

SENSIBLE PHOTONICS

Simplified sensors for a complex world.

Reliable Distributed Optical Fiber Sensing System for Early Warning of Failure in Energy Storage Systems

Award No. DE-SC0025125

DOE Peer Review

Sensible Photonics

August 7, 2025

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Company High Level Summary

Who We Are

Sensor tech startup spun out from University of Pittsburgh and US DOE National Energy Technology Lab, founded in 2021

Mission

Delivering more reliable, resilient, and safe energy infrastructure through low-cost fiber optic sensors that enable real-time predictive analytics to anticipate failures in critical energy assets.

Core Technology

Fiber optic sensing technologies and platforms

- Low-cost, scalable
- Monitor critical energy assets
- Real-time, multi-point, multi-parameter sensing
- Enabling AI-based data analytics

Funding to date

- >\$1M in dilutive and non-dilutive funding
- Previous technology development has received >\$5M in funding from various DOE programs

Strategic Focus

Critical Energy Infrastructure



Grid-Scale Storage Transformers Nuclear & Industrials

Intellectual Property Status

Exclusive Licenses secured from University of Pittsburgh and National Energy Technology Laboratory (NETL)



SBIR Project Team



Nick Frank, MS



Dr. Paul Ohodnicki



Dr. Subhashish Bhattacharya



Why This Matters – Industry Pressures & Technical Gaps



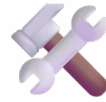
Regulations & Risk

- UL 9540A, NFPA 855
- Insurance + AHJ pressure

Our platform supports early event detection, root-cause forensics, and certification readiness



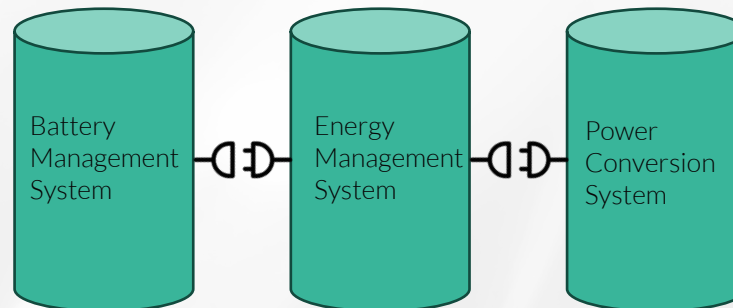
MOSS LANDING BATTERY FIRE IMAGE
NIC COURRY/BLOOMBERG VIA GETTY IMAGES



Technical Gaps

- Typical detection schemes create blind spots
- Controls schemes are disconnected, disparate systems

Sensible Photonics vision is to provide a sensing platform that creates synergy across all controls platforms



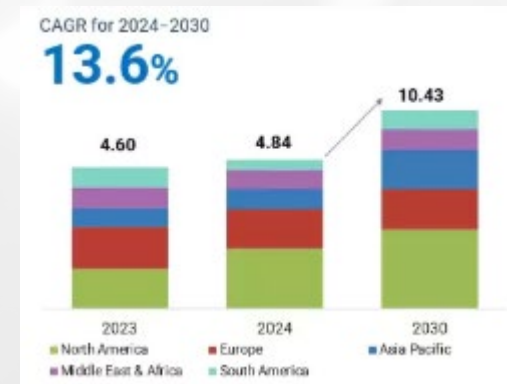
Siloed, disconnected controls systems



Grid-Scale Storage is Scaling & Evolving

- New chemistries, higher temperatures, unknown risks
- Markets are accelerating **LDES deployments**, but safety remains a gating factor

Our chemistry-agnostic solution can be applied to any battery energy storage type

