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Review On Life Cycle Optimization Of Residential Air Conditioner Replacement Using Artificial Neural Network

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Abstract- A two-in two-out steady-state artificial neural network (ANN)-based model for an experimental variable speed direct expansion air conditioning (A/C) system has been developed for simulating its total output cooling capacity and equipment sensible heat ratio under different combinations of compressor and supply fan speeds. Experiments were carried out, and totally sets of experimental data were obtained for ANN training and testing. An ANN-based model having the configuration of 2 neurons in the input layer, neurons in the output layer and neurons in each of the hidden layers, i.e. configuration, was thus developed. The ANN-based model developed can be used to predict the operating performance of the A/C system with a higher accuracy. It is expected that the model Review can help design a multivariable-input multivariable-output strategy to simultaneously control indoor air temperature and humidity.

Index Terms- Artificial neural network, indoor temperature, relative humidity, thermal comfort,

I. INTRODUCTION

HVAC is an acronym that stands for Heating, Ventilation, and Air Conditioning. The term HVAC is used to describe a complete home comfort system that can be used to heat and cool your home, as well as provide improved indoor air quality. HVAC can be easily confused with the term AC, but AC simply refers to air conditioning on its own, while HVAC refers to the broader system, which may or may not include an air conditioning unit [1].

Components Hvac System

A complete HVAC system has more than one component. In fact, it has multiple units and parts, both inside and outside your home, that all work together doing different jobs to bring you the complete home comfort you need. While there are many different components that can be part of an HVAC system, below are a few of the ones you're most likely to see in your system, plus what they do [2]:

- Air Conditioner - An air conditioner cools your home by removing heat and humidity from inside and transferring it outside.
- Heat Pump - Contrary to their name, a heat pump can both heat and cool your home. They use refrigerant to absorb, transport, and release heat, and they can reverse the flow of that refrigerant depending on if

you need heating or cooling. Heat pumps are powered by electricity, not fossil fuels.

- Furnace - Furnaces create heat by burning a fuel source like natural gas or propane. The heat they create is then distributed throughout your home, in order to increase the indoor temperature [3].
- Air Handler - Air handlers circulate both warm and cool air formed by other HVAC units throughout your entire home, in order to reach your desired temperature in every room [4].

II. HVAC SYSTEM WORKING

The goal of your HVAC system is to make your ideal home comfort circumstances become a reality. To do this, a complete system must be built from a combination of an air conditioner, furnace, air handler, ductwork, thermostat and even some other units like a humidifier or air purifier. Once the proper HVAC system for your home is selected and installed, you'll begin controlling the temperature inside with your thermostat.

When the thermostat tells the other HVAC units in your home the temperature needs to change, they will begin the process of producing warm or cool air. That newly warmed or cooled air will be distributed throughout your home with the help of ductwork or an air handler. If your home features a ductless system, refrigerant lines will help move the air through the system [5]. HVAC systems can be powered by either gas or electricity, though most systems are now electric. The main exception are furnaces, which tend to be either gas or oil powered [6].

III. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

Heating, ventilation, and air conditioning (HVAC)[1] is the use of various technologies to control the temperature, humidity, and purity of the air in an enclosed space. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a subdiscipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. "Refrigeration" is sometimes added to the field's abbreviation as HVAC&R or HVACR, or "ventilation" is dropped, as in HACR (as in the designation of HACR-rated circuit breakers) [7].

HVAC is an important part of residential structures such as single family homes, apartment buildings, hotels, and senior living facilities; medium to large industrial and office buildings such as skyscrapers and hospitals; vehicles such as cars, trains, airplanes, ships and submarines; and in marine environments, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors [8].

Ventilating or ventilation (the "V" in HVAC) is the process of exchanging or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, carbon dioxide, and other gases. Ventilation removes unpleasant smells and excessive moisture, introduces outside air, keeps interior building air circulating, and prevents stagnation of the interior air. Methods for ventilating a building are

divided into mechanical/forced and natural types.[2]

IV. LITERATURE REVIEW

[1] Santhosh Srinivasan, Modelling And Analysis Of Automatic Air Conditioning System Using Support VECTOR MACHINE: Automatic air conditioning system is encouraged in most of the automotive especially passenger cars. This system can enable higher standard of comfort to the passengers, so the automotive industries are trying to implement the automatic air conditioning system in most of their vehicle. One the other hand manufacturing simulation is additional processing experienced in most of the manufacturing industry, to analysis the complete performance of the product or vehicle before it manufacturing. In recent decade more than 100 simulators are developed to analysis the various operation of the manufacturing and vehicle.

