



Green hospital criteria

Assessing the Rahnemoon hospital sustainability factors

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Abstract

This paper is about a technical study of hospital buildings and assessing its conditions according to sustainable development elements. First of all the relation and interdependency between health and sustainability is investigated. Then the role of hospitals on sustainability and its negative environmental impacts will express. According to these problems and considering the organization's endeavor for solutions, the International rating systems for hospital buildings will introduce and among them LEED (The Leadership in Energy and Environmental Design) green building rating system will be analyzed in more details.

At the end Rahnemoon hospital as a health care building in IRAN will be evaluated according to LEED rating system. Concerning and obtaining the rating system certification is not a usual activity for hospitals in IRAN. As a conclusion this paper will demonstrate that if sustainability is an important factor in designing and construction of hospitals in IRAN or not.

Introduction

There has been a fundamental relation between human health and the public built environment -from the Baths of Caracalla constructed in 200 A.D till the current modern hospitals. Through this time the health public places has been evolved according to people needs and timely adjustments.

The concept of sustainability was created when people realize the impact of their activities on environment. Climate change, pollution, biodiversity loss, global warming and resource depletion were the consequences of humankind's exploitative actions. Such consequences cause starting a discussion on the need for environment protective actions. Subsequently the idea of sustainability came to being and affected the way of thinking, design and building the constructions such as health care buildings.

Sustainable development and health dependency

Sustainable Development and Health have a strong relation. “Healthy life is an outcome of sustainable development, as well as a powerful and undervalued means of achieving it. We need to see health both as a precious asset in itself, and as a means of stimulating economic growth and reducing poverty. (Gro Harlem Brundtland , WHO Director General Brundtland,2002)

Also In the conclusions from the first international conference on health promotion in Ottawa, it was stated:

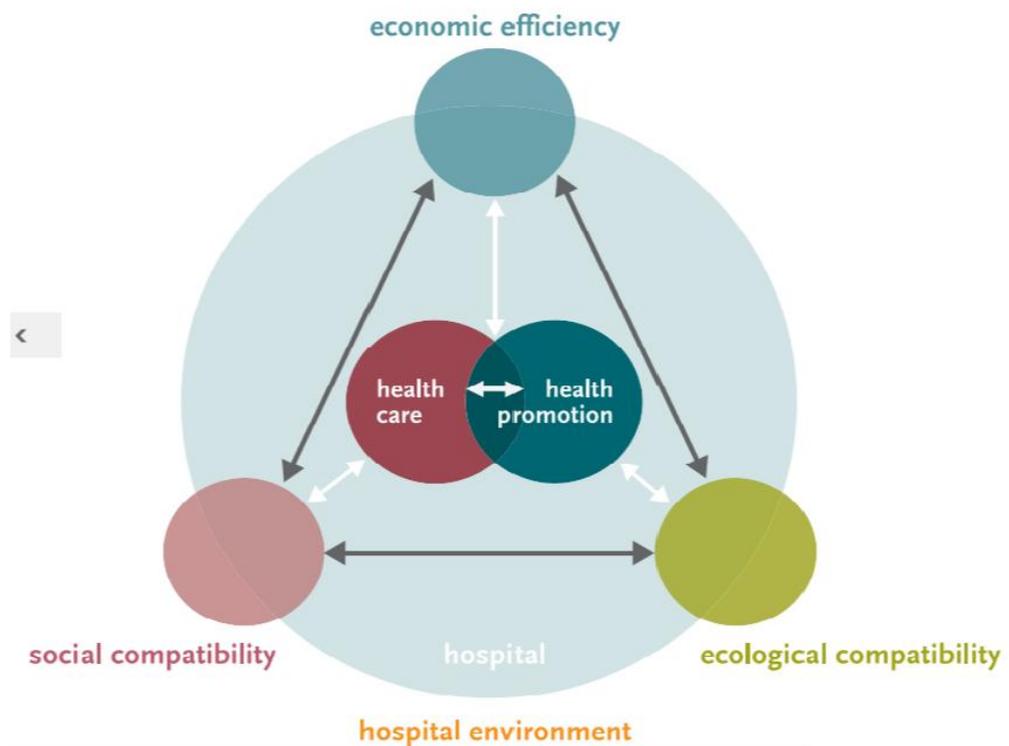
“Our societies are complex and interrelated. Health cannot be separated from other goals. The inextricable links between people and their environment constitutes the basis for a socio-ecological approach to health. The overall guiding principle for the world, nations, regions and communities alike, is the need to encourage reciprocal maintenance - to take care of each other, our communities and our natural environment. The conservation of natural resources throughout the world should be emphasized as a global responsibility.” (WHO, 1986)

The Adelaide Statement on Health in All Policies (WHO and the Government of South Australia, 2010) “outlines the need for a new social contract between all sectors to advance human development, equity and sustainability, as well as to improve health outcomes.” (Bente Kjærgård, 2014) Sustainable development is a tool that secure the quality of life (for us and next generations). “Health has central importance as both a result and a precondition: on the one hand, sustainable development supports and promotes health; on the other, sustainable development is not possible in the absence of health.” (UlliWeisz ,WilliHaas, JürgenM.Pelikan ,Hermann Schmied ,2011) .

