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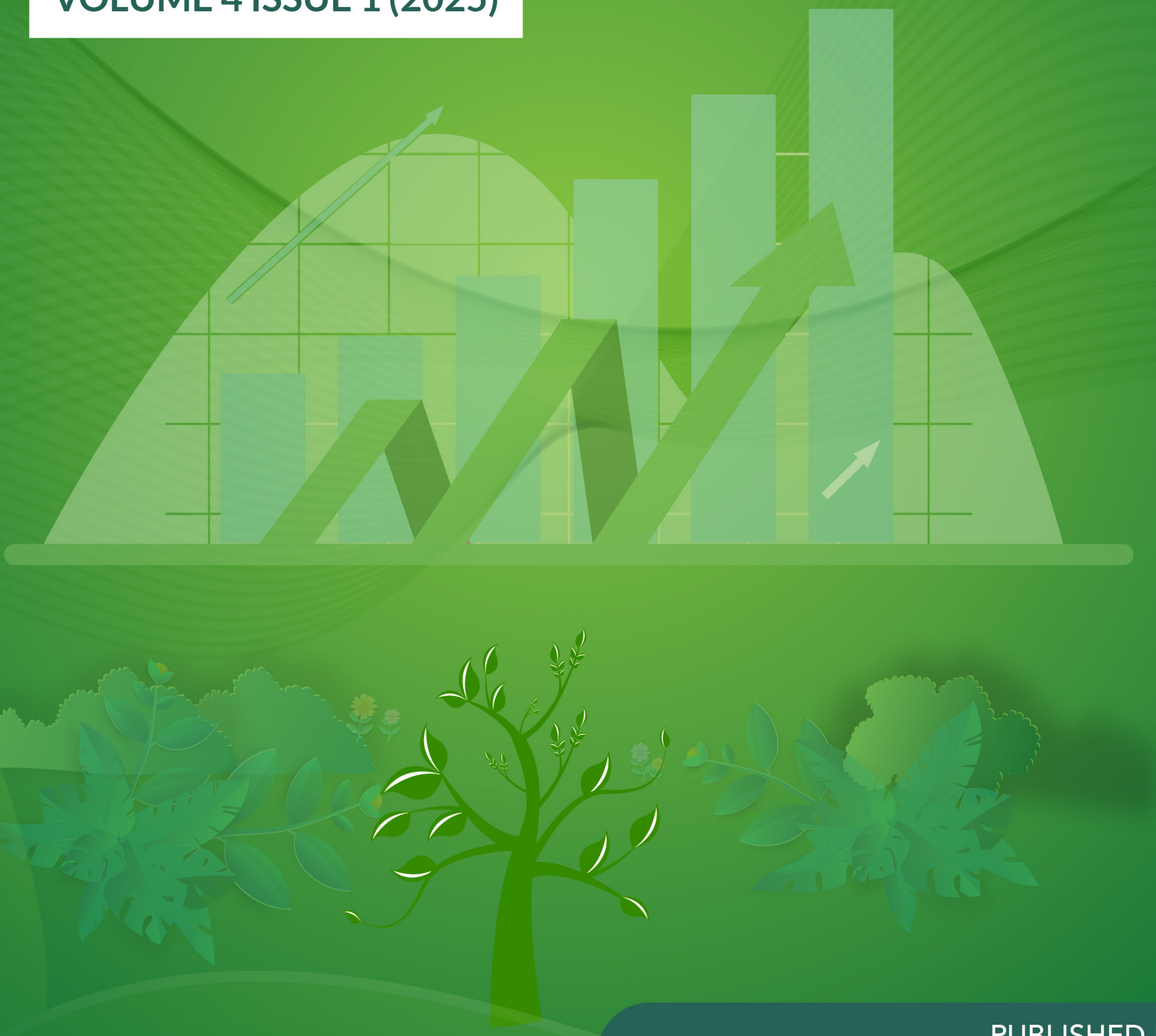

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Barriers to Adoption of Energy-Efficient HVAC Systems in Middle-Class Households in Pakistan

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ABSTRACT

Buildings and additional structures utilize a significant helping of the energy in the sphere. HVAC systems are mostly responsible for building energy use in middle class households in Pakistan. This study proposes a simulation-based optimization approach for efficiently measuring HVAC systems choices in the early design stages to get the optimal configuration in middle class households in Pakistan. This strategy is applied establishing HVAC systems in middle class households in Pakistan. The ventilated Dunkel cycle performs better than the other two designs for high COP systems in all three climate zones; nevertheless, ventilation is the superior choice in middle class households in Pakistan. Systematic simulations can help with the difficult process of optimizing HVAC systems designs in middle class households in Pakistan. This invention will assist HVAC systems design are selecting the optimal systems configuration and design parameters during the early design phase by accounting for various middle-class households in Pakistan.

