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RESEARCH ARTICLE

ENERGY MANAGEMENT SYSTEM IN BUILDING USING A MULTI-AGENT CONTROL METHODOLOGY

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ABSTRACT

In this paper, we depict a framework that comprises a set of attributes agents to control and monitor a building infrastructure for its energy utilization. It utilizes the energy power lines for communication between the agents and the electrical devices of the building infrastructure, i.e., ventilation, sensors and actuators for lights, heating etc. The paper proposed a multi-agents methodology that is embedded through the development and usage of the product. The agents are defined to present the attributes of building like heating agent will present the Heating attributes such as solar panel and boiler. These agents are given various standards which prompt the required control strategies of the building conditions. All the Simulations are done in Matlab tool. The results of proposed work are showing improved energy efficiency in terms of energy consumption and comfort level of users.

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INTRODUCTION

In this respect, the subject of smart building is presented. A smart building is one that uses digital technology to self-sufficiently oversee and adjust the building environment to enhance work efficiency, user comfort, safety and energy-consumption (Yang and Wang, 2013). The expression "smart" was initially used to portray buildings in the United States toward the start of the 1980s. The idea of 'smart building' was stimulated by the advancement of data innovation. Research on perceptive building has been led pervasively and exploration results have been distributed in numerous academic journals (Benjamin *et al*., 2011). These days, all administrations give careful consideration to energy-saving issues. So the requirement for energy benefit has expanded. Energy administration is an essential action for energy benefit (ASHRAE, 2009). Energy administration is measured as a huge variable to the energy saving of an operative unit of manufacture. The essential idea of energy supervision is the nonstop, methodical and decently sorted out review of energy utilization, going for energy cost advancement regarding energy requests, client attributes, financing ability, financing capacity and emanation diminishments accomplished (Doukas and Patlitzianas, 2007).

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The framework utilizes the current power lines for communication between the electrical gadgets and the agents of the building infrastructure, i.e., heating, sensors and actuators for lights, ventilation, and so forth (Torcellini *et al*., 2006). The destinations are both energy saving, and expanding consumer loyalty concluded worth included supervisions. Energy saving is acknowledged, e.g., room temperature being brought down and by lights being consequently switched off in empty rooms. Expanded consumer loyalty is acknowledged, e.g., by adjusting light and temperature power as indicated by each individual's close to home inclination (Peng *et al*., 2010). We present introductory results from simulation analyses of a building and its people. The energy utilization when utilizing the framework is contrasted with that of not utilizing the framework (Kusiak *et al*., 2010). The research paper is divided into seven sections. The Section I present a brief introduction to the paper and the proposed methodology of research work. The section II presents literature survey of related existing studies with their reviews. The section III defines the problem statement. The section IV presents the proposed architecture design and its attributes. The section V presents proposed methodology with proposed algorithm. The section VI presents the simulation results and section VII presents the conclusion.

Literature review

The literature demonstrates that the requirement for decision support inside operational building settings is immeasurable, yet synchronization in the middle of danger and situational handiness needs to be achieved (Siroky *et al*., 2011). The building business is a developing energy client, as nearly 90% (Zhu *et al*., 2010) of the populace invests the vast majority of their time in buildings infrastructure, therefore expending around 45 – 50 % of the general energy (Burkhart *et al*., 2014 and Heo *et al*., 2011). The yearly hiking rate of 1.9 – 2.1 % is documented for energy utilization in this part alone, alongside 1% peak interest increment of framework (Zhao *et al*., 2013 and Sanctis *et al*., 2011). Consequently, huge potential exists to diminish building energy request at decreased expenses with significant yields.

In a building framework, various techniques for comfort controller have been proposed. Prescient control model with climate forecasts combined with the energy saving capability of HVAC framework produced in (Wang *et al*., 2011; Hernández *et al*., 2013 and Barbato *et al*., 2009). Produced visual comfort controller with a fuzzy rationale control (Hawarah *et al*., 2010); related day with manufactured lighting framework for visualization comfort analyzed a strong control for wind current rate and (Gao and Whitehouse, 2009) create fuzzy thinking control appliance for air quality control. This model gives the way to element model association for comfort variables and power utilization. Stated fuzzy control model with human choice making and join the comfort variables. The primary target of this study is to drive the model association for the accuracy and element control plan equipped for fulfilling both indoor comfort and energy interest. As the standard interim stochastic model connection to energy utilization does not report in the past studies. The generated robust model is helpful in planning the building control attributes with knowledge and weighted choice making and plan the point for the sensor estimation component (Nguyen and Aiello, 2012).

