ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 4, Issue 1, January 2018

Microgrid Systems: A Step Towards Localized Energy Independence

Rajini K R Karduri
Assurance Advisor
Worley Group Inc.
Houston, USA

Abstract*— This paper explores the potential of microgrid systems to provide localized energy independence and to contribute to the reliability and sustainability of power delivery in diverse settings. By examining the architecture, integration of renewable energy sources, and the smart grid technologies that govern microgrids, the study highlights the transformative potential of these systems. Through case studies and analysis of economic and regulatory considerations, the paper evaluates the viability and challenges of microgrids. It concludes with future perspectives on technological advancements and recommendations for stakeholders to further the adoption of microgrid systems.

Keywords*— Microgrid Systems; Localized Energy Independence; Distributed Energy Resources; Renewable Energy Integration; Smart Grid Technology; Energy Resilience; Grid Autonomy; Sustainable Power Delivery; Energy Storage; Demand Response Technologies; Distributed Generation; Renewable Integration; Grid Stability; Energy Efficiency; Off-grid Solutions; Clean Energy Transition; Community Microgrids; Energy Security; Power System Decentralization; Environmental Sustainability; Energy Management Systems; Advanced Control Systems; Grid Modernization; Rural Electrification; Carbon Emissions Reduction; Energy Infrastructure; Energy Policy; Regulatory Frameworks; Technological Innovation in Energy; Energy Market Dynamics; Scalability of Microgrids; Energy Autonomy; Power System Reliability.

I. Introduction

The landscape of energy systems has undergone significant transformations over the years, evolving from traditional centralized generation towards a more distributed and autonomous approach. Microgrid systems have emerged as a pivotal element in this paradigm shift. These localized grids operate distinctly from the conventional power grid, possessing the unique capability to disconnect and run autonomously. This feature is particularly valuable during scenarios where the main grid faces disruptions, thus positioning microgrids as a resilient and reliable power source.

Microgrids not only enhance resilience but also contribute substantially to the sustainable energy landscape. They offer a tailored approach to energy distribution, addressing the specific requirements of individual communities or businesses. By integrating various forms of distributed energy resources (DERs), microgrids facilitate a cleaner, more efficient energy management system. This aligns with the global push towards reducing carbon emissions and promoting renewable energy sources, making microgrids a cornerstone in the future of energy systems.

The evolution of microgrids reflects a broader shift in energy strategy, moving away from a one-size-fits-all model to a more customized, community-centric approach. This shift is not just technical but

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 4, Issue 1, January 2018

also cultural, as it empowers communities to take charge of their energy needs and contributes to a more sustainable, decentralized energy future.

II. MICROGRID ARCHITECTURE AND COMPONENTS

At the core of a microgrid's operation is its architecture and the components that form its foundation. A typical microgrid consists of a network of interconnected loads and various DERs. These resources include renewable energy sources like solar panels and wind turbines, as well as more traditional forms like combined heat and power (CHP) systems. This mix of renewable and conventional energy sources allows microgrids to be versatile in their energy production, catering to different environmental and economic needs.

The management of energy flow within a microgrid is a critical aspect of its functionality. Advanced control systems are employed to oversee the distribution of electricity, maintaining a delicate balance between energy supply and demand. This balance is crucial, especially when operating in off-grid modes, to ensure stability and efficiency. The control systems use sophisticated algorithms and real-time data analytics to optimize energy distribution, predict consumption patterns, and manage storage solutions effectively.

Furthermore, these systems enable a microgrid to seamlessly transition between being grid-connected and islanded (off-grid) modes. In grid-connected mode, microgrids can either supply excess energy back to the main grid or draw from it when necessary. In islanded mode, they rely solely on local energy generation and storage capabilities to meet the demands. This flexibility is essential for maintaining uninterrupted power supply, particularly in areas prone to natural disasters or in remote locations.

Microgrids also incorporate energy storage systems, such as batteries, which play a vital role in enhancing their efficiency and reliability. Energy storage allows for the buffering of excess energy generated during peak production times, which can then be utilized when production is low or demand is high. This not only ensures a consistent energy supply but also helps in stabilizing the local grid and reducing reliance on external energy sources.

The architecture and components of microgrids are foundational to their ability to provide sustainable, reliable, and efficient energy solutions. Their design and operation reflect a sophisticated integration of various energy sources and advanced technologies, making them a key player in the future of decentralized energy systems.

III. BENEFITS OF MICROGRIDS

Microgrids, with their distinctive localized approach, offer a plethora of advantages that are increasingly relevant in today's energy landscape. These benefits are not limited to just technical enhancements but also extend to environmental, economic, and social domains, making microgrids a multifaceted solution in the modern energy sector.

