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Faculty of Graduate Studies

**ENERGY MANAGEMENT IN THE HOSPITAL
SECTOR: A CASE STUDY OF JENIN
GOVERNMENTAL HOSPITAL**

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Declaration

I, the undersigned, declare that I submitted the thesis entitled:

ENERGY MANAGEMENT IN THE HOSPITAL SECTOR: A CASE STUDY OF JENIN GOVERNMENTAL HOSPITAL

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

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Abstract

The hospital sector can be described as large energy-consuming buildings, especially in the form of electrical energy, so, this energy is utilized in many forms in order to provide comfort, treatment, and safety for human beings by relying on energy management and renewable alternatives to produce energy.

This study is based on rationalizing energy consumption and exploits solar energy in providing energy to the hospitals in Palestine, specifically in the West Bank, where the electrical energy consumption in the hospitals can be reduced from 4057.7 MWh/year to 2888.6 MWh/year. Also, there is the reduction of the production of one of the most greenhouse gases that are responsible for global warming in the world. Researched CO₂ production has been reduced by 1,292,134 kg of CO₂/year.

A set of detailed data was given regarding the proposed building, such as annual costs, annual cost per unit floor area, component cost as a percentage of total cost, annual energy and emissions summary (annual costs, annual energy consumption, annual emissions, annual cost per unit floor area, component cost as a percentage of total cost), annual energy costs - heating and cooling system, annual energy costs - new heating system, annual energy costs - new economizer system, annual energy costs - old cooling system and annual energy costs - old heating system, all these data appear in detail as shown in the Appendix (c).

It is worth mentioning that energy consumption in the air conditioning system has also been rationalized from 2178.7 MWh/year to 1167.4 MWh/year, which results in reducing CO₂ production to 1,092,139 kg/year.

Using diesel to operate the heating system, 340,20 kg of CO₂/year was produced, and the production of carbon dioxide gas was reduced to 31,069 kg of CO₂/year as a result of modernizing the heating system.

Depending on the design of the solar cell system, 148.8 Mwh/year of solar energy has been saved and carbon dioxide emissions were reduced as a result of generating this energy from a non-renewable source 160,766 kg of CO₂/year.

Keywords: Energy Consumption, Energy Consumption, Greenhouse gases.

Chapter One

Introduction

Energy has been a vital aspect in our lives in general that electric strategic movements play a crucial role in human existence, as well as in the operation of important frameworks and administrations. Nowadays, the majority of power users around the world are still produced by petroleum derivatives. Contrary to pure and limitless sources, sources like wind or solar energy, as well as the double-dealing of non-renewable energy sources, have a major ecological impact due to an increase in Earth's surface temperature, artificial weather changes, and health risks. Also, its momentum use outperforms typical recuperation, which forces an unavoidable asset consumption. These concerns have not only increased the desire for but also the need for, information if various sources or options are not utilized (Teke, A., & Timur, 2014).

One of the principal worries all over the planet is environmental change influenced by global warming. The question here is how to stop overheating by taking out or if nothing else moderating ozone depleting substance emanations. Numerous nations have been put as one of the main objectives to lessen these gases in the short and medium-term and accomplish net-no outflows over the long haul (Da'as, B. A. S. 2008).

Hence, clinics are huge structured-complexes that reflect most kinds of specialized frameworks coincidence for different sorts of undeniable level structures. Based on this, viable energy the executives estimates you should guarantee that energy use and expenses are low while keeping up with elevated degrees of solace, administration, and efficiency. (Guerrero Almirall, 2020)

Medical clinics represent around 6% of the all-out limit depreciation in the utility structures area. Warming and ventilation and Air molding (HVAC) frameworks are the principal part of power energy utilization in emergency clinics as cooling framework responsible for around 70% of the absolute power utilization. Electrical Hospital engines and lighting frameworks address approximately 19% and 21% of

the absolute energy utilization individually (Teke, A., & Timur, 2014). Accordingly, the chance of saving energy in these referenced frameworks while keeping up with a similar exhibition is fantastic (Leitao, J., Gil, P., Ribeiro, B., & Cardoso, 2020).

The clinic area is one of the primary energy-consuming areas In Palestine that experiences unimaginable and awful energy utilization as approved by energy administration that this concentration on energy the executive's procedures and consequences of examining electrical, warm and sun-oriented applications in the clinic area in Palestine. The viable utilization of energy and energy the executives in Palestine hospitals are no more excellent than most agricultural nations.

We are laying out a speed towards the productive utilization of energy and energy the board in emergency clinics by leading a few energy reviews in various clinics where lighting, cooling, and the utilization of sun-powered energy in the entirety of its circumstances (warm or changed over completely to electrical energy) (Hijjo, 2015.) Hence, units, power factors, or other help levels can be decreased without hurt for rest or medical care, thus Hospitals and clinic structures are significant purchasers of energy which they use in various ways (Hijjo, 2015.)

The primary thought of this business is the utilization of energy the board procedures and after effects of examining electrical, warm, and sun-oriented applications in the clinic area in Palestine in light of the energy reviews that it will give. The following elaborations are the goals of this examination:

1. Working on excusing energy utilization and profiting from the financial return.
2. Chipping away at using sunlight-based energy to produce electric power.
3. Using part of the emergency clinic's strong waste and changing over it into nuclear power.
4. Decreasing an Earth-wide temperature boost by lessening carbon dioxide discharges and diminishing it however much as could reasonably be expected coming about because of copying non-renewable energy sources to address the issues of the emergency clinic.

It is expected to accomplish these objectives through a coordinated strategy that are attuned with specialized, financial, and regulatory viewpoints sides simultaneously.

The message blueprint will be made sense of as follows:

In part one of this postulation, the energy in the West Bank of Palestine will be examined. Palestine imports every one of its necessities from energy (power and oil) from Israel makes the value unstable. There is a rising pace of energy interest because of the ascent expansion of the private area and wasteful utilization of energy in different areas.

The second section includes knowing how much the medical clinics consume out of the all-out energy in Palestine, knowing the energy utilization in medical clinics in adjoining nations, as well as all about the encounters of clinics in adjoining nations in overseeing energy inside them. It also includes contrasting them and clinics in Palestine and portrays the offices of the controlled emergency clinics; the annual utilization of electric energy and fuel notwithstanding the energy charge discussing the defense techniques in the objective frameworks in the exploration (AHVC, LIGHT, DHW, RES) Introduce measures to ration energy.

In the third chapter, the researcher depicts the controlled emergency clinic offices, the annual utilization of electric energy , fuel notwithstanding the energy bill, and energy utilization dispersed on (the area and the number of sickbeds in the medical clinic). The fourth chapter introduces, programming for energy management opportunities changing the main ways used in energy protection in medical clinics into numerical models for paving the way for methodical plans. Flowcharts for every opportunity measure, programming plan, check and View programming examination.

Chapter Two

Energy Situation in Palestine

The inability of people to access energy sources satisfactorily is known as energy destitution as it is a complicated, multi-layered problem. This study examines the eco-friendly energy mix that will help Palestine become less dependent on outside help and become more sustainably developed. Because of multiple inadequate network infrastructures and a lack of power that hardly satisfies family norms, Palestine experiences energy and fuel neediness, which contributes to the continuation of various problems for the energy sector. Hence, the energy supply in Palestine is confronting significant difficulties because of its reliance on Israel for 100 percent of its petroleum products, and 90% of its electrical supply. This reliance has led to a confrontation with the energy sector's political, social, economic, and social problems, which would affect the energy sector for political and economic transformation.

Some low-pay families battle to tie down their energy needs because of these obstructions alongside insufficient warming/cooling and lodging and expanded energy costs. This study proposes a few proposals that when it is viewed as that will assist with decreasing energy neediness in Palestine. The introduced results show that neediness and energy destitution in Palestine remains closely connected.

Zeroing in on state strategy apparatuses is basic lessening boundaries to the utilization of sustainable power sources is the brilliant string that will falter together financial growth, development, and environmental sustainability (Hamed, T. A., & Peric, K. 2020). A rise in energy imports in Palestine in all its forms was observed, as evidenced by the consumption of electrical energy in 2019 to 6,249,104 MWh, as published in the Palestinian Statistics Center. This is due to the expansion of all energy-consuming halls in Palestine in general. (PCBS, 2019) Most nations really

focus on giving energy measurements energy is vital on account of its job in the impression of the economy, individuals' government assistance, and way of life.

The state of the foundation is also reflected in energy data. Without a doubt, reliable access to quantifiable data on energy use is the key factor in organizing and enhancing procedures. Recently, there has been a significant shift in Palestine's financial structure and energy usage model. Furthermore, exploit the accessible resources of environmentally friendly power sources like solar energy, biomass, and wind energy creating realistic meaning represents things to come social and financial advancement of the country (Da'as, B. A. S.2008).

2.1 Energy Supply and Demand in Palestine

Palestine relies mainly on importing energy from neighboring countries and Israel, especially electricity generated and fossil fuels used to generate power in relatively small generators. (Hamed, T. A., & Peric, K. 2020).

According to the Palestinian Central Bureau of Statistics, the total electrical energy consumption in Palestine in 2019 was 5,929.5 GWh. This quantity is entirely imported from external sources, mainly from the Israel Electric Corporation (IEC), as shown in Table 1.

Table 1

Sources of Electricity in Palestine Based on Yearly Consumption

Electricity source	Quantity (GWh)	Percentage of total supply
Israel	5538.7	93.4
Gaza Electricity company	260.9	4.4
Egypt	36	0.6
Jordan	94.9	1.6
total	5929.5	100

Electricity was imported from neighboring countries with a capacity of 6249.1 GWh, diesel was imported with a capacity of 752887 (thousand liters), gasoline was imported with a capacity of 305612 (thousand liters), kerosene was imported with a capacity of 1690 (thousand liters), petroleum gas was imported with a capacity of about 177674 (tons), and tar is imported by 32,946 (tons), and firewood and coal are imported by 4,003 (tons) for 2019 to enable the work of the energy sector within Palestine in general and the West Bank in particular. The location of electric power operates a small part of the power sectors. (Palestinian Central Bureau of Statistics, 2022)

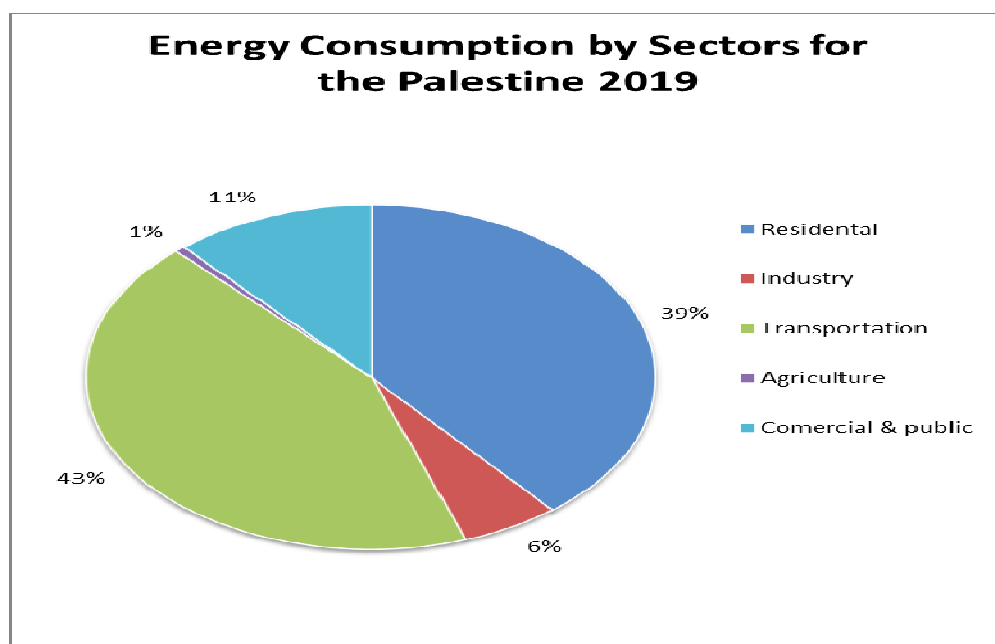
2.2 Energy Consumption by Sector

Measurements of energy use based on energy use within the domains show that household and health consumption are the main consumers of energy, accounting for 39% of the total. Consumption in 2019. (Palestinian Central Bureau of Statistics, 2022)

Figure (1) shows the sectors' energy consumption in Palestine

Figure 1

Sectors Consumption to Total Energy Consumption in Palestine



According to Palestine's energy supply-demand balance, final energy consumption increased by 2% from 2016 to 2017, by 6% from 2017 to 2018, and by 11.4% from 2018 to 2019. Figure (2) illustrates energy use by sector, energy form, and year despite the challenging economic circumstances at the time. The energy supply and demand in Palestine are shown in tables (2) and (5), respectively, along with the energy supply and demand in Palestine for the year 2019. (Central Bureau of Statistics for Palestine, 2022)

Figure 2

Energy Consumption by Sector, Energy Form And Year in (GWh) in Palestine

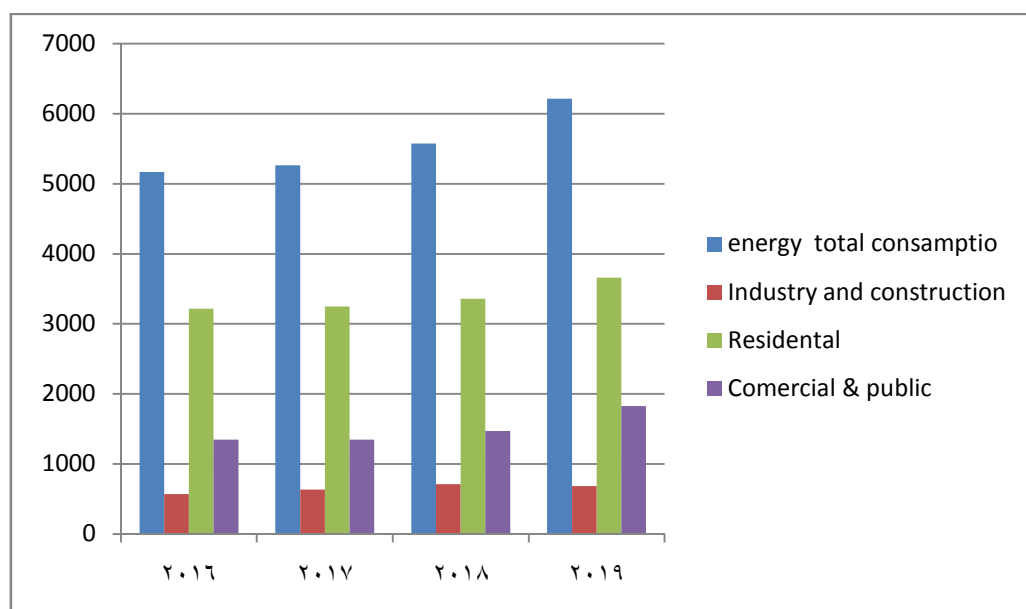


Table 2

The Summary of Energy Balance of Palestine 2019

Year	2019 (MWh)
Total energy supply	6369104
Primary production	120000
Imports	6249104
Final energy consumption	6213137
Industry and construction	685597
Household and other sectors	5527540

2.3 Energy Consumption in Hospitals Sector in Palestine

Medical clinics in Palestine are characterized under service institutes and are partitioned into two primary classifications: Governmental Hospitals, and Non-Governmental Hospitals. In 2008, the quantity of significant medical clinics in the West Bank were 17.

The consumption of electrical energy reached 10633716 (kilowatt hours) and the number of beds was 1693 beds in all hospitals in 2007. (Da'as, B. A. S., 2008).

In 2020, the number of operating hospitals in Palestine reached 87, 53 that operate in the West Bank, including East Jerusalem, and constitute 61% of the total operating hospitals in Palestine, where the electricity consumption in hospitals reached 6% of the total energy consumed in the buildings sector, and the number of beds reached 6,552 in all hospitals (Wafa, 2020).

2.4 An Overview of Renewable Energy Resources and applications in Palestine

In the Palestinian territories, there are no conventional energy sources, such as oil or petroleum gas, but there is also a lot of room for developing sustainable energy sources, particularly solar, wind, and biomass. Developing its energy sources is essential for Palestinian energy security. Despite significant political, specialized, and financial obstacles, all sources of information, resources, and techniques are available to advance this subject. However, the lack of domestic oil resources results in a heavy reliance on oil imports. As a result, it has become crucial to use sustainable power resources and advancements to power Palestine's whole organic industry. The main renewable energy sources with the most promise in Palestine are solar, wind, and biomass energy. While searching for the best R.E. Elective, taking into account everything potential R.E is significant. Sources, application, and market accessibility. Audit From the energy scene in Palestine and the accessible sustainable power sources in this segment in 2018, the essential energy utilization was in the Palestinian Territories.

around 75,178 Tera Joules fuel and gas represent around 58%, imported and produced power around 28%, and environmentally friendly power (sun-based energy, wood, and so forth) around 12%. (Yasin, 2021)

The survey's chosen signs of the Palestinian energy area is displayed as a table (3).

Of the energy scene in Palestine and accessible R.E sources are introduced in this segment

Table 3

Selected Indicators of the Palestinian Energy Sector 2016-2019

Indicator	2016	2017	2018	2019
Renewable energy share in the total final energy consumption (%)	13.6	10.3	10.7	11.7
Energy Dependency Rate (%)	84.7	87.3	86.9	86.4
The Energy Consumption of the Transport Sector to the total energy Consumption (%)	45.6	46.6	45.4	43.2
The Energy Consumption of the Household Sector to the total energy Consumption (%)	39.7	38.4	38	38.8
The Energy Consumption of the Service Sector to the total energy Consumption (%)	8.8	8.8	9.8	11.3
The Energy Consumption of the Industry Sector to the total energy Consumption (%)	4.8	5.4	6.1	5.6
Annual Electricity Consumption Per Capita (kWh /Capita)	1141.9	1138.3	1148.7	1280

2.5 Power Supply through Solar Energy

Palestine is currently suffering from a serious shortage of vital energy supplies. Nearly 90% of the electricity needs come directly from or through Electricity Distribution Companies. The Palestinian population is under constant pressure, mainly due to the current unstable political situation in the region. The Palestinians

have begun to try to explore local alternatives to lessen the impact of Israeli control vital sector. Palestine receives about 3000 hours of sunshine every year, an average of 8.2 hours per day, which makes it suitable for investing in solar energy (Hamada, S., & Ghodieh, A. . 2021).

Palestine receives more than 3000 hours of sunshine year, with an estimated 5.4 kWh/m²/day of solar energy falling on the horizontal surface. In the Jordan Valley region, radiation dose rates of 5.40–5.98 kWh/m² per day are experienced. The horizontal surface's exposure to solar radiation varies from a minimum of 2.63 kWh/m²/day in December to a maximum of 8.4 kWh/m²/day in June. Due to the fact that these estimates are high in a good way, Palestine is now one of the greatest places in the world for using solar energy for both large-scale energy production and autonomous systems. This makes investments in this field both practical and financially viable.

Water heating, water desalination, water pumping, drying of vegetable and fruit crops, and electrification of numerous rural areas and villages away from electric grids and in areas where there is no electricity within 24 hectares every day are just a few of the various uses for capturing solar energy.

The findings of earlier study demonstrated that using photovoltaic systems to electrify isolated and rural areas is more practical and cost-effective than using diesel generators or expanding the electrical grid. This essay explains solar energy technologies, including solar photovoltaic (PV). The foundation of solar photovoltaic technology is the ability of semiconductor-based photovoltaic cells to convert solar energy into electrical energy. Due to technological advancements and mass production, the price of solar energy has fallen over time. Since the end of 2010, the costs of PV-generated electricity and PV modules have fallen by 50% and 75%, correspondingly. (Hurst, (2015).

Solar thermal energy has also been utilized in the thermal industry, and Palestine will benefit greatly from the use of Solar water heating. Home solar water heating is widely used in DSWH, it was introduced to the Palestinian market from the Israeli market in the sixties. At present, more than 70% of families in Palestine make use of solar energy by using solar water heaters (Allen, (2010).

2.6 The Potentials of Renewable Energy in Palestine

Palestine is characterized by the diversity of renewable energy in its lands, despite the disparity in the energy generated from renewable energy systems. We will mention some types of renewable energy that can be exploited in Palestine.

Because it can be grown anywhere, biomass is a strategic source of energy generation for both developed and emerging nations. It also helps to safeguard the environment and lessen the damage done by the usage of fossil fuels. While electricity, biogas, and biofuels are produced from biomass energy today, cooking and heating are its primary traditional uses. Until the end of 2017, bioenergy made up 12.4%, or 46.0, of the world's energy supply (Appavou, F., Brown, A., Epp, B., Duncan, G., Kondev, B., McCrone, A.,... Sverrisson, F., 2019).

Palestine is regarded as an agricultural nation due to the predominance of this industry. Therefore, there is a chance for biomass energy production in the Palestine region. In the West Bank and Gaza Strip, various plant species can be used to create bioenergy. These plants fall under the categories of field crops (such wheat and barley), fruit and vegetable trees (Butterfield, 2000).

An important source of biomass is food processing waste from the agro-industry and agricultural trash. The heating value of this type of biomass has been predicted by a number of studies (Callejón-Ferre, A. J., Velázquez-Mart, B., López-Martnez, J. A., & Manzano-Agugliaro, 2011), and other studies have shown that this type of energy can be extracted and used to generate electricity through the gasification process.

A thermochemical method can be used to produce biodiesel or a biochemical method can be used to produce ethanol to produce biofuels from agricultural waste (lingo-cellulose-raw material).

