# ASSESSMENT OF SUITABLE ENERGY MANAGEMENT SYSTEM FOR RESIDENTIAL BUILDINGS: A DELPHI STUDY

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**Abstract.** Improving energy efficiency in residential buildings has become a critical priority for reducing operational costs and achieving sustainability targets, particularly in developing countries where energy demand continues to increase. However, selecting a suitable energy management system (EMS) remains challenging due to fragmented decision criteria, limited technical awareness among property stakeholders, and the absence of context-specific evaluation frameworks. The study aims to evaluate the most effective energy management systems for residential buildings in the South African context, as determined by experts. This study adopted a quantitative research method. Quantitative data were collected through a research questionnaire administered to 20 Delphi experts. The received data were analyzed using descriptive methods. The study found that the main suitable energy management systems for residential buildings consist of HVAC control systems, Solar panel systems, Smart plugs and outlets, Energy monitors and meters, Battery energy storage systems (BESS), and building energy management systems (BEMS). The study further found that Home Energy Management Systems (HEMS), LED Lighting Systems, Home automation systems (such as smart home hubs), Smart thermostats, Smart grid energy management systems (SGEMS), and Load controllers are suitable for energy management in residential buildings. The study focuses solely on residential buildings in South Africa. The findings may not be generalizable to other countries or regions with differing energy policies, climates, or building standards. The practical implications of the study include providing policymakers and developers with validated recommendations for implementing energy management systems that enhance energy efficiency and sustainability in residential settings. The value of the paper lies in its contribution towards identifying and advocating for effective energy management solutions tailored to South African residential buildings, thereby promoting sustainable energy practices and addressing energy challenges in the region.

**Keywords.** *Energy management system, Residential buildings, Energy saving, Sustainability, Energy Consumption, Energy efficiency*

## 1. Introduction

The energy terrain in South Africa exhibits an intricate interplay of challenges and opportunities, shaped by rapid urbanization, industrial expansion, and socio-economic inequalities (Nguyen et al., 2024). Due to a rapidly growing population and an expanding residential sector, the energy demand is increasing significantly. This is putting pressure on the country's ageing infrastructure and worsening supply reliability. The affordability issue remains a significant problem, especially for those on low incomes, as power prices are rising faster than incomes (Bird & Hernández, 2012). This situation is resulting in energy poverty and contributing to social inequality. In addition, South Africa faces environmental challenges, including significant carbon emissions from coal-fired power plants

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and the need to shift to cleaner, more sustainable energy sources to reduce the effects of climate change. Policymakers and stakeholders face a challenging task in balancing energy security, affordability, and environmental sustainability. This requires developing new solutions and collaborating to create a more resilient and fair energy future. This study will focus on the Energy Management System (EMS) in the residential sector, which controls and monitors households' energy usage.

Conducting research on appropriate EMS for residential buildings in South Africa is of utmost importance for several compelling reasons. First and foremost, due to rapid urbanization and population growth, household energy consumption has increased significantly (Madlener & Sunak, 2011). This surge in energy usage is putting considerable pressure on the national energy infrastructure and worsening concerns over energy security and dependability. By implementing a highly effective EMS specifically designed for the South African environment, it is possible to address these challenges by optimizing energy use, minimizing peak demand, and fostering a more reliable and robust energy supply (Ahmad et al., 2022). Furthermore, given the nation's socio-economic gaps, it is crucial to prioritize improving energy affordability to enhance the overall quality of life for all inhabitants. An EMS that prioritizes energy efficiency and cost-effectiveness can reduce the financial strain of high-power bills, especially for low-income families. This, in turn, can help reduce poverty and promote social fairness. Ultimately, South Africa can reduce its carbon footprint, mitigate environmental degradation, and support global efforts to combat climate change by adopting cleaner, more sustainable energy practices, such as integrating renewable energy and implementing demand-side management. A study conducted by khafiso et al. (2024) and Ramantswana et al. (2026) states that there is a lack of technological integration through EMS in the residential sector, and this may be contributed to by the lack of knowledge by the end users on the suitable energy management system convenient for their house setting. Essentially, conducting research and using appropriate EMS for residential structures in South Africa can not only bolster energy sustainability and economic progress but also boost the general welfare and resilience of its populations. To assess suitable EMS in South African residential buildings, the study adopted a Two-Round Delphi as the research design.

