20ᵗʰ Century Approach:
Manual Inspection

Infrared Leak Hunter (SF_6, Eco gas)

https://emt.global/sf6-leak-management/sf6-leak-surveys/

SF_6 Infrared Camera

https://www.nationalgrid.com/stories/energy-explained/what-is-sf6-sulphur-hexafluoride-explained

ARPA-E / GE Approach:
24/7 Unattended Monitoring for Predictive Maintenance

Photo by R. A. Potyrailo

Beyond 20ᵗʰ Century Approaches:
Multi-Gas Unattended Leak Monitoring of Gas-Insulated Equipment (GIE)

Radislav A. Potyrailo, Ph.D.
GE Research

ARPA-E Workshop: "Accelerating Grid Technology Introduction and Deployment", Febr. 29, 2024

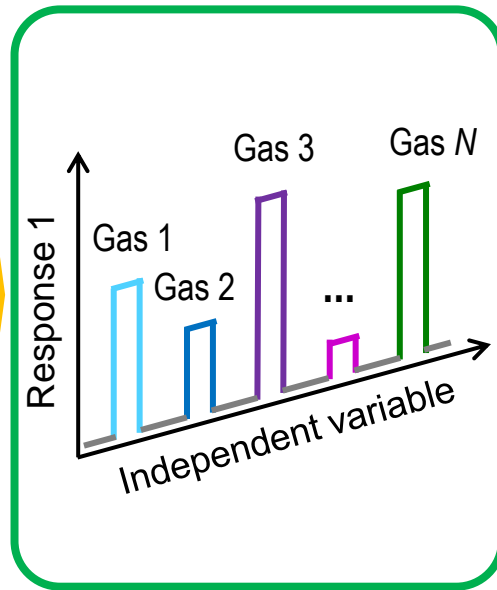ARPA-E PROGRAM: Detection-and-Fixation: A Lifecycle Management Framework for SF6-free Power Network
Team: Yang Cao and Stephen Suib (**UConn**), Radislav A. Potyrailo, Shiyao Shan, Baokai Cheng, Karim Younsi, Ibrahima Ndiaye, Yannick Kieffel (**GE**)

1

Shift from Manual to Remote Monitoring for Multi-gas Leaks
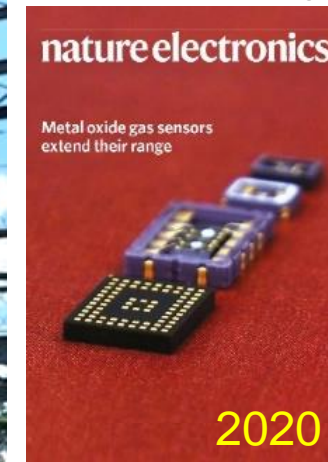
Existing solutions w/ consumables

