Development of a Networked Sensor Array for Gas Microseepage Detection near Injection Well Sites

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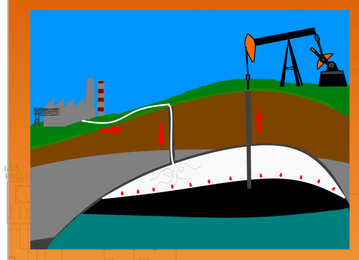
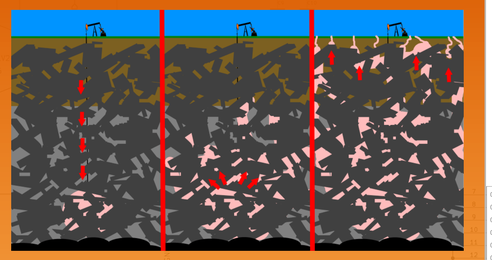
Abstract

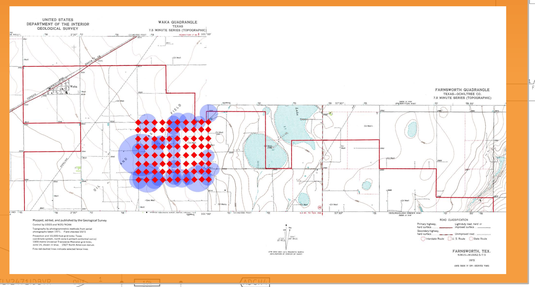
As part of the current drive to reduce carbon emissions to mitigate global climate change, many are considering the possibility of subterranean sequestration as a means of storing excess CO_2. This undertaking will require new technology to ensure its safe implementation. An array of sensors was developed using commercially available technologies to detect CO_2, CH_4, and atmospheric conditions near ground level. These solar-powered sensors are wirelessly networked to coordinate data retrieval, giving a reliable analysis of gas concentration over a broad area. Current results from this networked array on the environmental background show expected concentration changes based on daily variation, weather conditions, and animal presence.

Project Goals

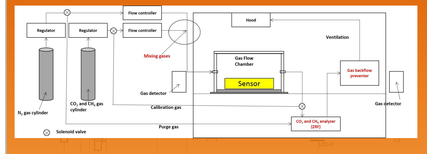




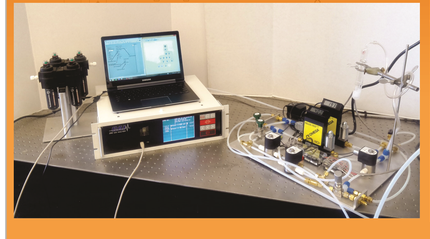
To determine the levels of microseepage plumes in carbon sequestration wells, an array of sensors operating over a large area was proposed to provide real time results. These sensors were designed to act as an early warning system for potential environmental and health-related disasters.

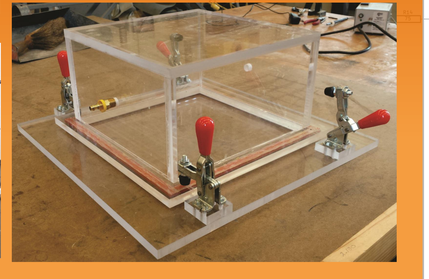


Sensor Selection



Calibration and standardization equipment for mixed gases was designed to test the performance of a selection of the commercially available gas sensors.





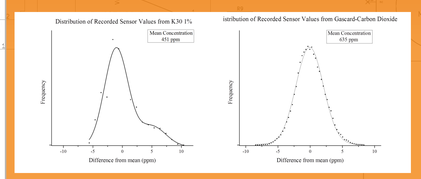
Results from Sensor Analysis

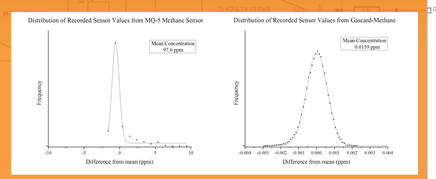
Sensor	Supplier	Type	Sampling Method	Cal. Range	Op. Range
K-30 SE-0018	CO_2Meter	NDIR	flow or diffusion	0-5000 ppm	0-10000 ppm
COZIR AMB GC-020	CO_2Meter	NDIR	flow or diffusion	0-5000 ppm	0-10000 ppm
Gascard CO_2	GHG Analytical	Modulated NDIR	flow	0-50000 ppm	0-50000 ppm
MSH-P/CO2/NC/5/V/P/F	Dynament	NDIR	diffusion	0-2491 ppm	0-5000 ppm
MSH-DP/HC/CO2/NC/P/F	Dynament	NDIR	diffusion	100-2500 ppm	0-5000 ppm
Telaire T6615	General Electric	NDIR	flow or diffusion	0-2000 ppm	0-2000 ppm

Sensor	Warm Up	T	Humidity	Auto-cal	V Input	Avg. I	Peak I
K-30 SE-0018	<1 min	0-50°C	0-95%	Yes	4.5-14 VDC	40 mA	<150 mA
COZIR AMB GC-020	<3 s	0-50°C	0-95%	Yes	3.25-5.5 VDC	1.5 mA	33 mA
Gascard CO_2	30 s	0-45°C	0-95%	Yes	7-30 VDC		
MSH-P/CO2/NC/5/V/P/F	45 s	-20-50°C	0-95%	No	3.0-5.0 VDC	75-85 mA	
MSH-DP/HC/CO2/NC/P/F	45 s	-20-50°C	0-95%	No	3.0-5.0 VDC	75-85 mA	
Telaire T6615	10 min	0-50°C	0-95%	Yes	0-5 VDC	33 mA	180 mA

