Grupo Energía Bogotá

EPRI
ELECTRIC POWER RESEARCH INSTITUTE

PingThings

EPRI + GEB
Lunch & Learn

June 28, 2023

The Team

DANIEL MUNOZ-ALVAREZ
Grupo Energía Bogotá
dmunoz@geb.com.co
Head of Innovation

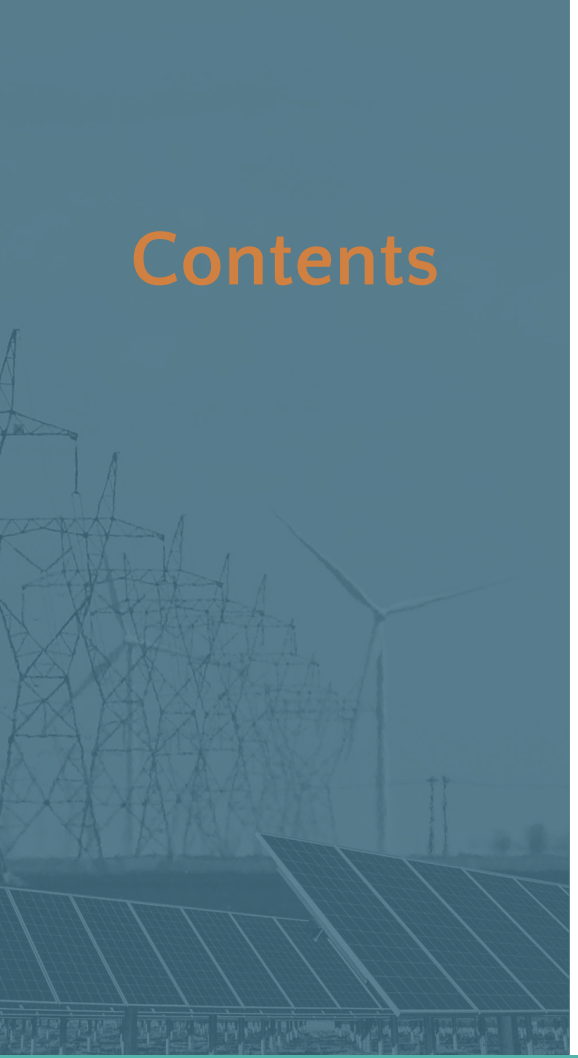
SEAN MURPHY
PingThings
sean@pingthings.io
CEO

NIKKO NIBRES
PingThings
nikko@pingthings.io
Project Manager

MATT BURTON
PingThings
matt@pingthings.io
CRO

ED BEROSET
EPRI
eberoset@epri.com
Technical Leader

Contents



1. Challenges with Data for the Energy Transition
2. Grupo Energía Bogotá and the Pilot Concept
3. PredictiveGrid Platform
4. Pilot Milestones
    a. Data Integration and Quality Assessment
    b. Prototype - Oscillation Detection
    c. Prototype - Lightning Detection
5. Lessons Learned and Next Steps

PingThings

Challenges with Data for the Energy Transition

Sensors Already Blanket the Grid

PingThings

	Already Deployed in the United States			Anticipated US Deployments	
Points per Year	**12.6T**	**3.2T**	**94.7 Peta**	**7.5 Exa**	**15.7 Exa**
Deployed Sensors	120M+	100k+	1M+	100M est	10M est
Sample Rate (Hz)	0.001	1	30	120	10,000+

Smart Meter and AMI 2.0

Power Quality

Transmission Synchrophasor

Distribution Synchrophasor

Continuous Point-on-wave

Industry Trend

Additional Time-Series Data Sources: Vibration, seismic, temperature, humidity, acoustic, weather, etc.

