Analysis of Different Control Approaches for a Local Microgrid: A Comparative Study

Abrarul Haque [1], Ibrahim Kholilullah [2], Anik Sharma [3], Ashif Mohammad [4], Saidul Islam Khan [5,*]
[1] Department of Electronic Information, Hubei University of Automotive Technology, China
[2] School of Energy and Electrical Engineering, Chang'an University, China
[3] Electrical and Electronics Engineering, Acharya Institute of Technology, India
[4] Renewable Energy Technology, University of Dhaka, Bangladesh
[5] Mechanical Engineering, Hubei University of Automotive Technology, China
Email: [1] abrarulhaque403@gmail.com, [2] ibrahim.supto@gmail.com, [3] aniksharma0078@gmail.com, [4] asif028628@gmail.com, [5] khansaidulislam2000@gmail.com
*Corresponding Author

***Abstract*—An analysis that contrasts various methods for managing a microgrid's operations in a community context is known as comparison research on control strategies for community microgrids. The study's objectives are to evaluate the benefits and drawbacks of various control schemes and to pinpoint the best approach for enhancing the microgrid's performance. Control methods include islanded mode control, hybrid mode control, grid-connected mode control, and advanced control strategies that combine economic dispatch with optimum power flow are usually compared in the research. A comparison is established. Depending on elements including resilience, cost-effectiveness, efficiency, stability and dependability. The comparative study's findings shed light on the optimal control approach for a particular community microgrid taking into account the resources that are available, the local energy consumption, and other variables. This review also emphasizes the advantages of using advanced control systems, these systems maximize energy management, maintain grid stability, and improve overall system performance by controlling the intricate interactions among distributed energy resources (DERs), such as solar photovoltaics, wind turbines, energy storage, and conventional generators. Energy efficiency will be increase in rural locations with high solar radiation and limited wind power by using advanced methods and grid-connected mode management. Demand response reduces dependency on external grids and associated expenses while improving resilience. Customized control strategies are essential for maximizing community microgrid performance. There includes discussion of a number of control systems, including distributed control, grid-forming control, energy management and optimization, frequency and voltage regulation, islanded operation, and demand response.**

***Keywords*—Microgrid, Community Microgrid, Control Strategies, Grid Connected Mode Control, Islanded Mode Control, Centralized Control, Decentralized Control**

I. INTRODUCTION

A community microgrid is an autonomous energy network that incorporates power generation, energy storage, and energy management components to serve the needs of a nearby community [1]. Community microgrid is a collection of distributed energy resources (DERs) and consumers in a designated electrical region that may autonomously disconnect from and reconnect to the main grid [2]. A community microgrid's primary goal is to reduce a community's reliance on the main grid while supplying a dependable and sustainable energy supply. Depending on the availability of power from the main grid, a community microgrid can operate in either an isolated mode or a mode that is connected to the main grid. When in island mode, the microgrid runs independently from the main grid and supplies all of the energy it needs from its own local resources [2]. The microgrid can draw power from the main grid when necessary while it is operating in grid-connected mode. Community microgrids can include various types of power generation resources such as solar panels, wind turbines, biomass, vibration energy and diesel generators [3]. Where, one dependable way to help sensor nodes in distant areas that are experiencing an energy shortage is using vibration energy sources. The society and upcoming researchers are fortunate to have access to vibration energy harvesting [4]. Energy storage systems, such as batteries and flywheels, are also incorporated to store excess energy and provide backup power during outages.

Advanced control strategies, such as optimal power flow and economic dispatch, can be used to optimize the operation of the community microgrid, ensuring that it operates in the most efficient and cost-effective manner. The use of community microgrids can improve the reliability and sustainability of the energy supply for the community, while also reducing dependence on the main grid [5]. A comparative study on various control strategies for community micro-grid is an analysis that aims to compare and evaluate different techniques for controlling the operations of a micro-grid in a community setting [6]. With the increasing use of micro-grids for decentralizing the energy supply, it is important to determine the best control strategy for optimizing the performance of these systems.