But simulation analysis of air conditioning system and automatic air conditioning system is challenging to the engineer. They may require to spend more time to analysis the performance of the automatic air conditioning system. Thus in later period soft computing based system for the effective performance prediction of automatic air conditioning system is proposed. But the prediction accuracy of the past technique is not in the satisfactory level. Hence in this paper, a novel soft computing technique is proposed for the effective prediction of the performance of the automatic air conditioning system. In the proposed system support vector machine is used for the prediction of the performance of automatic air conditioning system. The performance of the proposed technique is compared with the ANN.

[2]Marwan Marwan, Optimize electrical energy cost of air conditioning considering to different wall characteristics: The purpose of this study is to optimize the electrical energy cost (EC) of air conditioning (AC) with consideration of different wall characteristics. The type of wall characteristics is based on the varying composition of the wall. For example: Styrofoam, soil, calcium carbonate and iron. There are three kinds of wall that have been evaluated to design an economical building. To fulfill the goal of this research, a cooling model of building has been designed to optimize the electrical EC of the AC considering to temperature room.

Under numerical optimization the electrical EC can be computed by considering thermal conductivity (K) and outside temperature (Tout). Consequently, the electrical EC for Building-1, Building-2, and Building-3 can be reduced to IDR 25,000, IDR 23,000, and IDR 20,000, respectively. In addition, this model is tested considering the value of Tout in Barru South Sulawesi-Indonesia during the entire day of July 17th, 2021 in dry session with geographical coordinates are 4° 24′ 20″ South, 119° 36′ 23″ East and Latitude −4.436417.

[4] Zhen Tian, 4E analyses and multi-objective optimization for an innovative solar-ocean thermal energy conversion/air conditioning system: This paper proposes a solar-ocean thermal energy conversion system (S-OTEC/AC) with integrated air conditioning cycles to provide power, cooling capacity, and fresh water in the South China Sea. Solar energy and surface

seawater are used as heat sources in S-OTEC/AC system, the deep-sea water is used to absorb heat. The organic Rankine cycle (ORC) is selected as the main cycle of OTEC, with R134a as the working medium. In order to improve the sustainability of the system, energy, exergy, economic, and environmental (4E) analysis models were proposed for the system. Parametric studies are performed to investigate the effects of R134a temperature at the evaporator outlet, turbine inlet, and outlet pressures, and water flow rate of solar heater on the system performance indicators. Furthermore, multi-optimization is conducted with the Levelized Cost Of Energy (LCOE) and the product of energy-exergy efficiencies (ηen,sys*ηex,sys) as objective functions.

[5] Ehsan Saedpanah, Optimization of multi-source renewable energy air conditioning systems using a combination of transient simulation, response surface method, and 3E lifespan analysis: A new simulation-statistical optimization strategy for optimum design of a multi-source renewable energy air conditioning system that includes an absorption chiller (AC), a desiccant wheel, photovoltaic/thermal (PV/T) panels, ground source heat exchanger (GSHE), and thermal energy storage unit filled with phase change materials (PCMs) is developed in this study. The strategy is created by combining the transient-based simulation and response surface method (TRN-RSM) to achieve the optimal energy, economic, and environmental (3E) design of the hybrid cooling and heating system with a realistic computational cost over the system's 25-year lifespan. Desiccant wheel and AC subsystems are used to manage the latent and sensible load of the building separately.

[6] Jaafar Younes, Enhancing sustainability and resilience of elderly dwellings: Optimized refurbishing parameters and air conditioning operation: Refurbishing buildings to minimize lifecycle costs and increase reliance on natural ventilation may reduce building resilience to extreme weather. This is critical for elderly whose health is affected by exposure to thermally stressful conditions. This study proposes a novel approach for refurbishing elderly houses to enhance their sustainability and heatwave resilience with the aim of supporting low-income groups. This approach involves using multi-objective optimization to identify refurbishment parameters and an autonomous control strategy to provide thermoneutral indoor conditions at a low cost.

[7] Kashif Irshad, Novel optimized hybrid neuro-fuzzy approach for analysis of cold thermal storage system-assisted air conditioning system performance: HVAC (Heating, ventilation, and air conditioning) systems can be used as a basic flexible load to provide approximately 20% of a building's energy demand and possess the capacity to transfer energy. Effective cooling load forecasting is one of the most important methods for achieving energy savings in buildings. This study proposes a Heap Optimization Based Generalized Intelligent Neural Fuzzy Control (HO-GINFC) for estimating the cooling load of an air conditioning system with cold thermal storage. It was primarily utilized to research historical meteorological data on cooling load.

