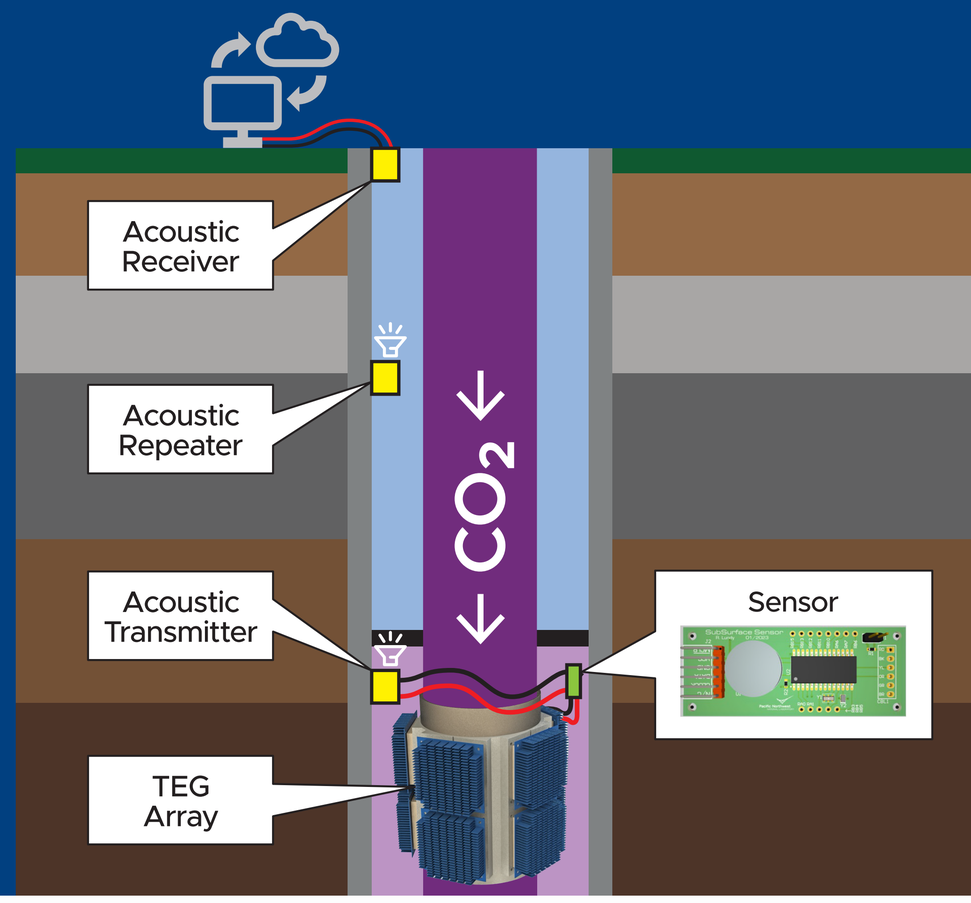
FWP 80754

Engineering Integrated Sensing, Power, Telemetry, and Data Processing Systems for Complex Subsurface Environments

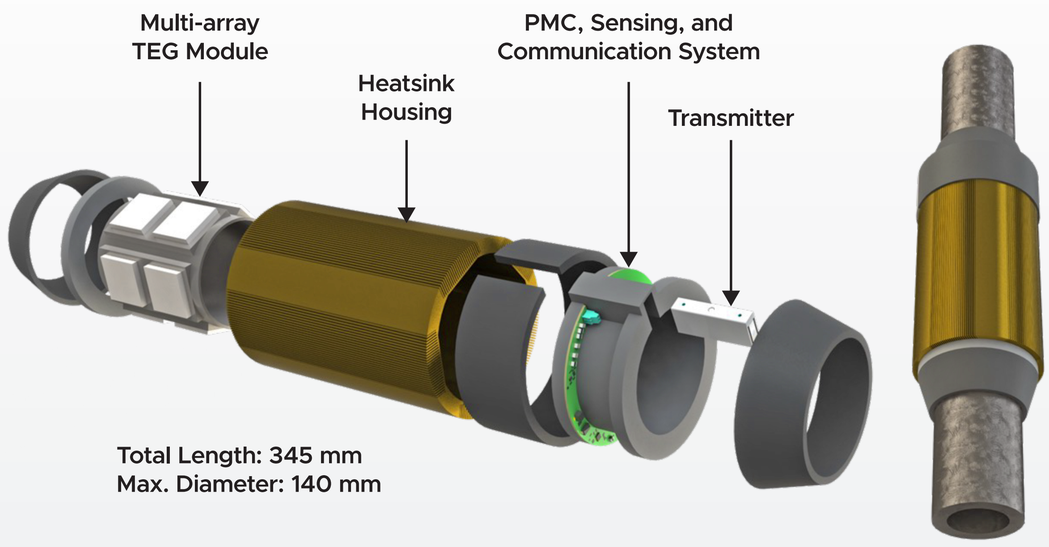
Xi Tan, Xiaoqin Zang, Hyunjun Jung, Jun Lu, Wonseop Hwang, Seunghwan Baek, Zhiqun Daniel Deng

