



Detecting Leaks of Flammable Refrigerants below the 5% Lower Flammability Limit with a Low-Cost Sensor Platform

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Drivers for low-GWP Refrigerants

- Phase out of HFCs and safe transition to low-GWP hydrocarbon (HC)/natural refrigerants are critical global issues
- Regulatory, business and climate impacts are the main drivers.
- The American Innovation and Manufacturing Act (AIM Act, 2019) and HFC phasedown regulations are forcing original equipment manufacturers (OEMs) and end-users to use alternative refrigerants to reduce GHG emissions.
- Serves DOE's energy efficiency (MDEC, kWh/day), GHG reduction (80% by 2050), and climate change objectives (<2°C rise by 2100).



Propane, a Natural A3 Refrigerant is gaining acceptance



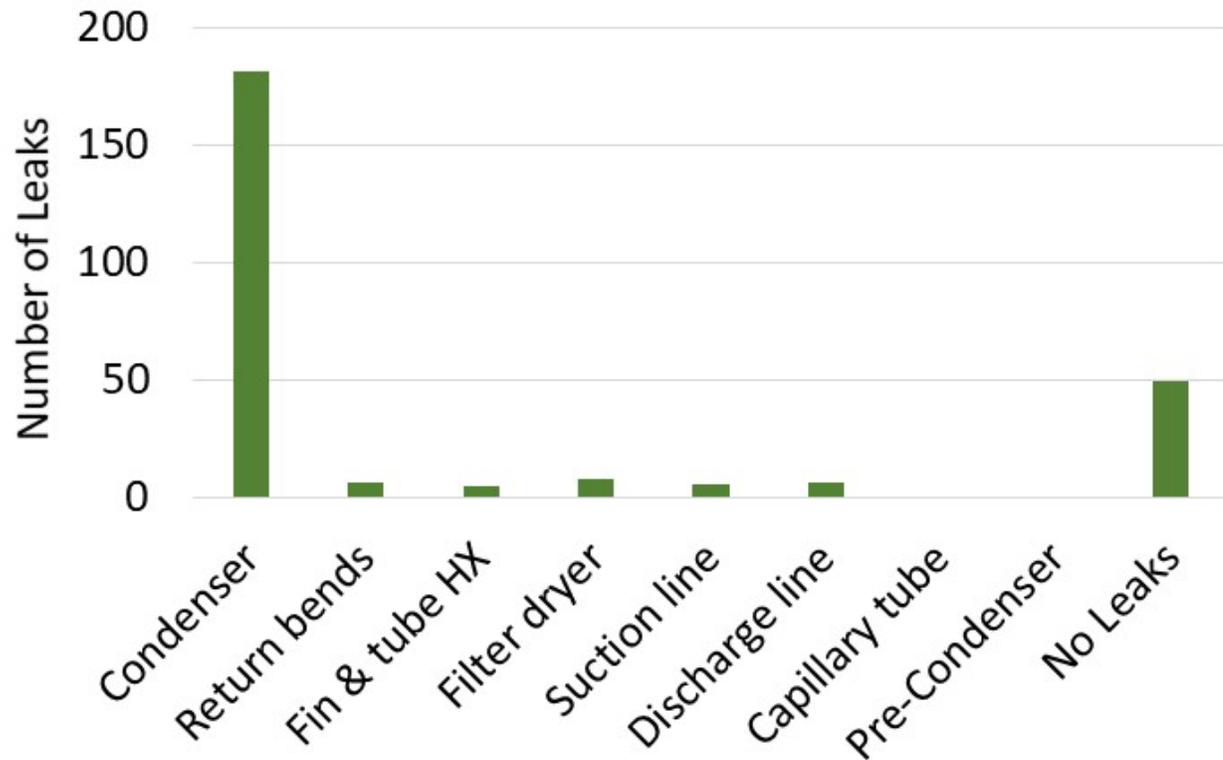
- Propane (R-290) has a 20-year and 100-year GWP of 0.072 and 0.02, respectively (2021 IPCC data).
- Propane has clear benefits among Low-GWP refrigerants in terms of efficiency and reduction of greenhouse gases emissions.
- Safety standards in both ASHRAE and UL require leak detection and mitigation to reduce the risk associated with any system leak or age
- The natural refrigerants market is expected to grow from \$1.5B in 2020 to \$3.5B by 2026 at 12% Compound Annual Growth Rate (CAGR).
- DOE is supporting the U.S. hydrofluorocarbon (HFC) phasedown proposal, which targets an 85% reduction by 2035, through R&D and testing of low-to zero-GWP technologies.



