A COMPREHENSIVE REVIEW OF ENERGY OPTIMIZATION TECHNIQUES IN CLOUD COMPUTING

[1]Ashish Kumar Pandey, [2]Abhishek Kumar Yadav,[3]Akarsh Pandey

[1]Assistant Professor, [2] B.Tech Student, [3] B.Tech Student
[1]Computer Science & Engineering,
[1]Institute of Engineering & Technology, Dr RML Avadh University, Ayodhya, India

Abstract: The most concerning problem on a global scale is the rise in energy usage. Massive data centers have been built as a result of the expansion and development of sophisticated data-intensive applications, which has raised the demand for energy. As a result, concerns related to energy efficiency are receiving more and more attention in corporate practice, theory development, and research related to cloud computing. The survey shows the research trends based on regions, journals, conferences, etc., in the domain of energy efficiency in cloud computing. The study includes Challenges or Issues, Existing Methods, Decisive Review Findings and Future Aspects/ Limitations. It is concluded with some of the critical findings that could be potential future directions.

Keywords – **Cloud Computing, Energy Consumption, Energy Saving.**

1. INRODUCTION

The information and communication technology (ICT) sector's energy consumption has recently grown to be a significant issue for the computing sector. Energy demands have increased dramatically as a result of technological advancements, as well as the proliferation of applications and services in the digital world. The trend of building large computer facilities has a negative impact on the amount of energy needed to provide dependable services and manage the complexity and increased scale of technological advancements made up to this point. As a result, there is currently a serious energy crisis. The methods used to implement the virtualized cloud environment with regard to energy efficiency have not been thoroughly researched. However, since virtualization is a fundamental component of cloud computing, it cannot be completely disregarded.

2. RESEARCH METHODOLOGY

The section on research methodologies presents the article's research objective. It provides a thorough explanation of the review technique and illustrates the motivations behind the study's conduct. There are two review plan have been conducted in this study.

2.1: Research questions

The various study questions are listed in Table I together with the corresponding motivation.

2.2: Comprehensive Review

The comprehensive review includes Challenges or Issues, Existing Methods, Decisive Review Findings and Future Aspects/ Limitations.

Table I: Study questions with corresponding motivation

Question	Motivation
1. Why is energy efficiency is important?	It helps to understand the implications of rising energy consumption throughout the world and also to locate the loopholes responsible for it.
2. What is the role of Information & Technology in energy efficiency?	Various estimates on rising energy wastage and Green House Gas emissions have been mentioned. These estimates clearly indicate the role played by ICT in raising energy wastage.
3. How is cloud computing beneficial in energy efficiency?	Computing with clouds has surfaced as a useful paradigm for handling the energy crisis. Although setting up of numerous data centers augments the energy problem, many different techniques implemented in cloud computing help to lessen rising energy consumption.
4. What are the existing strategies for realizing energy efficiency in cloud computing?	Many techniques to curb energy efficiency via cloud computing have been discussed with a thorough review, categorization, and comparison of the existing techniques. This review article is useful for future researchers to clearly understand the current status, need, and future requirements of energy efficiency.

