

# Beyond Access

*Measuring Power Quality Issues at 27 Healthcare Facilities in the  
Democratic Republic of the Congo*

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<sup>2</sup>  
**nLine Inc.**  
Independent Auditors of the  
World's Critical Infrastructure



# Energizing Health: Nowhere is reliable electricity more important than in healthcare facilities.

Energizing health:  
accelerating  
electricity access  
in health-care facilities



“Health services are fundamental to human capital development, and therefore to economic development and quality of life. Yet there is a **striking dearth of even the most fundamental data on energy access and energy requirements** for health-care facilities in many countries, as well as **consistent benchmarks for these requirements.**”

“The lack of data and data standardization [...] hinders the ability of ministries of health, planners and donors to **measure and comprehend the extent of the problem**; describe common challenges across countries and regions; **observe progress over time**; and identify the institutional, policy, technical and financial elements of successful solutions.”

“Supporting policies, such as subsidies and fiscal incentives for renewable energy products to be installed in health-care facilities, and **appropriate monitoring and accountability mechanisms to measure the impacts of investment** are often lacking.”

# We Must Do Better than binary, survey-based reliability metrics

In January's WHO/World Bank/Irena/SEforAll report, **reliable electricity supply** was defined as:

No mention of power quality (damaging voltage spikes, unusable low voltage, ...)!

Whether electricity was available at the facility during service hours at the time of, or preceding, the survey. For this analysis, power is considered reliable if the facility answers "no" to the question "*At any time in the previous one (or two) weeks, have you experienced an outage lasting more than two hours at a time?*"

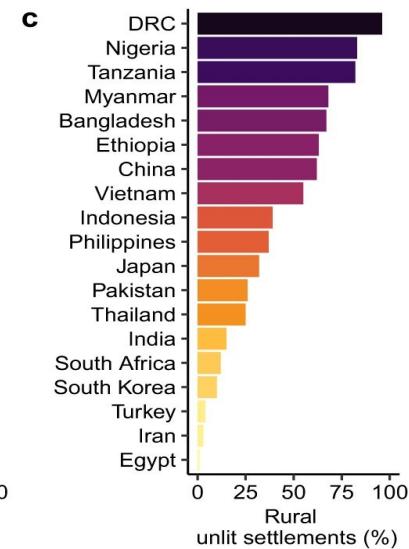
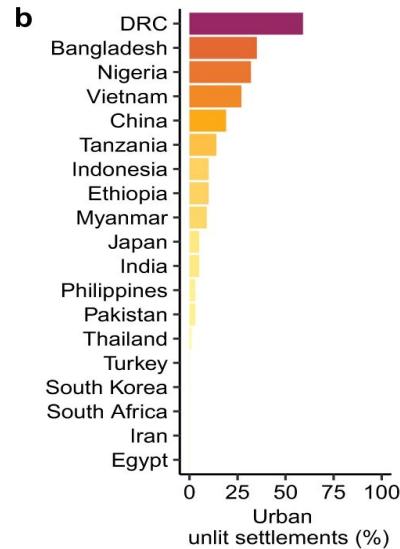
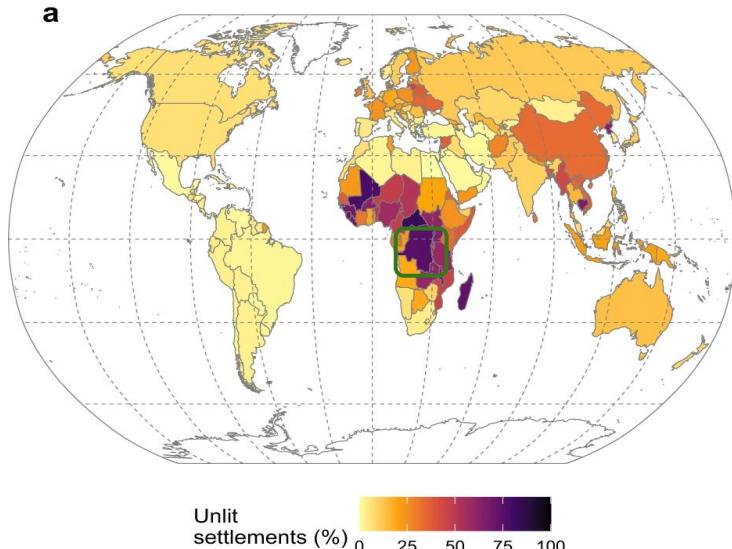
Startlingly low bar for "reliable!"

We *Can* Do Better than binary, survey-based reliability metrics

Our study is a proof of concept for  
***rigorous auditing of power quality***  
at healthcare facilities

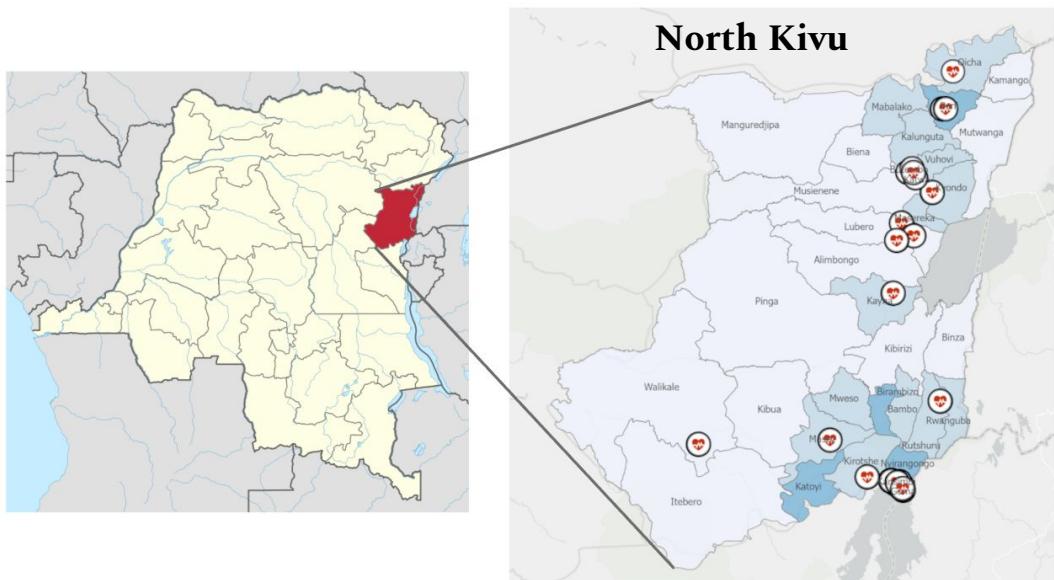
- Captures **exact duration and number of outages** and when they occur at a facility
- Directly measures power quality issues (voltage and frequency)
- Enables comparison between facilities and energy supply types

The DRC has the highest share of “unlit” urban and rural population in the world.