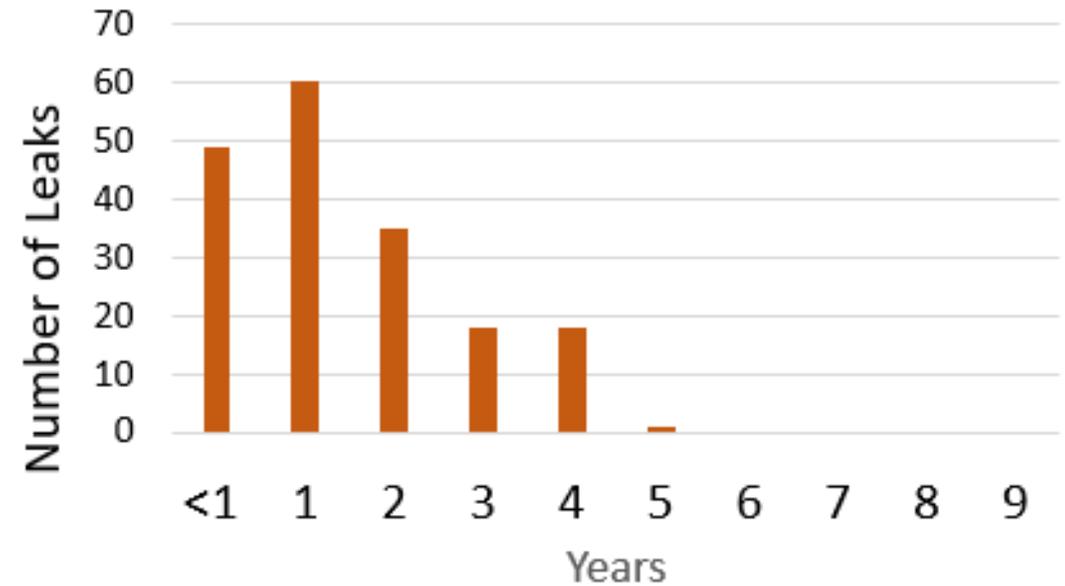
Leak occurrence and frequency

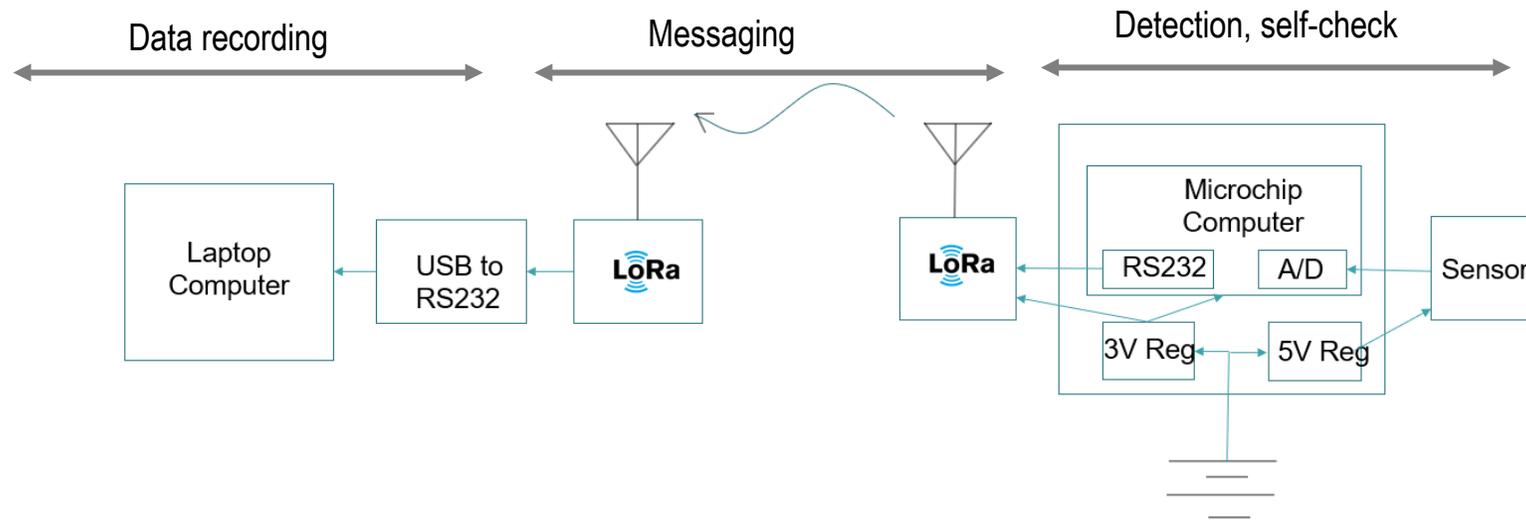


High-Pressure Leaks are Predominant

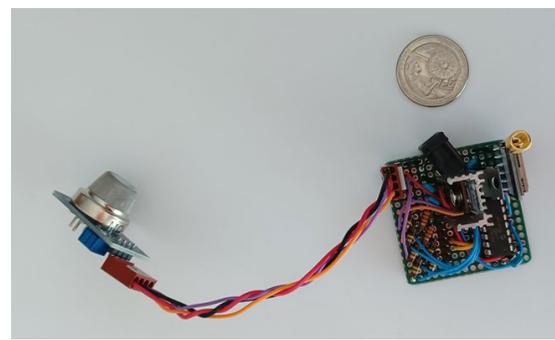


Occurrence of Condenser Leaks (181 total)