Table II: Comprehensive Review

Ref	Journals/ Conference	Challenges or Issues	Existing Methods	Decisive Review Findings	Future Aspects/ Limitations
[1]	*IEEE Transactions on Vehicular Technology*, 2016	A stochastic optimization problem that, subject to the necessary EE restriction and transmit power consumption	Lyapunov optimization technique, Leveraging the Lagrange dual decomposition technique	The theoretical analysis is strengthened by simulation findings	The real-time traffic applications on realistic networks, such as voice and mobile video
[2]	*IEEE Access*, 2016	The main problem with wireless sensor networks is that they have packet overhead, which increases energy consumption and lowers quality of service in sensor networks	Propose Directional Transmission based energy aware Routing Protocol is a directional transmission-based energy conscious routing technology	Delivers superior results, including lower bit error rates, delays, energy use, and throughput	It will expand to operate in dynamic situations
[3]	*IEEE Transactions on Mobile Computing*, 2016	Critical problems, such as lossy airborne channels and restricted unmanned aerial vehicle battery capacity, have a negative impact on network lifetime and success rate	Computationally efficient suboptimal algorithm	Reduces scheduling complexity and increases network lifetime while ensuring success	The suboptimal technique can reduce energy consumption
[4]	*IEEE Transactions on Intelligent Transportation Systems* 2016	The issue of operating high-speed trains while paying close attention to reducing energy use	Dual speed curve optimization technique is used	Subsections and speed limits are simultaneously used to employ the combination optimization approaches with genetic process	The dual optimization speed curve method and traction, a new energy-saving strategy is developed
[5]	*IEEE Transactions on Magnetics,* 2016	Accuracy issues of electromagnetic design	Two types of loops: parallel and serial. The parallel-loop approach employs two separate optimization loops	The first technique identifies inactive constraints. Which. The second method is for probabilistic constraints	The numerical outcomes demonstrate how much more accurate and effective the newly designed serial-loop technology is than the original

[6]	*IEEE Transactions on Sustainable Computing,* 2018	Dynamic voltage and frequency ascending technique might cause a substantial increase in transient processor failures	Energy-Efficient Fault-tolerant scheduling method that was implemented after an energy-efficient fault-tolerant scheduling algorithm	The energy consumption lowered by the proposed an energy-efficient fault-tolerant scheduling with a reliability goal is larger than those cut by existing techniques	The development of Energy-Efficient Fault-tolerance scheduling taking reliability aim and temporal restriction
[7]	*IEEE Transactions on Parallel and Distributed Systems,* 2018	Hadoop ecosystems are becoming more and more crucial for those who perform large-scale data analysis, but they also use a lot of energy	An Energy Efficient-Ant Base Routing Algorithm, Dynamic Voltage and Frequency Scaling with E-Ant	Seeks to decrease the total amount of energy used by a heterogeneous Hadoop cluster without reducing task performance	To further increase Hadoop's energy efficiency, we will investigate integrating E-Ant with resource provisioning and consolidation methods
[8]	*IEEE Transactions on Wireless Communications,* 2018	The methods (energy-efficient resource allocation for each fairness technique and successive interference cancellation ordering) now in use to tackle convex issues could not be immediately applied to the suggested optimization problems	Mesh Adaptive Direct Search algorithm, sine cosine algorithm approach and dual method	First, the proposed optimization issues are converted into monotonic optimization problems with canonical form, and then the best solution for each problem is found	Studying combined uplink and downlink transmission while taking into account both transmitter and receiver energy usage is another area
[9]	*IEEE Transactions on Mobile Computing,* 2017	Essential network topologies is important to note that the heterogeneous environment's potential for maximizing profits has not been investigated	Used the techniques of cell size user migration, Zooming, and sleep mode	The issue is translated into a Mixed Integer Linear Programming problem equivalent; the prior is resolved using a bisection procedure, whereas the concluding is dealt with by a ready-made software solution	The established framework sets the financial groundwork for cutting-edge green wireless networks looking to increase productivity and profitability
[10]	*IEEE Transactions on Cloud Computing,* 2017	The network infrastructure of service providers must be expanded to satisfy the rising traffic needs	Described a number of cutting-edge, locally and globally optimized reconfiguration techniques that save energy	The results of the simulation show that the suggested methods can save a significant amount of energy in physical links	It will be important to create energy-saving methods
[11]	*IEEE Access,* 2018	The intermittent and time-varying nature of Renewable energy sources makes their energy-efficient integration a difficult challenge	Binary particle swarm optimization, genetic algorithm, wind driven optimization.	The suggested plan prevents voltage increase issues in locations with significant renewable energy penetration	Both the service company and the group of consumers can benefit from suggested scheduling approach for the energy-efficient
[12]	*IEEE Access,* 2018	To optimize home energy management system that makes use of the demand side management load shifting method	For the suggested hybrid technique, they have put forth a fitness criterion that aids in balancing the load during OFF-peak and ON-peak hours.	That aids in balancing the load during OFF-peak and ON-peak hours.	To improve the system's performance, connect between the price of PAR, electricity and waiting time.
[13]	*IEEE Access,* 2018	Large data centres need a lot of energy, which increases operational costs	POWER BASED TECHNIQUE(Asymmetric Class Projection), POWER BASED TECHNIQUE	Offer energy-saving remedies that lessen the effects of the aforementioned problems	We hope to enhance the performance of the suggested strategies