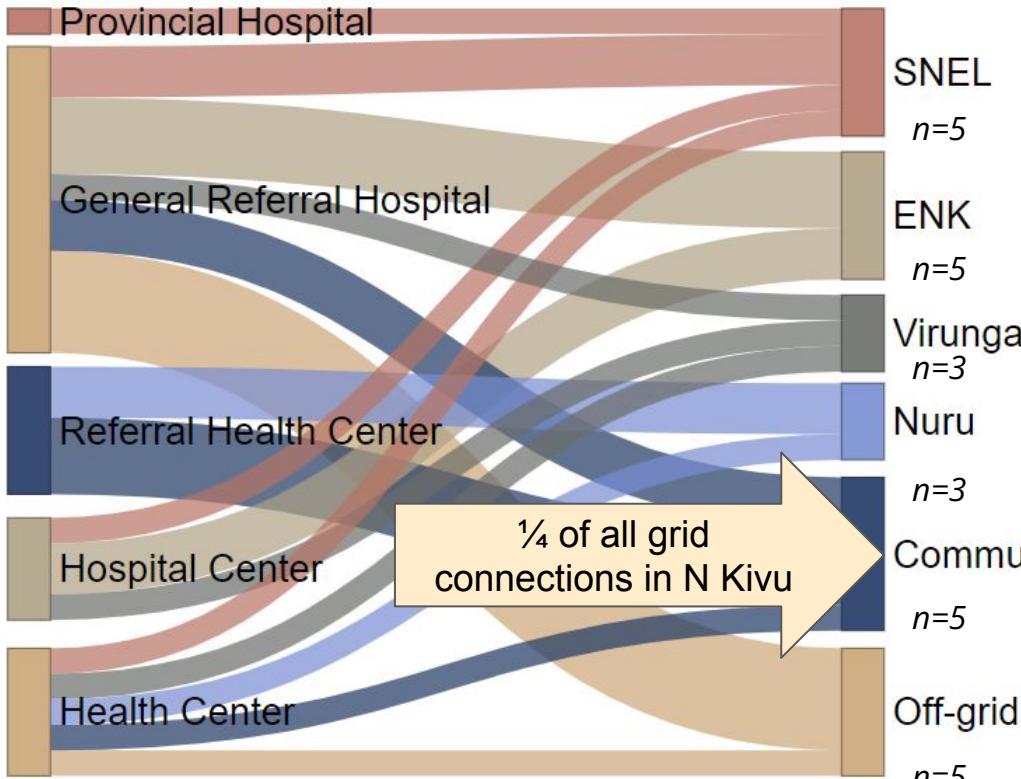
Source: [Estimating global economic well-being with unlit settlements](#) (2022)

# 27 Healthcare Facilities in (mostly) North Kivu, DRC



- Partnered with the **Research Center for Humanitarian Aid**, a research, advocacy, and community mobilization NGO based in Goma, and the **Provincial Health Department of North Kivu**
- With the Health Department, selected 25 health facilities in North Kivu (two more, not on the map, in Haut-Uélé and South Kivu)
- Long history of political instability in this region

# Diverse energy landscape



State-run utility, ~2MW **hydro plant** in South Kivu, ~10k connections between Bukavu & Goma

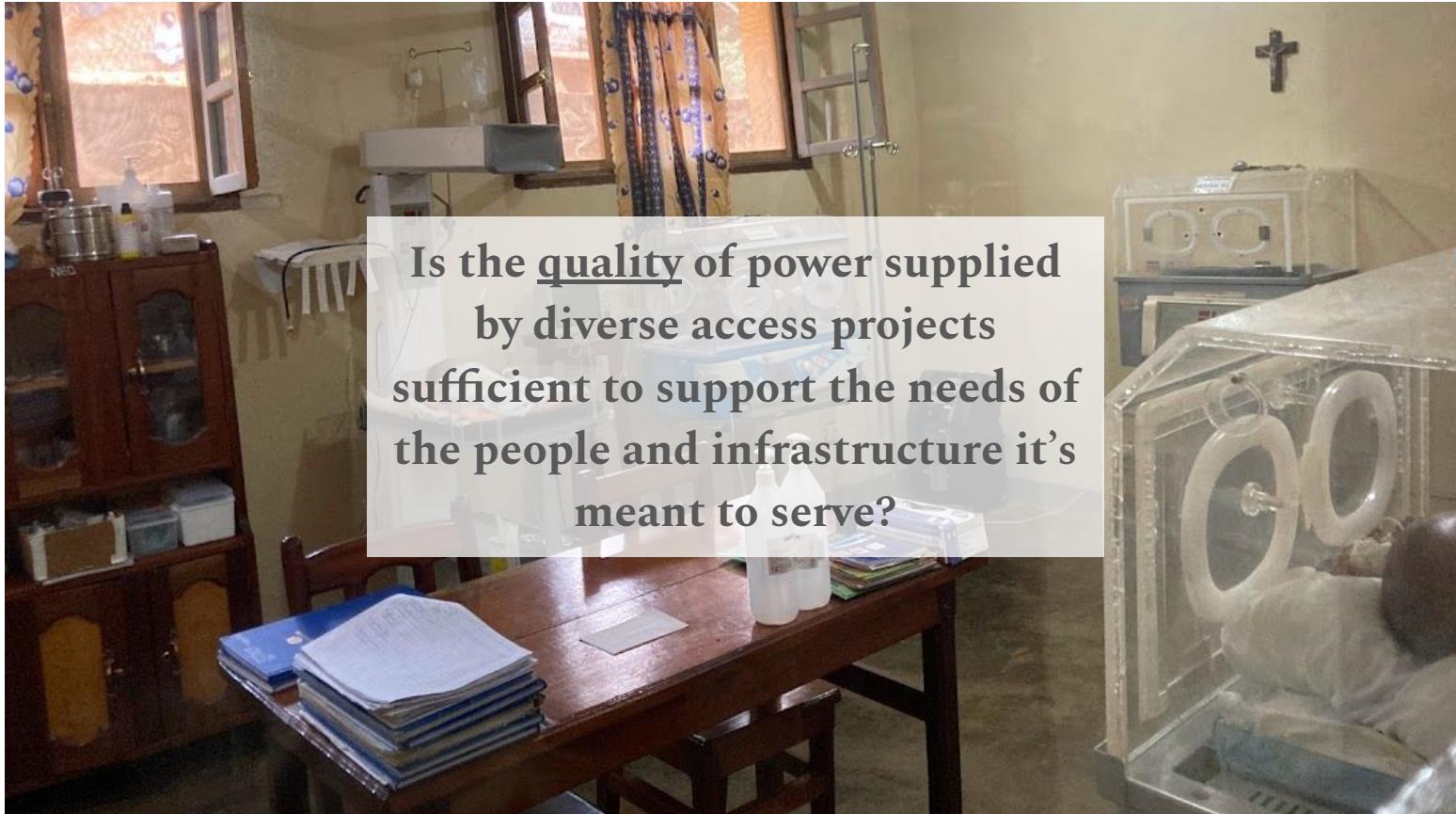
1.8 MW **hydro plant** supplying Beni & Butembo with several thousand connections

