



A dynamic maintenance planning methodology for HVAC systems based on Fuzzy-TOPSIS and failure mode and Effect Analysis

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ABSTRACT

Maintenance is critical to the efficiency of Heating, Ventilation, and Air Conditioning (HVAC) systems in buildings. The conventional maintenance methods are planned for ideal situations and cannot easily be adapted to prevailing management/operational conditions, resulting in increased use of resources and energy. This study developed a dynamic maintenance planning framework for HVAC systems employing Fuzzy-TOPSIS and FMEA and aimed at reducing and stabilising maintenance costs while enhancing system reliability. Fuzzy-TOPSIS technique was used to establish maintenance priorities based on a carefully identified set of criteria, including the risk priority number (RPN), which is adaptable to changing conditions and ensures continuous monitoring. This is a novel application to HVAC systems. A real-world implementation in an HVAC company involving data collection, fuzzification of expert evaluations, priority ranking of components, and development of maintenance ranking validated the framework's efficiency. The running conditions of the HVAC system under the new approach, expressed by the air quality and air leakages (by extension energy saving), showed a significant improvement at the various test points in the 600-h running. The results demonstrated significant cost savings, enhanced system reliability, improved energy efficiency, and better indoor air quality. This dynamic maintenance planning framework offers a concise and adaptable solution for optimising HVAC maintenance operations.

1. Introduction

Heating Ventilation and Air conditioning systems (HVAC) are integral to modern buildings and provide and maintain a conducive or suitable environment for the occupants or the process being conducted. The primary goals of any HVAC system are to control the ambient temperature, keep humidity levels in check, and ensure optimal air quality inside the building. HVAC systems, being one of the most energy-intensive components in buildings, contribute to almost half the total energy consumption within structures [1]. Consequently, implementing energy-efficient strategies to enhance HVAC operations can be a practical means to move closer to achieving net-zero energy consumption goals [2]. HVAC system operation efficiency directly relates to reduced energy consumption and carbon emissions. Studies have shown that effective maintenance is instrumental to achieving more energy-efficient and

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