Energy Reports 11 (2024) 5422–5435

Contents lists available at ScienceDirect

Energy Reports

journal homepage: www.elsevier.com/locate/egyr

Review article

Recent advancement in demand side energy management system for optimal energy utilization

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ARTICLE INFO

Keywords:
Demand side management
Energy management
Demand response
Smart grid
And optimization techniques

ABSTRACT

To enhance the low reliability of supply that has resulted in an increasingly serious energy crisis and environmental problems, extensive research on new clean renewable energy and energy management technologies with high effectiveness, low cost, and environmental friendliness is required. Demand-side management systems are effective tools for managing renewable energy. Unfortunately, the intermittent nature of renewable energy is the principal drawback of renewable energy sources. This necessitates the development of intelligent energy management systems to increase system reliability and improve efficiency. Demand-side energy management systems are an excellent choice for several reasons. Firstly, they enable consumers to actively monitor and control their energy usage, leading to significant cost savings through reduced consumption during peak hours and improved overall efficiency. Recent advancements in demand-side energy management represent a significant shift towards more intelligent, flexible, and sustainable energy management practices, empowering consumers and utilities alike to optimize energy usage and contribute to a more resilient and efficient energy system. Demand-side management challenges and demand response categories are covered in this paper. It also introduces and analyzes the fundamental control strategies of demand response. Finally, it gives a description of the present difficulties and potential future developments in the creation of novel high efficiency and multilevel control mechanisms.

1. Introduction

Recent advances in demand-side energy management systems have focused on leveraging cutting-edge technologies to optimize energy utilization (Williams et al., 2023; Mimi et al., 2023). One significant development involves the integration of artificial intelligence (AI) and machine learning (ML) algorithms into energy management platforms. These advanced algorithms analyze historical energy consumption patterns, predict future demand, and dynamically adjust energy usage in real-time (Shuvo and Yilmaz, 2023; Charles Raja et al., 2023; Almeida, 2023). This enables the system to adapt to changing conditions, such as fluctuations in renewable energy generation or unexpected spikes in demand, ultimately leading to more efficient and sustainable energy utilization.

Moreover, the increasing emphasis on demand response programs has played a crucial role in enhancing demand-side energy management (Stanelyte et al., 2022; Alikhani et al., 2023). These programs encourage consumers to adjust their energy consumption based on signals from the grid, such as pricing incentives or notifications of high-demand periods. By actively engaging consumers in the energy management process (Silva et al., 2023a; Dey et al., 2023a), these demand response initiatives contribute to a more flexible and responsive energy grid, ultimately leading to improved overall efficiency and reduced environmental impact.

Utilizing alternative energy sources is crucial to supplying future energy needs in an environmentally friendly and sustainable manner due to the rising demand for and use of traditional fossil fuels like petrol and diesel and their high cost. The electricity grid has transformed into a smart and dependable system (Kataray et al., 2023; Kumar et al., 2023a; Ourahou et al., 2020) in which information and communications technology have been integrated with the traditional grid to improve its performance.

To meet the growing demands, innovative and efficient DSM techniques are employed in aggregation with a variety of renewable energy sources, including solar, wind, and other energy sources (Ourahou et al., 2020; Barman et al., 2023). DSM is a power supply strategy that enables users to adhere to policies and practices that are advantageous to all involved. This allows for the analysis and modification of all abnormal

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https://doi.org/10.1016/j.egyr.2024.05.028
Received 17 January 2024; Received in revised form 20 April 2024; Accepted 14 May 2024
Available online 21 May 2024
2352-4847/

activity that alters the load demand (Elkholy et al., 2022; Paul et al., 2023; Mbungu et al., 2022). However, introduction of DSM has increased the complexity of existing power systems. As a result, additional expenses will be incurred for the installation of sensors, providing DSM with motivation, and managing general DSM tasks. Using DSM techniques, energy providers can transfer and deliver generated power to customers with low running costs within the smart grid (Saleem et al., 2023). The conventional method raises the power generating unit and produces user electricity to meet their energy needs when the demand for electricity exceeds the output. However, because of the greenhouse effect, this strategy is inappropriate.

The problem of energy demand can be solved by a properly functioning DSM, which manages and keeps track of the energy required for end users without the need to add an additional generator. By introducing planning algorithms, it controls demand. Demand-driven response minimizes energy use and guards against excessive use of the power grid (Ali et al., 2022; Ullah et al., 2022). Additionally, this would provide customers with a cost advantage and endure for decades by enforcing appropriate scheduling practices. A variety of demand side management methods are presented (Fig. 1). The three main pillars of DSM are strategic load growth, demand response, and energy conservation. There are two types of demand response programmers: reliability-based programmers and market-based programmers.

The primary contribution of this research will be the design of an intelligent control strategy for integrated energy that addresses issues related to electrical efficiency, system reliability, flexibility, and electrical cost. It provides an optimal solution by assuming that future user and grid information are known in advance. This study's scientific novelty lies in the rigorous analysis of demand-side energy management within various operational contexts, offering new insights into power system management.

This study stands apart from traditional demand-side management approaches by introducing a novel method for energy optimization, integrating artificial intelligence techniques for real-time optimization and decision-making. Its distinction lies in the integration of renewable energy systems within an artificially intelligent energy management framework. While traditional demand-side management strategies typically focus on shifting load demand from peak to off-peak hours or implementing load shedding techniques to reduce energy consumption during high-demand periods, they often compromise consumer comfort and operational flexibility. In contrast, this study transcends conventional demand-side management techniques by seamlessly incorporating renewable energy sources in a manner that ensures continuous load connectivity. By leveraging these renewable resources, consumers can not only diminish their reliance on grid power but also enhance the overall efficiency and sustainability of their energy infrastructure.

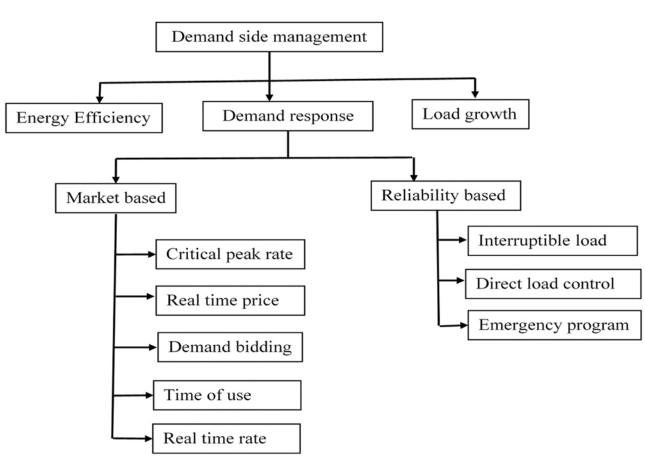

Fig. 1. Different demand side management strategies.

