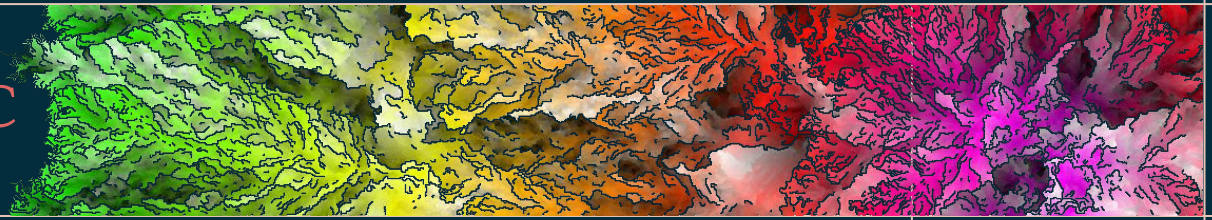
January 30, 2025 | Washington, DC

Canary in the Transformer

Predictive maintenance for the electric grid

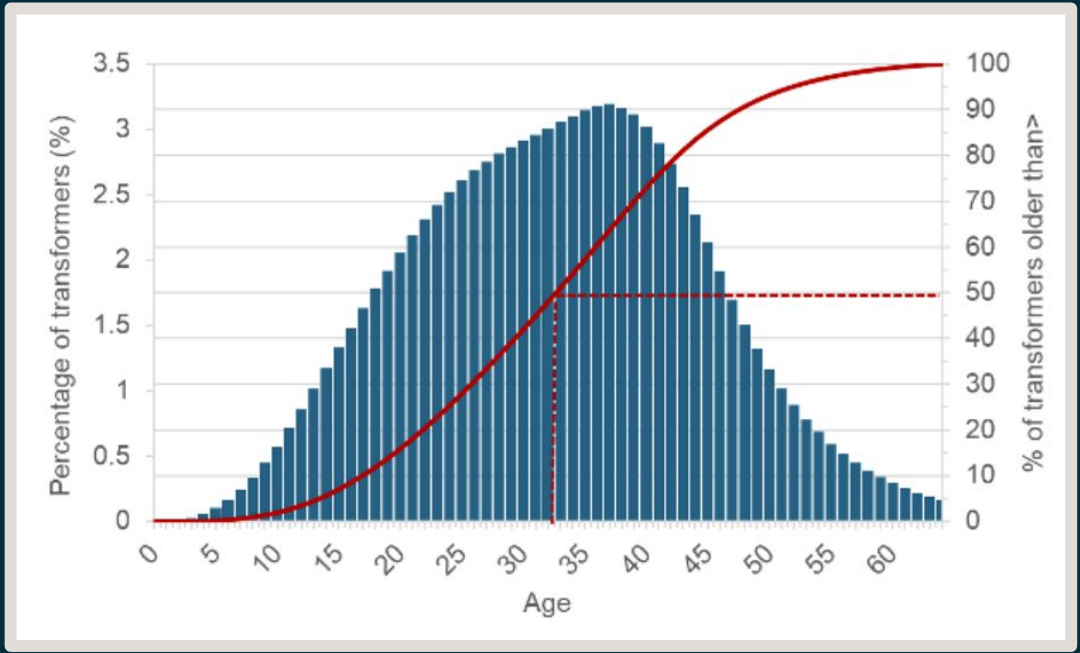
BELLWETHER, LLC



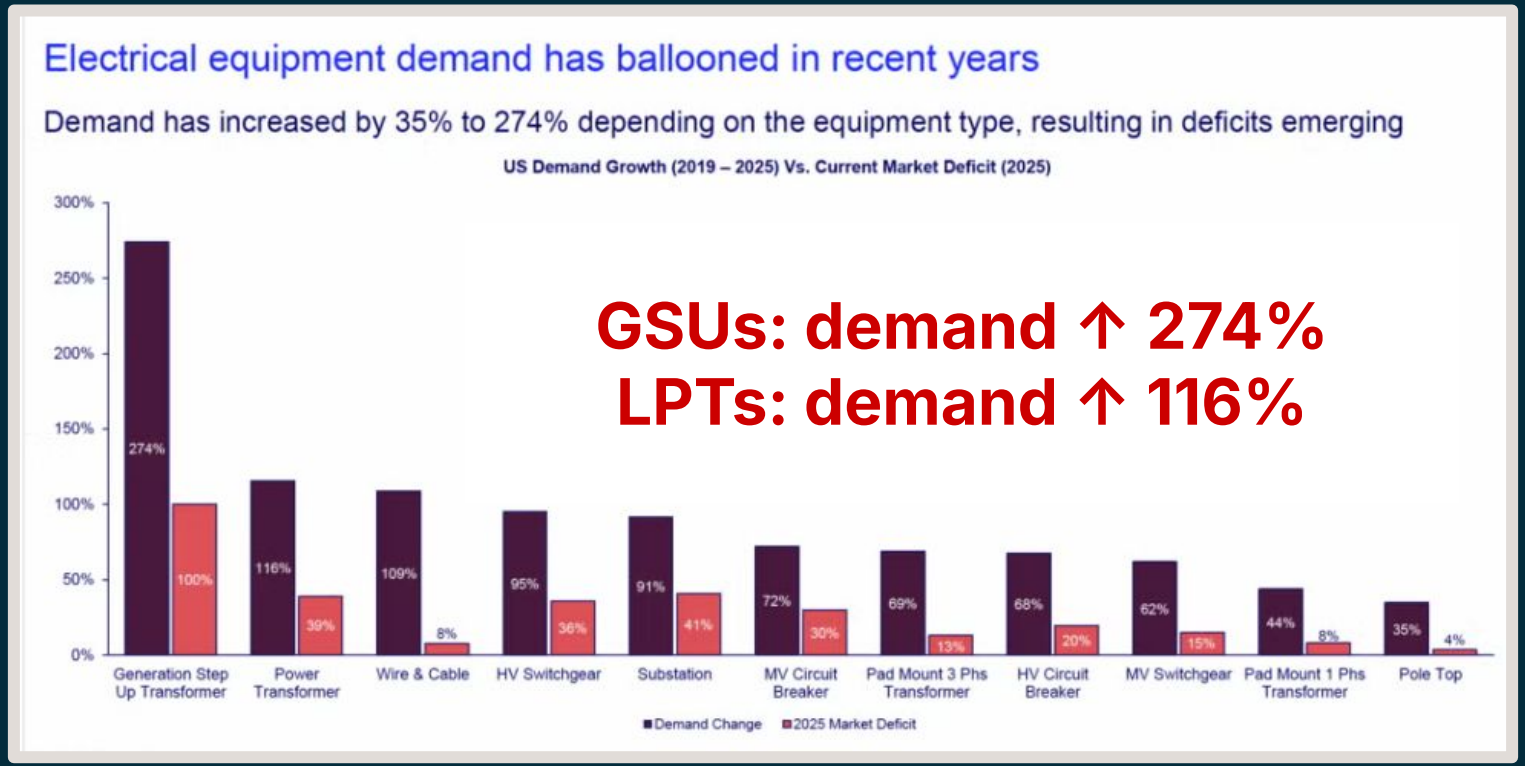
The Problem – *We can barely keep the lights*

Distribution transformers:
50% are 33+ years old

Transmission transformers:
70% are 25+ years old



The Problem – *Much less scale generation and distribution*



Technology

Which transformers to replace first?

Passive

Non-invasive

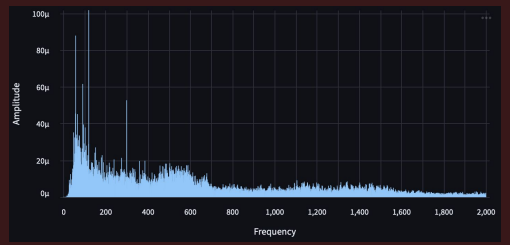
Up to 30 ft range

1

Listen to the transformer

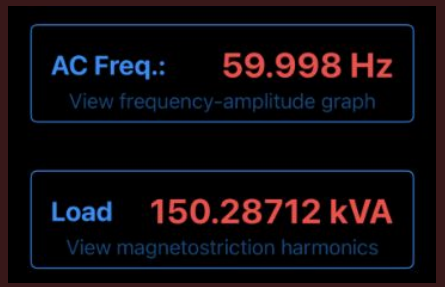
2

Analyze the acoustics



3

Get the assessments



Just use your phone

Find out:

1. Loading in kVA
2. Transformer's "time left to live"
3. Risk of fire

in 60 seconds

How much power are you using?

