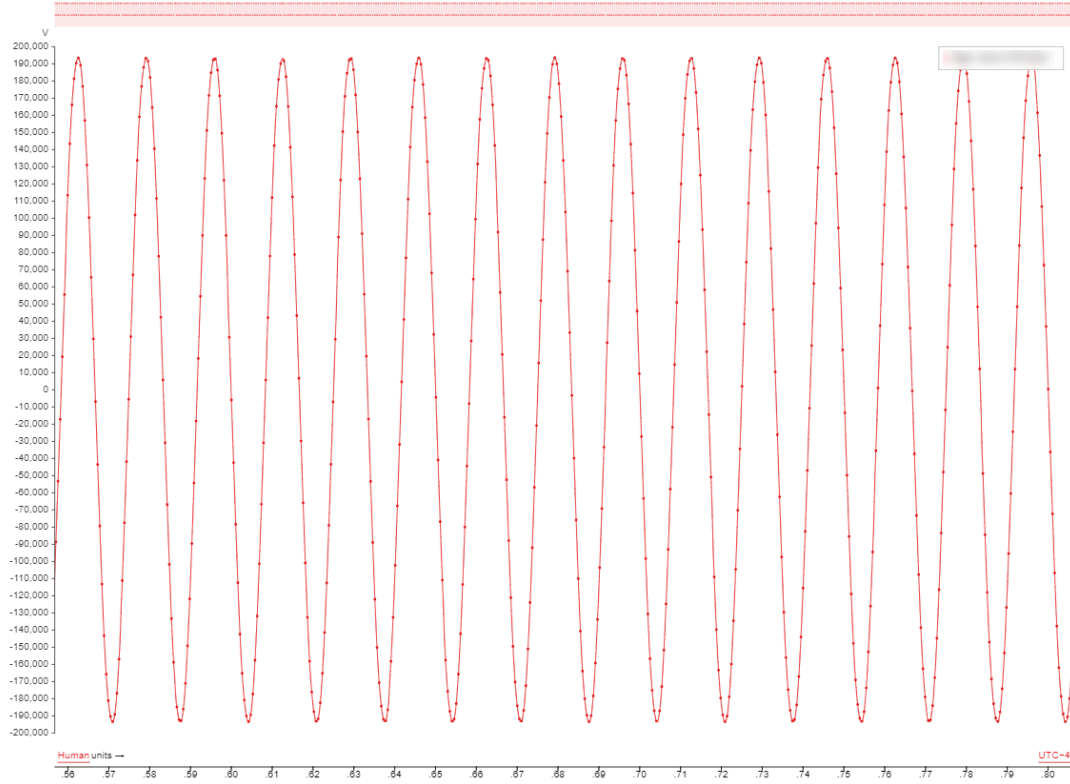


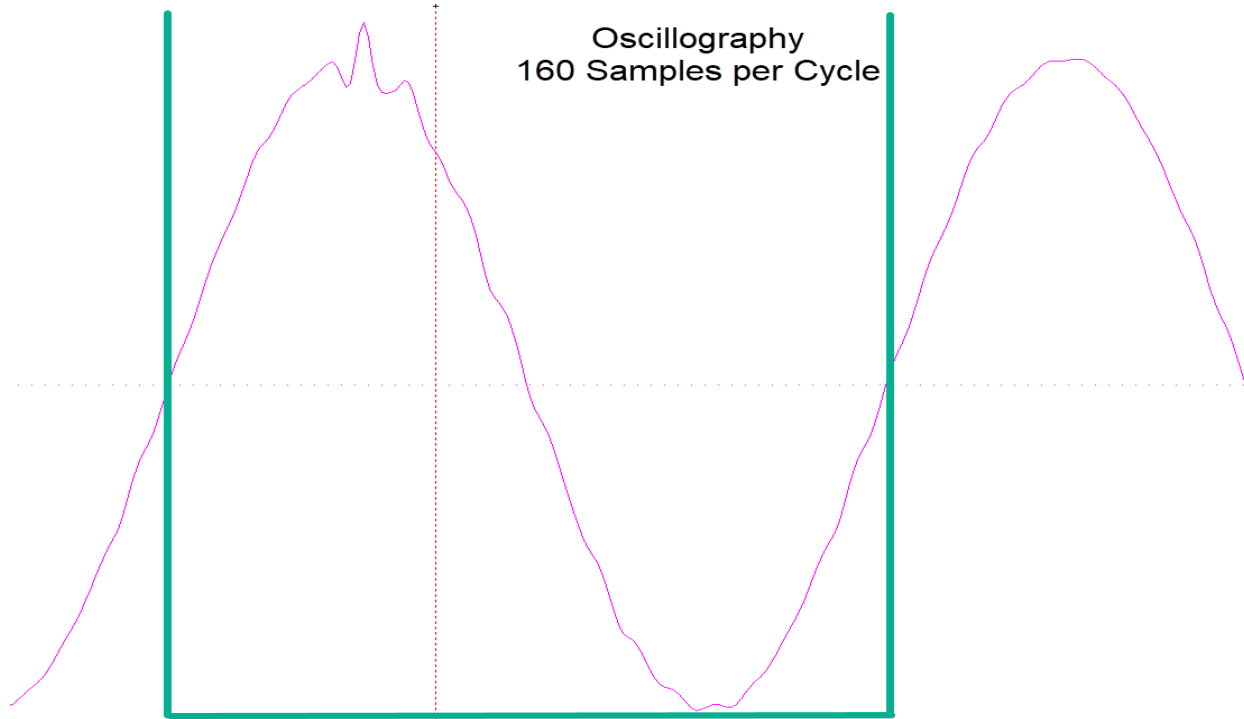
Continuous Oscillography Waveforms from the Substation to the Cloud