2. Overview on demand side energy management

(Table 1) summarizes previous works related to demand-side energy management systems. Several studies have investigated scheduling appliances with intelligent demand-side management systems that utilize real-time energy control. By integrating renewable energy sources, appliances can participate in real-time energy regulation through demand response tools (Rehman et al., 2021). Rolling optimization is employed to plan energy usage for off-peak hours, while an intelligent controller determines the integration of battery/photovoltaic and grid power. In a previous study (Saleem et al., 2022), a demand-side energy management system was implemented by controlling user energy usage without interfering with preference settings. Additionally, an intelligent energy management system based on fuzzy logic and neural networks was developed (Chojecki et al., 2020). This system was designed to receive inputs from external sensors, ambient conditions, battery storage, pricing, and consumer behavior. To minimize energy consumption, optimal energy efficiency was determined using the associative neural network. An artificial bee colony was utilized as the optimization algorithm in the development of a demand-side energy management framework, which aimed to optimize the system by scheduling household appliances when they are most affordable (Dashtdar et al., 2022). Another study (Shewale et al., 2022) presents an effective core algorithm for a demand-side energy management system that regulates water heaters and reduces the overall energy consumption of appliances.

3. Demand side management

Demand Side Management (DSM) is a strategy employed by utilities and energy providers to actively influence and manage the consumption patterns of electricity by end-users. The primary goal of DSM is to optimize the utilization of electricity resources, enhance grid reliability, and minimize overall energy costs. This approach involves implementing various techniques such as time-of-use pricing, demand response programs, and energy efficiency initiatives to encourage consumers to shift their electricity usage to off-peak hours or reduce consumption during periods of high demand. By actively engaging consumers in the management of their electricity demand, DSM not only helps in balancing the load on the grid but also contributes to environmental sustainability by reducing the need for additional power generation capacity.

DSM initiatives often leverage advanced technologies, such as smart meters and home automation systems, to provide real-time information to consumers about their energy usage. This enables end-users to make informed decisions about when and how they use electricity, leading to a more efficient and sustainable energy ecosystem. Additionally, DSM plays a crucial role in supporting the integration of renewable energy sources into the grid by aligning electricity demand with the intermittent nature of renewables. Overall, Demand Side Management represents a proactive and holistic approach to addressing the challenges of modern energy systems by promoting energy conservation, grid stability, and environmental responsibility.

Demand-side management (DSM) refers to the planning, implementation, and monitoring of activities designed to influence consumer use of electricity in ways that will result in desired changes in electricity demand patterns. The objectives of demand-side management generally revolve around improving overall energy efficiency, reducing peak demand, enhancing grid reliability, and achieving environmental sustainability. Here are some common objectives of demand-side management:

1. Reduce peak load;
2. Improve the economic feasibility and operation efficiency of the grid;
3. Keep supply and demand balance;
4. Improve the overall energy efficiency;
5. Increasing the economic viability of electricity distribution network;

Table 1
Previous works related to demand-side energy management systems.

Ref.	Problem Formulation Review	Description
(Motawa and Oladokun, 2021)	System dynamics modeling	Evaluate the adequacy of system dynamics modeling in capturing the interactions between energy-consuming devices, renewable energy sources, energy storage systems, and the grid infrastructure. Considerations include dynamic modeling of energy flows, time-varying constraints, and feedback loops.
(Daqaq et al., 2023)	Constraint representation	Assess how well the problem formulation represents various constraints, such as energy supply-demand balance, equipment operating limits, grid capacity constraints, and regulatory requirements. Ensure that constraints are accurately modeled to prevent infeasible solutions.
(Şahin and Kellegöz, 2019)	Optimization framework	Review the optimization framework used in the problem formulation, such as linear programming, mixed-integer programming, or heuristic approaches. Evaluate the suitability of the chosen framework in handling the complexity of real-world energy management scenarios.
(Reza et al., 2023)	Integration of uncertainty	Examine how uncertainty factors, such as weather variability, demand fluctuations, and equipment failures, are integrated into the problem formulation. Consider stochastic optimization, robust optimization, or scenario-based approaches to account for uncertainties effectively.
(Ahmad et al., 2023)	User preferences and constraints	Consider the incorporation of user preferences and constraints into the problem formulation, including comfort levels, scheduling preferences, energy budget constraints, and sustainability goals. Ensure that the formulation allows for customization to meet diverse user needs.
	Objectives/Multi-objective Functions	**Description**
(Wang et al., 2022a)	Energy cost minimization	Develop objective functions that minimize energy costs while meeting operational requirements and user preferences. Consider time-of-use pricing, demand charges, and incentives for energy conservation to optimize cost savings.
(Karimi and Jadid, 2020)	Environmental impact reduction	Formulate objective functions that minimize environmental impact by reducing greenhouse gas emissions, air pollutants, and resource consumption. Integrate renewable energy utilization, demand response, and energy efficiency measures to achieve sustainability goals.
(Camilo et al., 2021)	Grid reliability enhancement	Define objective functions that enhance grid reliability and stability by optimizing energy consumption patterns. Prioritize load balancing, voltage regulation, and congestion management to improve overall grid performance.
(Shaikh et al., 2018)	Consumer comfort optimization	Incorporate objective functions that optimize consumer comfort and satisfaction while minimizing energy consumption. Consider factors such as indoor temperature, lighting levels, air quality, and occupant preferences in the optimization process.
(Rathor and Saxena, 2020)	Peak load management	Develop objective functions for effective peak load management, aiming to reduce peak demand and alleviate stress on the grid during periods of high energy consumption. Implement demand response strategies, load shifting, and energy storage utilization to flatten load profiles.
(Hannan et al., 2020)	Integration of renewable energy	Formulate objective functions that maximize the integration of renewable energy sources into the energy management system. Optimize the use of solar, wind, and other renewables while ensuring grid stability and reliability.
(Petchrompo et al., 2022)	Multi-objective optimization	Employ multi-objective optimization techniques to balance conflicting objectives and identify Pareto-optimal solutions. Use optimization algorithms such as genetic algorithms, particle swarm optimization, or multi-objective evolutionary algorithms to explore trade-offs and find optimal solutions.
(Negri et al., 2022)	Integration of renewable energy	Optimize the integration of renewable energy sources like solar and wind power by forecasting generation patterns, coordinating energy consumption, and maximizing self-consumption and grid interactions.

6. Enhancing the stability and reliability of the electricity grid.

Reducing the generation side peak demand is very costly; a study conducted in (Saleem et al., 2023; Ali et al., 2022; Iqbal et al., 2021) found that at least 10% of supply costs only result in 1% of annual hours. Demand side management provides an affordable solution for handling such a problem. By altering the consumer's energy consumption pattern, Demand side management lowers the overall peak load demand and improves grid stability. This lowers energy consumption costs and carbon emission (Paul et al., 2023; Ali et al., 2022; Yuan et al., 2023). Demand response, distributed generation, energy storage, energy consumption optimization and scheduling, energy conservation and efficiency, and energy consumption are some of the DSM strategies (Fig. 1). The function of demand side management strategies (Fig. 2) (Taveres-Cachat et al., 2019). Peak shaving, valley filling, load shifting,

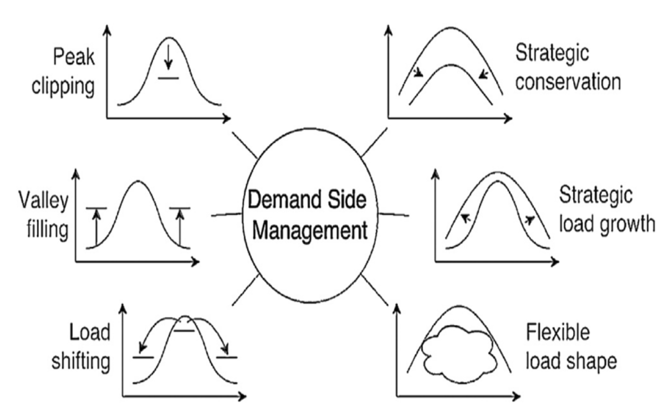

Fig. 2. Demand side management function (Taveres-Cachat et al., 2019).

strategic conservation, and time-shifting are some of these roles. The direct load control methods are valley filling and peak shaving. Direct demand reduction from the consumer is a component of strategic conservation. The demand is shifted from peak to off-peak hours by load and time shifting. Energy efficiency, distributed generation, incentive-based demand response (DR), price-based DR, load shifting, time-shifting through scheduling, energy storage, and strategic conservation through energy optimization and conservation are the methods used to achieve energy savings. More over the recent state of art are summarize (Table 2).