Time is More than Just Money

PingThings

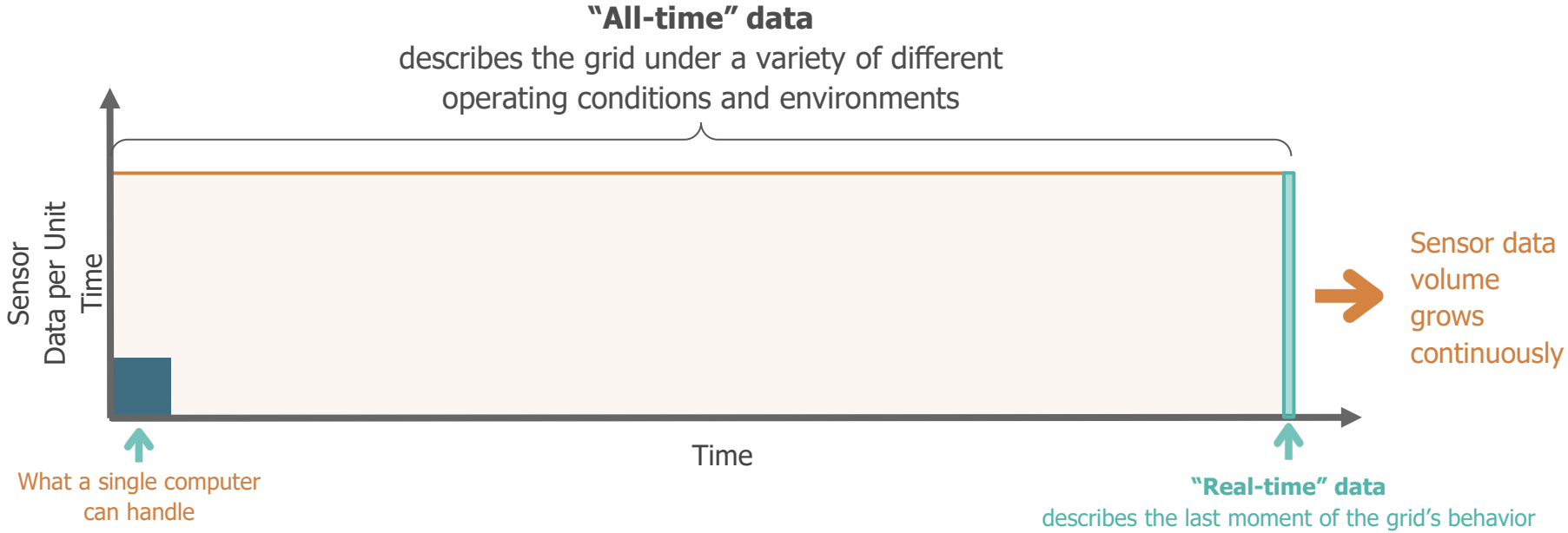
Actual Requirement from a Major US Utility

100 PMUs each with 20 channels of data @ 30Hz generating 1.9T data points in a year

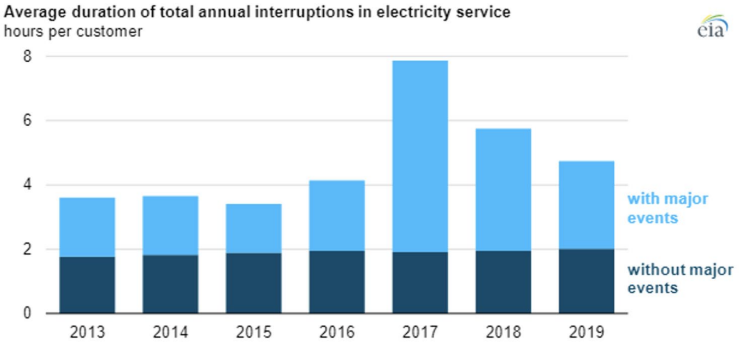
	Read Speed (data points per sec)	**Time to Read** 1.9T Data Points	*Your Data is…*
Legacy Historians	10,000	6.0 years	history, no one looks at it
Generic Cloud Solutions	100,000	7.3 months	unusable and frustrating; critical use cases areout of reach
	1,000,000	3.1 weeks	
PingThings	**10,000,000**	2.2 days	a catalyst for transforming your entire business, enhancing and accelerating all processes.
	100,000,000	5.2 hours	
	1,000,000,000	31.5 minutes	

All of your Data, Everywhere, All at Once

Transforming Data from a Cost Center to an Asset



Traditional Approaches are Not Sustainable



https://www.eia.gov/todayinenergy/detail.php?id=45796

Expansion of Inverter-Based Resources

Over the past few years there have been multiple major events resulting in **1,200 - 3,300 MW** lost from solar & wind plant trips.

These occurred due to **wide area oscillations** across the west coast and Texas, the two regions of the US with the highest renewable penetration.