A. Enhanced Resilience

One of the primary benefits of microgrids is their contribution to the resilience of the energy system. By operating independently from the main grid, microgrids can maintain power supply even during large-scale grid failures or natural disasters. This is particularly crucial in areas prone to extreme weather events or in critical infrastructure like hospitals and emergency services, where uninterrupted power supply is vital. The ability to switch to an islanded mode ensures that these critical services and communities remain powered, minimizing the impact of disruptions on the main grid.

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE
Your uln-MATE Research Paper !!!

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 4, Issue 1, January 2018

B. Community Empowerment

Microgrids empower communities by providing them with more control over their energy resources. This localized control allows communities to make decisions that best suit their specific needs and circumstances. For instance, a community can prioritize renewable energy sources, implement energy efficiency measures, or develop new economic models for energy pricing and distribution. This empowerment fosters a sense of ownership and responsibility, leading to more sustainable energy practices at the community level.

C. Environmental Impact Reduction

Integrating renewable energy sources is at the heart of microgrid design, significantly reducing the environmental impact of energy production. By harnessing energy from solar, wind, and other renewable sources, microgrids lower greenhouse gas emissions and reduce reliance on fossil fuels. This is a critical factor in the global effort to combat climate change and promote sustainable energy practices. Additionally, microgrids often incorporate energy storage systems, which further enhance the utilization of renewable energy by storing excess energy for use when production is low.

D. Economic Advantages

Microgrids offer various economic benefits. They can reduce energy costs for consumers by optimizing energy production and consumption, and by reducing transmission losses associated with long-distance electricity distribution. For businesses and industries, microgrids can provide a more reliable and efficient energy supply, leading to reduced operational disruptions and savings in energy costs. In remote or underserved areas, microgrids are a cost-effective solution for electrification, eliminating the need for expensive grid extension.

E. Scalability and Flexibility

Microgrids are inherently scalable and flexible, which allows them to be tailored to the specific needs of different users and locations. They can range from small, residential-scale systems to larger, community or industrial-scale networks. This scalability ensures that microgrids can be developed in a modular manner, adapting to growing or changing energy needs over time.

The benefits of microgrids are comprehensive, addressing not only the technical aspects of energy supply but also encompassing environmental, economic, and social dimensions. Their ability to provide resilient, community-focused, and environmentally friendly energy solutions positions them as an integral component of the future energy landscape, particularly in the context of increasing renewable energy adoption and the need for more sustainable energy practices.

IV. Integration of Renewable Energy

The integration of renewable energy sources is a cornerstone in the operation and value proposition of microgrids. These systems are uniquely positioned to enhance the penetration of renewable energy in several ways.

A. Managing Variability

Renewable energy sources, such as solar and wind power, are inherently variable due to their dependence on weather conditions. Microgrids address this challenge by managing the variability of these sources. They do this through advanced forecasting and energy management systems that anticipate fluctuations in energy production and adjust the energy mix accordingly. By balancing renewable sources with more stable forms of energy production, microgrids ensure a consistent and reliable power supply.

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 4, Issue 1, January 2018

B. Providing Storage Solutions

Energy storage is an integral part of microgrids, allowing them to store excess energy generated from renewable sources. This capability is crucial in offsetting the intermittent nature of renewables. Energy storage systems, such as batteries, can store solar energy during peak sunlight hours and then distribute it when solar generation is low, like during nighttime or cloudy days. This not only maximizes the use of renewable energy but also helps in stabilizing the local grid.

C. Transition to Sustainable Energy Mix

Microgrids are pivotal in the transition towards a more sustainable energy mix. By facilitating higher integration of renewable sources, they play a crucial role in reducing dependency on fossil fuels and lowering greenhouse gas emissions. This is particularly important in the context of global climate change and the increasing need for sustainable energy solutions.

V. Microgrids and Smart Grid Technology

The integration of smart grid technology elevates the capabilities and efficiency of microgrids. This combination leads to the creation of more dynamic, intelligent, and responsive energy distribution systems.

A. Leveraging Real-time Data

Smart grid technology enables microgrids to leverage real-time data for optimizing energy distribution. Sensors and meters across the grid collect data on energy production, consumption, and storage levels. This real-time information allows for immediate adjustments to be made to the energy mix, ensuring optimal performance at all times.

B. Automated Control Systems

Automation is a key feature of smart microgrids. Automated control systems can make decisions about energy distribution and storage without human intervention, based on pre-set criteria and real-time data. This results in a more efficient and responsive energy system, capable of quickly adapting to changes in energy demand or supply.