The primary aim of this comparative study is to assess various control strategies for community micro-grids, including islanded mode control, grid-connected mode control, hybrid mode control, and advanced control strategies that incorporate optimization techniques like optimal power flow and economic dispatch. The comparison is made based on factors such as stability, reliability, efficiency, cost-effectiveness, and resilience.

The objective of this research is to evaluate and compare different control systems designed for community microgrids, with a particular emphasis on resilience, cost-effectiveness, efficiency, stability, and dependability as important assessment factors. The research will examine distributed, decentralized, and centralized control strategies and evaluate how well they work in various operational contexts. The study aims to provide insights into the best design and operation of community microgrids, thereby advancing resilient and sustainable local energy infrastructure. It does this by looking at factors like steady-state operation, response to disturbances, energy efficiency, economic viability, and resilience to disruptions. This introduction serves as a foundation for the detailed analysis and comparison of the various control strategies for community micro-grids, and provides a roadmap for the rest of the study. Various control strategies can contribute to the successful operation of a community micro-grid by optimizing power generation, storage, and distribution. Some key strategies include:

- Centralized control: A centralized control system manages the generation and distribution of power within the micro-grid, which enables it to balance supply and demand and ensure the reliability and stability of the system [7].
- Decentralized control: Decentralized control allows individual units in the micro-grid to operate autonomously, which can improve flexibility, efficiency, and resilience [8].
- Demand-side management: Demand-side management strategies can help to reduce energy consumption during peak demand periods, which can help to lower costs and improve system reliability [9].
- Energy storage management: Energy storage systems can be used to balance supply and demand, provide backup power, and increase the use of renewable energy sources [10].

Renewable energy management: Community micro-grids can be designed to incorporate a variety of renewable energy sources, including solar, wind, and biomass, which can help to reduce greenhouse gas emissions and increase energy independence [11].

In this paper, we will address a variety of control techniques for overseeing community microgrid operations. We will compare and contrast different approaches such advanced control techniques, hybrid mode control, islanded mode control, and grid-connected mode control. We will compare and contrast these approaches using resilience, affordability, efficacy, stability, and dependability as our evaluation criteria in order to determine which is the best way to improve microgrid performance in certain community settings.

II. Control System for Microgrid

From the perspective of the client, a microgrid is a grid system that provides dependable, independent, and high-quality electricity. In order to construct a stable frequency and voltage controlling microgrid system, it is difficult to coordinate various micropower kinds, claims in [12]. The microgrid control goals include: (a) independent regulation of active and reactive power; (b) correction of voltage sag and system imbalances; and (c) meeting the grid's load dynamics needs. Power systems require appropriate control strategies in order to ensure proper operation. Micro source and load controllers, a central controller for the microgrid, and a distribution management system make up the microgrid control. Community microgrids have the ability to increase resilience during power outages, boost local economic development, and reduce the need for costly system upgrades [13]. The upstream network interface, microgrid control, and protection and local control make up the three parts of the function of microgrid control. Numerous research evaluates microgrid control, which can be categorized according on the Fig. 1. tree diagram. The research that were found in the literature served as the basis for this classification [14].