TJ Purcell P.E. DE Electric Transmission
Francis Wai Ph.D. APP Engineering Co-Owner
Jarad Johnston DE Electric Transmission
Micah Till Ph.D. DE Electric Transmission
Kevin Jones Ph.D. DE Electric Transmission

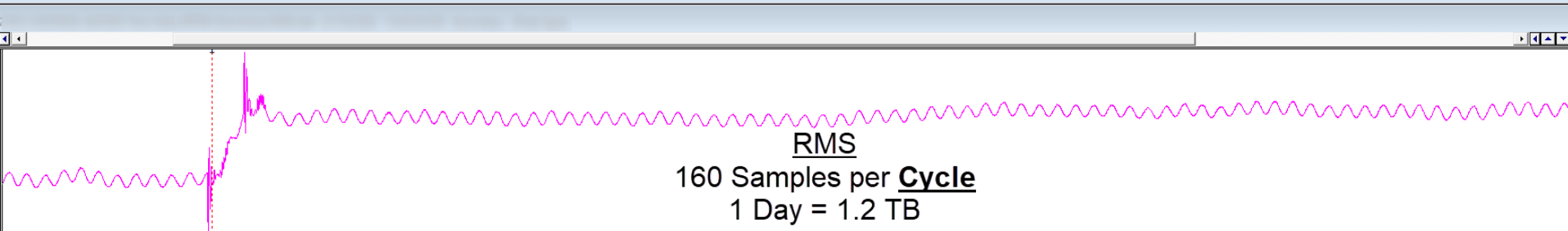
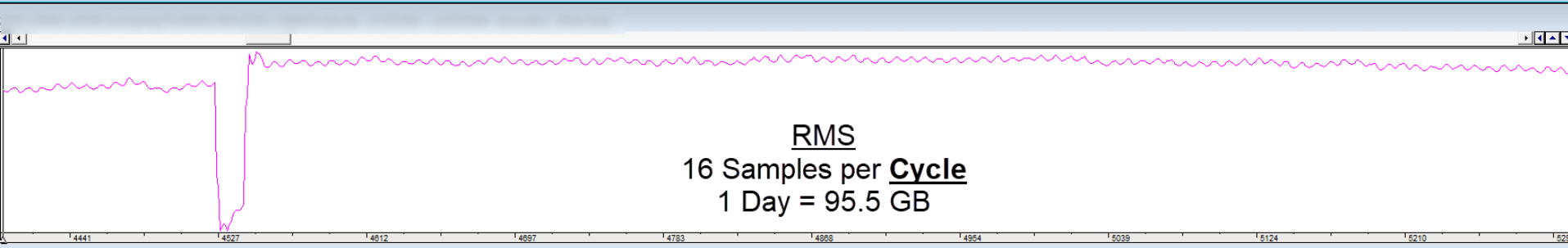
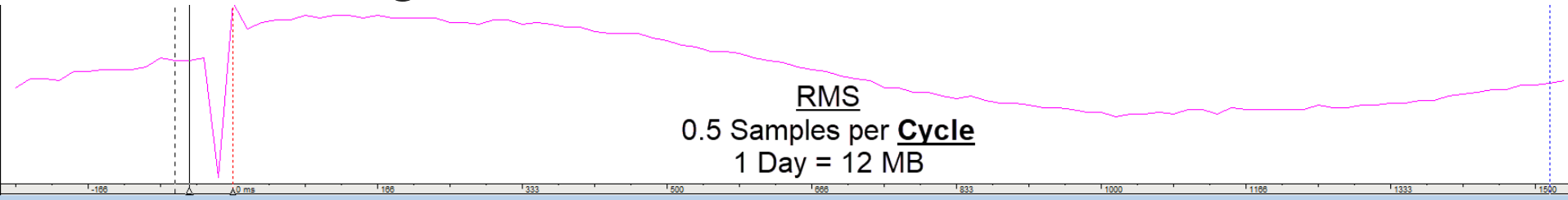
Success



