Power Outage Observations

March 2, 2022
Gridmetrics™ Brief

1. INTRODUCTION

As recently reported by The Wall Street Journal[1], the electrical grid of the United States is becoming less dependable. One measure of that dependability is the number of outages seen over time. Gridmetrics' unique suite of out-of-band (independent from the power providers) sensors transcends individual utility service area boundaries to provide an exclusive lens into the US electric grid. The Gridmetrics sensor network also measures a part of the electrical grid where the power providers have the least insight – the distribution portion of the grid. In particular, Gridmetrics has ~300,000 sensors sampled every 5 minutes (288/day) totaling more than 86 million measurements of grid voltage per day distributed over much of the continental US (see the Gridmetrics coverage map[2] for details). In fact, about 150 million people live within 1 km of a Gridmetrics sensor.

2. ANALYSIS

2.1 Duration of Outages

Fig. 1 shows the number of outages per month for different outage intervals. Here an "outage" is defined as two or more sensors having zero voltage within 1km of each other within the same five-minute sampling window. Sensors may be added to an event as the outage cascades through an area. The events were taken from the Gridmetrics Power Event Notification System (PENS) event data from 2020-Oct-01 through 2022-Jan-31. Note the difference between Oct 2020 through May 2021 (gradually increasing), the summer (higher and increasing baseline), and fall and winter 2021 (higher baseline). The higher summer outages make sense as more strain is put on the grid as well as increased forest fires during that period. The apparently higher baseline number of outages after the summer of 2021 might be indicative of systemic change in the grid. These outage effects were the same for the four different outage ranges considered. The number of sensors at the end of the study was 3.5% larger than at the start of the study so this small change does not account for the differences seen.

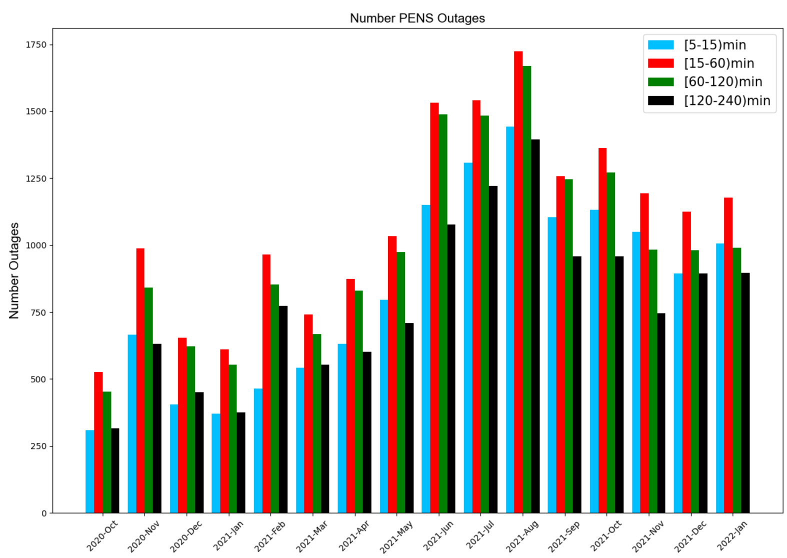

Fig. 1 Number of outages per month by outage duration.

[1] "America's Power Grid Is Increasingly Unreliable." Katherine Blunt, The Wall Street Journal, 2022-02-18.
[2] https://gridmetrics.io

Table 1 shows how the average number of outages varies for different temporal regions. The summer months are consistently larger than the preceding months and the following fall and winter months do not revert back to the "reference period" (2020-Oct:2021 May) values.

Table 1.

	Average Number of Outages / Month (change from 1st column)		
Outage duration	**2020-Oct:2021-May**	**2021-Jun:2021-Aug**	**2021-Sep:2022-Jan**
5-15 min	523	1300(+149%)	1037(+98%)
15-60 min	799	1600(+100%)	1223(+53%)
60-120 min	7244	1548(114%)	1094(+51%)
120-240 min	552	1231(+123%)	891(+61%)

2.2 Magnitude of Outages

Fig. 2 shows the number of outages but this time by the magnitude of the outage by the number of sensors involved. We see the same qualitative behavior as in the duration distribution with the summer outages being greater and the fall and winter outages seemingly establishing a new baseline above the pre-summer period. Note the single black bar in February, 2021 which captured the Houston disaster-level event.

