Rabat microgrid applications

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Energy conservation and efficiency are prerequisites for the continuous development of civilization. They are essential for maintaining body heat, preparing food, and providing illumination. They are also necessary for modern transportation, communication, healthcare, and industrial systems. Energy availability is essential for a prosperous economy and improving living standards. In addition, energy is a crucial component in the development and transmission of cutting-edge technologies that have the potential to address urgent issues on a worldwide scale, such as poverty, starvation, and damage to the natural environment1.

Energy plays a crucial role in our lives, but conventional energy systems have become a cause of concern due to the depletion of fossil fuels, climate change, and global warming. Renewable Energy Sources (RES) have been developed as a sustainable and eco-friendly alternative to traditional systems. Examples of RES include solar, geothermal, wind, hydroelectric, and biomass, which have the potential to provide reliable and sustainable power in the future2.

Despite significant advances in RES, rural villages and islands still deal with power shortages. As per the United Nations Development Program (UNDP), over 25% of the global population currently lacks access to electricity. This is especially true for individuals who reside in rural areas. Because of their remote location and the difficulty of developing electrical transmission lines across rugged terrain (such as steep hills or thick jungles), rural populations are frequently unable to afford them. Wind, solar, and hydropower are all examples of renewable resources that may be used to meet the electrical loads in these areas3.

Hybrid Renewable Energy System (HRES) combines different techniques of energy production and storage, or it powers a generator with two or more fuel types. HRES are critical in the move away from economies reliant on fossil fuels. HRES has many benefits, such as more renewable energy that can be used immediately and better access to power in rural areas. They also reduce the amount of energy that comes from fossil fuels and use more RES, even those that don''t work all the time, which improves energy efficiency and security8.

The most practical and affordable alternative for powering off-grid regions is to use renewable energy to create MSs, which improve energy supply9. Every MS is made up of distributed energy sources (such as PV, biomass, WT, and fuel cells), distributed energy storage units (such as BESU, supercapacitors, flywheels, and superconducting inductors), and a central control unit. Energy storage technologies are needed to use extra power or compensate for power shortages10. Also, static converters like DC/DC, AC/DC, and DC/AC converters help manage energy and voltage adaptation across the various parts of an MS to make it more reliable and cost-effective.

Autonomous microgrids powered by renewable energy are the most practical and cost-effective way to bring electricity to off-grid areas11. Considering the technical and economic perspectives, many things make it hard to plan and make the optimal design for such a system. The fact that RES are so weather-dependent makes them unpredictable. In many cases, the size of a microgrid is either too large or too small to provide for the needed load adequately. Excessive system size results in high yearly operating costs and surplus energy production. The opposite is true for undersized MSs, which cannot meet power demand.Microgrids run by renewable energy sources may be advantageous, but this is only the case if their dimensions are optimized. Their energy is controlled efficiently11.

Size, design, investment, operation, and stability of energy systems, as well as dynamic control, are all examples of complex issues in the energy sector that can be solved with a variety of methods that have been developed through research into artificial intelligence (AI) technologies and that were once thought to be impossible to solve without several simplified assumptions17. A branch of AI called "metaheuristic" or "heuristic optimization" uses appropriate computational changes to natural systems to search for global optimal solutions to non-deterministic polynomial time-hard (NP-hard) problems. These issues are incompatible with exact mathematical optimization techniques18.

The genetic algorithm (GA) has been used successfully to deal with a hybrid system with many factors19, even though it is hard to code. Particle Swarm Optimization (PSO), one of the most popular metaheuristic algorithms, is based on how fish and birds move in groups20. Since PSO is so good at solving problems, many different approaches have been tried in different situations21. PSO algorithms have been used to study various applications, such as optimizing PV, WT, and BESU22. PSO does better than GA because it responds much faster and gets to a solution more quickly23.

Table 1 provides a comprehensive review of the literature. It includes a summary and a complete analysis of previous work on the design and operation of the microgrid. This table lists information such as the authors of the previous work, the title of the studies, and a brief explanation of their research"s conclusions and essential contributions.

To date, as far as the authors know, there have been no published studies that specifically applied the ISSA and compared it to other algorithms like the SSA, ALO, DA, and MFO algorithms in the optimal sizing of autonomous microgrids in different configurations such as PV/BESU/DG, WT/BESU/DG, and PV/WT/BESU/DG. The possible innovations and contributions of this paper can be summarized as follows:

Application of ISSA with a new position adaptation mechanism for salp leaders involves a leader salp that moves based on both food availability and its previous position, addressing the convergence problem in the original SSA.

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