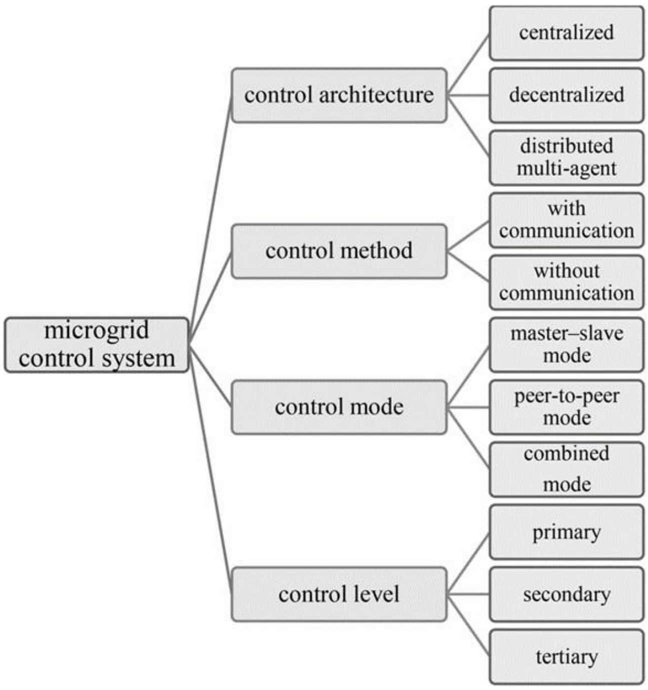

Fig. 1. Structure of microgrid control method

A control system for a microgrid is responsible for managing the power generation, storage, and distribution within the microgrid [15]. It involves a set of hardware and software components that work together to ensure that the microgrid operates reliably, efficiently, and safely. Some key components of a microgrid control system include:

- Power management system (PMS): The PMS is the brain of the microgrid control system, responsible for monitoring and controlling the power generation and distribution. It ensures that the microgrid operates optimally, by balancing supply and demand, and coordinating the use of different power sources [16].
- Energy storage system (ESS) management: The ESS management system ensures that the energy storage system is charged and discharged in the most efficient way. It controls the charging and discharging of the batteries or other storage devices, and determines the best times to store or release energy [17].
- Distributed energy resource management: The DER management system is responsible for monitoring and controlling the power output of each individual power source in the microgrid, such as solar panels, wind turbines, or diesel generators. It ensures that each source is used optimally and that the microgrid remains stable [18].

- Demand-side management (DSM): The DSM system is responsible for managing the power demand within the microgrid [19]. It can include strategies such as load shedding, time-of-use pricing, and energy efficiency measures, to help balance supply and demand and reduce energy costs.
- Communication network: The communication network connects the different components of the microgrid control system and allows them to communicate and exchange data [20]. It can be wired or wireless, and may use different protocols depending on the specific components being used.

III. Tyeps of Control Strategies for Community Micro-Grid

A localized collection of energy sources with the ability to function independently of the main power grid is known as a community microgrid. Usually, it provides services to a limited community, such as a hospital, academic campus, or neighborhood. A community microgrid's power sources are often a mix of battery storage and renewable energy sources, such as solar and wind power.

A. Islanded Mode Control

In this mode, the microgrid operates independently from the main grid and relies on its local resources for power generation and distribution [21]. The control strategy focuses on balancing the power demand and supply within the microgrid. In islanded mode, the microgrid. operates as a standalone system, and the control strategy focuses on maintaining the balance between power generation and demand shown in Fig. 2. This mode requires a fast and reliable control system to handle the dynamic changes in power demand and supply and prevent any power disruptions. Islanded mode control strategies include load shedding, generator management, and voltage and frequency control.

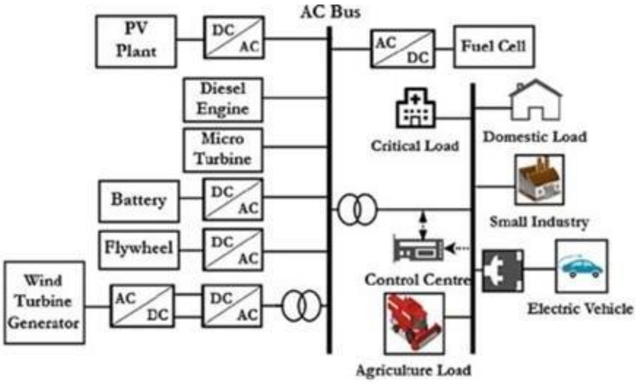

Fig. 2. Generalized schematic of a community Micro-Grid in islanded mode

B. Grid-Connected mode control

In this mode, the microgrid is connected to the main grid and can receive power from or feed power back to the grid. The control strategy focuses on optimizing the use of local resources and minimizing the cost of power generation. In grid-connected mode, the microgrid can receive power from the main grid and feed excess power back to it [22]. The control strategy in this mode focuses on minimizing the cost of power generation and maximizing the use of local resources. This mode requires coordination between the microgrid and the main grid to ensure a stable power flow and prevent any power disruptions. Grid-connected mode control strategies include active power management, reactive power management, and voltage control.