## 2. Literature Review

### 2.1. OVERVIEW OF ENERGY SOURCES AND CONSUMPTION PATTERNS

Energy sources and consumption patterns in South Africa are influenced by a combination of historical, economic, and geographical factors, resulting in complex interactions (Oosthuizen, 2016). Throughout history, coal has consistently been the primary energy source, responsible for the bulk of power production and playing a crucial role in the country's energy industry (Zou et al., 2016). Nevertheless, there has been a deliberate and coordinated effort to broaden the range of energy sources over the last several years, motivated by concerns about ensuring a stable energy supply, promoting ecological sustainability, and fulfilling global obligations to reduce carbon emissions (Johansson et al., 2012). Consequently, South Africa has achieved notable progress in increasing its renewable energy capacity, namely in solar and wind power, by successfully implementing several large-scale projects in recent years (Rathor & Saxena, 2020). Although there has been progress, there are still obstacles to overcome. These include the sporadic availability of renewable energy sources, limited infrastructure, and the need for ongoing investment in transmission and distribution networks to ensure reliable and equitable energy access nationwide (Aliyu et al., 2018). Moreover, there is a considerable disparity in energy consumption patterns across different sectors, with manufacturing, mining, and transport making substantial contributions in addition to the residential and commercial sectors (Bilgen, 2014). Gaining a comprehensive understanding of these dynamics is of utmost importance for formulating efficient energy policies and strategies that foster sustainable development, improve energy efficiency, and respond to the changing requirements of an expanding population and economy.

## 2.2. RESIDENTIAL ENERGY MANAGEMENT SYSTEMS

Panda et al. (2025) assert that Residential Energy Management Systems (REMS) have become crucial components in modernizing domestic energy infrastructure. Aliyu et al. (2018) state that these systems are specially designed to enhance energy efficiency and encourage sustainability by providing households with real-time data on their energy consumption patterns. Remote Energy Management Systems (REMS) often use a combination of advanced meters, sensors, and communication technologies to gather information on household electricity usage (Ma et al., 2017). By analyzing this data, homeowners can gain a comprehensive understanding of their energy profile, enabling them to identify inefficiencies and implement targeted strategies to reduce energy use (Flouri et al., 2025; Barbosa & Almeida, 2025). Furthermore, REMS often use sophisticated algorithms and automation features to optimize the performance of home appliances and systems (Mathew et al., 2020). This allows for immediate adjustments based on factors such as the current time, weather conditions, and electricity prices. The significant level of control not only leads to cost savings but also improves the overall resilience and reliability of residential energy usage (Ali, 2025). The adoption of REMS is closely linked to the broader transition towards intelligent, eco-friendly homes (Abel et al., 2025). As smart home ecosystems become more common, REMS is vital for integrating energy management into the broader framework of intelligent home automation (Khafiso et al., 2025). These systems are essential for integrating renewable energy sources, such as solar panels, into homes and managing and coordinating the creation and use of clean energy (Kudzin et al., 2025). Residential energy management systems (REMS) play a crucial role in demand response programs by enabling families to actively participate in grid-balancing initiatives by adjusting their energy use in response to grid conditions (Khafiso et al., 2024). Therefore, adopting REMS not only improves individual energy efficiency but also ensures the overall stability and sustainability of the broader energy system. Table 1 further outlines Energy management systems available for residential buildings

*Table 1: Existing EMS for residential buildings (Source: Authors)*

| **Energy Management System** | **Description** | **Citation (Harvard style)** |
|---|---|---|
| Home Energy Management Systems (HEMS) | Monitors and optimises household energy use in real time using smart devices. | (Hosseini & Mirvaziri, 2020; Wang et al., 2024; Khafiso, 2024) |