INTRODUCTION

As global temperatures rise, Pakistan is experiencing longer and more intense heat waves. Middle class households increasingly rely on HVAC systems for cooling, leading to higher electricity consumption, frequent power shortages, and growing carbon emissions. Although energy-efficient HVAC systems technologies—such as inverter air conditioners, smart thermostats, and solar-assisted cooling systems—are available, their adoption remains limited among middle-class households. Despite their potential for reducing energy bills and environmental impact, energy-efficient HVAC systems are not widely adopted in Pakistan's middle-class neighborhoods. Optimization of traditional setups and introduction of efficient innovation of HVAC systems utilizing renewable energy resources is one approach to the problem (McQuiston et al., 2000). Most of the expansion is taking place in developing nations that are not members of the OECD, particularly in Asia. Pakistan and other developing nations accounted for 44% of total energy consumption in 2006–07. By 2030, home energy use will have nearly doubled and accounted for the lion's share of total energy consumption. However, by 2030, it could only account for 32% of total final energy in middle class households (Ellis & Mathews, 2002). Growth in population, enhancement of comfort demand, global climate change, and time spent inside buildings anticipated the growing trend of energy consumption in building industry. The middle-class household's residential energy demand is anticipated to expand at an average pace of 1.1% per year from 2008 to 2035. Similarly, the growth in commercial sector is predicted to expand at an average rate of 1.5% each year from 2008 to 2035 (EIA, 2012). Therefore, due to increasing energy needs, pricing, and environmental challenges, the developed nations are focused on buildings sector as the biggest opportunity for energy savings (BPIE, 2011). The buildings energy demands are the major cause of considerable rise in the power consumption due to rising space heating, cooling, ventilation, and refrigeration requirements in middle class households in Pakistan (IEA, 2009). Energy usage in buildings is closely associated with energy needs of HVAC systems in middle class households in Pakistan. HVAC is the greatest energy end use both in the residential and non-residential sector. The air-conditioning is responsible for 10% to 60% of the overall building energy usage, depending on the building type (Ellis & Mathews, 2002). In developed countries, HVAC systems are the most energy consuming devices, accounting for about 10–20% of final energy use (Perez-Lombard et al., 2008). The HVAC systems configuration is a conceptual design of HVAC systems including the active components, airflow set-up, and the control strategies with set points. Selection of HVAC systems configuration is typically decided in the early stage of the design process in middle class households in Pakistan. The design phase of heating, ventilation, and air conditioning HVAC systems in a new building facility presents the greatest opportunity for energy savings. When compared to the cost of upgrading an old building with an efficient HVAC system, it is typically more cost-effective to install energy-efficient heating, ventilation, and air conditioning business equipment during the construction of a structure (Galitsky, 2007). This study seeks to identify the economic, social, technical, and informational barriers that prevent widespread uptake

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in middle class households in Pakistan. The study is investigating the economic, cultural, and informational factors which are used to prevent households from switching to efficient cooling technologies in middle class households in Pakistan. To identify key factors influencing consumer choices in HVAC systems among urban middle-income households. To analyze barrier to adopt energy-efficient HVAC technologies in middle class households in Pakistan. To assess awareness levels about energy-efficient options and long-term cost savings. To propose targeted policy and market-based interventions that could boost adoption in middle class households in Pakistan. This study addresses the intersection of climate adaptation, energy equity, and behavioural economics, offering practical solutions to reduce energy consumption and improve resilience to rising temperatures in middle class households in Pakistan. In order to evaluate the suggested strategy for the selection of optimal HVAC systems configuration through the use of a real chilled water systems, the goal is to establish an incremental simulation-based optimization methodology for the purpose of designing a chilled water system. The study provides the literature review to resolve the cost concerns, trust in new tech, lack of awareness, and installation challenges in middle class households in Pakistan. The results reveal that the clear insight into why middle-class households hesitate to switch to efficient cooling systems. Recommendations for policy makers, energy companies, and NGOs to design targeted incentives in middle class households in Pakistan.

