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Technologies for heating sports facilities

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Abstract
An active lifestyle is essential for maintaining a healthy heart, body, and mind. To satisfy WHO [1] standards, every fourth adult worldwide does not engage in enough physical exercise. As physical exercise has been shown to improve public health, disease prevention, and society's competitiveness, it has become more widely recognized as being important since the COVID-19 pandemic. Between 2000 and 2019 [2, 3, 4], the world's life expectancy increased by 6.6 years, whereas the rise in healthy life expectancy was only 5.5 years. To close the difference between the two numbers, exercise is crucial.

Keywords: Standards, every fourth adult, worldwide

Introduction

Air supported halls are buildings that make sure that overpressure is maintained while maintaining the height of a sports venue. These halls are perfect for cold climates because they are often built with plastic covers and insulation and may accommodate lengthy practice seasons for outdoor sports like football, golf, and running. Additionally, they can be utilized for military training, temporary movie theaters, and social gatherings that call for higher indoor temperatures. On the other hand, little is known about how these facilities operate and use energy. Energy utilization in these facilities can be greatly influenced by variables like operating time and activity type. For a thorough examination, it is essential to examine how much energy is used in these facilities. By dividing the percentage of return air in the total flow of supplied air, air recirculation may be determined as an effective energy efficiency method to reduce energy consumption. It's important to distinguish between athletes and the general population because athletes dress casually and train hard, whereas the general public dresses more formally and sits [15, 16].

Fig 1: Interior of the air supported sport hall in Mo i Rana, Norway [16]

Background

The amount of energy needed for each object determines how much energy is consumed throughout several sectors. Primary energy consumption, which accounts for the highest percentage of all energy consumption, and secondary energy consumption, which accounts for the lowest percentage of all energy consumption, are the three categories under which energy is consumed [18].

Primary energy consumption and secondary energy consumption are two categories that can be used to categorize energy consumption across many industries. Energy used for production and consumption is referred to as primary energy consumption, whereas energy used for production and consumption is referred to as secondary energy consumption.

Primary energy consumption, secondary energy consumption, and tertiary energy consumption are the three categories under which energy consumption is broken down in energy conservation. The percentage of energy used for production and consumption determines the percentage of energy utilized for both.

Renovations to a sports arena should take energy-related aspects like heat gains and losses into account in order to minimize energy use. The procedure need to be founded on fundamental ideas about how energy is used, such the idea that energy cannot be destroyed and needs to be balanced. Renovations should prioritize retaining heat within as much possible to save money and energy. is important to retain heat indoors as much as possible.

Indoor Environment Quiality

Due to autonomic thermoregulation and behavioral regulation, humans have varying perceptions of temperature settings. Engineering, physiological, and psychological approaches to thermal comfort are the three primary categories [5]. The body is viewed as a heat-exchanging entity in engineering, bodily functions are the focus of physiological study, and psychology research deals with personal experiences and expectations. The majority of the inhabitants must be content for there to be optimal comfort [6]. The human heat budget is taken from [7] and is printed after [8, 9].

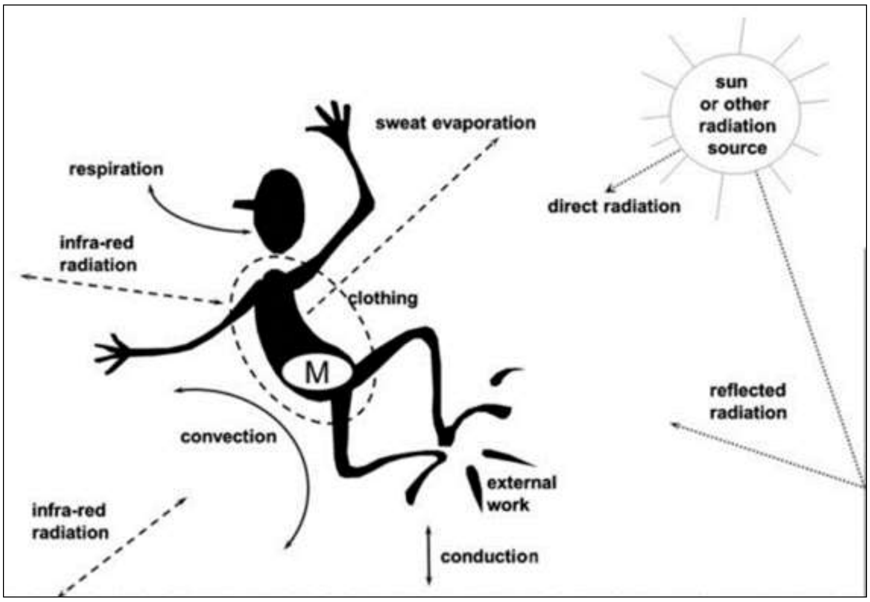

Fig 2: The human heat budget [10]