Multi-gas resolution

ARPA-E / GE high-sensitivity, semiconductor-based remote monitoring solution

SF6 decomposition products by gas chromatography

https://www.masatech.eu/portable-advanced-ion-mobility-spectrometer

Gas 1
Gas 2
Gas 3
...
Gas N

Response 1

Independent variable

Scientific recognition:
Dielectric excitation sensing

nature electronics

Metal oxide gas sensors extend their range

Industrial recognition:
AMA Innovation Award

TRL4

2024

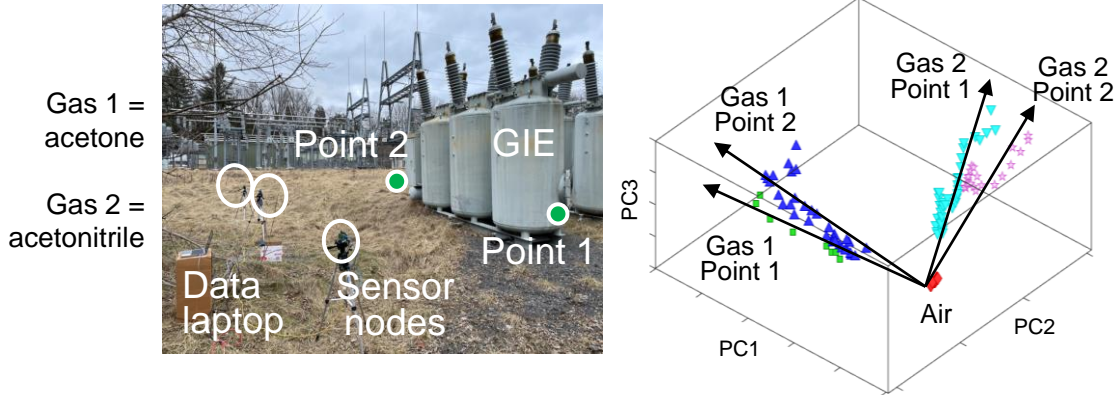Photo by R. A. Potyrailo

2020

2021

Our key innovation:

Modern electronics cross-pollinated with modern mathematics

Potyrailo, R. A.; Go, S.; Sexton, D.; Li, X.; Alkadi, N.; Kolmakov, A.; Amm, B.; St-Pierre, R.; Scherer, B.; Nayeri, M.; Wu, G.; Collazo-Davila, C.; Forman, D.; Calvert, C.; Mack, C.; Mcconnell, P. Extraordinary performance of semiconducting metal oxide gas sensors using dielectric excitation, *Nature Electronics* **2020**, *3*, 280–289
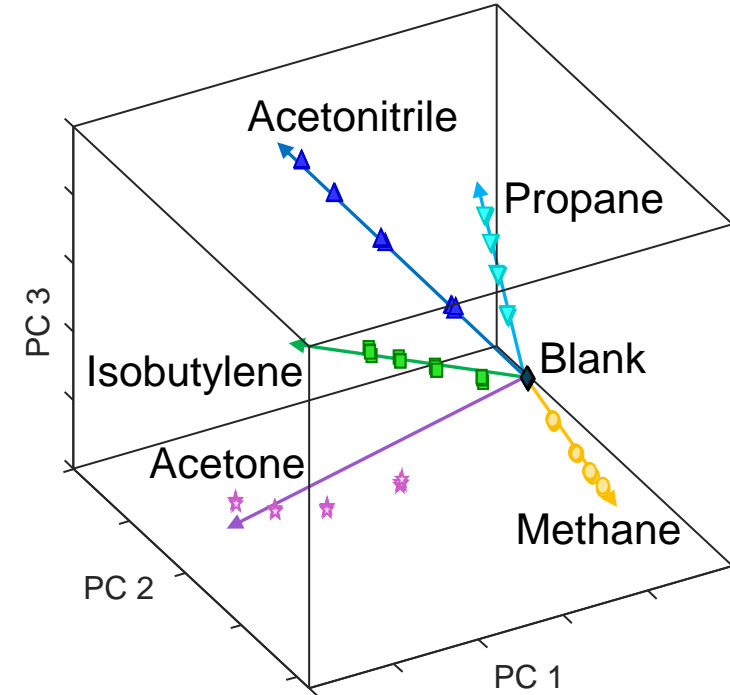https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=926663

Two development teams awarded the AMA Innovation Prize **2021**
https://www.ama-sensorik.de/en/science/ama-innovation-award/ama-innovation-award-2021/

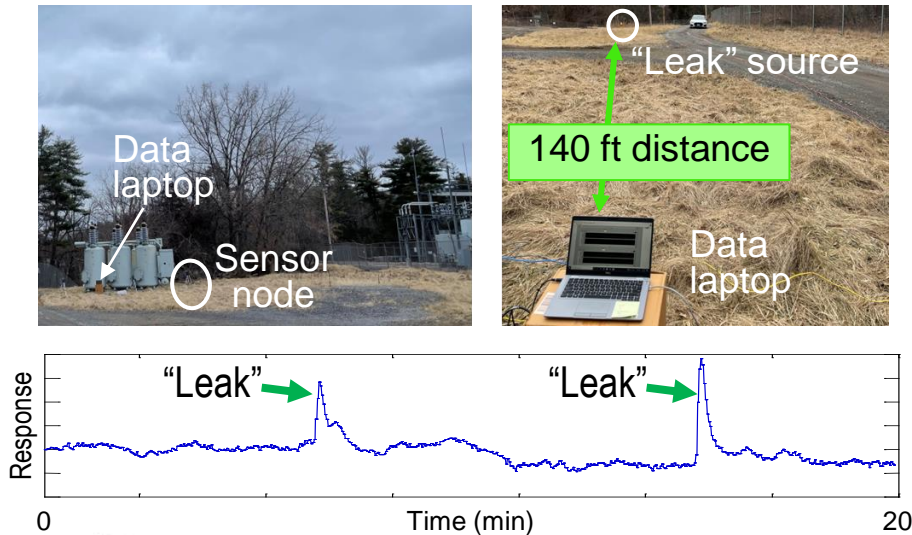# Tech Validation: Monitoring and Localization of Multi-gas Leaks in GIE

