

In Depth Q&A - How viable are microgrids as a mitigation strategy for energy poverty and climate change in the Global South?

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Introduction:

Access to electricity remains a significant challenge in the [Global South](#), where millions of people still lack reliable power. Expanding traditional grids to remote or underserved areas is often impractical due to high costs, challenging terrain, and logistical constraints. As a result, many communities continue to rely on inefficient, carbon-intensive energy sources such as kerosene lamps and diesel generators, which not only sustain energy poverty but also contribute to greenhouse gas (GHG) emissions and climate change.

[Micro Grids](#)—small, self-sustaining renewable energy systems—offer a viable and cost-effective alternative to this issue. By utilizing locally available energy sources like solar power, these decentralized systems can provide clean and affordable electricity to households and small businesses. In doing so, micro grids present a critical opportunity for integrating energy access into climate mitigation strategies, making them an essential topic within the scope of our Climate Change Mitigation Strategies course. This Q&A aims to explore the tangibility, global scale and benefits of micro grids as a renewable energy source and climate change mitigation strategy in the Global South.

Questions :

1. What is the expected lifespan of microgrids, what are their maintenance and operational costs?
2. To what extent can micro grids be scaled in different regions of the Global South?
3. How do microgrids compare to conventional off-grid energy sources, such as kerosene and diesel generators, in terms of emissions, air pollution, and environmental impact?
4. How do microgrids improve energy access for underserved communities, particularly marginalized groups such as women, rural populations, and low-income households?

5. Are microgrids a more cost-effective alternative over time compared to traditional solutions?
6. What role could microgrids play in meeting international energy access and climate targets by 2030 or 2050?



1. What is the expected lifespan of microgrids, and what are their maintenance and operational costs?

The lifespan of microgrids varies significantly depending on their design, technology, and their operational context. Studies and real-world examples provide insights into their durability. Some microgrids have demonstrated long-term viability. For instance, the [Keur microgrid in Senegal](#) was still operational seven years after its implementation, highlighting the potential for sustained success when systems are well-designed and supported. However, not all microgrids achieve such longevity. A study analyzing 50 microgrids implementation worldwide between 1994 and 2017, found that approximately [50% had failed](#). In Africa, many microgrids fail to last beyond the [initial funding phase](#), often due to financial, technical, or social challenges. The lifespan of a microgrid is heavily influenced by system design, particularly [battery bank sizing](#). Properly sized and maintained battery systems are crucial for ensuring reliable power supply and extending the systems operational life. Maintenance and operational costs are key determinants of a microgrid's sustainability. These costs include routine maintenance, battery replacement, and repairs to system components. Batteries are often the [most expensive](#) component of microgrids.

Most systems require battery replacements every 3-5 years, which can be a significant financial burden. Projects must generate sufficient revenue to cover these lifecycle costs to remain sustainable. Studies in [Malawi](#) have shown that 45% of microgrid systems experience some form of technical issue, with 38% losing all service at some point. These failures often stem from inadequate system design or poor maintenance practices, underscoring the importance of robust technical planning and community capacity building. This sustainability analysis in Malawi provides useful insights in the design of solar PV projects for community energy practitioners. Microgrids in remote and poor settings often rely on external financing or scaling up, negotiating tariffs, and subsidizing battery recycling. Without such support, many systems struggle to cover their operational costs, leading to eventual [failure](#). Many microgrids fail to generate enough revenue to cover their operational and maintenance costs, particularly in low-income communities. [External financing](#) and subsidies are often necessary to bridge this gap. Microgrids are more successful when they are embedded within and accepted by the community. Projects that lack local ownership or fail to align with community needs are more likely to fail. [Engaging local communities](#) in the planning, implementation, and management of microgrids fosters ownership and ensures that projects align with local needs and priorities. Frequent changes in electrification policies, as seen in [Ecuador](#), can disrupt microgrid projects. A stable regulatory framework is essential for long-term planning and investment.