Fundamental Processes → Reservoir Simulations → **Deployment & Monitoring**



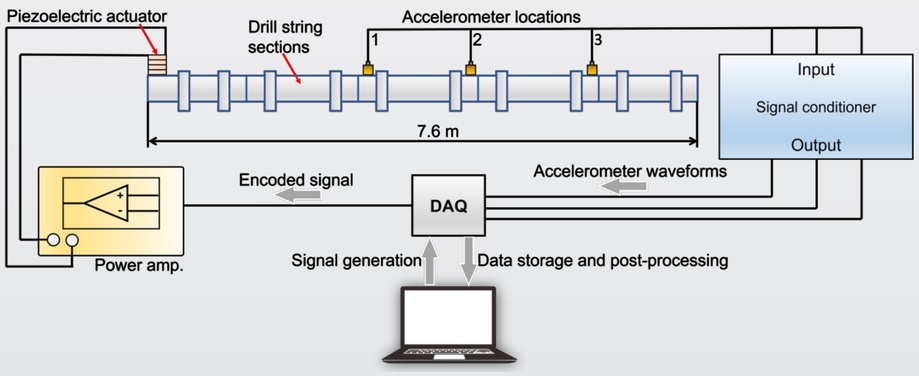
An integrated system for reliable and maintenance-free real-time monitoring

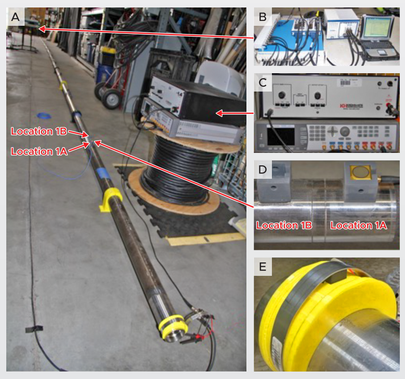
- Advanced monitoring technologies and reliable wireless communication protocols are needed to reduce costs and ensure safe CO_2 injection, and provide data for AI
- An acoustic telemetry system can transmit data from downhole to the surface wirelessly in real time.
- An energy harvesting system uses thermoelectric energy generators (TEGs) to power the integrated system, eliminating the need of external power supply
- A low-power sensing system was developed to monitor downhole temperature and pressure.