Political documents also have presented the intrinsic link between Health and sustainable development in the new ways. For example, in the Ottawa Charter (WHO1986) “peace, shelter, education, food, income, a stable ecosystem, sustainable resources, social justice, and equity” are named as “fundamental conditions and resources for health” (WHO1986, p.1). Obviously this expression consider the three dimensions of sustainable

development (social, economic, and ecological). So according to Interdependency between the health and 3 parameters of sustainable development and prior explanations this figure is extracted for the hospitals as a building for health care and health promotion.

Figure 1 – Proposed chart for interrelation between health and sustainable development elements



According to this Suggested sustainability triangle for hospitals health care and health promotion as the main principals of hospitals are at the center of the triangle and should be considered in their dynamic interrelations with the sustainability elements include social and ecological compatibility and economic efficiency.

Sustainability and Hospitals

Unlike the prior figure Building and operation of Hospitals cause some sustainability problems. Through their massive material use and energy consumption, construction of hospitals have a significant negative impact on the environment.

In operation phase the environmental impact is significant too for instance: “Hospitals are the second greatest commercial energy user behind commercial food services, according to advocacy group Practice Green health, emitting roughly 8 percent of the country's greenhouse gas emissions. (United States) They also produce more than 4.67 million tons of waste every year and use 7 percent of the country's commercial water supply. "The operating rooms have a huge environmental footprint. They use 30 percent of the supplies for the entire hospital," said, Cecilia Lynn, director of sector performance and recognition for Practice Green health”(Beth Jones Sanborn, 2017) “The National Health Service (NHS) in England has calculated its carbon footprint at more than 18 million tons of CO2 each year -- 25% of total public sector emissions”. (National Health Service, Sustainable Development Unit, Cambridge, 2009) Brazilian hospitals use huge amounts of energy, accounting for more than 10 % of the country’s total commercial energy consumption. (Energy Conversion and Management, 2004) “In the U.S., the health care sector is the single largest user of chemicals, many of which are known to cause cancer. In China, healthcare construction spending exceeds US\$10 billion a year, and is growing by 20% annually, consuming significant amounts of natural resources. There are many more examples.” (GLOBAL GREEN and HEALTHY HOSPITALS AGENDA, 2011) “Hospitals generate significant environmental health impacts both upstream and downstream from service delivery, through the natural resources and products they consume, as well as through the waste they generate.”(GLOBAL GREEN and HEALTHY HOSPITALS AGENDA, 2011)

Climate change and the energy crisis and shortages of physical resources are some growing global sustainability which increasingly impact negatively on the environment and consequently on health care system. In recognition of this situation, WHO called on hospitals to play an active role in the fight against climate change (WHO and HCWH, 2009)

Hospitals also endanger the health of their workers and even that of their patients. The workplace risk factors in hospitals in regard to psychological and physical health are higher than those in other occupational fields (e.g., Iseringhausen 2010). Patient health is endangered by unwanted side effects of treatment, such as medical error (IOM 2000), nosocomial (i.e., hospital-acquired) infections (Amato-Gauci and Ammon 2007), or hospitalism (University College London Institute for Global Health Commission, 2009). A central problem for hospitals concerns the demand for ever more efficient delivery of services. Since the mid-1980s, health care spending has increased disproportionately compared to economic growth in all developed countries, with the greatest increase generally in the hospital sector. Thus hospitals are central to the public debate about “sustainable” financing of the health care system (McKee and Healy 2002).

But how do hospitals solve these problems? The health care sectors endanger the health of mankind!! How do we excel such an alarming paradox?

Sustainability problems intensification, lead the systems to stricter environmental and social guidelines and regulatory measures. Sustainable development for hospitals is linked to optimization of various quality criteria, not only in the terms of hospital’s main activity, but also for its economic efficiency, and environmental (Jameton & McGuire, 2002) and social (Weisz et al., 2011) compability.

General public and various organizations have started to set out some standards or agendas to support all the efforts around the world for sustainability promotion and in the health sector to strengthen health systems in all of the world.