Despite the substantial studies and improvements identified, existing energy management systems have significant room for advancement before being effectively utilized in renewable energy contexts. With intelligent energy management, the intermittent nature of renewable energy does not adversely affect the supply system, as the energy management system effectively balances demand and supply.

In conclusion, despite plentiful research, major impediments such as reliability-based demand response and market-based demand response for energy and cost savings in electrical energy, along with customer comfort in micro-grid applications, remain unresolved. Consequently, future research should prioritize the development of intelligent energy management to address these issues, optimizing resource utilization, reducing electricity costs, promoting environmental friendliness, ensuring affordability, and leveraging abundant resources such as solar energy. Further research is also necessary to achieve efficiency improvements ranging from more than 11–24%.

3.1. Energy efficiency and energy conservation

Energy conservation and energy efficiency are distinct yet interconnected strategies aimed at optimizing energy use. Energy conservation involves reducing overall energy consumption through behavioral changes and prudent practices, such as turning off lights and appliances when not in use. It emphasizes minimizing waste and curbing unnecessary energy demand (Naimah et al., 2023; Nathaphan and Therdyothin, 2023) Proposed the energy audit method to conserve energy efficiently. There was no more intelligent approach to energy management for significantly reducing demand in a reliable manner. On the other hand, energy efficiency focuses on getting more output from the same amount of input, achieved through technological advancements and improved processes (Zhao et al., 2023; Kuang et al., 2023; Chu et al., 2023) these studies address energy management without considering the configuration of smart energy systems. They use a transitional approach for energy conservation. It aims to enhance the performance of energy-consuming systems, appliances, and industrial operations. While conservation addresses the need to lower overall energy demand, efficiency aims to achieve the same outcomes with less energy input. Together, these approaches form a holistic approach to sustainable energy management, contributing to environmental preservation, cost reduction, and the promotion of responsible resource use. The technological advancements include: Energy-Efficient Appliances: Advances in the design and engineering of appliances, such as refrigerators, air conditioners, washing machines, and lighting fixtures, have led to significant reductions in energy consumption while maintaining or even improving performance.

Smart Grid Technologies: The integration of digital communication and control technologies into electrical grids enables more efficient transmission and distribution of electricity, as well as better management of demand fluctuations through features like demand response and load shifting.

Renewable Energy Technologies: The continued development and deployment of renewable energy sources, such as solar, wind, and hydro power, contribute to overall energy efficiency by harnessing clean, sustainable sources of power to replace or supplement traditional fossil fuel-based generation.

Energy Storage Solutions: Innovations in energy storage technologies, including batteries and other storage systems, enable the capture and utilization of excess energy during periods of low demand for later use during peak demand times, thereby improving overall system efficiency and reliability.

Building Automation Systems: The integration of advanced sensors, controls, and automation technologies into building systems allows for more precise management of energy usage, including heating, cooling, lighting, and ventilation, based on real-time occupancy and environmental conditions.

Demand-side management (DSM) serves as a pivotal strategy for achieving energy efficiency improvements by focusing on consumer behavior and electricity consumption optimization (Ali et al., 2022; Bhaagat et al., 2023; Gyamfi et al., 2022). DSM initiatives leverage various tools, such as smart grid technologies, dynamic pricing, and behavioral interventions, to encourage end-users to adjust their energy consumption patterns. By implementing demand response programs that incentivize consumers to reduce usage during peak demand periods or adopt energy-efficient technologies, DSM contributes to a more

Table 2
A summary of the current state of the demand side management system.

No.	Attempt	Method used	Weakness	Year	Reff
1.	Reducing load consumption	Fuzzy based approach	Use fewer number of variables for logical descision-making	2019	(Atef and Eltawil, 2019)
2.	Home energy management system	Electrical power system analyis(ETAP)	Energy management lacked intelligence	2021	(Hussain et al., 2021)
3.	Demand side management of small scale loads	Glow-warm swarm optimation	Consumer comfort was not considered	2019	(Puttamadappa and Parameshachari, 2019)
4.	Energy management model for building	Building enegry managemet aproach	Smart technolgies were not concidered	2023	(Fernández Bandera et al., 2023)
5.	Supply snd demand balance	Agent based approach	Lack of coordination among agents	2020	(Ganesh and Patnaik, 2020)
6.	Energy management system fpr smart home appiance	quasi-Newton approach	Control aproach lacked intelligence and the consumer was not considered	2020	(Xu et al., 2020)
7.	Effects of demand response on industrilal consumption	Mathematical model of the load and the real data of the case study	Power system stability and the renewable energy was not taking into account	2022	(Siahchehre Kholerdi and Ghasemi-Marzbali, 2022)
8.	Reducing load consumption	Fuzzy-based optimization based on the current values of the input variables.	Consumer discomfort was not taking into account	2021	(Busisiwe et al., 2021)
9.	Demand side energy management for smart homes	Fuzzy expert framework based	Fewer parameter were used for controlling the load	2020	(Zhang et al., 2020)
10.	For oil and gas industry	Machine learning algorithms	Hardware communication techonolgy was not considered	2021	(Iqbal et al., 2021)
11.	For resedential loads	MPPT technique	Consumer comfort was not considered	2021	(Baliyan et al., 2022)
12.	Intelligent management for distributed power plant	Instantaneous current control approach	The management system lacked intelligence	2021	(Prakash et al., 2023)

sustainable and resilient energy infrastructure (Saleem et al., 2022; Castro et al., 2022; Haley et al., 2020). This proactive management of electricity demand not only minimizes the need for costly infrastructure upgrades but also facilitates a more balanced and efficient utilization of resources, ultimately fostering a greener and more cost-effective energy (Palomar et al., 2023; Shekhar et al., 2023). The performance of demand side management efficiency (Table 3).

3.2. Demand response in energy management

Demand response is a strategy employed in electricity markets to manage and balance supply and demand by encouraging consumers to adjust their electricity consumption in response to price grid conditions (Dey et al., 2023a; Dixit et al., 2023; Charoen et al., 2022). Instead of solely relying on traditional methods of adjusting electricity supply to meet demand fluctuations, demand response involves modifying the demand side of the equation. This can include actions such as shifting non-essential energy-intensive activities to times of lower demand or participating in programs that allow utilities to remotely adjust certain appliances during peak periods (Casalicchio et al., 2022; Batalla-Bejerano et al., 2022). By engaging consumers and businesses in actively managing their electricity usage, demand response helps enhance grid reliability, reduce the need for expensive peaking power plants, and contribute to a more efficient and sustainable energy system.