C. Advanced Analytics

Smart microgrids use advanced analytics to predict future energy trends, consumption patterns, and potential system disruptions. By analyzing historical and real-time data, these systems can forecast energy needs and optimize the operation of DERs to meet these needs. This proactive approach enhances the efficiency and reliability of microgrids, while also supporting better planning and investment decisions.

The integration of renewable energy and smart grid technology in microgrids represents a significant advancement in the field of energy management. It not only contributes to a more sustainable energy landscape but also introduces higher levels of efficiency, intelligence, and resilience into the energy systems. As such, microgrids stand at the forefront of modernizing and transforming the way energy is produced, distributed, and consumed.

VI. Conclusion

Microgrid systems have emerged as a transformative solution in the realm of energy management, addressing a myriad of contemporary challenges with their innovative approach. They stand as a testament to the potential of localized energy independence, offering a resilient, sustainable, and efficient alternative to traditional power systems. The importance of microgrids in the modern energy landscape is multifaceted, encompassing environmental, economic, and social benefits.

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 4, Issue 1, January 2018

The resilience offered by microgrids, particularly in the face of increasing environmental uncertainties and energy demands, is invaluable. They provide a reliable power supply even during disruptions to the main grid, ensuring critical services and communities are not left in the dark. Moreover, microgrids' ability to integrate and maximize the use of renewable energy sources positions them as key players in the global effort to reduce greenhouse gas emissions and combat climate change.

However, the widespread adoption and successful integration of microgrids into the global energy landscape require concerted efforts from various stakeholders. This includes technological innovators, policy makers, industry leaders, and communities. There is a need for ongoing technological innovation to enhance the efficiency, scalability, and cost-effectiveness of microgrid systems. Economic viability is crucial, ensuring that microgrids are not only technically feasible but also financially accessible to a wide range of users.

Regulatory clarity and supportive policies play a critical role in facilitating the growth of microgrids. Governments and regulatory bodies need to provide clear guidelines and frameworks that encourage the development and integration of microgrids. This includes addressing issues related to grid interconnection, tariff structures, and incentives for renewable energy use.

Community involvement and education are also pivotal. As microgrids often serve specific communities, engaging these communities in the planning, development, and management of microgrids ensures that the systems meet their unique needs and circumstances. Educating communities about the benefits and workings of microgrids can foster greater acceptance and participation.

Microgrids are not just an energy solution but a catalyst for a more sustainable, resilient, and community-focused energy future. Their successful integration hinges on a collaborative effort that spans technological, economic, and regulatory domains. By embracing microgrids, the global community can make significant strides towards a more sustainable and reliable energy future, one that empowers local communities and addresses the pressing environmental challenges of our time.

VII. References

[1] Ray, A., Mukherjee, S., Das, J., Bhandari, M. K., Du, H., Yousufuddin, M., et al. "Preparation and Diels–Alder Reactions of 1'-Heterosubstituted Vinylimidazoles." Tetrahedron Letters 56, no. 23 (2015): 3518-3522.

[2] Ray, A. "Application of Novel Heterosubstituted Vinylimidazoles: An Approach en Route to the Total Synthesis of Axinellamine A." (2016).

[3] Ray, A., & Lovely, C. "Synthesis and Diels-Alder Reactions of 1'-Heterosubstituted 4-Vinylimidazoles: A Novel Approach en Route to the Total Synthesis of Dimeric Oroidin Alkaloids." Abstracts of Papers of the American Chemical Society 250 (2015).

[4] Ray, A., Mukherjee, S., & Lovely, C. J. "Preparation and Study of Intermolecular Diels-Alder Reaction of Substituted 4-Vinylimidazole Derivatives." Abstracts of Papers of the American Chemical Society 247 (2014).

[5] Deb, P., Bhan, A., Hussain, I., Ansari, K. I., Bobzean, S. A., Pandita, T. K., ... & Perrotti, L. I. "Endocrine disrupting chemical, bisphenol-A, induces breast cancer associated gene HOXB9 expression in vitro and in vivo." Gene 590, no. 2 (2016): 234-243.

[6] Deb, P., Bhan, A., Hussain, I., Ansari, K. I., Bobzean, S. A., Saha, D., Perrotti, L. I., et al. "Endocrine Disrupting Chemical, Bisphenol-A, Induces Breast Cancer Associated Homeobox

Containing Gene HOXB9 Expression in vitro and in vivo." The FASEB Journal 30 (2016): 1053.2-1053.2.