Energy administration or estimation and confirmation inside existing building energy frameworks must face a plenty of vulnerabilities, including noise sensors, point measures of circulated phenomena (e.g., air temperature), and in secret variables. To catch complex, nonlinear, and multivariable associations, scientific methodologies, for example, Gaussian forms (Diaz *et al*., and Erickson *et al*., 2011), multi-agents choice making control techniques (Agarwal *et al*., 2010), and Bayesian-adjusted energy models have been utilized. Moreover, by the expansion of wireless sensor organizes in smart building, enthusiasm for surveying execution has expanded past energy into mold development and remediation, and additionally disaster readiness and services for occasions, for example, fires (Newsham and Birt, 2010), quakes, and bioterrorist assaults.

Problem statement

For a long time, buildings that offer agreeable, adaptable and energy efficient living environment at a minor expense has been the need of building managers and occupiers. The entire framework system of smart building utilizing a intellectual model as multi-agents approach with heuristic multi-objective algorithm, used to controller the comfort record and to monitor energy distribution in building described. This orders into two levels, upper level called as agent's controller and the lower level is termed as sub-ordinate agents. The fundamental job of agent controller is to manage power supply and the client request in buildings. It additionally uses client inclination and outside data. Though, the sub-ordinate controllers are utilized to control the indoor building temperature, air quality and number of people inside the room (Baker *et al*., 2009). The controller produces the sign to generate the action of lower level agents. The obligation of chief agents is to arrange every sub-ordinate agent combining customer inclination and team up with analyzer so as to increase occupants comfort quickly. The associations of the progressive agents use two correspondence modes (Erickson *et al*., 2011 and Dounis *et al*.,), named immediate and indirect modes. The imperative data from agents has been send to the database and returned to agents after transforming to make activities respectively. The communication framework request in less time and subsequently online observing and control could be attained.

Architecture design

The MAS in view of the rational system is described in the resulting parts. The MAS offered has specific motivation on the physical viewpoints, and control panel and GUI, counting energy controlling plans for cooling, electrical energy zones and heating of a business building.

Physical Phase of MAS

Fig. 1 demonstrates the building energy production, capacity, utilization units and the energy movement ways. The target of such a framework is to accomplish complete high energy efficiency, low outflows, and financial practicality, without trading comfort and the preference of clients. The proposed MAS have 3 zones: the multi agent zone, the control panel interface and simulator zone and the GUI zone. The electrical zone may have some RES- renewable energy sources.

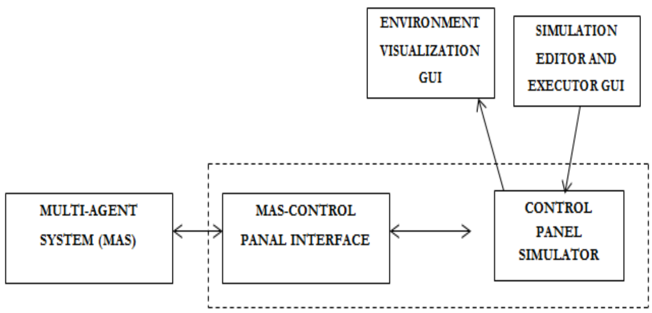

Fig. 1. Multi-agent System for energy management system of a building (8)

Control panel zone

The CPZ of the projected work is attained to by MAS method. In every zone recognized in the earlier subset, the energy transformation, storing, and utilization are exactly measured and transmitted by the smart agents implanted in interface part of the control panel zone. The separate agents are: 1) E-agents for power; 2) C-agents for cooling zones; and 3) H-agents for heating, individually. The 3 agents relate with one another through zonal network while the energy management assignment is further than the capacity of a solitary agents, or the agents are obliged to cooperate for a progression of assignments through simulator part of CPZ (Alexandridis and Dounis, 2007).

GUI zone

The GUI zone managed the user interface and environment management. It consists of two parts environment visualization GUI and simulator editor & executor GUI.