Why collect this data?



Background: #1 Substation Data Rates



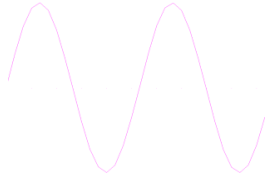
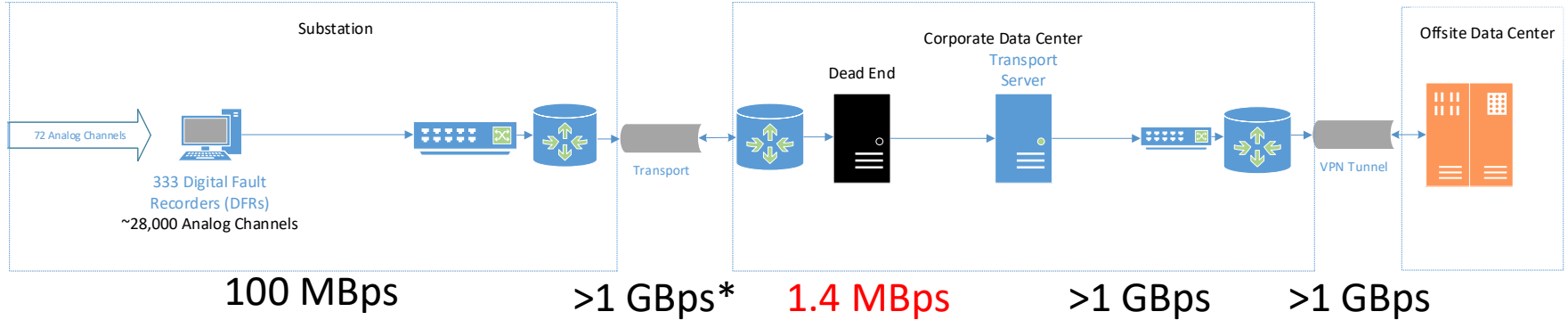
Background: #2 Digital Fault Recorder



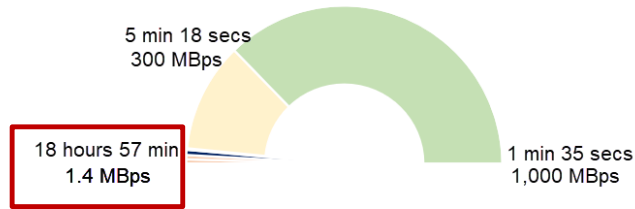
Data Type	Samples Per Cycle	Days Stored	Duration	1 Day Storage MegaBits (72 Analog Channels)	Access
SCADA	0.00007	∞	∞	25 MB	Corporate Network - Web Interface
Synchrophasors	0.5	∞	∞	12.48 MB	Corporate Network - Web Interface
Continuous Recording	16	14	∞	95,551 MB	Substation - File Directory
Triggered Recording	160	30	1 Second	1.7 MB	Corporate Network - File Directory



Problem



95,551 MegaBits



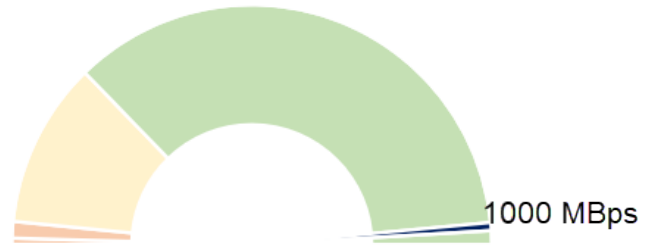
*Fiber connected substations. Some substations transport medium is slower.