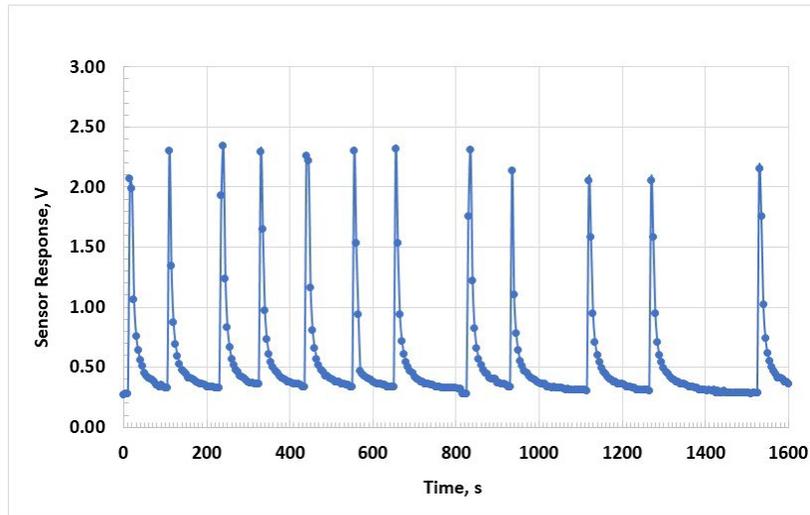




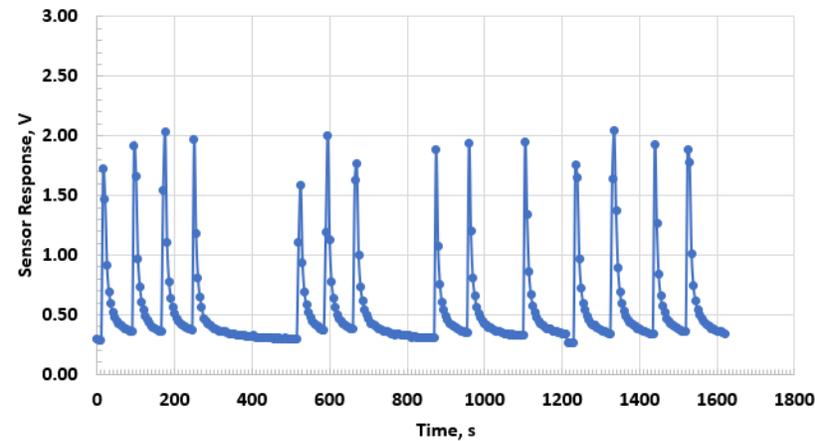
- LoRa operates in 902-928 MHz
- Range is 5-10 km
- Single receiving station can cover several square km.
- Data viewing is using a terminal emulator