C. Hybrid Mode Control

In this mode, the microgrid can switch between islanded and grid-connected modes. The control strategy focuses on maximizing the use of local resources while ensuring the reliability of power supply [23]. Hybrid mode allows the microgrid to switch between islanded and grid-connected modes. The control strategy in this mode focuses on ensuring reliable power supply while maximizing the use of local resources. This mode requires a fast and flexible control system that can quickly switch between modes and coordinate with the main grid. Hybrid mode control strategies include automatic mode switching, power management, and voltage and frequency control.

D. Advanced Control Strategies

These are more sophisticated control strategies that utilize advanced algorithms and technologies to optimize the operation of the microgrid [24]. They include optimal power flow, real-time monitoring and control, demand response, and energy storage management. Advanced control strategies utilize advanced algorithms and technologies to optimize the operation of the microgrid. They include optimal power flow, which determines the optimal power generation and distribution configuration to minimize costs and improve efficiency. Real-time monitoring and control systems allow for real-time monitoring and adjustment of the microgrid operation. Demand response systems adjust power generation and consumption based on changes in demand. Energy storage management optimizes the use of energy storage systems to improve the efficiency and reliability of the microgrid.

IV. Islanded Mode Control of Community Microgrid

Islanded mode control of a community microgrid refers to the control strategies that are used to manage the power generation and distribution of a microgrid when it operates independently from the main grid [25]. Energy can be salvaged from a wide range of sources, such as solar energy, ocean waves, piezoelectricity, thermoelectricity, and mechanical vibrations. Some systems, for instance, transform random vibrations into useful electrical energy that wireless sensor nodes can employ for independent operation. Energy collecting sources should be chosen based on the application [26]. The primary objective of islanded mode control is to maintain the balance between power generation and demand within the community. Here are some key aspects of islanded mode control in a community microgrid:

- Load management: Load management strategies are used to match the power generation with the power demand within the community [27]. Load management strategies can include load shedding, where non- essential loads are temporarily disconnected, and load shifting, where loads are shifted from peak to off-peak times to reduce demand.
- Generator management: Generator management strategies control the operation of the local power

generators in the community microgrid [28]. These strategies optimize the use of the local power generators and ensure that they provide the power needed to meet the demand.

- Voltage and frequency control: Voltage and frequency control strategies ensure that the voltage and frequency levels within the community microgrid are within acceptable limits [29]. These strategies help to prevent power disruptions and maintain the stability of the microgrid.
- Energy storage management: Energy storage systems, such as batteries, can be used to store excess power generated by the local power generators [30]. Energy storage management strategies optimize the use of these systems to improve the efficiency and reliability of the microgrid.

Islanded mode control is critical for the stability and reliability of a community microgrid [31], as it ensures that the power demand and supply are balanced and that the microgrid can continue to provide power to the community even in the absence of a connection to the main grid. In islanded mode, the community microgrid operates as a standalone system, disconnected from the main grid. In this mode, the microgrid relies on its own power generation and energy storage resources to meet the energy demand of the community. The islanded mode control of a community microgrid typically involves the following steps:

- Load Monitoring: The microgrid continuously monitors the energy demand of the community [32].
- Power Management: Based on the load monitoring, the microgrid adjusts the power generation of its local resources (e.g., generators, energy storage systems) to meet the energy demand.
- Voltage and Frequency Control: The microgrid regulates the voltage and frequency of the power supplied to the community to maintain stability and ensure that the power quality meets the standards.
- Automatic Mode Switching: In case of a power failure or if the local resources are unable to meet the energy demand, the microgrid automatically switches to grid-connected mode and starts drawing power from the main grid.