Solutions

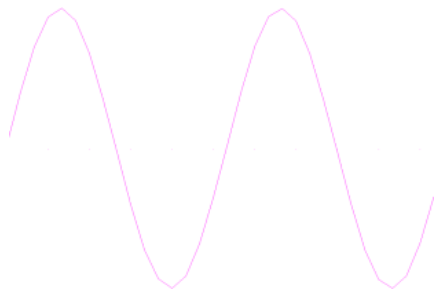
1. Compress Data



2. Increase Bandwidth



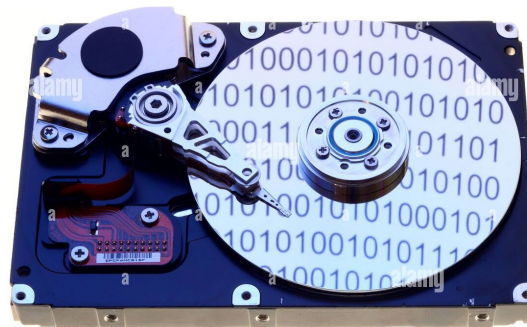
Solution 1: Compress Data



95,551 MB

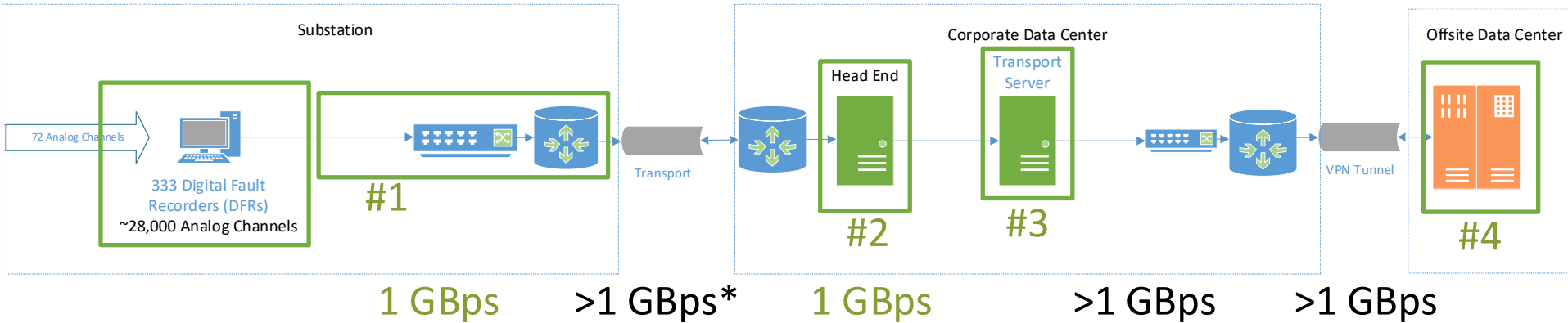


Reduce 68%
1 Hour and 2
minutes



30,602 MB

Solution 2: Increase Bandwidth



1. Substation Network **Switch/Router/Firewall upgrade** to 1GBps
2. Corporate **Head End upgrade** to 1GBps (to each substation)
3. Physical Transport **Server** in Corporate Data Center
4. Offsite Data Center **Decompress and Store**

The Numbers

66 Substations in Pilot

1 Day Total: 3.9 TB

30 Day Total: 118.1 TB

365 Day Total: 1,437 TB

Time Delay

2 – 26 Hour data time delay

Funding

Infrastructure Investment and Jobs Act (IIJA)

- 11/15/2021 Signed into Law [1]
 - \$73 billion to overhaul the nation's power infrastructure, clean energy transmission, and overall energy policy.
- 10/17/2023 IIJA awards Dominion Energy [2]
 - \$67.2 million split cost between Federal Government and Dominion Energy.