This documents provide a “comprehensive framework for hospitals and health systems everywhere in the world to achieve greater sustainability and to contribute to improved public environmental health.” (GLOBAL GREEN and HEALTHY HOSPITALS AGENDA, 2011)

Also “in order to encourage changes in the construction industry for meeting the sustainability agendas in several countries, certification of building system have been developed. Mainly focused on issues related to natural resources and environmental impacts,

these tools are also denominated green building seals.” (Paula Regina Mendes Grünberg; Marcelo Henrique Farias de Medeiros; Sergio Fernando Tavares, 2014)

International rating system for hospital building

The rating system is a framework for evaluating the quality criteria of building according to the sustainable development in the life cycle of project (phase of design, construction, operation ...). By assigning the design priorities and goals, appropriate design strategies; and developing the measuring performance methods, rating the system help the projects to perform the sustainable elements. There is hundreds of building rating systems worldwide for different types of projects with different goals. Nowadays 3 well known systems are recognized useful for hospital building assessment: 1. BREEAM, 2. LEED and 3. GREEN STAR. The differences between the three of them are shown in Table 1.

BREEAM (Building Research Establishment’s Environmental Assessment Method) was developed in the UK in 1990. According to BREEAM website, BREEAM is useful for any type of building, in any point of world

LEED (The Leadership in Energy and Environmental Design) green building rating system, developed by the U.S. Green Building Council (USGBC) in 1998, provides a suite of standards for environmentally sustainable construction. Since its inception in 1998, LEED has grown to encompass more than 14,000 projects in the US and 30 countries covering 99 billion m² of development area (Fowler KM, Rauch EM, 2006). LEED is developing the way design, construction, and operation in these projects.

The GREEN STAR rating system has been established according to Australian marketplace and environmental context. GREEN STAR is a voluntary environmental rating system for buildings in Australia. According to its site’s text: Green Star assesses the sustainable design, construction and operation of buildings, fit outs and communities. There are four Green Star rating tools available for certification of design, construction and operation of buildings, fit outs and communities. The tools cover a broad range of sustainable topics including energy and emissions...

Table 1. Healthcare-specific rating systems.

Country/Title	Type	Versions/Year	Elements and points	Ratings and level of certification
UK BREEAM (new builds, extensions & major refurbishments)	Environmental Assessment	Healthcare 2008	Management (12), Health and Wellbeing (15), Energy (19), Transport (8), Water (6), Materials (12.5), Waste (7.5), Land Use & Ecology (10), Pollution (10), Innovation (10). Total points = 110	Unclassified <30 Pass ≥30 Good ≥45 V Good ≥55 Excellent ≥70 Outstanding ≥85
US LEED (new construction and major renovations)	Environmental Assessment	Healthcare v2009	2009 Sustainable Sites (18), Water Efficiency (9), Energy and Atmosphere (39), Materials and Resources (16), Indoor Environmental Quality (18), Innovation In Design (6), Regional Priority Credits (4). Total points = 110	Certified 40-49 Silver 50-59 Gold 60-79 Platinum 80 and above
AUSTRALIA Green Star (building at the design phase as well as post construction phase 'As-Built')	Environmental Assessment	Healthcare v1	2009 Management (17), Indoor Environment Quality (32), Energy (29), Transport (12), Water (14), Materials (35), Land use & Ecology (8), Emissions (20), Innovation (5). Total points = 172	Best Practice (4 star) 45-59 Australian Excellence (5 star) 60-74 World Leadership (6 star) 75-100