These steps are repeated continuously to ensure the reliability and stability of the microgrid in islanded mode. By operating in islanded mode, the community microgrid can provide reliable and stable power to the community even in the absence of connection to the main grid.

V. Grid-Connected Mode Control of Community Microgrid

Grid-connected mode control of a community microgrid refers to the control strategies that are used to manage the power generation and distribution of a microgrid when it is connected to the main grid. The primary objective of grid-connected mode control is to minimize the cost of power generation and distribution while ensuring a stable and reliable power supply [29]. Microgrids are seen as a way to increase the use of renewable energy sources while improving the resilience and reliability of the electrical grid. Microgrids provide a lot of benefits, but if they are to be effectively developed and extensively deployed, a lot of challenges and limitations must be addressed [33]. Distinction between islanded mode and grid-connected mode shown in Table 1. Here are some key aspects of grid-connected mode control in a community microgrid:

- Active power management: Active power management strategies control the active power flow between the community microgrid and the main grid [34]. These strategies optimize the use of local power generators and energy storage systems, and minimize the amount of power that needs to be purchased from the main grid.
- Reactive power management: Reactive power management strategies control the reactive power flow between the community microgrid and the main grid [35]. Reactive power is required to maintain the stability of the power grid and can affect the efficiency of power generation and distribution. Reactive power management strategies optimize the use of reactive power to improve the efficiency of the microgrid.
- Voltage control: Voltage control strategies regulate the voltage level within the community microgrid and ensure that it remains within acceptable limits [36]. These strategies help to prevent power disruptions and maintain the stability of the microgrid.
- Coordination with the main grid: Grid-connected mode control requires coordination between the community microgrid and the main grid [37]. This coordination ensures a stable power flow and prevents any power disruptions. Coordination strategies can include real-time monitoring of the power flow and automatic mode switching between grid-connected and islanded modes.

Here's a high-level description of the flow diagram of grid-connected mode control of a community microgrid:

- Load Monitoring: The microgrid continuously monitors the energy demand of the community [38].
- Power Management: Based on the load monitoring, the microgrid adjusts the power generation of its local resources (e.g., generators, energy storage systems) to meet the energy demand while also drawing power from the main grid.
- Voltage and Frequency Control: The microgrid regulates the voltage and frequency of the power supplied to the community to maintain stability and ensure that the power quality meets the standards.
- Coordination with Main Grid: The microgrid communicates with the main grid to exchange information about the power generation and energy storage resources [39]. This coordination ensures that the microgrid is able to take advantage of excess power from the main grid and also supply surplus power back to the main grid when needed.
- Automatic Mode Switching**:** In case of a power failure in the main grid, the microgrid automatically switches to islanded mode and continues to provide power to the community using its own resources.

VI. Hybrid Mode Control of Community Microgrid

Hybrid mode control of a community microgrid refers to the control strategies that are used to manage the power generation and distribution of a microgrid when it can operate both in an islanded mode and a grid- connected mode [40].

The primary objective of hybrid mode control is to ensure a reliable power supply while maximizing the use of local resources. Here are some key aspects of hybrid mode control in a community microgrid:

- Automatic mode switching: Hybrid mode control requires a fast and flexible control system that can quickly switch between grid-connected and islanded modes. Automatic mode switching strategies are used to determine the optimal mode of operation based on the availability of local power generators and energy storage systems, and the status of the main grid [41].
- Power management: Power management strategies control the power flow between the community microgrid, local power generators, energy storage systems, and the main grid [42]. These strategies optimize the use of local resources and ensure that the power demand and supply are balanced.
- Voltage and frequency control: Voltage and frequency control strategies ensure that the voltage and frequency levels within the community microgrid are within acceptable limits. These strategies help to prevent power disruptions and maintain the stability of the microgrid.
- Coordination with the main grid: Hybrid mode control requires coordination between the community microgrid and the main grid. This coordination ensures a stable power flow and prevents any power disruptions. Coordination strategies can include real-time monitoring of the power flow and automatic mode switching between grid-connected and islanded modes.