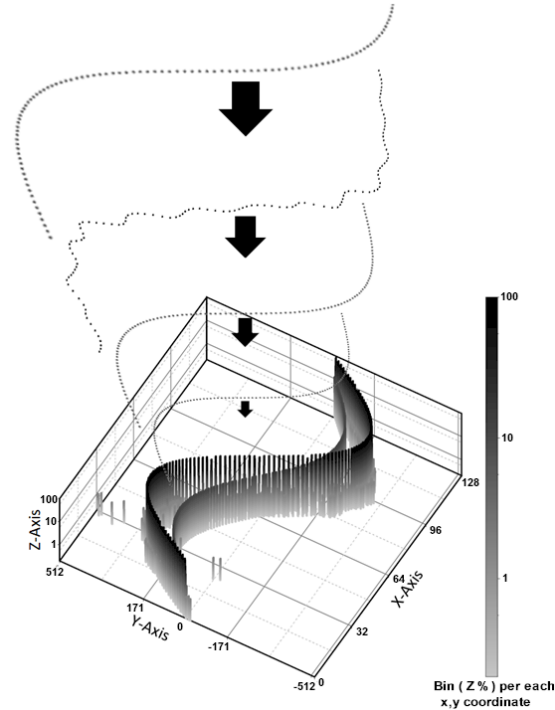
**Dominion
Energy[®]**

Alternate Solution: Cyclical Histogram

*This work was completed in 2015 by Thomas Cook @ EPRI

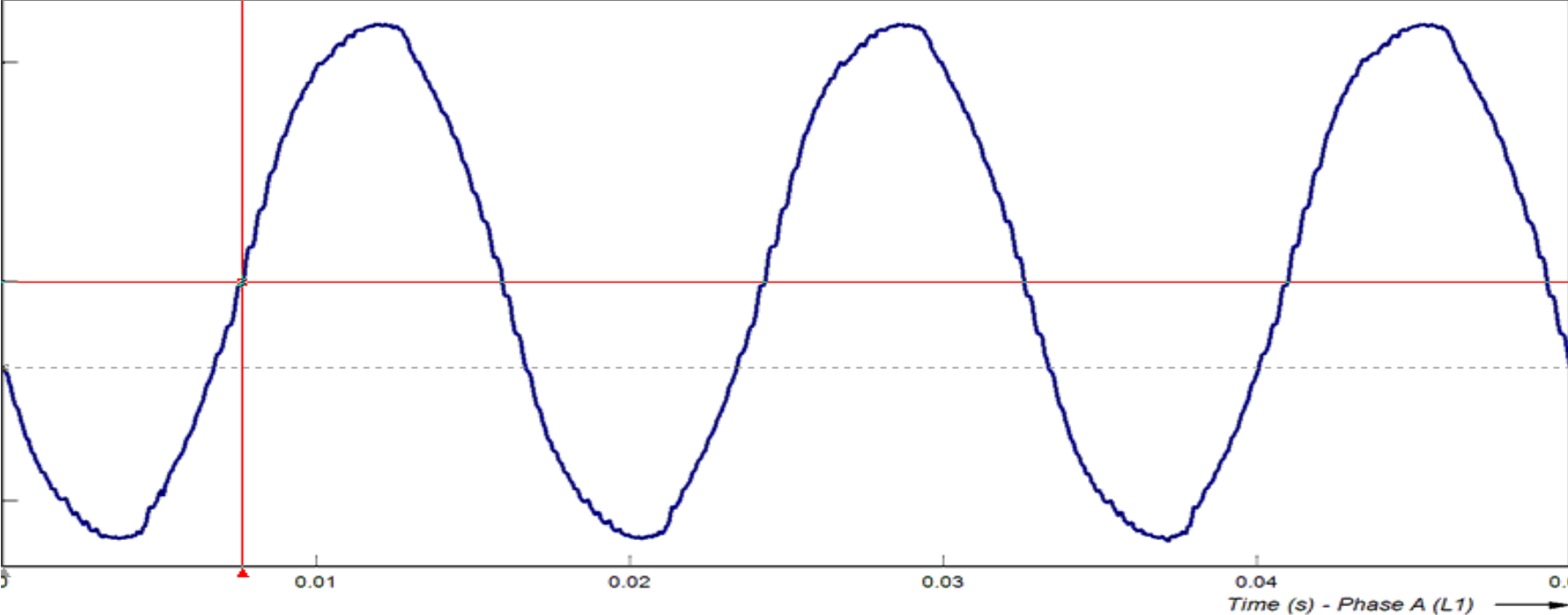
To ease storage, transfer, and display of the cyclic histogram, it can be distributed as a static image (gif, png, etc).