Governments should establish consistent and supportive policies for rural electrification to create an enabling environment for microgrid development. Inadequate system design, particularly undersized battery banks, is a common cause of failure. Properly designed systems that account for local energy needs and conditions are more likely to perform well over time. Also, [training local technicians](#) and



managers to operate and maintain microgrids is critical for ensuring their long-term functionality. Private entrepreneurs may prioritize financial returns over environmental and social sustainability, potentially leading to projects that do not fully address community needs or environmental impacts. Combining the efforts of governments, private sector actors, and NGOs can provide the necessary financial, technical, and social support for sustainable microgrid projects. Microgrids offer a flexible and context-sensitive solution for electrifying remote and underserved communities. However, their success depends on careful design, adequate financing, strong community engagement, and supportive policies. While some microgrids have demonstrated long-term viability, many fail due to technical, financial, or social challenges. By

addressing these issues through collaborative and context-specific approaches, microgrids can play a vital role in achieving universal energy access and sustainable development.

2. To what extent can microgrids be scaled in different regions of the global south?

In Sub-Saharan Africa, micro grids have shown both promise and limitations. The introduction of a mini-grid in [Entasopia, Kenya](#), had a positive impact on local businesses, including a petrol station, a cinema, an electrical repair shop, and a nightclub. This demonstrates the potential for pico grids to boost local economies and productivity. But, in countries such as Benin, Burkina Faso, Rwanda, Senegal, and Uganda, the impact of electrification on firm creation and development has been [modest](#). Researchers argue that in rural and remote areas, lack of market access is a greater constraint on non-agricultural productivity than access to electricity. Therefore, it is noted that scaling microgrids in Sub-Saharan Africa requires integrated approaches that address not only energy access but also market linkages and economic opportunities.

In Southeast Asia, [community-operated microgrids](#) have provided essential electricity services but face challenges related to reliability and governance. Many microgrids are governed by community leaders which can lead to inconsistent load management and operational inefficiencies. [Power outages](#) are common due to unfavorable weather, technical failure, and unexpected user behavior. Strengthening technical capacity and establishing clear regulatory frameworks are critical for scaling microgrids in Southeast Asia.

Bangladesh's solar home system (SHS) industry is a standout example of [successful](#) scaling in South Asia. Between [2003 and 2015](#), Bangladesh created 31,750 jobs in its solar manufacturing sector, with over four million SHSs distributed nationwide. Despite this success, households experience frequent power outages due to unfavorable weather, technical failures,



and user dependency. State support and industrial policy can drive scaling, but addressing reliability issues is essential for long-term sustainability.

The Pacific Islands have abundant solar resources but face [unique challenges](#). There are no specific policies or legislation on mini-grids in the Federated States of Micronesia, leading to ambiguities in rural electrification efforts. High import duties, taxes, and land access issues complicate the development of renewable energy projects. Tonga has successfully used solar PVs for household electrification in rural areas and remote islands for nearly [20 years](#). Clear policies, fiscal incentives, and community engagement are needed to unlock the potential of microgrids in the Pacific Islands.

3. How do microgrids compare to conventional off-grid energy sources, such as kerosene and diesel generators, in terms of emissions, air pollution, and environmental impact?

Microgrids offer significant environmental advantages over conventional off-grid energy sources like kerosene and diesel generators, particularly in terms of emissions, air pollution, and overall environmental impact. Diesel generators emit [2.5 kg](#) of CO₂ per liter of fuel consumed, making them a major contributor to climate change, with a leveled cost of energy (LCOE) ranging from [\\$0.92/kWh to \\$1.30/kWh](#), making them both environmentally harmful and economically unsustainable. In contrast, solar photovoltaic (PV) systems in hybrid renewable energy setups have an LCOE of [\\$0.40/kWh to \\$0.61/kWh](#), proving to be both a cleaner and cheaper alternative. LCOE is the average cost per unit of electricity generated over a system's lifetime, including capital, operation, and maintenance costs. It helps compare the cost-effectiveness of different energy sources.

Additionally, diesel and kerosene use releases particulate matter (PM), [nitrogen oxides \(NOx\)](#), and [sulfur oxides \(SOx\)](#), which contribute to respiratory diseases, cardiovascular issues, and environmental degradation, whereas micro grids powered by solar energy eliminate these emissions entirely, leading to cleaner air and improved public health especially useful in rural areas wherein people do not have access to advanced health infrastructure. Beyond air pollution, diesel-based energy sources require continuous [fuel transportation and maintenance](#), contributing to habitat destruction and pollution, while micro grids, particularly solar-powered ones, have [minimal ongoing environmental](#) impact after installation. The cost volatility of fossil fuels further makes diesel and kerosene an unreliable energy source, whereas micro grids powered by renewables offer stable, predictable and clean energy costs.