Sensor	Supplier	Type	Sampling Method	Cal. Range	Op. Range
MQ-5	Futurelec	Electrolyte	diffusion		200-10000 ppm
Gascard CH_4	GHG Analytical	Modulated NDIR	flow	0-50000 ppm	0-50000 ppm
MSH-P/HC/NC/5/V/P/F	Dynament	NDIR	diffusion	0-5000 ppm	0-10000 ppm
MSH-DP/HC/CO2/NC/P/F	Dynament	NDIR	diffusion	5000-11000 ppm	0-10000 ppm

Sensor	Warm Up	T	Humidity	Auto-cal	V Input	Avg. I	Peak I
MQ-5				No			
Gascard CH_4	30 s	0-45°C	0-95%	Yes	7-30 VDC		
MSH-P/HC/NC/5/V/P/F	30 s	-20-50°C	0-95%	No	3.0-5.0 VDC	75-85 mA	
MSH-DP/HC/CO2/NC/P/F	30 s	-20-50°C	0-95%	No	3.0-5.0 VDC	75-85 mA	



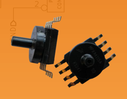


Designing the Units

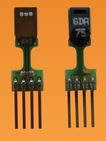
MQ-4 CH_4 sensor

K30 CO_2 sensor

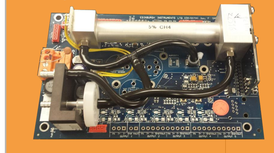
MPX6115 P sensor

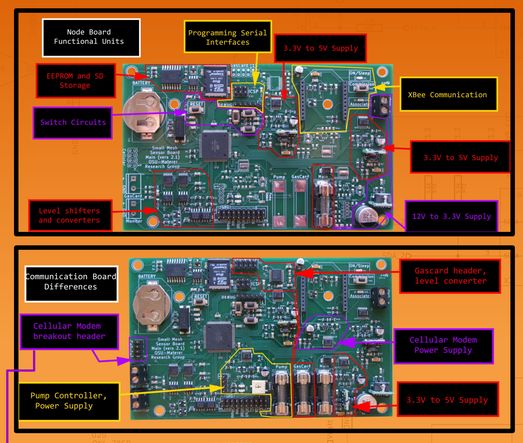


SHT75 T & Rh sensor

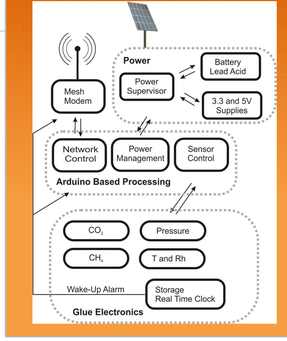


Gascard CH_4 sensor

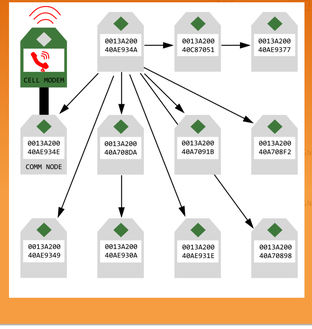




Network Technologies

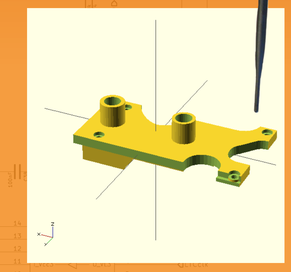


Sensor communications were designed to be modular with a tiered hierarchy of devices. Communication nodes route collected data from sensor nodes to a dedicated server over the cellular data network.



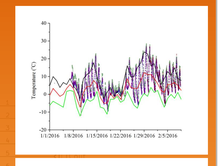
Finished Products

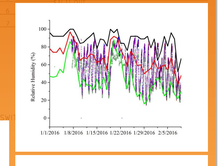
After passing out of a prototyping phase, approximately 120 sensor units were built . The finished units were produced in a ratio of 10:1 sensor nodes to communication nodes. Subnets were deployed near the Cooper Lab on the OSU campus for quality assurance. One subnet of 15 units was deployed at the Cooper Lab field site on a more permanent basis. These units are acting as test units, acquiring data to prepare the protocols for when the array is deployed to an actual well site.

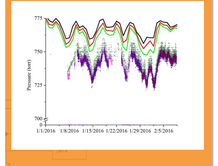


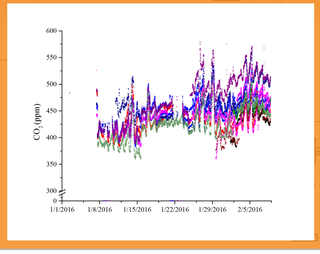
Results from Field Work

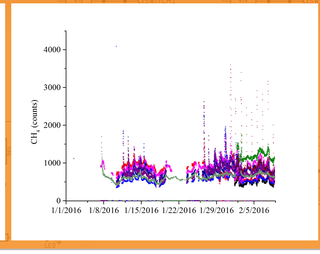
Results obtained from a test group deployed on the OSU campus show that the sensors output reliably reproducible data. Results from weather sensors included on the units show appropriate tracking with data obtained from NOAA. Data from the K30 CO_2 sensor cluster well near a mean result and behave predictably. Variation in response is likely correlated to the relative humidity near the sensor due to partial pressure change. Data from the MQ-4 CH_4 sensor is more prone to exaggerated peaks, though it appears to stay near the mean. Variation is likely due to wind speed and temperature changes. Correlation tests need to be performed to confirm these findings, and a special wind guard is currently being tested on the CH_4 sensor.











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