Guest Editorial on Emerging Technologies in Consumer Power and Energy Management

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Guest Editorial on Emerging Technologies in Consumer Power and Energy Management

EMERGING technologies in consumer power and energy management have become important as we adopt more smart devices, IoT applications, and smart homes. The development of consumer electronics and the eventual creation of a more sustainable and energy-efficient future depend on these technologies, which can function more efficiently, consume less energy, and integrate with smart home ecosystems more readily. Also, these technologies make our system more efficient and sustainable along with less energy consumption as well as reducing impact on the environment. Effectively, energy management helps not only the consumer to save money but also fights climate change by reducing the carbon footprint of our electronics.

By integrating these energy management technologies into consumer electronics, smart devices, Internet of Things apps, and home automation systems will continue to evolve. This special section will look at how these developments are influencing the next generation of consumer electronics, which is in line with IEEE Transaction on Consumer Electronics journal main objective of furthering the field of consumer electronics technology.

Research in this field is essential to drive innovation and stay ahead of technological advances. This could be done by looking into new ways of optimizing energy use, such as smart power distribution, energy harvesting, and efficient battery management to find those that make a difference. This research also sets up standards and best practices to make sure devices from different vendors can interwork smoothly and securely. These emerging technologies mean more efficient performing devices, supporting sustainability goals and meeting the needs of a tech-savvy world toward an efficient and sustainable future. This special section was thoughtfully organized to address the pressing challenges outlined above, aiming to bring together innovative research and practical solutions from a diverse range of experts. In response to our call for papers, we received an overwhelming 85 submissions from researchers around the world. Following a rigorous peer-review process focused on originality, technical depth, and relevance to the theme, only 15 high-quality papers were selected for publication. These accepted papers represent cutting-edge advancements and valuable contributions to the field.

Reference [A1] explores the integration of Deep Reinforcement Learning (DRL) and Model Predictive Control (MPC) for optimizing thermal energy management in buildings. It compares online DRL-MPC, which adapts in real time but requires higher computation, with offline DRL-MPC, which is less responsive but computationally efficient. To improve both, Differential Evolution (DE) and Particle Swarm Optimization (PSO) are used to fine-tune parameters. Results show online DRL-MPC outperforms in cost savings, energy efficiency, comfort, and overall performance despite greater computational demands. Reference [A2] addresses battery safety and performance in electric vehicles by applying deep learning to battery management systems. Convolutional Neural Networks (CNNs) with PSO are used to predict failures like thermal runaway, while Feedforward neural networks (FNNs) with Bayesian Optimization enhance charging cycles and energy use. Compared to rule-based systems, these models significantly improve accuracy and precision, underscoring deep learning's potential in safer, more efficient Electric Vehicle (EV) batteries. Reference [A3] introduces a deep learning framework as real-time Electrocardiogram Machine Learning (ECG) classification toward low energy consumption. Using Gated Recurrent Units (GRUs) optimized via modified PSO, the model fine-tunes hyperparameters such as learning rate and dropout rate. It outperforms traditional classifiers in accuracy, latency, and energy use, making it ideal for real-time, battery-powered Internet of Things (IoT) healthcare applications. Reference [A4] proposes a smart energy management system for pocket parks in smart cities to support elderly activity. It uses Deep Q-Learning (DQL) to personalize activity recommendations based on health data while optimizing energy use. Simulated Annealing (SA) fine-tunes system parameters to reduce waste. The combination of DQL and SA enhances both sustainability and health outcomes, supporting energy-efficient urban aging solutions. Reference [A5] presents a hybrid model including Recurrent Neural Network (RNN) and Long Short-Term Memory (LSTM) framework PSO for real-time cyber threat detection in smart cities. It targets IoT-related cybersecurity challenges by analyzing sequential network traffic data. The PSO-tuned model achieves 97.5% accuracy and 96.8% recall, enhancing detection speed and reliability. The study highlights machine learning's role in securing smart urban infrastructures.

Reference [A6] proposes a hybrid model combining Generative Adversarial Networks (GANs) and Differential Evolution (DE) to improve remote sensing data quality and optimize renewable energy resource assessments. GANs enhance satellite image resolution, while DE fine-tunes sensor settings and enhancement algorithms. The approach significantly boosts image quality and prediction accuracy, reducing costs and enabling better site evaluations. Case studies demonstrate its effectiveness for scalable, cost-efficient renewable energy planning. Reference [A7] presents an Artificial Intelligence (AI) based decision support system that uses Recurrent Neural Networks (RNNs) with Adam optimization to improve energy efficiency in autonomous consumer electronics. The framework processes real-time data to predict and adapt energy use in devices like smart thermostats and IoT lighting. Results show significant energy savings and improved prediction accuracy over traditional methods. This approach offers promising advances for reducing energy consumption in smart devices. Reference [A8] proposes a hybrid energy management approach for smart camera systems by combining CNNs for depth estimation, Stochastic Gradient Descent (SGD) for model training, and a modified PSO algorithm with crossover and mutation operators to reduce energy consumption. The CNN generates accurate depth maps, SGD fine-tunes the model, and the enhanced PSO optimizes camera settings. Experiments on the KITTI (Karlsruhe Institute of Technology and Toyota Technological Institute) and NYU Depth V2 (New York University Depth Dataset Version 2) datasets show significant energy savings with minimal loss in depth accuracy, outperforming baseline methods. Reference [A9] proposes a predictive maintenance framework combining Variational Autoencoders (VAE) for anomaly detection and PSO for model tuning in consumer electronics and intelligent energy networks. The VAE learns latent system behaviors, while PSO improves accuracy and efficiency. Results show 94% accuracy, 20% cost reduction, and a 5% false positive rate. The approach outperforms traditional methods and is scalable for real-time IoT and edge applications. Reference [A10] proposes a hybrid Deep Reinforcement Learning (DRL) and Genetic Algorithm (GA) approach to optimize energy use and traffic flow in signal control systems. DRL adjusts signals in real-time, while GA fine-tunes global schedules for efficiency. Simulations show 15–25% energy savings and notable reductions in congestion and delay, supporting smarter, greener urban mobility.