The heat produced by this type of plant has been explained in various articles, and many fruit trees in Palestine can be utilized as feedstock for ginseng cellulose (Vargas-Moreno, J. M., Callejón-Ferre, A. J., Pérez-Alonso, J., & Velázquez-Mart, B., 2012). According to Abu Hamed, T., Ismail, & Alshare (2017), the burning of olive peat can produce about 1.3% of Palestine's total electricity needs.

The process of converting trash into energy, such as electricity, heat, and fuels, according to the US Environmental Protection Agency, involves a number of steps, including incineration, pyrolysis, landfill gas recovery, anaerobic digestion, and gasification.

Solid Waste

The rapid growth of the medical sector over the past decade in most of the world, in addition to increasing the use of disposable medical products, have greatly contributed to the increase quantity of medical waste generated (Coker, A., Sangodoyin, A., Sridhar, M., Booth, C., Olomolaiye, P., & Hammond, F. 2009 ,) (Patwary, M. A., O'Hare, W. T., Street, G., Elahi, K. M., Hossain, S. S., & Sarker, M. H. . 2009).

The World Health Organization (WHO) specifically described categories of hazardous medical waste since the early 1990s. In developed countries, guidelines and legislation are good practices identifying medical waste and clarifying the different possible ways to deal with the treatment and final disposal of this waste (Blenkharn, 2006) (Tudor, T. L., Noonan, C. L., & Jenkin, L. E. T. 2005).

In many developing countries, little information is available regarding obstetrics, handling, and disposal of HSW. Most hospitals in developing countries (DCs) Dispose of their waste, along with general household waste, in open dump landfill outside the city, poses a great danger to the environment due to its high toxicity (Mühlich, M., Scherrer, M., & Daschner, F. D. 2003) and poses significant public health problems (Diaz, L. F., Savage, G. M., & Eggerth, L. L. 2005) due to pathogenic organisms cause infectious diseases (Birpınar, M. E., Bilgili, M. S., & Erdoğan, T. 2009).

Medical waste is considered hazardous because it may contain infectious agents and can cause unsafe effects on the environment and human health. This study aims at the possibility of producing thermal energy from medical waste for students in Jenin Governmental Hospital, Jenin, in light of the medical waste control regulations recommended by the World Health Organization. It also shows that the average generation rate of hazardous healthcare waste ranges from 0.54 to 1.82 kg/bed/day with a weighted average 0.78 kg/bed/day. Without the separation of healthcare waste in all hospitals, this waste is permanently disposed of in a central municipal sanitary landfill, is called cup flower (Al-Khatib, I. A., Khalaf, A. S., Al-Sari, M. I., & Anayah, F. 2020).

The global demand for energy and the generation of local solid waste is increasing as the quality of population and living continues to rise grow. Efforts are directed towards developing and adopting sustainable solutions. Palestinian territories they rely on imported energy (100% fossil fuels and 89% electricity) from Israel, and suffer from local solid waste. Accumulation of environmental consequences due to improper disposal method. The municipal solid waste generation rate in the West Bank was 2,600 tons per day (0.91 kg per capita per day) in 2019, and is increasing by 4% annually. There are three municipal solid waste dumping sites currently

operating, namely; Flower cup to serve the center and North West Bank region (88% exploitation rate), Minya (9% exploitation rate) to serve the southern region, and one in the city of Jericho (crowded). The strategic plans of the Palestinian government (2017 - 2022) aim to reducing dependence on imported energy, reducing carbon dioxide equivalent emissions, and adopting sustainable solutions for municipal solid waste removal. WTE is a promising solution to achieve these goals.

This study investigates three options from WTE for the West Bank, two of which are assumed to be productive electricity by burning, which is building a factory in Zahrat al-Finjan (1500 tons / day) or building smaller plant in a conversion plant (750 tons/day), the third option assumes the option to convert waste into heat locally industrial loads. To conduct the study, all local solid waste, energy and population data were collected and analyzed spatially. After that, the studied options were analyzed from an economic and environmental point of view.

Various operational incentives are proposed to enhance its feasibility. The results show that the waste to heat the station is the most feasible. Unfortunately, this option is impractical due to claim unavailability. For Zahrat El Fenjan power plants and transformer station (Tayeh, R. A., Alsayed, M. F., & Saleh, Y. A. . 2021) in the twenty-first century, major emphasis should be levied on environmental safety and concern regarding human health. In this context, solid waste management need major attention. Awareness in society is profusely obligatory for minimization of solid waste generation. Careful study reveals that municipal solid waste (MSW) provides a major contribution to the total amount of solid waste. However, e-wastes are the most frequently growing waste which is also an efficient source of various toxic elements. Globally, upsurge in the demand of nuclear energy enhances the generation of radioactive solid waste (RSW) that may be responsible for harmful effect of radiation. On the other hand, hospital solid wastes (HSWs) have great impact on environment and public health as it is the carrier of infectious diseases

and other toxic elements. Biodegradable organics are the major content of agriculture solid waste (ASW) along with some pesticides and heavy metals.

The total amount of solid waste (SW) is enhancing day by day, and as consequence proper solid waste management (SWM) methods are necessary which could minimize the total amount of SW as well as its hazardous effect on environment. This review is focused on generation of different SWs and corresponding techniques of SWM starting from conventional tools to modern technique like refuse-derived fuel (RDF), pyrolysis, incineration together with their advantages and limitations. (Banerjee, P., Hazra, A., Ghosh, P., Ganguly, A., Murmu, N. C., & Chatterjee, P. K. .2019).

Wind Energy

In the OPT, the typical wind speed is between 3 and 4 m/s. To 6-10 m/s in higher locations (as in the case of Hebron city in the West Bank) in coastal areas (Gaza Strip). The OPT has a moderate potential for wind power generation when taking into account that the minimum wind speed needed to operate a wind turbine is 6.5 m/s, which is almost equal to the average value of wind speeds in the OPT. However, wind energy projects are not feasible due to the high cost of wind energy technology, the lack of professional expertise in dealing with wind energy, the limited amount of space available for wind energy projects, as well as the political and geopolitical restrictions imposed on the Occupied Palestinian Territory.

Yet, several instances of wind energy in the Palestinian territories that are under occupation have been determined to be so established. These include proposed small-scale residential wind energy systems for installation in the Gaza Strip as well as wind turbines that are supposed to be constructed at the Al-Ahly Hospital site in Hebron, West Bank.

These systems are examined and analyzed as examples of wind energy potential projects in the occupied Palestinian territory in addition to the potential of wind energy in neighboring countries as a sustainable energy source, as well as the environmental impacts of wind energy (Salem, 2019).

Electricity may be produced locally, cleanly, and sustainably using wind energy (Montoya, 2014). According to study by Katana, Samra, and Al-Junaidi (2012), the total installed capacity of wind power generators was 94 GW, or around 1% of the world's total electricity consumption. Both large-scale and small-scale applications may be satisfied by wind energy (Nan, X., Li, Q., Qiu, D., Zhao, Y., & Guo, X., 2013).

Accurate and thorough understanding of the wind speed, wind energy, and topographic aspects of the region under investigation is necessary for the efficient utilization of wind energy for the generation of electricity. The design of power plants, wind farms, and agricultural applications like irrigation all depend on the wind speed distribution (Abu Hamed, T., Flamm, & Azraq, 2012).

Long-term measurements of wind speeds must be taken in order to get reliable and effective wind energy outcomes. Decision-makers in Palestine were motivated by conventional energy sources to look for renewable resources like wind energy to produce unconventional energy (Kitaneh, R., Alsamamra, H., & Aljunaidi, 2012). examining the maps of Palestine's wind resource potential.

Solar Energy

Palestine is now facing a severe lack of essential energy supplies. The majority of the world's electricity needs are met directly by electricity distribution companies (EDCs). The ongoing pressure on the Palestinian people is mostly brought on by the region's uncertain political climate. Since Palestine receives about 3000 hours of sunshine year, the Palestinians have started to look for indigenous alternatives to lessen the impact of Israeli authority. 8.2 hours on average every day, which

qualifies it for solar energy investment (Abu Hamed, T., Flamm, H., & Azraq, 2012).

Palestine receives more than 3000 hours of sunshine each year, with 5.4 kWh/m²/day of solar energy measured on the horizontal surface. In the Jordan Valley region, radiation dose rates of 5.40–5.98 kWh/m² per day are experienced. The horizontal surface's exposure to solar radiation varies from a minimum of 2.63 kWh/m²/day in December to a maximum of 8.4 kWh/m²/day in June. Due to the fact that these estimates are high in a good way, Palestine is now one of the greatest places in the world for using solar energy for both large-scale energy production and autonomous systems, which makes investment in this sector both practical and financially viable. Salfit had the maximum amount of solar radiation in 2010, followed by Ramallah, Hebron, and then Tubas with values of 5.65 kWh/m²/day, 5.5 kWh/m²/day, 5.14 kWh/m²/day, and 5.14 kWh/m²/day, correspondingly.

Water heating, water desalination, water pumping, drying of vegetable and fruit crops, electrification of many rural areas and villages away from electric grids, and areas where there is no electricity within 24 hectares each day are just a few of the many uses for capturing solar energy.

The findings of earlier study demonstrated that using photovoltaic systems to electrify isolated and rural areas is more practical and cost-effective than using diesel generators or expanding the electric grid. This essay explains solar energy technologies, including solar photovoltaic (PV). The foundation of solar photovoltaic technology is the ability of semiconductor-based photovoltaic cells to convert solar energy into electrical energy. Due to technological advancements and mass production, the price of solar energy has fallen over time. Since the end of 2010, the costs of PV electricity and PV modules have reduced by 50% and 75%, respectively (Hurst, 2015).

Solar thermal energy has also been utilized in the thermal industry, and Palestine will benefit greatly from the use of solar water heating. Home solar water heating is widely used in DSWH Palestine. It was introduced to the Palestinian market from the Israeli market in the 1960s. At present, more than 70% of families in Palestine make use of solar energy by using solar water heaters (Allen, S. R., Hammond, G. P., Harajli, H. A., McManus, M. C., & Winnett, A. B..2010).

Chapter Three

Energy management and application of renewable energy in the hospital sector

3.1 Status of the Hospitals Sector in Palestine

Public and private hospitals are the two categories that exist in Palestine. By offering fundamental secondary healthcare services, general hospitals (also known as government hospitals) cater to a constrained geographic area. Some of these facilities are big enough to provide an extensive array of advanced secondary and tertiary medical services. The vast majority of advanced secondary and tertiary services are provided by private (non-government) hospitals in a specific field of expertise. Hospitals and hospital buildings use energy in a variety of methods and forms on a larger scale. Hospitals are places of business that are open every day of the year, twenty-four hours a day. The high energy use in the Palestinian hospital sector presents both a challenge and an opportunity for energy management and conservation.

3.2 Energy Consumption in Hospitals

The statistics on hospital energy use are presented as gross annual consumption figures, which are broken down into electricity, gas, and thermal energy. Data is collected to make energy performance comparisons easier.

Several variables are introduced: total floor area, number of beds space, calculating the total energy use of hospitals in Western countries, in 2020, discovered that consuming this amount accounts for 6% of the healthcare sector's overall energy usage (Teke, A., & Timur, O, 2014).

3.2.1 Current Situation of Energy Management in the Hospitals Sector

In the utility buildings industry, hospitals account for roughly 6% of overall capacity depreciation. The main component of electricity is heating, ventilation, and air conditioning (HVAC) systems.

In hospitals, energy usage is a high system of air conditioning around 70% of total electricity use is accounted for by electricians' hospital motors and lighting systems account for around a quarter of the total cost of a hospital.

19% of total energy consumption and 21% of total energy consumption, respectively in this case, papers and profiles of end-use energy in hospitals in general (Teke, A., & Timur, 2014).

Jenin Governmental Hospital was selected to conduct an energy audit , direct and compatible monitoring for management and maintenance

3.3 Alternatives to Energy Management (EM)

Generally speaking, hospitals provide different specialized services, and each hospital building has its own unique design, size, and interior. Every situation is different; thus, they must build and modify their strategy to fit the requirements and needs.

Standards that specify how to meet these objectives through appropriate technological system design and operation, as well as building operation, are typically lacking in hospitals. Controlling the energy use design of a structure involves continuously and intentionally energizing the executives. They must limit energy and financial waste to the bare minimum permitted by the environment. The space, capabilities, and various parts of the structure set up and maintain a strong balance between the structure's annual tasks and actual annual energy consumption.

Furthermore, energizing the executives in emergency clinics, and energy the board, as a rule, might be characterized as a technique for further developing energy

productivity in a current office by chasing after low power utilization on a persistent premise including both activity and upkeep. Building in such a way that the improvements in energy efficiency are preserved. Many energy management options exist in Palestinian hospitals.

The basic purpose of energy management is to increase profits or lower costs. The following are some ideal sub-goals of energy management programs:

1. improving energy efficiency and thereby lowering energy consumption without sacrificing system quality .
2. Creating and implementing effective monitoring, reporting, and energy-efficient management procedures.
3. Developing new and improved methods for increasing energy yield
Research-based investments and development
4. Encouraging all staff to be interested in and committed to the energy management program.

Energy Management provides both energy and considerable cost savings.

Hospital energy-saving strategies are acceptable, but they differ from those used in most other industries. In general, hospitals are 28. Although receptive to initiatives to save energy costs, it is unlikely to be appealing. Regulatory requirements that raise operational expenses. In the healthcare sector, there are technological possibilities for energy conservation.

The hospitals themselves are as different as the patients they serve. It focuses on energy conservation in areas such as boiler efficiency, solar water heaters, air conditioning, and lighting. (Leitao, J., Gil, P., Ribeiro, B., & Cardoso, A., 2020).

From the standpoint of energy management opportunity and potential, each system will be studied and described independently . (Kolokotsa, D., Tsoutsos, T., & Papantoniou, S. 2012) .

3.3.1 Lighting systems that save energy

Hospital administrators are following tactics or methods to lower their energy costs and environmental effect because every structure has lights. Lighting upgrades are fairly popular as they usually provide a good return on investment not to mention that they require electricity to operate. They account for a significant portion of the overall electricity used in hospitals. Fluorescent, compact fluorescent (FL), and incandescent bulbs are all types of lighting.

In hospitals, lamps are often utilized for the task and office lighting, both of them.

The lighting designer's objectives are to:

1. Offer the proper amount of light.
2. Produce the appropriate quality of light.

It is not expensive to reduce energy consumption in lighting systems.

Some of these ways are listed below.

- Cut down on the number of light bulbs you use: this may be done by measuring the amount of light in a certain location and compare it to the average. This meter saves energy by complying with worldwide lighting regulations. A significant amount of energy, especially after the bulb is removed.
- Remove any ballast that uses a lot of energy.
- The installation of high-efficiency bulbs.

The goal is to run Long-lasting and energy-saving lamp. (Shabibi, 2014).

- Using Reflectors in Lighting Fixtures: Reflectors are highly polished metal discs.

Light is directed downward by "mirror-like" components, decreasing light loss by utilizing less power, reflectors can minimize the necessary wattage. (Kolokotsa, D., Tsoutsos, T., & Papantoniou, S..2012).

3.3.2 Boiler system energy conservation

Boilers are primarily used in hospitals for space heating and hot water, so improving the efficiency of boilers' performance has numerous economic and environmental benefits. The standard methods for measuring boiler efficiency will be discussed leading to determining how efficient the boiler is in comparison to the best efficiency.

Its fuel cost is frequently the facility's greatest, if not the second highest, energy expenditure as a result, the efficiency is rather low. Its plant optimization might save you more money in the long run than energy efficiency improvements in end users. Furthermore, most boiler facilities have excellent prospects for efficiency improvement.

Combustion, heat transmission, unnecessary losses, excessive air Energy consumption, water quality, and blasting are all examples of energy-saving potential in boiler systems, birds are the most important efficiency indicators:

1. Boiler-Combustion Measurements

The reduction of excess boiler air is the most important efficiency measure. The term "excess air" refers to the air that is delivered to the burner in addition to the air that is necessary for full combustion. Operating a boiler without enough air or "rich fuel" in a potentially dangerous state result in excess air being provided to the burner, as a result, more air is delivered to the burner than is necessary for combustion, resulting in a larger safety factor. More heat is lost heating that air instead of creating steam as more air is utilized to burn fuel.

For safety and to decrease NO_x emissions, air that is just over the optimal fuel/air ratio is required, although around 15% is adequate, boilers that haven't been serviced properly can have up to 140 percent surplus air, although this is uncommon, reduce the heat in this kettle. Even without constant automated monitoring, up to 15% of total fuel use can be saved.

The rule of thumb is that for every 15% decrease in extra air or a drop in flue gas temperature to 40°F (22°C), boiler efficiency may be raised by 1%. The boiler runs with just the right quantity of extra air and Improves combustion efficiency by reducing heat loss in the stack. The effectiveness with which the enthalpy of the fuel is transformed into useful heat is measured by combustion efficiency. The temperature of the flue gas and the quantities of oxygen (or carbon dioxide) in the flue gas are the two most important indicators of combustion efficiency. The precise or stoichiometric amount of air is necessary to totally react with a specified amount of fuel, given complete mixing. Combustion conditions are never optimum during exercising, therefore extra or "excess" air is required as they're there to ensure that the fuel burns completely.

Oxygen or carbon dioxide gas concentrations in the chimney are used to estimate the correct quantity of extra air. Excess air results are insufficient. It results in a lot of heat loss due to increased flue gas flow in unburned combustible components (fuel, soot, smoke, carbon monoxide) It reduces the overall efficiency of converting boiler fuel to steam. For each type of extra air process, there is an ideal level as there is a need for the type of fuel and the design of the stove or furnace. Also, more than this amount of air is required to enable full combustion of the fuel, since any more increases heat rejection to the stack, resulting in greater fuel consumption for a given process output. Then, excess air levels that are considered desirable are typically attained.

The maximum operating efficiency, which is assessed according to the kind of fuel and manner of combustion. (Doty, S., & Turner, W. C., 2004) The amount of unburned flue gas combustible elements, as well as the stack temperature rising above the input air temperature, are essential factors in determining the combustion process' efficiency. The most frequent approach for controlling the air-to-fuel ratio is to monitor excess oxygen (O₂) in the exhaust stack. However, in conjunction with O₂ monitoring, carbon monoxide (CO) readings may be utilized to modulate air

flow rates for more accurate control. To achieve optimal performance, careful attention to the oven's functioning is required.

2. Boiler Maintenance or Boiler Replacement

The functioning and maintenance of the boiler are inextricably linked well that the procedure includes carrying out the required daily and occasional maintenance. In other words, Low maintenance costs are dependent on effective daily operating control, and the system and fuel are compatible. Simple maintenance regimen to ensure that everything is in working order.

The boiler components work at peak efficiency, resulting in significant cost savings. The burner and Condenser systems might get out of tune if there isn't a solid maintenance strategy in place. These factors can reduce the efficiency of a steam system by up to 20%-30%. They anticipate that a 10% energy savings might be achieved on average. Improved maintenance may help minimize emissions of contaminants that violate air quality requirements.

The efficiency of boilers has increased over time and as a result of global development, and as a result of the regular maintenance process, replacing the boiler with a greater efficiency boiler becomes an effective supplier of maintenance work. (Li, X., Xie, W., & Zhu, J., 2022) After all, the term "preventive maintenance" was coined to describe the process of avoiding the problems you wish to avoid. It is crucial to take measures on a regular basis, and maintenance is performed.

3. Boiler - Recover Heat from Flue Gas

The temperature of the flue gases rejected to the stack is another important element that affects unit efficiency and, ultimately, fuel consumption. Fuel consumption is reduced as a result of increased operational efficiency, it is possible to do this by rejecting flue gases at the lowest possible process temperature. Basic design concepts are followed that when monitoring flue gas, extra heat recovery equipment

can help achieve this energy-saving aim in general. The temperature had risen to almost 250 degrees Fahrenheit.

3.3.3 Cooling System Energy Conservation

The usage of air conditioning in hospitals creates a slew of issues. It is not found in less demanding forms of structures, or cooling in the space. In electric-powered hospitals, the system covers nearly the full overall volume. The distinction in normal energy utilization between two seasons or measuring the general utilization of cooling frameworks might be utilized to decide the energy utilization of this framework. It may be done in refrigerated systems by setting the thermostat to 22°C, in addition to using current high-efficiency cooling systems. During the summer, the cooling system saves money. (Kolokotsa, D., Tsoutsos, T., & Papantoniou, S.. , 2012).

The following equation is used to compute it:

$$\text{Energy saving} = [(T \text{ existing} - T_{out}) - (T \text{ suggested} - T_{out})] / [(T \text{ existing} - T_{out})] \dots\dots\dots(1)$$

Where

- T existing: The temperature inside the room
- Tout: Before cooling the space
- T suggested: Suggested room temperature

It is possible to make appropriate selections regarding equipment replacement priorities and justifications. . (Kolokotsa, D., Tsoutsos, T., & Papantoniou, S..2012)

At this degree of energy efficiency, it may be necessary to replace or install existing equipment retroactively. When it comes to HVAC operations, available equipment components may be enhanced, it's bought and installed to replace the old, useless components.

According to the reference, HVAC components that use a lot of energy may be categorized into five categories: fans, cooling, heating, pumps, and cooling towers, Straight accounts for 34%, 27%, and 17% of total energy consumption for fans, cooling, and heating, respectively. Pumps and cooling towers account for 16 percent and 6% of the total, respectively. In retrospect, replacing current equipment that is responsible for these energy-intensive operations with more energy-efficient equipment might save a lot of money. Furthermore, present systems are frequently old and underperforming as a result of degradation over time, continuous operation, inadequate maintenance, and prolonged exposure may be the major causes of these systems' degeneration. Furthermore, the newly created technology may provide considerable energy efficiency benefits (Hohne, P. A., Kusakana, K., & Numbi, B. P. 2020).

