Sustainability of HVAC Systems in Buildings

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Increasing demand on heating, ventilation, and air-conditioning (HVAC) systems and their importance, as the respiratory system of buildings, in developing and spreading various microbial contaminations and diseases with their huge global energy consumption share have forced researchers, industries, and policymakers to focus on improving the sustainability of HVAC systems.

Keywords: HVAC systems ; sustainability ; energy efficient ; IAQ ; water recovery

1. Introduction

Population growth, modern technologies, and lifestyles are among the reasons for the necessity of heating, ventilation, and air conditioning (HVAC) systems in various types of buildings. Meanwhile, HVAC systems have an important role in the comfort and safety of indoor air quality (IAQ). However, these systems account for 40–60% of energy usage in buildings [1] or 15% of the world's total energy consumption (Rafique 2018). These facts illustrate the importance of considering HVAC sustainability development by researchers, industries, and policymakers. Furthermore, sustainability considerations and innovations in HVAC systems are necessary to provide a remarkable, healthy, productive, and sustainable built environment for occupants while reducing energy consumption and costs [2].

For the sustainable development of all three pillars, namely, economic, environmental, and social, reaching the immediate and long-term benefits of people, the planet, and prosperity must be carefully considered [3].

Various affecting parameters must be considered to improve the sustainability of HVAC systems. A remarkable understanding of human-in-the-loop HVAC systems could facilitate and improve the achievement of sustainability [4]. Considering all the related parameters will help minimize energy usage without compromising occupant thermal comfort.

The assessment of measurement and modeling techniques and their performance are important in planning to achieve sustainable HVAC systems considering occupancy, comfort, and building type [4].

2. Energy

The high energy share of HVAC systems in buildings, which increase greenhouse gas emissions and costs, motivates researchers to study the various parameters related to reducing energy consumption and finding sustainable solutions for HVAC systems [5][6]. Many studies have been conducted to develop advanced design and control strategies to optimize energy, thermal, and environmental performance and to make these strategies cost-effective for HVAC systems [2][7][8][9].

3. Environment and Society (Thermal Comfort and IAQ)

Spending more than 80% of peoples' time indoors reveals the importance of IAQ on the health and comfort of occupants [10]. Studies have shown that low IAQ decreases the work performance of occupants [11][12][13]. IAQ in buildings, such as temperature, humidity, airflow, and cleanliness, is directly related to HVAC systems and is considered the respiratory system of buildings [14]. However, improperly designed or operated HVAC systems could contain and develop various microbial contaminations and cause serious health issues for occupants.

4. Water Recovery

As a most treasured resource in the world, the investigation of water sustainability in buildings and HVAC systems is crucial. HVAC systems are considered air–water harvesting systems that liquefy the water vapor available in the air as they condensate; they are also a potential water source [15]. The recovery of condensate has more value, especially in a hot and dry climate which has water scarcity.

5. Retrofitting of Existing HVAC Systems (Modification of Old HVAC Systems)

The fact that more than 25% of existing buildings in Europe are more than 70 years old [16][17], 60% of residential building in the US are more than 30 years old [18], and a high percentage of developing countries are currently using low sustainability concepts suggests the importance of considering their retrofitting [19][20]. Retrofitting of existing buildings could decrease the global energy consumption and environmental impact remarkably [21].

Considering the high energy consumption of HVAC systems in buildings, their low sustainability reveals the vital attention required for their modification. This retrofitting could reduce the environmental impacts of the built environment. However, optimum decision making that considers various important parameters, such as energy modeling and assessment, retrofit designs, cost, and risk assessment, is crucial [22][23].

Recommendations:

Some important recommendations for the better optimization of HVAC systems in buildings are listed as follows:

• Improvement and retrofitting of the building design are very effective for improving the performance of HVAC systems.

• All decision-making parameters for the planning of sustainable HVAC systems, such as occupancy, comfort, health, building type, and cost must be extensively studied.

• Important parameters must be considered in using renewable technologies in HVAC systems to achieve sustainability.

• The use of developed and advanced designs and control strategies in the HVAC systems could increase their sustainability remarkably.

• Improving IAQ and occupants' health by focusing on ventilation systems and microbial contamination prevention in HVAC systems.

• Water and energy recovery in HVAC systems are crucial parameters for improving sustainability.

• The retrofitting of the existing HVAC system is a vital action in the current situation.

• Optimum plans need to take into account all the advantages and disadvantages of various options while considering the available facilities, conditions, risks, and cost.

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