Table 1. Distinction between islanded mode and grid-connected mode

Grid-Connected Mode Control	Island Mode Control
Connects to the main electrical grid.	Operations without reliance on the main power grid.
Generates energy from the grid and from nearby sources.	Depends only on locally produced and stored energy.
Depends on the main grid for backup power.	Increases resiliency via independent operation.
Rather difficult to maintain.	Advanced control algorithms are necessary.
Dependent on external grid for backup.	Depends on internal resources for creation and storage.

Hybrid mode control is important for the reliability and flexibility of a community microgrid, as it enables the use of both local and external power sources and allows for seamless switching between modes in response to changes in the power system. This results in a more reliable and resilient power supply for the community. Here's a high-level description of the flow diagram of hybrid mode control of a community microgrid:

- Load Monitoring: The microgrid continuously monitors the energy demand of the community.
- Power Management: Based on the load monitoring, the microgrid adjusts the power generation of its local resources (e.g., generators, energy storage systems) to meet the energy demand while also drawing power from the main grid.
- Voltage and Frequency Control: The microgrid regulates the voltage and frequency of the power supplied to the community to maintain stability and ensure that the power quality meets the standards.
- Coordination with Main Grid: The microgrid communicates with the main grid to exchange information about the power generation and energy storage resources. This coordination ensures that the microgrid is able to take advantage of excess power from the main grid and also supply surplus power back to the main grid when needed.
- Automatic Mode Switching: The microgrid can automatically switch between islanded mode and grid-connected mode depending on the availability of power from the main grid and the power generation and energy storage resources of the microgrid.

These steps are repeated continuously to ensure the reliability and stability of the microgrid in hybrid mode. By operating in hybrid mode, the community microgrid can take advantage of the stability and reliability of the main grid while also utilizing its own resources to meet the energy demand of the community, ensuring greater flexibility and resilience.

VII. Advanced Control Strategies of Community Microgrid

Advanced control strategies for a community microgrid refer to innovative and sophisticated methods for managing the power generation and distribution of the microgrid [43]. These strategies are designed to improve the reliability, efficiency, and flexibility of the microgrid and to support the integration of renewable energy sources. Some advanced control strategies for community microgrids include:

- Distributed Energy Resource Management System (DERMS): DERMS is a centralized control system that manages the power generation and distribution of a community microgrid [44]. DERMS uses real-time data to optimize the use of local power generators, energy storage systems, and other distributed energy resources.
- Optimal Power Flow (OPF) Control: OPF control uses mathematical optimization techniques to determine the optimal power flow within the community microgrid [45]. OPF control maximizes the use of local resources and minimizes the cost of power generation and distribution.
- Model Predictive Control (MPC): MPC is a control strategy that uses mathematical models of the power system to predict future conditions and optimize the control decisions. MPC is used to optimize the operation of the community microgrid and to support the integration of renewable energy sources.
- Artificial Intelligence (AI) and Machine Learning (ML) based control: AI and ML can be used to optimize the control of a community microgrid [46]. AI and ML algorithms can analyze real-time data and make predictions about future conditions. These predictions can be used to improve the operation of the microgrid and support the integration of renewable energy sources.
- Real-time monitoring and fault detection: Real-time monitoring and fault detection strategies use sensors and communication systems to monitor the power generation and distribution of the community microgrid [47]. These strategies can detect faults in real-time and trigger corrective actions to maintain the stability of the microgrid. These advanced control strategies are critical for the future of community microgrids, as they enable the

integration of renewable energy sources, improve the reliability and efficiency of the microgrid, and support the transition to a more sustainable energy system.

