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Literature Review of Energy Management Systems

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Abstract
Energy is a scarce commodity, which should be conserved utmost. There are several ways of conserving energy. In buildings like hotels, chillers are used to control the temperature. The load in terms of the presence of the non-living things and employees and customers inside the building keeps changing with respect to time. So, the chillers are to be controlled optimally such that the required temperature is maintained inside the building and at the same time the total kilo-watt consumed is minimized. This paper discusses the development and analysis of models for real time benchmarking of energy savers in chillers. Different models for estimating the kilowatt consumption based on system parameters are developed and they are analyzed for their accuracy. Finally, the powerful model is suggested for implementation.

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I. INTORDUCTION

The problem of global warming is viz. industrialization, the extension and intensification of agriculture and the rising demand for fossil fuels as populations grow rapidly in the developing world. All of these activities are producing huge quantities of greenhouse gases such as methane, nitrous oxide, surface ozone and CFCs, as well a as carbon dioxide. The greenhouse effect, whereby a proportion of the energy radiated from earth to space is captured to maintain an average global temperature of 15^oC. The problem is that a rapid growth in the effectiveness of this blanket of greenhouse gases is turning up the thermostat and leads to global warming. Hence, any effort to control and optimize the use of energy will certainly amounts to conservation of energy and reduction in global warming. Tim Jackson (1991) presented a methodology for comparison of the cost-effective technical options for the abatement of greenhouse gas emissions. The analysis concludes that of seventeen abatement options examined, the nuclear option is the most expensive, except for the marginal CO_2 savings achieved from advanced coal technology. Ute Collier (1993) examines to what extent the European Communality is progressing towards realizing its objective of integrating energy and environment policies developments; the CO_2 reduction strategy and the internal energy market (IEM) initiative.

Energy conservation is the key for sustained service to human kind. If it is not properly done, definitely at some early point in time, there will be depletion of energy sources which will lead to hardship to the society. In this direction, there are many alternatives to supplement energy. The most significant one is non-renewable sources of energy, viz. solar, wind tidal, etc. In addition to supplementing the energy through non-renewable sources, minimizing the energy which is consumed to operate a system is considered to be an important alternative, which will help the individual business houses and the world at large.

II. LITERATURE REVIEW

This Section presents an extensive review of literature on energy conservation techniques and models.

Darley (1978) focused on the conditions under which effective products, procedures and techniques for achieving energy conservation, will be adopted voluntarily. It is suggested that, first, that an economic incentive for the utilization of those energy-conserving techniques is not a sufficient condition for their adoption, and second that a psychologically-based theory of the diffusion of innovation will identify the critical variables for promoting the adaption of energy-conserving products and techniques.

Avraham Shama (1983) reported that the US building sector can produce 30-50% of its energy needs by more efficient use of energy, that by conservation. The cost of such energy conservation is below that of imported oil or new electric generation capacity. Yet, customer adoption of this type of energy is quite low. The author has emphasized the engineering, economic and behavioral perspectives and the importance of integration of these elements.

John Randolph (1984) reported that in the USA, states have identified four types of non-utility programmess to promote energy conservation and renewable energy: tax incentives, grant and loan programmes, regulations and standards, and research and development programmes. Based on a survey, there is a wide variation among the states in the extent to which these programmes have been initiated and implemented. There appears to be two factors influencing a state's involvement in these programmes: the dependence of the state on outside energy sources and the political nature of the state. Andrew Warren (1987) states that investment in energy conservation frequently provides better rates of return than investment in energy supply.

DeCanio (1993) discussed the barriers within firms to energy-efficient investments. Many investments in energy efficiency fail to be made despite their apparent profitability. Internal hurdle rates are set higher than the cost of the capital to the firm. Reasons for these practices include bounded rationality, principal-agent problems and moral hazard. The policy implication is that government can simultaneously improve overall energy efficiency and increase private sector productivity by providing informational and organizational services that go beyond the traditional regulatory framework.

Howarth and Bo Andersson (1993) examine the theory of the market for energy –using equipment, showing that problems of imperfect information and transaction costs may bias rational consumers to purchase devices that use more energy than those that would be selected by a well informed social planner guided by the criterion of economic efficiency. Customers must base their decisions on observed prices and expectations of post-purchase equipment performance.

Greening, Davis, Lee Schipper and Marta Khrushch (1997) presented the comparison of six different methods of aggregate energy intensity decomposition applied to the same set of data, for the manufacturing sector in 10 OECD countries from 1970 to 1982. The comparison is based on the size of the residual term, the variability of that term, and the ease of implementation of the method.

Tom Webster (2003) reports that in almost all buildings with chillers, there is an opportunity for savings. The potential varies with age of chiller and availability of Building Management System (BMS). The only case that has little opportunity is for those buildings with newer chillers that also have a BMS. This is small fraction of the population, less than 10% of federal floor space. There is much greater opportunity for significant performance improvements in all other cases, that is buildings with no BMS and new chillers, and buildings with older chillers with and without BMS. These later categories make up about 80% of buildings with chillers.