MATERIALS AND METHODS

The event of specific occasions interior the building (e.g., a man affecting starting with one room then onto the next) will produce messages to a portion of the agents that will activate some proper rules. The agents implement the rules, with the reason to change the surrounding conditions to some favored set of qualities. The rule will result in a succession of activities to be implemented, which will include correspondence between the agents of the framework. The frameworks adjust to various overall rules (limitations or decision strategies) that are encouraged to the agents. A few illustrations are scheduled below:

- Each room with no individuals in it essentially keeps up some defaulting environmental conditions.
- For normal rooms, like open or close corridors, terrace, the temperature stays stable irrespective of the number of persons in the room. The light is switched on just when at least one individual is in the room, else it is switched off.
- When a specific individual is in user's room, the room agents essentially adjust light, temperature, and so on to user's inclination; generally the stable conditions are kept up. If an insignificant individual (i.e., someone else than the ones that typically work in the workplace) come in that room, this does not influence the natural circumstances (aside from that the light will switched off if the room was vacant).
- For meeting rooms, the temperature circumstance is adapted to the average estimation of all the meeting members, and the light power to the maximum inclination value.

Multi-objective optimization algorithm

The objectives are normally in conflict with one another in multi-objective improvement issues. Along these lines, no particular arrangement can be found in these sorts of issues. A conventional of exchange off arrangements that depict the best probable settlements between the goals can be made. To manage multi-objective issue, the novel pattern of Fuzzy rationale (FL) is adapted accordingly. A normal issue with multi-target is communicated as follows

General multi-objective optimization issue;

$$(\text{MOP})\min_{x \in C} F(x) = \begin{pmatrix} f_1(x) \\ f_2(x) \\ \vdots \\ f_n(x) \end{pmatrix} \quad n \geq 2$$

where

$$C = \{x : h(x) = 0, g(x) \leq 0, a \leq x \leq b\}$$

The $x = (x_1, x_2 \ldots x_n)^T$ is the vector of decision variables, fi is the goal capacities; g_i and h_j are the constraint functions of the issue. A point $x^* \in C$ is Pareto Optimal for multi- objective optimization problem (MOP) if and if there is no $x \in C$ such that $fi(x) \leq fi(x^*)$ for all i ∈ 1, 2, 3. . . n with no less than one strict disparity.

RESULTS

The framework can be separated into two sections: first Part identified with sensors & agents and second with the energy controller. To some extent Part I, agents received information from indoor and outside sensors and circuit. At that point, this data is sent to the energy controller i.e. part II. Energy controller computes outputs (that to the controllers). The results of energy controller are then computed to generate the model of energy distribution for those particular inputs.