LITERATURE REVIEW

Modelling techniques for HVAC components, modelling approaches for HVAC control, and modelling approaches for HVAC systems are the three categories that may be used to classify the many modelling approaches for HVAC in middle class households in Pakistan. In addition, the methodologies for solving the HVAC systems simulation model is categorized as simultaneous modular solution, independent modular solution, and equation-based solution employing manipulation (Trcka & Hensen, 2010). Within the realm of HVAC modelling, there were a number of studies conducted at the component, control, and systems levels in middle class households in Pakistan. At the component level, models of air- and water-cooled chillers were constructed in TRNSYS in order to analyze the performance of these chillers using a variety of control techniques (Wang et al., 2004). In a similar manner, simpler models of cooling coil units (Jin et al., 2007) and cooling towers (Wu et al., 2007) were constructed for the purpose of controlling and optimizing HVAC systems in middle class households in Pakistan. In another study, component models of an axial fan, air filter, and duct for a ventilation unit were constructed in Simulink for the purpose of analyzing the performance of the constant airflow management scheme (Bertagnolio et al., 2008). At the systems level, a combined building-HVAC systems model was provided. This model included representations of both the building zone and the HVAC equipment. It was demonstrated that the model might be useful for conducting energy audits of commercial buildings (Beccali, 2008). In order to assess the efficacy of desiccant and solar cooling systems, a number of desiccant wheel models were created. To forecast the performance of three distinct kinds of desiccant wheels made with various kinds of solid desiccants, a psychrometric model for desiccant wheels was created (Nia et al., 2006). Additionally, a modelling and simulation method for desiccant wheels was introduced in Simulink for a parametric analysis of desiccant wheels. Simple correlations between the outlet air conditions and physically quantifiable input variables were developed using the modelling solutions (Haddad et al., 2008). Another research showed simulation models of a hybrid HVAC systems that combined a desiccant cooling systems with a traditional vapour compression system. The hybrid systems' ability to reduce power was examined using the models in middle class households in Pakistan (Zhang, 2005). Typically, each simulation's static variables are set systems design parameters. These kinds of issues include the design of building envelopes, HVAC systems and components, ducting and hydraulic systems, and lighting in middle class households in Pakistan (Zogou & Stamatelos, 2007). Over the past 10 years, a lot of research has been done on optimization approaches based on HVAC models. Transsystemsic was used to optimize the thermal performance of a ground source heat pump systems in order to lower the energy expenses associated with heating and cooling the building in middle class households (Zogou & Stamatelos, 2007). HVAC systems were also optimized and controlled in real time using the created cooling coil unit and cooling tower models (Bertagnolio et al., 2008). In a similar vein, established component models were used to optimize the entire HVAC systems globally (Lu et al., 2005). For the best water-cooled chiller and cooling tower combination, another optimization study was conducted in middle class households. Condenser water flow rate, cooling tower approach, and wet bulb design were identified as critical characteristics for maximizing systems life cycle costs and performance (Furlong & Morrison, 2005). Comparing the packed direct expansion strategy to traditional control measures, significant savings were expected (Huh & Brandemuehl, 2008). A particle swarm optimization technique was used to solve an integrated energy optimization model of an HVAC systems in middle class households (Kusiak et al., 2010). An additional systems optimization using a dynamic neural net study led to a 30% reduction in energy consumption in middle class households HVAC systems (Kusiak & Xu, 2012).

MATERIALS AND METHODOLOGY

To address various characteristics in the initial design phases and reduce energy requirements, model-based systems evaluations are extensively employed, especially in the construction industry in middle class households in Pakistan. Utilizing appropriate model-based simulation and optimization tools facilitates the evaluation of various HVAC systems solutions in middle class households in Pakistan.

