
Bridges to Nowhere: Poor Power Quality Prevents Growth

Summary: Access to electricity continues to expand worldwide, but even where people are connected to the power grid, they often face challenges including frequent power outages and, less visibly, intermittent periods where electricity is available but only with poor power quality.

Poor power quality — characterized by fluctuations and/or persistently low or high voltages — has far-reaching consequences and should receive much more attention. Like lack of access, poor power quality holds back economic growth. But it is much harder to track and its prevalence is unknown because systems to measure it are not in place. We installed sensors across Nigeria to assess power quality and its impacts on people and economic activity.

Why power quality matters:

- **Current investment is short-sighted:** The primary metric of global energy poverty targets like Sustainable Development Goal 7 (SDG7) is the electricity access rate. This has led to increased investment and research focused on expanding the number of on-grid and off-grid connections (see the U.S. Power Africa program as an example). However, billions of electricity customers, many of them newly connected, face challenges in effectively using their connections due to frequent and unpredictable power outages and intermittent and sustained periods of unsafe or unusable electricity, ultimately stifling consumption and economic growth.
- **The extent of the problem is underestimated:** While power outages are well understood to be a significant problem for electricity users in developing regions, poor power quality may be even more widespread. The scale and depth of poor power quality are often underestimated by utilities, policymakers, researchers, and key stakeholders in the electricity sector, which hinders effective measures to address it.
- **Unseen quality issues can seriously undermine development efforts:** Poor power quality results in a range of problems from demand suppression and appliance damage to decreased productivity and safety hazards or health risks. These issues are widespread in developing economies such as those across sub-Saharan Africa, where the aging grid infrastructure is capacity constrained. These power quality issues impact multiple industries, stifling economic and social development.
- **There is no coherent effort to address this issue:** Utilities and policymakers do not have the appropriate tools or policies to identify and improve power quality issues. An essential first step is to ensure consistent and universal power quality measurements to assess the scale and extent of the problem. Even with better sensing, the extent to

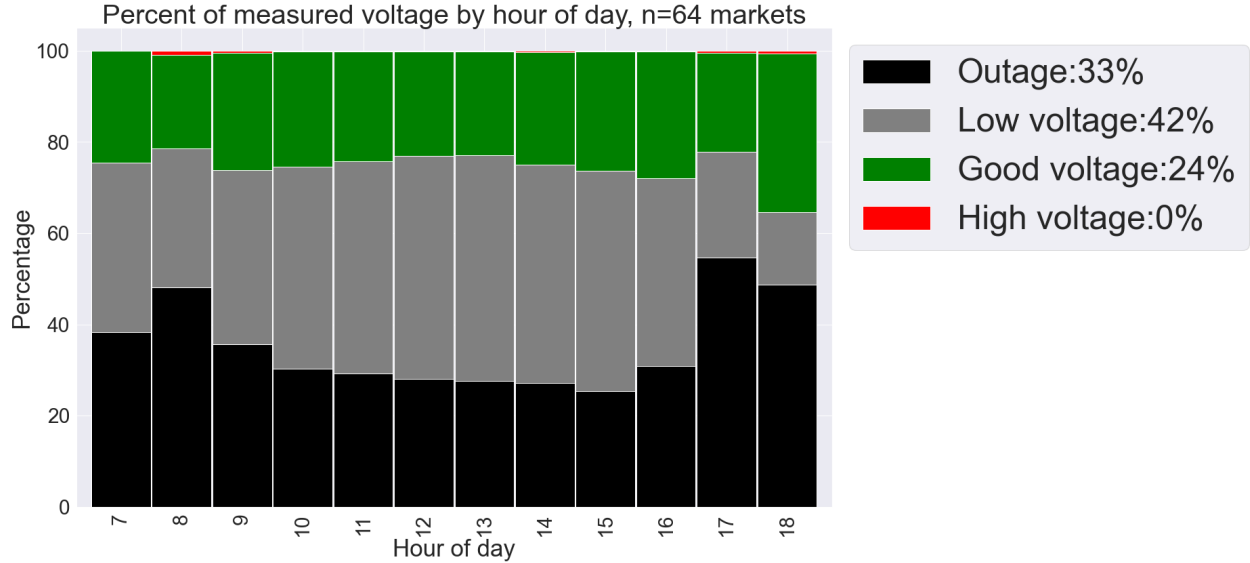
which poor power quality suppresses demand (for example, if it discourages people from investing in electric appliances and consuming electricity) remains unseen, and may be even more challenging to effectively measure, calling for surveys and historical case studies. Persistently poor quality prevents widespread use of electricity for productive purposes and serves as a drag on economic growth and equitable development.