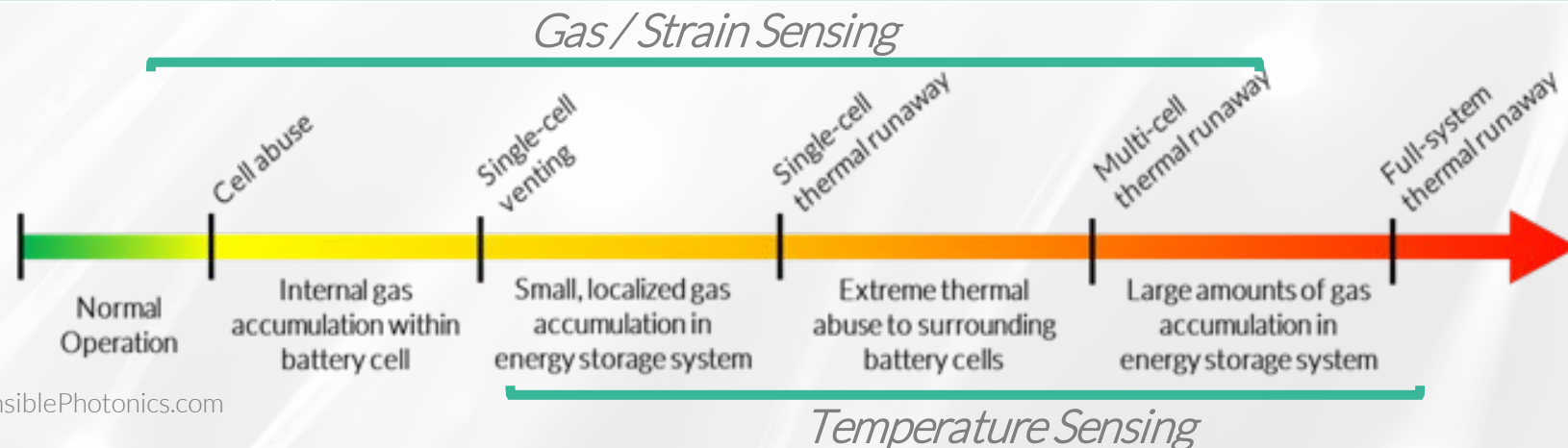


GROWTH PROJECTIONS FOR LONG DURATION ENERGY STORAGE

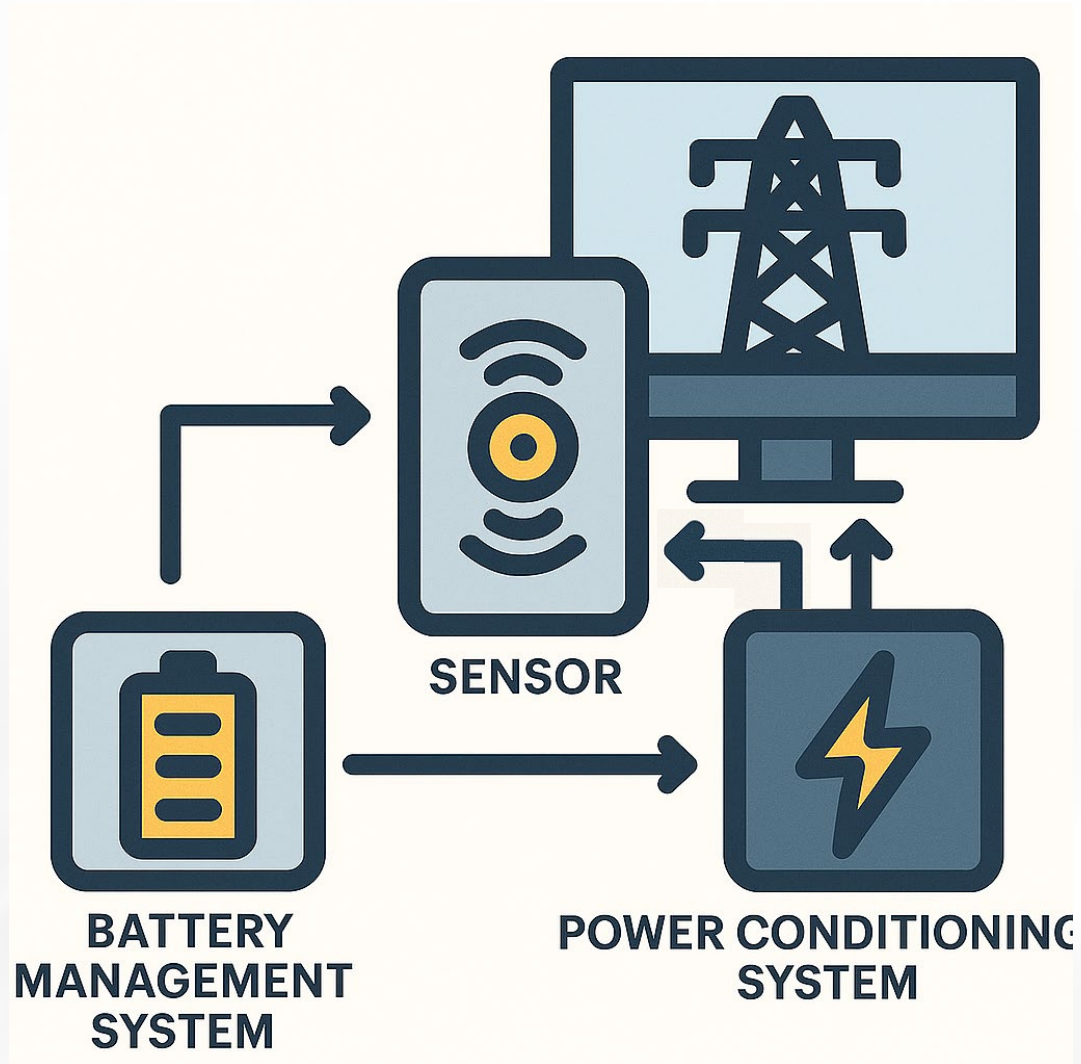
How We Directly Address DOE's Solicitation Goals

We eliminate sensor redundancy, reduce system latency, and provide a modular, future-ready sensing platform that aligns with DOE's vision of a unified, intelligent battery interface.

DOE Goal	Our Solution
Expanded Sensing	Fiber optic, cell-level temperature, cell-level strain (cell swelling), gas, acoustics (future), impedance (future)
Chemistry agnostic	Platform validated across several Li-ion Chemistries, expandable to any battery chemistry in the future
PCS – BMS – EMS Integration	Unified data stream supports harmony across power conversion hardware and increases system safety. Compatible with BMS platforms
Early Fault Detection	Detects swelling, deformation, hotspots, and gas release to provide incipient failure detection
Improved safety + reduced footprint	Less wiring, fewer components, passive architecture



Integrated BMS – EMS – PCS Sensing and Control Scheme



- Current Project Emphasizes Direct Storage System Monitoring Enabling Technology and Maturation
- Phase II Emphasis Will Integrate Into a Holistic Sensing and Integrated Monitoring Scheme
- Battery Cell / Module Monitoring (BMS)
- Energy Management System Monitoring (EMS)
- Power Conditioning System Monitoring (PCS)
- Future Vision: Integrated Monitoring System Coupling Battery – Power Conditioning System – Grid Interface

Key Advantages:

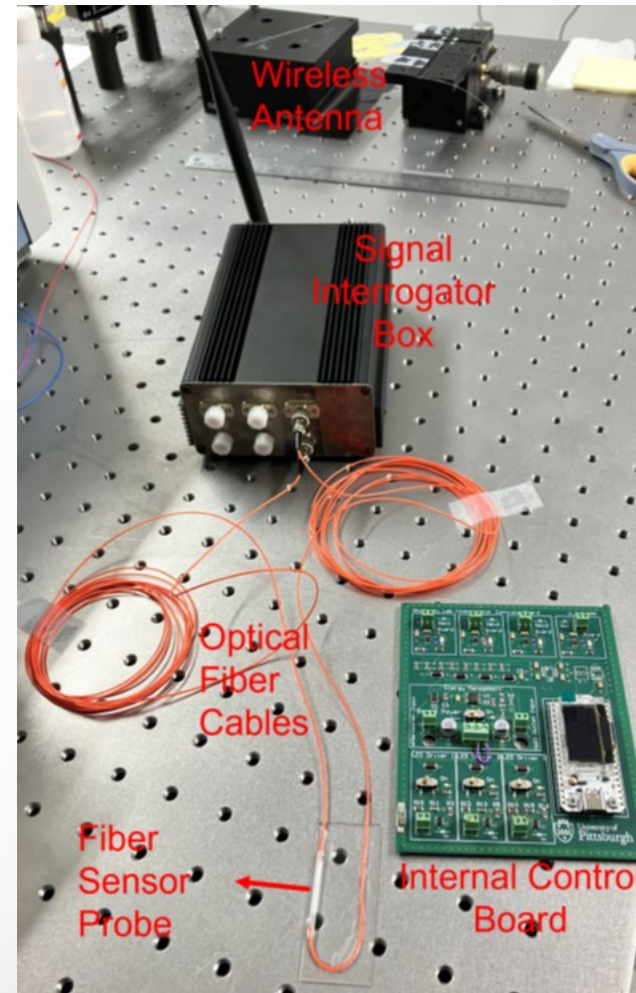
- 1) Ensure Optimized Grid Services
- 2) Mitigate Impacts of Grid Interface on Battery Stability
- 3) Enhance PCS System Reliability and Safety

Leveraging Unique Attributes of Sensible Photonics' Low-Cost Fiber Optic Sensing Technology Across Platforms!

Technology Overview

Redacted for IP Purposes

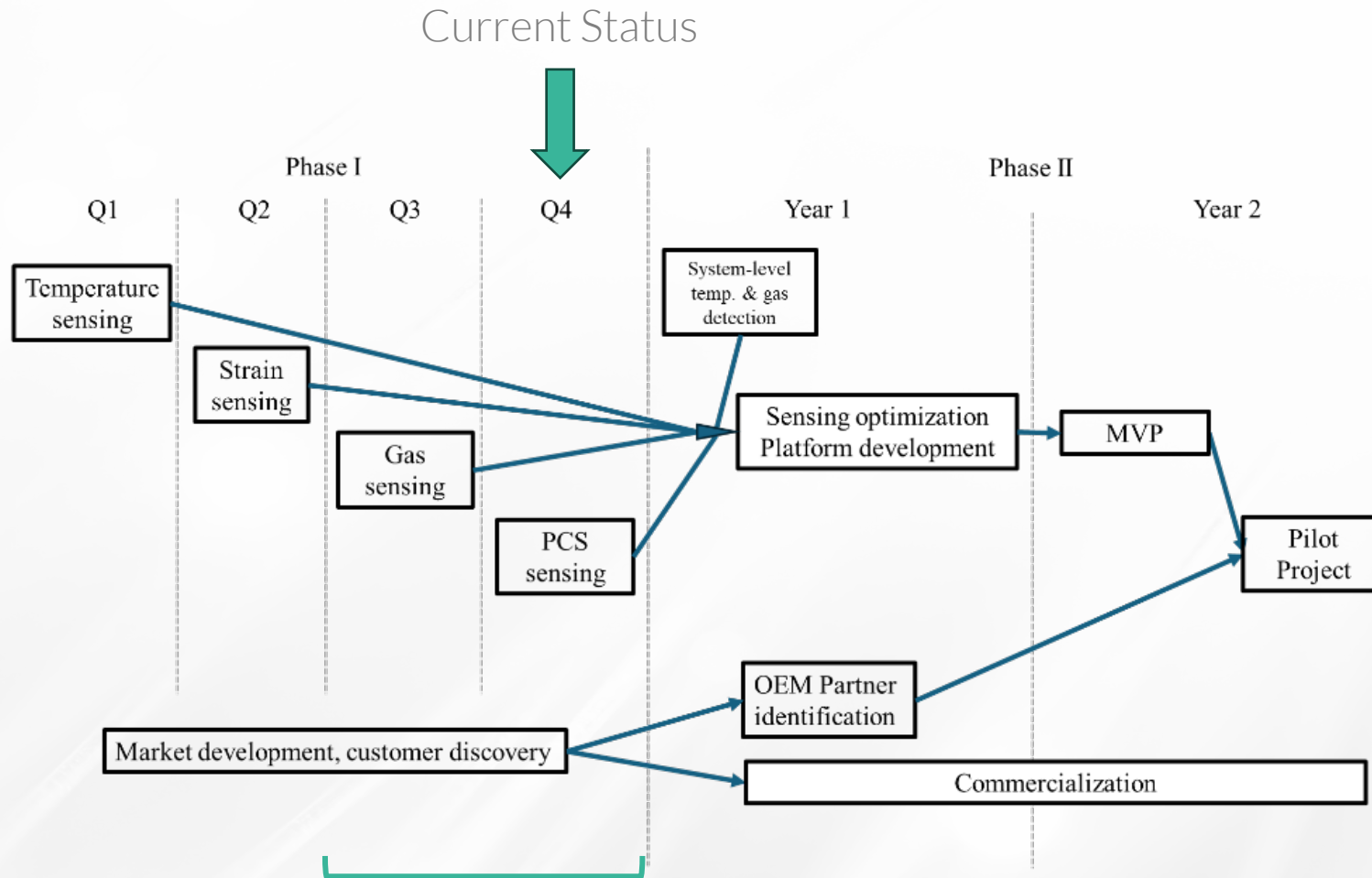
To be disclosed at DOE Peer Review



Key Capabilities

- Multi-channeling
- Simultaneous temperature, strain and gas sensing
- On-board signal-processing
- Expandable interfacing with existing communication protocols