~29 MW across 3 **hydro plants** supplying Goma, Rutshuru, & Lubero with ~27k connections (likely more including SOCODEE's retail distribution)

1.3 MW **solar plant** (with thermal backup) in peri-urban Goma, upgrading to 5 MW, supplying several thousand connections

Campus-level & town-level **hydro grids** between 8kW & 600 kW, financed by local gov't & churches in areas without national or commercial supplier

**PV**-only, **Gen**-only, and **PV-Gen Hybrid** ranging from 1kWp - 65 kVA



Is the quality of power supplied  
by diverse access projects  
sufficient to support the needs of  
the people and infrastructure it's  
meant to serve?

# nLine's PowerWatch sensor enables scalable and flexible power quality and reliability measurement.

Simple to install

Remote monitoring via a universal sim

Measures voltage, frequency and power state **every 2 minutes**

Powerful insight into **sub-cycle events** (spikes, sags, harmonics)

Companion app shows participants PQ at their sensor



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Off-the-shelf  
Voltage Sensors

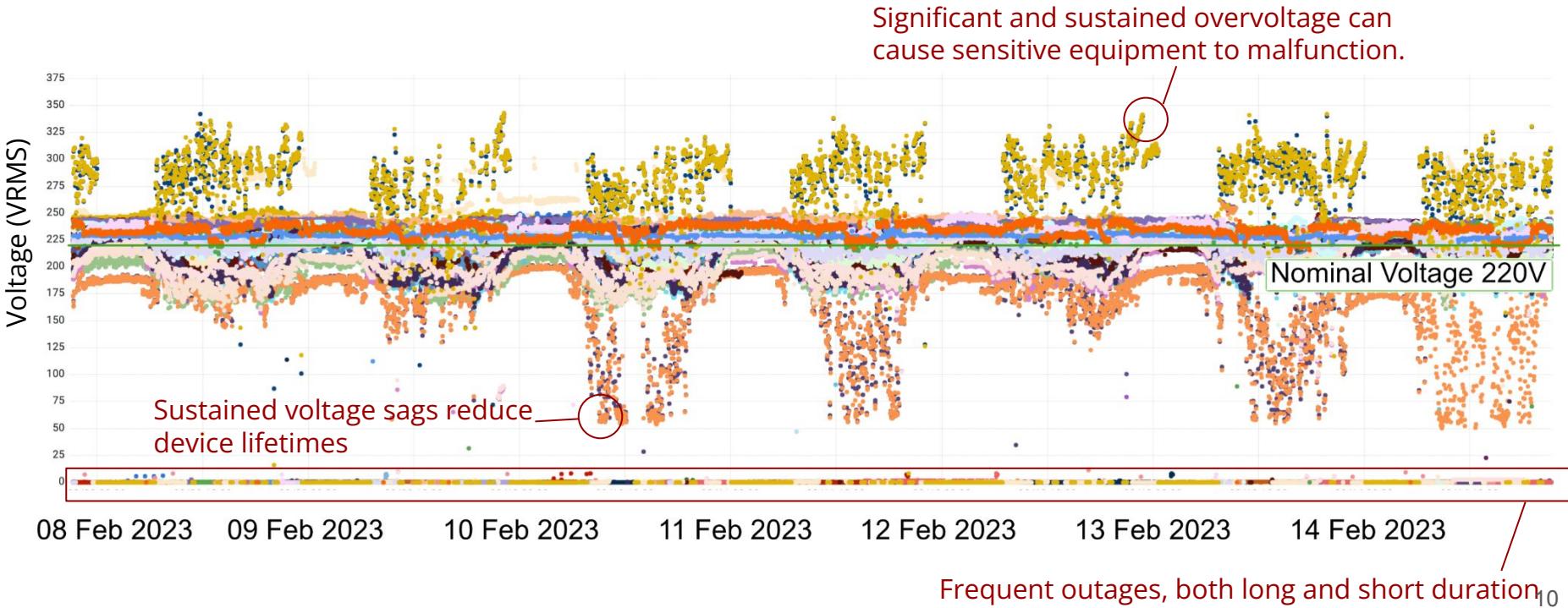


PowerWatch



Phasor Measurement Unit

Power quality and reliability in DRC is non-homogenous, with human and economic consequences.