3.4 Solar Energy for Thermal Applications Implementation (DHW)

Hot water is required in hospitals on a regular basis and in large quantities, despite the enormous disparity between departments and consumption, Up to 40 liters per bed on average, Hospital and Clinic Energy Efficiency (THERMIE, 1993). If there is a need to use hot water, it is feasible to take action based on continuous consumption assessment and monitoring. Work notwithstanding the reason for the periodic rise (leaks, inefficiency) taps, and so on. It is possible to enhance distribution and administration in most cases, and increase your efficiency as much as possible, solar water heaters (SWH) are commonly employed in both residential and non-residential applications.

In Palestine, solar water heater hospitals are modest and simple, and they must be created, regulated, and supervised, much like their upkeep. Whatever heating technique is utilized, the water temperature must be kept at or above a level appropriate for proper hygiene and disease prevention (about 60°C). Increasing the use of renewable energy (RE) is one of the most successful ways for promoting

sustainability. Solar water heating (SWH) is one of several commercially mature technologies that are highly appealing, since it reduces the hospital's whole reliance on diesel fuel; it was considered to construct the SWH system on the available roof of the hospital. (Alsayed, 2021)

3.4.1 Design a PV Solar System

Palestine is now experiencing a severe lack of essential energy supplies, nearly all of Israel's electrical demands are met directly or indirectly. Electricity Distribution Companies in Palestine: Every year, Palestine receives roughly 3000 hours of sunlight, it is favorable for solar energy investment since it has an average of 8.2 hours each day. The eastern and southern parts of the West Bank are the finest places to start (Hamada, S., & Ghodieh, A. . 2021).

Due to the advancement of science and technology, as well as the continual and rising demand for electrical energy to power the hospital's systems, solar cell systems must be used to generate electricity due to the sun's availability throughout the majority of the year. It is generated for the public network according to a system set up by the local power companies.

And given the availability of the space required to design a solar cell system on the back of the hospital to sell the energy produced to the electricity company at this time, or to supply the hospital with energy from the system in the future due to the fact that we are in the process of developing, manufacturing, and introducing electrical storage systems associated with solar cell systems. (Salah, W. A., Abuhelwa, M., & Bashir, M. J., 2021)

Chapter Four

The Description of Jenin Governmental Hospital and its Facilities

4.1 Description of the Facilities of the Audited Hospital

The hospital sector consumes 6% of the energy consumption in the building sector, due to the presence of several hospital income systems. For this reason, work has been done to rationalize and manage energy within the health sector in general and Jenin Governmental Hospital in particular, also known as (Dr. Khalil Suleiman Hospital), is considered A hospital affiliated with the Palestinian Ministry of Health in the West Bank.

Energy consumption in the hospital sector was studied to study the possibility of using a solar cell system and the possibility of managing and rationalizing energy consumption in hospitals to reduce and reduce energy bills.

To begin with, Jenin Governmental Hospital was visited and information about the establishment of the hospital and its evolution, the type of construction and designing the systems inside it and the renewable resources, and the most energy consuming systems inside the hospital were collected and investigated taking into account the annual energy consumption in the hospital.

Many measurement tools have been used to collect information about the systems for the most energy consumption inside the hospital. The energy consumption inside the hospital will be presented in this part.

4.2 Jenin Governmental Hospital

Jenin Hospital is an old government hospital located to the west part of Jenin, specifically the beginning of Jenin camp. It is also known as Dr. Khalil Suleiman Hospital, in relation to the martyr Dr. Khalil Suleiman. It was built in 1961, which is the part known as the old building, and it was developed and increased in space over several stages. In 2001, an emergency floor was added, and in the period between

(2008-2014) two floors were added, where the area of the first floor is (1357 m²) and the area of the second floor is (1678 m²).

Jenin Governmental Hospital is considered a general hospital, providing full medical services, as it has a pharmacy, internal and external clinics, laboratories, emergency department, surgery department, orthopedic department, and currently the heart and catheterization department is being prepared.

It consists of four floors, with a ground area of about 2,304 m², taking into account all stages of the engineering preparation of the hospital, where air conditioning is provided inside the entire hospital through six coolers as it is heated by boilers. The hospital has three boilers, two of them are used for heating and the other is used to provide hot water for use, knowing that there is a solar heating system that helps in giving hot water for use.

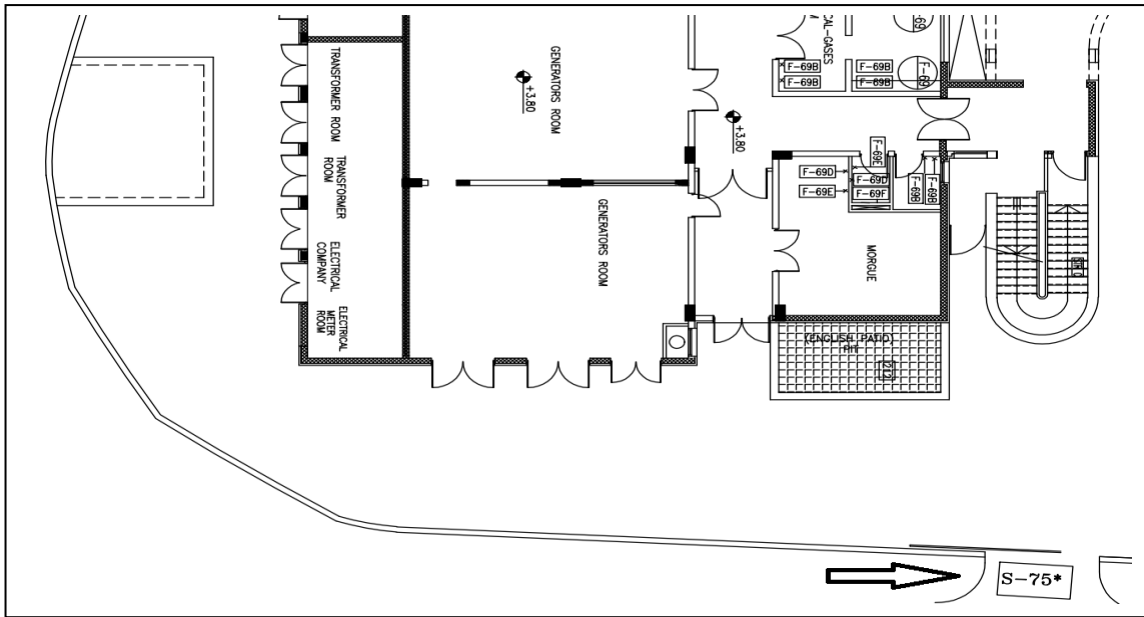
Lighting is provided to the hospital using combined fluorescent and LED lamps. The hospital's bed capacity is currently 300 beds, with 220 beds for lamps and 80 beds for immediate treatment. The number of government employees inside the hospital has reached 560 male and female employees. It has a total area of 3000 m², containing an old building and a new building adjacent to the point where the two buildings can be considered as one building with four floors. The hospital includes several departments (surgery, orthopedics, children, thalassemia, childbirth, cancer, kidney, emergency, internal medicine, and contains an internal and external pharmacy, in addition to laboratories, operating rooms, and intensive care units).

4.2.1 Jenin Governmental Hospital layout

Figure 3 the diagram of the Jenin Governmental Hospital, shows the general shape of the main capacity of the hospital

Figure 3

A schematic diagram of the Jenin Hospital site



4.2.2 Jenin Governmental Hospital Bill Analysis

Hospital consumption reached between 271991 and 483383 kWh/month. It is noted that there is a clear consumption difference in electrical energy. (Health F. D., 2020) There is volatility in the price of energy as a result of the global volatility of the price of diesel fuel. Table 4 shows the electrical energy consumption in the hospital (kWh/month) for the year 2021. (Health F. D., 2020)

Table 4*Electrical energy consumption and cost in Jenin Governmental Hospital, 2021*

Month	Consumption (kWh)	Cost (NIS)	EUI (kWh/m2)
January	359483.33	172552	49.69
February	309275	148452	42.75
March	309275	148452	42.75
April	311543.75	149541	43.07
May	311387.5	149466	43.04
June	339256.25	162843	46.90
July	356075	170916	49.22
August	483383.33	232024	66.82
September	352931.25	169407	48.79
October	353660.42	169757	48.89
November	299493.75	143757	41.40
December	271991.67	130556	37.60

A difference in monthly consumption is observed throughout the year for two reasons:

1. The great impact is the entry of the cooling system into the working system in the summer months.
2. The difference in summer temperatures outside the hospital and the temperature at which the air conditioning is set.

Table 5 shows the non-electrical energy consumption and cost (Diesel). Diesel fuel is used to power boilers in two parts:

1. It is used to operate boilers (2 boilers).

In large quantities 800 thousand kcal heating per hour for one boiler, which is equivalent to 930.4 kWh / boiler.

2. A smaller boiler consumes 120,000 calories, which is equivalent to 139.56 kWh / boiler to save hot water all year round.

In the summer, more reliance is placed on water heating in the DHW system, so a boiler is used to heat water when necessary. (Health F. D., 2020)

Table 5

Non-electrical energy use and cost in Jenin Governmental Hospital, 2021

Month	Consumption (L)	Cost (NIS)	EUI (L/m²)
January	8297.16	49700	1.146967
February	4165.28	24950	0.575791
March	4165.28	24950	0.575791
April	4165.28	24950	0.575791
May	564.82	3383	0.078078
June	564.82	3383	0.078078
July	564.82	3383	0.078078
August	564.82	3383	0.078078
September	564.82	3383	0.078078
October	564.82	3383	0.078078
November	564.82	3383	0.078078
December	564.82	3383	0.078078

Table 5 shows the largest consumption of diesel in the month of January, which is the beginning of the cold weather solstice, because the temperatures are very cold and the water temperature is also cold, a large amount of diesel is consumed.

While in the summer months, diesel consumption is low to start the air conditioning system, and the use of a small boiler to heat water in a few cases, to rely on the (DHW) system to provide hot water.

Chapter Five

Energy Management in Jenin Governmental Hospital and Software Simulation

5.1 The Used Software in the Simulation

The systems with high energy consumption that operate for long hours have been dealt with so that energy consumption is rationalized while maintaining human satisfaction with the system. The systems are the lighting system, heating, and cooling system, and building a solar cell system to supply the hospital with electric power and supply the local electrical network with the surplus of electricity. The output of the solar cell system.

The (HAP) and (PV SYS) programs were used in this thesis.

5.1.1 Hourly Analysis Program Software (HAP)

It is considered one of the most important existing programs that help design heating and cooling systems. The program was developed by the American company Kerri; the most important thing the program does is to help estimate thermal loads and design air systems, in addition to estimating energy for consumables and annual costs, which is the main objective of the program. (Zaphar, S., & Sheworke, T. 2018).

Time through which the weather condition in the place of the project design is defined and the project area and what it contains internal and external walls, internal and external ceilings, doors and windows, and the area of each of them are defined. Devices and the price of energy consumption are defined in their forms within the project, and after the simulation, and a report is given of what has been simulated.

5.1.2 PV syst Software

Solar cell electrical design program. Through this program, the system was designed for Jenin Governmental Hospital (Mermoud, A., & Wittmer, B2014 ,) In this study, the design of the PV-system was done based on net metering on-grid connected system. By using the program, the location of the project is determined to simulate the weather and temperatures, and the best angles are chosen to place the system based on them. A report is given to the status of the project after its design.

Through the use of the HAB simulation program, the percentage of electrical energy use in the systems used inside the hospital, and these percentages show the importance of rationalizing the consumption of electrical energy for these systems inside the hospital.

Figure 4 shows the percentage of electrical energy consumption for the systems inside the hospital.

Figure 4

Percentage of electrical energy consumption of the systems used inside the hospital

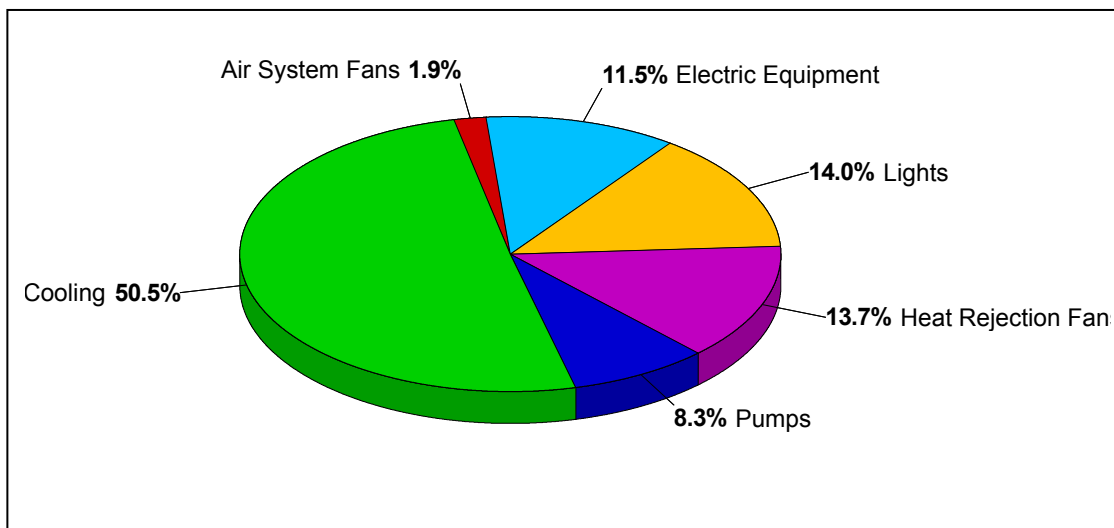


Figure 4 shows the energy consumption inside Jenin Governmental Hospital before conducting the rationalization of energy consumption inside the hospital, As the cost is 0.48 NIS/KWh .

5.2 Lighting System

The lighting system is basically a system that has a significant impact on vision and at the same time affects other systems. The most important systems that the lighting system affects, which is the air conditioning system as a result of the heat generated by lamps when converting electrical energy into lighting, and the type of lamp used has a significant impact on heat, as the LED lamp is better than fluorescent lamp. When replacing fluorescent lamps with LED lamps, it reduces the heat generated by the lighting system because LED lamps give better lighting, which leads to a reduction in fluorescent lamps that produce heat, and LED lamps do not contain a transducer to convert energy into suitable energy for the lamp.

Figure 5 also shows the percentage of electrical energy consumption reduction in the lighting system after replacing the lamps from fluorescent lamps to LED lamps.

Figure 5

Percentage of consumption of the lighting system when using led lamps in Jenin Governmental Hospital

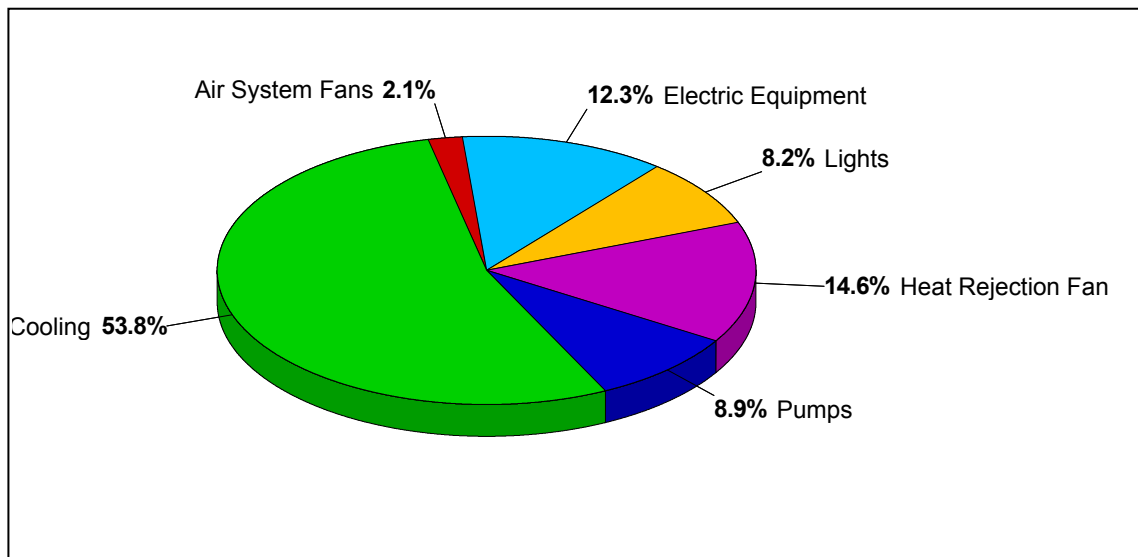


Figure 5 shows the amount of electrical energy saving in the lighting system, as it became 8.2% compared to 14% as shown in Figure 4.

The lighting measurement was taken in the entire hospital in detail as shown in the annex, and the energy rationalization in the lighting system was dealt with depending on the system's working hours to provide the appropriate standard lighting that provides comfort, the lighting measurement was done with a lux meter. Hence, the replacement of the lighting system is 66,000 NIS (Company, 2020) The intensity of lighting was reduced in places with high intensity of lighting, which negatively affected the comfort of the user (human) based on the stander lux.

After showing a part of the rationalization of energy consumption in the lighting system and after removing the lamps based on the ideal state of the intensity of lighting, In fact, the amount of rationalization of energy consumption in the lighting system has become approximately 73714.6 (kWh/year), with a savings rate of 35383 (NIS/year), and the reduction of harmful gases produced by 79661.8 kg of CO₂/yea.

5.3 Improving Boiler Operational System

In Jenin Governmental Hospital, three boilers have relied on two of them are used for the rudder, which is the largest in size, while the other boiler is used to impregnate water inside the hospital knowing that the price of a liter of diesel is 5 NIS.

A boiler was recently purchased, which forced us to completely rely on boilers for heating for several more years, as the text of the new heating system was purchased less than a year ago.

Thus, we had no choice but to work on replacing the rest of the boilers, which represent the other half of the heating system, due to their low efficiency as a result of continuous years from (2004-2022), where the efficiency of the boiler was as low as 60%, while the efficiency of the new boiler was 85%, as its purchase price reached 100,000NIS. (Jamal, 2020)

Figure 6 shows the percentage of diesel consumption in the heating system used.

Figure 6

Percentage of diesel use in heating in Jenin Governmental Hospital

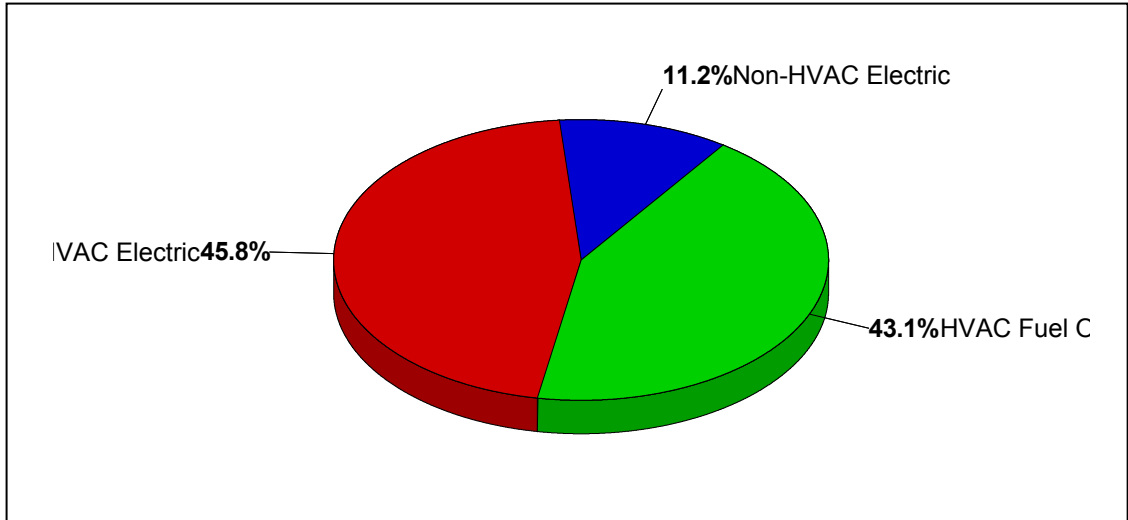


Figure 6 shows the amount of heating system consumption out of the total consumption inside Jenin Governmental Hospital before I worked on developing the system, as the system consumption amounted to 43.1% of fossil fuel use.

Figure 7 The percentage of diesel use in heating after replacing the boiler.