| Energy Management System | Description | Citation (Harvard style) |
|---|---|---|
| Building Energy Management Systems (BEMS) | Centralised system controlling lighting, HVAC, and appliances. | (Zhao et al., 2024; Du et al. 2024; Khafiso, 2024) |
| Energy Efficient Management Systems (EEMS) | Improves efficiency by reducing energy waste. | (Płachta, 2024; Siregar et al. 2024; Khafiso, 2024) |
| Digital Energy Management Systems | Uses IoT, AI, and analytics for optimisation. | (Chen et al. 2024; Gajdzik et al. 2024; Khafiso, 2024) |
| Solar PV Systems | Converts sunlight into electricity. | (IEA, 2023; DMRE, 2022; Khafiso, 2024) |
| Battery Energy Storage Systems (BESS) | Stores energy for later use. | (IEA, 2023; Eskom, 2023; Khafiso, 2024) |
| Hybrid Energy Systems | Combines grid, solar, and storage. | (IRENA, 2022; Eskom, 2023; Khafiso, 2024) |
| Smart Meters | Measures real-time energy consumption. | (DoE SA, 2021; Eskom, 2023; Khafiso, 2024) |
| Smart Thermostats | Automates temperature control. | (Zhao et al., 2024; Chen et al., 2024; Khafiso, 2024) |
| HVAC Control Systems | Optimizes heating and cooling systems. | (Du et al., 2024; Siregar et al., 2024; Khafiso, 2024) |
| Smart Plugs | Controls appliances remotely. | (Gajdzik et al. 2024; Wang et al. 2024; Khafiso, 2024) |
| Load Management Systems | Manages peak demand usage. | (IEA, 2023; Eskom, 2023; Khafiso, 2024) |
| DERMS | Controls distributed energy resources. | (IRENA, 2022; Chen et al. 2024; Khafiso, 2024) |
| Smart Grid Systems | Enables grid-user communication. | (DoE SA, 2021; IEA, 2023; Khafiso, 2024) |
| Microgrid Systems | Local independent energy systems. | (IRENA, 2022; Eskom, 2023; Khafiso, 2024) |
| Home Automation Systems | Integrates smart devices. | (Wang et al., 2024; Zhao et al., 2024; Khafiso, 2024) |
| Energy Monitoring Software | Analyzes energy usage patterns. | (Chen et al., 2024; Gajdzik et al., 2024; Khafiso, 2024) |
| IoT Energy Systems | Uses sensors for automation. | (Du et al., 2024; Wang et al., 2024; Khafiso, 2024) |
| LED Lighting Systems | Energy-efficient lighting. | (DoE SA, 2021; IEA, 2023; Khafiso, 2024) |

## 3. Research Methodology

The study adopted a quantitative research methodology. Quantitative research uses an approach that seeks to understand the development of a phenomenon by analyzing numerical data and emphasizing the differences among these data points (Abbato, 2009; Ivankova & Creswell, 2009). The quantitative research approach is an objective, formal strategy for collecting information from a specified population through self-reporting. This research collected quantitative data using the Delphi approach, which included mailing questionnaires rather than conducting in-person group discussions. The Delphi method is justified in this study because it enables structured, iterative consultation with energy and built environment experts to reach consensus on the most suitable energy management systems for residential buildings, particularly in contexts where empirical data is limited and expert judgement is critical. Furthermore, adopting a quantitative Delphi approach allows for the statistical aggregation and measurement of expert opinions (e.g., using Likert scales, mean scores, and consensus thresholds), thereby enhancing the objectivity, reliability, and generalizability of the findings. This enhanced the capacity of all participants to provide individual solutions, hence reducing the impact of group dynamics on reaching a consensus. The Delphi technique included many key elements, including anonymity, iterative procedures with controlled feedback, and the utilization of statistical data. The panel members' names are secret, and each member independently answers a series of questions. The iterative nature of the technique allows professionals to review and expand their judgments beyond their viewpoints. Thus, it yields the most efficient forecast based on the consensus of well-informed persons (Corotis et al., 1981). The approach is repeated until consensus is reached or until it becomes evident that no more agreement can be found among the experts. The number of rounds typically ranges from 2 to 7, while the number of experts ranges from 3 to 15 (Corotis et al., 1981).

Two rounds of relevant inquiries were undertaken for this research to assess suitable energy management systems for residential buildings in South Africa. Each specialist offered their viewpoint, and the collected replies from the first round were assessed. Subsequently, the collected data was sent to the specialists, guaranteeing anonymity and non-attribution, along with the subsequent questions. Afterwards, each expert considered the perspectives of the other participants when drafting their comments in the second round. Afterwards, this process was repeated for each subsequent iteration, with the expectation that by the last iteration, an agreement on the identified obstacles would have been reached. This was achieved through two rounds, with the expectation that the panel of experts would ultimately reach saturation, leading to convergence of their opinions (Aigbavboa, 2013). Therefore, the research underwent a Delphi procedure, as seen in Figure 1.

