

# ENERGY EFFICIENT, SUSTAINABLE AND ENVIRONMENTALLY FRIENDLY GREEN HEALTHCARE INDUSTRY IN THE GREEN ECONOMY

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REFERENCE NO	ABSTRACT
ENVR-03	The healthcare sector is a whole that include hospitals, outpatient clinics, laboratories, drugs and medical devices. It generates millions of tons of waste solid, liquid and gas and mercury. Changes in health politics and payment systems and possible financial crisis risk were produced the necessity of the investments more conscious and sensitive to environment planning in health sector. In this study, the concepts of sustainability, clean energy and green economy in the health sector were examined and green hospitals, digital hospitals, energy efficiency applications were put forward in the scope of environmental sustainability applications in hospitals and medical device sector which have the most important share in the health sector. Green healthcare industry have to be accelerated the development, use, and diffusion of environmentally preferable products, practices and construction of green buildings in hospitals and medical practices worldwide. The summarized informations in this study would be useful for all stakeholders in the healthcare industry.

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*Keywords:*  
*Green healthcare industry, Green hospital, Sustainable hospital, Green economy, Clean energy in healthcare*

## 1. INTRODUCTION

The main equation of health sector is provide healthcare services in a qualified, sustainable and easily accessible way. The purpose of health services is to better the quality of life. The development of countries not only cover the economic indicators but also cover education, health, culture and social structure and technology indicators. In addition sustainable development cover being healthy in longtime. Health expenditures are also development indicators. Therefore, healthy people and qualified human resources are very important for sustainable development. The concept of sustainable development was adopted in the United Nations Conference on Environment and Development (known as the Earth Summit), in June 1992. Sustainable development that we mostly use today is defined by three dimension: economic development, social development and environmental protection. After 20 years, a number of proposals and projects have been made for the advancement of "sustainable development goals" and the

green economy is seen as a vehicle of sustainable development in United Nations General Assembly [1]. With the concept of green economy, it has become necessary to make changes in existing practices in health sector as well as in many sectors. Sustainability interventions are a direct financial return on investments, but not only financial sustainability is important but also environmental sustainability is another important factor in the health sector [1], [2]. How to adapt the concept of sustainability to the health sector and also how to bring sustainability to the health care needs of today's populations and even future populations are less familiar but in the last 20 years, the concept of sustainability has come to a very important dimension and with the application of initiation of incentives in many sectors, the combination of environmental, financial and social sustainability, which are the dimensions of the green economy, has also come to the fore in the health sector [2],[3]. Green economy, green health, green health care, clean energy, green hospitals, such as the

concepts of the last year has gained considerable importance and important steps have been taken for the healthy world and healthy hospitals and for the healthy health industry.

In this study, the concepts of sustainability, clean energy and green economy in the health sector were examined and green hospitals, digital hospitals, energy efficiency applications were put forward in the scope of environmental sustainability applications in hospitals and medical device sector which have the most important share in the health sector.

## 2. HEALTHCARE INDUSTRY

One of the most important indicators of countries' socio-economic development levels is health services. World Health Organization (WHO) defines the health care system as “all organizations, institutions, and resources that are devoted to producing health actions.” A health action is defined as any effort, whether personal health care, public health service or inter-sectorial initiative, whose primary purpose is to improve health. In practice, the health care sector includes such a wide variety of practices and activities that precise definition of the sector's boundaries across countries and cultures can probably never be conclusive.

Healthcare sector is worthy of special attention due to its size, its growth, and its direct impacts on health. As perceived leaders in health-promoting activities and behaviour, health policy decision-makers also can be expected to lead initiatives that address global environmental health now and in the future [4].

Globally, the challenges of healthcare delivery vary widely, yet health systems around the world have similar objectives: to deliver the highest quality care to the most people possible at the lowest possible cost. Health care is a major economic sector worldwide. Healthcare spending around the globe continues to rise at unsustainable rates, consuming an ever-increasing slice of the world's economy. In 2015, the world spent USD 7.3 trillion on health, close to 10% of

global GDP. Health's GDP share is greatest in high-income countries at nearly 12% on average. In low-income countries, health expenditures account on average for 7% of GDP, and in middle-income countries 6% [4], [5]. Considering the amount of money spent on healthcare, there is a necessity to plan comprehensively any activity related to healthcare.