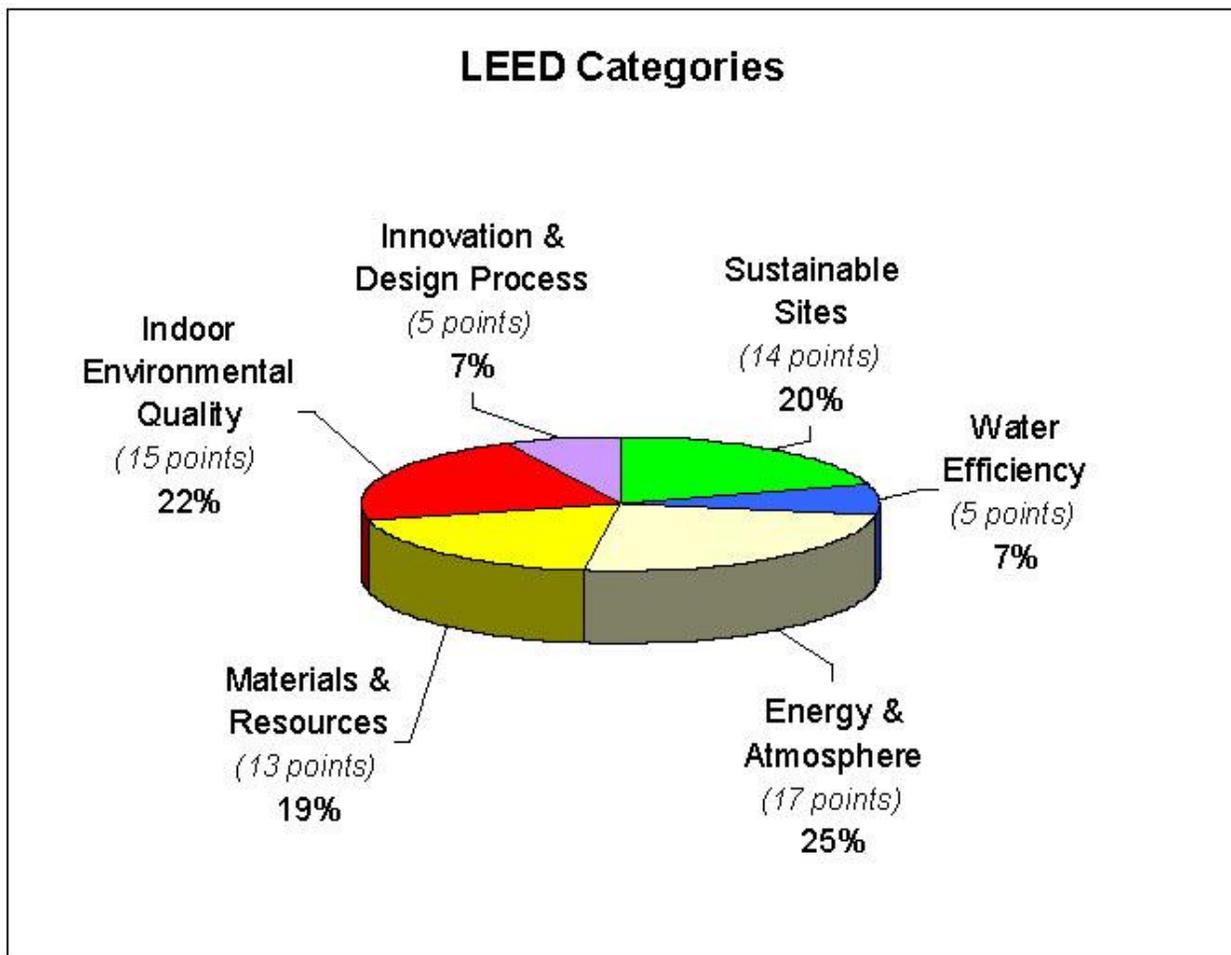
All of this rating systems are useful and important according to type of project, time and location of construction. But here we choose the LEED system for investigating and examining our case study at the rest of paper because it is “a nationally accepted benchmark for the design, construction, and operation of high performance green buildings. The LEED rating system is the current best practice standard for the building sector. LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings” (U.S. Green Building Council, 2006).

LEED key areas:

The LEED certification system was created by the United States Green Building Council (USGBC). It is a method of classification based on matching, weighting of credits (depending on the environmental impact and human health) and regionalization. The seal certifies buildings from a list of prerequisites and credits, and has four levels: Certified, Silver, Gold and Platinum (USGBC, 2012).

LEED promotes a whole-building approach to sustainability by recognizing performance in six key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality and Innovation in Design process.

Figure 2 – LEED categories and weighting of credits



1- Sustainable site development: It is primarily related to site selection, site access and site design. The major source of air pollution is transportation in the world. The health sector -- with its fleets of ambulances, hospital vehicles, delivery vehicles, and staff and patient travel -- is a transportation-intensive industry. So providing health care in suitable locations that makes the access of patients, staff and visitors is an important issue because it removes the unnecessary travels.

Some important consideration about the hospital site are:

1-1 ENVIRONMENTAL SITE ASSESSMENT: To ensure that the site is assessed for environmental contamination and, if contaminated, that the environmental contamination has been remediated to protect occupant health.

1-2 SITE SELECTION: To avoid the development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

1-3 ALTERNATIVE TRANSPORTATION—PUBLIC TRANSPORTATION ACCESS: To reduce pollution and land development impacts from automobile use.

2- Water saving: The Water Efficiency section addresses water holistically, looking at indoor use, outdoor use, specialized uses, and metering. Hospitals should implement a series of conservation, recycling and treatment measures to reduce hospital water consumption and wastewater pollution. For example they can consider harvesting rainwater and/or recycling water for process water uses or Implement on-site wastewater treatment technologies.

3-Energy efficiency: Buildings are a major consumer of energy and electricity across the globe, and predicting and lowering energy consumption in buildings are significant components of LEED. It includes three prerequisites:

3-1 MINIMUM ENERGY PERFORMANCE: To establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use.

3-2 OPTIMIZE ENERGY PERFORMANCE : To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

3-3 USING THE GREEN POWER: To encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

4-Materials and resource selection: The responsible harvest or extraction of materials used in building products is of universal importance. The credits on this part focus on building reuse; waste management; reused, recycled or certified materials; as well as local or regional materials. It includes one prerequisite:

4-1 SUSTAINABLY SOURCED MATERIALS AND PRODUCTS: To reduce the environmental burdens of materials and products acquired to construct building and to upgrade building services.