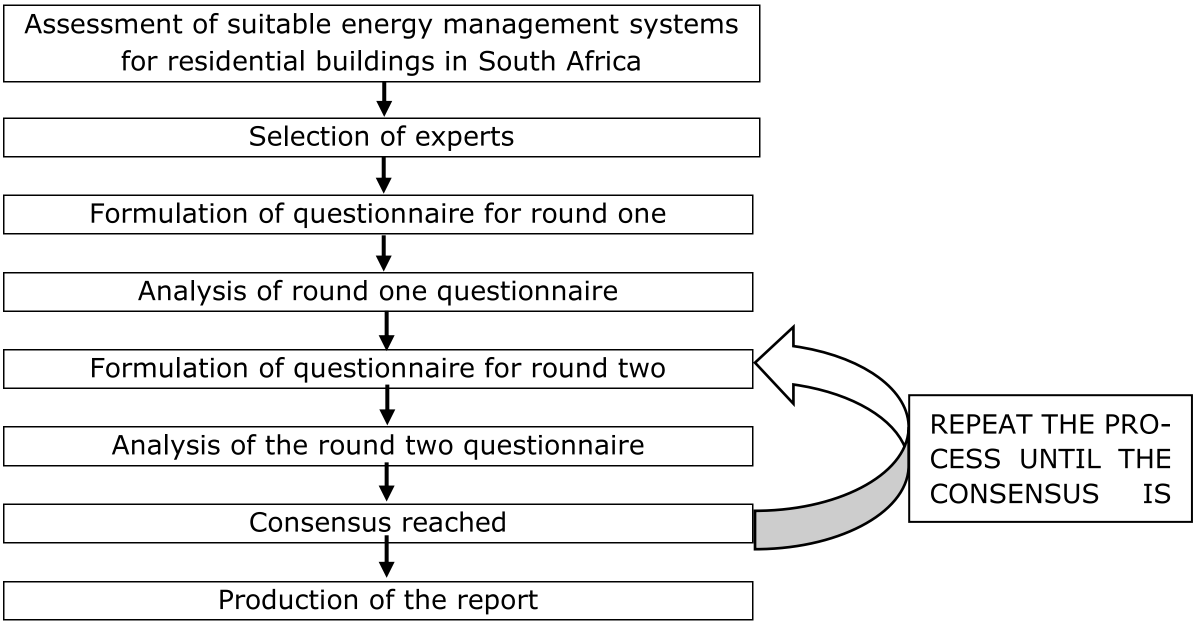


*Figure 1. Framework for the Delphi study*

### 3.1. EXPERT SELECTION

The participants in this study consisted of researchers specializing in residential energy, property owners, and property managers. A summary of their criteria is provided in Table 2. These conditions were implemented and deemed adequate for selecting an expert for the study. It offers a well-rounded, diverse group of professionals from both industry and academia. Individuals who met these criteria were contacted and selected to participate in the research, while those who did not were excluded. The study included 20 experts who participated in two rounds of the Delphi, as shown in Table 2.

*Table 2: Expert selection requirements*

| S/N | Researchers | Property managers/owners |
|---|---|---|
| 1 | Published more than 4 energy management-related papers | Having managed/owned the property for more than 3 years, with more than 100 residents per year |
| 2 | Having an energy/ electrical engineering qualification | Capacity and willingness to participate |
| 3 | Capacity and willingness to participate | Sufficient time to participate |
| 4 | Sufficient time to participate | Having sufficient records of energy usage for previous years |
| 5 | Having more than 3 years of experience in the energy industry | |

### 3.2. DELPHI ADOPTION IN THE STUDY

On 15 July 2025, a questionnaire with 27 energy management systems was sent to all 20 experts. The experts were asked to rate the 10 factors on a 10-point Likert scale, indicating their degree of agreement. In the second phase, the experts were given the aggregate ratings from the first round and asked whether they wanted to make any changes to achieve consensus. The questionnaire for the second iteration was sent on 25 July 2025, and the expert replies were received by 05 August 2025. It should be noted that none of the experts reviewed or modified their ratings; thus, consensus was reached regarding the study. Furthermore, the experts did not add any additional energy management system, which kept this study quantitative. All experts participated in both rounds of the Delphi. Table 3 lists the experts who participated in the study.