Today, the health care sector has a critical role to play in both reducing climate change effects and improving the resilience of the communities it serves. The provision of accessible, affordable and quality healthcare is directly dependent on the efficient performance of healthcare facilities. The health care industry is increasingly among the major energy consumers in any given region, Modern healthcare facilities, and procedures, require many costly and energy-intensive processes in terms of the use of water, lighting, heating, cooling and ventilation, as well as waste disposal. The healthcare sector generates millions of tons of waste solid, liquid and gas, including potent pollutants like dioxins and mercury. In addition, it uses plastics, paper, lumber and other resources. As a result of these and similar activities, the healthcare sector contributes to the loss of global habitat and biodiversity and the impairment of the health of the world's ecosystem.

Leading health care organizations are navigating shifting economics, patient expectations, and regulatory challenges to transform their practices to become leaders on a low-carbon development path and anchors for climate resilience. Three important ideas are reshaping 21st-century health care in the service of health and planetary survival: [6]

- Carbon mitigation through energy-efficiency measures transition to renewable energy sources,
- Anchoring community resilience through local economic investments and securing infrastructure for extreme weather events;
- Providing leadership and policy engagement in promoting

population health, climate change advocacy, and environmental programs.

### 3. SUSTAINABILITY AND HEALTHCARE SECTOR

Global warming, pollution of the environment and consumption of natural resources, as well as environmentally sensitive, ecological, sustainability etc. concepts come to an end and sustainability have become part of the development plan of many developed countries. Many businesses that embrace the concept of sustainability go for a balance between social, environmental, and economic performance, taking into account people, the world and their profits. Sustainable environment, sustainable economy and sustainable society are given as the three main dimensions of corporate sustainability [7]. Health is a precursor, an outcome and an indicator of these three dimensions. WHO developed Health-Care-facilities in the key economic sectors in the “green economy series as in seen Fig.1 [8].



Fig. 1 Dimensions of sustainability

A sustainable health and care system is achieved by delivering high quality care and improved public health without exhausting natural resources or causing severe ecological damage. Sustainable health and care sector involves ‘greening’ the sector with particular attention to energy, travel, waste, procurement, water, infrastructure adaptation and buildings. This ensures physical, financial and human resources used in the sector are to be used as efficiently and to be used responsibly. Sustainable healthcare is slightly broader, but more health care specific than sustainable health and care sector point. It

involves working across the health system and partners to deliver healthcare that deliver on the triple bottom line i.e. simultaneous financial, social and environmental return on investment. It includes adapting how we deliver services, health promotion, more prevention, corporate social responsibility and developing more sustainable models of care.

In the whole world there are several developments in order to make a more sustainable and qualified environment to handle the increase costs of the healthcare services industry [9]. Environmental sustainability in health sector is a connection between environmental operations and enhanced healthcare services. It can be easily said that environmental sustainability can decrease the operational cost in the health industry. The healthcare industry, which is highly regulated, has been slower than other sectors of the building industry to integrate sustainability into the development of its facilities [10].

Sustainability is preventative medicine on a grand scale, sustainability is not only good for the planet and the pocketbook, but it also supports total health. The World Medical Association is calling on all its members and on the global health community to adopt an environmentally responsible approach to their activities. Achieving change requires raising awareness and sustained advocacy. This includes making health practice environmentally responsible and greening medical associations.

Sustainability strategy focuses on five key areas: climate and energy; safer chemicals; water conservation; sustainable food; and waste reduction (Fig. 2).

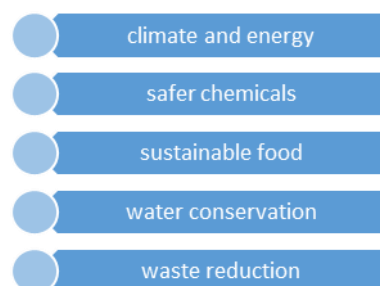


Fig. 2 Sustainability strategy in health care

Sustainable health care that's good for the environment, good for patients and staff, and good for the bottom line means action plans to eliminate mercury, reduce and recycle solid waste, reduce regulated and chemical waste, reduce energy and water consumption, create healing environments, and establish green purchasing policies.

If the complexity and diversity of health systems are considered, it is very difficult to construct sustainability in to the clinical operations and to the hospitals. But the environmental friendly green hospital buildings and efficient usage of resources and using less chemicals in the products enable the sustainable healthcare services [11].