Here's a high-level description of the flow diagram of advanced control strategies of a community microgrid:

- Load Monitoring: The microgrid continuously monitors the energy demand of the community.
- Power Management: Based on the load monitoring, the microgrid adjusts the power generation of its local resources (e.g., generators, energy storage systems) to meet the energy demand while also drawing power from the main grid.
- Voltage and Frequency Control: The microgrid regulates the voltage and frequency of the power supplied to the community to maintain stability and ensure that the power quality meets the standards.
- Coordination with Main Grid: The microgrid communicates with the main grid to exchange information about the power generation and energy storage resources. This coordination ensures that the microgrid is able to take advantage of excess power from the main grid and also supply surplus power back to the main grid when needed.
- Optimization of Power Management: Advanced control strategies such as optimal power flow (OPF), economic dispatch, and energy management systems (EMS) are used to optimize the power management of the microgrid. These strategies consider factors such as the cost of energy, the availability of resources, and the energy demand to ensure that the microgrid is able to meet the energy demand in the most efficient and cost-effective manner.
- Automatic Mode Switching: The microgrid can automatically switch between islanded mode and grid-connected mode depending on the availability of power from the main grid and the power generation and energy storage resources of the microgrid [48].

These steps are repeated continuously to ensure the reliability and stability of the microgrid with advanced control strategies. By utilizing advanced control strategies, the community microgrid can improve the efficiency and cost-effectiveness of its operations while also ensuring greater flexibility and resilience. Comparative table of Various control strategies of microgrid shown in Table 2.

"✔" indicates that the control strategy is applicable to the corresponding mode of microgrid operation.

"✘" indicates that the control strategy is not applicable to the corresponding mode of microgrid operation.

VIII. Result and Discussion

Important insights are revealed by contrasting island mode control versus grid-connected mode control in community microgrids. Grid-connected mode provides flexibility by providing access to both main grid power and local grid power, enabling income production and backup assistance. It is susceptible to grid breakdowns, however. On the other hand, island mode, which depends only on local resources to maintain self-sufficiency during outages, has difficulties with stability and regulation. Grid-connected mode contributes to overall grid stability, although both modes need sophisticated algorithms for stability. The decision is based on a number of variables, including scalability, robustness, and affordability. Hybrid approaches might provide customized ways to successfully strike a balance between flexibility and resilience.

Table 2. Comparative table of various control strategies of microgrid

Control Strategy	Islanded Mode	Grid-Connected Mode	Hybrid Mode	Advanced Control
Automatic Mode Switching [49]	✔	✔	✔	✔
Power Management [50]	✔	✔	✔	✔
Voltage and Frequency Control [51]	✔	✔	✔	✔
Coordination with Main Grid [52]	✘	✔	✔	✔
Distributed Energy Resource Management System (DERMS) [53]	✘	✘	✘	✔
Optimal Power Flow (OPF) Control [54]	✘	✘	✘	✔
Model Predictive Control (MPC) [55]	✘	✘	✘	✔
Artificial Intelligence (AI) and Machine Learning (ML) based control [56]	✘	✘	✘	✔
Real-time Monitoring and Fault Detection [57]	✘	✘	✘	✔

A comparative study on various control strategies for community micro-grids can provide valuable insights into the strengths and weaknesses of each approach [58]. This type of study typically involves the simulation or experimentation of different control strategies under various conditions and comparing the results in terms of performance metrics such as energy efficiency, reliability, and stability. One of the key findings of such a study could be the trade-off between centralization and decentralization in microgrid control [59]. While centralized control can ensure coordinated and efficient operation of energy resources, it may not be feasible for large-scale microgrids with multiple energy sources. On the other hand, decentralized control can provide local control and flexibility but may not be able to coordinate the operation of all resources effectively. The choice of control strategy will depend on the specific objectives and requirements of each microgrid.

Another important aspect to consider is the integration of the microgrid with the main grid. In the event of a power outage, the microgrid may need to disconnect from the main grid and operate in island mode. In such scenarios, the control strategy should ensure that the microgrid can operate reliably and securely in island mode. In brief, a comparative study on control strategies for community micro-grids can provide valuable insights into the various trade-offs and challenges involved in microgrid control. The results of such a study can inform the development of new and improved control strategies for community micro-grids and help to advance the field of microgrid research.