# “Access” is not enough

**Stable Power, Few/No Interruptions**



HGR Masisi

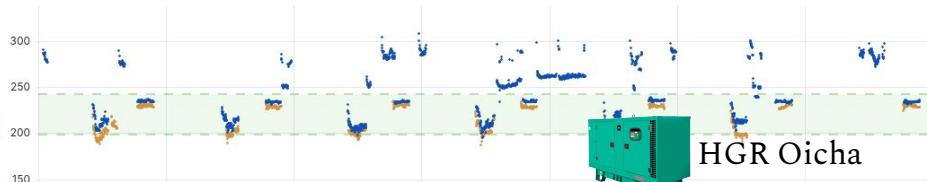


HGR Walikale

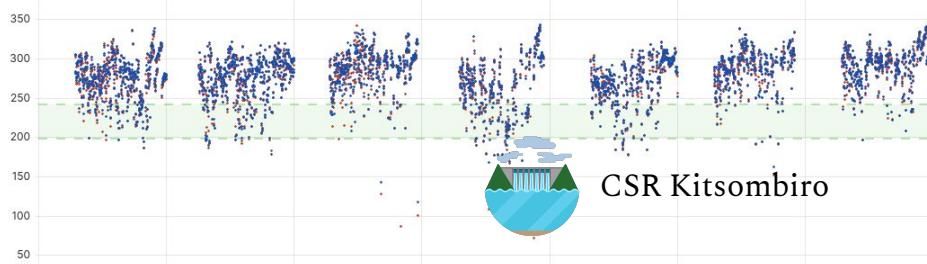


CSR Bakhita

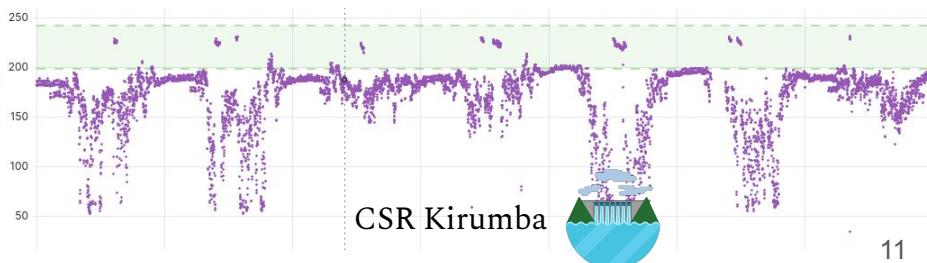
**Poor Power Quality, Daily Interruptions**



HGR Oicha



CSR Kitsombiro



CSR Kirumba

# PV can be really bad, or pretty good



*microgrid* → *metrogrid*

Voltage Time Series



# How does power quality affect healthcare delivery?

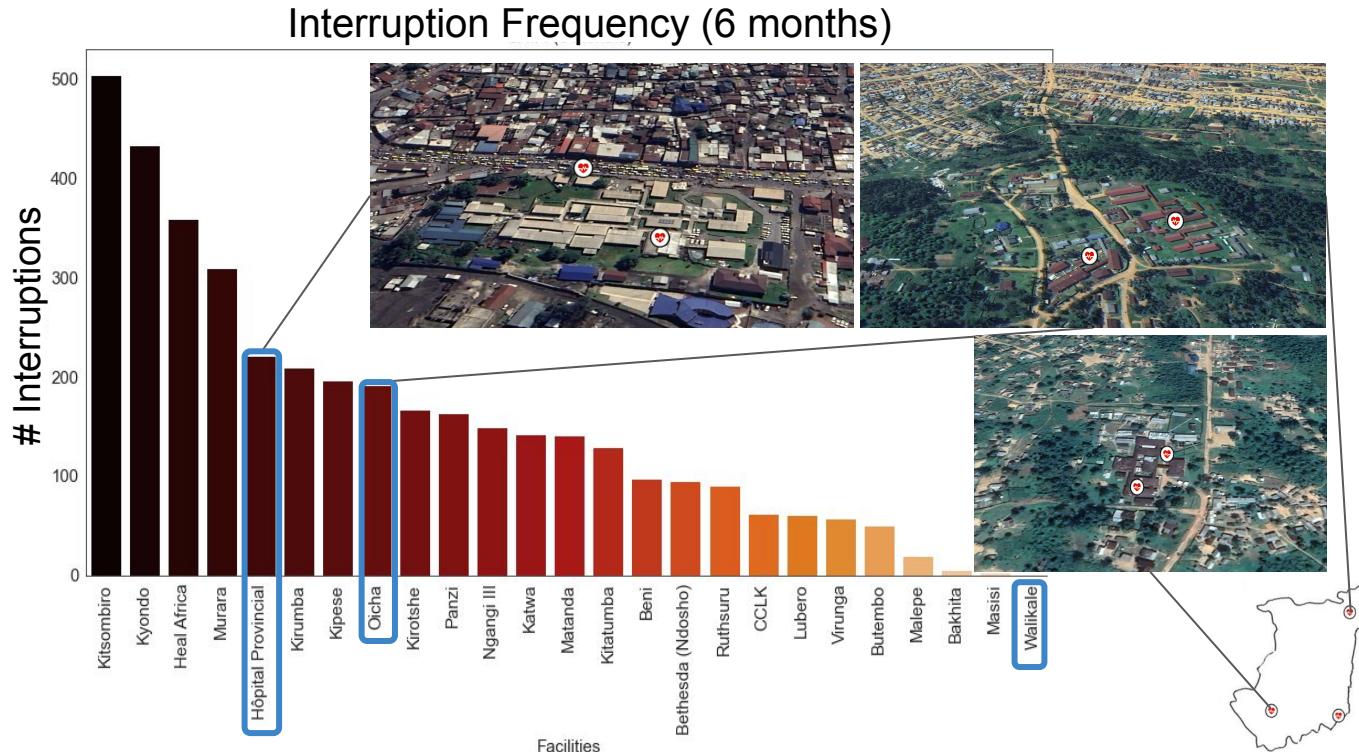
KPI Name	Definition	Type
Interruption Duration	Average cumulative outage time experienced by a customer [hours]	Reliability
Interruption Frequency	Average number of outages experienced by a customer [number of interruptions]	Reliability
Average Voltage	Average voltage delivered to customer [Vrms]	Quality
Hours Undervoltage	Average time customer experiences very low voltage [hours]	Quality
Minutes Overvoltage	Average time customer experiences very high voltage [minutes]	Quality
Average Frequency	Average synchronous grid frequency [Hz]	Quality