5- indoor environmental quality: “The findings showed that office furnishing quality has a significant impact on occupants’ satisfaction and performances; and indoor air quality affected the occupants’ performances” (Lee & Guerin, 2009).

An interesting note about lighting is the quality of the sunlight needs to be considered. For example, people with access to north-facing windows still had low, inadequate lighting (Lee & Guerin, 2009). This part includes three prerequisites:

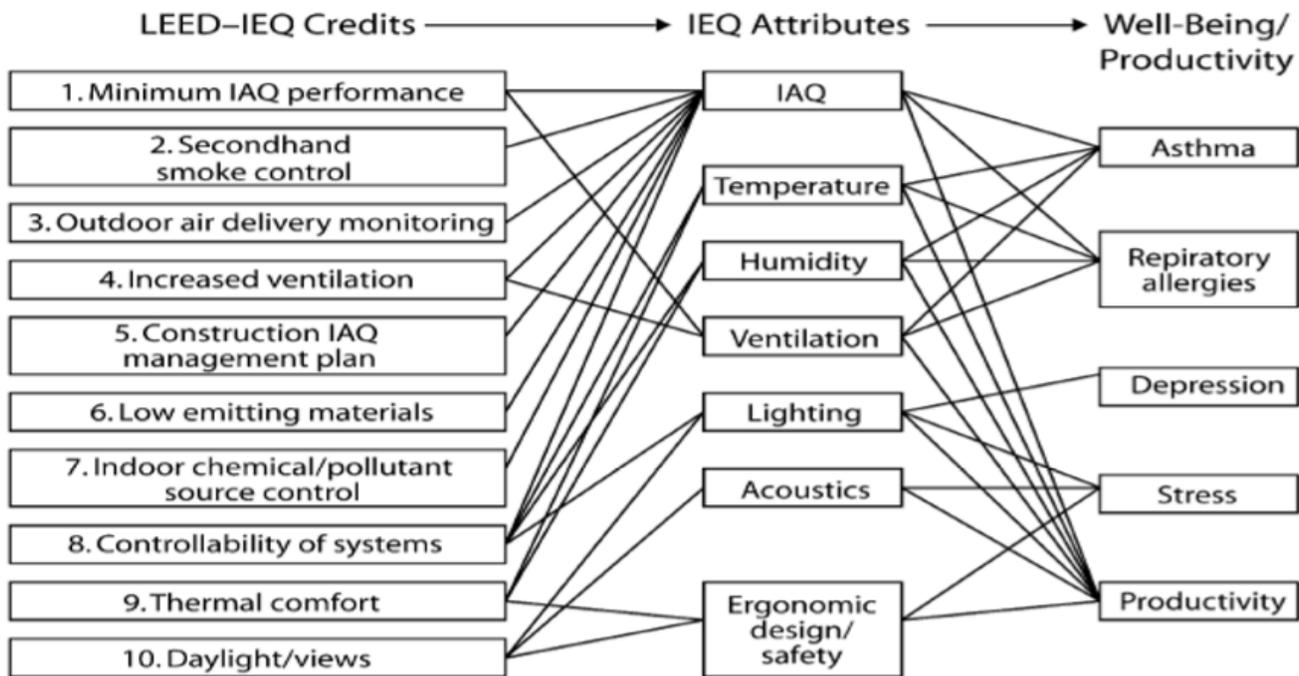
5-1 CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT PLAN—DURING CONSTRUCTION: To reduce indoor air quality (IAQ) problems and noise and vibration resulting from construction and/or renovation process in order to help sustain the comfort and well-being of construction workers and building occupants.

5-2 USING LOW-EMITTING MATERIALS: To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants

5-3 CONTROLLABILITY OF SYSTEMS—THERMAL COMFORT: To provide a high level of thermal comfort system control by individual occupants or specific groups in multi-occupant spaces and promote their productivity, comfort and well-being.

The effects of this part on wellbeing of patients and productivity of employees can be seen in the figure3:

Figure 3 – Effects of IEQ on Well-Being and productivity



Note. IAQ =indoor air quality. The LEED credits listed here represent typical IEQ-related concerns covered in LEED rating systems; however, different rating systems may use minor variations of these credits. Case study project 1 pursued all credits 1-10, and case study project 2 pursued all credits except credit 9.

6- Innovation: Sustainable design strategies and measures are constantly evolving and improving. New technologies are continually introduced to the marketplace, and up-to-date scientific research influences building design strategies. The purpose of this LEED category is to recognize projects for innovative building features and sustainable building practices and strategies.(ASHLEY JONES,2016)

Why Use LEED?