Another important aspect to consider in a comparative study of control strategies for community micro-grids is the scalability of each approach. As the size and complexity of the microgrid increase, the control strategy should be able to accommodate these changes without compromising its performance. For example, a control strategy that is effective for a small-scale microgrid may not be suitable for a large-scale microgrid with multiple energy sources and complex network configurations. Another important factor to consider is the level of user interaction and control over the microgrid [60]. In some cases, community members may want to have a greater level of control over the microgrid and its operations.

In such scenarios, a control strategy that provides greater user control and participation may be more appropriate. It is also important to consider the economic feasibility of each control strategy. The cost of implementing and maintaining the control system should be balanced against the benefits it provides in terms of energy efficiency and reliability. The choice of control strategy should also take into account any regulatory or policy constraints that may impact the microgrid's operation and performance [61]. A comparative study on control strategies for community micro-grids should consider a range of factors including scalability, user interaction and control, economic feasibility, and regulatory constraints. By evaluating these factors, the study can provide valuable insights into the most appropriate control strategies for different types of community micro-grids [62].

IX. Challenges and Future Scope

Here are some challenges:

- Availability and Quality of Data: It might be difficult to get accurate information on energy production, consumption, and system performance from a variety of sources. The accuracy and dependability of the analysis may be impacted by variations in the consistency and quality of the data.
- Complexity of control strategies: Control theory and power systems engineering knowledge are essential for comprehending and contrasting different control techniques, each of which has its own algorithms and operational needs. It might be difficult to analyze the details of these strategies and how they combine.
- Limitations on Resources: Limited resources, such as money, time, and experience, might limit the comparative study's breadth and depth. Achieving significant achievements within resource limits requires striking a balance between the need of in-depth investigation and realistic constraints.

Further research might concentrate on creating more complex control algorithms that are suited to the features of microgrids, including cutting-edge technologies like demand response and enhanced energy storage, and strengthening cybersecurity and resilience against attacks. Subsequent research endeavors may dive into optimization methodologies, corroborate outcomes via pragmatic experiments, and investigate the consequences of policy and regulatory structures. Future research endeavors to enhance energy resilience, optimize microgrid operations, and ease the shift to more sustainable energy systems by tackling these domains.

X. Conclusion

In conclusion, the choice of control strategy for a community microgrid will depend on several factors such as the size of the microgrid, the type of energy sources utilized, the level of integration with the main grid, and the specific objectives of the microgrid. Some of the commonly used control strategies for community microgrids include centralised control, decentralised control, hybrid control, and market-based control. Each of these strategies has its own advantages and disadvantages, and the appropriate choice will depend on the unique requirements of each microgrid. It is important to note that the implementation of a control strategy also requires careful consideration of technical, economic, and regulatory aspects. Centralized control is characterized by the use of a single central entity to control and coordinate all the energy resources within a microgrid. This type of control strategy is suitable for small-scale microgrids with a limited number of energy resources. Decentralized control, on the other hand, allows each energy resource to operate independently and make decisions based on local information. This type of control strategy is suitable for larger microgrids with multiple energy resources.

Hybrid control combines aspects of both centralized and decentralized control strategies and is a suitable option for microgrids that require a balance between centralized coordination and local control. It is important to note that the implementation of a control strategy also requires the integration of various technologies such as communication systems, energy management systems, and control algorithms. The control strategy should also be flexible enough to adapt to changing conditions and evolving energy demands within the microgrid. Grid-connected mode control allows for operational flexibility by providing access to the main grid and local generation, which may be used for revenue production and backup support. It is susceptible to grid outages, nevertheless, because of its dependence on outside resources. Conversely, island mode control operates independently, depending only on local production and storage, demonstrating its ability to promote self-sufficiency during grid disruptions. Island mode control has advantages such as reduced operating costs and increased resilience, but it also has drawbacks like stability management and regulatory compliance.

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