Flying Blind

Major grid events are increasing, and **SAIDI and SAIFI scores are suffering**. Many utilities don't even have their sensors turned on!

What if you could improve your SAIDI and SAIFI scores by having greater insights into the causes of **equipment failures** and **system faults**, and how to rectify them more quickly?

PingThings

Grupo Energía Bogotá and the Pilot Concept

GEB's Unique Portfolio

PingThings

Colombia

TGI	% ownership	100%
	% Consolidated EBITDA	31%
Transmisión	% ownership	100%
	% Consolidated EBITDA	9%
enel Colombia	% ownership	43%
	% Consolidated EBITDA	23%
EMSA	% ownership	16%
	% Consolidated EBITDA	n.m.
vanti Gas Natural	% ownership	25%
	% Consolidated EBITDA	2%
PROMIGAS	% ownership	15%
	% Consolidated EBITDA	2%

Guatemala

onecta	% ownership	100%
	% Consolidated EBITDA	2%

Brazil

ARGO	% ownership	50%
	% Consolidated EBITDA	n.m.
Gebbras	% ownership	100%
	% Consolidated EBITDA	n.m.

Peru

Cálidda	% ownership	60%
	% Consolidated EBITDA	18%
ElectroDunas / contalloc	% ownership	100%
	% Consolidated EBITDA	6%
ConTgas	% ownership	100%
	% Consolidated EBITDA	1%
isa REP / isa TRANSMANTARO	% ownership	40%
	% Consolidated EBITDA	5%

Generation | Transmission | Distribution | Gas Transportation | Gas Distribution

Consolidating Strategy

PingThings

Transmission assets investment portfolio

	2023 Operating Assets	Acquisitions LTM	Awarded /under construction[1]
Transmisión	2,057km	138 km Elecnorte	2,913km
Gebbras	1,095km		
conecta	712km	2,384 km 5 Concessions	
ARGO	1,743km		
isa	6,322km		
isa TRANSMANTARO	4,378km		
	16,307km +	2,522km +	2,913km

GEB Portfolio

21,742 km

+33% vs. operating assets[2]

GEB footprint countries requires investments of **USD 21.7 bn** by 2032

Transmission Infrastructure	Infrastructure As of 2021	Expansions[1]	%Growth
	28,455km	2,035km	7.1%
	175,273km	33,634km	20.9%
	16,392km	1,711km	10.4%

We will be a leading transmission grid management company with **attractive returns**

GEB's Innovation Model

PingThings

Innovation **Ecosystem**

- Corporate entrepreneurship programs

Innovation **Culture**

- Community
- Mindset 10x
- Dynamic
- Lean and Agile

Innovation **Governance**

- Innovation Committee
- Innovation Teams

Innovation **Process**

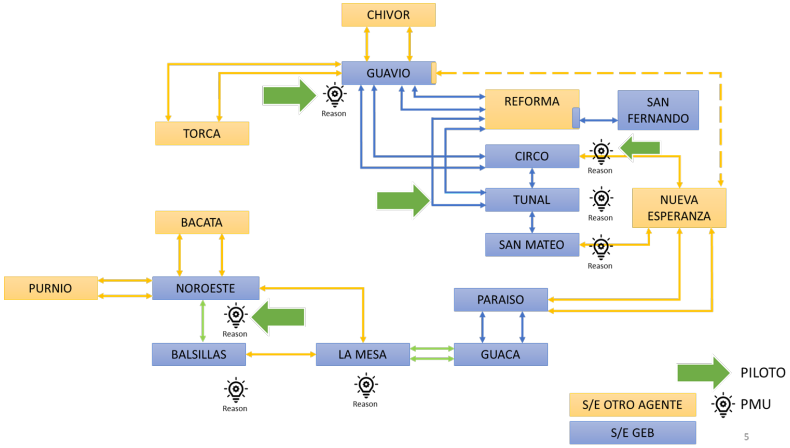
- Phase 1: Ideation
- Phase 2: Incubation
- Phase 3: Demonstration
- Phase 4: Scale

