Power Quality and Access Challenges in Low-Resource Settings

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Overview and Background

- **SDG7 - Ensure access to affordable, reliable, sustainable and modern energy for all**
- Globally, the number of people without access to electricity declined from 1.2 billion in 2010 to 759 million in 2019
- Estimated 759 Million people with no access to power and another billion have access but availability and quality are compromised
- Intermittent power availability rendering medical equipment inoperable in LMICs
- Lack of data on power availability and quality limiting evidence based policy making

Improved Access to Power = Better Healthcare

- Quality of energy access in health facilities may have crosscutting impacts on other aspects of health services
- Inefficient use of energy technologies contributes significantly to fuel waste and high costs
- A study of 11 major sub-Saharan countries found that roughly **1 in 4 health facilities had access to reliable electricity** - (Adair-Rohani et al, 2013)

eHealth AFRICA

MetaFridge Illuminating Power Availability & Quality

Power Quality

Power Quality is the degree to which the supplied power is compatible with the smooth operation of electrical equipment. These are characterised with pure sinusoidal waveform.

Any problem manifested in voltage, current or frequency deviations that results in mal-operation of customer equipment is termed poor power.

The power quality problem causes the deterioration of performance of various sensitive electronic and electric equipments.

Causes of power quality problem

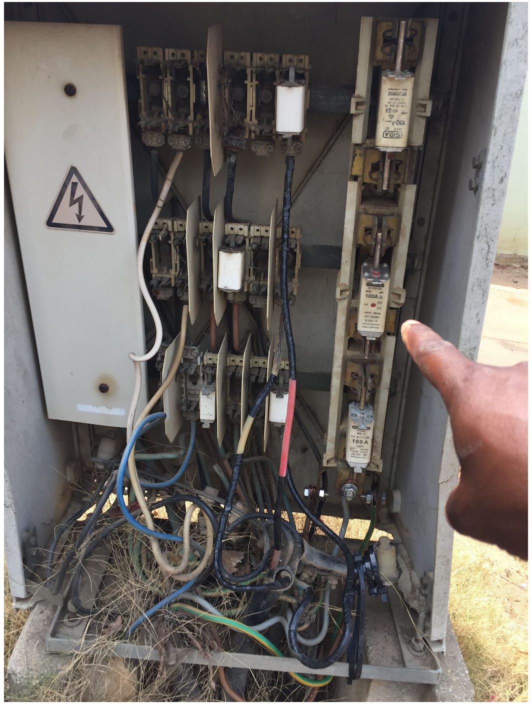
Aging power infrastructure

Causes of Power Quality Issues

1. Lack of maintenance and network refurbishment of ageing infrastructure
2. Growing customer base without commensurate increase in generation capacity
3. Illegal connections, increasing the unmetered demand to unknown levels beyond network design
4. Vandalization of public utility

Effects of Power Quality

- **Lost production:** Each time production is interrupted, your business loses the margin on the product that is not manufactured and sold.
- **Damaged product:** Interruptions can damage a partially complete product, cause the items to be rerun or scrapped.
- **Hidden costs:** If the impact of voltage sag is a control error, a product defect may be discovered after customer delivery. The costs of losing repeat sales, product recalls and negative public relations can be significant and hard to quantify.
- Loss of loss of medical equipment which eventually lead to loss of vaccine resulting in wastage.



Types of Power Quality & Definition of Terms

- Nominal voltage and frequency
- Usable Voltage or Normal Voltage
- Usable with Stabilization
- Unusable Voltage
- Overvoltage
- Undervoltage
- Data outage