Chow, Zhang, Lin, Z. and Song (2002) have introduced a new concept of integrating neural network and genetic algorithm in the optimal control of absorption chiller system. Based on a commercial absorption unit, neural network was used to model the system characteristics and genetic algorithm as a global optimization tool. They reported that the results appeared to be promising.

Mathews and Botha (2003) presented improved thermal building management with the aid of integrated dynamic HVAC (Heating, Ventilating and Air Conditioning) simulation. Yao-Wen Wang et al.(2004) presented a simplified modeling of cooling coils for control and optimization of HVAC systems. Existing CCU models for control and optimization are either linear approximations around an operating point or very complex nonlinear ones, resulting in difficulties for real time applications. Therefore, it is of practical importance to develop a simple, yet accurate CCU engineering model that will yield better real time control and optimization of feating, ventilating and air conditioning (HVAC) systems. They developed a simple, yet accurate engineering CCU model. The modeling technique is based on an energy balance and heat transfer principles. Commissioning information is then used to estimate, at most, three model parameters by either a linear or nonlinear least squares method. Ahn and Mitchell (2001) have studied the optimal supervisory strategy for the set points of controlled variables in the cooling plants by simulation. A quadratic linear regression equation for predicting the total cooling system power in terms of the controlled and uncontrolled variables was developed using simulated data collected under different values of controlled and uncontrolled variables. The optimal set temperatures such as supply air temperature, chilled water temperature and condenser water temperature are determined such that energy consumption is minimized as uncontrolled variables, load, ambient wet bulb temperature and sensible heat ratio are changed. The chilled water loop pump and cooling tower fan speeds are controlled by the PID controller such that the supply air and condenser water set temperature reach the set points designed by the optimal supervisory controller. The influences of the controlled variables on the total system and component power consumption were determined.

Fong, Hanby and Chow (2006) have proposed the simulation-optimization approach for the effective energy management of HVAC system. Due to complicated interrelationship of the entire HVAC system, which commonly includes the water side and air side systems, it is necessary to suggest optimum settings for different operations in response to the dynamic cooling loads and changing weather conditions throughout the year. A meta-heuristic simulation-EP(evolutionary programming) coupling approach, which can effectively handle the discrete, non-linear and highly constrained optimization problems, such as those related to HVAC systems.

Samuel and Chia (1983)have developed a model based on dynamic heat transfers through the building envelope and between the contents inside the building. This model has been incorporated into the computer aided building air-conditioning requirement and environmental temperature simulation program.

Lu Lu, Wenjian Cai, Yeng Soh Chai, Lihua Xie and Shujiang Li (2004) presented global optimization technologies for overall heating, ventilation and air-conditioning (HVAC) system. The objective function of the global optimization and constraints are formulated based on mathematical models of the major components. All these models are associated with power consumption components and heat exchanges for transforming cooling load. Lu Lu, Wenjian Cai, Yeng Soh Chai, Lihua Xie and Shujiang Li (2004) presented a model based optimization strategy for the condenser water loop of centralized heating, ventilation and air conditioning (HVAC) systems. Through analyzing each component characteristics and interactions within and between cooling towers and chillers, the optimization problem is formulated as that of minimizing the total operating cost of all energy consuming devices with mechanical limitations, component interactions, outdoor environment and indoor cooling load demands as constraints. A modified genetic algorithm for this particular problem is proposed to obtain the optimal set points of the process.

Yu and Chan (2008) investigated the energy performance of chiller and cooling tower systems integrated with variable condenser water flow and optimal speed control for lower fans and condenser water pumps. Thermodynamic-behaviour chiller and cooling tower models were developed to assess how different control methods of cooling towers and condenser water pumps influence the trade-off between the chiller power, pump power, fan power and water consumption under various operating conditions. Load based speed control was introduced for the tower fans and condenser water pumps to achieve optimum system performance.

Lee, Hua Chen and Yik (2008) presented the development of an empirical model for predicting the operational performance and energy consumption for the use of water-cooled air-conditioners.

Yu and Chan (2009) evaluated operating cost savings of a chiller system integrated with optimal control of cooling towers and condenser water pumps. A chiller system model was used to ascertain how different control methods influence the annual electricity and water consumption of chillers operating for the cooling load profile of a reference hotel. Koeppal (1996) developed a methodology for determining the optimal control of an HVAC system.

Marinakis, and Doukas (2018) developed an Advanced IoT-based System for Intelligent Energy Management in Buildings. They developed a framework , which aimed at unified and standardised modelling of the entities of the building environment.

Sadeeq and Zeebaree (2021) carried out a literature and policy analysis for the role of energy management system aggregators and the participation of end-users in subsidiary systems within Smart Grid programmers and technologies.

Zeeshan (2014) described the optimization process of managing energy consumption in an office building in Pakistan.

Najafi-Ghalelou (2018) presented optimal energy management of interconnected multi-smart apartment buildings considering energy flow among them.

III. CONCLUSION

Energy management is the key for the modern world with a view to reduce power consumption and in turn reduce pollution while generating power. This paper made an attempt to give a comprehensive review of literature on energy management, which will act as a source of future researchers in this direction.

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