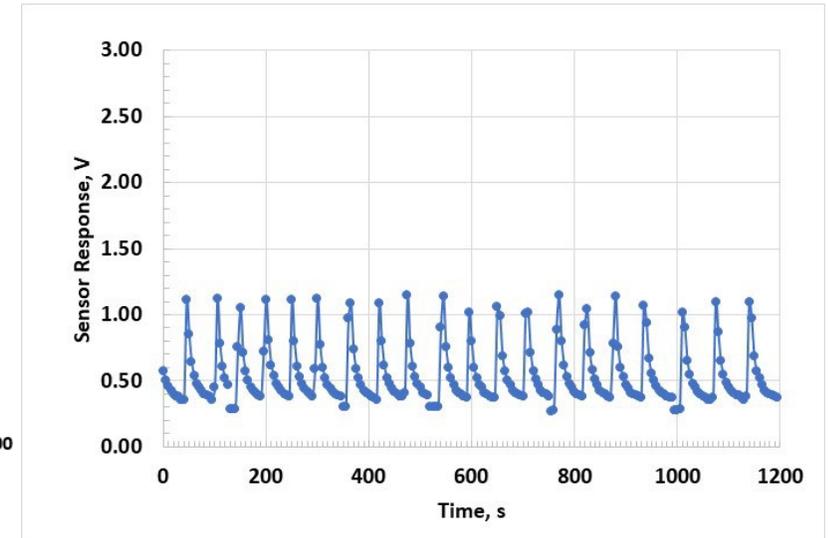
IEA HPT Rapid detection of Propane leaks



47.6% LFL (1% propane + air)



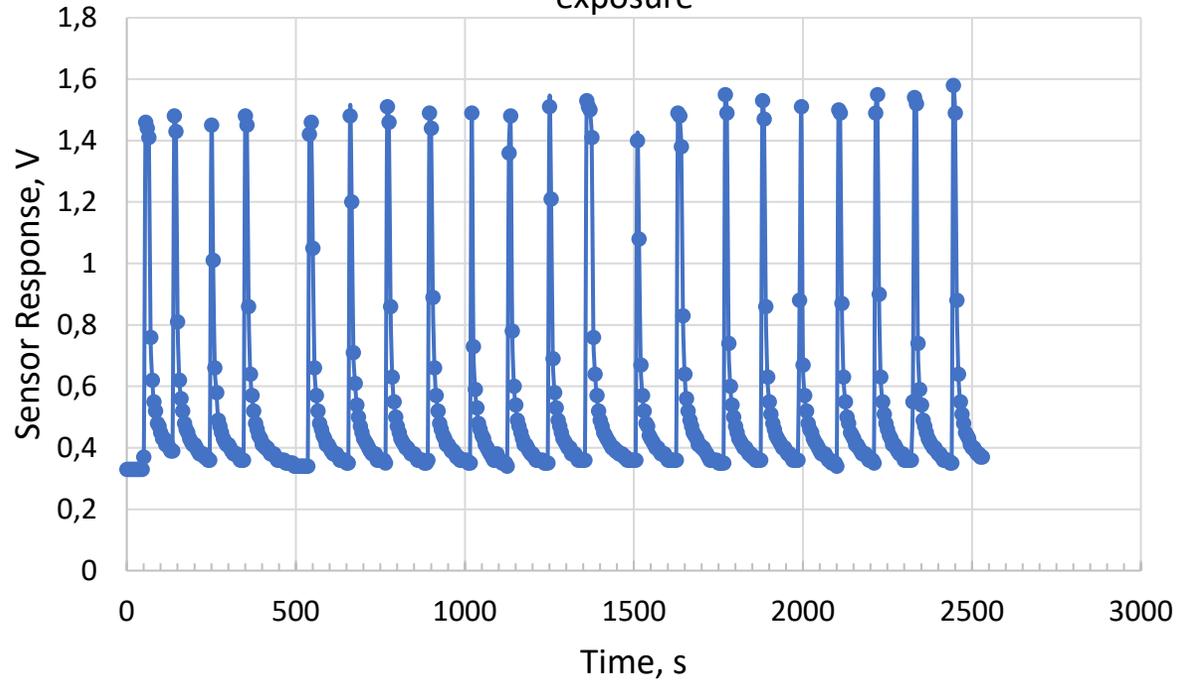
28.57% LFL (0.6% propane + air)