		and CO2 emissions	(Rapid Control Prototyping)		
[14]	*IEEE Transactions on Sustainable Computing*,2021	dynamic power management and dynamic voltage frequency scaling algorithms were primarily created for inter-task scheduling, without enough investigation	The energy-efficient scheduling problem can be expressed using mixed integer linear programming	The suggested strategy can save up to 30% more energy than other ways already in use	Enhanceable the refinement algorithm and research the energy-efficient mapping approach
[15]	*IEEE Computer Architecture Letters* 2018	The application level and affects both performance and energy consumption due to architectural complexity	Collaborative Filtering Auto-Tuning	CF-Tune uses a collaborating filtering technique to configure the application tunning parameters quickly and accurately	Suggested framework delivers high accuracy
[16]	*IEEE Access*, 2019	Rising load demand in residential areas and the unpredictable electrical load profile	They recommended binary multi-objective bird swarm optimization and a combination of bird swarm and cuckoo search methods	It attempts to manage the trade-off between competing goals, including electricity bill, appliance wait time, and load shifting	Multi-objective Cuckoo Search Algorithm is imprisoned in global optima. The suggested strategies can also work toward local and global optimum states
[17]	*IEEE Access*, 2019	Sensing coverage in Wireless Sensor Networks is regarded as one of the most crucial metrics	A common method is used for improving the network's energy efficiency is the use of Mobile Sinks	The purpose of this article is to optimize the MS's sojourn site in a heterogeneous home network, which enhances the network's performance and coverage time	The sojourn location has a greater influence on the network's energy efficiency than improving the MS's sojourn length and velocity
[18]	*IEEE Transactions on Vehicular Technology*,2019	Heterogeneous networks has become an unavoidable trend to improve the 5G system throughput and spectrum efficiency	A suboptimal approach was put out to alternatively maximize the system's energy efficiency	Results from simulations demonstrate that the suggested algorithms can achieve high system energy efficiency	It is anticipated that resource allocation plan will be an efficient way to increase the non-orthogonal multiple access Heterogeneous networks energy efficiency
[19]	*IEEE Sensors Journal*, 2019	The goal of designing an energy-efficient routing system for wireless sensor networks is to support applications like military surveillance and structural health monitoring	The clustering technique is used to optimize the energy	The shortest path is used to route the data from cluster head nodes to the sink. The sensor node position optimization is carried out utilizing the exhaustive search method	A greater information quality is possible with a low number of nodes and high residual energy
[20]	*IEEE Systems Journal*, 2019	The heating, ventilation, and air conditioning loads in metropolitan structures are mostly to blame for the rapid increase in global energy consumption	Multi objective optimum scheduling framework	Regulating heating, ventilation, and air conditioning equipment based on Johnson's simple circuit finding approach	This article's potential scope might be expanded to include our ongoing work to optimize the power consumption set-point
[21]	*IEEE Latin America Transactions*, 2020	The Particle Swarm Optimization technique, cannot	Binary particle swarm optimization algorithm and the original PSO are	The continuous space is mapped into a discrete space using an	Florena Island is required to have a Hybrid Power