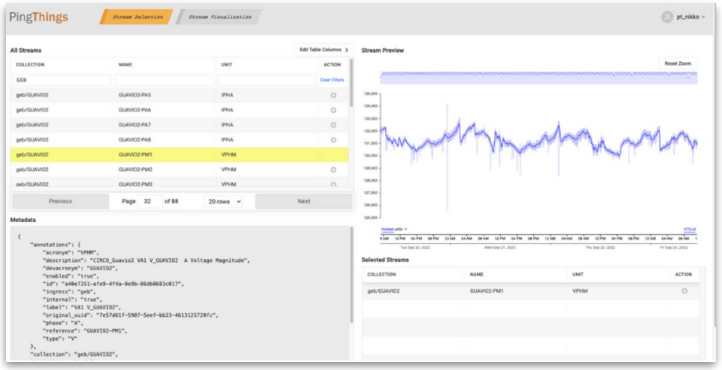
Innovation **Strategy**

- Goals
- Portfolio Management
- Resources
- Metrics

Knowledge Management

Goals of aPilot





Concept

- Test time series management platforms
- Validate capability to manage our PMUs data
- Identify & validate potential O&M use cases

Justification

- Exploratory in nature
- Meant as early validation of the value-generating potential of PMU-based analytics use cases

Potential Benefits

- Reduction in post-operative event analysis time
- Timely identification of events root cause
- Prompt response to real-time events
- Improved situational awareness (less errors in decisions)
- Risk reduction
- Identification of potential future applications

PingThings

PredictiveGrid Overview

PingThings is 3 Things

PingThings

1

A scalable, cloud-based platform for **time series measurements** from **physical systems with real world context**.

- Ingest
- Storage
- Query
- Time Series
- Metadata
- Geospatial and Topology Data

2

All the built-in **power tools** you need **to understand, analyze, learn from, and build with** your data.

- Real-time and All-time Analytics
- ML and AI
- Rapid Analytical App Development
- Data Collaboration and Governance
- Extensive APIs for all Services
- Rapid Dashboarding and Analytical Prototypes

3

A **rapidly growing suite of applications** driven by sensor data and an **active, expert user community**.

Build Your Own Applications

PredictiveGrid™ Platform

PingThings

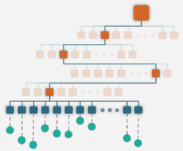
Data Sources

Data Concentrators
Historians & Archives
Cloud Systems
IOT / Devices

Sensors
- PMU
- AMI
- PQ
- DFR
- Point on Wave

Storage

Time Series DB



Meta Data

Asset Information

Grid Technology

Geospatial Data

Analytics

Distil

Real-time Distil

Jupyter Hub

User Defined Functions

Supported Analytics
- Apache Spark
- Ray
- Tensor Flow

Access

API

Realtime API

Access Control

Value

Data Exploration

Dashboards

Reporting

Jupyter Notebooks

Rapid Application Development

Management Apps

Utility-specific Apps

Event Detection

3rd Party Apps

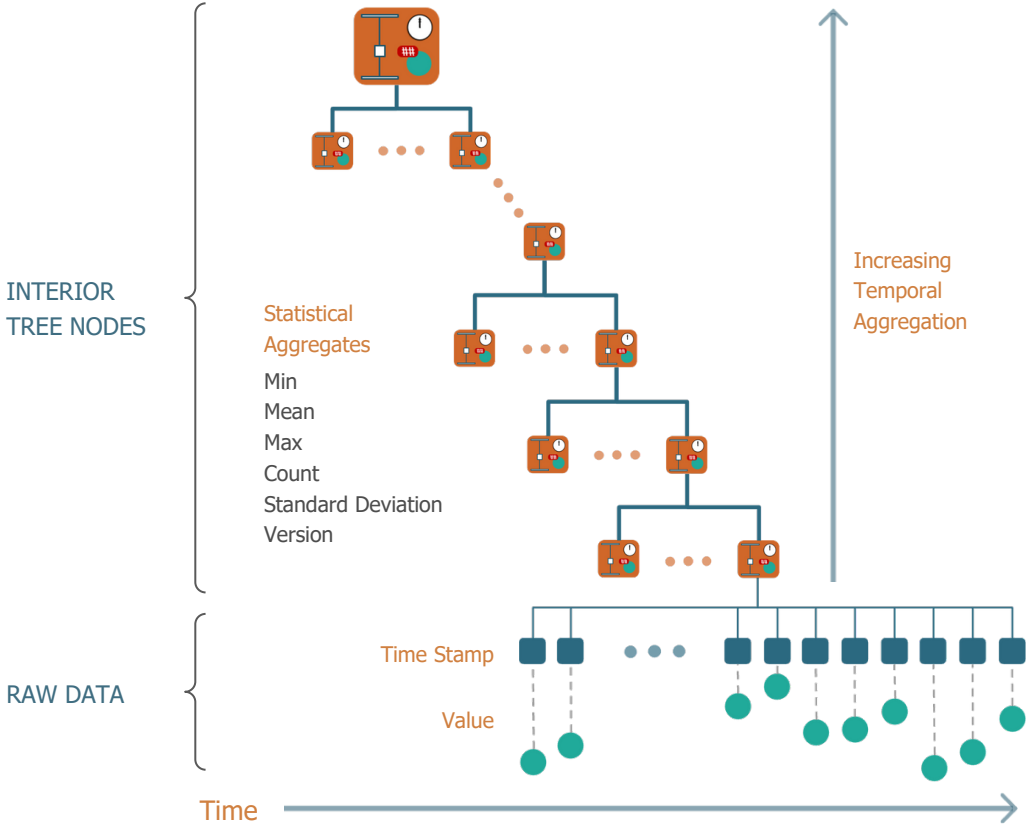
Containerized, secure, scalable, and reliable - deployed on: Microsoft Azure, AWS GovCloud (US), amazon webservices