To prevent large capital expenditures in generation capacity, the utility may use demand response, a procedure that involves remotely disconnecting such customer appliances or reducing the load at the customer's location. Brownouts, blackouts, sharp increases in fuel prices, and other emergency situations can all be handled with the help of demand response. Customers are encouraged to participate by demand response through a variety of rewards and penalties (Ming et al., 2020; Guo and Weeks, 2022; Lu et al., 2021a). Residential demand response programs allow a customer to control smart appliances and reduce electricity consumption, and scientists and researchers are becoming interested in these programs (Alikhani et al., 2023; Silva et al., 2023a; Xu et al., 2023). Demand response classification are shown (Fig. 3).

Table 3
Performance of DSM strategies for energy efficiency improvements.

No.	Attempt	Method used	Efficiency improvement	Year	Reff
1.	Energy management for residential loads	Mathematical model(PSO) based on incentives and time of use	24%	2020	(Philipo et al., 2020)
2.	Demand side management for energy efficiency	Approach using the Low Emission Analysis Platform (LEAP) model	18%	2023	(Bhaagat et al., 2023)
3.	Energy management of micro-grid operation with a focus on residential loads	A mathematical model integrating incentives and time-of-use consideration	11.11%	2020	(Philipo et al., 2020)
4.	Enegry side managemet for large number of loads	Genetic algorithm based approach	7.25%	2022	(Zhu et al., 2022)
5.	Energy management for residential and commercial builings	Energy auditing and incentive-driven approach to shift consumers from peak to off-peak consumption	10%	2023	(Kumar et al., 2019)

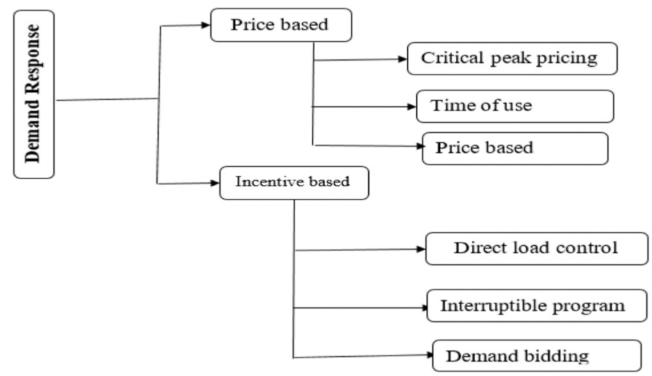

Fig. 3. Demand response categories.

The Advanced Metering Infrastructure (AMI), a combination of smart meters, communication networks, measurement terminals, data concentrators, and data management systems, utility delivers the demand response request to the customer (Silva et al., 2023a; Aketi and Sen, 2014; Eissa, 2019). To smartly monitor and control the micro-grid, communication technologies are also applied. Communication technologies enable two-way information exchange between the consumers and control and operation centers. Monitoring along the transmission lines, two-way communications capabilities between utility and consumer makes the micro-grid smart (Abbasi et al., 2023; Karra and Chandrasekhar, 2023; Azeem et al., 2023). The smart micro-grid consists of Advanced Metering Infrastructure (AMI), SCADA, and Distribution Automation which include (Karra and Chandrasekhar, 2023; Hasan et al., 2023; Tightiz et al., 2020).

Smart Meters: having the capacity to collect information about energy usage and transmitting the data through wireless/fixed communication networks to utility as well as receiving information like pricing signals form utility and conveying it to consumers (Fig. 4).

Communication Network**:** which enables two-way communication from smart meters to utility. The networks could be broadband power line, power line communications, fiber optic communication, fixed radio frequency or public networks.

Meter Data Acquisition System: software applications on the control center hardware and the data concentrator units used to acquire data from meters via communication network.

Meter Data Management System**:** A system which receives, stores and analyzes the metering information.

Demand Response**:** it seeks to adjust the demand for power instead of adjusting the supply (throttling). Utility requests customers to adjust the power demand by postponing some task that requires large amounts of power to off-peak time and the price will be reduced for them (the price of off-peak time would be cheaper than peak time). Compression

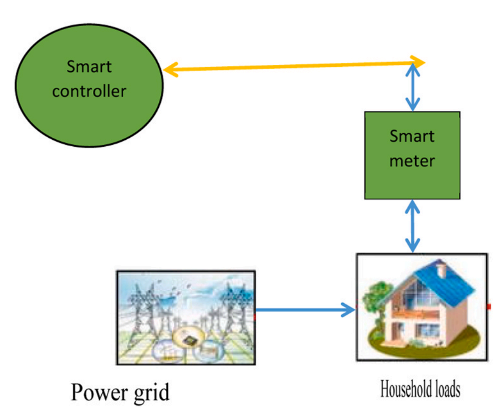

Fig. 4. Demand response strategy.

between price based and incentive based demand response are summarized (Table 4).

3.2.1. Price based demand response

Customers adjust their energy consumption habits during peak demand periods in response to various time-based pricing schemes known as tariffs under a price-based demand response program, also known as indirect load control. Users can then profit monetarily from this. Among the different pricing plans are Real-Time Pricing, Critical Peak Pricing, and Time-of-Use pricing (TOU). One popular tariff is the time of use, which divides usage charges into distinct time slots for various times of day (Wen et al., 2022; Wan et al., 2021). Since prices are typically higher during peak and lower during off-peak hours, customers may adjust their schedules accordingly. Although critical peak price and time of use are fairly similar, during the summer months when the system is overloaded, prices here fluctuate frequently. One day in advance of the change in price, the participants are informed (Judge et al., 2021; Lu et al., 2021b; Sharma et al., 2022). With real-time pricing or dynamic pricing, participants are informed of the time in advance and hourly prices are subject to change. To achieve overall price reductions through energy consumption pattern modification and real-time communication between utilities and customers, real time price implementation calls for the use of an energy management controller (Touma et al., 2021; Yousaf et al., 2021).

3.2.2. Incentive based demand response

Under incentive-based demand response programs, participants save energy during overload times in exchange for monetary incentives. Demand bidding, interruptible programs, and Direct Load Control (DLC) are three distinct strategies employed in energy management and utility demand response initiatives (Kaspar et al., 2022; Baraniya and Dar, 2022; Wei et al.). Demand bidding involves consumers actively adjusting their electricity consumption based on real-time pricing signals, responding to market fluctuations and reducing demand during peak periods. Interruptible programs allow utilities to temporarily suspend or reduce power supply to certain customers, often industrial or commercial entities, during periods of high demand or system stress (Shah et al., 2021; Carvallo and Schwartz, 2023; Meyyappan and Isac, 2023). Direct Load Control, on the other hand, gives utilities the ability to remotely manage and curtail electricity usage in specific devices or appliances within consumers' premises, aiming to balance overall demand. These demand response mechanisms play crucial roles in enhancing grid reliability, optimizing energy consumption, and supporting the integration of renewable energy sources by actively engaging consumers in the electricity market and mitigating peak demand challenges (Hampton et al., 2022; Snow et al., 2022).

3.3. Energy scheduling and Energy optimization

Load shedding is giving way to load scheduling as the traditional grid becomes more decentralized. Demand-side management is adjusting the energy consumption pattern of household appliances to schedule them. By moving the smart home appliances from on-peak to off-peak hours, scheduling is a load management technique that improves load factor by shaving peaks and filling valleys (Albogamy et al., 2022; Gull et al., 2022; Gu et al., 2023).