4. How do microgrids improve energy access for underserved communities, particularly marginalized groups such as women, rural populations, and low income households?

One of the most significant impacts of microgrids is their ability to boost income-generating activities, particularly for women and rural entrepreneurs. For example, in Tanzania, a [66-year-old entrepreneur](#) saw her monthly income rise by US 22-44 after gaining access to a single solar panel. Similarly, in Nepal, solar home systems (SHS) enabled rural women to earn additional income through [knitting and sewing](#). In Bangladesh, access to SHS increased women's income by [US \\$2](#) per day, contributing to higher household expenditure and income generation. Beyond individual benefits, microgrids also create jobs. According to [GOGLA](#), for every 100 SHS sold, an estimated four jobs are created in East Africa and 21 jobs in West Africa, with most employment concentrated in rural areas and undertaken by women.

These examples highlight how microgrids can serve as a catalyst for economic empowerment, particularly for marginalized groups. However, the benefits of electricity access are [not always evenly distributed](#). Affluence tends to be unequally distributed and because electricity has to be paid for, poorer groups risk being excluded from access. This underscores the importance of understanding the daily struggles of various groups and the barriers they face in taking advantage of available electricity services.

Microgrids often do more than just provide electricity—they can also strengthen social structures and foster community development. In [Sabah, Malaysia](#), for instance, microgrid projects have become a focal point for community coordination. Facing challenges such as the encroachment of palm oil plantations, villages have used microgrid projects as a platform to work together toward common goals. The collaborative nature of these projects fosters mutual benefits and strengthens community ties. However, the success of community managed microgrids depends on local capacity and accountability. While some communities excel at maintaining their systems and minimizing service interruptions, others struggle with technical

and operational challenges. This variability underscores the importance of providing adequate training and support to ensure long term sustainability.



5. What are the financial implications of transitioning to microgrids, considering both upfront costs and long-term savings?

The initial investment required to deploy microgrids can be substantial, often posing a significant barrier to adoption. Solar panels, batteries, inverters, and other equipment account for a large portion of upfront costs. Hardware costs for solar microgrids can range from [2,000 to 5,000 per kilowatt](#) (kW) of installed capacity. In remote areas, the lack of existing infrastructure can drive up costs for distribution lines, transformers and other grid components. Customized system design and engineering services are often required to tailor microgrids to local conditions, adding to upfront expenses. Despite the high initial investment, microgrids can generate significant long-term savings and economic benefits. By harnessing renewable energy sources such as solar and wind, microgrids can reduce reliance on expensive diesel generators or grid electricity.

Microgrids in remote areas can achieve levelized costs of energy (LCOE) as low as [0.20-0.30 per kilowatt-hour](#) (kWh), compared to 0.50-1.00 per kWh for diesel-based systems. Avoided grid expansion costs: In areas where extending the central grid is prohibitively expensive, microgrids offer a cost-effective alternative. Microgrids can [save up to 60% of the costs](#) associated with grid extension in remote regions. Access to reliable electricity can boost local economies by enabling income-generating activities, creating jobs, and improving productivity. Financing is a major challenge for microgrid deployment, particularly in low-income settings.

Several financing models have been explored:

Pay-as-you-go ([PAYG](#)): This model allows users to pay for electricity in small increments, making it more affordable for low-income households. However, it requires robust payment systems and can limit revenue generation for operators.

Public-private partnerships ([PPPs](#)): Collaborations between governments, private companies, and NGOs can provide the necessary capital and expertise for microgrid projects. However, aligning the interests of different stakeholders can be challenging.

Subsidies and grants: Government subsidies and international grants can help offset upfront costs, but they may not be sustainable in the long term.