Platform Data Structure

PingThings

PredictiveGrid™ **natively supports**

- Best in industry lossless compression
- Nanosecond time precision
- Up to 1 billion samples/second/stream
- Support for dynamic sampling rates
  - Adaptive sensors
  - Multi-resolution time-series
  - No configuration change required!
- High performance out-of-order insertion to handle data dropouts
- Data version control from the ground up
- Built-in data quality assessment



PingThings

Pilot Milestones

Scope of thePilot

Key Objectives

Use the PingThings platform to **ingest and manage** synchrophasor and other data sets provided by GEB

Explore and analyze potential use cases

Allow GEB to advance the state of **working with time series data** to operate a safe, reliable, and sustainable grid

From kickoff to two **fully functional** applications in less than **three months**

System Integration

Challenge

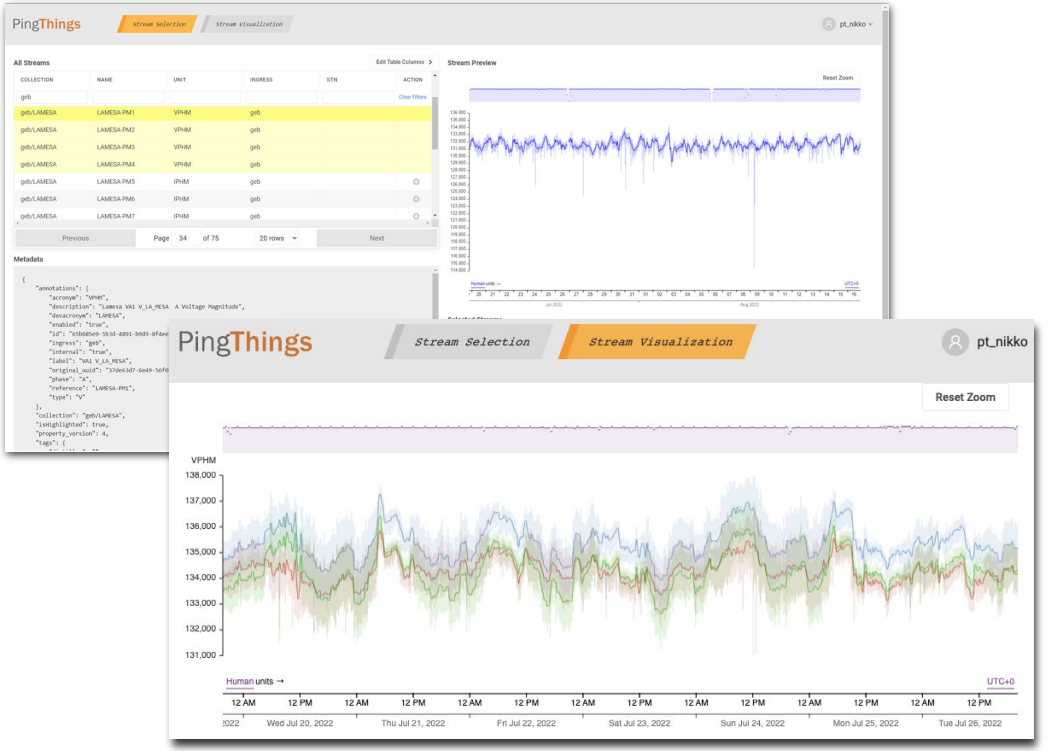
A secure connection between PingThings' PredictiveGrid platform and GEB's **OT and IT network** was required to enable use case exploration