*Table 3: List of the panel of experts who participated in the Delphi study*

| **Round 1 Experts** | | **Round 2 Experts** | |
|---|---|---|---|
| Expert | Number | Expert | Number |
| Researchers | 5 | Researchers | 5 |
| Property managers | 9 | Property managers | 9 |
| Property Owners | 6 | Property Owners | 6 |
| Total | 20 | Total | 20 |

## 4. Findings

4.1 DELPHI ROUND ONE FINDINGS

As illustrated in Table 4, the findings from the Delphi two rounds did not change from Round 1, indicating strong consensus regarding energy management systems. There was a very high level of agreement among the Delphi experts, especially regarding HVAC control systems, which are widely used across seasons to enhance occupant comfort. Additionally, solar panel systems were ranked very highly by the experts, illustrating that they are highly effective energy management systems, especially because they use renewable energy. Table 4 presents the findings from Rounds 1 and 2 of the Delphi study.

*Table 4: Suitable energy management system for residential buildings*

| **Round 1 Delphi findings** | | | | **Round 2 Delphi findings** | | | |
|---|---|---|---|---|---|---|---|
| Energy management systems | Mean | Standard deviation | Interquartile Range | Energy management systems | Mean | Standard deviation | Interquartile Range |
| HVAC control systems | 8,15 | 7,52 | 3.5 | HVAC control systems | 8,15 | 7,52 | 3.5 |
| Solar panel systems | 8,15 | 7,87 | 2,5 | Solar panel systems | 8,15 | 7,87 | 2,5 |
| Smart plugs and outlets | 8,1 | 7,83 | 2,5 | Smart plugs and outlets | 8,1 | 7,83 | 2,5 |
| Energy monitors and meters | 8,05 | 7,73 | 2,75 | Energy monitors and meters | 8,05 | 7,73 | 2,75 |
| Battery energy storage systems (BESS) | 8 | 7,76 | 3,00 | Battery energy storage systems (BESS) | 8 | 7,76 | 3,00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Building energy management system (BEMS)(Model predictive control [forecasting] & Real-time control algorithms ) | 7,95 | 7,57 | 3,75 | Building energy management system (BEMS)(Model predictive control [forecasting] & Real-time control algorithms ) | 7,95 | 7,57 | 3,75 |
| Home energy management systems (HEMS) | 7,8 | 7,45 | 3,00 | Home energy management systems (HEMS) | 7,8 | 7,45 | 3,00 |
| LED Lighting Systems | 7,75 | 7,44 | 2,75 | LED Lighting Systems | 7,75 | 7,44 | 2,75 |
| Home automation systems (such as smart home hubs) | 7,70 | 7,41 | 2,75 | Home automation systems (such as smart home hubs) | 7,7 | 7,41 | 2,75 |
| Smart thermostats | 7,65 | 7,40 | 2,50 | Smart thermostats | 7,65 | 7,40 | 2,50 |
| Home energy management system(residential energy management system) | 7,65 | 7,42 | 3,50 | Home energy management system(residential energy management system) | 7,65 | 7,42 | 3,50 |
| Smart grid energy management systems (SGEMS) | 7,6 | 7,36 | 2,75 | Smart grid energy management systems (SGEMS) | 7,6 | 7,36 | 2,75 |

## 5. Discussions of the findings

### 5.1. DELPHI FINDINGS

According to the study, the most suitable EMS is HVAC control systems, which optimize heating, ventilation, and air conditioning units to improve energy efficiency and comfort in residential buildings. Since South Africa has different seasons throughout the year, HVAC is required for heating and cooling. Nguyen et al. (2024) support this finding, stating that these systems are essential in residential buildings and can significantly reduce energy costs through automated adjustments based on real-time environmental and occupancy data. Solar panel systems, on the other hand, had a strong consensus due to their ability to convert sunlight into electricity, offering a renewable, clean energy source suitable for both residential and commercial applications. Since South Africa generates energy by burning coal, which emits greenhouse gases, Jia et al. (2024) further support these findings by stating that they reduce reliance on fossil fuels and can provide significant savings on electricity bills, especially with the addition of net metering systems. Smart plugs and outlets, as part of energy management systems, allow users to control and automate the operation of electronic devices remotely or via scheduled timers, leading to substantial energy savings.