Case study: Nigeria

Nigeria is the largest economy in Africa and on track to becoming the third most populated country in the world by 2047. Yet, as in many other developing economies, inadequate power supply is a significant barrier to economic progress. [e-GUIDE](#) carried out an energy audit in 74 commercial markets across the six regions of Nigeria where we installed [nline's PowerWatch sensors](#) to monitor power quality and grid reliability. We found:

- **Power quality and reliability:** Across the 74 markets, only 1 out of every 4 voltage readings were in an “acceptable” range (within 10% of the standard grid voltage). While outages were present in 1 out of every 3 samples, extremely low voltages were more prevalent (roughly 2 out of 5 samples — see Figure 1).
- **Impact of poor quality on appliances:** Appliances in these markets operate on extremely low voltages most of the time. This leads to damage, reduced lifespans, and unreliable performance – and forces businesses to either deal with the subpar operation or buy replacements, reducing profits in either case.
- **Demand suppression:** Businesses are not operating to their full potential due to suppressed demand. For example, a saloon owner had to return a second A/C unit because the voltage worsened when multiple appliances were in use. Another business owner highlighted that customers on a shared line often can't run appliances like heaters, refrigerators, or fans without knocking out the power. These restrictions hamper growth and are difficult to account for in grid planning processes.
- **Effect on Behavior:** As a result of poor quality and unreliable power supply, businesses resort to incurring extra costs by relying on other sources of energy. For example, 23% of grid-connected businesses also had personal/shared generators, which not only add additional costs but also present enormous environmental concerns.¹ In addition, businesses are compelled to invest in protective systems like surge guards and voltage stabilizers.

FIGURE 1



Bottom Line: Power Quality Challenges Have Broad Effects on Developing Regions

These findings from Nigeria are consistent with measurements taken in [informal settlements of Uganda](#), [rural communities in Kenya](#), and [cities across India](#), among others. As the world strives to meet SDG7 and achieve universal access to affordable, reliable, sustainable, and modern energy, it is crucial that we take a longer-term view and think beyond electricity access. Utilities need investments to ensure more widespread and frequent measurements, policymakers and regulators need to ask questions about electricity customer experience, and governments, donors, and investors need to recognize that poor power quality is a priority issue that endangers the societal impact and financial value of their investments in electricity infrastructure. In short: poor power quality is a crucial impediment to sustainable economic development — and we need to pay it more attention.

Endnotes

1. "Sustainability implications of electricity outages in sub-Saharan Africa." Farquharson, D., Jaramillo, P., and Samaras, C. Nature Sustainability. 2018.
<https://www.nature.com/articles/s41893-018-0151-8>
2. Fobi et al. (2018) A longitudinal study of electricity consumption growth in Kenya, Energy Policy: <https://www.sciencedirect.com/science/article/abs/pii/S0301421518305949>
3. nLine reports and publications on power quality and reliability measurements
<https://nline.io/publications.html>
4. e-GUIDE is leading energy audit and power quality monitoring in Nigeria with support from [REA](#) and the Energizing Economies Initiative (EEI)
5. Power quality in Nigeria: <https://www.sinalda.com/world-voltages/africa/voltage-nigeria/>
6. An academic consortium led by the University of California, Berkeley, includes Arizona State University, University of Massachusetts Amherst, University College London, and Makerere University, with NGO partners ACTogether Uganda
7. World population review: [Nigeria population 2023](#)
8. The fraction of time spent in outage vs voltage states are preliminary results. The brief, rotating deployments used in this project pose particular data analysis challenges due to sampling rate jitter and reporting gaps which can slightly impact the calculated proportion of time in each state but are unlikely to alter the overall scale and trends of power quality issues shared here. In follow-up work, we will nevertheless develop techniques to mitigate these impacts to further refine our results.