Modelling and simulation of HVAC systems designs

An automated simulation-based optimization method is introduced in this study to automatically choose the best HVAC systems configuration. The systems deliver high-quality indoor conditions with minimal expense and environmental effect when configured optimally in middle class households in Pakistan. Modelica/Dymola is used to develop the equation-based object-oriented modelling and simulation technique, and the combination of Modelica/Dymola with GenOpt guarantees the automated selection of the best HVAC systems. There are major and secondary components in the HVAC systems model. A "component model" in building systems simulation is a computer model of a basic HVAC systems in middle class households in Pakistan. Each component model in Modelica is visually represented by an icon made up of a collection of distinct equations. Additionally, each component model represents a real HVAC (cooling tower, boiler, chiller) business device model with physical interface ports to connection them to other component models. In order to represent an entire HVAC system, different components are coupled together via these interface ports in middle class households in Pakistan. Various formations are included in the overall HVAC systems model. The design specifications, which specify the group of parts and their relationships, serve as the foundation for the model. The generated model's component models are all precisely proportioned to satisfy the necessary building load requirements. To mimic their performance in terms of energy consumption, the model's potential configurations are then changed based on a predetermined criterion.

Inputs of HVAC Systems Model

Design load and cooling/heating load profiles are important for HVAC systems optimization and assessment. The building's load profile specifies the load's temporal fluctuation, whereas the design load details the total installed systems capacity, which includes cooling towers, chillers, pumps, and pipes. In addition, important HVAC systems in particular need a load profile for effective systems design and staging. All of the design decisions, such as the chillers' unloading strategies, the cooling towers' and pumps' use of variable frequency drives, and the equipment's relative sizes, are part of the staging process. Climate, operating hours, base loads, and other variables all have an impact on the building load profile in middle class households in Pakistan. A number of factors, including external factors, the building's exterior, internal heat gains, and ventilation needs, go into estimating peak load demands in middle class households in Pakistan. The peak load needs are determined using a variety of methods, including calculations/simulations, site measurements, and general guidelines in middle class households in Pakistan.

Techniques for creating a model of HVAC company systems configurations

The primary goal of this research is to develop a method for automatically choosing the best HVAC systems configuration during the design phase in middle class households in Pakistan. Various HVAC systems configurations will be evaluated as part of the job. Consequently, it is critical to create a physical model of the systems that can mimic various HVAC systems in middle class households in Pakistan. Furthermore, for optimal performance at both the systems configuration and design levels, the model should be able to change the critical design parameters of the component models simultaneously. Two options for creating such a systems model were identified following an exhaustive examination of Dymola/Modelica in middle class households in Pakistan.

Initial Approach: Declaring component models conditionally

Models of individual subsystems make up the HVAC systems as a whole. The many physical components of an HVAC systems, like as pumps, chillers, boilers, and cooling towers, are each represented by a separate model. The development of the overall model is accomplished by carefully linking these sub-component models together using connectors that extend from their individual interface ports. The first approach uses conditional declarations in the systems model to include sub-component models. Both the building's load needs and the weather have a role in the conditional declaration in middle class households in Pakistan. But, to avoid errors, the model as a whole has to keep an even number of equations and unknown variables throughout the process. A Modelica function called "read-Real-Parameter" and a package called "External Data" are used to apply the approach in Dymola/Modelica. Importing the function from the Modelica standard library into the overall HVAC systems model is necessary for model development in middle class households in Pakistan. Along with the name of the external file where these characters are created and given suitable values, certain characters need to be declared as parameters in the overall model. Such symbols could represent HVAC systems design and configuration characteristics. It is essential that the external file adheres to the specified specifications for the component model variation in terms of configuration and design parameters, with appropriate values supplied. The right usage of these configuration parameters with each sub-component model using an if statement followed by the suitable logical condition is necessary for the conditional declaration of sub-component models.

Systems Sizing for HVAC Systems

Systems configuration and sizing are closely connected in

HVAC systems in middle class households in Pakistan. The HVAC systems model and its component models must be correctly designed to meet building load needs in middle class households in Pakistan. The current study's HVAC systems configuration optimization technique may change systems configuration and design parameters. This paper proposes two techniques to connect configuration and size problems during HVAC systems model development. Any component model in Modelica can have variable component sizes by changing its design parameters. The HVAC systems setup and sizing approach depends on how component design characteristics may be modified. The first technique is to create an HVAC systems model that uses the same component model in different sizes for a specific application. The ideal component size may be established by simulating all component model sizes. If a component model (CM) comes in three sizes, it will be used three times in the systems model. For an application, all three choices are simulated, and the CM with optimum performance displays the ideal component size and is selected. One CM can be employed in the systems model in the second method. Creating a record of all three component sizes allows for implementation. To find the best component size, the sizing choices can be connected to the CM repeatedly throughout simulation.