Figure 7

Percentage of consumption of the new diesel heating system in Jenin Governmental Hospital

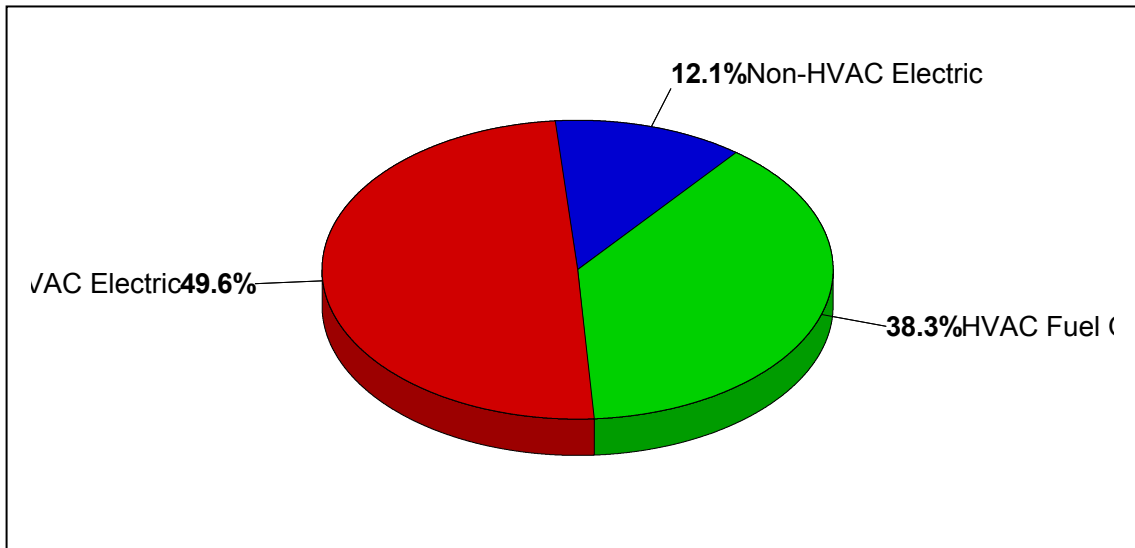


Figure 7 shows the amount of heating system consumption from the total consumption inside Jenin Governmental Hospital, as the system was developed, as the system consumption amounted to 38.3% of the total fossil fuel use.

Table No. 6 shows the amount of energy consumption rationalization in the heating system.

Table 6

Amount of energy consumption rationalization in the heating system in Jenin Governmental Hospital

System	Consumption (L)	Cost (NIS /year)	kgCO2 produce
Old system	30000	151875	340200
New system	27398	138703	310693

5.4 Building Insulation

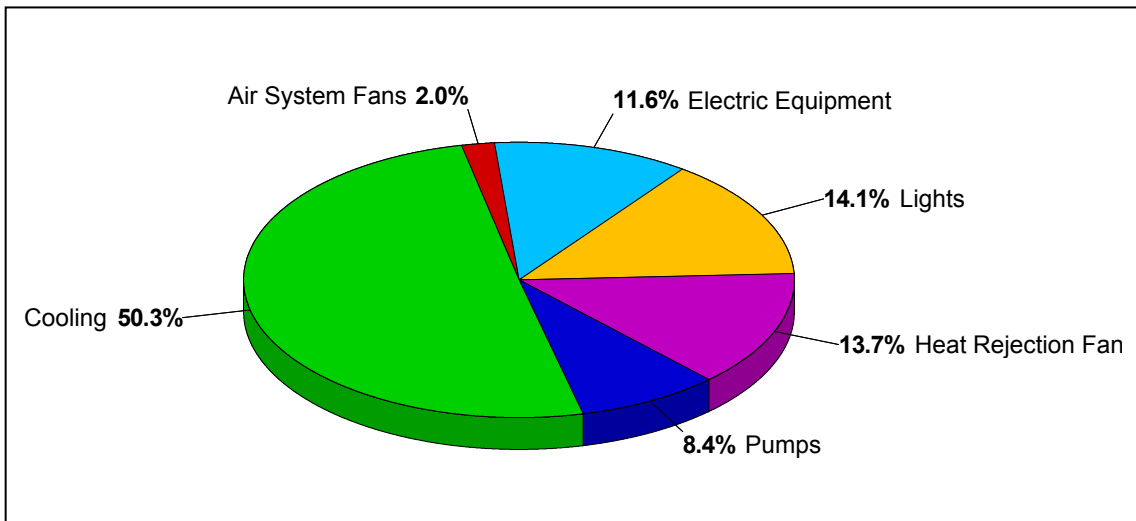
The air conditioning system is a system that is greatly affected by external factors such as the surrounding weather conditions, and internal factors such as the heat of electrical appliances and the heat resulting from lighting down to the temperature of the human body.

When working on isolating the walls of the hospital with gypsum boards and isolating the final ceiling of the hospital, the effect of isolating the building appears on the amount of energy consumed in the air conditioning system, as the cost of isolating Jenin Governmental Hospital amounted to 254,000 NIS. (Ahmed, 2020)

Figure 4 shows the percentage of electrical energy consumption by the systems before any rationalization of the systems inside the hospital, and Figure 8 shows the percentage of electrical energy consumption in the air-conditioning systems after isolating the building.

Figure 8

Percentage of consumption of the adaptation system after isolating the building in Jenin Governmental Hospital



The lighting system inside the hospital works for long periods of the day, and the fact that the lighting from fluorescent lamps produces heat that affects the adaptation system so that it consumes more energy to reach the required level of adaptation, when replacing fluorescent lamps to LED lamps reduces the energy consumption of the adaptation system to reach the level required. Figure 9 shows the percentage of energy consumption in the adaptation system when replacing fluorescent lamps with LED lamps.

Figure 9

Percentage of consumption of the air conditioning system after replacing fluorescent lamps with LED lamps in Jenin Governmental Hospital

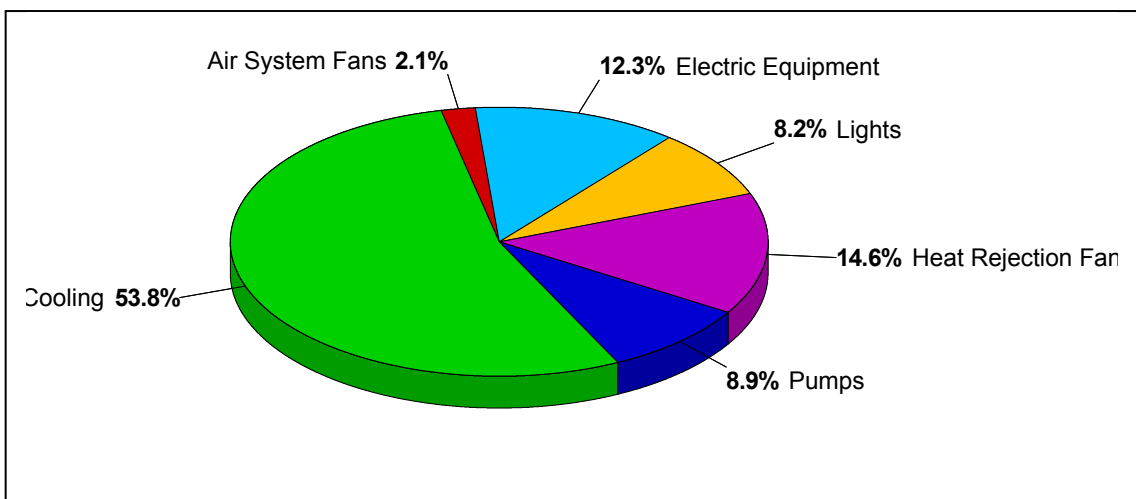


Table No. 7 shows the effect of insulation and replacement of lighting lamps on the consumption cost of the air conditioning system.

Table 7

The effect of building insulation and changing the lighting system on the cost of the air conditioning system in Jenin Governmental Hospital

System	Cost (NIS /year)	Consumption (kwh)	kgCO2 produce
The normal condition of the building	1045780	2178708	2353004
Energy saving in lighting systems	1036987	2160389	2333220
Energy conservation through building insulation	1037238	2160913	2333786
Rationalization in energy through lighting and building insulation	1030927	2147765	2319586

5.5 Air-Conditioning

The hospital contains six chillier of different types, which are Petra, Leaf and Tren.

As the hospital's cooling system works for 7 consecutive months.

It proposed two systems to save energy in the cooling system, namely:

- Variable Refrigerant Flow (VRF) system
- Economizer

1. VRF system

It is a system that is used either for cooling or heating or cooling and heating at the same time. The cooling or heating system has been adopted for its availability and in addition to its low cost if it is combined with the cooling and heating system together, As the cost of the system amounted to 1,400,000 NIS. (Yasser, 2020)

Where Table No 8 shows the energy consumption of the entire system in cooling and heating.

Table 8

Energy consumption of the entire system in cooling and heating in Jenin Governmental Hospital

System	Consumption (kwh)	Cost (NIS /year)	kgCO2 produce
(VRF) system	1330894	638,829	1437365
(VRF) system With energy savings	1305540	626,659	1409983

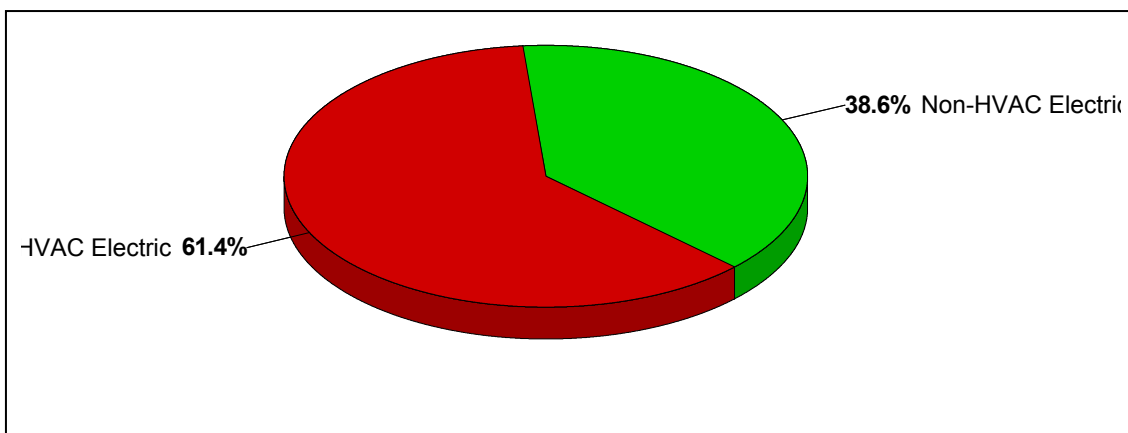
2. Economizer

The other suggestion is to use the economizer in the cooling system because the hospital does not have this device.

Figure 10 shows the percentage of electrical energy consumption when using this device in air conditioning. Also, the energy consumption in the cooling system was reduced from 74% to 61.4%, and the cost of adding this device to the refrigeration unit is 140000NIS. (Yasser, 2020)

Figure 10

The percentage of electrical energy consumption in the air conditioning system (Economizer) in Jenin Governmental Hospital



When using this option to work, air conditioning and energy consumption have been rationalized inside the building, by replacing the lamps of the lighting system with LED lamps, and working to isolate the building.

Table 9 shows the consumption of the cooling system after using the device.

Table 9

Consumption of the cooling system in Jenin Governmental Hospital

System	Consumption (kwh)	Cost (NIS /Year)	kgCO2 produce
ECOUNEMIZER	1185881	569,223	1280752
ECOUNEMIZER With energy savings	1167469	560,385	1260866

5.6 Design in PV system

The Jenin Governmental Hospital is characterized by being than the rest of the houses and institutions around it, which gave the possibility of designing and building an electrical energy production system from solar cells with great reliability due to the number of hours sunlight is available on the solar cell system.

Taking into account the exploitation of the maximum available space on the roofs of the hospital, and given the area of the panel and the distance required for the periodic maintenance of the system, it was found through the use of simulation software that the maximum number of panels of solar cells can be installed (158 panels) on the roof of the facility of type proposed solar cells (Jinkosolar: JKM535M-72HL4-V) 535 watts per solar cell

$$\text{System Capacity} = \text{Number of Solar Cells} \times \text{Solar Cell Panel Capacity} \dots\dots (2)$$

$$= 158 \text{ panels} \times 0.535 \text{ kW}$$

$$= 84.53 \text{ kW}$$

As per latest modified net metering law (PENRA 2020) The distribution company deduct 10% of the total energy exported to the network, in return for recycling 90%.

The price per kilowatt of solar cells was assumed at the average market prices for the proposed volume of 2750 shekels per kilowatt of the solar cell system. The total system price is estimated at 233,750 NIS. The annual costs for system maintenance and cleaning have been assumed at NIS 2,000 per year. The cost of retrofitting the grid, and switchboards, and installing a new meter for the solar system at the hospital was assumed to be NIS 6,800. Therefore, the price of the inverters to be paid after the expiry of the life span in the tenth year is 31,000 shekels (Amjad, 2020)

It is assumed that 50% of the energy produced from the solar system is not consumed in the facility at the same moment and is exported directly to the electricity distribution network, which in turn deducts 10% of the amount of energy exported to its network, in return for recycling this energy as a credit to the facility to be consumed later during the year productivity extending from April 1 to March 31 of the following year*.

The 10% fee was imposed by Cabinet Resolution No. (59/59/18/M.W/M.A) for the year 2020.

After calculating on a monthly basis between the system's production of renewable energy with the electricity bills consumed after conserving energy for a period of 20 years, taking into account the decrease in the productivity of solar cells on an annual basis by 0.6%, and the tariff price for the hospital, it was found that the savings are 78,740 NIS for the first year. decreasing by 0.6% and reaching NIS 69,764 in year 20.

To calculate the payback period, the comparison between capital costs, operational costs, and periodic maintenance of the system with the annual savings of electrical energy, as shown in the following table 10.

Table 10*Period of capital recovery from the PV project in Jenin Governmental Hospital*

Year	Cash flow	Cumulative cash flow
1	-240,550	-240,550
2	+78,740	-161,810
3	+78,267	-83,543
4	+77,795	-5,748
5	+77,323	+71,575
PBP	4	0.1

Chapter Six

Conclusions and Recommendations

6.1 Conclusions

One of the most important problems that we faced in providing energy is the lack of resources and funding for energy management within the hospital. Hospitals are one of the biggest consumers of energy, as they operate 24 hours a day to provide treatment services to all patients, and this means that the hospital contains complete systems to provide comfort to patients and provides special treatment equipment, hence the importance of managing and rationalizing energy consumption within the hospital.

The management and rationalization of energy consumption and the use of renewable energy help reduce the cost of operating the hospital and reduce the environmental pollution caused by the energy needed to operate the hospital throughout the day and throughout the year, by maintaining that the provision of comfort is not negatively affected for patients and all those inside the hospital.

In this study, it was proved that there is the possibility of saving energy through managing and rationalizing energy use, relying on renewable energy, and protecting the environment from carbon dioxide, which is one of the most important greenhouse gases, in contrast to what is currently practiced in hospitals.

The consumption of electrical energy in Jenin Governmental Hospital amounted to 4057.7 MWh/year, and as a result of this energy consumption, it resulted in 4,382,376.75 co₂/year, where the decrease in energy consumption is significant and negatively affects the environment due to its production of one of the most dangerous greenhouse gases in large quantities.

After making the measurements and calculations, it was found that the lighting, heating, and cooling system consumes a large part of the total energy inside the

hospital. The above-mentioned systems were dealt with in proportion to the rationalization and management of energy consumption, each system separately. Energy consumption in the lighting system has been rationalized to 259,618 kWh/year out of 333.3 MWh/year. The energy consumption in the air conditioning system has also been rationalized from 2178.7 MWh/year to 1167.469 MWh/year, which results in reducing CO₂ production to 1,092,139 kg/year.

As a result of using diesel to operate the heating system, 340,200 kg of CO₂ / year was produced, and the production of carbon dioxide gas was reduced to 310,693 kg of CO₂ / year as a result of modernizing the heating system. Depending on the design of the solar cell system, 148,857kwh/year of solar energy was saved and carbon dioxide emissions were reduced as a result of generating this energy from a non-renewable source 160,766 kg of CO₂/year.

This is the first study that talks about the rationalization of energy consumption and the exploitation of solar energy in providing energy to the hospital in Palestine, specifically in the West Bank, where the electrical energy consumption in the hospital was reduced from 4057.7 MWh/year to 2888.6 MWh/year, in addition to reducing the production of one of the most important The greenhouse gases responsible for global warming in the world Researched CO₂ production has been reduced by 1,292,134 kg of CO₂/year. In addition, a set of detailed data was given regarding the building, such as Annual Costs, Annual Cost per Unit Floor Area, Component Cost as a Percentage of Total Cost, Annual Energy and Emissions Summary (Annual Costs, Annual Energy Consumption,

Rationalization of energy consumption has been achieved on the most energy-consuming systems inside the hospital, where the electrical energy consumption in the lighting system has been rationalized by approximately 35383 (NIS/year) and the capital recovery period is 1.8 year, and the energy consumption resulting from fossil fuels used in the heating system has been rationalized by 13172 (NIS/year) and the capital recovery period is 7.5 year, and the isolation of the hospital worked

to save approximately 14,853 (NIS/year) and the capital recovery period was 17 years, and the use of the accessory device to save energy in the cooling system worked to save energy by an amount of 476,557 (NIS/year). The year and the capital recovery period is 3 months, and relying on solar cell systems to provide the hospital with renewable energy saved 148,857(kWh) amount 78,740 (NIS/year), and the capital recovery period is 4.1 year.

6.2 Recommendations

In order to work on saving and managing energy inside hospitals, direct measures must be taken from them:

1. Increasing awareness within the health sector about the importance of energy and the importance of saving energy without compromising the provision of complete comfort inside the hospital.
2. Raising the awareness of the importance of using renewable energy in general and solar energy in particular, and its positive effects on the environment
3. Raising the awareness of the importance of maintenance using advanced modern systems
4. It is necessary to inform the stakeholders in the management and rationalization of energy consumption that the main goal in energy management and rationalization is to maintain complete comfort inside the hospital without causing any shortage of comfort due to energy conservation.
5. Supporting and establishing small research centers specialized in energy management and renewable energy-saving systems and power generation systems for the hospital.
6. Working on training the technical and engineering staff to use advanced systems and equipment.

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Appendices

Appendix A

Solar system design results

PVSYST V6.81		10/06/22	Page 1/6
Grid-Connected System: Simulation parameters			
Project : jenen.hospital			
Geographical site	Jenin	Country	Palestine, State Of
Situation	Latitude: 32.46° N	Longitude	35.30° E
Time defined as	Legal Time: UTC zone UT+2	Altitude	158 m
Albedo	0.20		
Meteo. data:	Jenin	Meteozone: 7.2 (1990-2004), Sat=100% - Synthetic	
Simulation variant : New simulation variant			
Simulation date		10/06/22 16h24	
Simulation parameters	System type	Sheds on a building	
2 orientations	tilts/azimuths	20°/18° and 15°/18°	
Sheds configuration	Nb. of sheds	11	
Shading limit angle	Sheds spacing	Collector width	3.48 m
	Limit profile angle	Ground cov. Ratio (GCR)	49.9 %
Models used	Transposition	Perez	Diffuse Perez, Meteozone
Horizon	Free Horizon		
Near Shadings	Detailed electrical calculation	(acc. to module layout)	
User's needs :	Unlimited load (grid)		
PV Arrays Characteristics (4 kinds of array defined)			
PV module	Si-mono	Model	JKM535M-72HL4-V
Custom parameters definition	Manufacturer	Jinkasolar	
Sub-array "Sub-array #1"	Orientation	#2	Tilt/Azimuth 15°/18°
Number of PV modules	In series	15 modules	In parallel 4 strings
Total number of PV modules	Nb. modules	60	Unit Nom. Power 535 Wp
Array global power	Nominal (STC)	32.1 kWp	At operating cond. 29.33 kWp (50°C)
Array operating characteristics (50°C)	U opp	556 V	I opp 53 A
Sub-array "Sub-array #2"	Orientation	#1	Tilt/Azimuth 20°/18°
Number of PV modules	In series	15 modules	In parallel 2 strings
Total number of PV modules	Nb. modules	30	Unit Nom. Power 535 Wp
Array global power	Nominal (STC)	16.05 kWp	At operating cond. 14.66 kWp (50°C)
Array operating characteristics (50°C)	U opp	556 V	I opp 28 A
Sub-array "Sub-array #3"	Orientation	#1	Tilt/Azimuth 20°/18°
Number of PV modules	In series	11 modules	In parallel 4 strings
Total number of PV modules	Nb. modules	44	Unit Nom. Power 535 Wp
Array global power	Nominal (STC)	23.54 kWp	At operating cond. 21.51 kWp (50°C)
Array operating characteristics (50°C)	U opp	407 V	I opp 53 A
Sub-array "Sub-array #4"	Orientation	#1	Tilt/Azimuth 20°/18°
Number of PV modules	In series	12 modules	In parallel 2 strings
Total number of PV modules	Nb. modules	24	Unit Nom. Power 535 Wp
Array global power	Nominal (STC)	12.84 kWp	At operating cond. 11.73 kWp (50°C)
Array operating characteristics (50°C)	U opp	445 V	I opp 26 A
Total	Arrays global power	Nominal (STC)	85 kWp
	Module area		407 m ²
		Total	158 modules
		Cell area	259 m ²

Grid-Connected System: Simulation parameters

Sub-array "Sub-array #1" : Inverter		Model	SG30KTL-M	
Original PVsyst database		Manufacturer	Sungrow	
Characteristics	Operating Voltage	280-950 V	Unit Nom. Power	30.0 kWac
Inverter pack	Nb. of inverters	2 * MPPT 50 %	Total Power	30 kWac
			Efficiency ratio	1.07
Sub-array "Sub-array #2" : Inverter		Model	SG15KTL	
Original PVsyst database		Manufacturer	Sungrow	
Characteristics	Operating Voltage	380-800 V	Unit Nom. Power	15.0 kWac
Inverter pack	Nb. of inverters	2 * MPPT 50 %	Total Power	15.0 kWac
			Efficiency ratio	1.07
Sub-array "Sub-array #3" : Inverter		Model	TRIO-20.0-TL-OUTD-400	
Original PVsyst database		Manufacturer	ABB	
Characteristics	Operating Voltage	200-950 V	Unit Nom. Power	22.0 kWac
Inverter pack	Nb. of inverters	2 * MPPT 50 %	Total Power	22 kWac
			Efficiency ratio	1.07
Sub-array "Sub-array #4" : Inverter		Model	PVI-12.5-TL-OUTD	
Original PVsyst database		Manufacturer	ABB	
Characteristics	Operating Voltage	175-850 V	Unit Nom. Power	12.5 kWac
Inverter pack	Nb. of inverters	2 * MPPT 50 %	Total Power	12.5 kWac
			Efficiency ratio	1.03
Total	Nb. of inverters	4	Total Power	80 kWac