Optimization is the process of choosing the optimal component from a range of options in order to accomplish a goal. In mathematical terms, it deals with determining the maximum or minimum of a function that is constrained (Mishra et al., 2023). The best parameters required for intelligent energy management are found through energy consumption optimization. Current indoor parameters and user-desired parameters are two crucial parameters (Rehman et al., 2021; Mishra et al., 2023; Wang et al., 2023). Error is the result of the difference between the two, and it is minimized by optimizing energy consumption. Hourly consumption cannot be predicted by traditional energy management, which is based on load forecasting and machine learning using data from traditional meters (Cordeiro-Costas et al., 2023). Either digital meters are used in place of these ones, or demand response-based load forecasting is used to solve the problem (Alotaibi, 2022). Optimizing energy consumption requires energy prediction (Vasanthkumar et al., 2022). When thinking about the optimization problem, the user's comfort level is a major consideration. Numerous scholars have suggested a range of optimization strategies to manage energy usage without compromising user comfort.

3.4. Decentralized generation

A source of electricity that is directly connected to the distribution level or the user end is known as distributed generation, also known as decentralized generation (DG) (Alonso-Travesset et al., 2022; Ayalew et al., 2022). In the context of demand-side management (DSM), decentralized generation plays a crucial role in optimizing energy consumption patterns and enhancing overall grid efficiency. DSM involves strategies that aim to influence when and how electricity is used, and decentralized generation aligns seamlessly with these principles by offering flexibility in power production (Nguyen et al., 2022; Panda et al., 2022). Integrating decentralized generation sources, such as rooftop solar panels or small-scale wind turbines, allows consumers to generate their own electricity and even contribute surplus energy back to the grid (Stennikov et al., 2022; Jayaram et al., 2022). This decentralized approach empowers consumers to actively participate in managing their energy demand, promoting a more balanced and responsive energy system.

Decentralized generation in conjunction with demand-side management can lead to a more resilient and adaptable energy

Table 4
Comparison between price based and incentive based demand response.

No.	Attempt	Method used	Incentive based	Price based	Year	Reff
1.	Demand response for energy savings	Mathematical modelling approach	Time independent	Time dependent	2019	(Asadinejad and Tomsovic, 2017)
2.	Demand resonse for economic use electricity	PSO algorithms	Offered payment to achieve load reduction	Voluntarily respond to reduce load	2021	(Laitsos et al., 2021a)
3.	Application of Demand response to save energy consuption and cost	PSO algorithms approach	Mostly address emegenies during overloading coditions	Mostly used to have less electricity use at peak hours	2021	(Laitsos et al., 2021b)
4.	Application of demand response in energy savings	Bootstrapping approach	Offer incentives for consumer to be flexible	Voluntarily demand response to reduce loads	2021	(Cortez et al., 2024)
5.	Designed the demand response based on end users preference	Distributed algorithms and adaptive pricing scheme	Incorporating end-user preferences when designing demand response programs	Time dependent	2019	(Zhou et al., 2019)
6.	Demand response for benefits of both consumers and company	PSO algorithm approach	Incorporated demand response into load management	Respond to reduce peak load	2021	(Priya et al., 2022)

infrastructure. By enabling consumers to actively control and adjust their electricity consumption in response to grid conditions, peak demand can be mitigated, reducing the need for costly infrastructure upgrades (Zantye et al., 2022; Twaisan and Barışçı, 2022). Moreover, decentralized generation supports the development of smart grids that facilitate real-time communication between consumers and utilities. This bidirectional communication enhances the ability to implement demand response programs, where consumers can voluntarily adjust their energy usage in exchange for incentives, contributing to a more efficient and sustainable energy ecosystem (Bai et al., 2016). As the energy landscape continues to evolve, the synergy between decentralized generation and demand-side management offers a promising avenue for creating a more responsive, consumer-centric, and sustainable energy grid.

3.5. Energy storage

Energy storage plays a crucial role in modern energy systems by mitigating the intermittent nature of renewable energy sources and providing stability to the grid. It involves capturing and storing energy during times of excess supply and releasing it when demand is high (Amir et al., 2023; Kalair et al., 2021; He et al., 2021). Various technologies are employed for energy storage, including batteries, pumped hydro storage, compressed air energy storage, and thermal storage systems. Batteries, such as lithium-ion batteries, are widely used for their efficiency, scalability, and versatility in applications ranging from portable electronics to electric vehicles and grid-scale storage. Pumped hydro storage utilizes the gravitational potential of water to store and release energy (Rana et al., 2023). Compressed air energy storage involves storing compressed air in underground caverns and releasing it to drive turbines when needed. Thermal storage systems store energy in the form of heat, which can be released for power generation (Rashid et al., 2023). Advances in energy storage technologies are crucial for building a more resilient and sustainable energy infrastructure, supporting the integration of renewable energy sources, and ensuring reliable power supply.