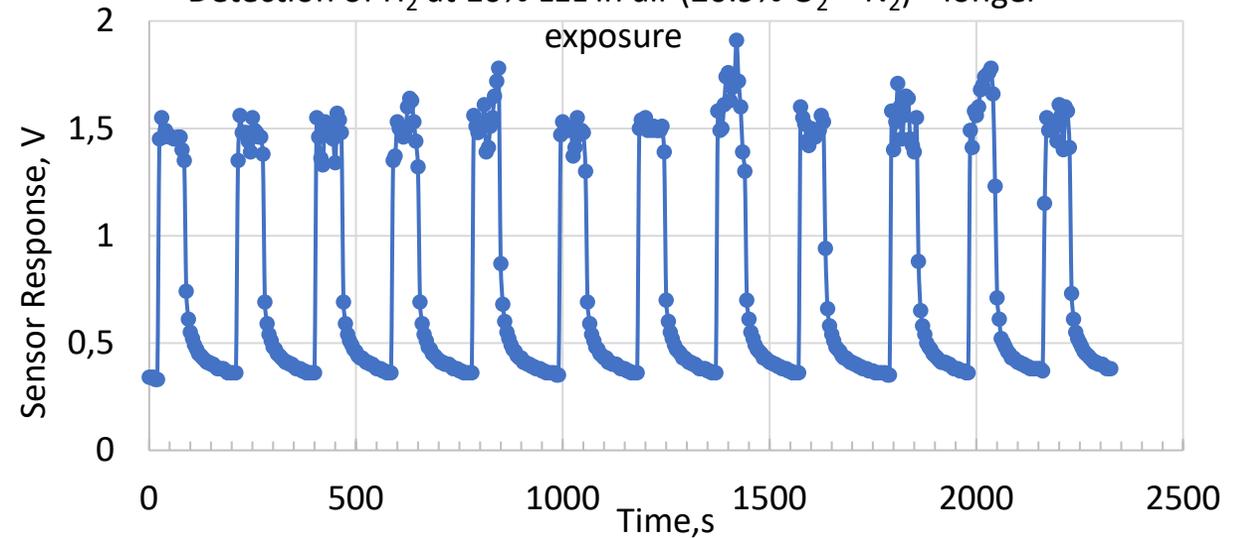
4.75% LFL (0.1% propane + air).

LFL of Propane is 2.1 % by volume in air

Detection of H₂ at 10% LEL in air (20.9% O₂ + N₂)--short exposure



Detection of H₂ at 10% LEL in air (20.9% O₂ + N₂)-- longer exposure



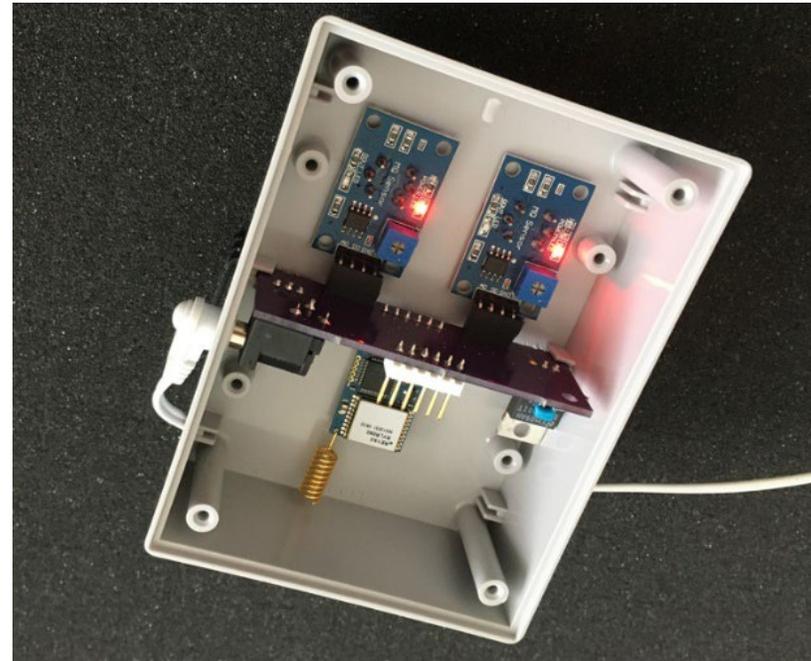


Sensor platform has the following properties

- Low cost (under \$25). Could be reduced by 50% or more for larger market
- Self-check and diagnostic capability (every 5 seconds, but can be altered through software modification)
- Able to detect small leakage at less than 5% Lower flammability Limit (LFL)
- Fast response rate (less than 5 seconds)
- No field calibration required
- LoRa is a wireless modulation technique derived from chirp spread spectrum technology and is used extensively in Internet of Things (IoT)
- LoRa transmission is robust against disturbances
- LoRa radios use the unlicensed 902-928 MHz band and thus do not require any licensing fees.



Technology is near commercialization



For licensing technology, please contact Commercialization Manager: Andreana Leskovjan, leskovjanac@ornl.gov