There can be multiple images for each phase, voltage and current. Furthermore, there may be multiple pages of images representing different time periods (i.e. 1 hour, 1 day, or maybe 1 week) [3]



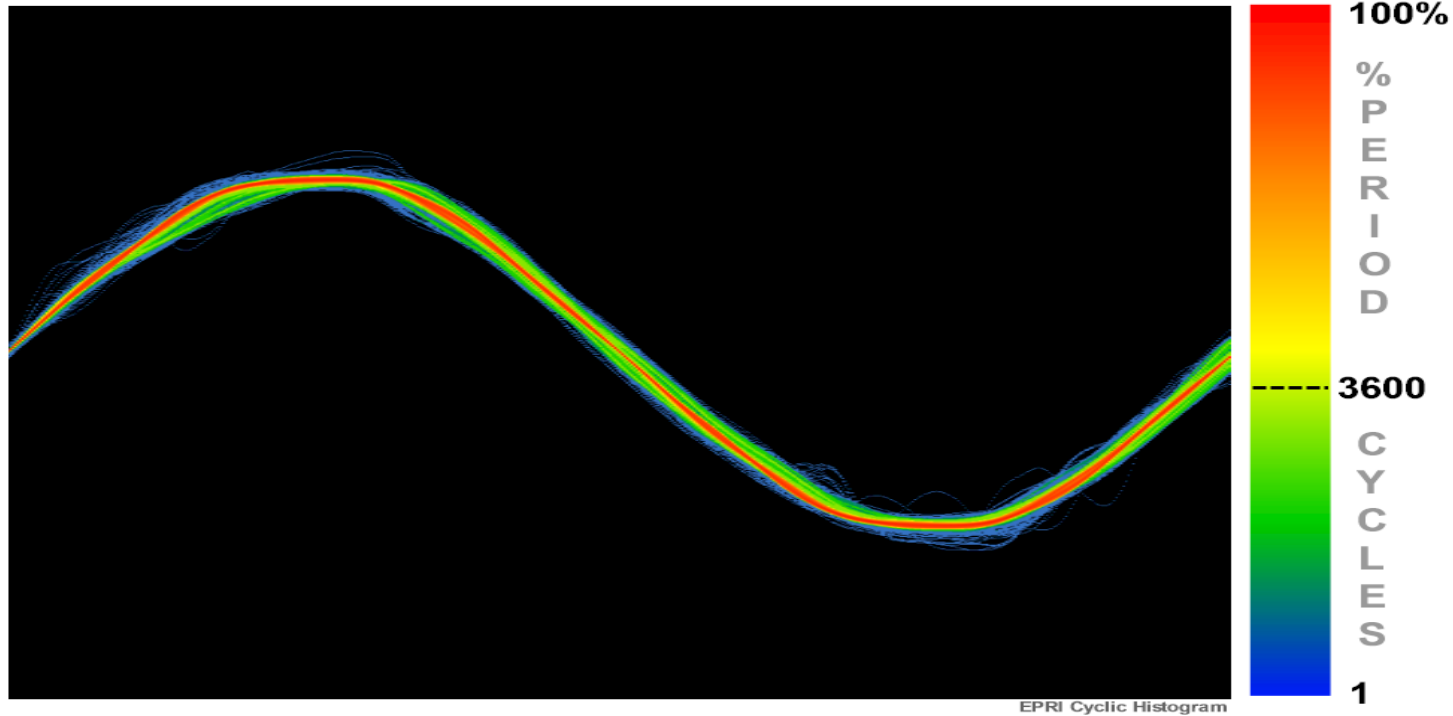
Alternate Solution: Cyclical Histogram

*This work was completed in 2015 by Thomas Cook @ EPRI



Alternate Solution: Cyclical Histogram

*This work was completed in 2015 by Thomas Cook @ EPRI



References

1. <https://www.congress.gov/bill/117th-congress/house-bill/3684>
2. <https://www.energy.gov/sites/default/files/2023-10/DOE-GRIP-Virginia-Electric-and-Power-Co.pdf>
3. <https://www.epri.com/research/products/3002002849>