Performance Plan

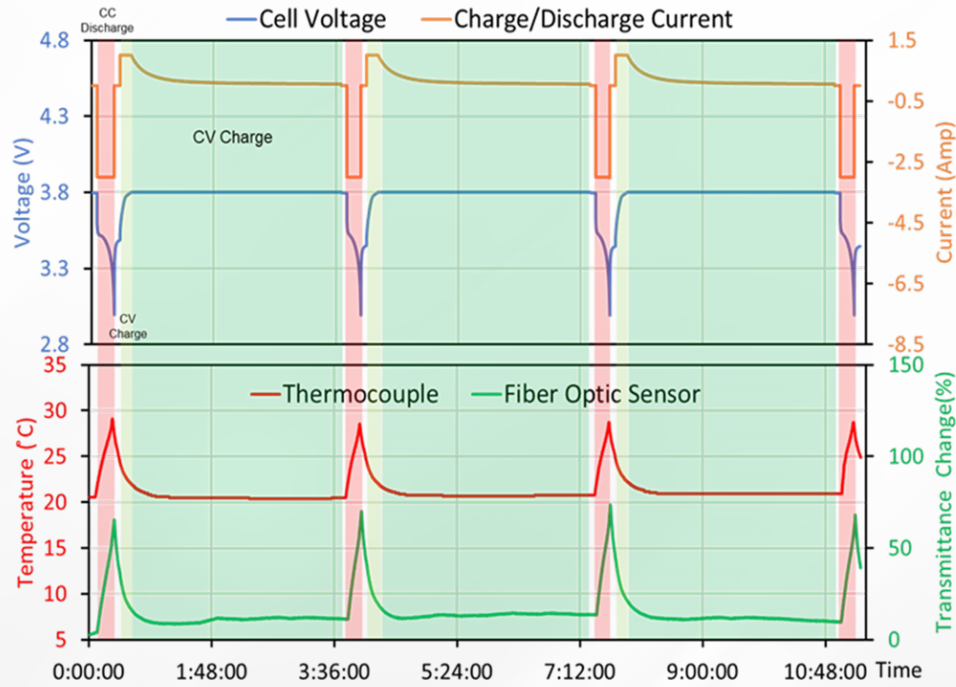


~6 Month No-Cost Time Extension
Due to Delay in Phase II Solicitation

	Q1			Q2			Q3			Q4		
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Task 1	X	X	X									
Subtask 1.1	X											
Subtask 1.2	X											
Subtask 1.3	X	X	X									
Milestone 1.1	X											
Milestone 1.2	X											
Milestone 1.3			X									
Task 2				X	X	X						
Subtask 2.1				X								
Subtask 2.2				X								
Subtask 2.3	X			X	X	X						
Milestone 2.1				X								
Milestone 2.2				X								
Milestone 2.3						X						
Task 3							X	X	X			
Subtask 3.1							X					
Subtask 3.2							X					
Subtask 3.3							X	X	X			
Milestone 3.1							X					
Milestone 3.2							X					
Milestone 3.3									X			
Task 4										X	X	X
Subtask 4.1										X	X	
Subtask 4.2											X	X
Milestone 4.1											X	
Milestone 4.2												X
Task 5												
Subtask 5.1	X	X	X									
Subtask 5.2				X	X	X	X	X	X	X	X	X
Subtask 5.3	X	X	X	X	X	X	X	X	X	X	X	X
Subtask 5.4				X	X	X	X	X	X	X	X	X
Milestone 5.1			X									
Milestone 5.2						X						
Milestone 5.3									X			
Milestone 5.4												X
Milestone 5.5												X

Temperature Sensing Development

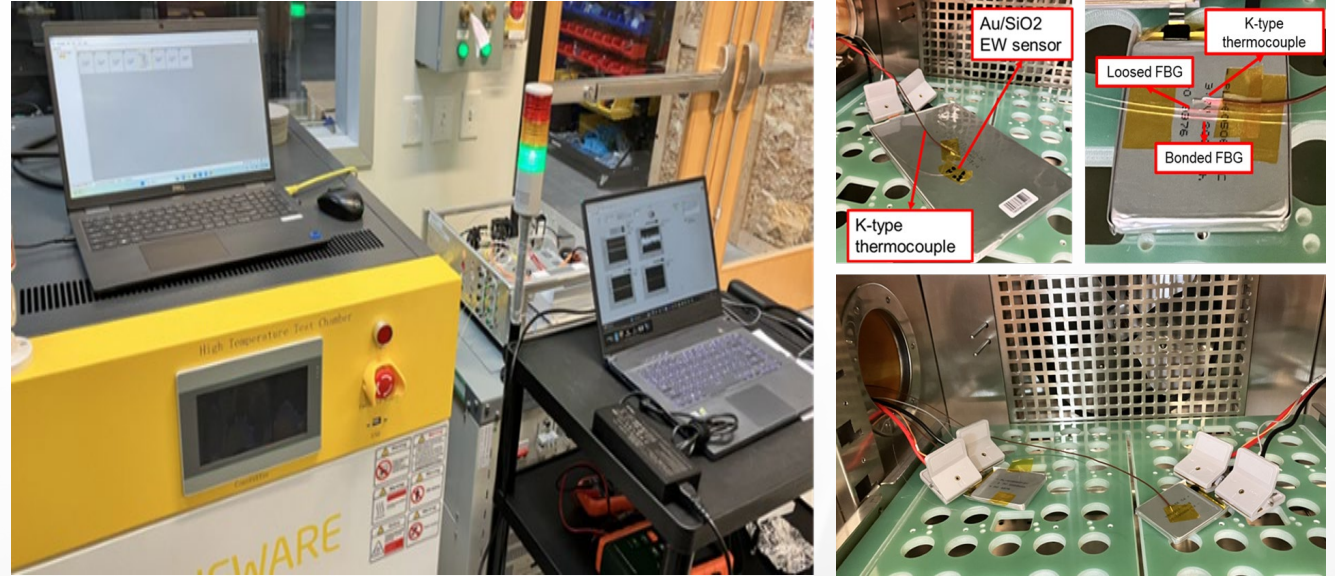
Cell-level fiber optic temperature measurements