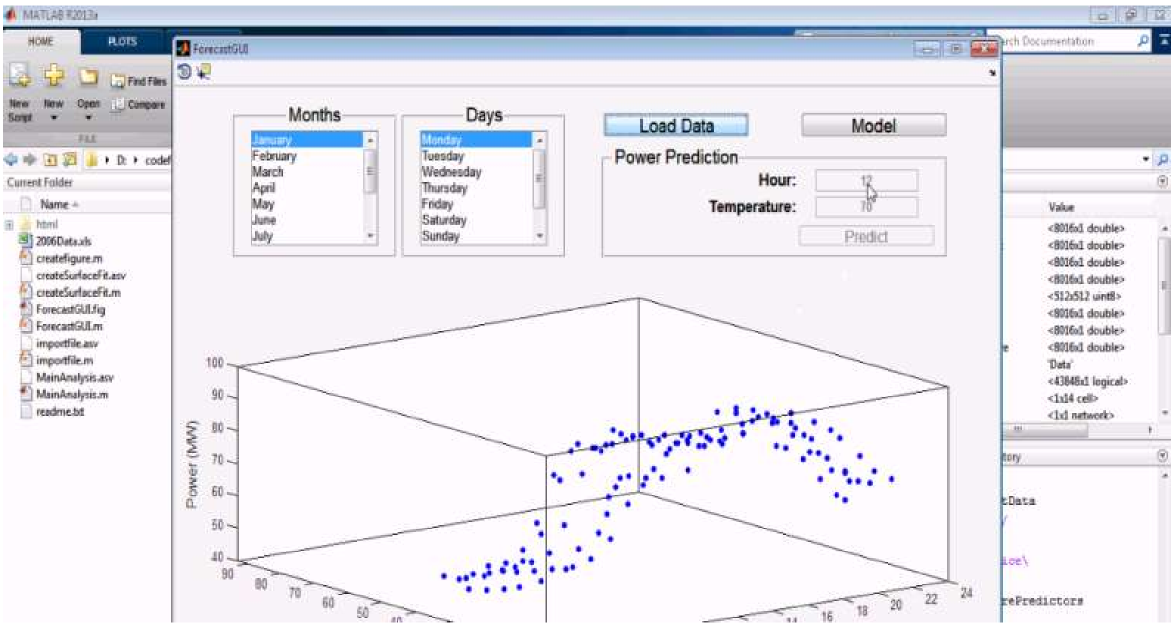

Fig. 2. Energy distribution of 2006 data in proposed system

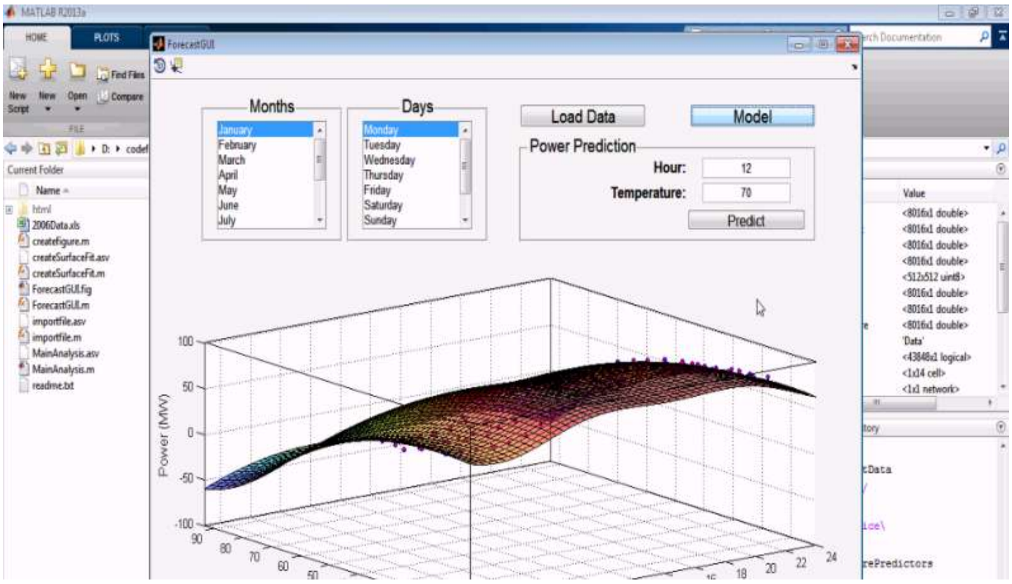

Fig. 3. Application GUI and sample data of year 2006 in proposed system

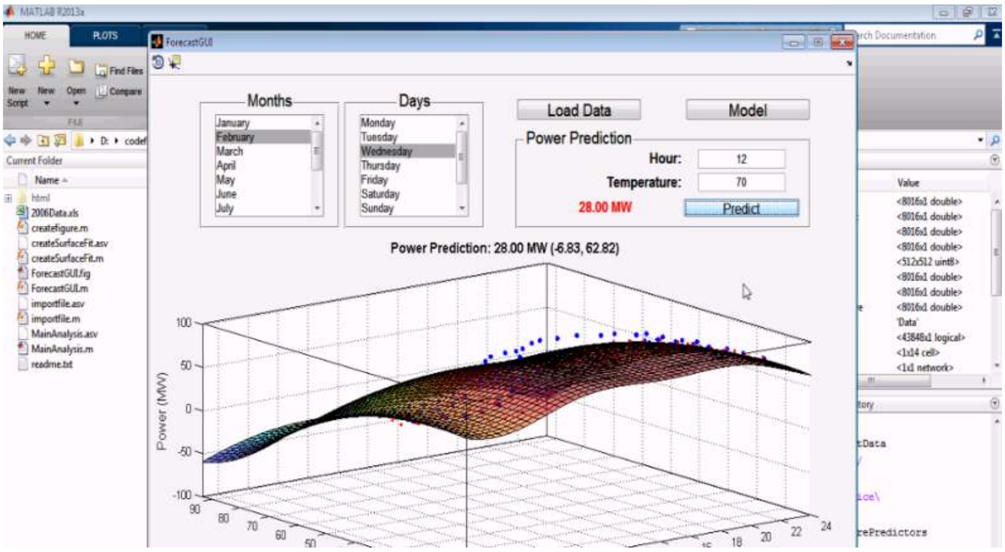

Fig. 4. Energy management graph for Wednesday February in proposed system

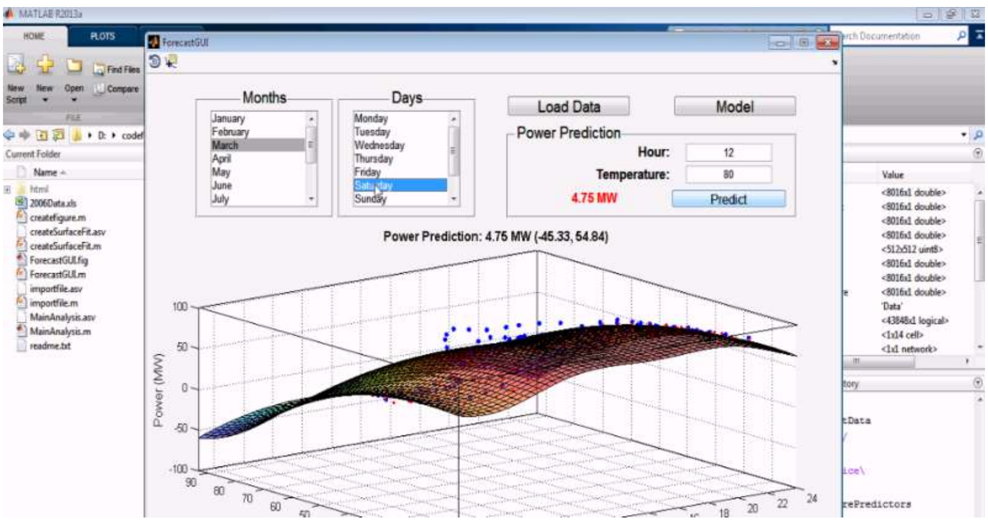

Fig. 5. Energy management graph for hour 12 and temperature 80 in proposed system

Conclusion

The generated multi-agents control framework helps accomplishing the balance between the energy utilization and inside environmental comfort. The energy utilization capacity of the every actuator framework sustained the framework operation. What's more, the control framework has been installed with a developmental genetic algorithm for advancing energy administration of the buildings. The smart execution of the developed multi-agents control framework displays the change and the potential for energy asset management in the buildings. The client characterized preference and a considerable level of smartness upgrades the operability of the control framework. In future work, the GA algorithm will be further tuned to maximize its efficiency.

REFERENCES

Agarwal, Y., B. Balaji, R. Gupta, J. Lyles, M. Wei, T. Weng, 2010. Occupancy-driven energy management for smart building automation, in: Proceedings of the 2nd ACM Workshop on Embedded Sensing Systems for Energy-Efficiency in Building, BuildSys '10, ACM, New York, NY, USA, pp. 1–6.

