Reliable Electricity Supply as a Foundation for Sustainable Development: Challenges, Opportunities, and Future Energy Strategies

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Abstract

Reliable electricity underpins almost every aspect of sustainable development, from industrial productivity and job creation to health care, education, and digital services. Yet in 2023, more than 666 million people still lacked basic access to electricity, about 85% of them in Sub-Saharan Africa (IEA et al., 2025). At the same time, demand is rising quickly in many economies, driven in part by the rapid growth of data centers and artificial intelligence (AI). This article examines why reliable supply matters for development, the challenges that threaten it, and the opportunities and strategies that can strengthen it. It draws on evidence on energy access, the economic cost of power shortages, the grid impacts of large new loads, and the potential of flexible demand and stranded power. It argues that future energy strategies must expand access, integrate renewable energy, harness demand flexibility, and use digital tools to manage increasingly complex power systems.

1. Introduction

Electricity is often described as an enabler rather than an end in itself. Factories need it to run machines, hospitals to keep vaccines cold and equipment working, schools to provide lighting and digital learning, and households to cook, study, and communicate. Increasingly, entire economies depend on digital services that rely on a constant flow of power to data centers and communication networks. For all of these uses, the reliability of supply matters as much as its availability. A connection that fails for hours each day cannot support a modern business or a functioning health system.

The United Nations recognized this in Sustainable Development Goal 7, which calls for universal access to affordable, reliable, sustainable, and modern energy by 2030. Progress has been made, but the goal remains out of reach for hundreds of millions of people. Meanwhile, countries that already have near-universal access face a different reliability challenge: rapid growth in demand from new sectors. Anioke (2025) shows that the expansion of data centers is raising total electricity demand, creating new risks for grid stability, and complicating the transition to sustainable energy.

This article treats reliable electricity as a foundation for sustainable development and asks how it can be secured in a period of rising demand and energy transition.

2. Why Reliable Electricity Matters for Development

2.1 Access as a Starting Point

The most basic form of reliability is having a connection at all. The latest global tracking report on energy access found that nearly 92% of the world's population had basic access to electricity in 2023, leaving more than 666 million people without it (IEA et al., 2025). Sub-Saharan Africa is home to about 85% of those without access. The same report found that about 2.1 billion people still relied on polluting fuels for cooking, with serious consequences for health, particularly for women and children.

2.2 The Economic Cost of Unreliable Supply

Access alone is not enough. In many developing economies, businesses with a grid connection still face frequent outages. Allcott et al. (2016) studied the effect of electricity shortages on Indian manufacturing. They found that at average shortage levels, plant revenues and producer surplus fell by about 5 to 10 percent. Productivity losses were smaller, because many inputs can be stored during outages, but shortages also distorted the economy. Because backup generators involve large fixed costs, smaller plants without generators were hit harder than larger ones. Unreliable power therefore holds back the small and medium enterprises that are often the main source of jobs in developing countries.

2.3 Health, Education, and Daily Life

Reliable power also shapes human development directly. Health clinics need electricity to refrigerate vaccines, sterilize equipment, run diagnostic tools, and provide light for care at night. Schools need it for lighting, computers, and internet access. Households use it to study after dark, run small businesses from home, and stay connected to information and public services. When supply is unreliable, these benefits shrink or disappear, and families often turn to costly and polluting alternatives such as kerosene lamps or diesel generators. Reliability therefore affects not only incomes but health, learning, and gender equality, since women often bear the greatest burden of energy poverty.

2.4 Reliability in a Digital Economy

As economies digitalize, the cost of unreliable power rises. Banking, government services, education, and commerce increasingly depend on data centers and networks that must run continuously. Anioke (2025) notes that data centers both depend on and affect the reliability of the grid. The reliability of electricity supply has therefore become a foundation not only for traditional development goals but for participation in the digital economy.

3. Challenges to Reliable Electricity Supply

3.1 Persistent Access Gaps and Underinvestment

Closing the access gap requires sustained investment in generation, grids, and off-grid systems. The tracking report found that international public financial flows to clean energy in developing countries reached USD 21.6 billion in 2023, up from the previous year but still below their 2016 peak (IEA et al., 2025). Without greater investment, many countries will struggle to extend reliable supply to remote and low-income communities.

3.2 Rapid Demand Growth

In many economies, demand is now rising faster than at any time in decades. Data centers are a major driver. The International Energy Agency (IEA, 2025) projects that global data center electricity consumption will more than double from about 415 TWh in 2024 to around 945 TWh in 2030, and estimates that grid constraints could delay about 20% of planned projects. Data centers also tend to cluster in particular regions, concentrating pressure on local grids (Anioke, 2025). Rapid growth from one sector can strain supply for all other users if generation and transmission do not keep pace.

3.3 New Types of Load and Grid Stability

Some new loads also behave differently from those that grids were designed for. Chen et al. (2025) explain that AI data centers can change their demand sharply within seconds and connect to the grid through power electronic converters, which respond to disturbances differently from traditional equipment. In July 2024, a transmission fault in Northern Virginia caused about 1,500 MW of data center load to disconnect at once as facilities switched to backup power (North American Electric Reliability Corporation [NERC], 2025). The grid remained stable, but NERC (2025) warned that such events pose a growing risk as large loads expand.