### **2.1 Hospital sector and sustainability**

Healthcare, in particular hospitals and teaching hospitals are major contributors to environmental pollution contributing pathological, pharmaceutical, chemical, radioactive, health risk and other wastes [12]. Hospitals could be a strong partner for public health issues and also hospital sector has a heavy consumption of material and energy and a huge production of waste and carbon dioxide. Hospitals are more complex buildings that different services given from medical devices used in diagnosis to patient care services and to devices used for heating. Energy usage is in high level in hospitals due to the necessity of continuously giving service in 7 days and 24 hours. Different energy types must be used at the same time in hospitals. The energy consumption in hospitals is more than 2.5 times more than the energy consumption of a commercial business. This high energy consumption brings with it increased costs These costs affect both profit-oriented and non-profit healthcare institutions [13].

Hospitals consume vast amounts of energy and generate huge streams of hazardous waste, so how they approach sustainability is important to environmental health. For modern hospitals, sustainability is a paradox. On the one hand, climate change and pollution present serious public health risks, and reducing them would lower the strain on

hospital resources. At the same time, hospitals consume large amounts of energy and produce high levels of waste. Many caregivers and administrators fear that they cannot lower their facilities' environmental impact without compromising patient care [14].

According to the Organisation for Economic Co-operation and Development (OECD), hospitals worldwide absorb 30 to 40 percent of all healthcare spending; for example, about one-third of U.S. healthcare is provided by hospitals, 35 percent in France, 42 percent in Australia and Korea, 44 percent in Turkey and the Czech Republic and 45 percent in Denmark, while nearly half of healthcare in Japan is provided by hospitals. At the same time, healthcare delivery is moving beyond the hospital walls to focus on the patient in less expensive environments that facilitate care management from clinics and ambulatory centers to the home [14].

Changes in health politics and payment systems and possible financial crisis risk were produced the necessity of the hospital investments more conscious and sensitive to environment planning. The environmentally friendly hospitals were obligated for operation costs. It is impossible for hospitals stand off from this consciousness. By controlling energy management and costs; hospitals can save money to raise patient care and provide expensive medical and technological improvements [14].

### **2.2 Medical device sector and sustainability**

The changes in health sector also affect the medical device sector directly as the medical device sector is the most important key of health sector and that is why the concepts element such as environment, sustainability and green are very important in medical device sector.

Medical device sector is a sector that contain many different product groups and high level technologies. Generally drugs, cosmetics, living animal cells and human cell, organs out of transplant organs and most every instruments used in the hospitals are all within the scope of medical devices. Imaging devices, prostheses, cardiac pacemakers,

defibrillators, lighting devices and many devices and product groups can be classified in medical device sector.

Medical device sector is the initiator sector of R and D an innovation activities and is the big actor of the innovation. The innovation of new product process is very long in medical device sector but the life cycle of products are very short. Since 2010, world medical device market is reached to 250 million USD and more. Although it is hard to difficult to say the total expense of R and D expenditures in the world, in global label, the total budget for R and D for the most biggest firm that have a 60% or more part in market is 19.808 USD and this amount is greater than 10% of total income. This total is indicates that the significant amount of income in the sector is used to R and D activities and with compared other sectors, this amount is the indicator of this rate is much greater than the average amount [15].

Medical devices that comprise less chemicals, more healthy foods, destruction of chemicals and toxic gases accepted as sustainable initiatives results in more healthy results in terms of patients.

Since 1990, the works of green firms on sustainability has been derived a profit to the firms and it has been seen that well conducted and strong firms have a strong environmental administrative systems and programs. If price competitive products are a matter, consumers prefer sustainable products. But it is known that the percentage of consumers who prefer sustainable products to cost and more qualifications are very low. Successful firms and firms have a profit and have global purchasing and have significant voice on marketing have to take on a task on sustainability [16].

There is defined standards and directives to increase the value of medical devices designs in the world. According to European and international environmental standards, actions to be taken for environmental problems occurred during the design of products are standardized. Lean production and quality management systems in medical device and health sector decrease the production costs

and support the environment performance [17].

### 3. Green Economy and Green Healthcare Industry and Clean Energy Initiatives:

The term “greening” is used to improve business practices around the use of renewable resources, the environmental and human rights. This includes businesses that may want to operate in a socially responsible manner, as well as protect the environment [17].

Green economy is defined as: "an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" [18]. A green economy can be thought of as an alternative vision for growth and development; one that can generate growth and improvements in people’s lives in ways consistent with sustainable development. A green economy promotes a triple bottom line: sustaining and advancing economic, environmental and social well-being (Fig.3). The transition to a green economy has a long way to go, but several countries are demonstrating leadership by adopting national “green growth” or “low carbon” economic strategies. And there are many examples of successful, large-scale programs that increase growth or productivity and do so in a sustainable manner [4].