South Africa is still behind with digital technologies, according to the experts. This innovative technology is suitable for residential settings to mitigate high energy consumption, and Mathew et al. (2020) support this finding, stating that it is particularly effective in residential settings for managing standby power consumption of gadgets and appliances. Energy Monitors and Meters track energy consumption in real time, providing valuable data to identify wasteful practices and improve energy efficiency. They are suitable for both residential and commercial users looking to monitor their energy usage and reduce overall electricity costs (Kowalska-Pyzalska, 2024). Battery Energy Storage Systems (BESS) is also considered suitable by experts, as it stores excess energy generated during low-demand periods for use during peak-demand periods, helping stabilize the grid and reduce electricity costs. Ngepah (2010) supports this finding, stating that they are particularly effective when combined with renewable energy sources because they can store intermittent energy for later use. Furthermore, experts agreed that BEMS is suitable since it uses forecasting and real-time control algorithms to optimize energy usage across commercial buildings, significantly reducing operational costs and enhancing the building's environmental performance. Heydari et al. (2024) agree that they are ideal for residential buildings that require precise control over various energy-consuming systems. Home Energy Management Systems (HEMS) were also considered suitable, as they integrate various home systems and appliances to provide a centralized method for monitoring and controlling energy use, thereby enhancing overall efficiency. Ren et al. (2024) agree that these systems are increasingly popular in smart homes, where they contribute to substantial energy savings and increased comfort.

There was also strong consensus on the suitability of LED lighting systems, which are highly energy-efficient and have a longer lifespan than traditional lighting technologies, making them an excellent choice for both residential and commercial lighting needs. Bessho & Shimizu (2012) argue that they drastically reduce lighting energy consumption, offering a quick return on investment. Home Automation Systems centralize control of lighting, heating, cooling, and security, enhancing the convenience and energy efficiency of residential spaces. Smart home hubs are particularly beneficial for managing energy use in real time, allowing adjustments based on actual usage patterns (Asadullah & Raza, 2016). Smart thermostats adjust home heating and cooling based on residents' habits and preferences, as well as external weather conditions. They are effective in reducing unnecessary energy consumption and can be controlled remotely, offering enhanced convenience and energy savings (Daim & Iskin, 2010). The Home Energy Management system provides tools for detailed monitoring and management of home energy usage, optimizing the operation of heating, cooling, and electrical appliances to minimize costs and energy consumption (Rehman, 2021). It is particularly useful in households looking to improve energy efficiency and manage renewable energy integration. Smart Grid Energy Management Systems (SGEMS) enhance the operation and reliability of the electrical grid by integrating advanced technologies that dynamically manage energy flow and demand response. They are key to modernizing grid infrastructure and accommodating renewable energy inputs and electric vehicle charging demands (Rathor & Saxena, 2020).

Load controllers actively manage the electrical load to prevent system overloads and optimize performance, particularly in industrial and commercial settings. They are crucial for maintaining system integrity and reducing peak demand charges on electrical utilities (Ilic et al., 2002). The Energy Efficient Management System (EEMS) systematically improves energy use across sectors through advanced technologies and management practices. They are essential in settings that require strict energy use regulations and aim to achieve high standards of sustainability and cost efficiency (Johansson et al., 2012). A Digital Home Energy Management system uses digital tools to provide homeowners with detailed insights into their energy consumption patterns, offering suggestions for improvement and remote-control capabilities. It is ideal for tech-savvy users who want to engage actively with their home energy management (Liu et al., 2013). Renewable Energy Management Systems (REMS) optimize the use of renewable energy sources like solar and wind by managing production, storage, and distribution. They are critical for maximizing the efficiency and integration of renewable energies into the existing power systems (Harizopoulos et al., 2009).

A mobile-based feedback system delivers real-time energy usage data to users' mobile devices, enabling immediate feedback and promoting energy-saving behaviours. It is suitable for individuals who prefer managing their energy consumption on the go, using intuitive applications (Olatomiwa et al., 2016). Distributed Energy Resource Management Systems (DERMS) coordinate various types of distributed energy resources to maintain grid stability and efficiency. They are increasingly important as energy grids move toward a more decentralized model involving multiple energy sources and storage solutions (Mathew et al., 2020). Hybrid power systems combine multiple types of power generation technologies, such as solar and diesel generators, to provide a reliable power supply. They are especially suitable for remote or off-grid locations where single-source power systems may not be reliable (Rehman, 2021). Pervasive Service-Oriented networks integrate multiple services, including energy management, to create comprehensive, user-focused solutions. They are particularly suited for smart city applications where various infrastructure systems need to interact seamlessly (Shen et al., 2021).