		be directly applied to real-world issues like the sizing of hybrid energy generating systems	combined	S-type transfer function	Generator System .
[22]	*IEEE Access*, 2020	The rapid growth presents a significant obstacle to the creation of cellular networks	load balancing technique	Implementation of the load balancing technique to improved resource block consumption	User association algorithm for multi-tier networks using the coordinated multipoint technique
[23]	*IEEE Transactions on Industrial Informatics*, 2020	There will soon be a tsunami of Big Data due to the quickly changing industry standards and revolutionary developments in the Internet of Things arena	1)creating a consolidated Software-Defined Data Center-based model to jointly optimize the process of virtual machine for decreased energy consumption.2) defining a multiobjective optimization problem to determine the best distribution of resources. 3) creating an effective method based on heurism	A first fit decreasing algorithm-based suboptimal strategy is presented	Develop the suggested work on a real-time testbed
[24]	*IEEE Transactions on Vehicular Technology*, Nov. 2020	It's anticipated that next-generation wireless communications will offer dependable, high-speed connectivity	Successive Interface Cancellation techniques	Energy efficiency optimization issue looked into the relationship between the caching probability and the delivery of energy-efficient content	Account the joint task offloading and content caching in the suggested framework
[25]	*IEEE Journal on Selected Areas in Communications*, 2020	To fulfill the demand for ultra-high capacity in the future, terahertz (THz) band communication has been extensively explored	To maximize the EE of a THz- Multi-antenna techniques, convergence scheme, alternating direction method of multipliers algorithm	Designed a distributed alternating direction method of multipliers algorithm	By utilizing improved K-means machine learning algorithm, quick convergence method for user clustering
[26]	*IEEE Transactions on Industry Applications*, 2021	Due to their effective administration and control of distributed energy resources, virtual power plants have emerged as a major force in the decentralized energy sector	1) Optimizing the receding horizon. 2) Fuel Cell: A hybrid prediction technique	The output powers of Renewable energy resource and the loads are forecasted using the Kalman filter	These techniques computes the answers in a reasonable amount of time for real-time operation
[27]	*IEEE Access*, 2021	Edge Clouds face substantial issues because to their carbon emission and high energy costs	The Dynamic Energy Cost and Carbon Emission-Effective Application Placement Method for Edge Clouds is presented	The initial deployment of applications on Edge Clouds and subsequent placement optimization	It will address DECA's inability to effectively support more interactive contexts
[28]	*IEEE Access*, 2021	Energy storage systems have the ability to significantly reduce the rate of expansion of intermittent renewable energy sources and sustain the frequency of microgrids	Model predictive control and adaptive droop control are two control techniques	When the suggested Model Predictive Controller is compared to the proportional-integral and fuzzy logic proportional-integral controllers	It will create a single controller that can control the State of Charge of both Energy Storage System and electric vehicle

