Monitoring Electric Grid Reliability Using Satellite Imagery Data

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MOTIVATION

- Expensive sensing infrastructure → Poor maintenance → Poor reliability → Unhappy customers
- Power outage → Lights go off
- Nighttime satellite imagery – easily available, consistent, routinely updated, affordable
- Develop NL based wide-area long-term electric grid reliability indices.

DATASETS

NIGHTLIGHTS DATA

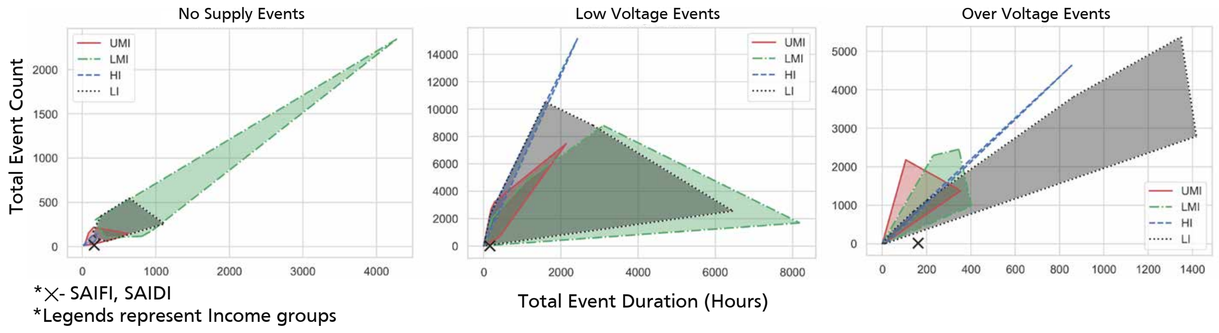
- **Dataset:** VIIRS DNB Nighttime Lights
- **Produced by:** Earth Observation Group & NOAA
- **Pixel Resolution:** 15-arc seconds
- **Pixel Info.:** Average radiance in nanoWatts/cm^2/sr
- **Temporal Granularity:** 1 month

RELIABILITY DATA

- **Dataset:** ESMI Kenya
- **Info.:** Voltage data for 51 connections in Nairobi
- **Temporal Granularity:** 1 minute
- **Availability:** Nov 2017 to Oct 2018

RELIABILITY ON THE GROUND

- Reliability indices as reported by Kenya Power
  - SAIFI = 16.5 outages/year per customer
  - SAIDI = 162.3 hours/year per customer
- Observed distribution of outages (ESMI Kenya)



*×- SAIFI, SAIDI
*Legends represent Income groups

OBSERVATIONS:

- Customers experienced deteriorated reliability issues than reported
- Observed a wider range of outages than the reported SAIDI and SAIFI

SATELLITE VIEW OF RELIABILITY

- 8 reliability indicators per site
- Radiance values per site from Nov 2017- Oct 2018
- Correlation coefficient (CC) of radiance with reliability indicators

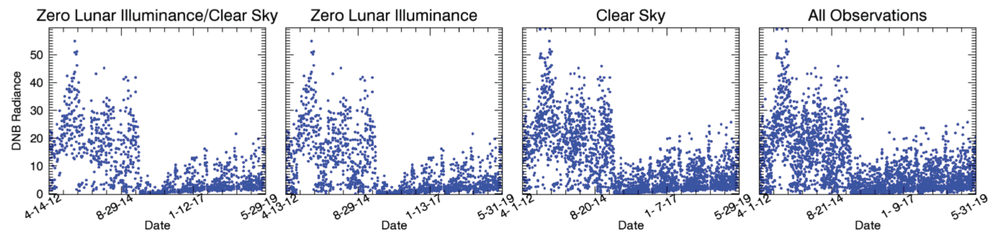
Indicator	Site count	Mean CC
Low V duration	6	0.69
Low V count	4	0.62
No SPLY duration	11	0.58
No SPLY count	10	0.74
Normal V duration	3	0.57
Normal V count	7	0.53
Over V duration	3	0.55
Over V count	7	0.62

OBSERVATIONS

- No strong patterns observed between radiance and outages
- Calls for development of a new paradigm to estimate grid reliability using NL data

LIMITATIONS

- Resolution of NL data spatially limits the reliability estimates to wide areas only
- Only monthly and annual estimates are feasible
- Loss of imagery data due to quality - based filtering



FUTURE WORK

- Defining and quantifying unique NL-based monthly & annual reliability indices
  - % Blackouts
  - % Brownouts
- Tuning indices for different settings:
  - Sparse & dense settlements
  - Developed & developing countries
- Developing an API to make the NL-based reliability indices publicly accessible

REFERENCES

[1] Earth Observations Group (EOG) at Colorado School of Mines and NOAA National Centers for Environmental Information (NCEI). Version 1 VIIRS Day/Night Band Nighttime Lights. https://eogdata.mines.edu/download_dnb_composites.html

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[3] Kenya Power. [n. d.]. System Average Interruption Frequency Index (SAIFI). https://kplc.co.ke/content/item/795/.

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