Mock 18.5V-22Ah battery module



5V-20A 8-Channel Battery Testing Station

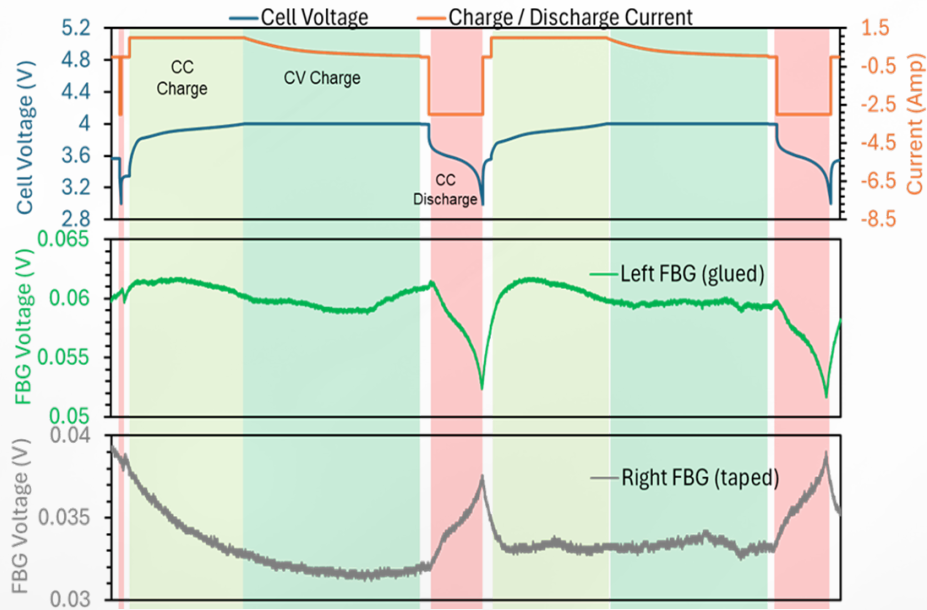


100V-100A Tester and Abuse Test Chamber

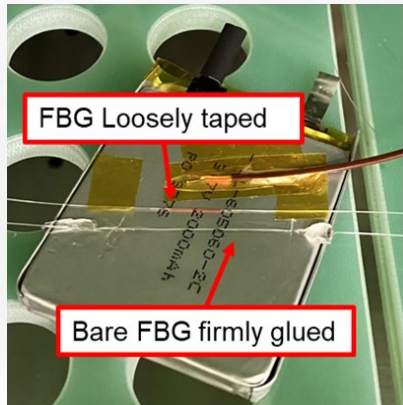
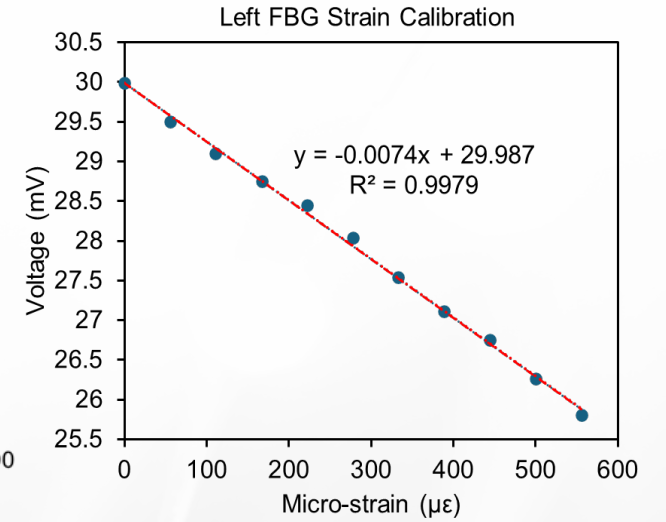
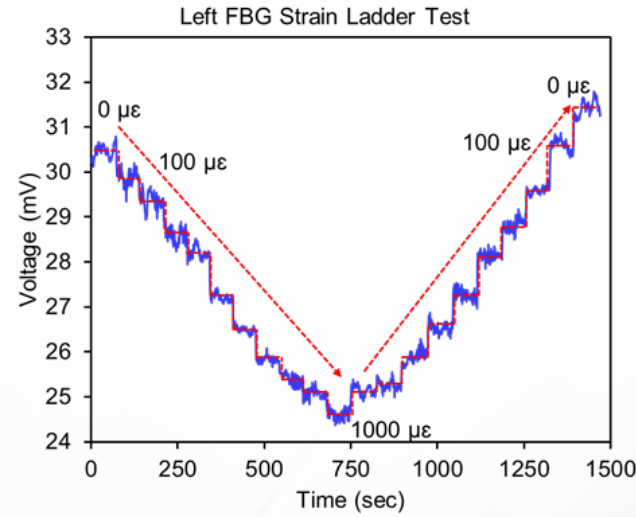