PV Array loss factors

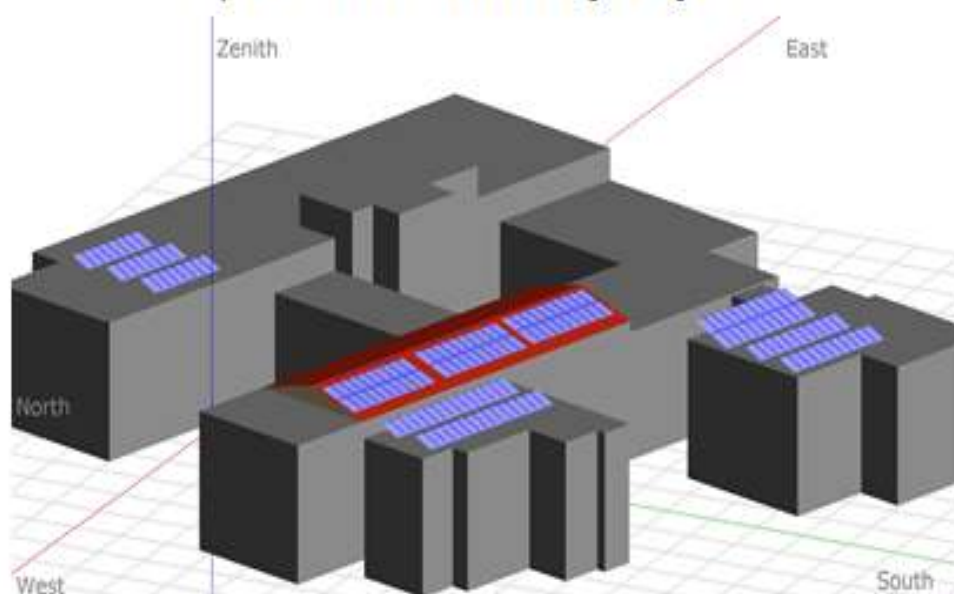
Array Soiling Losses		Loss Fraction	3.0 %
Thermal Loss factor	U_c (const) 20.0 W/m ² K	U_x (wind)	0.0 W/m ² K / m/s
Wiring Ohmic Loss	Array#1 174 Ω/Box	Loss Fraction	1.5 % at STC
	Array#2 347 Ω/Box	Loss Fraction	1.5 % at STC
	Array#3 127 Ω/Box	Loss Fraction	1.5 % at STC
	Array#4 278 Ω/Box	Loss Fraction	1.5 % at STC
	Global	Loss Fraction	1.5 % at STC
Module Quality Loss		Loss Fraction	-0.8 %
Module Mismatch Losses		Loss Fraction	1.0 % at MPP
Strings Mismatch loss		Loss Fraction	0.10 %
Incidence effect, ASHRAE parameterization	IAM = $1 - b_0 (1/\cos i - 1)$	b0 Param.	0.05
Unavailability of the system	7.3 days, 3 periods	Time fraction	2.0 %

Grid-Connected System: Near shading definition

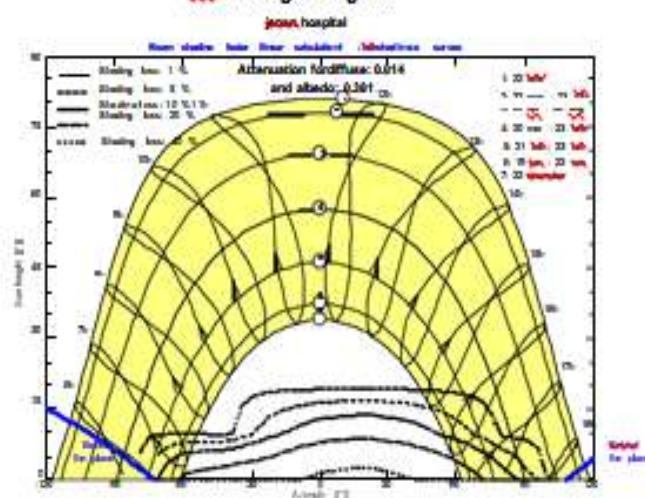
Project: jenen hospital
Simulation variant: New simulation variant

Main system parameters	System type	Sheds on a building	
Near Shadings	Detailed electrical calculation	(acc. to module layout)	
PV Field Orientation	2 orientations	Tilt/Azimuth = 20°/18° and 15°/18°	
PV modules	Model	JKM535M-72HL4-V	Power: 535 Wp
PV Array	Nb. of modules	158	Power total: 84.5 kWp
Inverter	Model	SG30KTL-M	Power: 30.0 kW ac
Inverter	Model	SG15KTL	Power: 15.00 kW ac
Inverter	Model	TRIO 20.0-TL-OUTD-400	Power: 22.00 kW ac
Inverter	Model	PVI-12.5-TL-OUTD	Power: 12.50 kW ac
Inverter pack	Nb. of units	4.0	Power total: 79.5 kW ac
User's needs	Unlimited load (grid)		

Perspective of the PV-field and surrounding shading scene



Geo-shading diagram



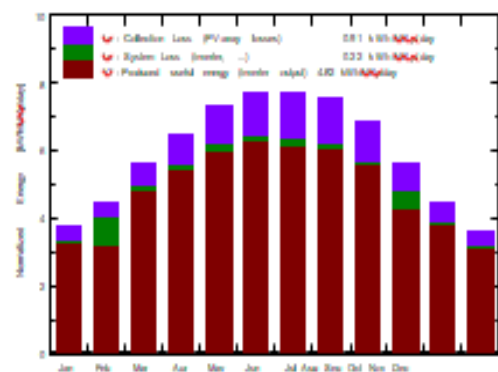
Grid-Connected System: Main results

Project: jenen hospital
Simulation variant: **New simulation variant**

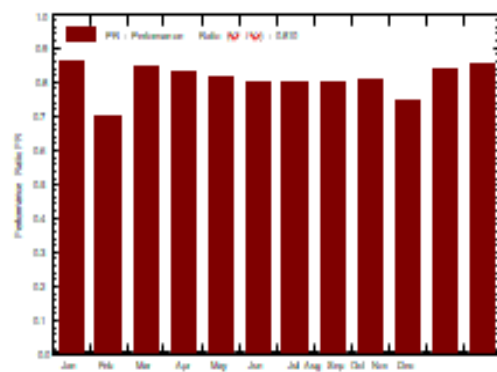
Main system parameters	System type	Sheds on a building	
Near Shadings	Detailed electrical calculation	(acc. to module layout)	
PV Field Orientation	2 orientations	Tilt/Azimuth = 20°/18° and 15°/18°	
PV modules	Model	JKM535M-72HL4-V	E_{array} 535 Wp
PV Array	Nb. of modules	158	E_{array} total 84.5 kWp
Inverter	Model	SG30KTL-M	E_{inv} 30.0 kW ac
Inverter	Model	SG15KTL	E_{inv} 15.00 kW ac
Inverter	Model	TRIO-20.0-TL-OUTD-400	E_{inv} 22.00 kW ac
Inverter	Model	PVI-12.5-TL-OUTD	E_{inv} 12.50 kW ac
Inverter pack	Nb. of units	4.0	E_{inv} total 79.5 kW ac
User's needs	Unlimited load (grid)		

Main simulation results
 System Production **Produced Energy 148804 kWh/year** Specific prod. 1760 kWh&Wp/year
Performance Ratio PR 80.98 %

Normalized productions (per installed kWp): Nominal power 84.5 kWp.



Performance Ratio PR



New simulation variant
Balances and main results



	G_{tot}H_{tot} kWh/m ²	G_{tot}D_{tot} kWh/m ²	T_{a,Amb} °C	G_{tot}I_{tot} kWh/m ²	G_{tot}E_{tot} kWh/m ²	E_{array} kWh	E_{inj,Grid} kWh	PR
January	89.0	34.58	12.63	116.8	109.0	8740	8528	0.864
February	104.8	48.28	13.62	127.2	119.0	9511	7628	0.790
March	155.6	56.61	16.66	178.3	164.6	12867	12542	0.946
April	185.1	72.76	19.40	198.5	183.3	14147	13793	0.899
May	225.3	71.18	22.74	227.3	213.4	16147	15746	0.819
June	241.3	80.04	26.66	232.7	216.8	16301	15884	0.807
July	244.6	80.17	28.13	238.6	224.3	16552	16127	0.800
August	226.2	85.29	28.38	233.8	221.1	16213	15800	0.800
September	184.5	48.01	26.17	204.6	192.5	14378	14016	0.811
October	146.0	44.09	21.75	176.4	168.3	12888	11197	0.791
November	103.6	36.66	18.96	134.5	128.0	9815	8570	0.842
December	84.0	36.22	14.68	111.3	103.6	8286	8077	0.858
Year	1994.8	619.96	20.94	2173.9	2090.8	155548	148804	0.810

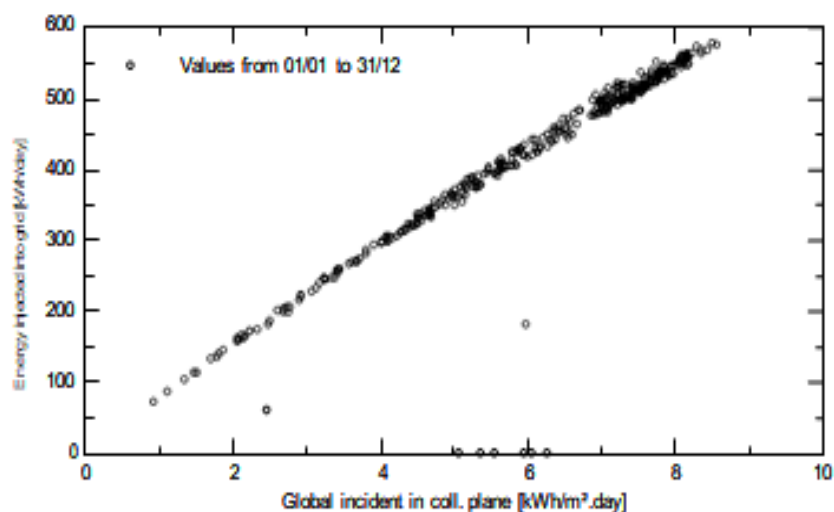
Legends: G_{tot}H_{tot} Horizontal global irradiation G_{tot}E_{tot} Effective Global, corr. for IAM and shadings
G_{tot}D_{tot} Horizontal diffuse irradiation E_{array} Effective energy at the output of the array
T_{a,Amb} Ambient Temperature E_{inj,Grid} Energy injected into grid
G_{tot}I_{tot} Global incident in coll. plane PR Performance Ratio

Grid-Connected System: Special graphs

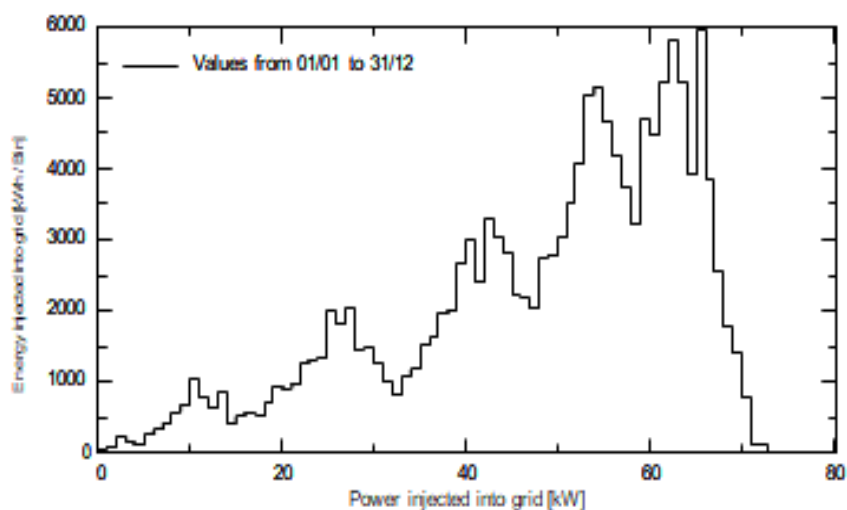
Project: jenen hospital
Simulation variant: **New simulation variant**

Main system parameters	System type	Sheds on a building	
Near Shadings	Detailed electrical calculation	(acc. to module layout)	
PV Field Orientation	2 orientations	Tilt/Azimuth = 20°/18° and 15°/18°	
PV modules	Model	JKM535M-72HL4-V	Power 535 Wp
PV Array	Nb. of modules	158	Power total 84.5 kWp
Inverter	Model	SG30KTL-M	Power 30.0 kW ac
Inverter	Model	SG15KTL	Power 15.00 kW ac
Inverter	Model	TRIO-20.0-TL-OUTD-400	Power 22.00 kW ac
Inverter	Model	PVI-12.5-TL-OUTD	Power 12.50 kW ac
Inverter pack	Nb. of units	4.0	Power total 79.5 kW ac
User's needs	Unlimited load (grid)		

Daily Input/Output diagram



System Output Power Distribution

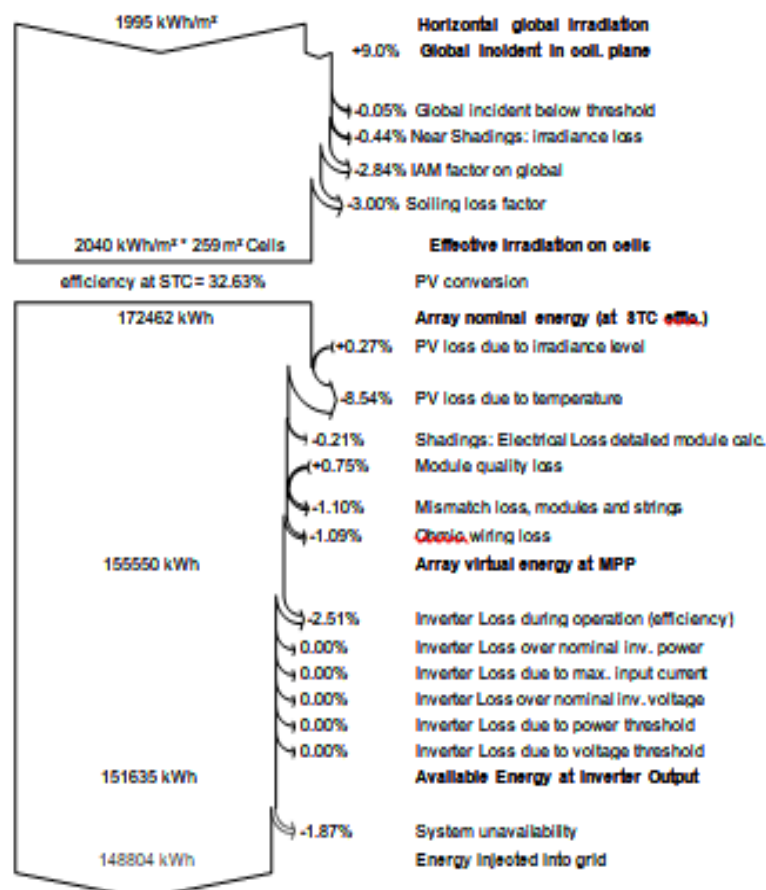


Grid-Connected System: Loss diagram

Project: jenen hospital
Simulation variant: New simulation variant

Main system parameters	System type	Sheds on a building
Near Shadings	Detailed electrical calculation	(acc. to module layout)
PV Field Orientation	2 orientations	Tilt/Azimuth = 20°/18° and 15°/18°
PV modules	Model	JKM535M-72HL4-V Eppm 535 Wp
PV Array	Nb. of modules	158 Eppm total 84.5 kWp
Inverter	Model	SG30KTL-M Eppm 30.0 kW ac
Inverter	Model	SG15KTL Eppm 15.00 kW ac
Inverter	Model	TRIO-20.0-TL-OUTD-400 Eppm 22.00 kW ac
Inverter	Model	PVI-12.5-TL-OUTD Eppm 12.50 kW ac
Inverter pack	Nb. of units	4.0 Eppm total 79.5 kW ac
User's needs	Unlimited load (grid)	

Loss diagram over the whole year



Appendix B

The Results of Applying the Appropriate Standard Lighting

Place	Existing Condition						Measured (LUX)	Standard (LUX)	Recommended Condition			Saving	
	Type	Number Of lamp	Power Rating (W)	Annual operation hours	Load (kW)	Consumption (kWh)			Removed Lamps	Load (kW)	Consumption (kWh)	Load (kW)	Consumption (kWh)
Old part													
Waiting	LED	3	45	4000	0.135	540	250	200	0.0	0.135	540	0	0
Corridor	FL	36	36	3000	1.296	3888	175	150	5.0	1.116	3348	0.18	540
storehouse	FL	24	36	3000	0.864	2592	230	200	5.0	0.684	2052	0.18	540
Corridor	FL	10	36	3000	0.36	1080	100	150	0.0	0.36	1080	0	0
Office	FL	12	36	3000	0.432	1296	180	400	0.0	0.432	1296	0	0
Office	FL	16	36	3000	0.576	1728	250	400	0.0	0.576	1728	0	0
Office	FL	16	36	3000	0.576	1728	300	400	0.0	0.576	1728	0	0
Office	FL	16	36	3000	0.576	1728	480	400	2.0	0.504	1512	0.072	216
storehouse	FL	9	36	3000	0.324	972	300	300	0.0	0.324	972	0	0
storehouse	FL	20	36	3000	0.72	2160	300	300	0.0	0.72	2160	0	0
pharmacy	FL	16	36	3000	0.576	1728	105	300	0.0	0.576	1728	0	0
Office	LED	8	18	3000	0.144	432	300	400	0.0	0.144	432	0	0
storehouse	FL	20	36	3000	0.72	2160	232	300	0.0	0.72	2160	0	0
Corridor	LED	10	45	8000	0.45	3600	400	150	6.0	0.18	1440	0.27	2160
laboratory 104	LED	6	45	8000	0.27	2160	870	600	1.0	0.225	1800	0.045	360
laboratory 105	LED	4	45	8000	0.18	1440	1013	600	1.0	0.135	1080	0.045	360
Office	LED	2	45	8000	0.09	720	550	400	0.0	0.09	720	0	0
Staff rooms	LED	4	45	8000	0.18	1440	717	300	2.0	0.09	720	0.09	720
blood bank	LED	8	45	8000	0.36	2880	550	500	0.0	0.36	2880	0	0

Place	Existing Condition						Measured (LUX)	Standard (LUX)	Recommended Condition			Saving	
	Type	Number Of lamp	Power Rating (W)	Annual operation hours	Load (kW)	Consumption (kWh)			Removed Lamps	Load (kW)	Consumption (kWh)	Load (kW)	Consumption (kWh)
blood donation rooms	LED	5	45	8000	0.225	1800	943	300	3.0	0.09	720	0.135	1080
laboratory 101	LED	11	45	8000	0.495	3960	744	600	2.0	0.405	3240	0.09	720
Orthopedic department													
Patient Room 201	FL	6	36	5500	0.216	1188	240	200	1.0	0.18	990	0.036	198
Patient Room 202	FL	12	36	5500	0.432	2376	400	200	6.0	0.216	1188	0.216	1188
Patient Room 203	LED	2	18	5500	0.036	198	400	200	1.0	0.018	99	0.018	99
Patient Room 204	FL	16	36	5500	0.576	3168	135	200	0.0	0.576	3168	0	0
Patient Room 205	FL	20	36	5500	0.72	3960	135	200	0.0	0.72	3960	0	0
Patient Room 206	FL	24	36	5500	0.864	4752	280	200	6.0	0.648	3564	0.216	1188
Patient Room 207	LED	24	18	5500	0.432	2376	500	200	14.0	0.18	990	0.252	1386
Patient Room 208	FL	12	36	5500	0.432	2376	375	200	5.0	0.252	1386	0.18	990
Patient Room 209	LED	4	45	5500	0.18	990	640	200	2.0	0.09	495	0.09	495
Patient Room 210	FL	12	36	5500	0.432	2376	320	200	4.0	0.288	1584	0.144	792
corridor	FL	20	36	3000	0.72	2160	245	150	7.0	0.468	1404	0.252	756
WC1	FL	4	36	3000	0.144	432	166	150	0.0	0.144	432	0	0
WC2	FL	4	36	3000	0.144	432	170	150	0.0	0.144	432	0	0
children section													
Reception	FL	8	36	3000	0.288	864	290	200	2.0	0.216	648	0.072	216
Corridor	LED	7+9	25+45	3000	1.12	3360	415	150	10.0	0.42	1260	0.7	2100
Patient Room 215	LED	5	45	5500	0.225	1237.5	400	200	2.0	0.135	742.5	0.09	495
Patient Room 216	LED	5	45	5500	0.225	1237.5	300	200	1.0	0.18	990	0.045	247.5
217 Nurse's Room	LED	4	45	8000	0.18	1440	300	200	1.0	0.135	1080	0.045	360
Patient Room 218	LED	2	45	5500	0.09	495	300	300	0.0	0.09	495	0	0
Patient Room 219	LED	5	45	5500	0.225	1237.5	500	200	3.0	0.09	495	0.135	742.5
Intensive care 214	LED	6	45	5500	0.27	1485	610	400	2.0	0.18	990	0.09	495