4. Communication technology

For DSM techniques to be implemented, communication systems are

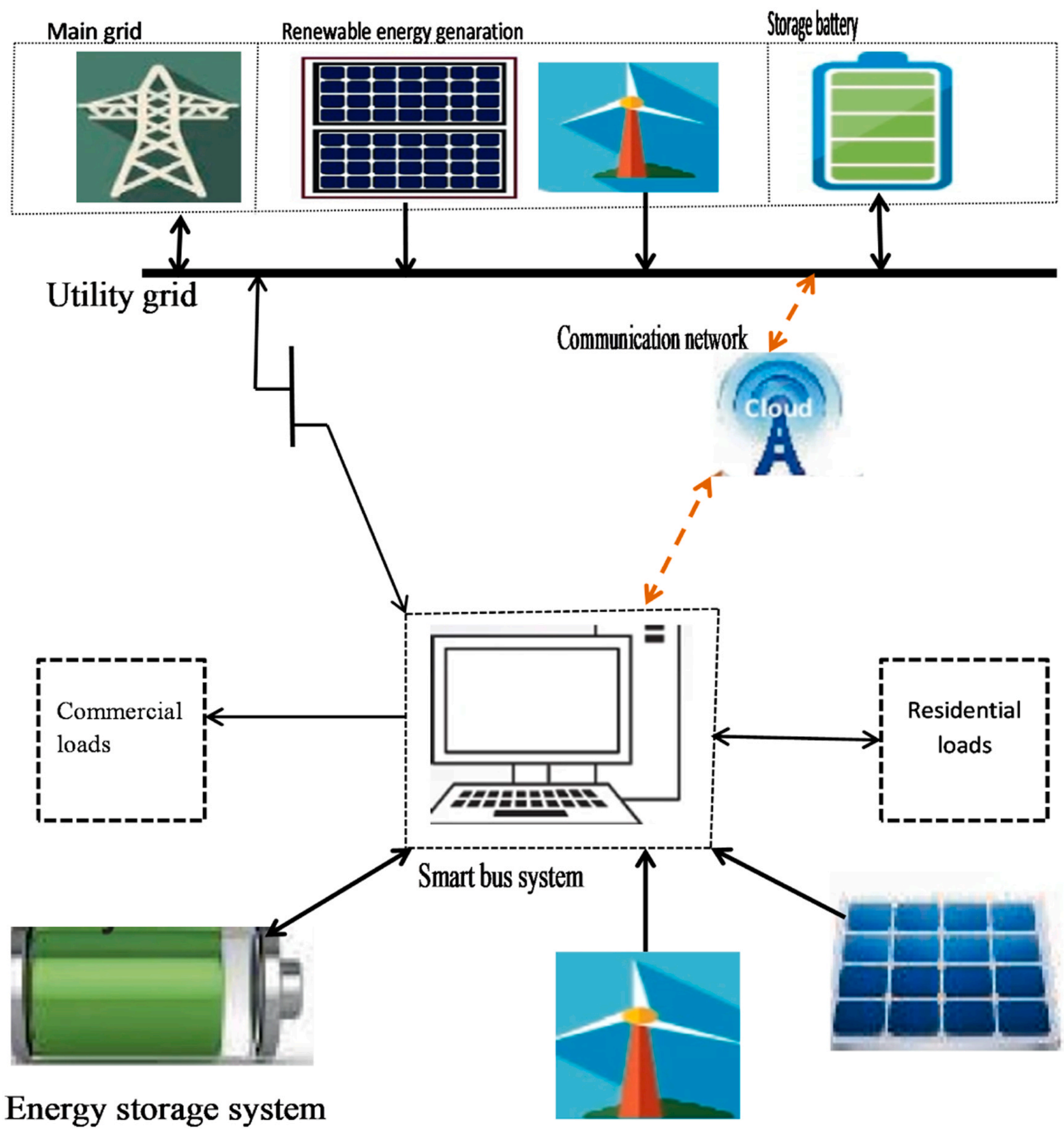

Fig. 5. Simplified smart grid structure with communication.

necessary primarily for relaying information about market and contingency signals through metering setups, using either unidirectional or bidirectional communication links between utility operators and end-user consumers(Fig. 5). A very economical way to communicate information is through unidirectional communication, which is mostly used for warning campaigns or DSM event notifications (Said, 2022a; Saffre and Gedge, 2010). However, they do not make monitoring and control operations easier than bidirectional communication. Due to their ability to recognize the diverse distribution of interconnected units in the DSM architecture, bidirectional communication systems are more dependable despite their higher cost when it comes to deploying control and monitoring tasks. Their combined operation with energy management system would be more reliable and secure with better and enhanced communication protocols and channels. In order to facilitate information exchange within the energy management system environment, wired or wireless communication systems may be implemented (Alhasnawi and Jasim, 2021; Rinaldi et al., 2018).

(a) Wireless communication: A communication channels, HAN, NAN, or WAN can all be used to depict the wireless communication architecture. Two commonly used wireless communication protocols in this field are Wi-Fi and ZigBee are examples of these protocols (Kuthadi et al., 2022; Zhou et al., 2021). The AMI infrastructure, which consists of multiple interconnected units, also utilizes these two channels of operation for implementing smart metering communication. The range of wireless communication channels is typically restricted to 10–15 km. additionally; these channels require physical medium relaying, which can be achieved through wired communication techniques or data logging. WAN-based communication channels such as GPRS, UMTS, LTE, or (Wi-Max) can be implemented to further improve the capabilities of these technologies (Sadeeq and Zeebaree, 2021; Vuddanti and Salkuti, 2021).
(b) Wired communication: A range of technologies may be used in wired communication, depending on the coverage area. Fiber optic-based communication can be implemented for WAN applications, typically covering distances greater than 10 km, while power line communications (PLCs) can be adopted at HAN and NAN levels to cover localized smart grid locations, typically up to 100 m (Taghizad-Tavana et al., 2022).

Smart meters: consist of an electronically controlled system connected to utility companies via a communication channel. They record consumers' load consumption and other relevant power quality metrics at specific intervals, transmitting this data via a communication channel to the utility's central energy management operator for metering purposes. End-user appliances can access this data to inform users about their load usage for each device and the entire residential property. This enables users to make improvements to their load usage patterns and reduce expenses by controlling their consumption (Munoz et al., 2022; Kumar et al., 2023b).

Advanced Metering Infrastructure (AMI): plays a crucial role in Remote Energy Management Systems (EMS), providing consumers with the ability to actively participate in the electricity market by enabling two-way information exchange through utility grid configuration and on-site smart metering infrastructure. It serves as a fundamental component of IoT-enabled energy management system, incorporating features such as information sharing, data logging, remote device monitoring, consumer data security, and the ability to display dynamically changing tariff prices provided by the utility provider (Abdullah et al., 2023; Saeed et al., 2023; Springmann et al., 2022).

5. Soft computing based demand side management

Soft computing techniques have been effectively use to address energy management issues related to intelligent building control, including those that are uncertain or imprecise, due to their numerous applications (Chen et al., 2022; Rocha et al., 2021). The demand side management are categorized as Fuzzy Logic, Artificial Neural Network, or Evolutionary Computation based on the kind of soft computing techniques used.

Soft computing-based demand-side management involves the application of computational techniques inspired by the human mind's ability to reason and learn adaptively to optimize electricity consumption (Anthony et al., 2021). This approach utilizes fuzzy logic systems, neural networks, and evolutionary algorithms to address the complexity and uncertainty inherent in demand patterns. By employing fuzzy logic controllers, systems can interpret imprecise and uncertain information related to energy consumption preferences and dynamically adjust demand response strategies (Paul et al., 2023; Paramathma et al., 2021). Neural networks enable the modeling and prediction of intricate demand patterns, allowing for the development of personalized and adaptive demand management schemes. Evolutionary algorithms optimize decision-making processes by iteratively refining strategies based on historical data (Sanjeevikumar et al., 2022; Rabaza, 2020). Overall, soft computing techniques enhance the flexibility and efficiency of demand-side management systems, contributing to a more responsive and intelligent energy consumption landscape.

5.1. *Fuzzy logic based demand side management*

Fuzzy logic-based demand-side management (Fuzzy DSM) is an intelligent approach to optimize energy consumption in a decentralized manner. Unlike traditional demand-side management techniques, which often rely on fixed rules, fuzzy logic enables a more flexible and adaptive control system (Bustos et al., 2022). By employing linguistic variables and fuzzy sets to represent uncertain and imprecise information, Fuzzy DSM can effectively model and respond to the dynamic nature of energy demand (Samuel et al., 2023; Bolurian et al., 2022). This approach allows for a nuanced decision-making process, considering factors such as user preferences, weather conditions, and load variations. Fuzzy logic controllers can adjust power consumption levels in real-time, promoting energy efficiency and reducing overall demand during peak periods (Elavarasan et al., 2021). As a result, Fuzzy DSM contributes to a more resilient and sustainable energy grid by enhancing the integration of renewable energy sources and minimizing the need for additional infrastructure investments.

For many years, fuzzy logic has been widely used to control and monitor home appliances because of its exceptional ability to handle uncertainties and nonlinearities, as well as its simplicity, adaptability, and flexibility (Paul et al., 2023; Rabaza, 2020). Fuzzy logic controller provides the best performance and achieves effective energy savings (25–30% more than the traditional ON/OFF controller) (Wang et al., 2022b; Al Sumarmad et al., 2022). Compared to fuzzy PD, fuzzy PI, fuzzy PID, and adaptive fuzzy PD controllers, the fuzzy P controller results in an annual energy savings of 76% for electric lighting, according to a study in (Bustos et al., 2022).