Strain Sensing Development

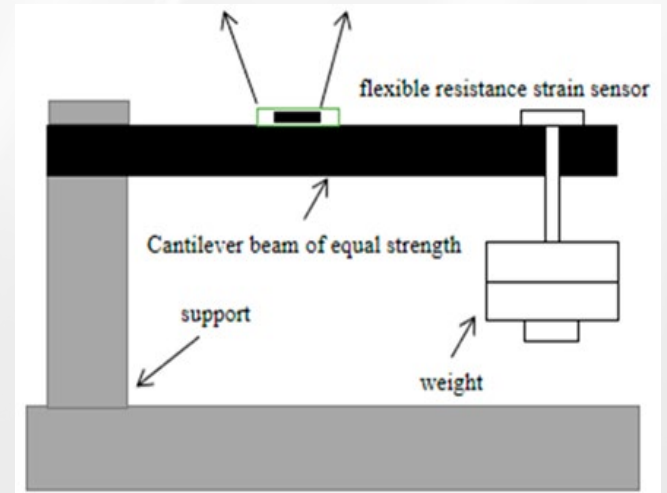
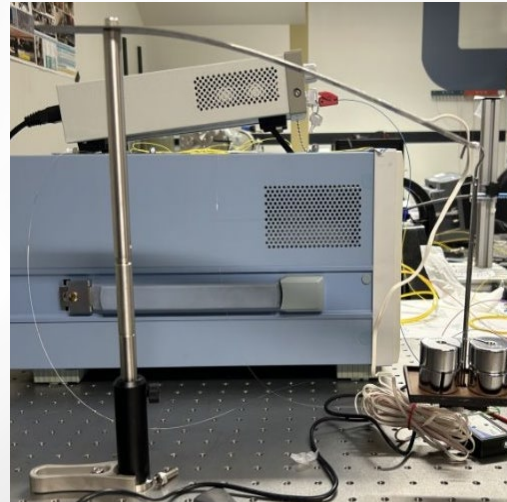
Cell-level fiber optic strain measurements



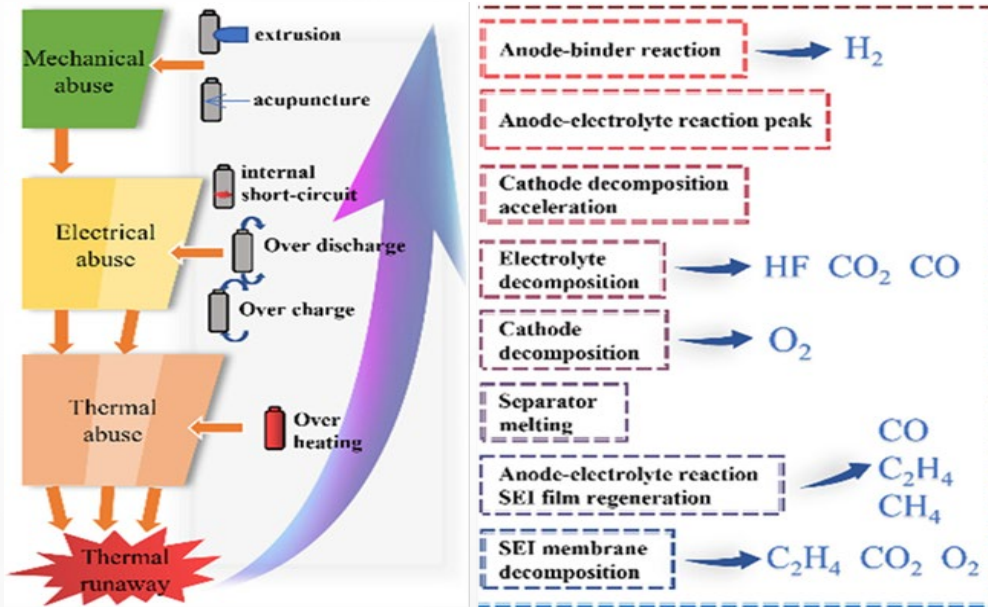
Cell swelling and strain calibration with cantilever beam



Tested Metrics Prior to Signal Processing	
Raw Resolution at 50 dB gain	0.2 mV
Temp. LOD	0.45 °C
Strain LOD	14.3 $\mu\epsilon$