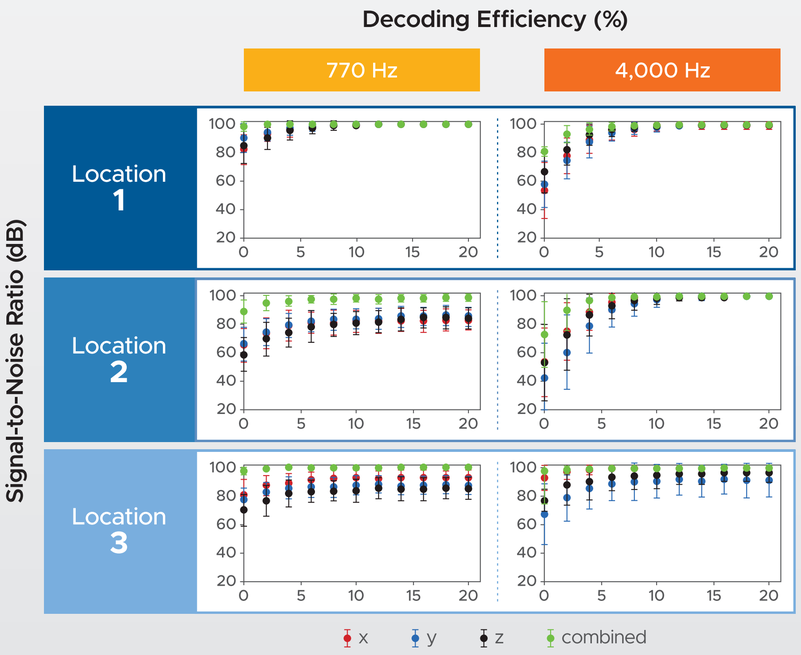


An acoustic telemetry system with high accuracy

- An acoustic telemetry system was integrated in the lab.
- The acoustic properties of the tube-string were investigated to select the carrier frequency.
- Signal processing protocols were designed for the unique tube-string communication channel.
- Both BPSK and DPSK schemes were developed and tested in lab experiments.
- A 100% decoding efficiency was achieved in the lab tests at a signal-to-noise ratio as low as 0 dB.

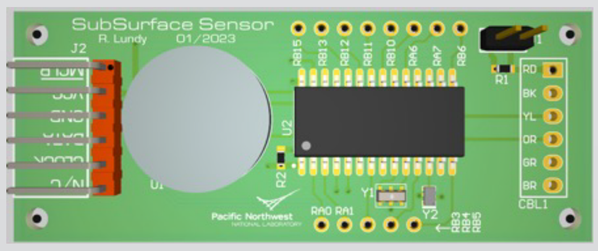




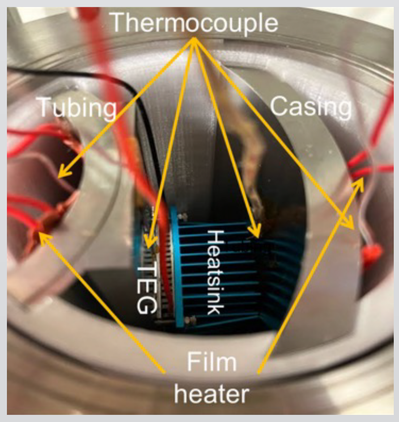


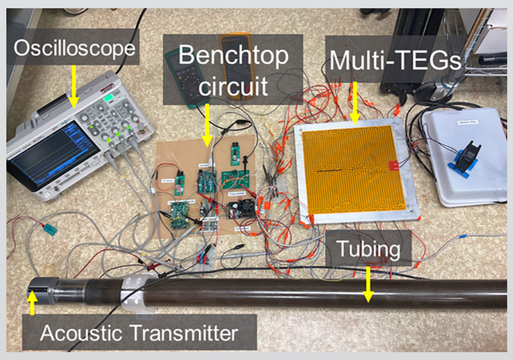
Energy harvesting & sensing systems for self-powered monitoring

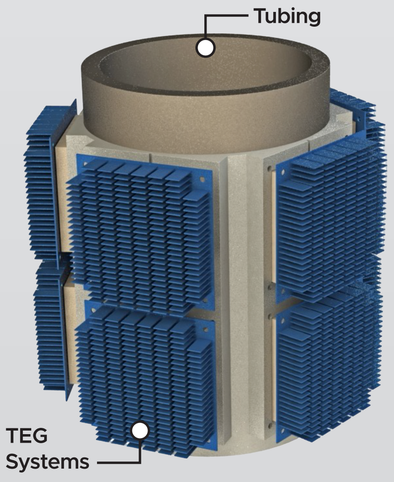
- TEGs will be mounted in annulus to harvest thermal gradient energy between casing and tubing
- An average power of 1.06mW per TEG is generated in high pressure chamber with temperatures mimic the field data from MRCSP (Northern Michigan)
- Multi-array TEG systems with benchtop circuit successfully supply power to acoustic transmitter (approximately 1.036kJ per day, 1448m transmission distance under lab conditions)
- Developed custom sensing system that can operate under high temperature (110°C) and pressure (14500 PSI), with low power consumption



Sensing monitoring system on PCB







Pacific Northwest NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

BATTELLE

Xi Tan
xi.tan@pnnl.gov

www.pnnl.gov

July 2024 | PNNL-SA-201664