5.2. *Evolutionary computation based demand side management*

Due to its well-known ability to produce highly optimized solutions, evolutionary computation is frequently used to address challenging nonlinear, non-convex, and constrained optimization issues. With a potential energy savings of 7%, an effective energy management reset scheme utilizing evolutionary programming was put forth (Kanta and Berglund, 2015). The authors minimized costs and interruptions by scheduling interruptible loads using Binary Particle Swarm Optimization (BPSO) (Menos-Aikateriniadis et al., 2022). Subswarms were created from the swarms in order to significantly improve scheduling. A heuristic evolutionary algorithm was used to create a day-ahead load scheduling technique that can handle a range of loads (Jasim et al., 2022).

Ant Colony Optimization (ACO) is a metaheuristic inspired by the foraging behavior of real ant colonies. In ACO, artificial ants traverse a solution space, depositing pheromones on their paths based on the quality of solutions they encounter (Silva et al., 2023b). This decentralized approach allows the algorithm to efficiently explore and exploit solution spaces for optimization problems. Over time, paths with higher pheromone concentrations become more attractive, guiding subsequent ants to focus on promising areas of the solution space (Behera and Choudhury, 2023). ACO has proven particularly effective in solving combinatorial optimization problems, such as the traveling salesman problem and job scheduling. Its decentralized nature and ability to adapt to changing environments make it a powerful tool for finding near-optimal solutions in complex, dynamic problem domains.

Artificial Bee Colony was used in the works in (Menos-Aikateriniadis et al., 2022; Kreishan and Zobaa, 2023) to schedule appliances for energy management that took renewable energy sources into account. An approximate 47% cost reduction is achieved by the algorithm.

The Binary Backtracking Search Algorithm for energy management schedules appliances in real time (Menos-Aikateriniadis et al., 2022). Energy management system consisting of GA, Cuckoo Search Algorithm, BPSO, and Crow Search Algorithm (Ebrahimi and Abedini, 2022) were designed with real time price and time of use pricing models, respectively, for peak load reduction and electricity cost (Ebrahimi and Abedini, 2022; Liu et al., 2023). Renewable energy sources and energy storage were also taken into account in the research. PSO was used to solve the optimization problem and find the best energy scheduler for load reliability (Idrissi et al., 2021). For smart home energy management, a real-time electricity scheduler that takes renewable energy sources and energy storage resources into account was created (Babu et al., 2021). The multi-objective optimization problem was resolved using GA. Prior to scheduling, it was assumed that loads would be forecasted for the next day. A hybrid Harmony Search-PSO algorithm was then used to optimize scheduling using a central controller, various loads, and a human-machine interface (Roy and Das, 2021).

The Light-learn controller, which is based on reinforcement learning, was presented and put into use in the study (Sang et al., 2022). It learned the user's behaviour and adjusted to controlling actions in accordance because of its adaptive nature. A bi-level deep reinforcement learning method for appliance scheduling was recently presented in research. Additionally, it included EV and energy storage charge and discharge schedules (Kathirgamanathan et al., 2020). The Dijkstra algorithm was used in (Dey et al., 2022) to solve a load scheduling problem. The simulation results are compared with those of GA, BPSO, and the Optimal Pattern Recognition Algorithm. The outcomes revealed a roughly 51% cost reduction. Systems for storing and producing renewable energy were also taken into account. Contributions soft computing based demand side management are summarized (Table 5).

6. Challenges of demand side management

The fundamental technologies needed to put DSM into practice have already been developed, and the concept itself is not new. But DSM's implementation has moved slowly. There exist several possible explanations, some of which might be unique to the DSM scheme and system in question. These might consist of:

6.1. Lacks of information technology

The lack of Information and Communication Technology (ICT) infrastructure poses a significant challenge to the effective implementation of demand-side management (DSM) strategies. In the context of energy consumption and efficiency, DSM relies heavily on real-time data collection, communication, and analysis to optimize energy usage patterns (Said, 2022b; Schott, 2021). However, in regions or industries where ICT infrastructure is deficient or inadequately developed, the seamless integration of smart technologies becomes a formidable task. Without robust communication networks and data processing capabilities, it becomes challenging to gather accurate information about energy demand patterns, consumer behavior, and other critical factors necessary for implementing effective DSM initiatives (Wen et al., 2022; Schott, 2021). A thorough evaluation of the advantages and disadvantages of putting in such a complex infrastructure is required. The argument for DSM would be much stronger if there was a dedication to its application.

Data Acquisition and Sensors: DSM relies heavily on real-time data from various sources such as smart meters, sensors, and IoT devices. These sensors measure parameters like electricity consumption, temperature, occupancy, and renewable energy generation. Technical details include the types of sensors used, communication protocols (e.g., Zigbee, LoRaWAN), and sampling rates.

Data Management Systems: IT systems manage the vast amounts of data collected from sensors. This includes databases for storage, data warehouses for historical analysis, and real-time data processing engines. Technical aspects encompass database architectures (e.g., relational, NoSQL), data replication strategies, and data compression techniques to optimize storage and processing efficiency.

Communication Networks: DSM requires robust communication networks to transmit data between devices and central control systems. Technical details involve the choice of communication technologies (e.g., wired, wireless, cellular), network topologies (e.g., star, mesh), and protocols (e.g., TCP/IP, MQTT) for reliable and secure data exchange.

Cyber security Measures: Protecting IT systems from cyber threats is

Table 5
Contributions soft computing based demand side management.

No.	Attempt	Method used	Contribution	Year	Reff
1.	Residential energy mangemnt	Fuzzy logic control	Improve efficiency by 45%, energy saving by1.25and reduce cost by 0.5%	2021	(Anthony et al., 2021)
2.	Load scheduling	Fuzzy logic control	Reduce the cost of electricity by $11.87 per day	2023	(Ibrahim et al., 2023)
3.	Energy management for micro-grid opperation	Fuzzy logic control	Save 3.7 kW of energy per month	2020	(Philipo et al., 2021)
4.	Energy management for smoothing grid power profile	Fuzzy logic control	Maximum power reduction: 11.4%	2021	(Arcos-Aviles et al., 2021)
5.	Multi-objective optimazation	Genetic algorithm	Reduced the cost by 41.46%	2023	(Babu et al., 2023)
6.	Energy managemnt based on GA for load scheduling	Genetic algorithm	Cost saving of 63.48% compared to the base	2023	(El Makroum et al., 2023)
7.	Energy consunmption management systen by load shifting	Genetic algorithm	Cost savings of 49.32% on electricity	2023	(Gheouany et al., 2023)
8.	Demand side managenet for residential. Commercial and industrial	Evolutionary computation	Reduce consumption by 8.2%. Reduce residential costs by 17.25%, commercial costs by 20.76%,and industrial costs by 21.15%	2019	(Gomathinayagam and Balasubramanian, 2019)
9.	Energy management for micro-grid operation	PSO	12% cost reduction	2019	(Hossain et al., 2019)
10.	Energy management	PSO	68% energy savings	2023	(Gao et al., 2023)

essential for ensuring the integrity and availability of DSM operations. Technical aspects involve implementing security measures such as encryption, authentication, access control, and intrusion detection/prevention systems.

