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USE OF MICROGRID SYSTEMS IN THE ENERGY SECTOR

As the world transitions towards more sustainable and resilient energy systems, microgrids have emerged as a crucial component of modern electrical infrastructure. A microgrid is a localized energy system that can operate independently or in conjunction with the main power grid. The growing interest in microgrids is driven by their ability to enhance energy reliability, support renewable energy integration, and improve grid resilience. This paper explores why microgrids are gaining popularity, the scientific advancements in the field, and their role in the future of energy systems.

A microgrid is a local intelligent power grid. It is a combination of electricity generation systems from renewable energies such as solar and wind power or combined heat and power plants as well as energy storage systems to form a local grid. All components are connected to local consumers via a bidirectional cable and communication network and software. Microgrids can operate autonomously and therefore independently of the Smart Grid (off-grid) and maintain a decentralised and local power supply. Or they can be integrated into a smart grid as a single unit [1].

Depending on the fluctuating availability of electricity from renewable energy sources, they use intelligent control software to ensure security of supply and resilience. The software is programmed in such a way that it can switch off large consumers when power availability is low or send them a signal when they are allowed to connect to the grid. Important basic functions at this local level, such as lighting, water supply and telecommunications, are prioritised.

Microgrids' ability to function independently and cut off from the main grid in the event of an outage is its greatest resilience advantage. As a result, during an outage, facilities that are powered by and connected to the microgrid can continue to serve a community. The social and financial consequences of disruptive events can be lessened by the capacity to continue supplying vital loads, such as grocery stores or medical institutions [2].

Beyond the advantages of energy resilience, microgrids might potentially be able to offer the following other advantages, depending on their constituent parts. Microgrids that employ renewable energy sources can improve the environment by lowering air pollution and greenhouse gas emissions.

However, microgrids are just one way to improve the energy resilience of an electric grid and they do have some potential disadvantages [3]: depending on the complexity, microgrids can have high upfront capital costs; microgrids are

complex systems that require specialized skills to operate and maintain; microgrids include controls and communication systems that contain cybersecurity risks.

Researchers and engineers are continuously working to enhance microgrid technology in several key areas:

- advanced control systems: scientists are developing AI-driven and machine learning-based algorithms to optimize energy distribution and storage within microgrids;
- energy storage solutions: new battery technologies, such as lithium-ion and solid-state batteries, are improving energy storage capabilities, making microgrids more reliable;
- Smart Grid integration: the incorporation of smart meters and IoT devices enables real-time monitoring and management of microgrid performance;
- peer-to-peer energy trading: blockchain technology is being explored to facilitate decentralized energy transactions within microgrids, allowing consumers to buy and sell electricity efficiently.

Despite their numerous benefits, microgrids face challenges such as high initial costs, regulatory barriers, and technical complexities in grid integration [4]. However, with continued research and policy support, microgrids are expected to become more widespread. Future developments in energy storage, artificial intelligence, and decentralized finance could further enhance their efficiency and accessibility.

REFERENCES

1. Shafiullah, M.; Refat, A.M.; Haque, M.E.; Chowdhury, D.M.H.; Hossain, M.S.; Alharbi, A.G.; Alam, M.S.; Ali, A.; Hossain, S. Review of Recent Developments in Microgrid Energy Management Strategies. *Sustainability* 2022, 14, 14794. <https://doi.org/10.3390/su142214794>
2. Moslem Uddin, Huadong Mo, Daoyi Dong, Sondoss Elsawah, Jianguo Zhu, Josep M. Guerrero, Microgrids: A review, outstanding issues and future trends, *Energy Strategy Reviews*, Volume 49, 2023, 101127, ISSN 2211-467X. <https://doi.org/10.1016/j.esr.2023.101127>.
3. Punyam Rajendran Sai Sasidhar, Alemayehu Gebremedhin, Ian Norheim, Multi-energy microgrid design and the role of coupling components—A review, *Renewable and Sustainable Energy Reviews*, Volume 216, 2025, 115540, ISSN 1364-0321. <https://doi.org/10.1016/j.rser.2025.115540>.
4. Tekai Eddine Khalil Zidane, Zarina Ab Muis, Wai Shin Ho, Younes Zahraoui, Ali Saleh Aziz, Chun-Lien Su, Saad Mekhilef, Pietro Elia Campana, Power systems and microgrids resilience enhancement strategies: A review, *Renewable and Sustainable Energy Reviews*, Volume 207, 2025, 114953, ISSN 1364-0321. <https://doi.org/10.1016/j.rser.2024.114953>.