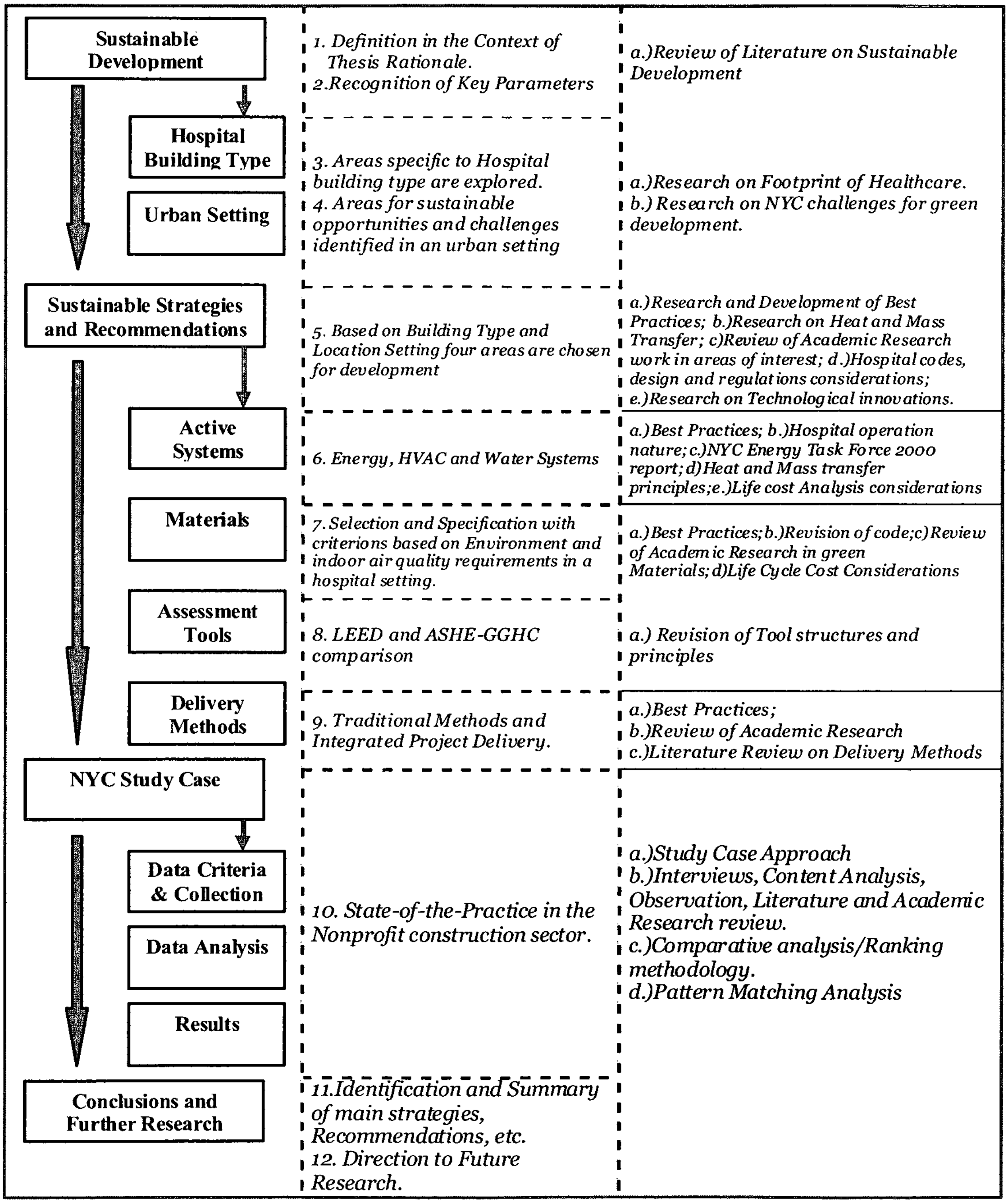


Figure 1.F Methodology

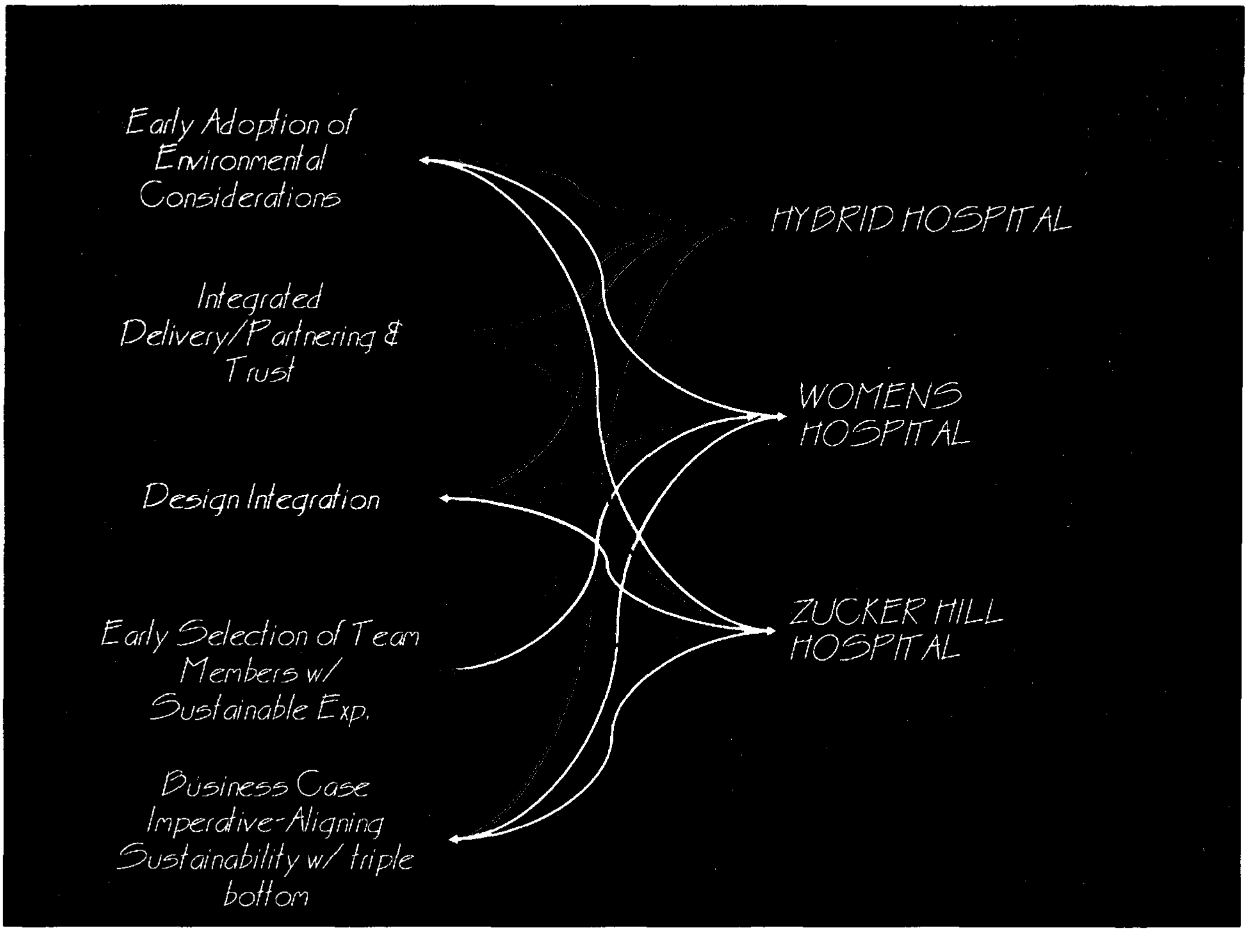


Figure 2.F Pattern Matching Results

Category	Technology Area/Name	Criteria/Attributes	Reference (Thesis)
Energy	**Renewable/Fuel Cell**	**-Extra electricity can be used to meet loads in heating or for specialized processes**	**6.3.1.1**
Energy	**Renewable/CCHP**	**-Elimination of Transmission and Distribution losses. -Higher fuel efficiency -Power Quality and Reliability -Emergency Power independency**	**6.3.1.2**
Energy	**Renewable/Biomass, Photo- voltaic, Daylight and Wind Energy.**	**-Alternatives to Replace fossil fuels -Passive and Natural Cooling and Ventilation save energy.**	**6.3.1.3**
Energy	**Renewable/Green Power Contracts**	**-Environmentally responsible way of energy consumption. If federal or states incentives are available it can compete with conventional energy source.**	**6.3.1.4**