[29]	*IEEE Transactions on Industrial Informatics*,2021	Huge Internet of Things and big data analytics, have attracted a lot of attention recently from academia and the commercial world	Brand-new Machine Learning-driven mobility management approach. A brand-new architecture comes next	Experimental findings are retrieved with great energy efficiency, higher Quality of Experiences and Quality of Services	To investigate cognitive approaches and intelligent edge computing for the transmission of video content over 6G network
[30]	*IEEE Access*, 2021	Hybrid Electric Vehicle types vary due to the variety of energy storage technologies used and the different control techniques used	Analysis of the energy storage systems, as well as procurable optimization	The experimental setup, improved driving cycles, and mathematical models of each control strategy are also analyzed	More investigation can be done to maintain optimal performance, it is important to emphasis the improvement of driving cycles in HEV operations
[31]	*IEEE Transactions on Sustainable Computing, 2022*	Transport massive data loads from various services and applications to end user	The suggested strategy uses split-and-merge clustering to lower the number of controllers	To minimize the chosen objective function, they combine a split and merge method with a modified incremental k-mean clustering approach	Fault-tolerance, switch migration fallback strategies measures to make split or merge decisions research areas that might be further studied
[32]	*IEEE Transactions on Cloud Computing, 2022*	One of the main challenges in network virtualization is to embed a series of virtual networks with node and connection limitations onto the physical network	Energy Aware-Virtual Network Migration and Group based enhanced virtual network migration algorithm are two energy conscious virtual network migration algorithms	EA-VNM-G decreases the high time complexity problem of EA-VNM	Energy-aware Virtual Networking embedding approach would be intriguing to use it in a real-world setting, such as the PlanetLab
[33]	*IEEE Internet of Things Journal*, 2022	Software-defined networking . Wireless sensor networks, SDN controller and few different algorithms to determine the routing path, but none of them are powerful enough to produce the optimum routing path	Reinforcement learning is a useful method for choosing the optimal routing path	The author of this essay optimized Software Defined Wireless Sensor Networks through RL	We intend to improve the aforementioned criteria putting out some fresh ideas and putting the large-scale network into practice
[34]	*IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, 2022*	Tensor computation has emerged in recent years as a viable technique for tackling issues in big data analysis, machine learning, medical image processing, and EDA	First suggestest algorithm-hardware co-design. The second thing they do is offer a case study that illustrates the value of processing data	The suggested TTD Engine is at least 14.9 and 4.1 times quicker than its CPU and GPU counterparts	We intend to expand TTD Engine in two directions: 1) Cross-approximation is used by advanced TT Decomposition for low-rank matrix factorization. 2) Using the newly announced TTformat data processing pattern
[35]	*IEEE Transactions on Automation Science and*	Major networks and microgrids connected to the	Algorithm for Harris hawks optimization	The suggested Harris Hawks Optimization - based approach is	Concentrate on expanding the resolution of

	Engineering,2022	main grid face the difficult task of improving the sustainability and efficiency of distribution networks		evaluated against the performance of the particle swarm optimization algorithm and Cuckoo search algorithm	reconfiguration problems

3. CONCLUSION

In today's scenario advancement of Information and Communication Technology industry consumes huge amount of energy. The continuously growing popularity of cloud computing technologies is responsible to rise in energy consumption. The methods of energy efficiency are comprehensively reviewed in this assessment. This survey emphasizes the energy optimizations in cloud computing. In this research survey examine how various energy-efficiency methods affect performance and quality of services. It is possible to create an ideal strategy that handles energy performance and efficiency as a whole while providing advantages for the economy. Energy consumption by networking components and input-output devices must be taken into account while developing ways to reduce energy waste. Performance is improved by significantly balancing workloads among several machines at runtime in the virtualized cloud environment using dynamic Virtual Machine migrations in addition to the use of multicore CPUs. It takes an effective strategy to evenly distribute the workload across all devices in a network.

4. FUTURE RESEARCH DIRECTIONS

Numerous scheduling and resource utilization techniques for energy consumption in cloud computing have been developed in the last few decades, but still, it is a challenging task. Some of the critical issue is found as future research directions.

- Fault-tolerance and switch migration fallback strategies.
- Dynamic and heterogeneous environments in Cloud environment.
- Reducing the energy consumption of task requests in Cloud of Things (CoT).
- Needs to apply Machine Learning algorithm to optimize System cost in over-provisioning networks during peak demand times
- Energy savings can be done through optimizing live virtual machines migrations.

ACKNOWLEDGEMENT

REFERENCES

[1] J. Li, M. Peng, Y. Yu and Z. Ding, "Energy-Efficient Joint Congestion Control and Resource Optimization in Heterogeneous Cloud Radio Access Networks," in *IEEE Transactions on Vehicular Technology*, vol. 65, no. 12, pp. 9873-9887, Dec. 2016. doi: 10.1109/TVT.2016.2531184.

[2] G. S. Brar, S. Rani, V. Chopra, R. Malhotra, H. Song and S. H. Ahmed, "Energy Efficient Direction-Based PDORP Routing Protocol for WSN," in *IEEE Access*, vol. 4, pp. 3182-3194, 2016. doi: 10.1109/ACCESS.2016.2576475.