Stand-off localization of multi-gas leaks

140-ft stand-off "leak" detection field test

Edge computing-based machine learning (ML) differentiates multiple gases

- Model volatiles utilized to mimic (to replicate) decomposition products of SF6 and g3 gases
- Successful identification of gases in lab tests with <90 ppb cross-validation error
- Principal Components Analysis (ML) plotted

Benefits for Utilities, Markets, and Next Steps

Illustrative electric substation with fielded multi-gas sensor systems

Sensor nodes
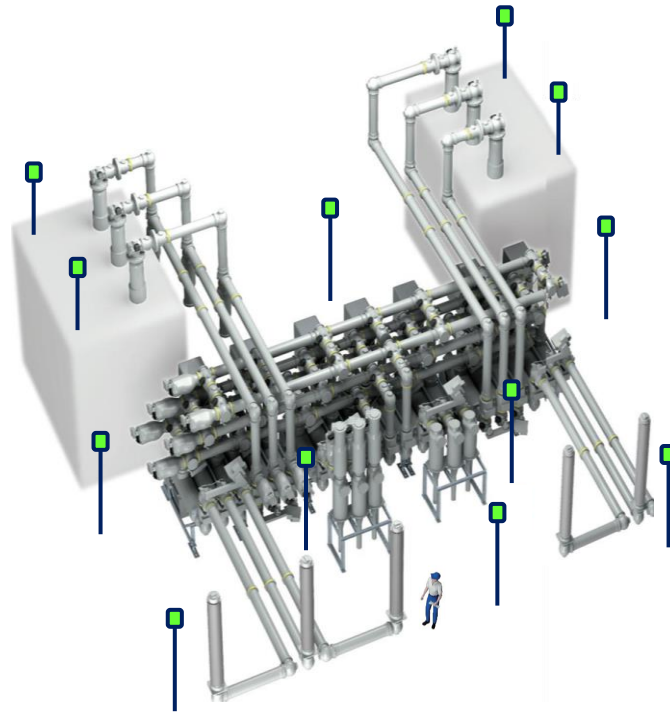
Key benefits of GE solution for utilities:

✓ **Detects and locates** minor and typical multi-gas leaks for prognostics

✓ Monitors **legacy SF6 GIE** and **new generation GIE** without modifications

✓ **Eliminates** unscheduled **maintenance**

▸ **Markets:**

2030: Transmission & Distribution GIE (~270,000 units globally)

2035: Power Gen, Mining, Oil & Gas (~500,000 units globally)

▸ **Growth 5-year plan:**

NPI* via field validations in US and Globally

*NPI = New Product Introduction

▸ **Next steps:**

– Field tests with prognostics of SF6 GIE

– Seeking commercialization partners for field tests, certification, and product distribution

Unattended Monitoring of Multi-gas Leaks:
Meeting Demands for New Technological Solutions for Aging Electric Grid

https://www.tdworld.com/substations/article/21264618/systems-with-intelligence-transforming-an-aging-grid-where-should-utilities-focus-investments

Radislav A. Potyrailo, Ph.D.
GE Research
Potyrailo@ge.com

https://utilityanalytics.com/2019/03/making-sense-of-sensors-in-the-age-of-the-smart-grid/

https://www.bloomberg.com/news/articles/2023-09-26/aging-us-electric-grid-s-significant-risks-undercut-reliability-safe-says