3.4 Climate Risks and Aging Infrastructure

Power systems face growing physical risks. Heatwaves increase demand for cooling while reducing the efficiency of power plants and transmission lines. Storms, floods, and wildfires can damage poles, substations, and generation facilities, causing long outages. In many countries, much of the existing grid infrastructure is also aging and in need of replacement. Building reliability in the future therefore means not only adding capacity but making grids more resilient to extreme weather and investing in the maintenance and modernization of existing assets.

3.5 Affordability

Reliability must also be affordable. If the cost of new generation, transmission, and grid upgrades is passed on to consumers without care, electricity can become too expensive for low-income households and small businesses. Anioke (2025) notes that fair allocation of the costs created by large new loads, such as data centers, is essential if their growth is to remain sustainable and publicly accepted.

3.6 Integrating Variable Renewable Energy

Renewable energy is essential for sustainable development, but wind and solar output varies with the weather. Integrating large amounts of variable generation requires storage, flexible demand, stronger grids, and better forecasting. Where transmission is weak, renewable output is often curtailed because it cannot be delivered, wasting clean energy that could have supported development (Kim et al., 2017).

4. Opportunities for Strengthening Reliability

4.1 Renewable and Decentralized Energy

Falling costs of solar panels and batteries have made decentralized systems a practical way to extend reliable power to communities far from the grid. Mini-grids and solar home systems can deliver electricity faster than grid extension in many rural areas. At larger scale, renewables are now among the cheapest sources of new generation in many countries, allowing supply to grow without increasing fuel imports or emissions.

4.2 Demand Flexibility

One of the most promising opportunities lies on the demand side. Norris et al. (2025) examined the 22 largest balancing authorities in the United States and found that existing grids could accommodate about 76 GW of new load if that load accepted curtailment for an average of just 0.25% of the year. Grid stress is concentrated in a small number of peak hours, so large customers that can reduce demand during those hours allow far more load to be served reliably without new infrastructure. Allcott et al. (2016) reached a related conclusion in India, finding that offering interruptible electricity contracts could substantially reduce the impact of shortages on industry. In both rich and developing economies, flexibility is a low-cost route to reliability.

4.3 Recovering Stranded Power

Anioke (2026) describes stranded power as electricity or capacity that exists but goes unused, including renewable output that is curtailed and capacity reserved inside facilities that is rarely drawn. Putting this power to productive use can improve both reliability and sustainability. Kim et al. (2017) showed that flexible data centers placed optimally across a power system can absorb surplus renewable energy, reduce stranded power, and lower system costs. The same principle can apply to other flexible loads, such as water pumping, cold storage, or industrial processes.

4.4 Regional Interconnection and Grid Modernization

Connecting national and regional grids allows countries to share generation resources, balance variable renewable output across larger areas, and support each other during emergencies. Regional power pools can reduce the cost of reliable supply, particularly for smaller economies. Modernizing distribution networks with automated switching and

better monitoring can also shorten outages and isolate faults more quickly, improving reliability for every customer on the network.

4.5 Digital Tools and Analytics

Managing increasingly complex power systems requires better information. Smart meters, sensors, and forecasting tools give utilities a clearer picture of demand and supply. Enterprise systems can help organizations link energy data to operations and planning. Asuri (2019) examines how embedded analytics and modernized interfaces within enterprise resource planning (ERP) systems can improve visibility and operational performance, and Asuri (2023) describes how large language models can be integrated with enterprise platforms to enable intelligent automation. Applied to energy, such tools could help utilities and large consumers track reliability, plan maintenance, and manage demand more effectively.

5. Future Energy Strategies

Building reliable electricity systems that support sustainable development will require action on several fronts:

1. **Close the access gap** through a combination of grid extension, mini-grids, and off-grid solar, backed by increased international finance (IEA et al., 2025).
2. **Plan for rapid demand growth,** including new loads such as data centers, using scenario-based forecasts and coordinated investment in generation and transmission (Anioke, 2025; IEA, 2025).
3. **Make flexibility a core resource** through interruptible contracts, demand response, and flexible interconnection for large loads (Allcott et al., 2016; Norris et al., 2025).
4. **Strengthen grid stability standards** so that large new loads stay connected during routine disturbances, and model their behavior in planning studies (Chen et al., 2025; NERC, 2025).
5. **Integrate renewables with storage and flexible demand,** and put stranded renewable power to productive use (Anioke, 2026; Kim et al., 2017).
6. **Invest in digital tools and analytics** to manage supply, demand, and reliability in real time (Asuri, 2019, 2023).

6. Conclusion

Reliable electricity is a foundation on which nearly every other development goal rests. Without it, businesses lose revenue, small firms struggle to grow, health and education services falter, and countries cannot fully join the digital economy. The challenges are considerable: hundreds of millions of people still lack access, investment remains insufficient, demand is rising rapidly in many regions, and new types of load and variable renewable generation are making grids more complex to manage. Yet the opportunities are equally significant. Decentralized renewable systems can extend access quickly, flexible demand can make existing grids go further, stranded power can be recovered, and digital tools can help operators manage complexity. Future energy strategies that combine these approaches can deliver electricity that is not only available but reliable, affordable, and sustainable, providing a firm foundation for development in the decades ahead.

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