Energy	Lighting/ Daylighting	-Patient Recovery outcome can be improved -Reduces loads by artificial lights	6.3.2
Energy	Lighting/Light Controls	-Useful for non-medical and medical spaces that are not used regularly to save energy. -Patient comfort and patient visibility	6.3.2
Energy	Modeling/ Energy Modeling	-Parametric analysis can optimize integration of technologies	6.3.3

Figure 3F. Energy Technologies Summary

Category	Technology Area/Name	Criteria/Attributes	Reference (Thesis)
HVAC	Heating and Cooling/ on site-District Systems	-More potential for co-generation techniques -Fuel efficiency potential -Elimination of Boilers and Chiller plants in building. -Chemical waste reduced in hospital building -Higher Thermal efficiency -Opens up spaces in mechanical rooms in hospital buildings.	6.4.1
HVAC	Ventilation/ Displacement Ventilation System	-Improved air quality and noise control ideal for hospital environments.	6.4.2
HVAC	Ventilation/Mixed-Mode Ventilation	-Saves energy when fresh air and temperature are ideal.	6.4.3
HVAC	Heat and Ventilation/Radiant Heat Technique	-Peak loads can be reduced due to thermal Energy Storage.	6.4.4
HVAC	Heat and Cooling/ Ground & Couple Heat Pumps	-Ideal for hospitals where cooling and heat are needed simultaneously in back to back patient rooms -Saves energy by creating free hot water in the summer, and savings in the winter due to free thermal energy from the earth ground.	6.4.5
HVAC	Heat & Cooling/ Absorption Chillers	-Fuel Flexibility -Thermal Energy operation available can save electricity money-Easier to expand load due to independency from hospital electrical grid	6.4.6
HVAC	Ventilation, Heat & Cool/VAV	-Recirculation of air minimized -Thermostatically efficient technique	6.4.7

		due to controlled variable operation	
HVAC	Ventilation and Cooling/ Desiccant Cooling and Dehumidification	-Heat Recovery available for other building operations -Air quality -Heat is recycled from exhaust operations	6.4.8
HVAC	Ventilation, heat &cooling/ Chilled Beam Cooling	-Transfer heat via convection -Off duct system operation reduces duct fans	6.4.9

Figure 4F. Summary of HVAC Technologies

Category	Technology Area/Name	Criteria/Attributes	Reference (Thesis)
Water	Steam distribution/ Condensate water Recycling From Heat & cool systems, Sterilization	-condensate water can be recycled back to cooling towers	6.5.1
Water	Sanitary/Dual flush toilets	-Domestic Water reductions potential -Minimize sewage overwhelming potential	6.5.2
Water	Sanitary/Waterless Urinals	- Domestic Water reductions potential - Minimize sewage overwhelming potential	6.5.2
Water	Processes in Medical Equip./ X-Ray Water Conservation	-Recycling of rinse water can reduce operation cost.	6.5.3
Water	Processes in Medical Equip./ Replacement of X-Ray equip.	-Digital Imaging Processors can produce sharper images at lower O&M costs	6.5.3
Water	Processes in Medical Equip/ Steam Sterilizers condensate cooling by non-potable water	-Wasted chiller water can be used to cool condensate can save potable water for better uses.	6.5.3
Water	Sanitary, Irrigation and HVAC processes/ Rain Water Harvesting	-Rainwater can recycled to supply toilets and HVAC systems saves considerate potable water percentages.	6.5.4

Figure 5F. Summary of Water Technologies

Construction Manager at Risk	**-Earlier Inception of Construction Manager will strengthen their input** **-Responsibility silos worded in agreement should be changed towards a more sharing, collaborating view. -An advisory role can be specified when inception earlier is made.** **-BIM for clash detention and MEP Coordination can be an initial step.**
Design-Build	**-Lower the risk to Design-Build Company by changing role of owner involvement during the project.** **-Deferring GMP later in the process increases owner involvement and promotes partnership among stakeholders.** **-BIM for clash detention and MEP Coordination can be an initial step.**

Figure 6F. Summary Delivery Methods Recommendations