-----► No oxygen

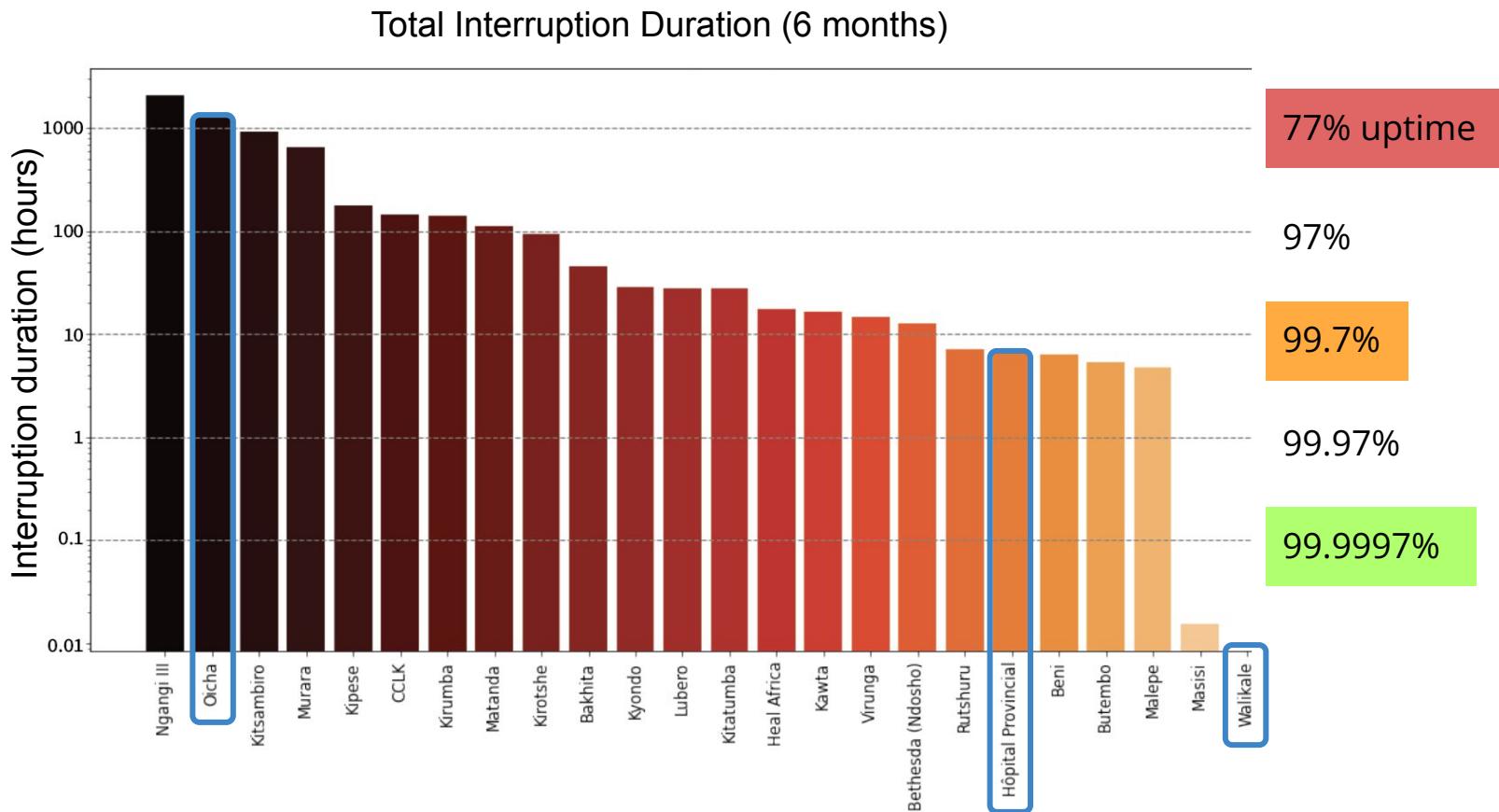
-----► Failed lab tests

-----► Equipment malfunction (e.g., x-ray machines, autoclaves)

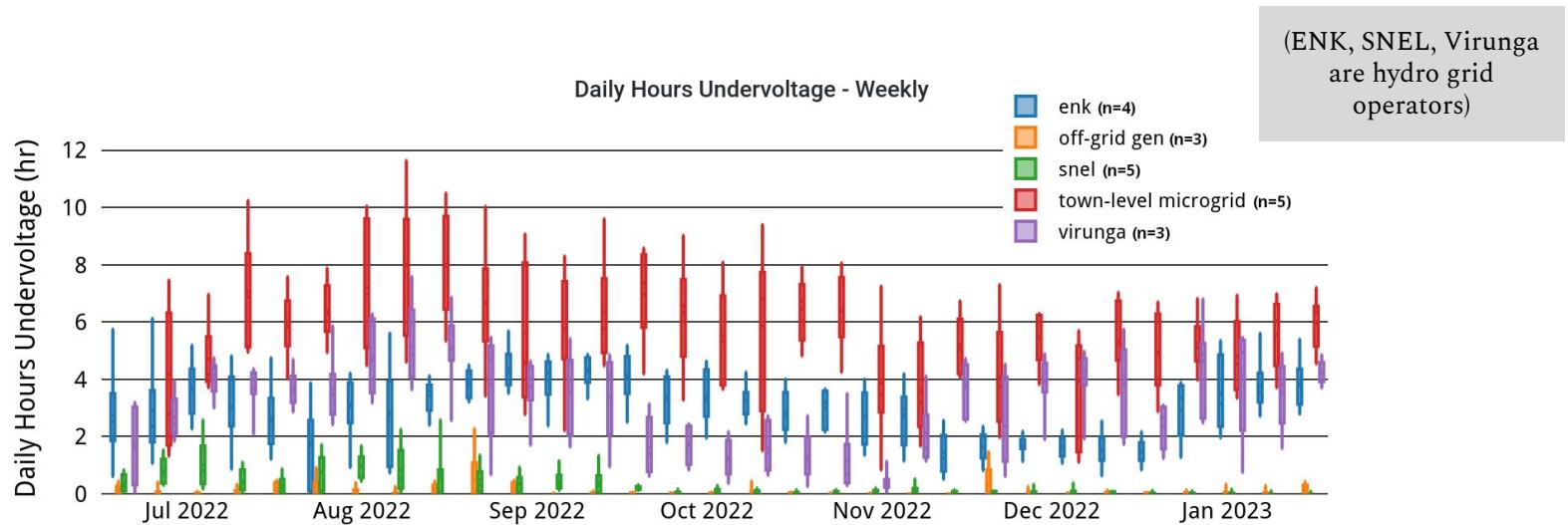
# Power reliability measurements reveal how different energy systems serve critical infrastructure in the DRC.