LEED is a voluntary program; however, obtaining a LEED certification projects a positive environmental image to the community. Additionally, using many green building practices can result in energy and cost savings over the life of the structure. Other advantages include better indoor air quality and plenty of daylight. Studies have shown that workers in these environments have increased labor productivity, job retention, and days worked. These benefits contribute directly to a company's profits because salaries—which are about ten times higher than rent, utilities, and maintenance combined—are the largest expense for most companies occupying office space. In addition, students in these environments have higher test scores and lower absenteeism. Retail sales are higher in daylight buildings.

(<http://www.concretethinker.com> Accessed February 18, 2018)

What Benefits Can You Obtain Through a LEED Certification?

Not to mention, that it will create a healthier and more productive workplace and it can also be an excellent selling point for your project. Additional benefits of being LEED certified is that it will:

- Increased Building Valuation
- Reduces liability
- Promote better employee relationships
- Reduce energy and water usage
- Promote better indoor air quality
- Reduce maintenance and operation costs
- Triggers innovation and processes to optimize building performance
- Reduce construction waste during the process
- Promote and attracts companies with sustainable goals
- Reduce 'sick building' syndrome in the employees
- Increase employee performance
- Promote the usage of recycled material. (Juan Rodriguez, 2016)

Case study of evaluating the sustainability elements in Rahneemoon Hospital project

The Rahneemoon Hospital is a trauma center in Yazd city (IRAN) with 35,000 Sq.m and 280 bed health care facility that houses 1 basements, ground+8 story structure.

“A trauma center (or trauma centre) is a hospital equipped and staffed to provide care for patients suffering from major traumatic injuries such as falls, motor vehicle collisions, or gunshot wounds. A trauma center may also refer to an emergency department (also known as a "casualty department" or "accident & emergency") “(Wikipedia)

There is a 5000 Sq.m clinics building beside the hospital which facilitate the treatment process of patients.

The hospital has 2100 full-time-equivalent staff members, 35,000 inpatients, 13,000 day patients, and 130,000 outpatients per year.

Rahneemoon Hospital not only control water and electricity consume, but also increase the wellbeing of patients and productivity of employees by desirable indoor environment quality.

Figure 4 – 3D design of Rahneemoon hospital



According to LEED standard the hospital can be assessed on following key areas:

1- sustainable site

- The hospital design consider the natural lights in all the patient areas, which helps to patient's wellbeing and reduces the consumption of electricity. Orientation to North and South with elongated boundaries towards East and West, the large windows and open sky light keep the interior area attractive along with incoming natural light.

Figure 5 – Plan view of Rahnemoon , Orientation to North and South .



Figure 6 – large windows and natural lights in all the patient areas



- According to the nature of this hospital (trauma center) it is in the center of city and accessible by public transportation.
- The designer consider a floored parking adjacent to the main building for servicing the employees and visitors.

Figure 7 – Rahnemoon hospital helipad on the roof



- The designer consider a helipad for emergency patients which is performed in the roof of hospital.
- The Hospital is located in the traditional part of the city. But the façade and number of floors is not proportionate with the urban context so it's a great defect.

Figure 8 – Disproportionate appearance of hospital with the urban context



2- water savings:

- The waste water from various zones of the hospital is treated using many program at the Sewage Treatment Plant. But it is not used in hospital. It joins to urban sewage system (For industrial use)

- The public facilities which is installed are Water-saving devices. For example sensor faucets, modern water dispensers with timer control which decrease the water and electric consumption, low-flush toilets and two-stage flushing devices
- According to aridity in Yazd city, there are some raining and Storm water collector which have filters for removing the suspended solids. The collected water replaced usage of tap water for irrigation.

3- Energy efficiency:

- In the Rahneemoon hospital, the windows are thermal breaks and the walls are 3D-panels include a 75mm thick polystyrene insulation on the external wall that cause a great energy efficiency for this project.
- Internal electrical system uses the latest technologies and fundamental principles of energy conservation and safety that encompass protection against electric shocks, thermal effects, over current, fault current and over voltage.
- Instead of Conventional light bulbs such as compact fluorescents (CFLs), Light emitting diodes (LED) were supplied at the Rahneemoon hospitals. Choosing this

Figure 9 – Using LED instead of Conventional light bulbs



Type of light bulbs cause: 1- Energy efficiency: LED lights use about 50 percent less electricity than fluorescents 2- Extended life 3- Cold temperature operation 4- Durability 5- Instant on 6- Rapid cycling 7- Controllability 8- No IR or UV Emissions

- According to Yazd characteristic and conditions (severe solar irradiance) using the solar system for lighting and air condition was a suitable choice which is not performed in this hospital and this opportunity was neglected.

4- indoor environmental quality:

- Patients and visitors have a comfortable working environment with changeable humidity and heat conditions. The operators can adjust ventilation and cooling even humidity output to precise temperature set points through their tablet or smartphone. So the building is at the desired temperature by all of the tenants.