Innovative financing models are needed to overcome the high upfront costs and ensure the financial sustainability of microgrids. Transitioning to microgrids involves significant upfront costs but offers [substantial long-term savings](#) and economic benefits. By reducing energy costs, avoiding grid expansion expenses, and enabling economic development, microgrids can play a vital role in improving energy access and sustainability. However, addressing the financial challenges of microgrid deployment—including high upfront costs, ongoing O&M expenses, and financing barriers—is essential for scaling their impact. Innovative financing models, public-private partnerships, and effective O&M strategies will be critical for ensuring the long-term financial viability of microgrids. As the world continues to grapple with energy access and climate change, microgrids offer a promising pathway to a more equitable and sustainable energy future.

6. What role could microgrids play in meeting international energy access and climate targets by 2030 or 2050?

Microgrids, as a form of decentralized energy solution, could play a critical role in advancing international energy access and climate targets by 2030 and 2050. Their impact can be analyzed across several key areas:

[Expanding Energy Access](#): By 2030, micro-grids are projected to provide energy to an estimated 630 million people. These small-scale energy systems can reach remote and underserved communities, especially in regions where traditional grid expansion is not feasible. In countries like Kenya and India, where decentralized solar energy solutions have seen rapid adoption, micro grids further accelerate electrification efforts.

[Leveraging Solar Power for Development](#) : The exponential growth of solar photovoltaic (PV) capacity—from 1.8 GW in 2000 to 187 GW in 2014—highlights the increasing viability of solar energy as a solution for global energy needs. The falling costs of solar technology, which in some developing regions are already cheaper than fossil fuels, make solar-powered micro grids a cost-effective and sustainable energy alternative. The transition to renewable energy is central to global climate strategies. [The IEA's World Energy Outlook](#) 2023 projects that, based on current policy settings, renewables' share of the global electricity mix will approach 50% by 2030, up from around 30% today. Micro grids facilitate the integration of renewable energy at the local

level, reducing reliance on fossil fuels and contributing to the decarbonization of the energy sector.

Meeting International Targets - The deployment of microgrids, particularly those powered by renewable energy sources, aligns closely with international climate commitments and decarbonization efforts. Notably, the [COP29 Global Energy Storage and Grids Pledge](#) sets ambitious targets to enhance global energy infrastructure by 2030, including: Deploying 1,500 GW of energy storage, which is more than six times the capacity of 2022 levels and developing or refurbishing [25 million kilometers of grid infrastructure](#), aiming to double global grid investments. Microgrids contribute significantly to these objectives by enabling localized renewable energy generation and storage, thereby reducing reliance on fossil fuels and lowering carbon emissions. Their integration into the broader energy network enhances grid resilience and supports the transition to a sustainable, decarbonized energy system.

Microgrids are more than just a technological innovation; they represent a transformative shift toward energy sovereignty, affordability, and sustainability. By providing cheaper electricity, reducing reliance on fossil fuels, and fostering local economic resilience, microgrids empower communities—especially in the Global South—to take control of their energy futures. Their ability to integrate renewable energy sources makes them a crucial tool in mitigating climate change, directly supporting international commitments like the Paris Agreement and the Sustainable Development Goals. As the world faces increasing energy insecurity and environmental crises, microgrids stand as a practical, scalable, and equitable solution—bridging the gap between energy access and a cleaner, more resilient future.



Calculations and Figures to support our findings -

1. Emissions calculation for 630 Million People gaining energy access from Solar VS Diesel

- In India, the average daily electricity consumption per person is roughly [1.33 megawatt-hours per year](#)
- Diesel Generators: Approximately [1,000 grams CO₂ per kWh generated](#)
- Solar PV Micro Grids: Approximately [48 grams CO₂ per kWh generated](#) (considering life-cycle emissions)

1. Per Day average consumption = $(1.33 \text{ MWh/year} * 1000 \text{ KWh})/365 \text{ days} = 3.64 \text{ kWh/day}$

2. Total annual electricity consumption for 630 million people = $630,000,000 \times 3.64 \times 365 = 837.9 \text{ billion kWh/year}$

3. Diesel Generator emissions =

$837.9 \text{ billion kWh} \times 1000 \text{ g CO}_2/\text{kWh} = 837.9 \text{ million metric tons of CO}_2 \text{ annually}$

4. Solar PV emissions =

$837.9 \text{ billion kWh} \times 48 \text{ g CO}_2/\text{kWh} = 40.2 \text{ million metric tons of CO}_2 \text{ annually}$

Transitioning 630 million people from diesel-based energy to solar-powered Microgrids could result in an annual CO₂ reduction of approximately 797.7 million metric tons. This represents a 95% decrease in emissions compared to diesel generation, significantly advancing global climate goals. Proving that Microgrids can play a crucial role in CO₂ mitigation especially in the Global South.