Alexandridis, K., A.I. Dounis, 2007. Supervisor of digital pi-like fuzzy logic controllers for indoor lighting control in buildings, in: Proceedings of the International Scientific Conference eRA— (2): 12-21

ASHRAE Handbook, 2009. "Fundamentals," (I-P Edition). American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Baker, N., A. Fanchiotti and K. Steamers, 2009. Daylighting in Architecture: A European Reference Book. London: James & James for the Commission of the European Communities, (1): 48-59.

Barbato, A., L. Borsani, A. Capone, S. Melzi, 2009. Home energy saving through a user profiling system based on wireless sensors, in: Proceedings of the First ACM Workshop on Embedded Sensing Systems for Energy-Efficiency in Buildings, BuildSys '09, ACM, New York, NY, USA, pp. 49–54.

Benjamin, P., Julien, E., Stephane, G. & Monique, P. 2011. "Hybrid PID -fuzzy scheme for managing energy resources in buildings," Applied Soft Computing, 11, 5068–5080.

Burkhart, M.C.; Heo, Y.; Zavala, V.M. 2014. "Measurement and verification of building systems under uncertain data: A Gaussian process modeling approach," Energy and Buildings 75; pp. 189 – 198.

Diaz, P., T. Olivares, R. Galindo, A. Ortiz, F. Royo, T. Clemente. The EcoSense Project: An Intelligent Energy Management System with a Wireless Sensor and Actor Network, doi:10.1007/978-3-642-17387-5 24.