Figure 10 – The environment quality is suitable for tenants



- The air conditioners installed are equipped with Variable Refrigerant Flow (VRF) which provides precise temperature comfort control in different zones in this building.
- Rahnemoon hospitals use multi-zone air handling units designed for applications wherein temperature control is required for groups, or "zones." Multi-Zone units are best suited for serving an area that contains custom-built spaces requiring independent space thermostatic control such as hospitals.

5- Materials selection and resources :

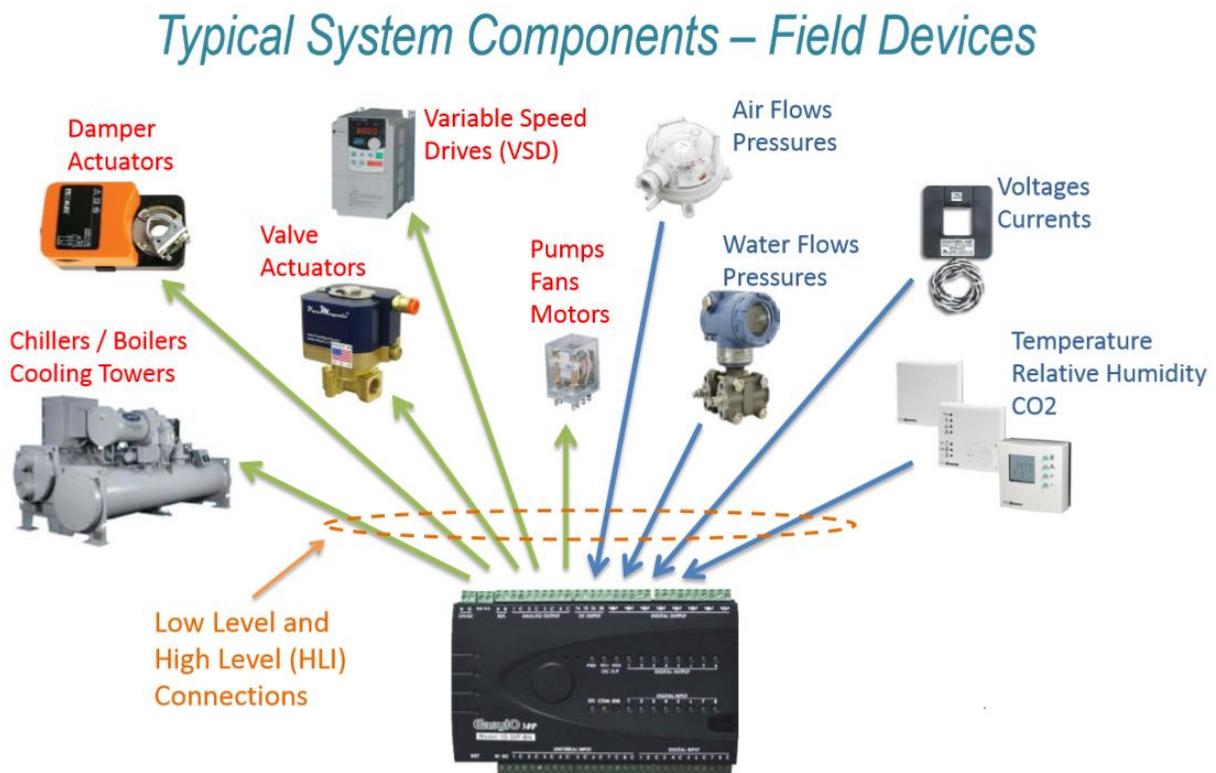
- 85% of Building Materials were locally sourced. Materials such as steel, Concrete, Sand, Cement, Glassless, Aluminum profiles, ceramic tiles... were procured within a radius of 40 Kms. from Yazd.
- Painting of Rahnemoon hospital is performed by acrylic water-based paints which are not hazardous for the tenants and can be rehabilitated easily.

6- Innovation in Design process:

The Rahnemoon hospital is equipped with Building management system. BMS systems are "Intelligent" microprocessor based controller networks for Monitoring and Control of various parameters in a building for all utilities such as air conditioning, Fire detection and extinction systems, Cameras and security systems, water system, ventilation, lighting, , medical gas, diesel generator ...

Smart building management systems use motion sensors to detect when tenants exit from any section of the building. Automated energy conservation features turn off the lights and cooling systems in the unoccupied areas. By eliminating unnecessary energy use and making all the systems in the building work together as effectively as possible, intelligent building management systems can lower energy costs by as much as 30 percent.

