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EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: ENERGY MANAGEMENT IN BUILDINGS

Energy usage in buildings has become a critical concern globally, and with that, the concept of energy management in buildings has emerged to help tackle these challenges. The energy management system provides a new opportunity for the building's energy requirements, and is an essential method for energy service, i.e., energy saving, consumption, supply, etc. The wide-scale implementation of an energy management system and development of energy management mechanismsof mobile applicationsare faced with the following challenges:

- **Integrating demand responses, smart technologies and intelligent controllers in other available smart grid systems**: To reduce energy usage and home energy costs, environmental concerns, load profiles, and consumer comfort, and also how to integrate these into the existing smart grid, is one challenge faced.
- **Advanced energy scheduling, energy-saving, energy supply, and load monitoring mechanism**: With the growing requirements of load balancing, stable energy services are faced with great challenges in order to reduce energy cost and serve buildings' energy user. It is necessary to accurately analyze data and determine the electrical consumption so that demand for energy can be adjusted efficiently and intelligently.
- **Robust systems and effective mechanisms for smart buildings**: Among many applications in robust systems, energy consumption could be linked and mined to gain useful insights for optimization of energy efficiency. At the same time, load balancing systems can be efficiently scheduled to single and multiple homes during off-peak hours, improving their energy efficiency. Further energy efficient learning-based mechanisms are needed to save energy in smart buildings, which is instrumentalin making critical decisions for the development of energy management.

This Special Section in the IEEE ACCESS focuses on the architectures and applications on the Internet of Energy. 18 high-quality articles have been accepted from leading groups around the world after a rigorous peer-review process. IEEE journals are considered as the flagship journals in the engineering field. The IEEE ACCESS is a new multidisciplinary, application-oriented, all-electronic archival journal which continuously presents the results of original research or development across all the IEEE's fields of interest. Because of its open access nature, this Special Section is freely accessible to all readers.

Region specific fuzzy logic strategies are proposed which cover all regions of the world. However, in the article, ''Energy management with a world-wide adaptive thermostat using fuzzy inference system,'' by Javaid *et al*., the authors' proposed approach achieves a minimum energy savings of 6.5%, irrespective of where it is used around the world. Research will extend the region-specific solutions for a worldwide adaption.

The increasing demand for electricity and the emergence of smart grids have presented new opportunities for a home energy management system (HEMS) that can reduce energy usage. HEMS incorporates a demand response (DR) tool that shifts and curtails demand to improve home energy consumption. Shareef *et al*., in their article, ''Review on home energy management system considering demand responses, smart technologies, and intelligent controllers,'' develop a cross-time hierarchical energy distribution scheme to coordinate energy distribution of DC sector and AC sector and exploit the elasticity of DC sector loads on both day-ahead basis and real-time basis, leading to a mitigation of distribution load fluctuation. Then, power distributions are optimized separately for different procedures of the scheme.

Policy makers are approving measures to improve building energy efficiency in order to foster sustainable energy usage. However, the intelligence of existing building energy management systems (BEMS) or net-zero energy buildings (nZEBs) is inadequate. To solve these issues, in the article by Hannan *et al*., ''A review of internet of energy based building energy management systems: Issues and recommendations,'' a BEMS or nZEB solution based on the Internet of Energy (IoE) provides disruptive opportunities for revolutionizing sustainable building energy management. The authors present a critical review of the potential of an IoE-based BEMS for enhancing the performance of future generation building energy utilization.

Scientific organizations and researchers are eager to apply recent technological advancements, such as sensors and actuators, in different application areas, including environmental monitoring, the creation of intelligent buildings, and precision agriculture. Technology-assisted irrigation for agriculture is a major research innovation which eases the work of farmers and prevents water wastage. However, in the article

by Khan *et al.*, "Technology-assisted decision support system for efficient water utilization: A real-time testbed for irrigation using wireless sensor networks," the authors propose that the system's accuracy is directly proportional to the accuracy of dynamic data generated by the deployed WSN. A simplified outlier-detection algorithm is thus presented and integrated with the proposed DSS to fine-tune the collected data prior to processing.

With the explosive growth of smart terminals, access points (APs) are densely deployed in the buildings of enterprise, campus, hotel, and so on, to provide sufficient coverage and capacity for peak user demands. However, existing studies show that during the off-peak periods, not all the capacity is needed and a large fraction of low-utilization or idle APs cause a great deal of energy waste in these buildings. In the article by Li *et al*., "A state transition-aware energy-saving mechanism for dense WLANs in buildings," the authors propose a mechanism in order to set relevant parameters reasonably.

Smart building is an effective solution to address the issue of energy consumption in today's cyber-physical systems (CPSs) connected world. As an important tool to collect information from a fleet of electric appliances installed in the building scope, a wireless sensor network is widely employed for this purpose. In the article by Zhan *et al.,* "A novel error correction mechanism for energy-efficient cyber-physical systems in smart building," the authors propose to incorporate forward error correction into the media access control layer of IEEE 802.15.4 standard for packets transmission, as the originally used automatic repeat request mechanism is a timing and energy consumed process that should be avoided in the noisy wireless channel of a smart building environment.

An energy hub integrates various energy conversion and storage technologies. This enables energy hub to be an ideal energy system design for smart and green buildings. In the article by Zhong *et al*., "ADMM-based distributed auction mechanism for energy hub scheduling in smart buildings," the authors propose a distributed auction mechanism for multi-energy scheduling of an energy hub. Finally, simulation results based on a household energy consumption dataset are presented to evaluate the energy scheduling performance and to verify the incentive compatibility of the auction mechanism.