[3] K. Li, W. Ni, X. Wang, R. P. Liu, S. S. Kanhere and S. Jha, "Energy-Efficient Cooperative Relaying for Unmanned Aerial Vehicles," in *IEEE Transactions on Mobile Computing*, vol. 15, no. 6, pp. 1377-1386, 1 June 2016. doi: 10.1109/ TMC. 2015. 2467381.

[4] Y. Song and W. Song, "A Novel Dual Speed-Curve Optimization Based Approach for Energy-Saving Operation of High-Speed Trains," in *IEEE Transactions on Intelligent Transportation Systems*, vol. 17, no. 6, pp. 1564-1575, June 2016. doi:10.1109/TITS.2015.2507365.

[5] D. -W. Kim, B. Kang, K. K. Choi and D. -H. Kim, "Enriched Serial-Loop Optimization Method for Efficient Reliability-Based Electromagnetic Designs," in *IEEE Transactions on Magnetics*, vol. 52, no. 3, pp. 1-4, March 2016, Art no. 7201404. doi: 10.1109/TMAG.2015.2481003.

[6] G. Xie, Y. Chen, X. Xiao, C. Xu, R. Li and K. Li, "Energy-Efficient Fault-Tolerant Scheduling of Reliable Parallel Applications on Heterogeneous Distributed Embedded Systems," in *IEEE Transactions on Sustainable Computing*, vol. 3, no. 3, pp. 167-181, 1 July-Sept. 2018. doi: 10.1109/TSUSC.2017.2711362.

[7] D. Cheng, X. Zhou, P. Lama, M. Ji and C. Jiang, "Energy Efficiency Aware Task Assignment with DVFS in Heterogeneous Hadoop Clusters," in *IEEE Transactions on Parallel and Distributed Systems*, vol. 29, no. 1, pp. 70-82, 1 Jan. 2018. doi: 10.1109/TPDS.2017.2745571.

[8] M. Moltafet, P. Azmi, N. Mokari, M. R. Javan and A. Mokdad, "Optimal and Fair Energy Efficient Resource Allocation for Energy Harvesting-Enabled-PD-NOMA-Based HetNets," in *IEEE Transactions on Wireless Communications*, vol. 17, no. 3, pp. 2054-2067, March 2018. doi: 10.1109/TWC.2017.2788406.

[9] C. -C. Hsu and J. M. Chang, "Spectrum-Energy Efficiency Optimization for Downlink LTE-A for Heterogeneous Networks," in *IEEE Transactions on Mobile Computing*, vol. 16, no. 5, pp. 1449-1461, 1 May 2017. doi: 10.1109/TMC.2016.2584046.

[10] E. Ghazisaeedi and C. Huang, "Off-Peak Energy Optimization for Links in Virtualized Network Environment," in *IEEE Transactions on Cloud Computing*, vol. 5, no. 2, pp. 155-167, 1 April-June 2017.doi: 10.1109/TCC.2015.2440246.

[11] N. Javaid, G. Hafeez, S. Iqbal, N. Alrajeh, M. S. Alabed and M. Guizani, "Energy Efficient Integration of Renewable Energy Sources in the Smart Grid for Demand Side Management," in *IEEE Access*, vol. 6, pp. 77077-77096, 2018. doi: 10.1109/ ACCESS.2018.2866461.

[12] A. Khalid, N. Javaid, M. Guizani, M. Alhussein, K. Aurangzeb and M. Ilahi, "Towards Dynamic Coordination Among Home Appliances Using Multi-Objective Energy Optimization for Demand Side Management in Smart Buildings," in *IEEE Access*, vol. 6, pp. 19509-19529, 2018. doi: 10.1109/ACCESS.2018.2791546.