Solution

Pings engaged with Grid Protection Alliance to help guide GEB in the deployment of two OpenPDCs:

- One server hosted in their OT network gathered all of their data streams together.
- The second server hosted in their IT network acted as a proxy where PingThings was able to securely retrieve all of the sensor data.

Server configurations, firewall configurations, and network bandwidth issues were resolved to configure a publisher and subscriber framework for **successful data streaming**.



Data Quality

Challenge and Solution

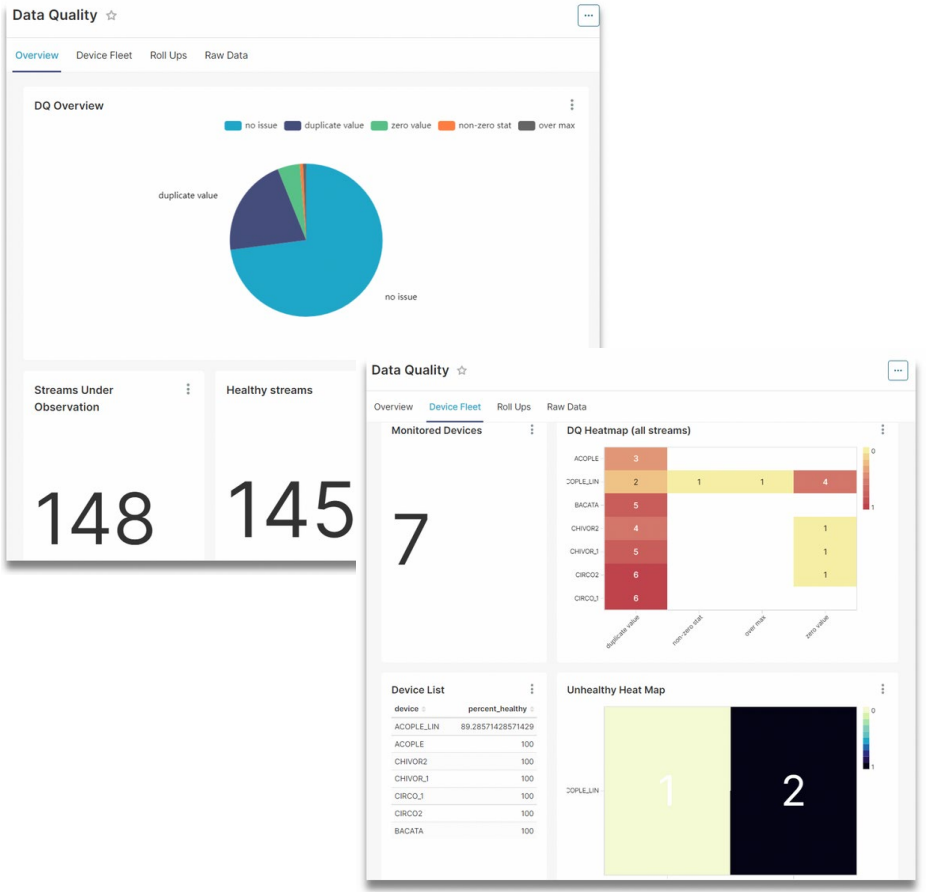
There was no centralized system for understanding or **analyzing data quality issues** from existing sensors. PingThings first brought in the original author of the current data collection system to support.

The PredictiveGrid utilized our out-of-the-box **data quality toolsets** to holistically analyze data quality ahead of starting development.