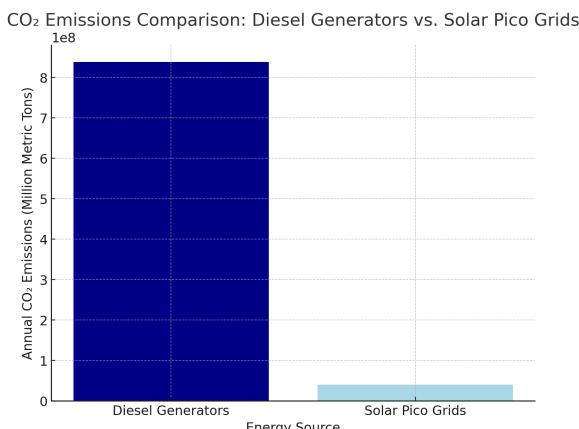


Figure showcasing the data visualization of the emissions calculation for the projected 630 Million people gaining energy access from Solar VS if they gained access from diesel generators.

2. LCOE of diesel generator VS solar micro grid

[LCOE for diesel generators](#)

Capital Cost: \$700/kW

Fuel Cost (including O&M): \$0.20/kWh

Lifetime: 10 years

$$= (700/10) + 0.20 = 70.2 \text{ USD/MWh}$$

LCOE for Solar PV

Capital Cost: \$1,200/kW (for utility-scale solar)

O&M Cost: \$0.02/kWh

Lifetime: 25 years

Capacity Factor: 20% (0.02)

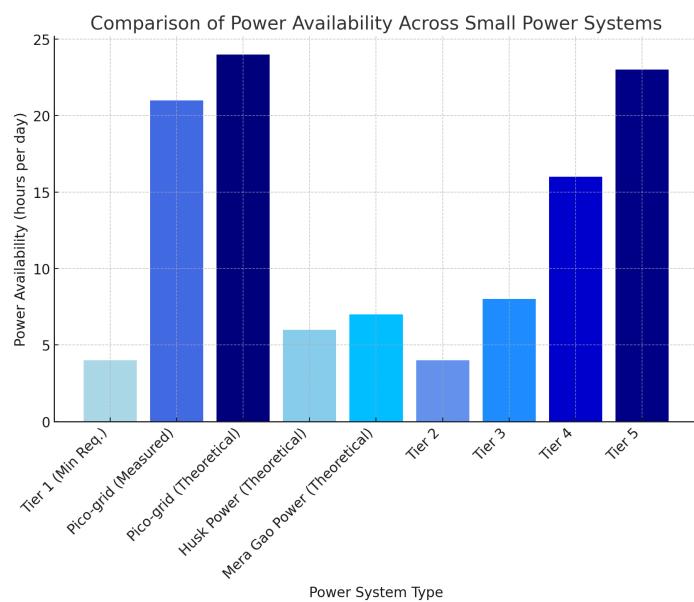
Total Hours per Year: 8,760 hours

$$0.2 \times 8760 = 1,752 \text{ kWh/year}$$

$$1200 / (25 * 1752) = 0.027 + 0.02 = 47.4 \text{ USD/MWh}$$

The LCOE for Solar PV is about \$22.8 less than that of the LCOE of a diesel generator. Proving that Solar PV powered microgrids are both cost effective and green!

Figure 2 - Comparison of Power Availability Across Small Power Systems



Using data from [Table 3](#) of the article, we can argue that the data strongly supports micro grids as a viable and scalable solution for providing energy access in rural and underserved regions. With near 24-hour availability, they outperform alternative small power systems while remaining more feasible than full-scale(Tier 5) grid infrastructure. (Note - pico grid here is a synonym for microgrid).