[13] S. Mustafa, K. Bilal, S. U. R. Malik and S. A. Madani, "SLA-Aware Energy Efficient Resource Management for Cloud Environments," in *IEEE Access*, vol. 6, pp. 15004-15020, 2018. doi: 10.1109/ACCESS.2018.2808320.

[14] K. Huang *et al.*, "Expected Energy Optimization for Real-Time Multiprocessor SoCs Running Periodic Tasks with Uncertain Execution Time," in *IEEE Transactions on Sustainable Computing*, vol. 6, no. 3, pp. 398-411, 1 July-Sept. 2021. doi: 10.1109/ TSUSC.2018.2853621.

[15] E. Christoforidis, S. Xydis and D. Soudris, "CF-TUNE: Collaborative Filtering Auto-Tuning for Energy Efficient Many-Core Processors," in *IEEE Computer Architecture Letters*, vol. 17, no. 1, pp. 25-28, 1 Jan.-June 2018.doi: 10.1109/LCA.2017.2716919.

[16] Z. A. Khan, A. Khalid, N. Javaid, A. Haseeb, T. Saba and M. Shafiq, "Exploiting Nature-Inspired-Based Artificial Intelligence Techniques for Coordinated Day-Ahead Scheduling to Efficiently Manage Energy in Smart Grid," in IEEE Access, vol. 7, pp. 140102-140125, 2019. doi: 10.1109/ACCESS.2019.2942813.

[17] N. Gharaei, S. J. Malebary, K. Abu Bakar, S. Z. Mohd Hashim, S. Ashfaq Butt and G. Sahar, "Energy-Efficient Mobile-SinkSojourn Location Optimization Scheme for Consumer Home Networks," in *IEEE Access*, vol. 7, pp. 112079-112086, 2019.doi:10.1109/ACCESS.2019.2932086.

[18] F. Fang, J. Cheng and Z. Ding, "Joint Energy Efficient Subchannel and Power Optimization for a Downlink NOMA Heterogeneous Network," in *IEEE Transactions on Vehicular Technology*, vol. 68, no. 2, pp. 1351-1364, Feb. 2019 doi: 10.1109/TVT.2018.2881314.

[19] J. M. C. Geoffrine and V. Geetha, "Energy Optimization With Higher Information Quality for SHM Application in Wireless Sensor Networks," in *IEEE Sensors Journal*, vol. 19, no. 9, pp. 3513-3520, 1 May1, 2019.doi: 10.1109/JSEN.2019.2892870.

[20] N. Chakraborty, A. Mondal and S. Mondal, "Multiobjective Optimal Scheduling Framework for HVAC Devices in Energy-Efficient Buildings," in IEEE Systems Journal, vol. 13, no. 4, pp. 4398-4409, Dec. 2019. doi: 10.1109 /JSYST.   2019. 2933308.

[21] O. Llerena-Pizarro, N. Proenza-Perez, C. E. Tuna and J. L. Silveira, "A PSO-BPSO Technique for Hybrid Power Generation System Sizing," in IEEE Latin America Transactions, vol. 18, no. 08, pp. 1362-1370, August 2020.doi: 10.1109/TLA.2020.9111671.

[22] M. S. Hossain et al., "Towards Energy Efficient Load Balancing for Sustainable Green Wireless Networks Under Optimal Power Supply," in IEEE Access, vol. 8, pp. 200635-200654, 2020.doi: 10.1109/ACCESS.2020.3035447.

[23] K. Kaur, S. Garg, G. Kaddoum, E. Bou-Harb and K. R. Choo, "A Big Data-Enabled Consolidated Framework for Energy Efficient Software Defined Data Centers in IoT Setups," in IEEE Transactions on Industrial Informatics, vol. 16, no. 4, pp.2687-2697, April 2020. doi: 10.1109/TII.2019.2939573.

[24] K. Wang, J. Li, Y. Yang, W. Chen and L. Hanzo, "Content-Centric Heterogeneous Fog Networks Relying on Energy Efficiency Optimization," in IEEE Transactions on Vehicular Technology, vol. 69, no. 11, pp. 13579-13592, Nov. 2020. doi:10.1109/TVT.2020.3013020.