In order to comprehend the heat balance of the human body from an engineering perspective, it is necessary to examine how much heat is produced, used, and transferred to the environment. This strategy is based on the first thermodynamic theorem, which takes into account the weather, the amount of activity of people, and clothes. However, it excludes physiological factors like sweat rate, skin temperature, and skin wetness that regulate heat fluxes. The development of human physiological models and further investigation into human thermoregulation systems are motivated by this equation [7].

Exercise speeds up breathing, which exposes the body to the most toxins through breathing. To reduce the effects of air pollutant exposure on sportsmen and athletes, indoor sports venues should maintain appropriate indoor air quality. Ventilation is a useful method for regulating indoor air quality, but because of the high occupancy rates and a range of physical activity intensities in indoor sports facilities, it presents extra challenges. Athletes' thermal comfort must be maintained while ventilation is planned for and put into place to guarantee acceptable indoor air quality.

Rational energy use in sport objects

By 2020, the EU wants to utilize 20% less primary energy, 20% more renewable energy, and 20% less greenhouse gas emissions [5].

In public and commercial buildings, conventional ventilation systems run constantly, calculating air exchange, heating, and cooling capacity depending on the maximum number of people and occupancy hours [12].

The environment is greatly impacted by energy use in today's society, with greenhouse gas emissions leading to issues on both a local and global scale. Building energy efficiency is essential for addressing climate change challenges and protecting our energy supply. Concerns about supply issues, the depletion of energy resources, and severe environmental effects such ozone layer depletion, global warming, and climate change have been raised by the fast expanding global energy use [13, 14].

Buildings now account for a growing portion of worldwide energy consumption-between 20% and 40% in affluent nations-which includes both residential and commercial usage. Due to the rising population, rising comfort standards, and rising time spent inside buildings, energy efficiency in buildings has become a top priority for energy policy at the regional, national, and worldwide levels. Among building services, HVAC system energy use is particularly significant [13, 14].

Since more than 4,000 years ago, sports have played a fundamental role in human nature, promoting creativity and socializing through enjoyable, competitive activities. A healthy body and mind go hand in hand, according to the ancient Greeks, who also emphasized the value of athletics in daily life and spiritual development. However, there aren't always natural sporting environments available, such cool temperatures, humidity levels, lighting, and ventilation. These innate disparities can be changed by humans to enhance sporting events.