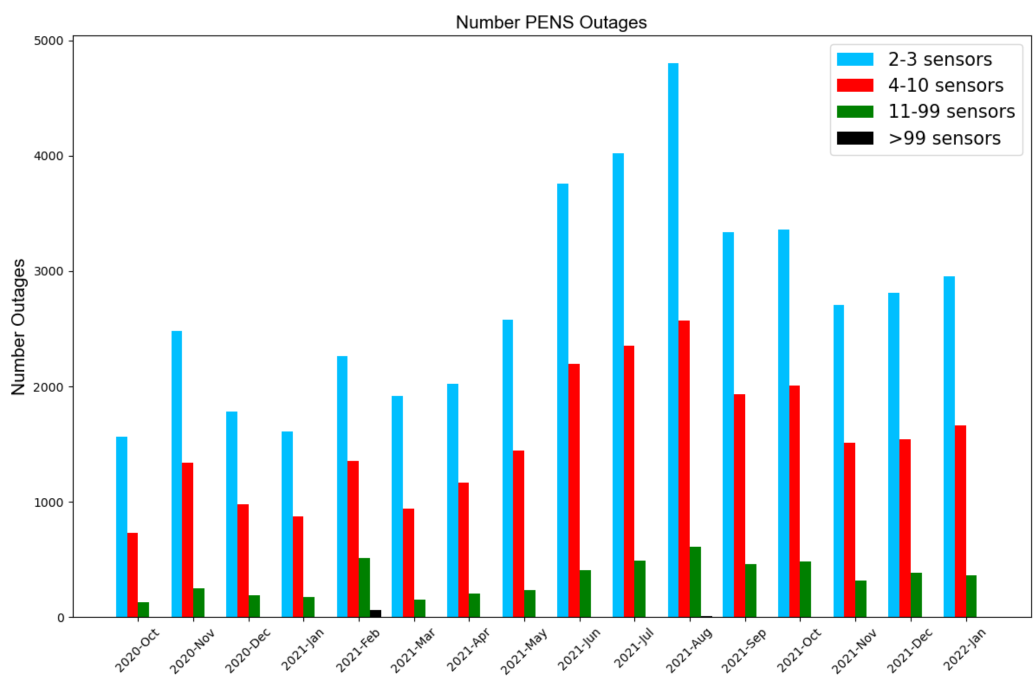

Fig. 2 Magnitude of outages by number of sensors involved.

As with the duration of outage data shown in Table 1, we see the large increase (roughly doubling) in events of all types during the summer and an increase in outages (roughly 50%) in the fall and winter of 2021 versus the reference values from the fall and winter of 2020, and spring of 2021.

Table 2.

	Average Number of Outages / Month (change from 1st column)		
Outage duration	**2020-Oct:2021-May**	**2021-Jun:2021-Aug**	**2021-Sep:2022-Jan**
2-3 sensors	2028	4194(+107%)	3032(+50%)
4-10 sensors	1103	2374(+115%)	1732(+57%)
11-99 sensors	231	503(+118%)	402(+74%)

2.3 Population Impact of Outages

Fig. 3 shows a 3-D plot of the population per USNG cell (log10) versus the number of outages in that cell. For reference, the US National Grid projection is composed of 1 km x 1 km uniquely identifiable cells. The population data came from daytime population as reported by Landscan[3] and mapped to the USNG 1 km projection plane. Over 90,000 USNGs cells were used from the Gridmetrics data set. The population per cell was normalized by the number of sensors in that cell so that outages in cells with multiple sensors were not overcounted.

Fig. 3 shows that the number of outages per sensor has a longer tail for smaller populations—the bar skew toward smaller populations as the number of outages per sensor increases. This is especially noticeable for USNG populations under 300 where the fraction of events with an average of greater than 1.5 outages and with a population up to 300 represented 61.3% of the occurrences, populations with 301-2000 represented 31.5% and populations > 2000 represented 7.2% (see also Table 3). This suggests that more rural settings have a greater tendency for outages. This makes sense intuitively as the power provider may have fewer resources to devote for maintenance, etc., in outlying less densely populated areas as there are more miles of infrastructure per person to maintain. Additionally, in a rural setting their will be fewer complaint-driven requests for repairs than in an urban area, which could lead to rural areas being under-maintained, all of which can lead to relatively more outages in rural areas than urban areas.

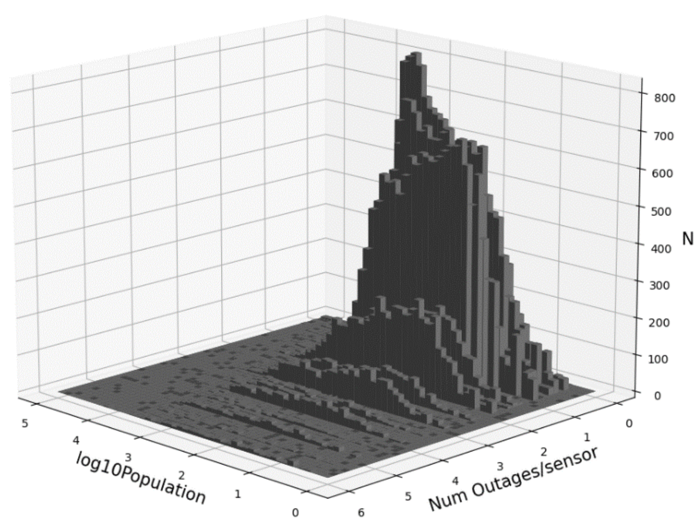

Fig. 3 Log10 population / USNG cell vs. Number of outages / cell / sensor.

Table 3.

Population Range	Fraction of Outages w/> 1.5 avg outages	Fraction of Outages w/≤1.5 avg outages
1-300	**61.3%**	**46.2%**
301-2000	**31.5%**	**41.3%**
>2000	**7.2%**	**12.5%**

[3] https://landscan.ornl.gov/

3. TAKEAWAYS

Gridmetrics' vast sensor network transcends utility service area boundaries and thus provides an exclusive lens to the state of the US electric grid in near real-time as well as how it changes over time. Overall, in this brief we have given an example of how Gridmetrics' vast sensor network can reveal seasonal and systematic power outage effects. This knowledge has implications for many markets including utilities, local-state-federal government, real-estate, and financial services such as insurance.