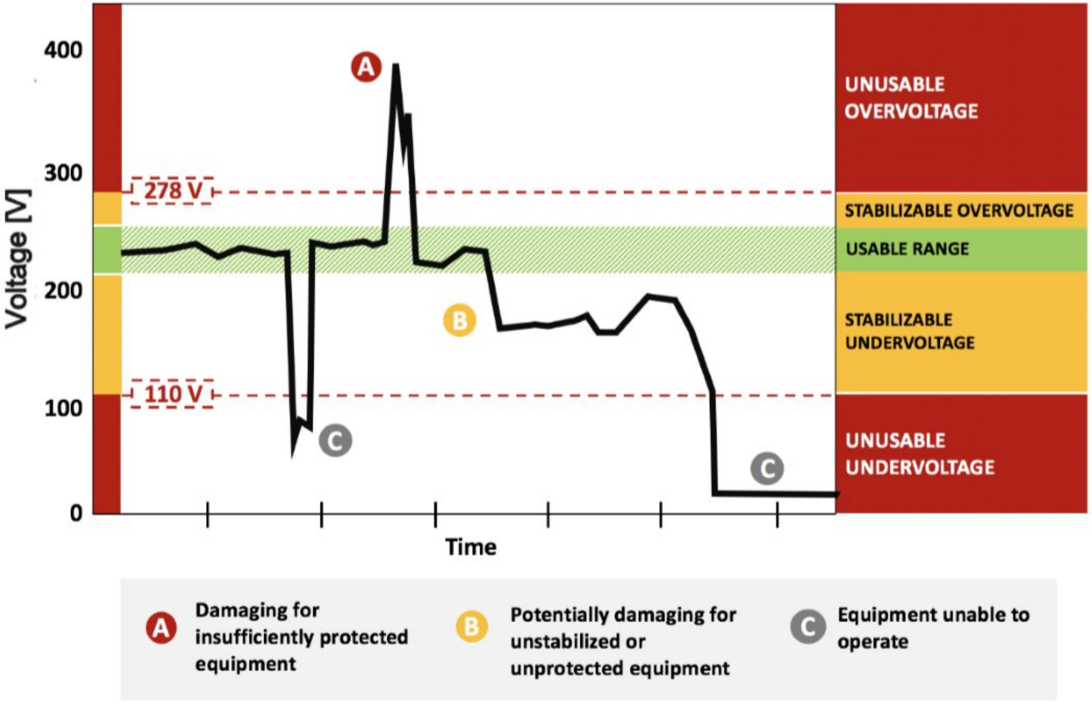


Figure 3: Simulated plot of voltage versus time to illustrate voltage range definitions.

MetaFridge Illuminating Power Availability & Quality

- In Nigeria, 93 devices were monitored in 8 states and including the Federal Capital Territory
- Data collection began as devices were installed beginning March 9, 2018 and continuing until August 31, 2019
- Data was collected via the MetaFridge integrated Remote Performance Monitoring System
- All devices reported power data for at least 1.5 continuous months, with an average of 10 months of data reported per device