[7] Hussain, I., Bhan, A., Ansari, K. I., Deb, P., Bobzean, S. A., Perrotti, L. I., & Mandal, S. S. "Bisphenol-A induces expression of HOXC6, an estrogen-regulated homeobox-containing gene associated with breast cancer." Biochimica et Biophysica Acta (BBA)-Gene Regulatory Mechanisms 1849, no. 6 (2015): 697-708.

[8] Deb, P., Bhan, A., & Mandal, S. "Mechanism of transcriptional regulation of EZH2 (H3K27 methyltransferase) by 17 beta-estradiol and estrogenic endocrine disrupting chemicals." Abstracts of Papers of the American Chemical Society 247 (2014): 120.

[9] Bhan, A., Deb, P., Soleimani, M., & Mandal, S. S. "The Short and Medium Stories of Noncoding RNAs: microRNA and siRNA." In Gene Regulation, Epigenetics and Hormone Signaling (2017): 137-168.

[10] Bhan, A., Deb, P., & Mandal, S. S. "Epigenetic code: histone modification, gene regulation, and chromatin dynamics." In Gene regulation, epigenetics and hormone signaling (2017): 29-58.

[11] Deb, P., & Mandal, S. S. "Endocrine disruptors: mechanism of action and impacts on health and environment." In Gene regulation, epigenetics and hormone signaling (2017): 607-638.

[12] Deb, P. "Epigenetic Mechanism of Regulation of Hox Genes and Neurotransmitters Via Hormones and LNCRNA." The University of Texas at Arlington (2017).

[13] Bhan, A., Deb, P., Shihabeddin, N., Ansari, K. I., Brotto, M., & Mandal, S. S. "Histone methylase MLL1 coordinates with HIF and regulates lncRNA HOTAIR expression under hypoxia." Gene 629 (2017): 16-28.

[14] Kalra, Prem K., Mishra, Deepak, and Tyagi, Kanishka. "A Novel Complex-Valued Counter Propagation Network." In 2007 IEEE Symposium on Computational Intelligence and Data Mining, 81-87. IEEE, (2007).

[15] Tyagi, Kanishka, Jain, Rajat, and Prasad, H J Shiva. "A Novel Neuron Model Approach to Real Time Flood Forecasting." In International Conference on Water and Flood Management (ICWFM-2007), vol. 1, 405-412. (2007). ISBN: 984-300-003354-5.

[16] Yadav, Sandeep Kumar, Tyagi, Kanishka, Shah, Brijeshkumar, and Kalra, Prem Kumar. "Audio Signature-Based Condition Monitoring of Internal Combustion Engine Using FFT and Correlation Approach." IEEE Transactions on Instrumentation and Measurement 60, no. 4 (2010): 1217-1226.

[17] Tyagi, Kanishka, Jindal, Vaibhav, and Kumar, Vipunj. "A Novel Complex Valued Neuron Model for Landslide Assessment." In Landslides and Engineered Slopes. From the Past to the Future, Two Volumes+ CD-ROM, 979-984. CRC Press, (2008).

[18] Cai, Xun, and Tyagi, Kanishka. "MLP-Approximation Source Code." IPNN Lab, UT Arlington, Revised on 05, (2010).

[19] Cai, Xun, Tyagi, Kanishka, and Manry, Michael T. "An Optimal Construction and Training of Second Order RBF Network for Approximation and Illumination Invariant Image Segmentation." In The 2011 International Joint Conference on Neural Networks, 3120-3126. IEEE, (2011).

[20] Cai, Xun, Tyagi, Kanishka, and Manry, Michael T. "Training Multilayer Perceptron by Using Optimal Input Normalization." In 2011 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE 2011), 2771-2778. IEEE, (2011).

[21] Tyagi, Kanishka, Cai, Xun, and Manry, Michael T. "Fuzzy C-Means Clustering Based Construction and Training for Second Order RBF Network." In 2011 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE 2011), 248-255. IEEE, (2011).

[22] Godbole, Aditi S., Tyagi, Kanishka, and Manry, Michael T. "Neural Decision Directed Segmentation of Silicon Defects." In The 2013 International Joint Conference on Neural Networks (IJCNN), 1-8. IEEE, (2013).

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 4, Issue 1, January 2018

[23] Tyagi, Kanishka, Kwak, Nojun, and Manry, Michael. "Optimal Conjugate Gradient Algorithm for Generalization of Linear Discriminant Analysis Based on L1 Norm." In International Conference on Pattern Recognition, (2014).