Place	Existing Condition						Measured (LUX)	Standard (LUX)	Recommended Condition			Saving	
	Type	Number Of lamp	Power Rating (W)	Annual operation hours	Load (kW)	Consumption (kWh)			Removed Lamps	Load (kW)	Consumption (kWh)	Load (kW)	Consumption (kWh)
Nurse's Room 220	LED	5	45	5500	0.225	1237.5	420	200	2.0	0.135	742.5	0.09	495
Patient Room 221	LED	5	45	5500	0.225	1237.5	310	200	1.0	0.18	990	0.045	247.5
Intensive care 222	FL	8	36	5500	0.288	1584	204	400	8.0	0	0	0.288	1584
Patient Room 223	LED	8	25	5500	0.2	1100	530	200	0.0	0	0	0.1245 28302	684.90 56604
Patient Room 224	LED	5	45	5500	0.225	1237.5	300	200	5.0	0.0754 71698	415.094 3396	0.09	495
W.C	LED	2	18	3000	0.036	108	178	150	2.0	0.135	742.5	0	0
Operations room	FL	28	36	8000	1.008	8064	300	400	0.0	0.036	108	0	0
Thalassemia department	FL	20	36	3000	0.72	2160	330	300	0.0	1.008	8064	0	0
Intensive care	FL	16	36	8000	0.576	4608	270	400	0.0	0.72	2160	0.252	2016
Corridor	FL	14	36	3000	0.504	1512	310	150	7.0	0.324	2592	0.504	1512
Department of Surgery - Women													
Patient Room 304	LED	5	45	5500	0.225	1237.5	375	200	2.0	0.135	742.5	0.09	495
Patient Room 305	LED	5	45	5500	0.225	1237.5	470	200	2.0	0.135	742.5	0.09	495
Patient Room 306	LED	4	45	5500	0.18	990	480	200	2.0	0.09	495	0.09	495
Patient Room 307	LED	5	45	5500	0.225	1237.5	480	200	2.0	0.135	742.5	0.09	495
Patient Room 308	LED	4	45	5500	0.18	990	500	200	2.0	0.09	495	0.09	495
Patient Room 309	LED	5	45	5500	0.225	1237.5	380	200	1.0	0.18	990	0.045	247.5
Doctor Room	LED	5	45	8000	0.225	1800	370	300	1.0	0.18	1440	0.045	360
medicine preparation	FL	8	36	5500	0.288	1584	700	300	3.0	0.18	990	0.108	594
Intensive care 303	LED	14	45	8000	0.63	5040	700	400	11.0	0.135	1080	0.495	3960

Place	Existing Condition						Measured (LUX)	Standard (LUX)	Recommended Condition			Saving	
	Type	Number Of lamp	Power Rating (W)	Annual operation hours	Load (kW)	Consumption (kWh)			Removed Lamps	Load (kW)	Consumption (kWh)	Load (kW)	Consumption (kWh)
W.C	LED	5	18	3000	0.09	270	165	150	0.0	0.09	270	0	0
Reception	FL	8	36	5500	0.288	1584	320	300	4.0	0.144	792	0.144	792
Corridor	FL	20	36	3000	0.72	2160	240	150	3.0	0.612	1836	0.108	324
Waiting	FL	28	36	3000	1.008	3024	90	200	0.0	1.008	3024	0	0
Department of Surgery - Men													
Patient Room 313	LED	5	45	5500	0.225	1237.5	308	200	1.0	0.18	990	0.045	247.5
Patient Room 314	LED	5	45	5500	0.225	1237.5	375	200	2.0	0.135	742.5	0.09	495
Patient Room 315	LED	5	45	5500	0.225	1237.5	375	200	2.0	0.135	742.5	0.09	495
Patient Room 316	LED	5	45	5500	0.225	1237.5	380	200	2.0	0.135	742.5	0.09	495
Patient Room 317	LED	5	45	5500	0.225	1237.5	375	200	2.0	0.135	742.5	0.09	495
Patient Room 318	LED	5	45	5500	0.225	1237.5	540	200	2.0	0.135	742.5	0.09	495
Doctor Room 319	LED	5	45	8000	0.225	1800	307	300	0.0	0.225	1800	0	0
Reception	FL	8	36	5500	0.288	1584	335	300	4.0	0.144	792	0.144	792
W.C	LED	7	18	3000	0.126	378	135	150	0	0.126	378	0	0
Corridor	FL	18	36	3000	0.648	1944	300	150	0.0	0.648	1944	0	0
New part												0	0
Emergency	FL	60	36	8000	2.16	17280	220	500	0.0	2.16	17280	0	0
surgery room	FL	16	36	5500	0.576	3168	260	400	0.0	0.576	3168	0	0
Doctor room	FL	24	36	4000	0.864	3456	370	300	4.5	0.7005 40541	2802.16 2162	0.1634 59459	653.83 78378
x_ray place													
Doctor Room	FL	8	36	3000	0.288	864	370	200	0.0	0.288	864	0	0
Office	FL	8	36	3000	0.288	864	430	400	0.0	0.288	864	0	0

Place	Existing Condition						Measured (LUX)	Standard (LUX)	Recommended Condition			Saving	
	Type	Number Of lamp	Power Rating (W)	Annual operation hours	Load (kW)	Consumption (kWh)			Removed Lamps	Load (kW)	Consumption (kWh)	Load (kW)	Consumption (kWh)
Office	FL	16	36	3000	0.576	1728	540	400	7.0	0.324	972	0.252	756
Office	LED	4	45	3000	0.18	540	600	400	1.0	0.135	405	0.045	135
X-ray hall	LED	1	45	3000	0.045	135	150	300	0.0	0.045	135	0	0
Office	FL	6	36	3000	0.216	648	300	400	0.0	0.216	648	0	0
MRI room	LED	4	45	4000	0.18	720	740	400	2.4	0.0729 72973	291.891 8919	0.1070 27027	428.10 81081
Waiting	FL	20	36	4000	0.72	2880	400	300	0.0	0.72	2880	0	0
Accounting Department													
Office	FL	14	36	3000	0.504	1512	400	400	0.0	0.504	1512	0	0
accounting fund	FL	10	36	3000	0.36	1080	450	400	1.0	0.324	972	0.036	108
archives	FL	14	36	3000	0.504	1512	758	400	10.0	0.144	432	0.36	1080
pharmacy	FL	12	36	3000	0.432	1296	600	400	6.0	0.216	648	0.216	648
esoteric women													
Corridor	FL	12	36	5500	0.432	2376	400	150	6.0	0.216	1188	0.216	1188
Doctor Room 108	FL	8	36	5500	0.288	1584	300	300	2.0	0.216	1188	0.072	396
Patient Room 109	FL	8	36	5500	0.288	1584	300	200	2.0	0.216	1188	0.072	396
Patient Room 110	FL	10	36	5500	0.36	1980	190	200	0.0	0.36	1980	0	0
Patient Room 111	FL	12	36	5500	0.432	2376	600	200	8.0	0.144	792	0.288	1584
Patient Room 112	FL	12	36	5500	0.432	2376	672	200	8.0	0.144	792	0.288	1584
Patient Room 113	FL	14	36	5500	0.504	2772	620	200	7.0	0.252	1386	0.252	1386
Patient Room 114	FL	8	36	5500	0.288	1584	240	200	0.0	0.288	1584	0	0
Reception	LED	4	18	3000	0.072	216	100	300	0.0	0.072	216	0	0
Nurse's Room	FL	4	36	3000	0.144	432	250	300	0.8	0.1152	345.6	0.0288	86.4
medicine preparation	FL	8	36	5500	0.288	1584	250	300	1.0	0.252	1386	0.036	198

Place	Existing Condition						Measured (LUX)	Standard (LUX)	Recommended Condition			Saving	
	Type	Number Of lamp	Power Rating (W)	Annual operation hours	Load (kW)	Consumption (kWh)			Removed Lamps	Load (kW)	Consumption (kWh)	Load (kW)	Consumption (kWh)
esoteric men													
Patient Room 101	FL	12	36	5500	0.432	2376	400	200	6.0	0.216	1188	0.216	1188
Patient Room 102	FL	12	36	5500	0.432	2376	450	200	6.0	0.216	1188	0.216	1188
Patient Room 103	FL	8	36	5500	0.288	1584	200	200	0.0	0.288	1584	0	0
Patient Room 104	FL	10	36	5500	0.36	1980	200	200	0.0	0.36	1980	0	0
Patient Room 105	FL	20	36	5500	0.72	3960	228	200	2.0	0.648	3564	0.072	396
Patient Room 106	FL	20	36	5500	0.72	3960	140	200	0.0	0.72	3960	0	0
Patient Room 107	FL	8	36	5500	0.288	1584	425	200	2.0	0.216	1188	0.072	396
medicine preparation	LED	2	18	5500	0.036	198	122	300	0.0	0.036	198	0	0
Reception	FL	4	36	3000	0.144	432	240	300	0.0	0.144	432	0	0
sterilization	FL	64	36	5500	2.304	12672	335	300	6.7	2.0632	11348.0	0.2407	1323.9
Office	LED	8	18	5500	0.144	792	285	400	0.0	0.144	83582	16418	40299
Kidney Department													
Patient Room 1	FL	8	36	5500	0.288	1584	145	300	0.0	0.288	1584	0	0
Patient Room 2	FL	68	36	5500	2.448	13464	270	300	0.0	2.448	13464	0	0
Patient Room 3	FL	32	36	5500	1.152	6336	380	300	0.0	1.152	6336	0	0
Office	FL	4	36	5500	0.144	792	250	400	0.0	0.144	792	0	0
Office	FL	8	36	3000	0.288	864	210	400	0.0	0.288	864	0	0
Doctor Room	FL	8	36	5500	0.288	1584	266	300	3.0	0.18	990	0.108	594
Doctor Room	FL	8	36	5500	0.288	1584	55	200	0.0	0.288	1584	0	0
Corridor	FL	18	36	5500	0.648	3564	70	150	0.0	0.648	3564	0	0
Cancer Department	FL	68	36	3000	2.448	7344	610	300	23.0	1.62	4860	0.828	2484
Operations room	LED	64	18	8000	1.152	9216	860	400	41.0	0.414	3312	0.738	5904
Office	FL	8	36	8000	0.288	2304	264	400	0.0	0.288	2304	0	0

Place	Existing Condition						Measured (LUX)	Standard (LUX)	Recommended Condition			Saving	
	Type	Number Of lamp	Power Rating (W)	Annual operation hours	Load (kW)	Consumption (kWh)			Removed Lamps	Load (kW)	Consumption (kWh)	Load (kW)	Consumption (kWh)
nursery 1 isolation rooms	LED	2	45	8000	0.09	720	240	300	0.0	0.09	720	0	0
nursery 2	LED	13	45	8000	0.585	4680	300	300	0.0	0.585	4680	0	0
Corridor	LED	4	45	4000	0.18	720	250	150	0.8	0.144	576	0.036	144
Nursing rooms	LED	2	45	4000	0.09	360	280	300	0.0	0.09	360	0	0
Nurses Room	LED	2	45	5500	0.09	495	205	300	0.0	0.09	495	0	0
Bleeding and childbirth department													
Patient Room 201	FL	12	36	5500	0.432	2376	215	300	0.0	0.432	2376	0	0
Patient Room 202	FL	8	36	5500	0.288	1584	180	300	0.0	0.288	1584	0	0
Patient Room 203	FL	20	36	5500	0.72	3960	172	300	0.0	0.72	3960	0	0
medicine preparation storehouse	FL	28	36	5500	1.008	5544	410	300	7.0	0.756	4158	0.252	1386
Patient Room 205	FL	10	36	5500	0.36	1980	390	300	2.0	0.288	1584	0.072	396
Doctor Room 206	FL	8	36	5500	0.288	1584	450	300	2.0	0.216	1188	0.072	396
Patient Room 207	FL	8	36	5500	0.288	1584	300	300	2.7	0.192	1056	0.096	528
Patient Room 208	FL	10	36	5500	0.36	1980	550	300	4.0	0.216	1188	0.144	792
Patient Room 209	FL	16	36	5500	0.576	3168	185	300	0.0	0.576	3168	0	0
Patient Room 210	FL	16	36	5500	0.576	3168	228	300	0.0	0.576	3168	0	0
211 Patient Room	FL	10	36	7000	0.36	2520	865	300	6.0	0.144	1008	0.216	1512
Nurses Room	FL	8	36	5500	0.288	1584	280	300	0.0	0.288	1584	0	0
Doctor Room	FL	6	36	5500	0.216	1188	195	300	0.0	0.216	1188	0	0
Nurses Room	FL	4	36	5500	0.144	792	200	300	0.0	0.144	792	0	0
Nurse's Room	FL	8	36	5500	0.288	1584	130	300	0.0	0.288	1584	0	0

Place	Existing Condition						Measured (LUX)	Standard (LUX)	Recommended Condition			Saving	
	Type	Number Of lamp	Power Rating (W)	Annual operation hours	Load (kW)	Consumption (kWh)			Removed Lamps	Load (kW)	Consumption (kWh)	Load (kW)	Consumption (kWh)
medicine preparation	FL	4	36	5500	0.144	792	350	300	2.0	0.072	396	0.072	396
medicine preparation	LED	1	45	5500	0.045	247.5	400	400	0.0	0.045	247.5	0	0
review room	LED	12	18	3000	0.216	648	260	300	2.0	0.18	540	0.036	108
Patient Room	FL	45	36	3000	1.62	4860	227	300	15.0	1.08	3240	0.54	1620
Doctor Room	FL	4	36	3000	0.144	432	287	300	1.0	0.108	324	0.036	108
Corridor	FL	6	36	3000	0.216	648	850	150	4.0	0.072	216	0.144	432
Corridor	FL	8	36	3000	0.288	864	200	150	2.0	0.216	648	0.072	216
Corridor	FL	16	36	3000	0.576	1728	131	150	0.0	0.576	1728	0	0
Corridor	LED	6	18	3000	0.108	324	300	200	2.0	0.072	216	0.036	108
Corridor	LED	64	18	3000	1.152	3456	300	150	32.0	0.576	1728	0.576	1728
Corridor	LED	66	18	3000	1.188	3564	343	150	37.0	0.522	1566	0.666	1998

Appendix C

The Results of Rationalizing Energy Consumption in the Systems Inside the Hospital

Annual Cost Summary

Jenin Governmental Hospital-final - final 11/01/2022

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Table 1: Annual Costs

Component	heating and cooling system (NIS)	new heating system (NIS)	new ecounmizer system (NIS)	old cooling system (NIS)	old heating system (NIS)
Air System Fans	0	0	16,023	27,329	0
Cooling	607,986	0	400,891	709,230	0
Heating	30,843	121,884	0	0	135,055
Pumps	0	16,819	58,647	116,840	16,819
Heat Rejection Fans	0	0	93,661	192,381	0
HVAC Sub-Total	638,829	138,703	569,223	1,045,780	151,875
Lights	197,036	151	197,036	197,036	151
Electric Equipment	161,212	18,922	161,212	161,212	18,922
Misc. Electric	0	0	0	0	0
Misc. Fuel Use	0	0	0	0	0
Non-HVAC Sub-Total	358,247	19,073	358,247	358,247	19,073
Grand Total	997,076	157,776	927,470	1,404,028	170,948

Table 2: Annual Cost per Unit Floor Area

Component	heating and cooling system (NIS/m ²)	new heating syestem (NIS/m ²)	new econumizer system (NIS/m ²)	old cooling system (NIS/m ²)	old heating syestem (NIS/m ²)
Air System Fans	0.000	0.000	0.564	0.962	0.000
Cooling	21.408	0.000	14.116	24.973	0.000
Heating	1.086	17.167	0.000	0.000	19.022
Pumps	0.000	2.369	2.065	4.114	2.369
Heat Rejection Fans	0.000	0.000	3.298	6.774	0.000
HVAC Sub-Total	22.494	19.536	20.043	36.823	21.391
Lights	6.938	0.021	6.938	6.938	0.021
Electric Equipment	5.677	2.665	5.677	5.677	2.665
Misc. Electric	0.000	0.000	0.000	0.000	0.000
Misc. Fuel Use	0.000	0.000	0.000	0.000	0.000
Non-HVAC Sub-Total	12.614	2.686	12.614	12.614	2.686
Grand Total	35.108	22.222	32.658	49.438	24.077
Gross Floor Area (m ²)	7100.0	7100.0	7100.0	7100.0	7100.0
Conditioned Floor Area (m ²)	7100.0	7100.0	7100.0	7100.0	7100.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3: Component Cost as a Percentage of Total Cost

Component	heating and cooling system (%)	new heating system (%)	new economizer system (%)	old cooling system (%)	old heating system (%)
Air System Fans	0.0	0.0	1.7	1.9	0.0
Cooling	61.0	0.0	43.2	50.5	0.0
Heating	3.1	77.3	0.0	0.0	79.0
Pumps	0.0	10.7	6.3	8.3	9.8
Heat Rejection Fans	0.0	0.0	10.1	13.7	0.0
HVAC Sub-Total	64.1	87.9	61.4	74.5	88.8
Lights	19.8	0.1	21.2	14.0	0.1
Electric Equipment	16.2	12.0	17.4	11.5	11.1
Misc. Electric	0.0	0.0	0.0	0.0	0.0
Misc. Fuel Use	0.0	0.0	0.0	0.0	0.0
Non-HVAC Sub-Total	35.9	12.1	38.6	25.5	11.2
Grand Total	100.0	100.0	100.0	100.0	100.0

Annual Energy and Emissions Summary

Jenin Governmental Hospital-final - final

11/01/2022

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Table 1: Annual Costs

Component	heating and cooling system (NIS)	new heating system (NIS)	new economizer system (NIS)	old cooling system (NIS)	old heating system (NIS)
HVAC Components					
Electric	638,829	78,262	569,227	1,045,765	78,262
Natural Gas	0	0	0	0	0
Fuel Oil	0	60,441	0	0	73,613
Propane	0	0	0	0	0
Remote HW	0	0	0	0	0
Remote Steam	0	0	0	0	0
Remote CW	0	0	0	0	0
HVAC Sub-Total	638,829	138,703	569,227	1,045,765	151,874
Non-HVAC Components					
Electric	358,247	19,073	358,247	358,247	19,073
Natural Gas	0	0	0	0	0
Fuel Oil	0	0	0	0	0
Propane	0	0	0	0	0
Remote HW	0	0	0	0	0
Remote Steam	0	0	0	0	0
Non-HVAC Sub-Total	358,247	19,073	358,247	358,247	19,073
Grand Total	997,076	157,775	927,474	1,404,012	170,947

Table 2: Annual Energy Consumption

Component	heating and cooling system	new heating system	new economizer system	old cooling system	old heating system
HVAC Components					
Electric (kWh)	1,330,893	163,045	1,185,889	2,178,677	163,045
Natural Gas (na)	0	0	0	0	0
Fuel Oil (*)	0	12,088	0	0	14,723
Propane (na)	0	0	0	0	0
Remote HW (na)	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0
Remote CW (na)	0	0	0	0	0
Non-HVAC Components					
Electric (kWh)	746,348	39,735	746,348	746,348	39,735
Natural Gas (na)	0	0	0	0	0
Fuel Oil (*)	0	0	0	0	0
Propane (na)	0	0	0	0	0
Remote HW (na)	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0
Totals					
Electric (kWh)	2,077,242	202,780	1,932,237	2,925,026	202,780
Natural Gas (na)	0	0	0	0	0
Fuel Oil (*)	0	12,088	0	0	14,723
Propane (na)	0	0	0	0	0
Remote HW (na)	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0
Remote CW (na)	0	0	0	0	0

(*) Energy Units differ among Buildings.

