The Review of Contemporary Scientific and Academic Studies
An International Multidisciplinary Online Journal
www.thercsas.com

ISSN: 2583-1380 Vol. 4 | Issue No. 3 | March 2024 Impact Factor: 4.736 (SJIF)

Microgrids and Distributed Energy Resources (DERs)

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 Crossref/DOI: https://doi.org/10.55454/rcsas.4.03.2024.002

Abstract: *DERs and microgrids are novel technologies that offer a plethora of benefits to consumers and the grid. The technologies ensure a steady supply of eco-friendly energy at affordable rates to end users. Besides, microgrids and DERs provide extra energy sources to the grid, reduce grid operational costs, reduce grid load, and enhance the resilience of grids. These technologies can be integrated into the grid sustainably by modernizing the grid to accommodate them and leveraging weather forecasting tools to predict their future energy output.*

Keywords: DERs, Eco-Friendly Energy, Microgrids, Power Grids, Renewable Energy

Article History: **Received: 28 Feb- 2024;** **Accepted: 10 March- 2024;** **Published/Available Online: 30 March- 2024**

Introduction

Populations across the globe have always relied on the grid to fulfill their electricity needs. Power supply systems have always been able to meet the energy needs of the populations it serves. However, recent reports from countries across the globe indicate that power grids are becoming incapable of meeting end users' energy needs. For instance, the United States grid has increasingly become unable to meet the power demands of its people sustainably [1]. Prolonged brownouts and blackouts have become a norm in many states, with some cases resulting in deaths. A Study by Scientific American indicates that since 2013, incidences of prolonged blackouts have doubled [2]. Similar cases are replicating in many developed countries such as France, Japan, and Canada.

While the worsening unreliability of power grids across the globe can be attributed to factors such as lack of continued investments, the reality is that current power grids are more advanced and capable than previous electricity systems. Problems facing contemporary grids relate to surging demand for electric power and emerging trends in energy consumption. As the global population rises, the demand for electricity also grows. Similarly, as more technologies, such as EVs, shift to the grid, the demand for electric energy also increases. Vacillations in electricity demand throughout the day and week are also affecting the stability of the grid. High demands in the morning and extremely low demands in the evening are exerting pressure on the grid. One of the solutions to grid instability is promoting the development of microgrids and Distributed Energy Resources (DERs).

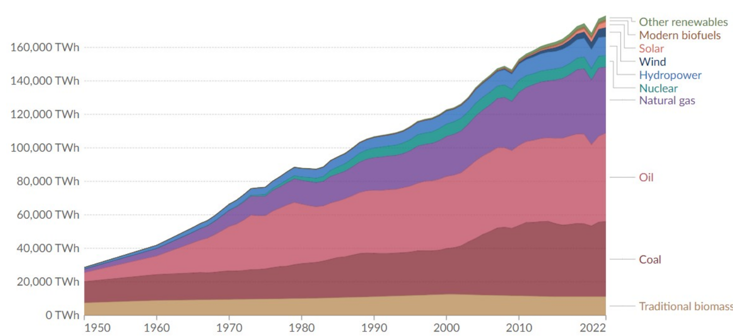

Figure 1: Electricity demand growth since 195. Source: Our World in Data.

Microgrids and Distributed Energy Resources

The National Renewable Energy Laboratory defines microgrids as a group of interconnected loads and distributed energy resources that can be controlled independently from the grid [3]. Microgrids can be connected or disconnected from the grid to operate in grid-connected or island mode. Microgrids usually comprise multiple sources of power, like solar panels, wind turbines, and generators. Typically, these mini power supply systems serve discrete geographic footprints such as schools, hospitals, business centers, and neighborhoods. Distributed energy resources are modular energy generation and storage technologies that provide electric energy for serving its immediate surroundings. DERs produce less than 10 megawatts of power. Like microgrids, DERs can either be connected to the grid or not. They include technologies such as photovoltaics, microturbines and reciprocating engines [4].

Proliferation of Microgrids and DERs

Microgrids and DERs are emerging technologies that are yet to make a significant impact on power grids. According to insights from the Center for Climate and Energy Solutions, microgrids provide less than 0.3 percent of the United States electricity. However, the report notes that microgrids capacity has grown by 11 percent in the past four years and is set to grow exponentially in the future [5]. Precedence Research asserts that the microgrid market size is about $36.05 billion and is projected to grow at a compound annual growth rate (CAGR) of 18.7 percent, surpassing the market value of $168.64 billion by the end of 2032 [6]. The United States Distributed Energy Resources is expected to double its capacity by 2027. According to Wood Mackenzie's report, about 262 gigawatts of DER sources will be installed across the United States [7]. Grand View Research propounds that the global distributed energy generation market size is expected to grow at a compound annual growth rate of 11.5 percent, reaching a value of $ 580.8 billion by 2027 [8].

The proliferation of microgrids and distributed energy resources is mainly fueled by the benefits they offer. Some of the top benefits these technologies offer include:

Power reliability: These technologies can provide reliable power supply in regions with frequent brownouts and blackouts. With their own power sources and energy storage facilities, power grids, and DERs can ensure critical loads are always powered.