[25] H. Zhang, H. Zhang, W. Liu, K. Long, J. Dong and V. C. M. Leung, "Energy Efficient User Clustering, Hybrid Precoding and Power Optimization in Terahertz MIMO-NOMA Systems," in IEEE Journal on Selected Areas in Communications, vol.38, no. 9, pp. 2074-2085, Sept. 2020. doi: 10.1109 /JSAC .2020. 3000888.

[26] G. Mohy-ud-din, K. M. Muttaqi and D. Sutanto, "Adaptive and Predictive Energy Management Strategy for Real-Time Optimal Power Dispatch From VPPs Integrated With Renewable Energy and Energy Storage," in IEEE Transactions on Industry Applications, vol. 57, no. 3, pp. 1958-1972, May-June 2021. doi: 10.1109/TIA.2021.3057356.

[27] E. Ahvar, S. Ahvar, Z. Á. Mann, N. Crespi, R. Glitho and J. Garcia-Alfaro, "DECA: A Dynamic Energy Cost and Carbon Emission-Efficient Application Placement Method for Edge Clouds," in IEEE Access, vol. 9, pp. 70192-70213, 2021. doi:10.1109/ACCESS.2021.3075973.

[28] M. U. Jan, A. Xin, H. U. Rehman, M. A. Abdelbaky, S. Iqbal and M. Aurangzeb, "Frequency Regulation of an Isolated Microgrid With Electric Vehicles and Energy Storage System Integration Using Adaptive and Model Predictive Controllers," in IEEE Access, vol. 9, pp. 14958-14970, 2021. doi: 10.1109/ACCESS.2021.3052797.

[29] A. H. Sodhro et al., "Toward ML-Based Energy-Efficient Mechanism for 6G Enabled Industrial Network in Box Systems," in IEEE Transactions on Industrial Informatics, vol. 17, no. 10, pp. 7185-7192, Oct. 2021. doi: 10.1109/TII.2020.3026663.

[30] A. K. Podder, O. Chakraborty, S. Islam, N. Manoj Kumar and H. H. Alhelou, "Control Strategies of Different Hybrid Energy Storage Systems for Electric Vehicles Applications," in IEEE Access, vol. 9, pp. 51865-51895, 2021. doi:10.1109/ACCESS.2021.3069593.

[31] A. Boukerche and N. Aljeri, "An Energy-Efficient Controller Management Scheme for Software-Defined Vehicular Networks," in IEEE Transactions on Sustainable Computing, vol. 7, no. 1, pp. 61-74,1 Jan.-March 2022. doi:10.1109/TSUSC.2021.3086418.

[32] Z. Zhang, H. Cao, S. Su and W. Li, "Energy Aware Virtual Network Migration," in IEEE Transactions on Cloud Computing,vol. 10, no. 2, pp. 1173-1189, 1 April-June 2022. doi:10.1109/TCC.2020.2976966.

[33] Wireless Sensor Networks Routing Performance Using Reinforcement Learning," in IEEE Internet of Things Journal, vol. 9,no. 5, pp. 3495-3508, 1 March1, 2022. doi: 10.1109/JIOT.2021.3102130.

[34] Z. Qu et al., "Hardware-Enabled Efficient Data Processing With Tensor-Train Decomposition," in IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, vol. 41, no. 2, pp. 372-385, Feb. 2022. doi:10.1109/TCAD.2021.3058317.

[35] A. M. Helmi, R. Carli, M. Dotoli and H. S. Ramadan, "Efficient and Sustainable Reconfiguration of Distribution Networks via Metaheuristic Optimization," in IEEE Transactions on Automation Science and Engineering, vol. 19, no. 1, pp. 82-98, Jan.2022. doi: 10.1109/TASE.2021.3072862.