Using the quantitative data of a massive Saudi Arabian commercial structure, the model is validated. Using the HO algorithm, the performance of GINFC is optimized. Additionally, the cold storage tank's maximum capacity can be reached. Moreover, the results demonstrated that the HO-GINFC model accurately predicted the CV-RMSE (coefficient of variation of the root mean squared error), MSE (Mean Square Error), MAE (mean absolute error), R2 (squared correlation coefficient), and RMSE (root mean squared error) values to be 2.107%, 100%, 0.258%, 0.992%, and 1.058%, respectively. Comparative studies demonstrate that the HO-GINFC model outperforms neural networks in terms of prediction accuracy, execution speed, and resiliency when dealing with a large number of samples. The predictions of the model proposed in this work provide significant technical support for computing rising energy demands and can be implemented in actual engineering.

[8] Frank Porras, On the adoption of stricter energy efficiency standards for residential air conditioners: Case study Guayaquil, Ecuador: Space cooling is the fastest-growing energy end-use in buildings worldwide, and Ecuador is no exception. Nevertheless, the last update of the Minimum Energy Performance Standards (MEPS) for air conditioners was in 2013 (EER 3.2W/W); since then, no new standards have been proposed in Ecuador. This study is the first assessment of stricter MEPS and estimation of benefits for the consumers and society of the residential sector in Guayaquil, Ecuador.

The life cycle cost, payback time, net present value, electricity savings, and CO2 mitigation are the outputs from the Policy Analysis Modeling System (PAMS) methodology followed. The analysis considers future economic scenarios until 2035. Also, a new engineering approach based on linear optimization defines ACs designs in compliance with the proposed MEPS at the lowest cost. Therefore we can avoid setting less ambitious energy-efficiency targets when efficiency options are limited in the market (this is the Ecuadorian case). The analyzed MEPS are those proposed by UNEP and by the renewal program of inefficient equipment of the Ecuadorian Government. Our estimates show that AC demand can reach 17.3% of the total residential electricity demand in the business-as-usual scenario and 21.4% in the high economic growth scenario until 2035.

[9] Wenqiang Li, A method for energy consumption optimization of air conditioning systems based on load prediction and energy flexibility: A new method for heating ventilation and air conditioning (HVAC) energy consumption optimization based on load prediction and energy flexibility is proposed. First, the energy consumption prediction of the chillers and air conditioning terminals is made.

Then, an optimal chiller loading (OCL) equation is built, and is new in the following aspects: the electricity consumption of air conditioning terminals is included and amended by a penalty coefficient to consider thermal comfort. This penalty coefficient is calculated based on energy flexibility. The prediction results are used as constraints of the OCL equation. Next, the sensitiveness of the system's energy

consumption with different penalty coefficients and different settled comfort air temperatures are tested.

All cases are solved by the particle swarm optimization (PSO) algorithm and validated by the genetic algorithm (GA). Finally, economic analyses are made. The results show that the comprehensive energy-saving ratio is about 10%, and the discounted payback value is 5.8 years. The penalty coefficient is more sensitive than the settled comfort air temperature for the system's energy saving. This proposed method is significant for improving the reliability of the feedforward control strategy and reducing the response time of the feedback control strategy.

[10] Ali Akyüz , Experimental investigation of a solar-assisted air conditioning system: Energy and life cycle climate performance analysis: Among building elements, HVAC (heating, ventilation, and air conditioning) systems use the most energy. In this regard, effective solutions should be developed to reduce the energy consumption and negative environmental impacts of these systems and improve their efficiency. In addition, the relative coincidence of energy availability and cooling demand makes indoor space cooling a significant possibility for solar energy use. In this study, the effect of air conditioners (ACs) on reducing energy consumption in the case of supporting AC systems used in residential air conditioning with solar energy from renewable energy sources was experimentally studied.

For this purpose, if the outdoor temperature in August was 32, 36, and 38 °C, and the indoor temperature was kept at 18, 19, and 20 °C, the performance of the solar-powered AC system was compared with a conventional AC system under the same ambient conditions. For comparison, two rooms with the same internal volume and insulation properties were built. Increasing the input temperature of the compressor saved about 8–28% of the energy. Moreover, the environmental effects of energy savings from the proposed system for the hottest summer times in residential buildings were examined by life-cycle assessment, and depending on the decrease in energy consumption, there was a decrease in emission values between 7.74 and 28.27%.