Energy independence: Microgrids and DERs can give their owners energy independence by enabling them to generate and store their energy. Users no longer have to wait for utilities to maintain or upgrade their grids to meet their changing needs.

Remote energy: Utilities often find serving remote populations economically unviable. Microgrids and DERs allow households and institutions in remote areas to harness the energy within their surroundings and convert it into electricity.

Cost savings: Microgrids and DERs are cost-effective. Once the technologies are installed, users may not have to pay monthly power bills. Most of these technologies are quite reliable and only require minimal maintenance.

Resilience: Microgrids and DERs are made of small supply networks. Even in the face of natural disasters such as extreme weather conditions, these networks are hardly affected. They can continue powering critical loads even when main grids are down.

Environmental sustainability: Microgrids and DERs typically generate power from renewable resources such as wind and solar. Households and institutions that leverage these technologies can significantly reduce their carbon footprint.

Impact of Microgrids and DERs on the Grid

The advent of microgrids and DERs has had a profound impact on the grid. While issues, such as integration challenges and the variability of energy produced by these technologies, considerable challenges; their overall effect is positive. Some of the defining impacts of DERs and microgrids on the grid include:

- *Extra energy sources:* The global demand for electricity is continuously surging. Most projections indicate that by 2030 many countries' contemporary energy grids may not be able to support their citizens' energy needs. To keep at par with the growing energy demand, power utilities must find alternatives to ramp up their power production. Distributed energy sources provide a novel way for utilities to produce extra energy. Currently, the European Union produces 21 percent of its energy from DERs and aims to increase the share to 32 percent by 2030 [9]. Countries that adequately exploit DERs and microgrid technologies can enhance their grid power generation by as much as 50 percent.
- *Lower grid load:* One of the major problems facing the grid is the increased demand for power due to global population growth and many technologies shifting from fossil fuel energy to electric

ISSN: 2583-1380 Vol. 4 | Issue No. 3 | March 2024 Impact Factor: 4.736 (SJIF)

energy. Power utilities can reduce grid load by encouraging consumers to generate their own electricity using DERs. For example, instead of solely investing in centralized electricity generators and power networks, utilities can alter their business models by launching programs for installing photovoltaics in consumers' homes. These institutions can also invest in initiatives that help facilities such as schools and hospitals to develop their own microgrids.

- *Clean grid:* The grid has traditionally relied on non-green energy sources such as coal and oil. Though these sources can produce large quantities of electricity, they have an adverse carbon footprint on the environment. DERs such as photovoltaics and wind turbines can decarbonize the grid by reducing reliance on non-green sources. Many governments are keen on integrating DERs into their grids in an effort to create smart grids that are environmentally friendly [5].
- *Resilient grid:* One of the top benefits of integrating DERs and microgrids into the grid is enhanced stability, reliability, and resilience of the grid [10]. The primary cause of blackouts is the failure of interconnected power lines. DERs and microgrids can operate independently as islands. Failure in the main grid is less likely to affect these systems, preventing cascading blackouts. These technologies can also be designed to inject extra electricity to the grid. This provides additional electric energy in the grid to meet the growing load.
- *Economic benefits:* DERs and microgrids offer multiple economic benefits to the grid. Unlike fossil fuels, these technologies harness free renewable energy. Microgrids and DERs also require minimal maintenance. For example, photovoltaics can operate without significant hitches for up to 20 years. Grid expansion is quite expensive. According to the International Growth Center, grid transmission expansion costs can range from $1.0 to $1.5 million per mile, with an additional $0.5 million per mile for distribution [11]. Instead of expanding the grid to serve remote areas, utilities can cost-effectively build DERs and microgrids to serve these regions.

Impact on Utilities' Business Model

Traditionally, power systems were designed for information and power to flow in one direction, from the grid to end users. The advent of microgrids and DERs has disrupted this structure. Modern grids are multidirectional [12]. DERs and microgrids have enabled the emergence of prosumers. Prosumers are end users who use DERs to generate their electricity and feed surplus into the grid. Prosumers impact utilities' business model in two major ways. One, utilities have to install meters that can measure grid energy used by prosumers, and the energy prosumer systems feed into the grid. Utilities calculate energy input into the grid from microgrids and only bill prosumers for the extra energy they use from the grid, that their DERs do not compensate. This results in low power bills for consumers. Two, instead of utilities selling electricity to end users, they loan them DER and microgrid technologies and bill them monthly until the debt is settled.

Conclusion

DERs and microgrids are novel technologies that not only enhance grid resilience and stability but also offer their users cost benefits. Despite their profound impact on the grid, the assimilation of these technologies is challenging due to various issues. The most concerning issue is the variability of energy produced by these systems. Renewable sources such as wind and solar depend on the weather patterns. This weakness can be addressed by leveraging weather forecasting tools that can help users prepare for low-energy production in advance. Another issue relates to challenges integrating the technology into outdated grid systems. This can be addressed by modernizing the grid. Generally, DERs and microgrids are progressive technologies that promise to strengthen the grid and lower energy costs.

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