1

What is the loading?

2

How long until the transformer fails?

3

Are you at risk of fire?

How much power are you using?

1. Can you support a new data center?
2. How long until you are held hostage by your supply chain?
3. Are you at risk of a multi-million dollar settlement for a fire?

USA market highlights

Total US ARR

$792M

Distributed solar ARR

$198M

11,000 companies

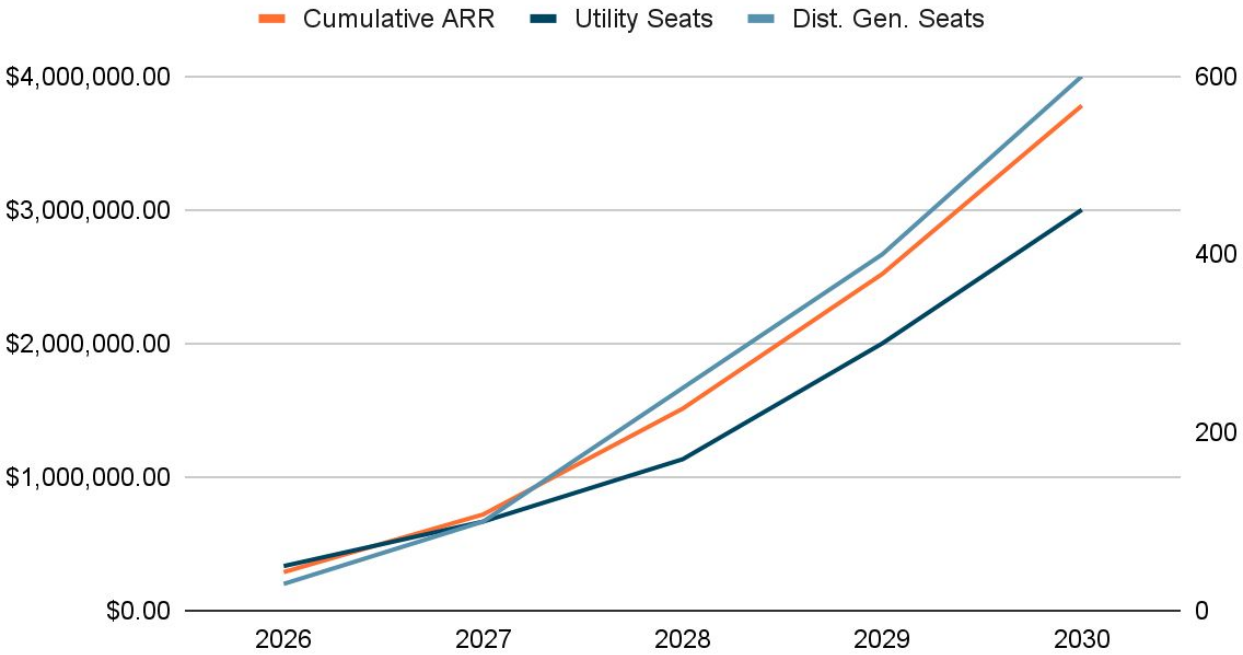
Electric utility ARR

$594M

55,000 substations

$300/month/license seat

Year-over-year revenue growth



+$1M ARR YoY

Customers are:

- Electric utilities
- Distributed solar generation
- Wind generation
- Data centers
- Industrial plants

Utility use case

$3B	**in yearly damage to substations**
$280k	**5-year cost without us**
$45k	**5-year cost with us**
84%	**savings**

↑ Reliability

↓ Cost

Competition

Magnetometer

- Oktogrid
- Magnefy

Invasive installation	Canary is **passive and non-invasive**
Expensive	Install on your phone, **use endlessly**
Unable to be used by utilities	Allows for **online assessment**