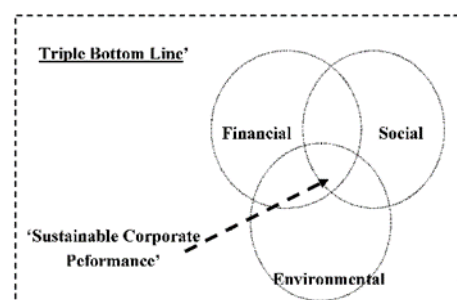


Fig. 3 Triple bottom line of green economy

Moving away from fossil fuels and toward clean, renewable energy sources protects public health. Clean energy is equal to healthier people. Generating clean and reliable energy is but one example of how the health sector can create a series of co-benefits by pursuing climate-friendly strategies. In

general, these co-benefits can be grouped into three categories; health, economic and social. The health care sector consumes a massive amount of energy, releasing large amounts of dirty carbon into the atmosphere. Hospitals require round-the-clock energy consumption to power ventilators, heating and cooling systems, lighting, and medical equipment. They also generate greenhouse gas emissions associated with food service, waste disposal, and transportation. Many hospitals, health systems and health professionals around the world are beginning to play leadership roles in moving toward healthy energy sources, installing onsite renewables, constructing more efficient buildings, and advocating for energy policies that protect public health. WHO implements initiatives on health sector greening energy efficiency and access to renewable energy (heating, cooling and lighting) in healthcare, buildings design and resilience, procurement of equipment and management of consumables, transport (reduce unnecessary travel needs), water, sanitation and wastes are main dimensions of greening the healthcare (Fig.4). [8]. Energy access is particularly crucial for health facilities as electricity is needed to store vaccines and perform life-saving operations [19]. Challenges such as fuel shortages, high energy costs, global warming and environmental issues must drive policies that target more affordable and sustainable energy solutions [20].

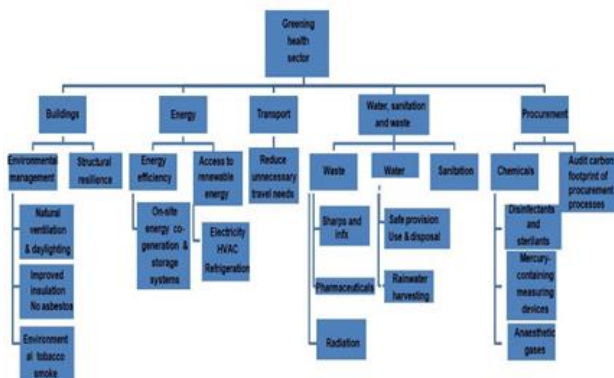


Fig.4 Framework for Greening the health sector

In essence, one way to overcome poverty, promote health and educational services and enhance socioeconomic development is to ensure reliable, sustainable and affordable

energy for everyone. Hence, the United Nations has established “Ensuring access to affordable, reliable, sustainable and modern energy services for everyone” as one of its Sustainable Development Goals to be reached by 2030 [21], [22]. A typical hospital consumes far more energy than the average commercial building. As such, more often than not, administrators are forced to direct a disproportionate amount of their budgets towards energy expenses, to the detriment of much-needed facility upgrades, hiring of new medical personnel, or investment in the latest medical equipment [23].

The 91% of energy used in hospitals is gained from electric energy, 6% from gases and 3% from fuel oil. The electricity and gas consumption per bed is 5 thousand TL in a year in health institutions. Energy demand is increasing depending on the increasing demand to modern technological buildings in health sector. Decreasing the ecological effects of health systems, protection of resources, pollution prevention and environment management systems applications are very important for green hospitals when preventing the people health at the same time. In green hospitals, patients were discharged averagely 2.5 days early.