# Interruption frequency doesn't tell the whole story

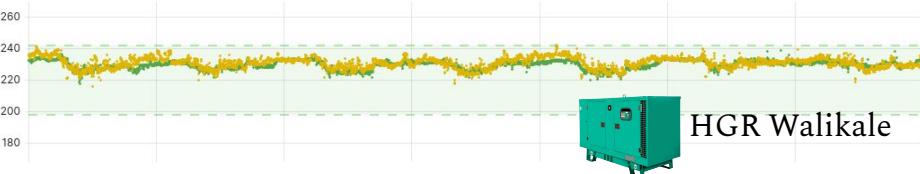
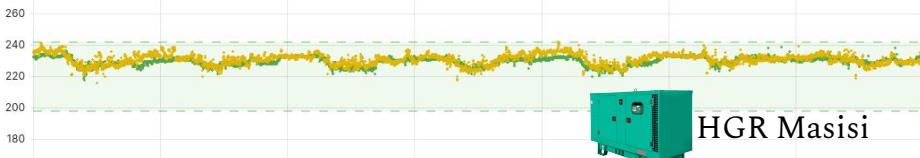


# Compare grid operators and power supply types

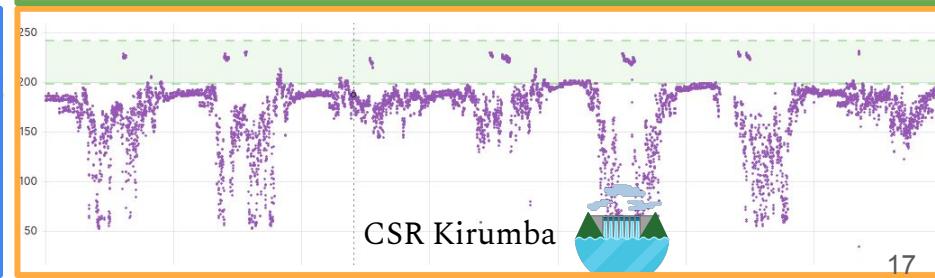
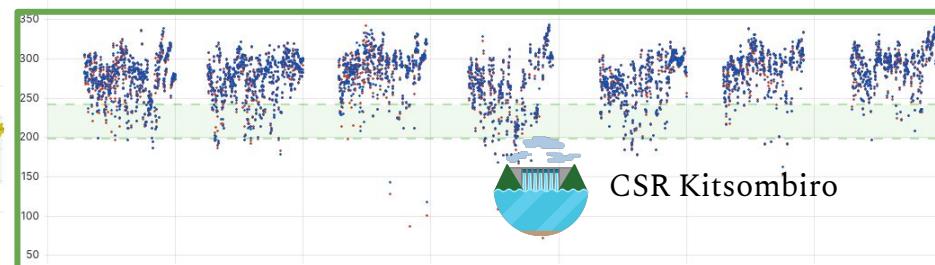
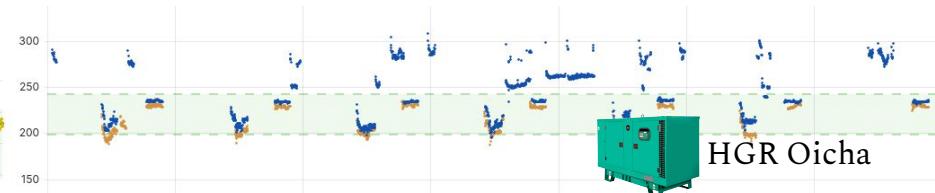