Figure 11– Some components of BMS



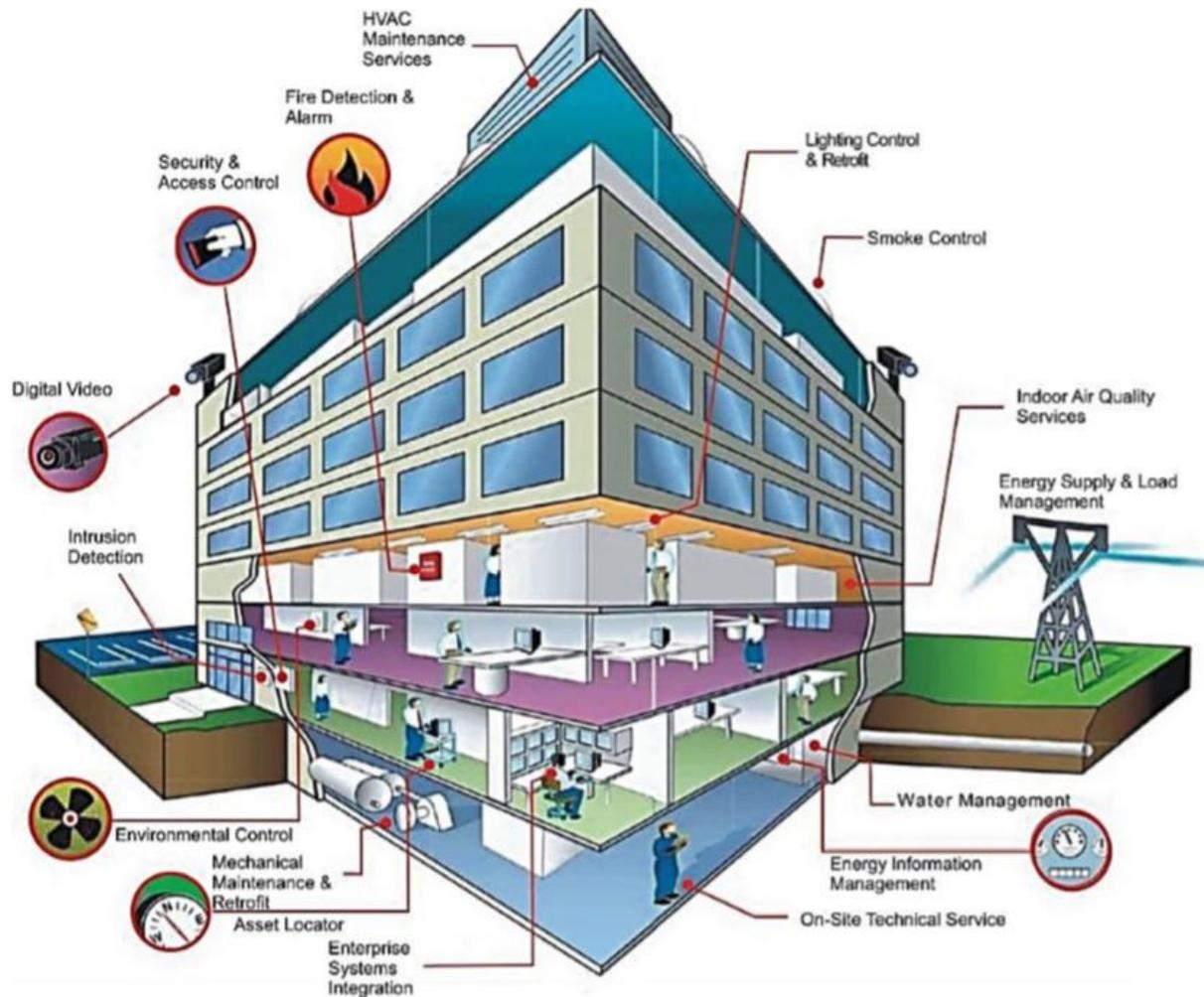
The benefit of this system for Rahnemoon hospital are:

- Energy savings by minimizing energy usage and waste
- Providing security for hospital property, building and employees
- Precision and comfort control
- Automatic operations (Specially In the emergency conditions)
- Safety Interlock
- Better Maintenance management
- Good Information Systems

Using the BMS system in hospitals addresses the 4 main key factors of LEED standards: 1- water savings 2- energy efficiency 3-Avoiding materials waste and emission, and 4-indoor environmental quality.

So it is a great innovation and choice in design process which leads the hospitals to sustainability.

Figure 12 – Range of BMS application



Conclusion:

Although hospitals in IRAN are reluctant to obtain the international certification of rating systems for green buildings but lately they consider the sustainable development elements in life cycle of their hospitals. One reason is increasing cost of fuels and resources in this country and the other reason is concerning about the environment. As we know IRAN is somehow a victim of environmental problems such as dust floated on air and drought. So government and other organizations endeavor to decrease the negative environmental impacts in all the activities. Also recent health promotion in IRAN leads the hospital and other healthcare systems to respect the sustainability elements and other requirements of population.

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