Vibrational

- Traction
- Betavib
- Extech
- Fluke

Invasive installation	Canary is **passive and non-invasive**
Requires power source	Operates from your **phone in 60 seconds**
Complex analysis is required	Analysis is **done for you, without internet**

Ultrasonic

- Fluke
- UE Systems
- SDT 340
- Mistras

Unable to detect winding issues	Canary monitors **ultrasonic and audible**
Expensive	Affordable installation **by license seat**
Unable to detect loading	Automatic loading analysis **instantly done**

Competitive advantage

No one else is doing this

Hardware costs keep competitors out
No one else uses acoustics like this
Most transformers completely unmonitored

Passive, non-invasive

Transformers **stay online**
No interruption of service

Hardware already deployed

All on your **smartphone**

Jacobson Award Funding

Continuous monitoring device

1

Low-power

Operate in extreme environments for up to 6 months

2

Weather-proof

Survive the harshest of conditions with zero human input

3

Internet connection

Connect and reconnect to the internet, despite outages and weather

4

Easy to produce

There are 60 million distribution transformers in the US — this product needs to support rapid construction and installation

The only team who can do this

Ari

Nuclear Engineer | Acoustician
Submarine Officer

Chad

Former DoD AI Lead

Labstart

NAVAJO TRIBAL UTILITY AUTHORITY
NTUA
UTILITIES FOR THE NAVAJO NATION

Hydro Québec

Cypress Creek RENEWABLES

NRECA
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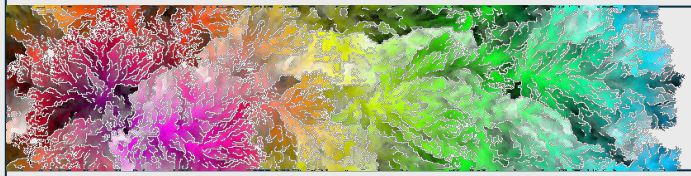

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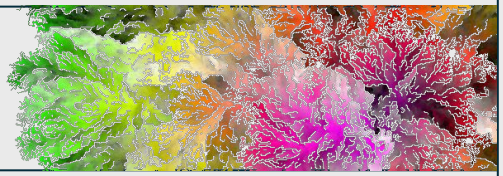
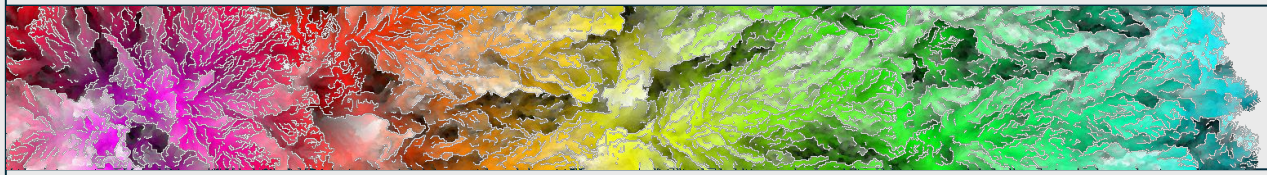


Appendix



How much power are you using?

1. Data is **imprecise**
2. Data is **inaccurate**
3. Data is **closely guarded**
4. Requires **invasive meters**

Which areas have high loading?

Utilities ask...

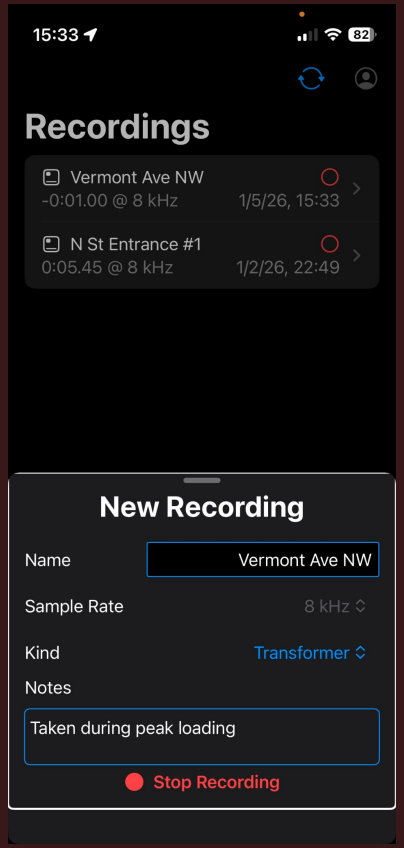
1. High loading increases **risk of failure**
2. Transformer health is **unknown**
3. Utilities need **3-5 years** to get new transformers
4. Identify a problem **before the blackout**