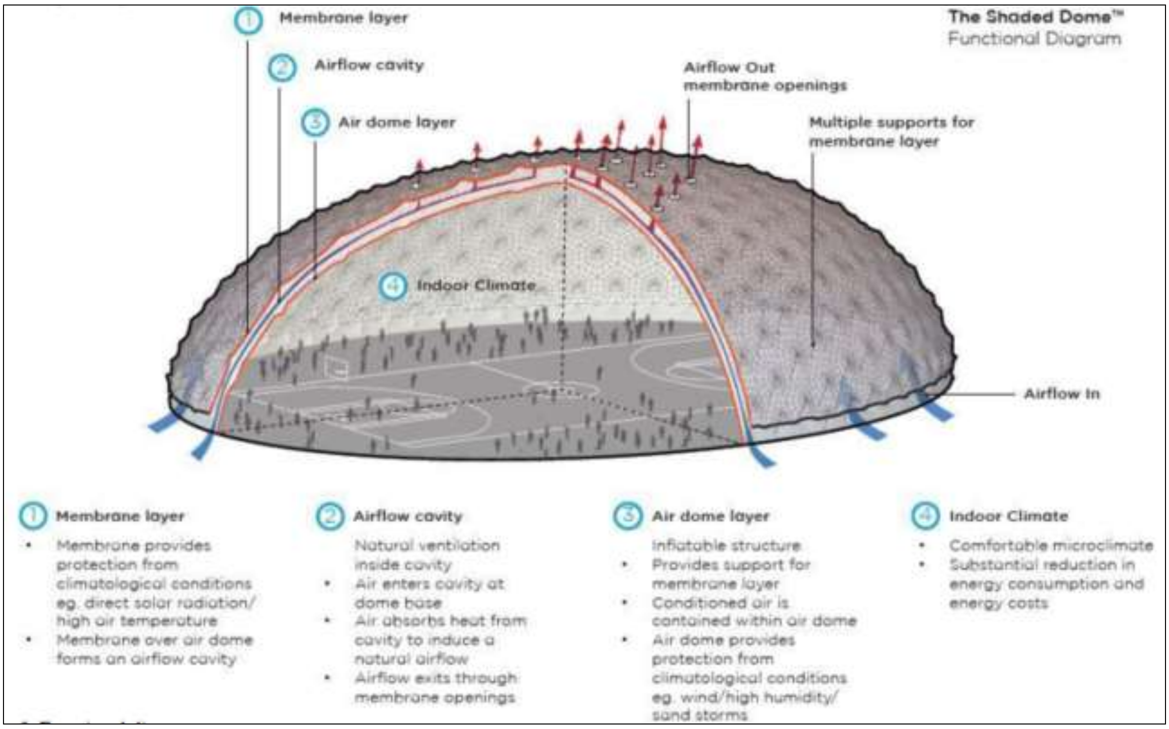

Fig 3: Functional diagram [15]

Canvas-covered sports arenas offer protection from wind, rain, and snowfall but not from cold. Renewable energy sources, such as solar energy, have been employed as a heat source for heating in an effort to reduce emissions. However, because solar energy is unpredictable, it might be difficult to balance the supply of the source with the demand for energy for heating.

Technology provides a remedy for this problem in the form of energy storage in heat tanks, which can be utilized in the summer when solar energy is abundant and heating needs are low or not stored at all and used in the winter when energy needs rise. To overcome these difficulties, research is required to determine the most effective ways to heat and cool the tent.

The demand for power has increased as a result of the changing geopolitical landscape and the aim to transition as rapidly as feasible to renewable energy sources. The power grid is frequently overloaded, which restricts the user's ability to connect and the ability to connect new solar power plants.Good building insulation is without a doubt one of the most crucial techniques for reducing energy use in buildings. However, it is also important to consider the economy of specific measures when dealing with "temporarily" constructed facilities that are only heated or cooled for a few hours each day.

Heat accumulators in the storage of solar energy

The precise computation of temperature and energy intensity is a need for the design of heat storage units for renewable energy devices. Building materials with a high heat accumulation rate can now be produced thanks to modern technology. Methods to compute operating modes based on numerical models are needed to increase efficiency and dependability. They examined the fundamentals of developing heat storage devices based on various heat storage medium in the article [17]. A numerical solution program was created together with a mathematical model of the solar heat storage tank. The working fluid's daily average temperature in the heat storage tank made of zeolite and gravel was calculated. Zeolite batteries can be twice as tiny in volume and have two times the energy efficiency of gravel batteries.

In order to store and remove peak loads, control voltage and frequency, provide a hot power reserve, and act as an emergency power source, heat accumulators are essential for the renewable power economy, notably in solar energetics. They are employed to deal with the problems of diurnal periodicity, erratic solar energy supply, and ongoing heating energy supply. Heat accumulators also offer sky coverage and load coverage at night [17].

When compared to lithium iron phosphate batteries (LIPB), using thermal storage batteries dramatically lessens the environmental impact across eight comparison categories. By choosing affordable and effective structural materials and heat accumulating media, heat accumulators for power installations can be designed for the best performance. The performance of a heat accumulator is based on the accumulation of sensible and latent heat, and is influenced by factors like storage capacity, the rate at which heat is inputted and outputted, the length of the accumulation cycle, the temperature range, the heat loss coefficient, and capital and operating costs [17].

The integration of these systems efficiently lowers heat losses and boosts thermal efficiency, according to a survey of several solar air heaters loaded with sensible heat storage materials. Gravels outperformed cement and concrete in terms of thermal efficiency, but free convection solar air heaters produced better results for blackened pebble stones [17].

Heating, ventilation and air conditioning (HVAC) system

Heat is transferred through conduction, convection, and radiation in the sport hall heating system. Many improvements to the heating systems have been suggested, ensuring that the necessary heat levels are maintained while preserving energy. For large athletic arenas with ongoing heating requirements, district heating's central heating systems are preferable since they save a significant amount of energy. Localized and locally controlled heating systems use less energy, particularly in athletic venues where heating is only delivered when it is needed. When utilized in high bay sport venues, gas-fired radiant tubes are more effective and require less energy [13].

It is proposed that under-floor heating be used to increase room temperatures to the level necessary for comfort. A sport hall can be effectively heated and ventilated using a warm air system with full heat and ventilation provisions. A heat exchanger and possibilities for air recirculation are included in this system to absorb heat gains from occupants. For small to medium-sized athletic venues, careful ventilation process control can reduce energy consumption and operating expenses [13].