Results

PingThings' **data quality assessment** review identified the following issues to be addressed, which are very common for distributed sensor fleets:

- Data gaps
- Time configuration issues
- Low voltage streams
- Incorrect phase labels
- Missing voltage measurement streams and more



Lightning Strike Application
Development & Deployment

Challenge

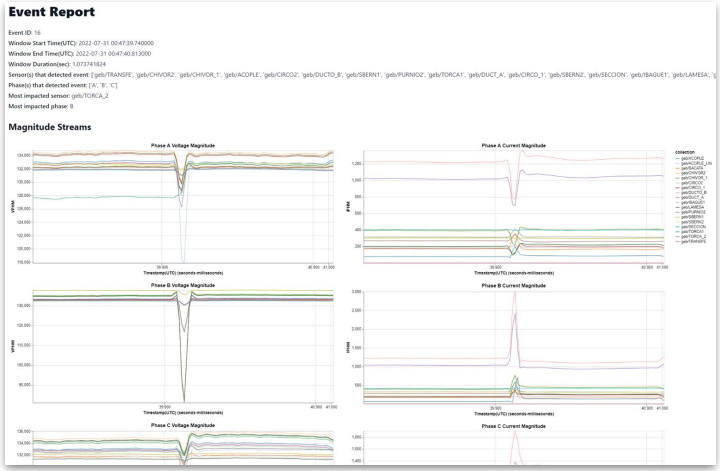
Lightning strikes are frequent and **heavily impact GEB's transmission system**, but the propagation of these impacts and when they occur are difficult to track.

Solution

PMU voltage magnitudes were **rapidly scanned** for potential lightning strikes and correlated suspicious events. If any events were recognized across multiple streams, these were flagged as a potential strike and record the duration, severity, and extent.

Using this information, the team automatically generated a report that visualized all voltage magnitudes and frequencies for all affected PMUs, along with a severity table and map detailing which sensors were most affected. We also calculate reactive and active power calculations to provide insight on grid state.

The PredictiveGrid platform is able to scan two months of the entire system in **less than 10 seconds** to provide GEB's response and post-analysis teams actionable intelligence to make informed decisions.



Results calculated **27x faster** compared to current capabilities

Oscillation Detection
Development & Deployment

Challenge

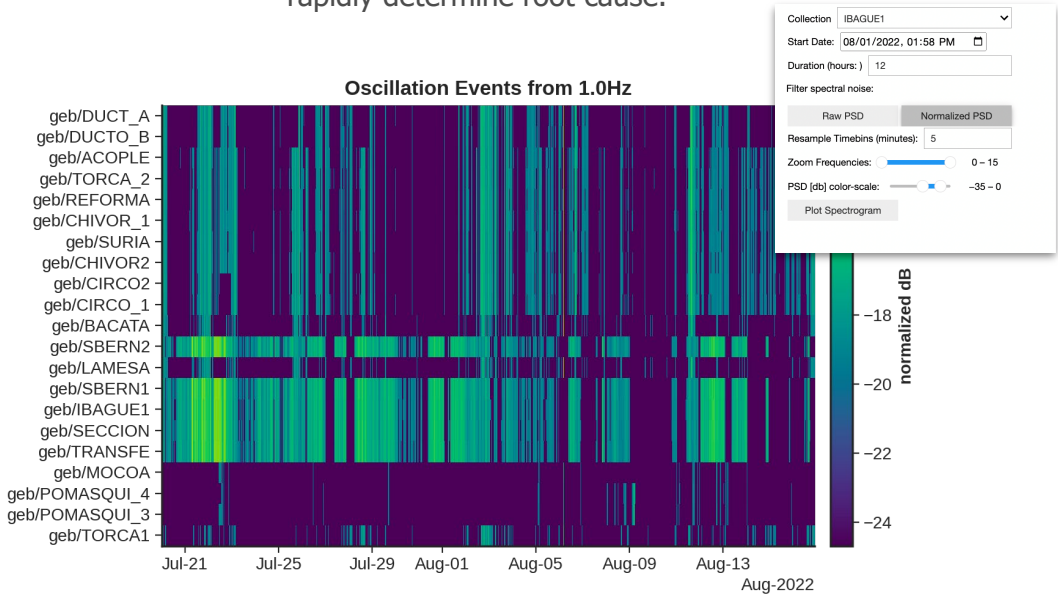
Without a robust data platform in place, GEB did not have the ability to visualize or analyze any grid oscillations.

Solution

Oscillations were detected using the PredictiveGrid by generating spectrogram reports for all sensors in GEB's fleet through all possible frequencies.