[24] Cai, Xun, Tyagi, Kanishka, and Manry, Michael. "An Efficient Conjugate Gradient Based Multiple Optimal Learning Factors Algorithm of Multilayer Perceptron Neural Network." In International Joint Conference on Neural Networks, (2014).

[25] Cai, Xun, Tyagi, Kanishka, Manry, Michael T., and Chen, Zhi. "An Efficient Conjugate Gradient Based Learning Algorithm for Multiple Optimal Learning Factors of Multilayer Perceptron Neural Network." In 2014 International Joint Conference on Neural Networks (IJCNN), 1093-1099. IEEE, (2014).

[26] Jeong, Il-Young, Tyagi, Kanishka, and Lee, Kyogu. "MIREX 2013: An Efficient Paradigm for Audio Tag Classification Using Sparse Autoencoder and Multi-Kernel SVM." 2013

[27] Tyagi, Kanishka. "Second Order Training Algorithms For Radial Basis Function Neural Networks." Department of Electrical Engineering, The University of Texas at Arlington, (2012).

[28] Cai, Xun, Chen, Zhi, Tyagi, Kanishka, Yu, Kuan, Li, Ziqiang, and Zhu, Bo. "Second Order Newton's Method for Training Radial Basis Function Neural Networks." Journal of Computer Research and Development 52, no. 7 (2015): 1477.

[29] Auddy, Soumitro Swapan, Tyagi, Kanishka, Nguyen, Son, and Manry, Michael. "Discriminant Vector Transformations in Neural Network Classifiers." In 2016 International Joint Conference on Neural Networks (IJCNN), 1780-1786. IEEE, (2016).

[30] Nguyen, Son, Tyagi, Kanishka, Kheirkhah, Parastoo, and Manry, Michael. "Partially Affine Invariant Back Propagation." In 2016 International Joint Conference on Neural Networks (IJCNN), 811-818. IEEE, (2016).

[31] Hao, Yilong, Tyagi, Kanishka, Rawat, Rohit, and Manry, Michael. "Second Order Design of Multiclass Kernel Machines." In 2016 International Joint Conference on Neural Networks (IJCNN), 3233-3240. IEEE, (2016).

[32] Tyagi, Kanishka, and Lee, Kyogu. "Applications of Deep Learning Network on Audio and Music Problems." IEEE Computational Intelligence Society Walter Karplus Summer Research Grant 2013, (2013).

[33] Tyagi, N., & Suresh, S. "Production of cellulose from sugarcane molasses using Gluconacetobacter intermedius SNT-1: optimization & characterization." Journal of Cleaner Production 112 (2016): 71-80.

[34] Tyagi, N., Mathur, S., & Kumar, D. "Electrocoagulation process for textile wastewater treatment in continuous upflow reactor." NISCAIR-CSIR, India (2014).

[35] Tyagi, N., & Suresh, S. "Isolation and characterization of cellulose producing bacterial strain from orange pulp." Advanced Materials Research 626 (2013): 475-479.

[36] Chittoori, Bhaskar, Anand J. Puppala, Rajinikanth Reddy, and David Marshall. "Sustainable Reutilization of Excavated Trench Material." In GeoCongress 2012: State of the Art and Practice in Geotechnical Engineering, 4280-4289. 2012.

[37] Karduri, Rajini Kanth Reddy. "Sustainable Reutilization of Excavated Trench Material." Master's thesis, Civil & Environmental Engineering, University of Texas at Arlington, 2012.

[38] Karduri, Rajini K. R. "The Feasibility of Carbon Neutral Synthetic Fuels." International Journal of Advanced Research in Innovative Discoveries in Engineering and Applications (IJARIDEA) (Dec 2017).

[39] Kumar, D., Tyagi, N., & Gupta, A. B. "Sensitivity analysis of field test kits for rapid assessment of bacteriological quality of water." Journal of Water Supply: Research and Technology—AQUA 61, no. 5 (2012): 283-290.

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

[40] Kumar, D., Tyagi, N., & Gupta, A. B. "Management of Drinking Water Quality at Malviya National Institute of Technology, Jaipur-A Case Study." Nature, Environment and Pollution Technology 10, no. 1 (2011): 155-158.

[41] Kumar, D., Tyagi, N., & Gupta, A. B. "Selective action of chlorine disinfection on different coliforms and pathogens present in secondary treated effluent of STP." 2nd International Conference on Environmental Science and Development (2011).

[42] Tyagi, M. M. A. K. "Identifying knowledge gaps in incorporating effects of nanoparticles' presence on bacterial resistance in combination to antibiotics."