# Stark contrasts

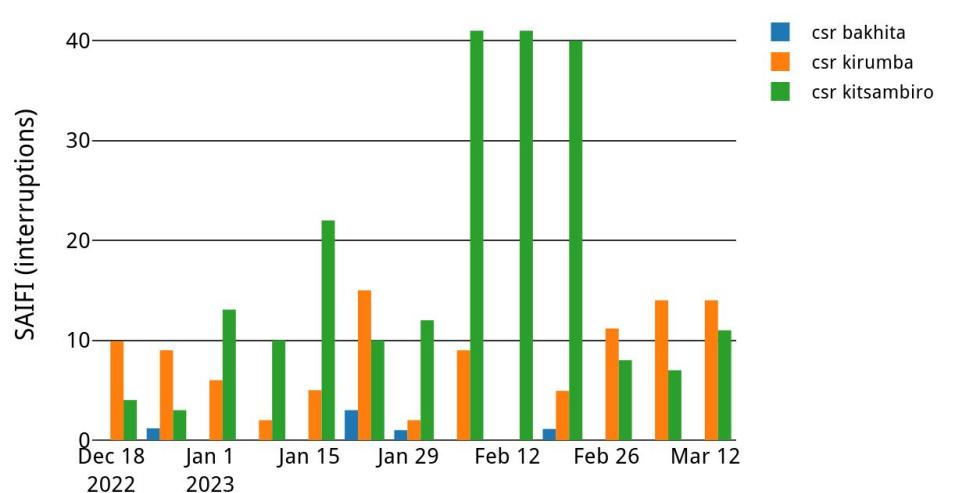
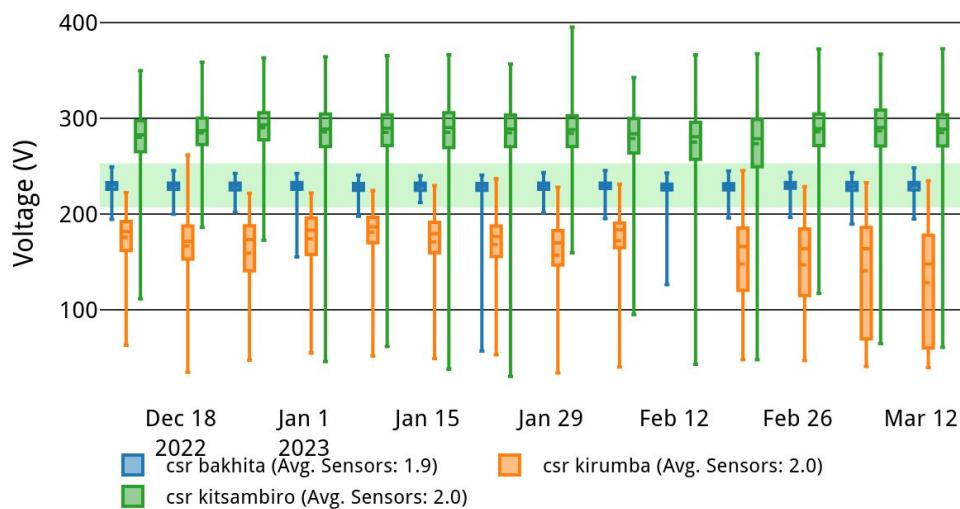
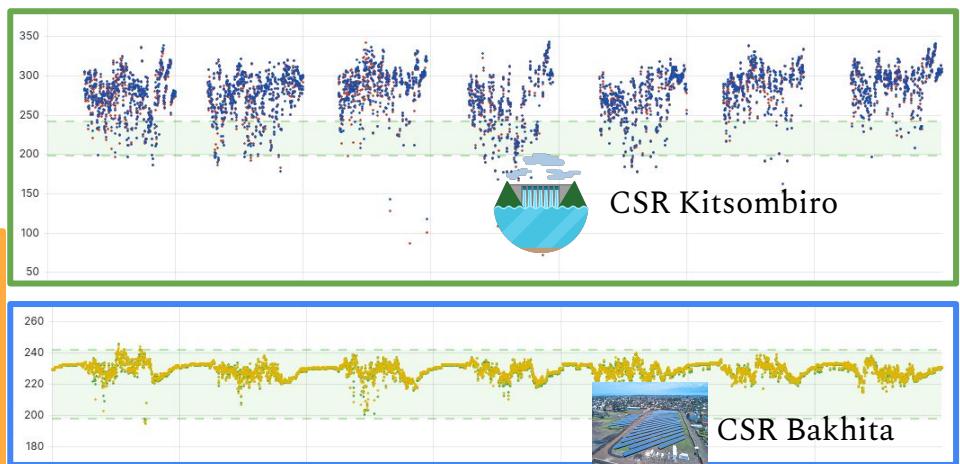
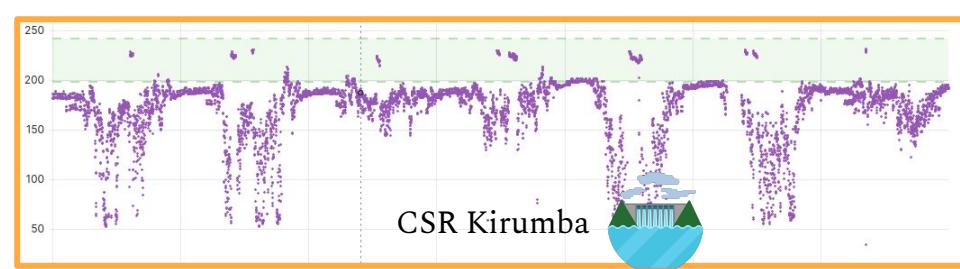
**Stable Power, Few/No Interruptions**