The PredictiveGrid platform allowed the team to not just look at oscillations in real time, but to look at all oscillations that have occurred historically throughout the system so that causal patterns can inform and train more robust models.

An **interactive coding environment** we deployed to allow GEB to more readily analyze specific oscillations and more rapidly determine root cause.



Lessons Learned & Next Steps

PingThings

This analysis requires working at a scale only made possible by PredictiveGrid™

Quickly achieved PMU data availability (~1 month)

- The pilot allowed Enlaza to identify the IT/OT infrastructure requirements for making PMU data available, and to make it readily available for experimentation through PingThings platform

Identified & prioritized PMU data use cases

- Once up and running, potential PMU data-based use cases that could help transmission assets O&M teams to generate value were identified, discussed, and prioritized

Implemented 2 use cases

- Two (2) use cases valuable for the safe and reliable operation of the assets were prioritized and developed
- Detection of power oscillations and post-operative event analysis

PingThings

EPRI
ELECTRIC POWER
RESEARCH INSTITUTE

Thank You!

Grupo Energía Bogotá
PingThings
EPRI

info@pingthings.io

+1 (202) 991 - 0887

pingthings.io

1 Unrivaled presence in Colombia and Peru, markets with strong fundamentals

Grupo Energía Bogotá

Colombia

- Generation: **19% of installed capacity**
  4,083 GWh generation — 2nd
- Transmission: **22% of national system income**
  2,197 km transmission lines[1] — 2nd
- Distribution: **21% of market share (by end-users)**
  4.2 million connections — 1st
- Gas transportation: **~52% of national network (km)[2]**
  4,033 km gas pipelines — 1st
- Gas distribution: **32% of market share (by end-users)**
  2.5 million connections — 2nd

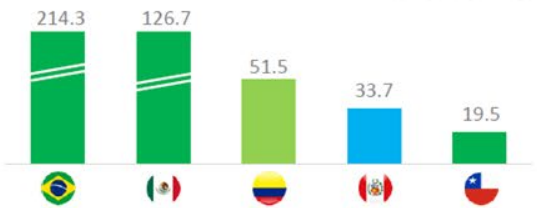
Peru

- Transmission: **66% of national system income**
  10,701 km transmission lines — 1st
- Distribution: **3% of distributed energy**
  264,000 connections
- Gas transp. / distr.: **80% of Peru's volumes**
  1.6 million connections — 1st

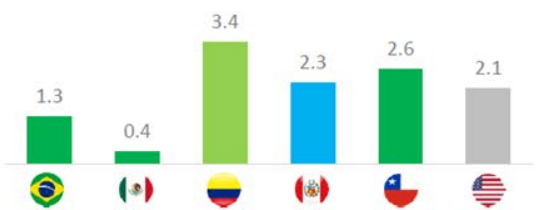
Market Position

Country dynamics

Population (millions)



Avg. GDP growth '18-'22 (%)



Avg. country risk[3] '18-'22 (%)

Source: World Bank Data, JPM's Emerging Markets Bonds Index (EMBI).
Notes: (1) Includes 138 km from Elecnorte (2) Figure represents TGI's network in the national network, excludes Promigas which has a 37% share. (3) Based on average EMBI for each country during the 5-year period ending 2022.

Demo Project: Transmission data analytics experimentation platform

Solutions and technologies explored: PMU-based descriptive and predictive analytics

Horizon: H1 (core)
Vertical: Electricity
Focus: Industry 4.0
Effort: Low
Impact: Very low

Business need

- Hundreds of measurement devices across Enlaza's power transmission substations
  - Time series with varying sampling rates
  - 20+ PMUs
- Vast amount of data generated
- Challenges:
  - Manage time series data
  - Generate & capture value
- Aligned with objective:
  - Operate network safely, reliably, and sustainably

Description

- Test time series management platforms
- Validate capability to manage our PMUs data
- Identify & validate potential O&M use cases

Justification

- Exploratory in nature
- Meant as early validation of the value-generating potential of PMU-based analytics use cases

Potential benefits

1. Reduction in post-operative event analysis time
2. Timely identification of events root cause
3. Prompt response to real-time events
4. Improved situational awareness (less errors in decisions)
5. Risk reduction
6. Identification of potential future applications