In order to keep sport venues warm and conserve electricity, heat recovery is crucial. The heat recovery system draws wet, stale air from particular spaces, including restrooms and changing rooms, and uses a heat exchanger to release it outside. The heat that is still in the exchanger is transferred to the designated rooms by the fresh air. Operating systems with 10 air changes per hour or more are advised by Sport Scotland.

Solar energy

Solar energy is a possible alternative for heating, however due to its erratic nature, heating system components must incorporate thermal energy storage (TES). In order to ensure effective use and prospective use in the event of failure, TES stores excess heat. Combinations of heat pumps and solar thermal systems have been investigated for possible energy savings. Low-temperature solar energy can be used as a heat pump source in the winter. Due to its ability to supply energy at temperatures higher than outdoor air temperature, the solar collecting system's capacity and COP are higher than those of traditional air-source heat pumps alone. Numerous theoretical and experimental studies have been sparked by this combination [19].

Solar energy in particular is a developing and dependable source of electricity from renewable sources. Buildings can be powered by solar energy, which is an alternative to fossil fuels and offers a long-term, fixed-price electricity supply. It can replenish electricity from the electric transmission system and has less of an impact on the environment. The number of solar modules installed determines a solar system's size and generating capability, making solar technology applications scalable and adaptable.

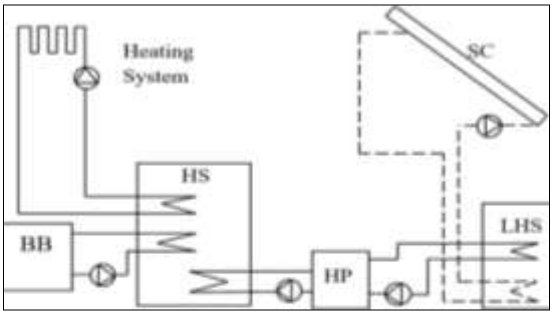

Fig 4: Scheme of the heating system [3]

The two ways that solar energy is utilised are thermal and photovoltaic. To heat hot water, pool water, and other parts of buildings, thermal solar energy is used. Without any machinery or moving components, photovoltaic solar energy, which is frequently constructed of silicon cells, generates electricity. It is non-polluting, requires little upkeep and supervision, has a 20–30 year lifespan, and has low operating expenses. It is distinctive since no extensive installation is necessary.

However, solar energy is reliant on sunshine and building exposure, which varies according to geographic location, the presence or absence of clouds, the time of year, and the season. The initial expense of purchasing the tools required to install a solar energy system can be significant.

Instead of focusing on energy demands, sports halls and facilities should concentrate on energy supply. The amount of energy the system produces can be impacted by things like shading, location, tilt, and sun exposure. A financial model can assist in lowering system acquisition costs and shortening the payback period.

A power audit is necessary before installing solar panels in sports arenas in order to evaluate existing energy usage and propose concrete methods for reducing energy waste. This audit is essential for figuring out the system's objectives and scoping prospective on-site projects. Depending on the objective, the solar system will either serve as the main source of energy or as a backup to the electrical grid.

Prior to constructing the solar power system, a feasibility study is necessary to confirm the sport hall's fundamental specifications, address concerns regarding the facility's size and location, link the solar system to the existing electrical system, and monitor data. Installing solar panels in locations with the most sunlight exposure will boost energy output. The most ideal solutions for solar panel installation on a building's roof are classic crystalline silicon solar panels and thin film cells solar panels. For uncovered parking lots, carport-like installations are a possibility; however, the cost of erecting the entire system may increase if racking structures are used.

To ensure optimum energy production and shorten payback times, solar energy in sports facilities requires meticulous planning and implementation.

Comparison between traditional and advanced building envelopes or tents

Tensile membrane structures that are supported by air and stabilized by positive differential pressure between the inner and outer sides make up pressostatic envelope systems. Since its inception in the 1950s, this construction technology has been improved with self-cleaning, transparent films and strong technical textiles. Pressostatic envelopes have moved beyond brief events to include permanent, seasonal, and ephemeral structures. HVAC systems are frequently needed in permanent or semi-permanent applications to maintain hygrothermal comfort levels, and the air inflation system can also function as the heating/cooling system [20].

More focus is now being placed on the thermal-physical characteristics of membrane envelopes in order to increase indoor comfort and lower climatization energy usage. In place of single layer envelopes, double or multiple layer pneumatic cushions are becoming more common. Permanent structures frequently have transparent double skins composed of technological textiles, but ETFE foil cushions are primarily being researched for transparent skins. Surface thermal resistances in single layer applications and air gaps resistances in multiple layer cases dominate the thermal transmittance or U-value [20].