Table 3: Annual Emissions

Component	heating and cooling system	new heating system	new economizer system	old cooling system	old heating system
CO2 Equivalent (kg)	0	0	0	0	0

Table 4: Annual Cost per Unit Floor Area

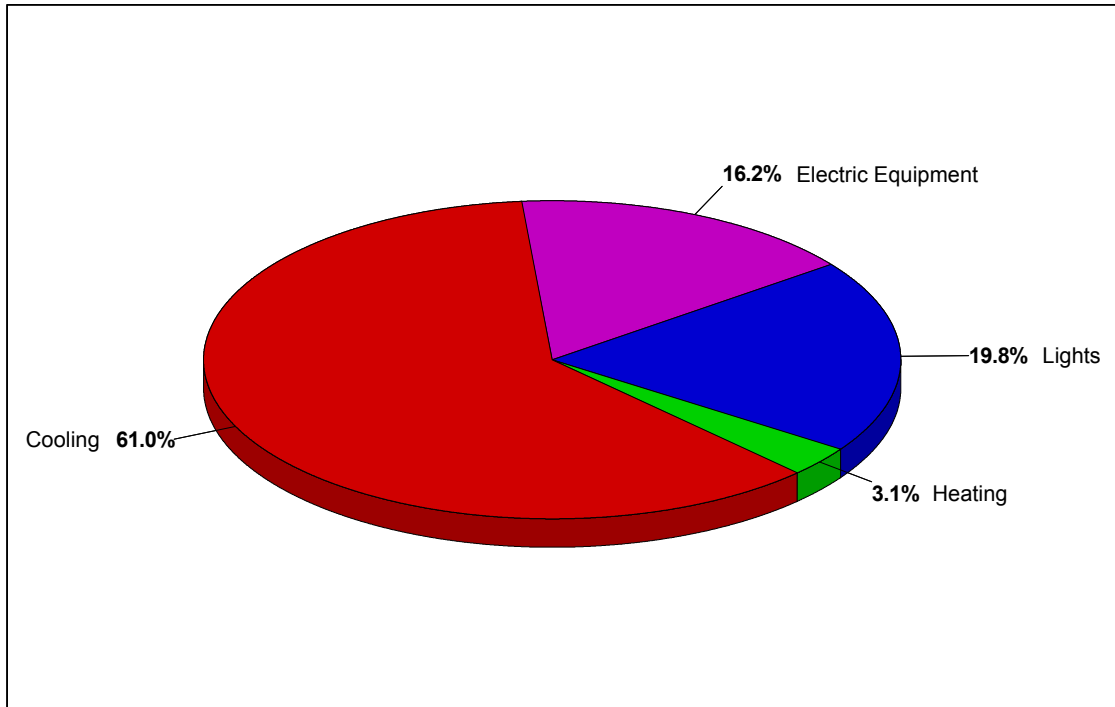
Component	heating and cooling system (NIS/m²)	new heating system (NIS/m²)	new economizer system (NIS/m²)	old cooling system (NIS/m²)	old heating system (NIS/m²)
HVAC Components					
Electric	22.494	11.023	20.043	36.823	11.023
Natural Gas	0.000	0.000	0.000	0.000	0.000
Fuel Oil	0.000	8.513	0.000	0.000	10.368
Propane	0.000	0.000	0.000	0.000	0.000
Remote HW	0.000	0.000	0.000	0.000	0.000
Remote Steam	0.000	0.000	0.000	0.000	0.000
Remote CW	0.000	0.000	0.000	0.000	0.000
HVAC Sub-Total	22.494	19.536	20.043	36.823	21.391
Non-HVAC Components					
Electric	12.614	2.686	12.614	12.614	2.686
Natural Gas	0.000	0.000	0.000	0.000	0.000
Fuel Oil	0.000	0.000	0.000	0.000	0.000
Propane	0.000	0.000	0.000	0.000	0.000
Remote HW	0.000	0.000	0.000	0.000	0.000
Remote Steam	0.000	0.000	0.000	0.000	0.000
Non-HVAC Sub-Total	12.614	2.686	12.614	12.614	2.686
Grand Total	35.108	22.222	32.658	49.437	24.077
Gross Floor Area (m ²)	28400.0	7100.0	28400.0	28400.0	7100.0
Conditioned Floor Area (m ²)	28400.0	7100.0	28400.0	28400.0	7100.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 5: Component Cost as a Percentage of Total Cost

Component	heating and cooling system (%)	new heating system (%)	new economizer system (%)	old cooling system (%)	old heating system (%)
HVAC Components					
Electric	64.1	49.6	61.4	74.5	45.8
Natural Gas	0.0	0.0	0.0	0.0	0.0
Fuel Oil	0.0	38.3	0.0	0.0	43.1
Propane	0.0	0.0	0.0	0.0	0.0
Remote HW	0.0	0.0	0.0	0.0	0.0
Remote Steam	0.0	0.0	0.0	0.0	0.0
Remote CW	0.0	0.0	0.0	0.0	0.0
HVAC Sub-Total	64.1	87.9	61.4	74.5	88.8
Non-HVAC Components					
Electric	35.9	12.1	38.6	25.5	11.2
Natural Gas	0.0	0.0	0.0	0.0	0.0
Fuel Oil	0.0	0.0	0.0	0.0	0.0
Propane	0.0	0.0	0.0	0.0	0.0
Remote HW	0.0	0.0	0.0	0.0	0.0
Remote Steam	0.0	0.0	0.0	0.0	0.0
Non-HVAC Sub-Total	35.9	12.1	38.6	25.5	11.2
Grand Total	100.0	100.0	100.0	100.0	100.0

Annual Component Costs - heating and cooling system
Jenin Governmental Hospital-final - final **11/01/2022**
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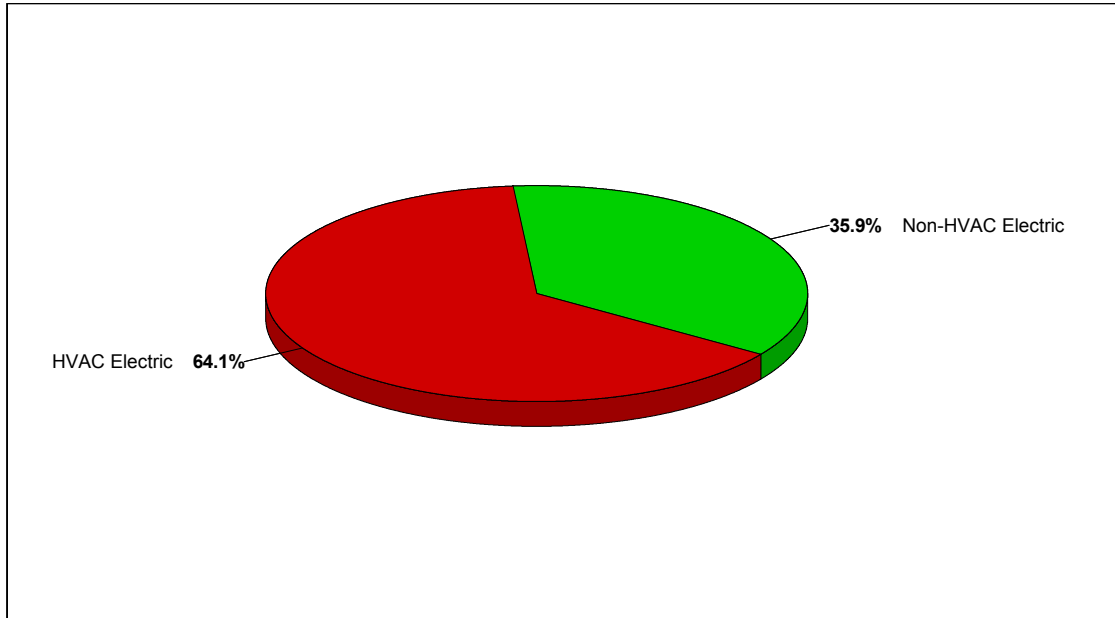
Component	Annual Cost (NIS)		Percent of Total (%)
Air System Fans	0	0.000	0.0
Cooling	607,986	21.408	61.0
Heating	30,843	1.086	3.1
Pumps	0	0.000	0.0
Heat Rejection Fans	0	0.000	0.0
HVAC Sub-Total	638,829	22.494	64.1e
Lights	197,036	6.938	19.8
Electric Equipment	161,212	5.677	16.2
Misc. Electric	0	0.000	0.0
Misc. Fuel Use	0	0.000	0.0
Non-HVAC Sub-Total	358,247	12.614	35.9
Grand Total	997,076	35.108	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual Energy Costs - heating and cooling system
Jenin Governmental Hospital-final - final **11/01/2022**
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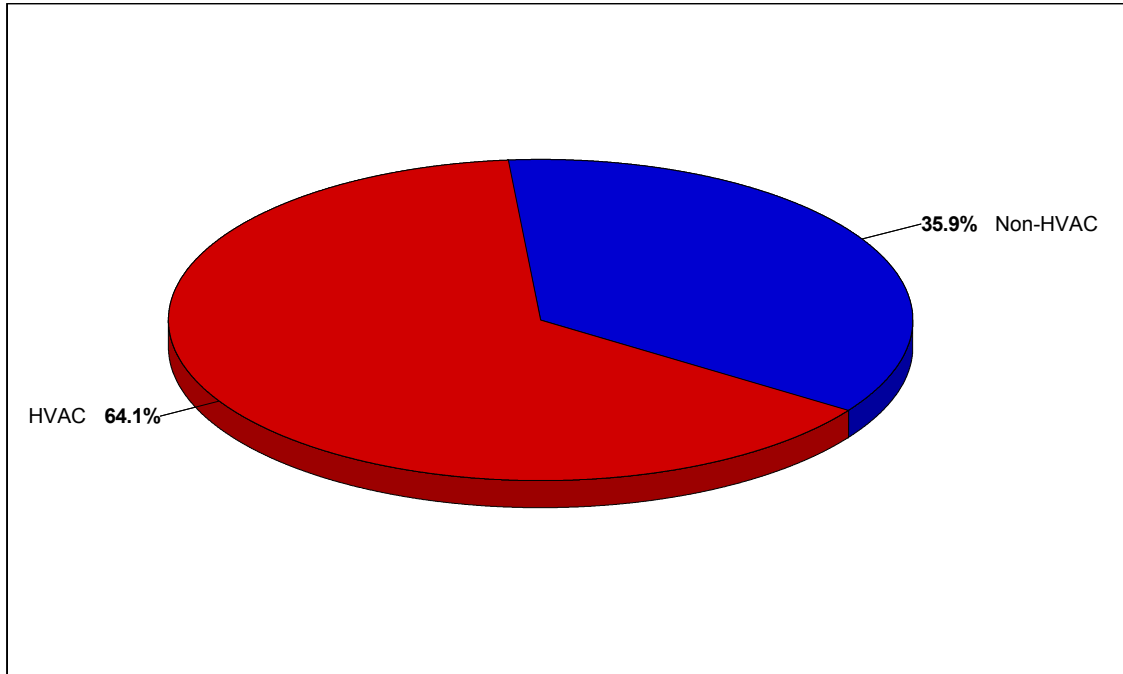
Component	Annual Cost (NIS/yr)	(NIS/m ²)	Percent of Total (%)
HVAC Components			
Electric	638,829	22.494	64.1
Natural Gas	0	0.000	0.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Remote Chilled Water	0	0.000	0.0
HVAC Sub-Total	638,829	22.494	64.1
Non-HVAC Components			
Electric	358,247	12.614	35.9
Natural Gas	0	0.000	0.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Non-HVAC Sub-Total	358,247	12.614	35.9
Grand Total	997,076	35.108	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual HVAC & Non-HVAC Cost Totals - heating and cooling system
Jenin Governmental Hospital-final - final **11/01/2022**
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1. Annual Costs

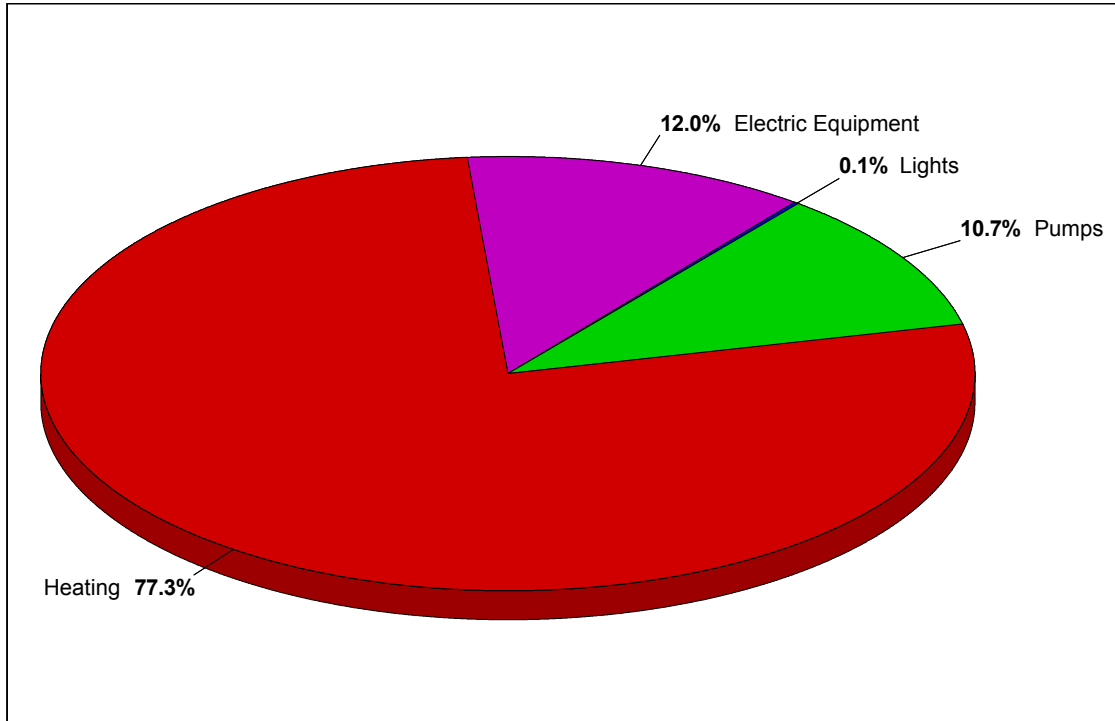
Component	Annual Cost (NIS/yr)	(NIS/m²)	Percent of Total (%)
HVAC	638,829	22.494	64.1
Non-HVAC	358,247	12.614	35.9
Grand Total	997,076	35.108	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual Component Costs - new heating system
Jenin Governmental Hospital-final - final **11/01/2022**
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1. Annual Costs

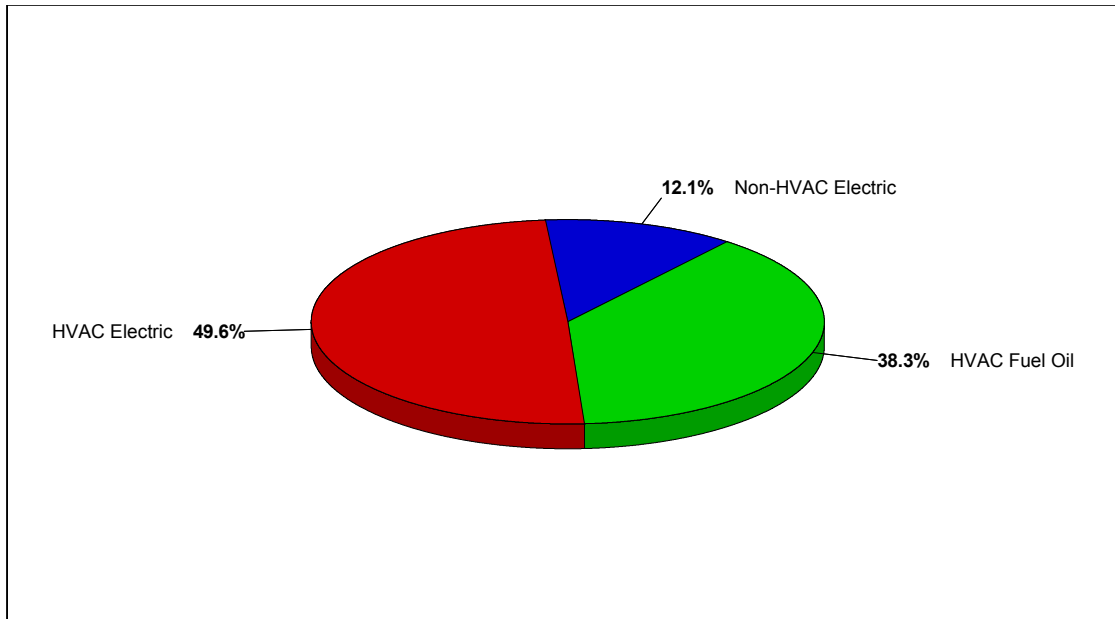
Component	Annual Cost (NIS)	(NIS/m ²)	Percent of Total (%)
Air System Fans	0	0.000	0.0
Cooling	0	0.000	0.0
Heating	121,884	17.167	77.3
Pumps	16,819	2.369	10.7
Heat Rejection Fans	0	0.000	0.0
HVAC Sub-Total	138,703	19.536	87.9
Lights	151	0.021	0.1
Electric Equipment	18,922	2.665	12.0
Misc. Electric	0	0.000	0.0
Misc. Fuel Use	0	0.000	0.0
Non-HVAC Sub-Total	19,073	2.686	12.1
Grand Total	157,776	22.222	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual Energy Costs - new heating system
Jenin Governmental Hospital-final - final **11/01/2022**
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1. Annual Costs

Component	Annual Cost (NIS/yr)	(NIS/m ²)	Percent of Total (%)
HVAC Components			
Electric	78,262	11.023	49.6
Natural Gas	0	0.000	0.0
Fuel Oil	60,441	8.513	38.3
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Remote Chilled Water	0	0.000	0.0
HVAC Sub-Total	138,703	19.536	87.9
Non-HVAC Components			
Electric	19,073	2.686	12.1
Natural Gas	0	0.000	0.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Non-HVAC Sub-Total	19,073	2.686	12.1
Grand Total	157,775	22.222	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

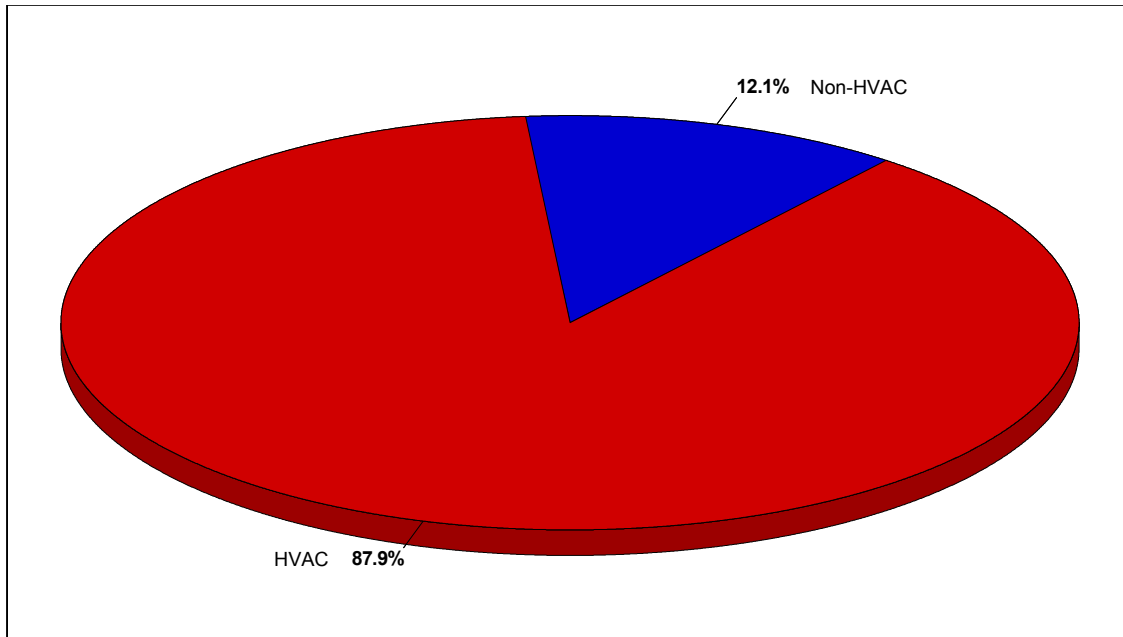
Annual HVAC & Non-HVAC Cost Totals - new heating system

Jenin Governmental Hospital-final - final

11/01/2022

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1. Annual Costs

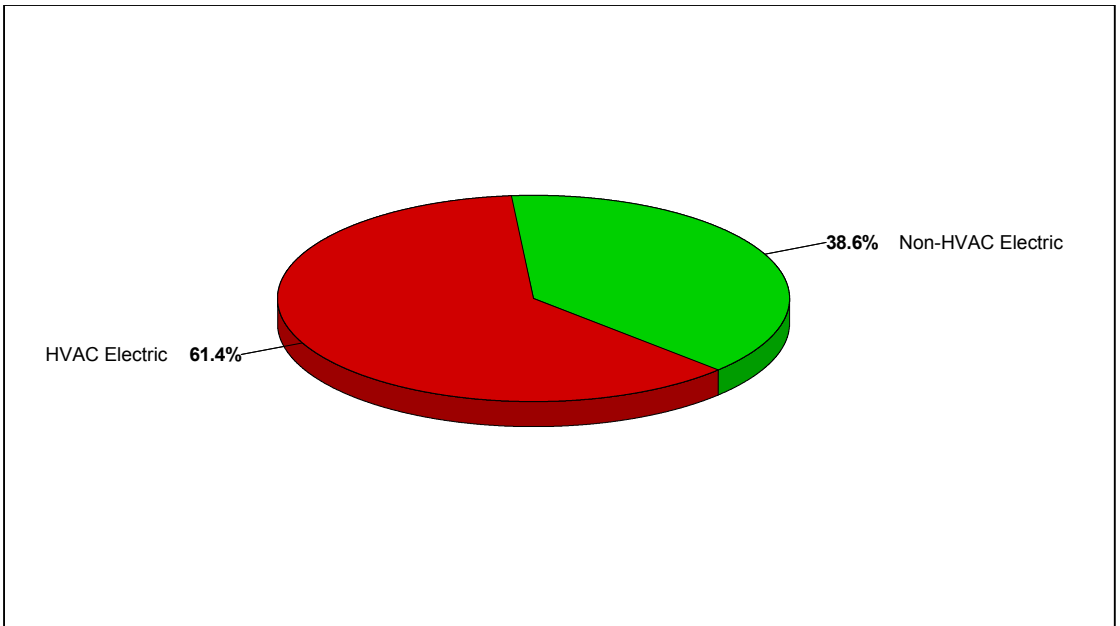
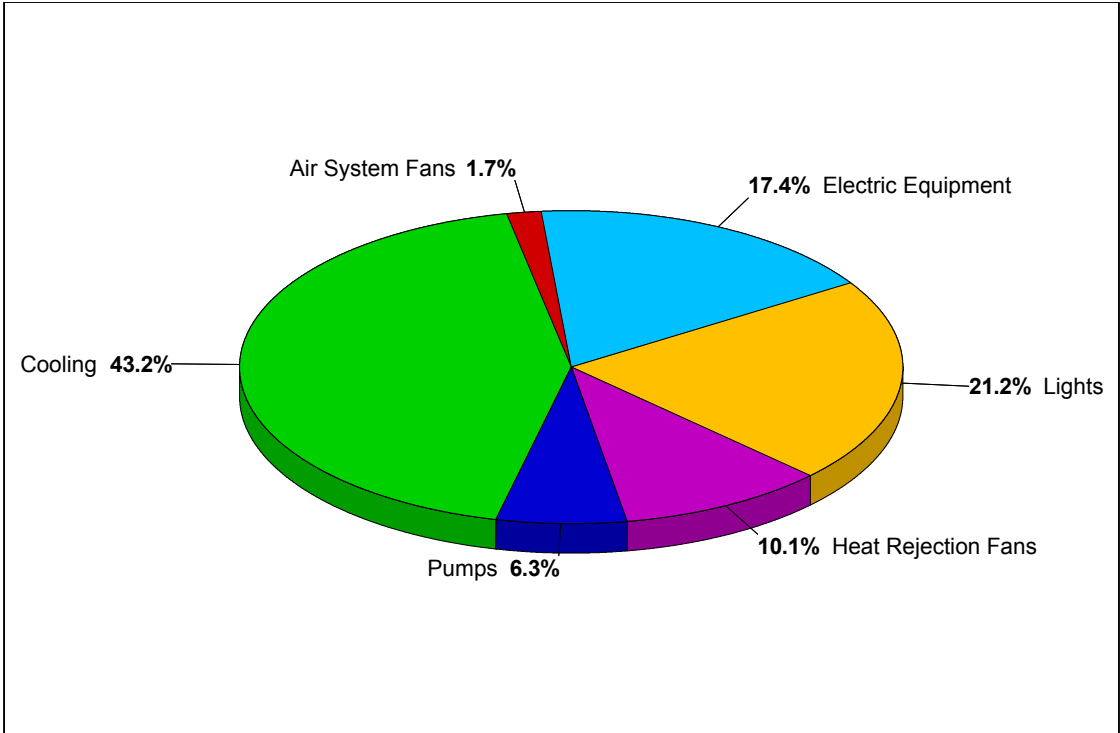
Component	Annual Cost (NIS/yr)	(NIS/m ²)	Percent of Total (%)
HVAC	138,703	19.536	87.9
Non-HVAC	19,073	2.686	12.1
Grand Total	157,776	22.222	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual Energy Costs - new economizer system
Jenin Governmental Hospital-final - final 11/01/2022
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1. Annual Costs