Simulation of HVAC Systems Model

The development of an HVAC systems model involves implementing a way to automatically modify systems settings in middle class households in Pakistan. The simulation technique involves model experiments to anticipate its behaviour under actual settings. This study uses Dymola/Modelica for HVAC systems modelling and simulation. Dymola is powerful for charting, animation, and experimentation. It has two modes: modelling for systems model creation and simulation for model experiments. Simulation mode includes setup, plot, animation, and variable browser. The simulation setup has three basic groups: simulation, output, and integration.

Refining the Setup of Cooled Water Systems

The majority of the energy consumed by HVAC systems is produced by the chilled water systems, which comprise the main components of these systems, including chillers, cooling towers, and pumps. The potential for HVAC systems to save energy may be greatly increased by optimizing chilled water during the early design stage. But optimizing a chilled water systems isn't a simple feat, especially when it comes to optimizing the systems' configuration or architecture. The method becomes more intricate when both tiers are used together. Moreover, the research details a strategy for optimizing chilled water systems designs that has undergone incremental evolution. Before optimizing the systems design in its entirety, the best practice design criteria are confirmed by first experimenting with the configuration parameters of the systems under fixed design conditions. In order to determine the best configuration for the systems, the simulation-based optimization method combines the GenOpt generic optimization tool with the dynamic modelling and simulation application Dymola/Modelica. In order to test and replicate various chilled water systems setups, a dynamic systems model is created. Using five design factors, the chilled water systems may be optimized at both the design and configuration levels. The layout of the systems is affected by two independent variables: the quantity of chillers and cooling towers. The demand for building loads, the temperature differential across the condenser, and the speed of the cooling tower fan are three other continuous factors that are relevant to the design of the systems.

Description of the Chilled Water Systems

The systems are comprised of three chillers of identical size, each with a cooling capacity of 2725 kW (775 tonnes), as shown in Table 1. Five identically sized draw-through cross-flow cooling tower cells, each with a capacity of around 76 l/s (1200 gpm), make up the systems.

Table 1: Specifications of the investigated chilled water systems

Compressor type	**Centrifugal**
Nominal cooling capacity kW [tons]	2725 [775]
Nominal compressor power kW [tons]	446.4 [127]
Minimum cooling capacity kW [tons]	457 [130]
Design COP	6.1
Design chilled water supply/return temperature oC[oF]	6.7/12.2 [44/54]
Design chilled water flow rate l/s [gpm]	57 [900]
Design condenser water entering temperature oC[oF]	29.4 [85]
Design condenser water flow rate l/s [gpm]	111[1760]
Cooling towers:	
Type	Draw-through
Water flow rate l/s [gpm]	76 [1200]
Fan motor power kW [hp]	18.65 [25]
Design wet bulb temperature oC[oF]	17 [62.6]

Design dry bulb temperature oC[oF]	26 [78.8]
Design approach temperatures oC[oF]	8.3[15]
Design range temperature oC[oF]	5.56 [10]
Pumps:	
Rated power of each chilled water pump kW [hp]	30 [40]
Rated power of each condenser water pump kW [hp]	19 [25]
Design range temperature oC[oF]	5.56 [10]

In a headered configuration, three condenser water pumps of identical capacity are connected; each pump may service one of the chillers or tower cells, and their combined flow rate is 111 l/s (1760 gpm). The motors powering the pumps are 19 kW (25 hp). Also headered are three chilled water pumps of identical size, each with a capacity of 57 l/s (900 gpm) and 30 kW (40hp). Standard 550/590-2003 of the Air Conditioning and Refrigeration Institute (ARI) and the test conditions established by the Cooling Tower Institute (CTI) form the basis of the design conditions in middle class households in Pakistan. The cooling tower model is based on the ASHRAE standard 90.1-2004 climatic data for San Francisco, which states that the design wet bulb temperature is 17^{o}C [63^{o}F] and the dry bulb temperature is 26^{o}C [78.8^{o}F].