For hospital and healthcare facility administrators, gaining control of their energy spend is essential, but they also need to ensure that their building automation system runs optimally 24/7/365; reducing maintenance, operational, and equipment costs, all while maintaining patient comfort and physician, nurse, and administrative staff productivity. For hospital administrators, understanding where their energy dollars are going and being able to identify areas of improvement are also priorities. Additionally, growing awareness and demand means that decision makers face increased pressure to cut their facility’s carbon footprint [6]. Hospitals consume large amounts of energy due to its operation characteristic. Many systems in hospital are operated 24 hours, including electricity system, HVAC (Heat, Ventilation and Air-Conditioning) system, and emergency systems which should all be maintained stably to

provide reliable service. Among all the electricity consumption in hospitals, HVAC system accounts for nearly 50%, equipment use accounts for 30%, lighting use accounts for 20% [23]. In the context of energy efficiency and access to renewable energy, energy-saving design in HVAC system have been developed and are widely adopted by designers in recent years, including using VSD (variable speed drive) chillers, variable air volume system, and variable speed pump to increase energy use efficiency. The above systems are the most widely adopted HVAC energy saving designs [23].

By use of solar panels for electricity or water heating: e.g. electricity for the cold chain of vaccines for immunization/vaccination in healthcare centers in rural settings and during emergencies as well, by efficient use of electric equipment/lighting/heating and cooling, less consumption of electricity, reduced energy costs and reduced carbon foot print of the health sector co-benefits can be gained [8]

Buildings design and resilience is another dimension. Natural ventilation coupled with good day lighting enhance potential for higher worker morale and patient satisfaction and outcomes and prevent air borne transmissible diseases (e.g. TB) while minimizing energy and carbon foot print. Also, use of green building designs and building codes for healthcare (insulation, ventilation, orientation, exposure to Solar radiation, etc) minimize the use of energy, energy costs, reduce the carbon foot print and promote patients and workers' health (e.g. improved thermal comfort, reduced humidity and moulds as well as reduction of airborne diseases by natural air exchange flow) [8].

Non-incineration technologies for waste treatment can minimize transmission of diseases within and outside healthcare facilities and reduce the carbon foot print of the health sector and fuel/energy costs. Of the total amount of waste generated by health-care activities, about 80% is general waste. The remaining 20% is considered hazardous material that may be infectious, toxic or radioactive. Every year an estimated 16 000

million injections are administered worldwide, but not all of the needles and syringes are properly disposed of afterwards. Health-care waste contains potentially harmful microorganisms, which can infect hospital patients, health-care workers and the general public [8].

There are various ways to make hospitals and clinics environmentally responsible. Some methods include a wiser management of waste, such as limiting waste incineration, recycling non-hazardous wastes responsibly and reducing paper usage with the use of Electronic Medical Records (EMRs). Procurement of non-incineration technologies for waste treatment reduce infections transmissions, less carbon emissions and cost savings. Safe and efficient management of pharmaceuticals (e.g. FIFO) will reduce the volume of pharmaceuticals to be treated and disposed of: less emissions of pollutants impacting (directly/indirectly) public health, reduced disposal costs, reduced occupational health. Special attention should be made to management of cytotoxic to avoid their discharge in water ecosystems. Procurement of mercury free devices is another dimension. Less mercury vapor in HCFs (e.g. from broken thermometers) which might harm patients and workers' health, less discharge of mercury in water ecosystems and thus less impact on drinking and recreational waters.

Efficient management of consumables and pharmaceuticals would reduce transportation and thus less pollutants emissions and reduced public health impacts. Siting of health facilities in proximity to public transport reduces pollutants emissions from health workers and hospital visitor's travel and thus less impacts on public health. Use of telemedicine (telecommunication and virtual technology to deliver healthcare) reduces health care related transport (particularly for vulnerable people, diabetes, cardiac diseases, mental health, high-risk pregnancy monitoring) and improves access of poor people to healthcare services/facilities. Thus, less pollutants emissions occur and impacts on public health reduce.

Recycling medical plastics reduces emissions of dioxins (cancerogenic), furans and GHG as well as disposal costs, provide raw plastic materials for processing non-medical products, provide revenue for the hospital and protect the environment. On-site medical waste autoclaves reduce emissions and GHG, generate savings compared to incineration and prevent diseases transmissions within and outside the healthcare facility. On-site wastewater pre-treatment in healthcare facilities reduce transmission of diseases within and outside healthcare facilities (patients and health workers) and prevent aquifer and ecosystem damage [8]

The climate footprint of health care facilities, health care facility activities have been estimated to represent 3–8% of the climate change footprint in developed-country settings [8]. Going green is not only good for the planet, but also it's often the right thing for a hospital's bottom line. Consider this: 'It's estimated every dollar a not-for-profit healthcare organization saves on energy is equivalent to generating \$20 in new revenue.' What's more, environmentally sound buildings can lower operating costs by as much as 13.6 percent and increase building value by almost 11 percent.