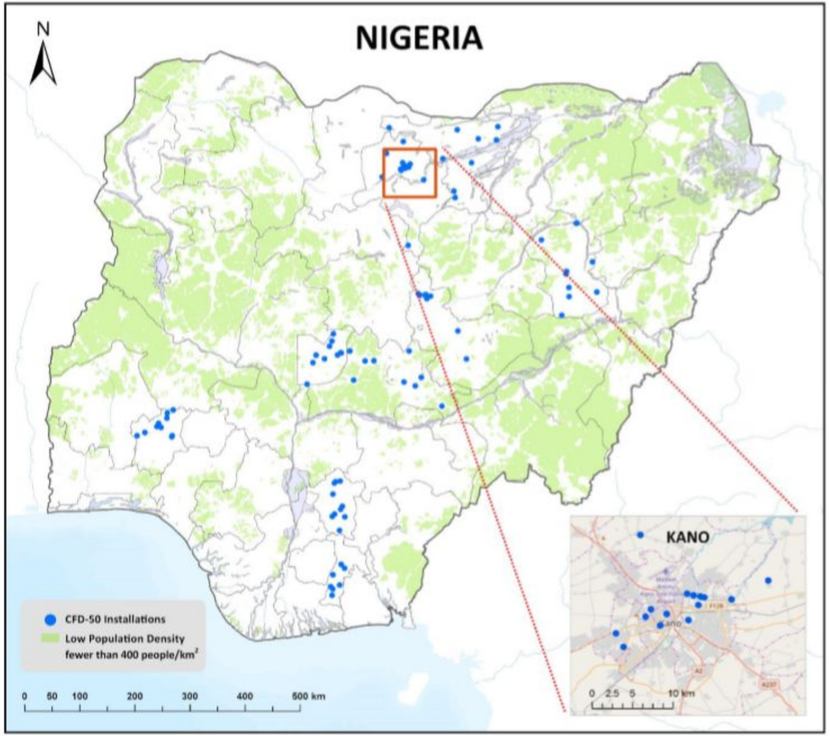


Figure 5: Locations of 93 facilities in the FCT and eight states in Nigeria where power data were collected.

Findings - Availability of Usable Voltage

- Devices in Nigeria reported voltage within the usable range 27% of the time
- Voltage was stabilizable 15% of the time, which suggests that wider use of voltage stabilizers could improve equipment performance at health facilities in Nigeria.
- The remaining 58% of the time voltage was unusable during the study period

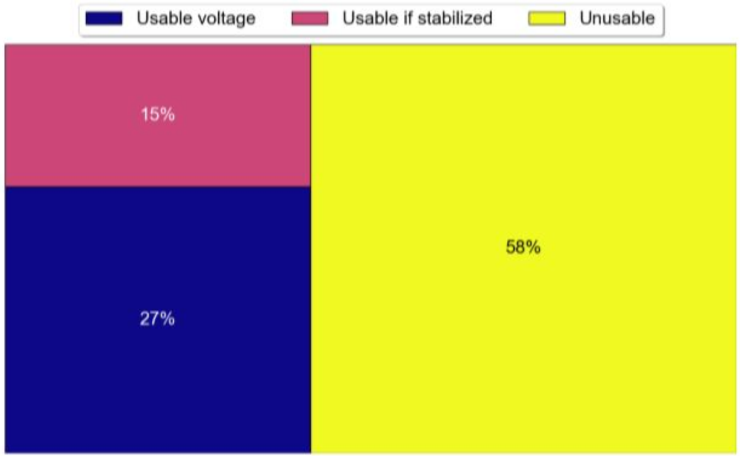


Figure 7: Percentage of time in each voltage range in Nigeria.

Findings - Interruptions

- An interruption is a period with unusable voltage outside the 110 V to 278 V input range of a PQS extended voltage stabilizer
- Across **93 devices** in Nigeria
  - **1,145 reported interruptions longer than 48 hours**
  - **36,549** interruptions longer than 30 minutes.
  - That averages to **15 interruptions per year longer than 48 hours**, and 453.1 interruptions per year longer than 30 minutes for each device.

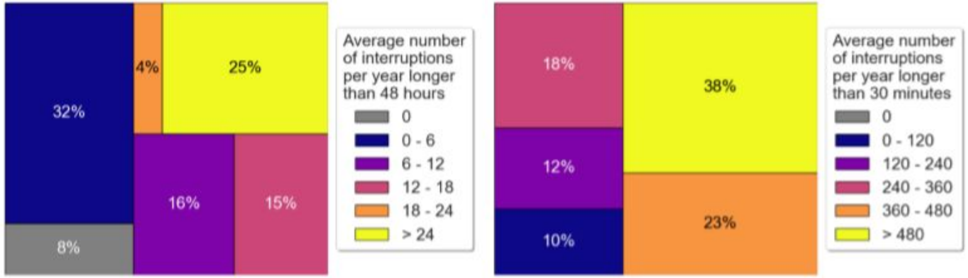


Figure 13: Percentage of devices that reported interruptions longer than 48 hours (left) and longer than 30 minutes (right) in Nigeria.