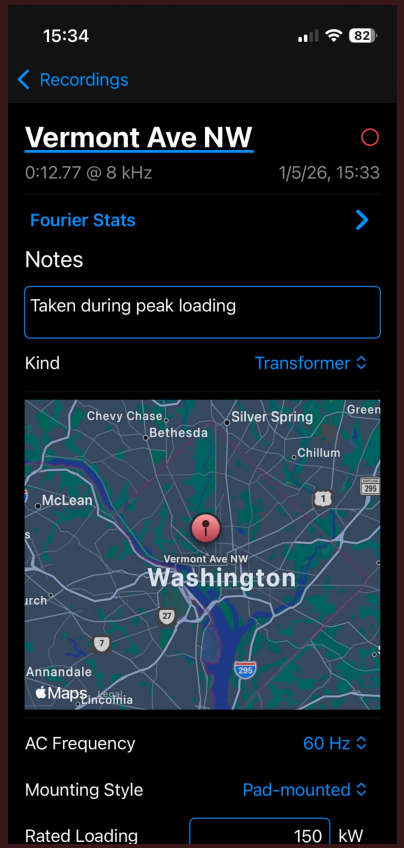
Which areas have low loading?

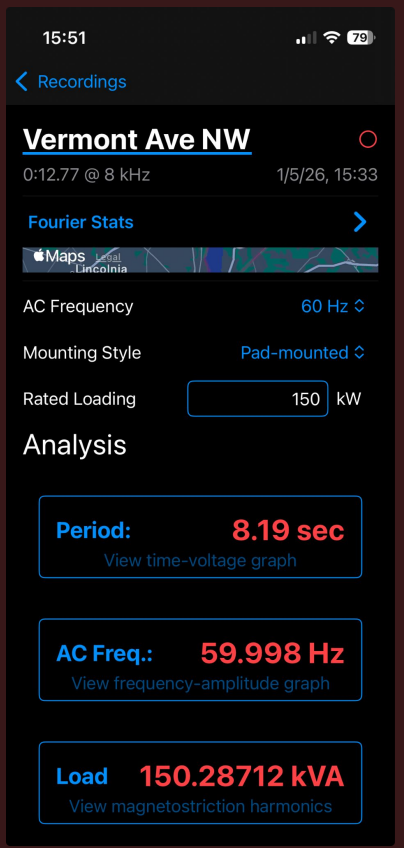
Distributed generators and data centers ask...

1. Transformer loading is **private knowledge**
2. Developers **want this knowledge**
3. Build where upgrades are **not required**
4. Eliminate unnecessary **upgrades**

Appendix: Screenshots







Appendix: Magnetostriction

60 Hz ac creates 120 Hz magnetostriction tone

2025 IEEE paper corroborates work

4 chinese scientists found this is a great way to determine loading

Causes of noise

- Magnetostriction
- Acoustic resonance
- Non-linear loads
- Core delamination
- Cooling fans
- Load conditions
- Overloading

Physical Phenomenon of Magnetostriction

- **60 Hz ac electricity**
- 60 Hz ac creates **60 Hz oscillating magnetic field**
- **Ferromagnetic grains expand/contract with peaks and nadirs**
- Expansion happens 2x/cycle, which creates a **120 Hz acoustic tone**

Appendix: Problem

Major transformer failure costs

Based on 7 days of downtime / major transformer failure
24 hrs of downtime / substation / year, based on a 2018 study

$14k/MVA	28 MVA	$392k	$56k
Major transformer failure Costs of a failure	**Standard substation** Average size	**Material costs** Only the material, capital expenditure costs per transformer — labor and overtime are all considered extra, O&M costs	**Cost / substation / year**