When moving from single to double layers, the U-value is approximately halved, ranging from around 6 to 3 W/(m2 K). The direction of heat transfer is determined by the cushion's horizontal or vertical installation rather of the U-value calculation method, which is not crucial. In order to counteract the effects of thermal bridges at the cushion edges, a new generation of pressostatic double layered envelopes has been designed. In order to keep the two envelopes apart, a space is made between them, and air is continuously introduced into it. Due to its low thermal inertia and large air volumes and internal surface temperature variations, membrane enclosures are susceptible to changes in the indoor environment as well as the external environment. The summertime behavior of a test membrane exposed to the environment was examined experimentally and numerically [20].

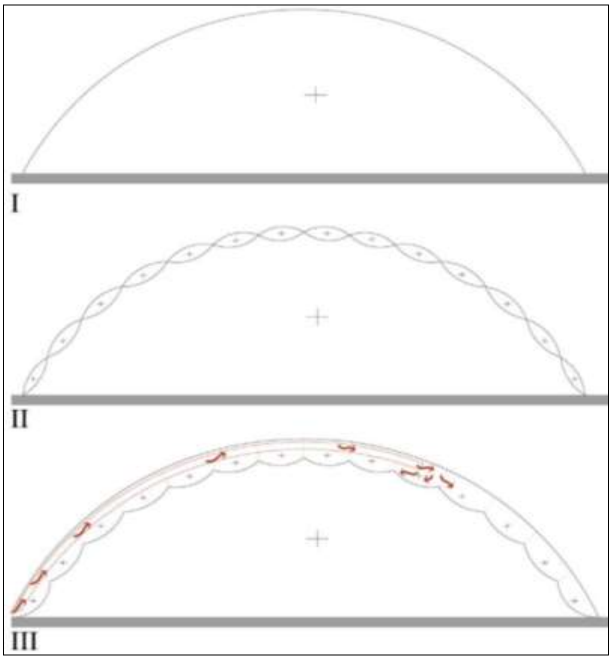

Fig 5: Schematic section of 1st, 2nd and 3rd generation 20].

Simulation methods can be used to forecast the effects of material qualities on solar transmission, which has a considerable impact on the temperature climate of space under membrane structures.

Simulation methods can be used to forecast the effect of material qualities on the thermal environment of the area beneath membrane structures, which is significantly influenced by solar transmission. The impacts of a passive cooling method based on evaporative cooling pavements can be assessed using joint thermal modeling and computational fluid dynamics (CFD). A comparison of the energy efficiency of various membrane envelopes hasn't been done, though. The thermal-physical behavior of all three types is examined in one work [20], which also assesses thermal comfort levels and quantifies energy savings in single- to double-layer designs. A sports facility in Milan, Northern Italy, that utilises an air-supported fabric for winter performance is featured in the case study. Site evaluations, simulation models, and dynamic simulations using the ESP-r tool are all included in the technique [20]. Condensation may develop on the membrane's internal surfaces during the winter as a result of inadequate insulation and low surface temperatures.

Conclusions

Many town and village authorities can no longer afford to heat some buildings due to growing electricity costs. Sports facilities are frequently among the first to experience budget cuts because they use 50% more energy on average than other commercial buildings.

Local government authorities and managers of sporting venues can conserve energy and lessen their environmental effect thanks to competence in HVAC (heating, ventilation, and air conditioning). With the continued development of smart buildings, HVAC has created service options that are ever-more precisely tailored to the unique requirements of each building, particularly sports facilities, which have a wide range of requirements and limitations.

Few buildings have less in common with a sports facility than another sports facility, ranging from swimming pools, velodromes, stadiums, and huge multi-use buildings to small local gyms, structures with or without stands, open or enclosed. The size and type of an HVAC system are determined by a number of factors, such as the building's size, purpose, and occupancy levels.

Local officials and sports facility owners can reduce their environmental impact and save money on energy thanks to HVAC expertise. Heat builds up in every building. The need for heat recovery technologies grows as ceiling height increases. In a particular sport object, you are already dealing with a lot of air, but you also need to take evaporation into account. This energy can be recovered by intelligent HVAC systems and used to warm the water and other amenities like changing rooms, showers, and toilets.

Every institution has a unique remedy. However, HVAC knowledge is becoming increasingly important in addressing the issues of reversibility, digital innovation, the environment, and air quality in sporting stadiums.

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