Longer interruptions fell into two categories:

1. **Facilities using generators**
2. **Facilities with electrical wiring issues**

Why Interruptions Matter

- Mains-powered (CCE) broadly deployed must continuously maintain performance through interruptions
- This ability to maintain temperature in the safe 2–8 °C range for vaccines through interruptions is commonly referred to as **holdover time**
- WHO PQS standard for holdover time of intermittent-mains powered devices is broken into three categories **[PQSRF03]**
  - Short: 20 Hours to 48 hours
  - Medium: 48 Hours to 120 hours
  - Long: 120 hours or more

Conclusions & Recommendations

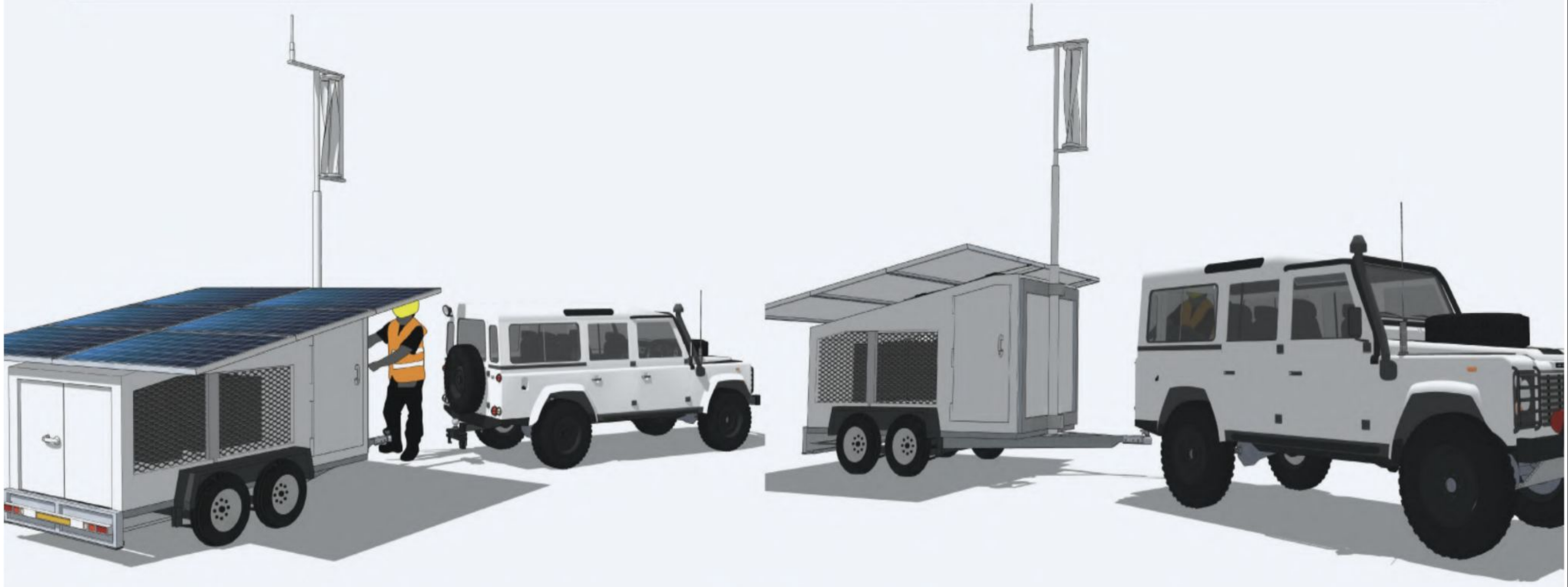
- Reported voltages deviated significantly from nominal, so voltage stabilization can improve equipment reliability and lifespan
- Interruptions were common, and many health facilities experienced them
- Extreme voltage and frequency conditions can pose a risk of permanently damaging medical equipment.

eHA Approach to Power Quality Issues

AVR at eHA Residence

AVR Installed at NCDC-NRL

eHealth Africa Approach to Power Quality Issue



Conceptual drawings of planned RDST prototype for medical applications https://www.youtube.com/watch?v=4vBjvwyBnl0

13:33-14:28 After power quality slide

https://www.youtube.com/watch?v=wUmIFuNNxqc

1:55-2:35 After effects