Appendix: TAMs of Other Industries

$180M
Commercial fishing

Classify species of fish based on sounds

Minimize bycatch and increase fishing efficiency

$200M
Hydroelectric turbines

Predictive maintenance

Siting

Hydro-Québec has specifically asked for this

$355M
Wind turbines

Predictive maintenance

Siting

Appendix: Market (Substations)

20% figure comes from publicly available federal hydroelectric operators (PMAs)

Assume same 20% ratio holds for private grid operators

Material repairs are lessened by early identification

Private operators have significantly more capital available per substation

Rural utilities as a bloc have an outsized representation of federal operators

Rural utilities have trade association to pool resources (**NRECA**)

$5k/license seat/year

Train of Thought

- **20% of O&M budget** is for substations (based on federal hydroelectric operators)
- Substation O&M budget is: **~$130k/substation/year**
- 3% * $130k/subs. = **$3.9k/subs./year**
- Substations monitored by untrained worker 4-6x/year; **likely different employee every time**

Appendix: Market (Wind)

77,100 figure comes from a 2022 study

Average wind turbine capacity is 3.5 MW

$1,391/kW is average cost/kW for on-shore wind

Avg. cost is 3500 kW * $1,391/kW = $4.8M

O&M budget is $40/kW/year

3500 kW * $40/kW/year = $140k/year

71,000 turbines * $5k/turbine/year =
$355M/year TAM

$5k/turbine/year

Train of Thought

- **77,100 wind turbines**
- Average wind turbine **cost is $4.8M**
- O&M budget is **$140k/year**
- **Charge $5k/turbine/year;** only 3.5% of yearly O&M budget

Appendix: Market (Hydroelectric)

2024 study: **250 billion kWh generated** from hydroelectric dams

28 million kW capacity / 2800 kW/turbine = **10,000 turbines**

Assume Kaplan turbine, 8m pump head, 42 m^3/s

Based off Norwegian report

$20k/turbine/year is 3% of total cost

10,000 turbines * $20k/turbine/year = **TAM $200M**

$20k/turbine/year

Train of Thought

- **10,000 hydroelectric turbines**
- **Cost ~$700k/turbine** from Norwegian report
- Charge **$20k/turbine**

Appendix: Market (Fishing)

2023: 36,000 registered commercial fishing vessels

Fish identification is done through **active sonar** and **size identification**

Passive identification allows for **more reliable** identification at a **greater distance**

Furuno Omni Sonar is most popular tool
$100k/vessel

36,000 * $5k/vessel/year = **TAM $180M/year**

$5k/vessel/year

Train of Thought

- **36,000 vessels**
- **$100k/vessel** for sonar equipment
- 5%/year * $100k/vessel = **$5k/vessel/year**

Appendix: Competition

Vibration	**Tractian**	Believed to be dependent upon savings Good for bearing assessment Unable to find evidence of it being used or working — **VAPORWARE**
Vibration	**Betavib**	$35,000 for total system (+ $12,000/machine) — **EXPENSIVE** Only does bearing assessment
Vibration	**Extech VB450**	$749 Manual operation
Vibration	**Fluke**	$15,000 for Fluke 810 — **EXPENSIVE** Fragile Extensive usage manual — **HARD TO USE**
Ultrasound	**Fluke**	$30,000 for Fluke 910 — **EXPENSIVE** Extensive usage manual — **HARD TO USE**
Ultrasound	**SDT 340**	$2,290 per unit Limited analysis
Ultrasound	**Mistras Group**	Monitors stray gassing and delamination No signature analysis Requires experienced operator

Appendix: Competition

Magnefy

- Magnetometer
- Ultrasonic microphone
- Temperature sensor
- Gas analysis

- Hardware licensed from Stanford
- Software licensed from UCF

Oktogrid

- Magnetometer
- Ultrasonic microphone
- Temperature sensor
- Gas analysis

- Danish company

Invasive installation	Invasive installation
Likely $5,000/transformer installation	Likely $5,000/transformer installation
No product yet	**Product deployed in limited quantities**
No signature analysis	No signature analysis
Requires de-energizing transformer for installation	**Requires de-energizing transformer for installation**