Doukas, H. and K.D. Patlitzianas, 2007. "Intelligent building energy management system using rule sets," Building and Environment, (10): 3562-3569

Dounis, A.I., P. Tiropanis, A. Argiriou, A. Diamantis, 2011. Intelligent control system for reconciliation of the energy saving with comfort in buildings using soft computing techniques. Energy and Buildings, (43): 66- 74.

Erickson, V., M. Carreira-Perpinan, A. Cerpa, OBSERVE: occupancy-based system for efficient reduction of HVAC energy, in: in: Information Processing in Sensor Networks (IPSN), 2011 10th International Conference on, 2011, pp. 258–269.

Gao, G. and K. Whitehouse, 2009. The self-programming thermostat: optimizing setback schedules based on home occupancy patterns, in: Proceedings of the First ACM Workshop on Embedded Sensing Systems for Energy-Efficiency in Buildings, BuildSys '09, ACM, New York, NY, USA, pp. 67–72.

Hawarah, L., S. Ploix, M. Jacomino, 2010. User behavior prediction in energy consumption in housing using Bayesian networks, in: Proceedings of the 10th international conference on Artificial intelligence and soft computing: Part I, ICAISC'10, Springer-Verlag, Berlin, Heidelberg, pp. 372–379.

Heo, Y.; Augenbroe, G.; Choudhary, R. 2011. "Risk analysis of energy-efficiency projects based on Bayesian calibration of building energy models," Twelfth Conference of International Building Performance Simulation Association, pp. 2579 – 2586. Sydney, AUS.

Hernández, L.; Baladrón Z., C.; Aguiar P., JM.; Carro, B.; Sanchez-E., A.; Lloret, J.; Chinarro, D., 2013. Multi-Agent System Architecture for Smart Grid Management and Forecasting of Energy Demand in Virtual Power Plants, IEEE Communications Magazine. 51(1):106-113.

Kusiak, A., M. Li, Z. Zhang, 2010. "A data driven approach for steam load prediction in buildings," Applied Energy, (87): 925-933.

Newsham, G.R., B.J. Birt, 2010. Building-level occupancydata to improveARIMA-based electricity use forecasts, in: Proceedings of the 2nd ACM Workshop on Embedded Sensing Systems for Energy-Efficiency in Building, BuildSys '10, ACM, New York, NY, USA, pp. 13–18.

Nguyen, T. A., M. Aiello, 2012. Beyond Indoor Presence Monitoring with Simple Sensors, in: Proceedings of the 2nd International Conference on Pervasive and Embedded Computing and Communication Systems, to appear.

Peng, Z., S. Suryanarayanan, M. Godoy Simões, 2010. "An Energy Management System for Building Structures Using a Multi-Agent Decision-Making Control Methodology," IEEE Industry Applications Society Annual Meeting (IAS).

Sanctis, G.D.; Fischer, K.; Kohler, J.; Fontana, M.; Faber, M. 2011. "A probabilistic framework for generic fire risk assessment and risk-based decision making in buildings," Zurich, Switzerland: CRC Press.

Siroky, J., F. Oldewurtel, J. Cigler and S. Privara, 2011. "Experimental Analysis of model predictive control for an energy efficient heating system," Applied Energy, (88): 3079-3087.

Torcellini, P., S. Pless and M. Deru, 2006. "Zero energy buildings: A critical look at the definition," presented at the ACEEE Summer Study, Pacific Grove, CA, pp: 14-18.

Wang, Z., Dounis, A. I., Wang, L. & Yang, R. 2011. "An information fusion based multi- agent control system for indoor energy and comfort management in smart ad green buildings," In IEEE PES innovative smart grid technologies Anaheim, CA, (pp. 1–8).

Yang, R. and L. Wang, 2013. “Multi-zone building energy management using intelligent control and optimization," Sustainable Cities and Society, 6: 16-21.

Zhao, Y.; Wang, S.; Xiao, F. 12 2013. “Pattern recognition-based chillers fault detection method using Support Vector Data Description,” Applied Energy 112; pp. 1041–1048.

Zhu, W., Y. Rui and W. Lingfeng, 2010. “Multi-agent control system with intelligent optimization for smart and energy-efficient buildings,” 36th IEEE Industrial Electronics Society IECON 2010

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