There is also increasing evidence that more climate friendly and energy efficient provision of healthcare services may also improve aspects of healthcare service functioning, safety, and climate change/emergency resilience. These same strategies may also improve aspects of healthcare access, particularly for the poor and vulnerable. And, there is evidence that some strategies can reduce risks of certain diseases, or otherwise directly improve certain health outcomes. These positive impacts are commonly called "co-benefits." "In light of this growing body of evidence, more climate-friendly and energy efficient healthcare facilities may yield a double or triple benefit in terms of patients, healthcare workers, and the communities served.

### 3.1 Digital hospitals-Green hospitals

Digital hospitals are complex ecosystems with hundreds of clinical and business processes made up of thousands of sub-processes. When properly integrated, these processes should seamlessly unite patients, clinicians, staff, assets and information throughout the hospital, delivering the right information and resources at the right time to the point of care (Fig.5) [25]. More efficient digital hospitals are emerging as critical hubs in these integrated healthcare networks that hold the potential to drive greater efficiency, improve quality of care and provide access for more people than ever before. To deliver the highest quality care to meet the needs of their communities, integrated health systems are leading in the transformation of healthcare, migrating from its traditional focus on acute care episodes toward providing more coordinated, patient centered care [24].



Fig.5 IBM Digital Hospital Framework

Within the scope of digital hospital models green hospitals are economically precious and preventing the investment buildings. The Green Hospital is defined as a hospital that has taken the initiative to do the one or more of the following: choose an environmentally friendly site, utilizes sustainable and efficient designs, uses green building materials and products, thinks green during construction and keeps the greening process going. A Green Hospital is constructed around a facility that recycles, reuses materials, reduces waste, and produces cleaner air.

The green hospital movement began years ago following the U.S. Green Building Council (USGBC)'s release of their Leadership in Energy and Environmental Design (LEED)



standards for building construction. Although initial cost to adopt green practices might be higher but they are the best investment in health facility. Green hospitals have been shown to reduce long-term energy costs. In addition, there is a growing consensus among the health care profession that pollutants generated by medical facilities must be reduced. Moreover, green hospital design has been linked to better patient outcomes and staff retention. In the past few years, a number of newly constructed and renovated hospital buildings have strived for and received LEED certification.

The hospital sector can employ seven key strategies to become more climate-friendly, while at the same time saving money and generating significant health, economic and social co-benefits.

- Food at the hospital
- Water use at the hospital
- Waste at the hospital
- Alternate Energy at the hospital
- Green Building Design at the hospital
- Energy Efficiency at the hospital
- Transportation in and around the

hospital

A green hospital is defined according to physicians for social responsibility as a hospital that has taken the initiative to choose an environmentally friendly site, and uses green building materials and products and thinks green during construction and keeps the greening process going. A green hospital is constructed around a hospital that recycles, reuses materials, reduces waste, and produces cleaner air. They court to hospital managers in terms of costs. Especially they have preventive properties to hospital infections for personnel and patients, they decrease the health risks. It is determined that green buildings can save 50% to 70% energy in energy saving.

Greener buildings promote environmental sustainability and decrease atmospheric emissions that contribute to global warming. Green buildings use ~30% less energy, produce less waste, and use less water. Greener buildings make business sense and save hospitals money. Energy efficient

buildings save money due to: reduced energy purchases and decreased peak energy demand, increased worker productivity, and lower operations and maintenance costs. Buildings constructed to Leadership in Energy and Environmental Design (LEED) standards can save more than 250% of its up-front costs over the course of its 40-year useable life cycle. Healthcare organizations spend over \$8.3 billion on energy each year to meet patient needs. Every dollar a nonprofit healthcare organization saves on energy is equivalent to generating new revenues of \$20 for hospitals or \$10 for medical offices. Just a 5 percent reduction in energy costs in for-profit hospitals, medical offices, and nursing homes can boost earnings a penny per share [25].

### **Conclusion**

No one knows the precise of the health sector's global climate footprint, but we know that it is substantial. Effects on health of climate change will be felt by most populations in the next decades and put the lives and wellbeing of billions of people at increased risk. Health care industry can become a model for the world by developing an ecological approach to emerging environmental and health challenges.

The implementation of environmentally friendly green strategies for the development and improvement of sustainable systems, the adoption of eco-friendly approaches to health in the framework of social responsibility, and the consciousness of employees, patients, relatives and the community can be suggested to hospital administrators.

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