The non-intrusive load monitoring (NILM) method has attracted considerable research interest, since it only requires a set of voltage and current sensors to be installed at the electrical service entry (ESE) for load disaggregation. However, the main challenge of NILM is to accurately analyze data from the ESE and determine the electrical consumption of each appliance. In the article by Andrean *et al*., "A hybrid method of cascade-filtering and committee decision mechanism for non-intrusive load monitoring," the authors' proposed method enhances the load identification capability of the NILM. A platform is built to validate the proposed method.

By using the unipolar transistor control the threshold voltage of the rectifier changes dynamically, through RF matching, and double voltage rectification measures the supply for the low power nodes. In the article by Ma *et al*., "A RF energy supply method for end nodes in smart buildings," the authors propose a circuit aimed at reducing the threshold voltage of the transistor forward bias to increase power and output voltage of the harvester and increasing the reverse bias of the threshold voltage for reducing the leakage current. It prevents the loss of stored energy. The low power characteristics of the nodes at the end of the Internet of Things make it possible to convert the RF energy to electric energy.

In order to meet the load demand of electricity consumers, the following authors schedule the load in day-ahead and real-time basis. In the article by Khalid *et al*. "Towards dynamic coordination among home appliances using multi-objective energy optimization for demand side management in smart buildings," the authors propose a fitness criterion for proposed hybrid technique. Then they present the concept of coordination among home appliances. Finally, they evaluate the behavior of the proposed technique for three pricing schemes.

Broadband Internet access in the building has fundamentally changed almost every aspect of our lives. As the use of indoor portable systems and devices grows, saving their energy consumption becomes an interesting and important issue for smart buildings. In the article by Wang *et al*., "Energy efficient learning-based indoor multi-band WLAN for smart buildings," the authors proposed an energy efficient learning-based indoor multi-band WLAN system, in which the end device predicts the distinct service areas by learning the influences of reflected waves in buildings. They have performed extensive experiments in different indoor environments, and the evaluation results demonstrate that the proposed mechanism could substantially improve the performance compared with the existing approaches.

Interference management and energy management are two important issues in ultra-dense heterogeneous cellular networks (HetNets). However, load balancing investigated for system capacity on interference coordination is not efficient for energy saving in HetNets. Thus, in the article by Zheng *et al*., "Joint energy management and interference coordination with Max-Min Fairness in ultra-dense HetNets," the authors investigate energy consumption jointly. The simulation results verified the effectiveness of the proposed algorithm and fairness achieved for energy efficiency of users.

Video streaming has become one of the most prevalent mobile applications and uses a substantial portion of the traffic on mobile networks today. With the limited bandwidth of mobile networks, understanding the user perception of the quality of video streaming services is thus paramount for content providers and content to flexibly configure network bandwidth, video servers, routing devices, and other

network resources to save energy smart cities. In the article by Pan *et al*., ''QoE assessment of encrypted YouTube adaptive streaming for energy saving in smart cities,'' first, the authors filter HTTPS YouTube traffic based on the previously established video to the traffic characteristics of several previous packets. Next, they identify the bitrates and resolutions of HTTP Live Streaming and Dynamic Adaptive Streaming over HTTP modes according to the characteristics of video chunks. Finally, to evaluate the effectiveness of MBE, they have chosen the video Mean Opinion Score (vMOS) proposed by a leading telecom vendor as the QoE assessment framework, and have conducted comprehensive experiments to study the impact of bitrate estimation accuracy on its KPIs for the HTTPS YouTube video streaming service.

As a promising future Internet architecture, named data networking (NDN) supports name-based routing and caching for content retrieval throughout the network, which enables fast, reliable, and, more importantly, energy-efficient content dissemination in smart cities. However, NDN's vulnerability against the content poisoning attack is considered to decelerate the process of applying NDN to energy management in smart cities. In the article by Hu *et al*., ''Mitigating content poisoning with name-key based forwarding and multipath forwarding based inband probe for energy management in smart cities,'' the authors propose a light-weight mitigation mechanism by enhancing NDN with a name-key-based forwarding and multipath forwarding-based inband probe.

The robustness of an integrated power grid and natural gas network can be transformed into a graph theory problem theoretically. With the concept of tree-coritivity, a novel assessment to analyze the robustness of the interdependent network is proposed in the article by Wang *et al*., ''A novel index for assessing the robustness of integrated electrical network and a natural gas network.'' The proposed tree-coritivity shows the advanced performance in terms of the connected and unconnected network.

With the emergence of smart grid (SG), consumers have the opportunity to integrate renewable energy sources (RESs) and take part in demand side management. In the article by Javaid *et al*., ''Energy efficient integration of renewable energy sources in the smart grid for demand side management,'' the authors introduce generic home energy management control systems (HEMCS) to efficiently schedule the household load and integrate RESs.

Wi-Fi access has become a fundamental technology for smart buildings as reliable and efficient Wi-Fi is the foundation that effectively enables indoor smart devices in smart buildings. Recently, the IEEE 802.11ax standards were introduced to facilitate high-bandwidth wireless transmission in high-density environment as the new generation wireless local area network technology. In the article by Hang *et al.*, ''On energy saving in IEEE 802.11ax,'' a power saving design designated on the uplink multi-user system in 802.11ax is proposed. Additionally, an analytical analysis is developed to evaluate the effectiveness of the proposed power saving mechanism with further computer simulations to verify.

We are happy with the technical depth and span of this Special Section, and also recognize that it cannot cover all of the Energy Management in Buildings. Finally, we sincerely thank all the authors and reviewers for the tremendous efforts, and of course the IEEE ACCESS Editor-in-Chief and staff members for their great guidance.

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