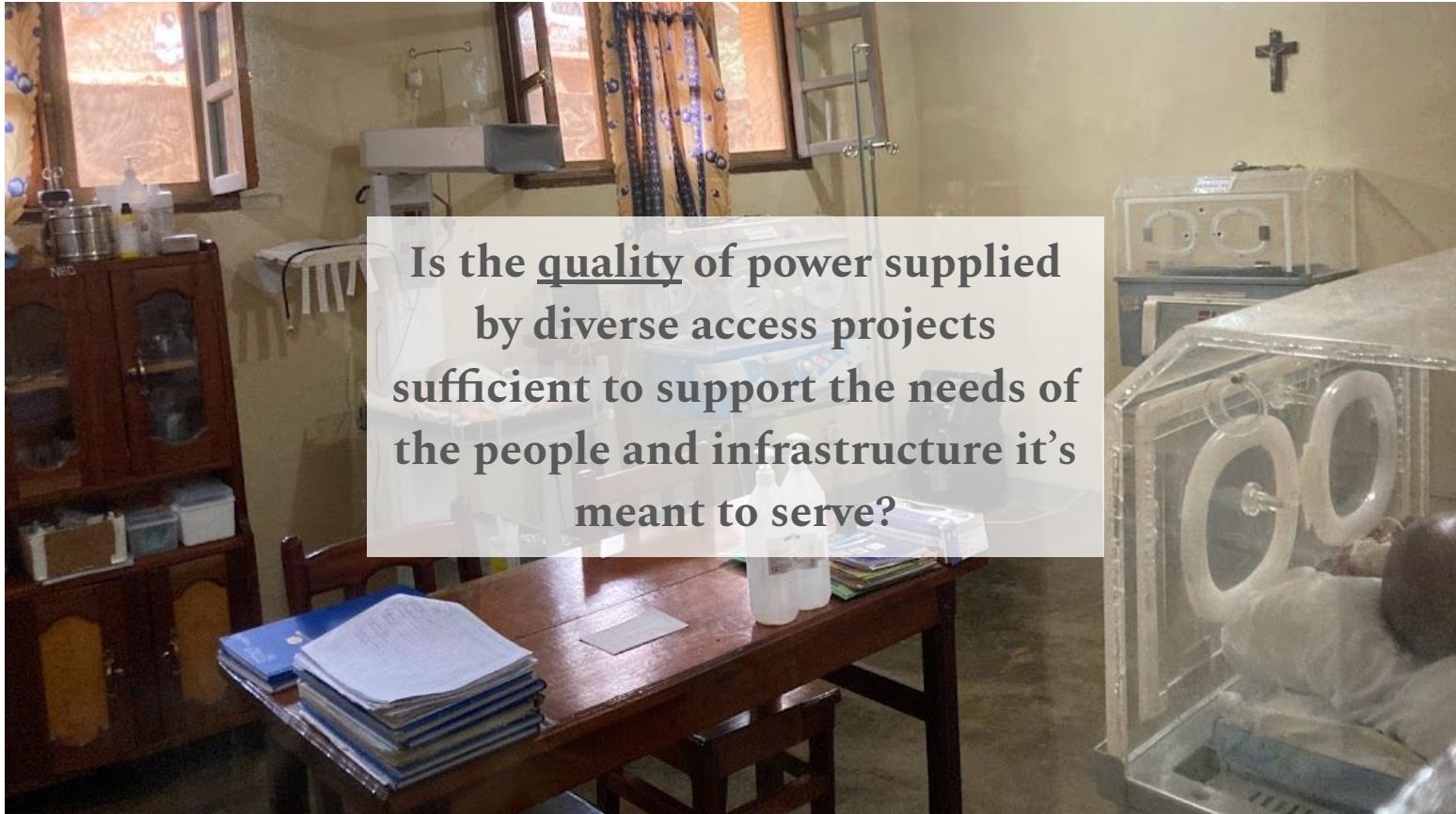


**Poor Power Quality, Daily Interruptions**



# Stark contrasts





Is the quality of power supplied  
by diverse access projects  
sufficient to support the needs of  
the people and infrastructure it's  
meant to serve?

The power quality issues we observed varied widely in nature and scale.

*Different PQ issues will require different intervention/mitigation strategies.*

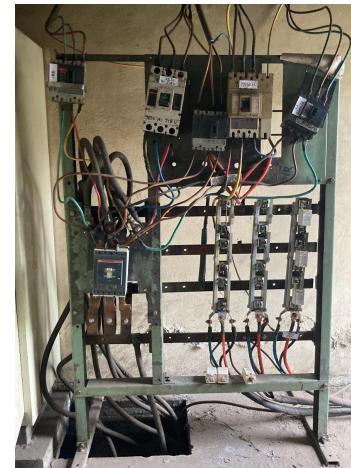
## Our next steps in the DRC:

- Associate the power quality issues we've observed with health outcomes, mortality and morbidity
- Create a set of energy reliability KPIs and standards for healthcare facilities. *How should these inform how we design energy systems?*
- Working with the rural and peri-urban electrification agency ANSER in the DRC to transition monitoring of the 27 healthcare facilities



# What is to be done?

- We must go beyond simple binaries of **connected** and **not connected**.
- **Access without a reasonable level of power quality is a broken promise.**
- It's now simple and affordable to collect power quality and reliability data. **Anyone deploying an energy solution should be monitoring the quality of power delivered.**



# nLine Projects Past, Present and Future



Senegal  
Evaluating Distribution  
Grid Upgrades  
Upcoming - 2024



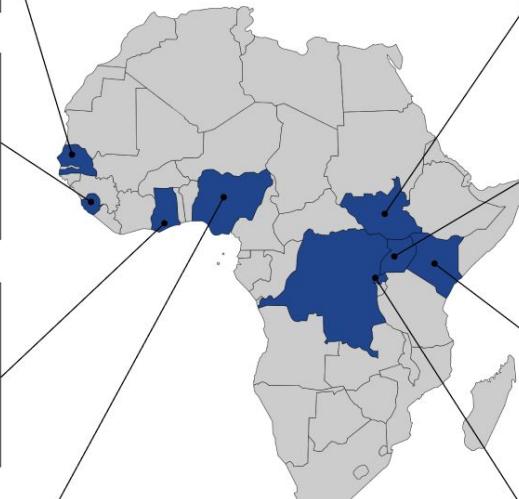
Sierra Leone  
Health facility power  
quality monitoring  
15 Health Clinics



Ghana  
Evaluating Distribution  
Grid Upgrades  
480 Transformers



Nigeria  
Energy system planning  
in markets  
78 Markets



South Sudan  
Health facility power  
quality monitoring  
Upcoming - 2023



Uganda  
Equity in power quality  
25 informal settlements



Kenya  
Evaluating Grid Expansion  
150 villages



DRC & Rwanda  
Health facility power  
quality monitoring  
31 Health clinics



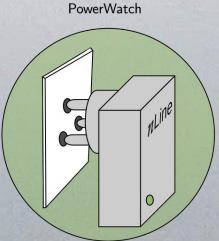
# We want YOU... to use these data



[www.nline.io](http://www.nline.io)  
[info@nline.io](mailto:info@nline.io)

We believe this data can be empowering to energy system modelers to create models that accurately reflect and help to rectify these realities of power quality:

- Models for **optimal sizing of backup** given realistic data on outage frequency & durations
- Models for understanding the **impacts of PQ extremes on various loads** to inform appropriate system design
- Models for **grid expansion planning & resource adequacy** that account for **realistic levels of lost load**
- **New approaches to macro/micro grid design that mitigate these issues?**



# Thank you!



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**nLine Inc.**  
Independent Auditors of the  
World's Critical Infrastructure



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# Annex: Sensors can enable novel site-level power diagnostics