The Adaptive Living Interface System uses AI to automatically adapt the living environment to user preferences, optimizing energy use while enhancing comfort and convenience. It is well-suited for advanced residential settings that prioritize energy efficiency and user comfort (Olatomiwa et al., 2016). Energy Wizard systems offer personalized energy management advice and automated control solutions, making them suitable for users seeking expert guidance to reduce energy consumption. They are particularly effective in settings that require detailed energy usage analysis and recommendations (Roy et al., 2024). Watt Depot is a tool for collecting and analyzing energy data from multiple sources, facilitating comprehensive energy management strategies for businesses and large institutions. It is ideal for entities requiring detailed energy tracking and management capabilities (khafiso, 2024). Microgrid Energy Management Systems (MEMS) manage localized grids that can operate independently from the main grid, providing energy security and efficiency in remote or critical areas. They are crucial for integrating local renewable energy sources and providing reliable power in isolated environments (Harizopoulos et al., 2009).

The ViridiScope system tracks and analyzes environmental and energy data to provide insights into organizations' sustainability practices. It is particularly useful in research settings where detailed environmental impact data is crucial for ongoing projects (Kim et al., 2009). Enterprise Energy Management Systems (EEMS) help large organizations manage energy consumption across multiple facilities through centralized control systems and data analytics. They are essential for enterprises aiming to reduce operational costs and comply with environmental regulations (Khafiso et al., 2025). Industrial Energy Management Systems (IEMS) focus on improving energy efficiency in industrial processes by integrating advanced sensors, controls, and energy data analytics. They are vital for manufacturing facilities looking to minimize energy costs and enhance production efficiency (Rathor & Saxena, 2020).

Across the two Delphi rounds, the results demonstrate a stable hierarchy of energy management technologies, with minimal variation between rounds, indicating convergence of expert judgment rather than substantial shifts in perception. Technologies associated with real-time operational control and immediate energy savings were consistently prioritized, with HVAC control systems ranked highest, followed by solar panel systems, smart plugs and outlets, energy monitoring and metering devices, and battery energy storage systems. This pattern suggests that participants favour solutions that enable monitoring, automation, and on-site energy generation because of their direct, observable impact on building energy performance. Technologies of moderate importance included building and home energy management systems, LED lighting, smart thermostats, load controllers, and smart grid management platforms, reflecting acknowledgement of integrated management approaches but with comparatively lower immediacy of benefit than direct control technologies. Lower priority was consistently assigned to large-scale or enterprise-level solutions such as microgrids and industrial or enterprise energy management systems, which were perceived as more complex, costly, or less suitable for typical residential applications. Overall, the similar ranking structure across both rounds confirms consensus among experts, indicating a clear preference for practical, building-level monitoring and control technologies over broader infrastructure-scale energy management solutions when identifying an appropriate energy management system

## 6. Conclusion

The research concludes that energy management systems (EMS) are essential for improving energy efficiency and sustainability in residential sectors across South Africa. There has been strong agreement on the suitability of EMS in residential buildings; therefore, integrating these technologies in South African Residential buildings is highly feasible. This transition could even reduce load shedding since less energy will be consumed in residential buildings, and it may also influence the use of clean energy, as the existing energy is produced by burning coal, which harms the environment. Participants agree that improved EMS can not only reduce energy use but also substantially lower home energy expenses. These systems, designed to address the specific requirements and circumstances of residential structures in South Africa, are expected to have a crucial impact on the country's efforts to achieve its energy-efficiency objectives and sustainable development aspirations. Moreover, the research promotes a comprehensive strategy for implementing EMS, proposing the use of intelligent technologies, user-friendly interfaces, and immediate feedback on energy use to provide households with the information and resources they need to effectively control and regulate their energy consumption. Government assistance, including incentives and legal frameworks, is considered crucial for expediting the implementation of these systems. By adopting these suggestions, South Africa could improve its home energy management, leading to significant economic and environmental benefits at the national level. Further research can be conducted to scientifically evaluate the efficiency of various energy management systems and determine the most effective, economically sustainable option in the long run.

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