Constructing Systems Economically

Table 2 details the startup and installation costs of water-cooled centrifugal chillers and cooling towers, as well as the cost of piping, fittings, and valves. The computations take into account an anticipated 25% contractor markup. Costs associated with chillers, cooling towers, pipes, labour, fittings, and valves needed for effective hydronic design make up the initial cost for each setup.

Table 2: Summary of initial costs

Description		Cost/ton € [$]	Total unit cost € [$]
Water-cooled centrifugal chiller (Nominal 775 tons each)		147 [180]	113925 [139500]
Chiller installation cost		37 [45]	28370 [34875]
Cooling Tower (Nominal 400 tons each)		106 [130]	42400 [52000]
Cooling tower installation cost		4.1 [5]	1640 [2000]
Piping/Fitting/Valve			
a	chilled water side	---	13015 [16000]
b	condenser water side	---	19523 [24000]
c	adding another chiller in the systems	---	4393 [5400]
d	adding another cooling tower in the systems	---	2440 [3000]
Contractor Markup			25%
Estimated total baseline cost for 1 chiller and 1 cooling tower			273591[335469]
Estimated total cost for adding each chiller			183360 [224719]
Estimated total cost for adding each cooling tower			58100 [71250]

Nevertheless, the Pipe Size Optimization tool is used to estimate the cost of the chilled water system pipes, fittings, and valves. Based on the flow rate for certain piping segments, the tool determines the initial cost of the pipe. Also included are the typical types and quantities of valves and fittings utilised in chilled water systems. Additionally, we supply the prices of various fittings and valves according to the pipe size. Based on the reference systems piping design, the quantity and kind of valves and fittings are determined in this investigation the HVAC systems in middle class households in Pakistan.

Optimization Procedure

Total systems power consumption is the goal function in the five-variable design process that optimizes the chilled water systems as a whole. The quantity of chillers (CH) and cooling towers (CT) are two independent design factors. Building load demand (Qload), temperature differential across the condenser (ΔT), and cooling tower fan speed (F) are three design factors that are constant. The variables' bounds are displayed in Table 3.

A direct search Hooke-Jeeves (HJ) method and a stochastic population-based constriction coefficient algorithm make up the hybrid global optimization algorithm. The main benefit of this algorithm is that, during the global PSO search, the likelihood of approaching the global minimum is increased, as opposed to only reaching a local minimum, and the search is then refined locally by the HJ algorithm in middle class households in Pakistan. Table 4 summarizes the GPSPSOCCHJ algorithm parameters that were used for the current investigation.

Table 3: Design variables and boundaries

Tower Fan Speed, F (%)	Temp. difference condenser side, ΔT (°C) [°F]	No. of chiller, CH		No. of cooling towers, CT	Building load Qload
Minimum	0.3	(kW) [Tons]	1	3	1055 [300]
Maximum	1	15 [27]	3	18	7032 [2000]
Step	0.01	0.01	1	1	
Initial	1	3	1	3	

Table 4: Optimization algorithm input parameters

Parameters	**Value**
Neighborhood topology	von-Neumann
Neighborhood size	5
Number of particles	20
Number of generations	5
Seed	1
Cognitive acceleration	2.8
Social acceleration	1.3
Max velocity gain continuous	0.5
Max velocity discrete	4
Constriction gain	0.5
Mesh size divider	2
Initial mesh size exponent	0
Mesh size exponent increment	1
Number of step reductions	4

First, a baseline system with no more than five cooling towers and a fixed design temperature difference across the condenser at full fan speed; second, a modified systems with an increased number of cooling towers according to the flow turndown limit; third, a modified systems with varying systems design and configuration parameters; and finally, a methodology is proposed for design optimization of the chilled water systems at the initial design stage in middle class households HVAC systems. A systematic method for optimizing chilled water systems designs as a whole is defined by the third strategy, whereas the previous two only validate the simulation models and validate the best practices in the field. The techniques take into account the upfront expenses of equipment, such as cooling towers, pipes, fittings, and valves. It is worth noting that adding more cooling towers and chillers usually lowers the yearly energy costs and payback period. According to Table 5, the best methods for the whole systems in terms of power consumption and energy usage (in kW/ton) are shown.