6.2. Lack of understanding Demand side management solutions

The lack of understanding regarding the benefits of demand-side management (DSM) often stems from a limited perspective on the intricacies of energy consumption and distribution. Many individuals and businesses fail to recognize that DSM goes beyond mere energy conservation; it plays a pivotal role in enhancing grid reliability, reducing peak demand, and promoting sustainability (D'Ettorre et al., 2022; Kanakadhurga and Prabaharan, 2022). The nuanced benefits, such as lowering electricity costs through load shifting and optimizing energy use during non-peak hours, are frequently overlooked. Moreover, the potential for integrating renewable energy sources is often underestimated, as DSM enables the efficient incorporation of fluctuating renewable outputs into the grid. A lack of awareness regarding these multifaceted advantages hinders the widespread adoption of DSM, impeding progress toward a more resilient and environmentally friendly energy landscape.

A thorough evaluation of the technical, financial, and environmental performance of current and upcoming DSM programs is required (Batalla-Bejerano et al., 2022; Oskouei et al., 2022).

Demand side management (DSM) is a multifaceted approach aimed at influencing consumers' electricity consumption behaviors. It encompasses a range of strategies, including load shifting, energy efficiency programs, demand response initiatives, and distributed generation integration, all geared towards achieving a more balanced and efficient use of electricity resources. However, a prevalent lack of understanding of DSM often arises from several factors. Firstly, there's a misconception regarding the complexity and technical intricacies involved in implementing DSM measures, particularly among consumers who may not be familiar with energy systems or grid operations. Additionally, there's often a disconnect between the perceived benefits of DSM and the tangible outcomes experienced by consumers, leading to skepticism about its effectiveness in addressing energy challenges such as peak demand management and grid reliability.

6.3. Complexity of demand side management

Demand Side Management (DSM) is intricately complex due to the convergence of various factors. Coordinating the diverse energy needs and behavioral patterns of a broad spectrum of consumers presents a challenge, requiring nuanced strategies for effective demand response. The integration of advanced technologies, such as smart grids and meters, introduces technical intricacies that demand seamless interoperability and real-time data management (Dey et al., 2023b; Ponce et al., 2023). Regulatory frameworks and policy incentives further compound the complexity, necessitating a delicate balance between encouraging participation, ensuring fair compensation, and maintaining grid reliability. The dynamic nature of energy markets, coupled with the increasing prominence of renewable sources, introduces uncertainty that must be navigated with sophisticated algorithms and predictive models (Golmohamadi, 2022). In essence, the complexity of DSM lies in the intricate interplay of technological, regulatory, and market-driven variables, requiring a comprehensive and adaptive approach for successful implementation.

Demand side management (DSM) is inherently complex due to its multifaceted nature and the diverse array of factors that influence electricity consumption patterns. At its core, DSM involves orchestrating the interaction between energy users, utility providers, regulators, and technological systems to achieve specific energy management goals. One aspect of this complexity arises from the dynamic nature of electricity demand, which can vary significantly based on factors such as time of day, seasonality, weather conditions, and economic activity.

6.4. Lacks market structure and encouragements

The absence of a well-defined market structure poses significant challenges for economic actors and stakeholders. Without clear market frameworks, it becomes difficult for participants to anticipate and respond to changing conditions, leading to inefficiencies and a lack of coordination. Market structure provides the foundation for fair competition, price discovery, and resource allocation. In the absence of such a structure, market participants may face ambiguity regarding rules, regulations, and property rights, hindering their ability to make informed decisions (Benetton, 2021; Kurpjuweit et al., 2021). This lack of clarity can deter investments, stifle innovation, and create an environment prone to monopolistic practices, ultimately impeding overall economic growth and development.

Furthermore, inadequate incentives within a market can exacerbate existing issues and impede optimal resource allocation. Incentives are crucial in guiding the behavior of economic agents, encouraging efficiency, and fostering innovation. When incentives are lacking or misaligned, economic actors may prioritize short-term gains over long-term sustainability, leading to suboptimal outcomes (Nkwae, 2023). For instance, a failure to reward environmentally friendly practices or penalize harmful ones can result in environmental degradation. Similarly, if incentives for fair competition are absent, monopolies or oligopolies may emerge, distorting market dynamics and reducing consumer welfare. A robust market system requires well-designed incentives that promote competition, innovation, and the efficient allocation of resources.

6.5. Prospective of demand side management

This review highlights the recent advances and intelligent aspects of energy management systems for residential, commercial, and industrial consumers. Therefore, the aim of this review is to provide valuable understanding and insights for researchers, students, and experts to increase innovation in energy management systems for efficient use of energy. Despite recent significant progress, there are still a lot of issues that need to be resolved. The problems with energy management for residential, commercial, and industrial consumers are resistance from consumers, a lack of awareness, technological barriers, and initial costs and investments. However, most of these are closely related to the understanding and relevance of energy management systems. Communication technology is the key component in smart energy management systems, which improves the performance of grids and micro-grids in terms of cost and energy savings. An integrated energy management system gets high consideration. Due to being highly efficient, environmentally friendly, and keeping consumers comfortable.

As technological advancements continue to facilitate the integration of smart grids, smart meters, and home automation systems, DSM presents an opportunity to enhance energy efficiency, reduce peak demand, and mitigate stress on the grid (El Gohary et al., 2023; Mäkivierikko et al., 2023). By empowering consumers with real-time information and incentives, DSM can promote a more sustainable and resilient energy ecosystem. The potential for load shifting, demand response programs, and the integration of renewable energy sources aligns with the broader goals of achieving energy sustainability and addressing climate change. As DSM gains traction, it not only offers economic benefits through cost savings and improved grid reliability but also contributes to a more environmentally conscious and adaptive energy infrastructure (Pallathadka et al., 2023; Cortez et al., 2023). The prospective success of DSM lies in collaborative efforts among stakeholders, effective regulatory frameworks, and ongoing innovation in energy management technologies.

7. Conclusion

Intelligent energy management leads to improved power system reliability, cost-effectiveness, and stability. Increasing the efficiency of the power system using traditional methods is difficult. To ensure power system performance, it is crucial to address the issue of low efficiency by intelligently integrating energy sources or functional smart grids. There are still challenges for power systems in various application scenarios from the perspective of practical implementation. Enhancing reliability and cost-effectiveness is the primary goal of research on demand-side-based energy management. Demand-side energy management is highly efficient. Using traditional energy management systems, it is challenging to enhance power system performance. To ensure power system performance, it is crucial to address the issue of low-performance power systems by intelligently integrating energy sources or functional smart grids. Energy management systems still face challenges in various application scenarios from a practical standpoint. Better real-time control systems are required for power systems. An intelligent energy management system requires flexible loads and sufficient power output to meet consumer demands. Therefore, additional study is needed to improve the electrical efficiency of power systems. Energy management techniques should not limit the development of energy management systems. On the other hand, increasing the power system reliability of renewable energy using existing studies to reduce the intermittent nature of renewable energy sources is difficult. Thus, integrating them with other renewable energy sources to enhance supply reliability can still be pursued as a research direction for future studies.

Ethical approval

Not Applicable

CRediT authorship contribution statement

Abraham Hizkiel Nebey: Writing – original draft, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

This is to certify that the manuscript entitled “Recent advancement in demand side energy management system for optimal energy Utilization” submitted to this journal is a record of original work. All sources of materials used for the manuscript has been clearly stated and attributed. I declare that there is no conflict of interest in this submission.

Data availability

No data was used for the research described in the article.

Acknowledgment

I would like to thank electrical and computer Engineering, Bahir Dar institute of technology, and Bahir Dar university for their support to this work successfully.

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