[11] Wentao Hu, Optimization of the thermal performance of self-insulation hollow blocks under conditions of cold climate and intermittent running of air-conditioning: The self-insulation wall is widely used in the field **of architecture because it involves a simple** construction process, saves resources, and reduces environmental pollution. In this study, self-insulating block experimental groups of different filling rates and filling place positions were made to obtain the most suitable filling scheme for self-insulating hollow blocks in cold climates and intermittent running of air-conditioning. The working conditions of different types of self-insulating block groups were simulated and recorded using hot and cold box-heat flow meter methods in a cold climate and intermittent operation of air-conditioning. The results show that some previous research conclusions are still applicable in a cold climate and intermittent running of air-conditioning. The experimental group filled with insulation materials in the middle of the hole showed a better thermal performance at a filling rate of 25%; the

experimental group filled with insulation materials in both sides of the hole exhibited better thermal properties at a filling rate of 50%. When compared with 5 other types of cases, the average heat flow of Case 2 was the smallest and was between 18.36 W/m2 and 21.89 W/m2, therefore, the intermittent running mode of Case 2 was found to be the best**.**

[11] Mohammadreza Baghoolizadeh, Improving CO2 concentration, CO2 pollutant and occupants' thermal comfort in a residential building using genetic algorithm optimization: Environmental air pollutants pose a serious threat to human society's health and way of life, and their amount is rising quickly. Given that we spend the majority of our time indoors, good indoor air quality (IAQ) is essential. When the concentration of pollutants that have seeped into the building space, like CO2, is reduced, this favorable air quality becomes significant. 39 design factors, including the temperature setting of the air conditioning system's (Acs) thermostat for cooling and heating, the insulation level of the residents' clothing and the air speed for all months of the year, the level of activity envelope building, and the amount of clean air that is transferred from the outside to the inside of the building by the air conditioning, have been taken into account in this research in order to solve this significant problem in the residential sector.

[12] Shobhit Chaturvedi, Application of PSO and GA stochastic algorithms to select optimum building envelope and air conditioner size - A case of a residential building prototype: Simulation aided building design optimization process can support architects and engineers in selecting high-performing building materials, glazing size, type, and precise sizing of air conditioners. To this end, this paper presents the application of two stochastic algorithms, i.e. Particle Swarm Optimization (PSO) and Genetic Algorithm (GA), to minimize annual cooling energy consumption for a residential building prototype situated in a hot and dry (Köppen climate classification: BSh) region of India.

[13] Tareq Salameh, Optimization and life cycle analysis of solar-powered absorption chiller designed for a small house in the United Arab Emirates using evacuated tube technology: Due to the significant increase in the energy demand, mainly driven by air conditioning electrical loads in residential and industrial sectors of the United Arab Emirates (UAE), according to climate change and population increase.

[14] Markel Arbulu, Environmental and economic optimization and prioritization tool-kit for residential building renovation strategies with life cycle approach: The most recent regulations, as well as the scientific studies, remark the importance of the evaluation of the entire life cycle on building renovations, relative to the environmental impact and economic feasibility, making the Life Cycle Assessment (LCA) the prioritizing analysis.

[15] Yanjie Li, A life cycle analysis techno-economic assessment framework for evaluating future technology pathways – The residential air-conditioning example: Clarity on cost and environmental benefits of individual technologies evaluated in a systemic and systematic manner is necessary in communicating the results at the policy level so as to enable effective

decisions. Yet, the highly complex nature of many energy modelling tools makes it difficult for non-specialists to interpret and make sense of their results. An integrated life cycle analysis and techno-economic assessment framework is proposed in this study, as a first step towards developing an alternative and potentially more intuitive energy systems modelling tool.

V. CONCLUSION

According to the present results, concerning the stopping criteria of the suggested meta-model generation method, we can deduce that appropriate stopping criteria should estimate the efficiency of the artificial neural network through the sample of validation and for all outputs of the ANN, make the correlation coefficient r proper then. This has been approved by Fig.5, where the ANN-MMs give an appropriate efficiency for small sizes of the sample with $r > 0.8$, but not for the samples of validation. Notably, it is required for the sample of validation to be the design space representative, as it has been assumed in this study, creating another sample, which is independent, by the Latin hypercube sampling approach.

For developing ANN-MM with a few simulations based on physics and for obtaining precise results in multiple-criteria optimization problems of the building this method is suggested that solves the shortcomings of classic Trial and Error methods. Nevertheless, it is globally considered that the efficiency of the meta-model is enhanced in the overall design space following each increase in the sample size of the training. While this is accepted in the present utilization, for other applications such as energy labeling of the building it is flawless. It is needed for an optimum meta-model to have average global precision but a proper efficiency on the Pareto set for multiple-criteria optimization. Therefore, the number of needed simulations based on physics can be decreased by iterative methods with a smart sampling technique.

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