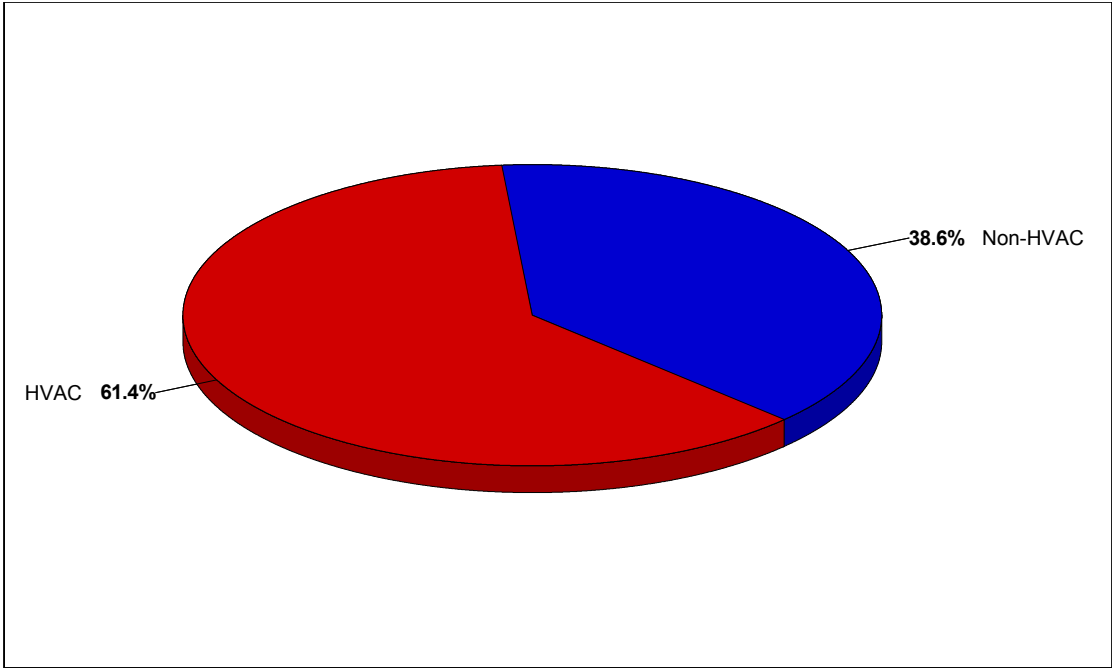
Component	Annual Cost (NIS/yr)	(NIS/m ²)	Percent of Total (%)
HVAC Components			
Electric	569,227	20.043	61.4
Natural Gas	0	0.000	0.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Remote Chilled Water	0	0.000	0.0
HVAC Sub-Total	569,227	20.043	61.4
Non-HVAC Components			
Electric	358,247	12.614	38.6
Natural Gas	0	0.000	0.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Non-HVAC Sub-Total	358,247	12.614	38.6
Grand Total	927,474	32.658	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual HVAC & Non-HVAC Cost Totals - new economizer system
Jenin Governmental Hospital-final - final **11/01/2022**
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1. Annual Costs

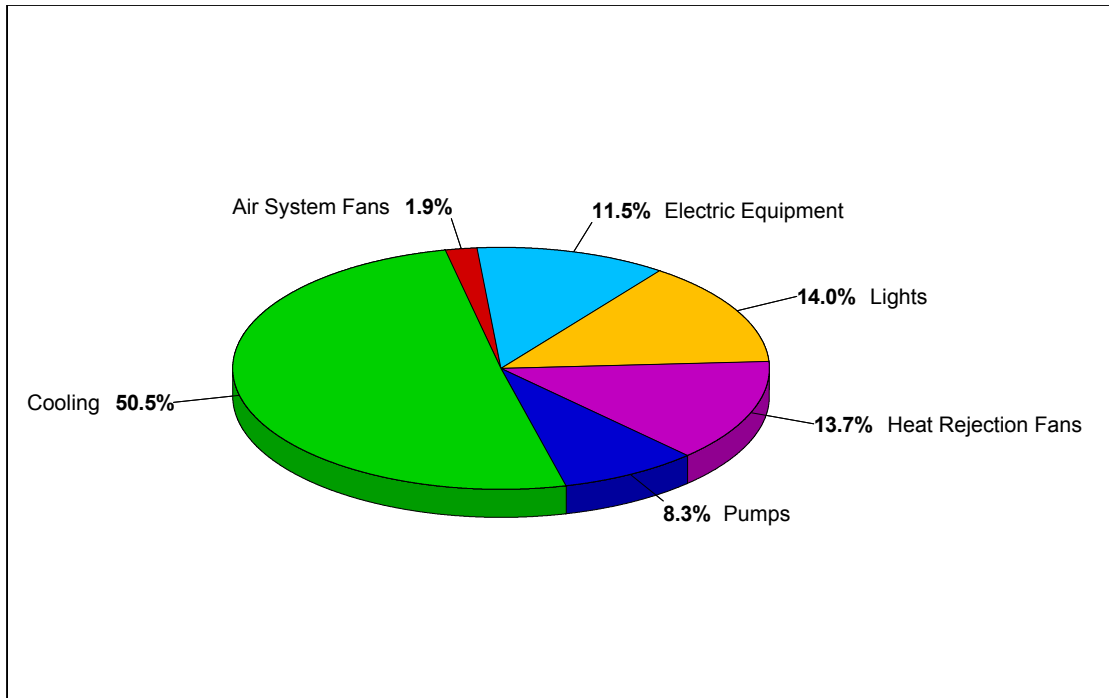
Component	Annual Cost (NIS/yr)	(NIS/m²)	Percent of Total (%)
HVAC	569,223	20.043	61.4
Non-HVAC	358,247	12.614	38.6
Grand Total	927,470	32.657	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual Component Costs - old cooling system
Jenin Governmental Hospital-final - final **11/01/2022**
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1. Annual Costs

Component	Annual Cost (NIS)	(NIS/m ²)	Percent of Total (%)
Air System Fans	27,329	0.962	1.9
Cooling	709,230	24.973	50.5
Heating	0	0.000	0.0
Pumps	116,840	4.114	8.3
Heat Rejection Fans	192,381	6.774	13.7
HVAC Sub-Total	1,045,780	36.823	74.5
Lights	197,036	6.938	14.0
Electric Equipment	161,212	5.677	11.5
Misc. Electric	0	0.000	0.0
Misc. Fuel Use	0	0.000	0.0
Non-HVAC Sub-Total	358,247	12.614	25.5
Grand Total	1,404,028	49.438	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual Energy Costs - old cooling system
Jenin Governmental Hospital-final - final **11/01/2022**
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1. Annual Costs

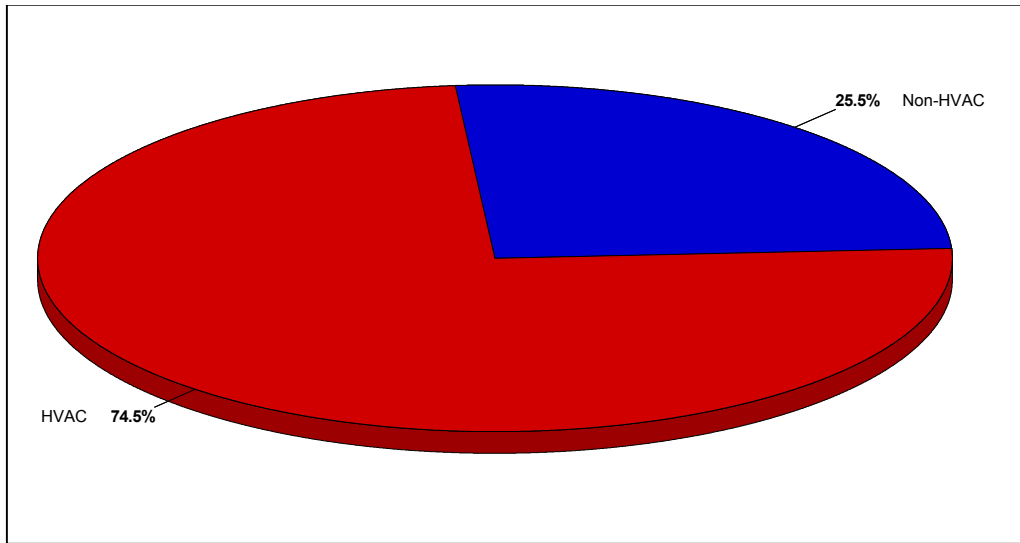
Component	Annual Cost (NIS/yr)	(NIS/m²)	Percent of Total (%)
HVAC Components			
Electric	1,045,765	36.823	74.5
Natural Gas	0	0.000	0.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Remote Chilled Water	0	0.000	0.0
HVAC Sub-Total	1,045,765	36.823	74.5
Non-HVAC Components			
Electric	358,247	12.614	25.5
Natural Gas	0	0.000	0.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Non-HVAC Sub-Total	358,247	12.614	25.5
Grand Total	1,404,012	49.437	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

Annual HVAC & Non-HVAC Cost Totals - old cooling system
Jenin Governmental Hospital-final - final **11/01/2022**
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1. Annual Costs

Component	Annual Cost (NIS/yr)	(NIS/m ²)	Percent of Total (%)
HVAC	1,045,780	36.823	74.5
Non-HVAC	358,247	12.614	25.5
Grand Total	1,404,028	49.438	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 7100.0 m²

Conditioned Floor Area 7100.0 m²

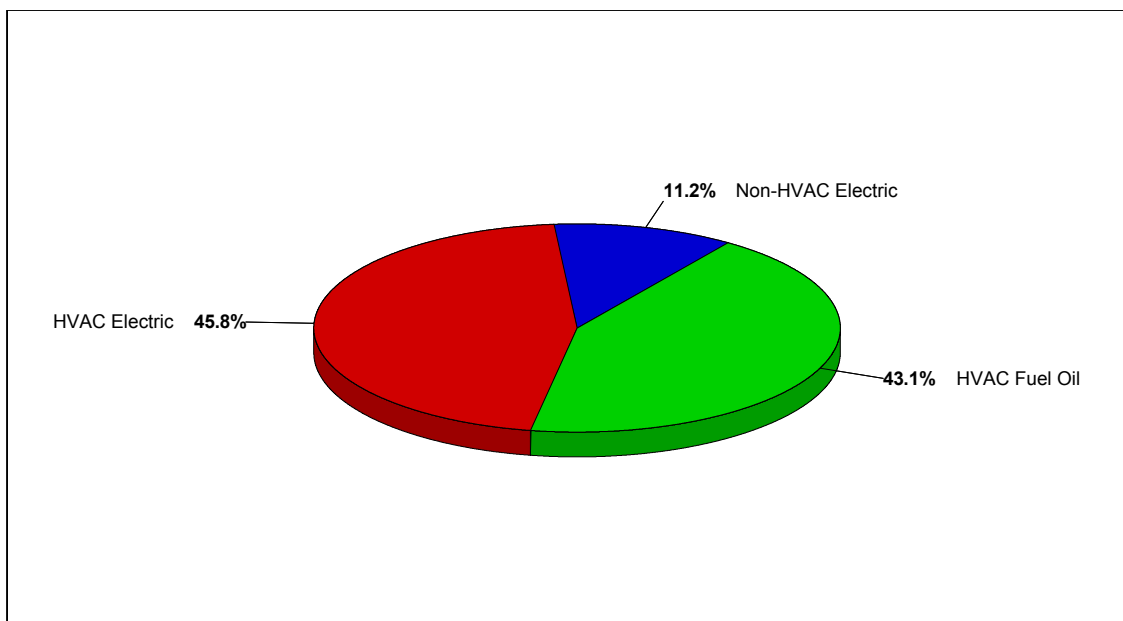


Table 1: Annual Costs

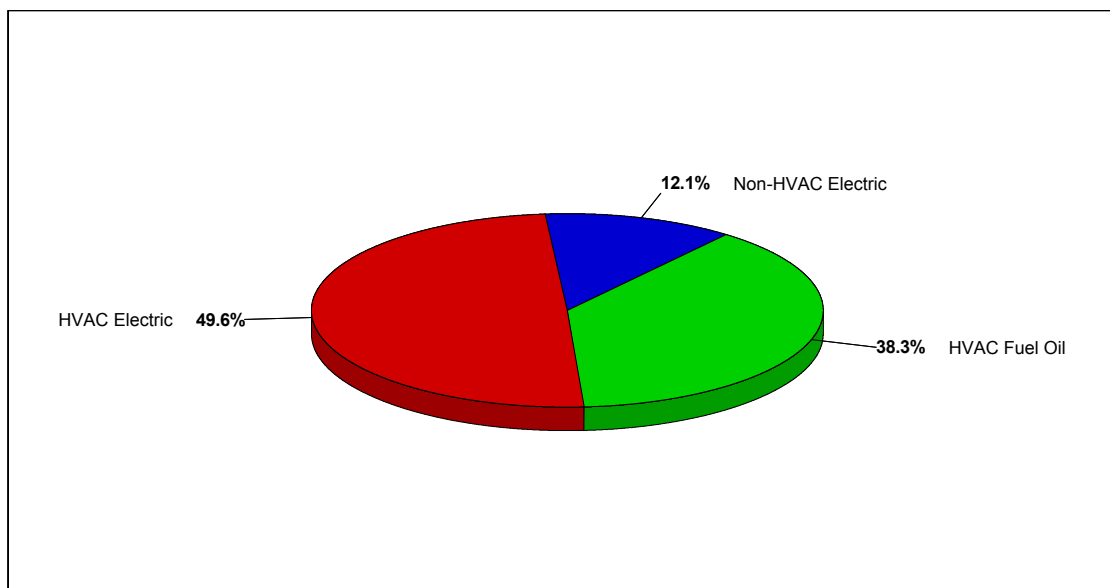
Component	heating and cooling system (NIS)	new heating system (NIS)	new economizer system (NIS)	old cooling system (NIS)	old heating system (NIS)
HVAC Components					
Electric	626,659	78,262	560,385	1,030,928	78,262
Natural Gas	0	0	0	0	0
Fuel Oil	0	60,441	0	0	73,613
Propane	0	0	0	0	0
Remote HW	0	0	0	0	0
Remote Steam	0	0	0	0	0
Remote CW	0	0	0	0	0
HVAC Sub-Total	626,659	138,703	560,385	1,030,928	151,874
Non-HVAC Components					
Electric	268,686	19,073	268,686	268,686	19,073
Natural Gas	0	0	0	0	0
Fuel Oil	0	0	0	0	0
Propane	0	0	0	0	0
Remote HW	0	0	0	0	0
Remote Steam	0	0	0	0	0
Non-HVAC Sub-Total	268,686	19,073	268,686	268,686	19,073
Grand Total	895,344	157,775	829,071	1,299,613	170,947

Table 2: Annual Energy Consumption

Component	heating and cooling system	new heating system	new economizer system	old cooling system	old heating system
HVAC Components					
Electric (kWh)	1,305,539	163,045	1,167,470	2,147,766	163,045
Natural Gas (na)	0	0	0	0	0
Fuel Oil (*)	0	12,088	0	0	14,723
Propane (na)	0	0	0	0	0
Remote HW (na)	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0
Remote CW (na)	0	0	0	0	0
Non-HVAC Components					
Electric (kWh)	559,762	39,735	559,762	559,762	39,735
Natural Gas (na)	0	0	0	0	0
Fuel Oil (*)	0	0	0	0	0
Propane (na)	0	0	0	0	0
Remote HW (na)	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0
Totals					
Electric (kWh)	1,865,301	202,780	1,727,231	2,707,528	202,780
Natural Gas (na)	0	0	0	0	0
Fuel Oil (*)	0	12,088	0	0	14,723
Propane (na)	0	0	0	0	0
Remote HW (na)	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0
Remote CW (na)	0	0	0	0	0

(*) Energy Units differ among Buildings.

Figure 1: Annual Emissions





جامعة النجاح الوطنية

كلية الدراسات العليا

إدارة الطاقة في قطاع المستشفيات دراسة حالة لمستشفى جنين الحكومي

إعداد

عبد الرحيم حلمي محمد خريوش

إشراف

د. محمد السيد

د. عماد بريك

قدمت هذه الرسالة استكمالاً لمتطلبات الحصول على درجة الماجستير في هندسة الطاقة النظيفة وترشيد الاستهلاك، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس - فلسطين.

2023

إدارة الطاقة في قطاع المستشفيات: دراسة حالة لمستشفى جنين الحكومي

إعداد

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الملخص

يمكن وصف قطاع المستشفيات بالمباني الكبيرة المستهلكة للطاقة الكهربائية، لذلك يتم استخدام هذه الطاقة في العديد من الأشكال لتوفير الراحة والعلاج والأمان للإنسان من خلال الاعتماد على إدارة الطاقة والمتجددة لإنتاج الطاقة. تستند هذه الدراسة إلى ترشيد استهلاك الطاقة واستغلال الطاقة الشمسية في توفير الطاقة للمستشفيات في فلسطين وتحديدًا في الضفة الغربية حيث يمكن تخفيض استهلاك الطاقة الكهربائية في المستشفيات من 4057756 كيلوواط بالساعة سنويًا إلى 2888657 كيلوواط بالساعة سنويًا. كما أن هناك انخفاض في إنتاج أحد أكثر غازات الدفيئة المسؤولة عن ظاهرة الاحتباس الحراري في العالم. تم تقليل إنتاج ثاني أكسيد الكربون الخاضع للبحث بمقدار 1292134 كجم من ثاني أكسيد الكربون سنويًا.

تم تقديم مجموعة من البيانات التفصيلية المتعلقة بالمبنى المقترح، مثل التكاليف السنوية والتكلفة السنوية لكل وحدة مساحة أرضية وتكلفة المكون كنسبة مئوية من إجمالي التكلفة والطاقة السنوية وملخص الانبعاثات (التكاليف السنوية والاستهلاك السنوي للطاقة والانبعاثات السنوية والتكلفة لكل وحدة مساحة أرضية، تكلفة المكون كنسبة مئوية من إجمالي التكلفة)، تكاليف الطاقة السنوية - نظام التدفئة والتبريد، تكاليف الطاقة السنوية - نظام التدفئة الجديد، تكاليف الطاقة السنوية - نظام الاقتصاد الجديد، تكاليف الطاقة السنوية - نظام التبريد القديم (نظام التدفئة القديم)، كل هذه البيانات تظهر بالتفصيل كما هو مبين في الملحق (C).

ومن الجدير بالذكر أنه تم أيضًا ترشيد استهلاك الطاقة في نظام تكييف الهواء من 2178708 كيلوواط بالساعة سنويًا إلى 1167469 كيلوواط بالساعة سنويًا، مما أدى إلى تقليل إنتاج ثاني أكسيد الكربون إلى 1092139

كغم سنويا. باستخدام الديزل لتشغيل نظام التدفئة، تم إنتاج 340،20 كغم من ثاني أكسيد الكربون سنويا، وتم تقليل إنتاج غاز ثاني أكسيد الكربون إلى 31069 كغم من ثاني أكسيد الكربون سنويا نتيجة لتحديث نظام التدفئة. اعتمادًا على تصميم نظام الخلايا الشمسية، تم توفير 148857 كيلووات بالساعة سنويا من الطاقة الشمسية وتم تقليل انبعاثات ثاني أكسيد الكربون نتيجة لتوليد هذه الطاقة من مصدر غير متجدد 160،766 كغم من ثاني أكسيد الكربون سنويا.

الكلمات المفتاحية: استهلاك الطاقة؛ طاقة متجددة؛ الغازات الدفيئة.