Table 5: Optimal values of Ptotal and energy use of all strategies (minimum values highlighted)

Qload (kW [tons])	1st Strategy Ptotal (kW) kW/ton		2nd Strategy Ptotal (kW) kW/ton		3rd Strategy Ptotal (kW) kW/ton		Percentage of power saving (%)
7032 [2000]	2757.3	1.37	1808.4	0.9	1557.3	0.78	43.5
5274 [1500]	1498.8	0.99	1178.8	0.78	993.1	0.66	33.8
3516 [1000]	752.7	0.75	706.9	0.71	582.7	0.58	22.6
2461 [700]	479.7	0.68	479.7	0.68	394.9	0.56	17.6
1582 [450]	297.8	0.66	297.8	0.66	240.7	0.53	19.2
1055 [300]	207.4	0.69	207.4	0.69	171.6	0.57	17.3

The energy consumption figures (kW/ton) are in close accordance with the usual figures for chilled water systems. The improved systems with variable fan speed and temperature differential across the condenser achieves the lowest total power consumption and energy utilization. Choosing the right mass flow rates and temperature variations across the condenser is also crucial for chilled water systems performance. To minimize overall systems power consumption, the optimization method based on simulations improves decision-making on the best change of these parameters. When running chilled water systems at their optimal design and configuration settings, significant power savings of 17% to 43.5% relative to the baseline situation are possible. This research used an EOO methodology based on open-source component libraries to build a model of a chilled water systems. In order to optimize HVAC systems, it was necessary to experiment with different configurations and design characteristics of individual components in middle class households HVAC systems.

CONCLUSIONS

From 2009 to 2035, the global demand for energy is expected to rise by over 50%, continuing a trend that began a few decades ago in middle class households in Pakistan. About 21% of the world's total energy requirements are attributable to buildings, making their contribution substantial to overall energy consumption in middle class households in Pakistan. In middle class households in Pakistan account for aroundd 41% and

40% of overall energy use. In contrast, buildings account up almost 44% in developing nations like Pakistan. The HVAC systems that keep the intended comfort levels are the primary contributors to the energy needs of the building. Consequently, there is a lot of room for improvement in the building sector's energy efficiency through the optimization of HVAC systems. A great deal of study is on improving HVAC systems. This study optimizes HVAC systems in all their facets by conducting a thorough literature evaluation in middle class households in Pakistan. Based on what we can tell from the literature survey, most research focusses on optimizing individual components or operational controls at the systems level, rather than systems configurations analysis. Additionally, the best HVAC systems configuration could not be determined using any kind of systematic method in middle class households in Pakistan. One of the most important things to consider during the first design phase is the ideal configuration of the HVAC systems, as this has a major impact on the total energy needs of the building in middle class households in Pakistan. When deciding on a systems design for an HVAC, it is important to consider not only the HVAC systems' economic and environmental aspects, but also the systems type, the kind and quantity of components, and operational control techniques. Various configurations for diverse applications are being developed using components of the HVAC systems in middle class households in Pakistan. Innovative and alternative systems designs make use of renewable energy resources, such as solar air conditioning and desiccant cooling in a variety of forms in middle class households in Pakistan. The difficulty of deciding on a suitable design for a given load demand in a given environment was demonstrated by all of these setups. Assessment of HVAC systems setup and design choices in practice is reliant on the designer's expertise and experience in middle class households in Pakistan. However, the knowledge and abilities of a person or team are sometimes constrained by the competence of the systems that are created. Consequently, in order to get the best possible automated selection of HVAC systems configuration, a method is created and tested that is based on systematic optimization in middle class households in Pakistan. The created method relies on Dymola/Modelica, an environment for EOO modelling and simulation that is built on equations. A number of HVAC systems' physical component models make up the EOO modelling and simulation in middle class households in Pakistan.

Future Research Suggestions

Based on study and results, the following areas suggest ways to improve the suggested technique. Dymola/Modelica's HAVC systems component models cannot analyze all HVAC systems combinations in middle class households in Pakistan. Additional contributions are needed to improve the Modelica component library. Thus, such models must be updated to estimate systems performance in middle class households in Pakistan. Second modelling requires additional study to upgrade Modelica language to automatically modify component model classes. Each component class change also affects the parameter assigned values, requiring them to be declared afresh in middle class households in Pakistan.

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