Reference [A11] introduces a novel framework combining GNNs, reinforcement learning (RL), and meta-learning for predictive energy optimization in IoT-enabled consumer electronics. Using Proximal Policy Optimization (PPO) based RL and Model-Agnostic Meta-Learning (MAML) enhanced Meta-GNNs, the model adapts to dynamic energy demands and sparse data. Experiments show up to 25.2% energy savings and over 92% accuracy, highlighting its efficiency and adaptability for smart grids, industrial IoT, and connected homes. Reference [A12] proposes a hybrid Deep Q-Network (DQN) and Ant Colony Optimization (ACO) framework to improve energy efficiency in computer vision systems. The approach achieves 30% energy savings, 8.24% accuracy improvement, and 20% faster processing. It proves highly adaptable, benefiting energy-critical applications like autonomous driving, surveillance, and mobile computing. Reference [A13] This study presents an AI-based energy management system for smart homes using Deep Deterministic Policy Gradient (DDPG) combined with PSO. IoT sensor data guides adaptive decision-making, while PSO fine-tunes DDPG hyperparameters. Results show up to 25.2% energy savings over traditional methods, demonstrating improved efficiency without compromising user comfort. Reference [A14] proposes an AI-driven energy optimization framework for autonomous vehicles, leveraging Autoencoders for data reduction and Simulated Annealing (SA) for system optimization, alongside 5G and edge computing. The approach improves average speed by 12.5%, boosts acceleration, and reduces system downtime and error rates. Results highlight enhanced energy efficiency and reliability, offering scalable potential for sustainable transportation. Reference [A15] presents an AI and Big Data Analytics framework for optimizing energy use in IoT-enabled smart homes, using Variational Autoencoders (VAEs) for feature extraction and Differential Evolution (DE) for parameter optimization. The approach achieved a 40% energy reduction and up to $300 in annual savings per household, while boosting user satisfaction by 25%. Results highlight improved energy distribution and user engagement, demonstrating the framework's effectiveness in sustainable smart home management.

APPENDIX: RELATED ARTICLES

[A1] A. Almutairi, S. Abiyo and J. Hyejian, "Secured and Smart System for Energy Management in Microgrids Using Deep Reinforcement Learning," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3576696.

[A2] Q. Zhang and X. Huang, "Deep Learning Approaches for Enhancing Battery Safety and Performance in Electric Vehicles," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3573593

[A3] C. Liu, J. Liu and D. Wang, "Energy-Efficient Health Monitoring in Smart Devices: Deep Learning-Based Technique for Wearable ECG Systems," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3569456.

[A4] L. Zhu, N. A. Samsudin, Z. J. M. H. Hamid and H. Xu, "An Intelligent Framework for Optimal Consumer Electronics' Management in Smart Pocket Parks for Stimulating the Vitality of the Elderly," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565411.

[A5] T. Wang, Y. He and M. Hao, "Real-Time Cyber Threat Detection in Smart Cities Using Artificial Intelligence," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565011.

[A6] Y. Han, X. Zhang, J. Liu, G. Liu and W. Yan, "Application of Remote Sensing Technologies in Monitoring and Managing Renewable Energy Sources," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565573.

[A7] G. Zhang and Z. Wu, "Intelligent Decision Support Systems for Energy-Efficient Autonomous Systems in Consumer Electronics," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565596.

[A8] T. Su, Y. Jiang and C. Hu, "Machine Learning-Based Depth Estimation for Energy Optimization in Smart Camera Systems," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565287.

[A9] Jiangke-Cheng, Desheng-Yang and Shengnan-Wang, "Unsupervised Learning Applications for Predictive Maintenance in Consumer Electronics and Intelligent Energy Networks," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3573649.

[A10] T. Ji, P. Cheng, K. Li, Z. Cao, Z. Duan and C. Lyu, "Adaptive Traffic Signal Control for Energy Efficiency Using Deep Learning and Consumer Electronics," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3574218.

[A11] H. Li, M. Ge, D. He and B. Xia, "AI-Based Graph Neural Networks for Predictive Energy Optimization in IoT-Enabled Consumer Electronics," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565365.

[A12] J. Duan and J. Li, "Artificial Intelligence-Enabled Image Processing for Energy Optimization in Computer Vision Systems," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565308.

[A13] Z. Fang and Z. Xu, "Real-Time Intelligent Control Systems for Energy Efficiency in Smart Homes Using IoT Sensors," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565557.

[A14] S. Han and Y. Jia, "AI-Driven Energy Solutions and Optimization for Autonomous Vehicles in 5G-Enabled Consumer and Edge Networks," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3573440.

[A15] Y. Li and Q. Song, "Big Data-Intelligence Analytics for Energy Optimization in IoT-Enabled Smart Home Devices," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2025.3565590.

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