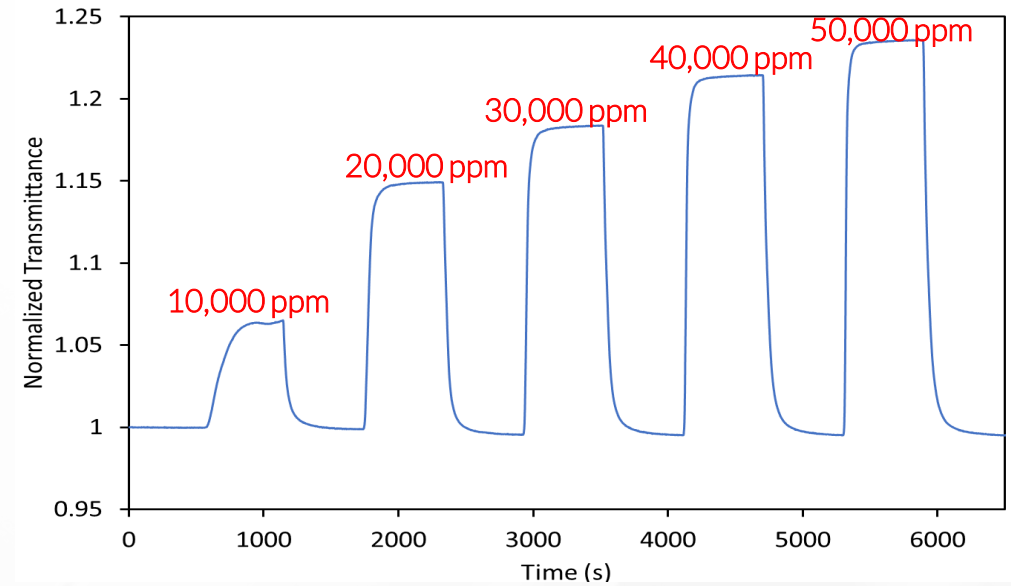
Gas sensing development



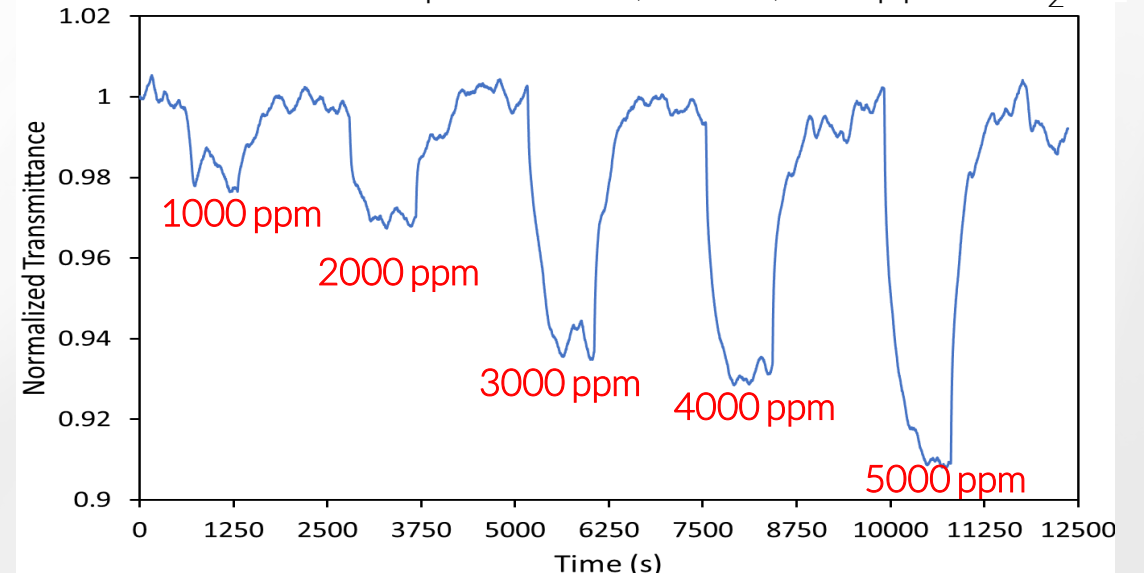
CO₂ and H₂ off-gassing concentrations at various SOCs

Conditions		CO ₂	H ₂
Overheating	NCA cylindrical (I), SOC = 0%–25% [21]	62.7–96.6%	0.8–15.5%
	NCA cylindrical (I), SOC = 50%–143% [21]	16.2–33.8%	17.5–28.8%
	NCA cylindrical (I), SOC = 100% [17]	9.8–20.4%	15.9–43.2%
	↳ First-venting	82.2–100%	0–2.4%
	LFP cylindrical (I), SOC = 0%–130% [21]	48.3–93.5%	2.7–34%
	LFP cylindrical (I), SOC = 100% [22]	53%	30.9%
	LFP cylindrical (I), SOC = 100% [23]	11.1%	80.1%
	LCO/NMC cylindrical (I), SOC = 100% [22]	24.9%	30%
	NMC cylindrical (I), SOC = 100% [22]	41.2%	30.8%
	NMC prismatic (I), SOC = 100% [24]	25.2%	10.4%
	NMC pouch & hard case (A), SOC = 100% [25]	36.6%	22.3%
	LCO cylindrical (I), SOC = 100% [26]	12.7–13.9%	18.2–18.5%
	LCO cylindrical (A), SOC = 100% [26]	8% (peak)	–
↳ First-venting	2%	–	
Nail Penetration	NMC pouch (A), charged to 4.3V [27]	>2%	Detected
	LFP cylindrical (A), at the end of test [28]	47%	23%
Overcharging	LFP cylindrical (A), total gas [28]	18%	9%
	↳ First-venting	DMC > CO ₂ > CO	–
Cell Leakage	NMC prismatic (A) [29]	32.2–58.4%	–
	LCO cylindrical, vacuum [30]	1.7%	–

Sensor Response to 10,000-50,000 ppm H₂



Sensor Response to 1,000-5,000 ppm CO₂



Commercial Pathways: Ideal Customers

Example Customer Profile: Cabinet-Style ESS Manufacturers



Fluence Cube



CATL EnerOne

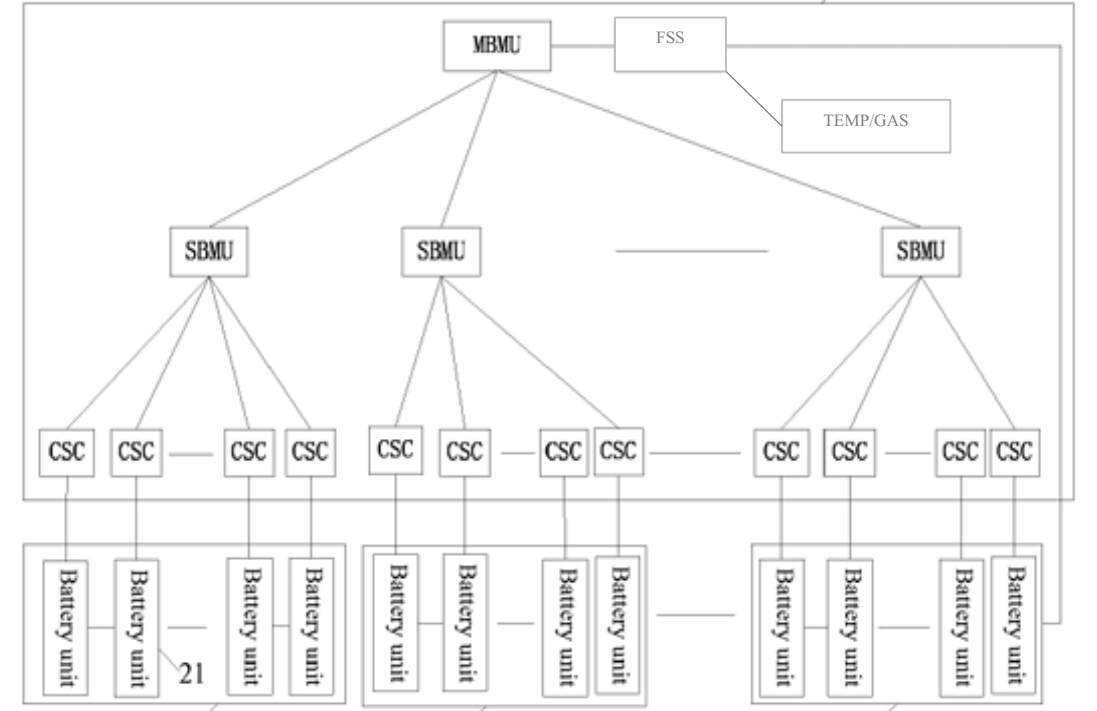
Pain Points:

Thermal propagation, data defensibility, predictive diagnostics, fire mitigation, risk visibility, sensor consolidation, fault localization

Buyer Persona:

OEM Engineers, Safety Leads, Integrators

Existing Cabinet-Style ESS Controls Scheme



MBMU: Master Battery Management Unit

SBMU: Slave Battery Management Unit

FSS: Fire Suppression System

CSC: Cell Supervision Circuit

Commercial Pathways: MVP thrusts

Thrust 1: Fire Detection / Early Failure Sensing Platform

Redacted for IP Purposes

To be disclosed at DOE Peer Review

Benefits:

- FSS Detection in one sensing platform
- Improved signal reliability with temperature-calibrated gas signals
- Extended failure mode studies with fiber-based "remote" sensors
- High temperature compatibility and survivability

Challenges:

- Certification barriers
- Existing electrical sensor competitors

Benefits:

- Reduces existing cell-level sensing system complexity
- Enables cell-level temp/strain sensing

Challenges:

- Partnerships with foreign Battery OEM
- Change to OEM controls scheme

Customer Discovery and Traction for Commercialization

Entity Type	Primary Role	Examples
Technology providers or battery original equipment manufacturers (OEMs)	Develop storage systems and technologies	Tesla, LG Chem, CATL, Samsung SDI
System Integrators	Combine technology, control, and software.	Fluence, Wartsila
Project Developers	Plan and execute projects	AES, RES, EDF
Utilities	Operate and integrate storage into grids	PG&E, Duke Energy, AEP
EPC Contractors	Build and commission storage systems	Black & Veach, Burns & McDonnell
Financing Entities	Provide capital for projects	Macquarie Group, Clean Energy Ventures
Grid Operators/Regulators	Ensure grid reliability and enforce rules	PJM, CAISO, ERCOT
Insurance Providers	Mitigate financial, technical, and operational risks	Allianz, Munich RE
Technology regulators & standards organizations	Develop energy-storage specific standards and regulations	NFPA, IFC, UL, IEC, IEEE

Segmentation expedites:

Tailoring value propositions, enhancing competitive positioning, facilitating pricing strategies, improving product-market fit, driving marketing and sales efficiency

Phase II Plans –Productization and Commercialization

Proposed Sensing Scheme of Multimodal Sensing for an Integrated BMS / EMS / PCS Monitoring Scheme – Example BMS Integration Highlighted

Redacted for IP Purposes
To be disclosed at DOE Peer Review

Phase II Plans

Task 1: Sensor technology maturation

- Chemical sensing
- Temperature sensing
- Strain sensing
- Power conditioning system sensing and interface

Task 2: Product integration and benchmarking

- Thrust #1 – Fire safety and early failure detection
- Thrust #2 – Incipient failure detection
- Thrust #3 – Customer specific solutions

Task 3: Minimum Viable Product (MVP) Maturation and Pilots

- Ruggedization of sensors and sensing platform
- Pilot MVP with Li-ion Chemistry OEMs
- Pilot MVP with alternative chemistry OEMs
- Finalize MVP for commercial product

Task 4: Commercialization and Market Development

- Commercialization plan refinement and execution
- Regulatory certification and customer approvals

Appendix

Performance Plan

Task 1: Temperature sensing development (August 2024 – October 2024)

- ✓ Milestone #1.1: Defined temperature range and accuracy specifications (August 2024)
- ✓ Milestone #1.2: Identified light source, fiber optic cable active layers, and detector for temperature range and accuracy specifications (August 2024)
- ✓ Milestone #1.3: Demonstrated temperature detection across range and accuracy in simulated battery conditions (October 2024)

Task 2: Strain sensing development (November 2024 – January 2025)

- ✓ Milestone #2.1: Defined strain range and accuracy specifications (November 2024)
- ✓ Milestone #2.2: Identified light source, fiber optic cable active layers, and interrogator for strain range and accuracy specifications (November 2024)
- ✓ Milestone #2.3: Demonstrated strain detection across range and accuracy in simulated battery conditions (January 2025)

Task 3: Gas sensing development (February 2025 – April 2025)

- ✓ Milestone #3.1: Defined gas species and concentration specifications (February 2025)
- ✓ Milestone #3.2: Identified light source, fiber optic cable active layers, and interrogator for gas species and concentration (February 2025)
- ✓ Milestone #3.3: Demonstrated gas detection across range and accuracy in simulated battery conditions (April 2025)
- ✓ Milestone #3.4: Developed state-of-safety algorithm (April 2025)

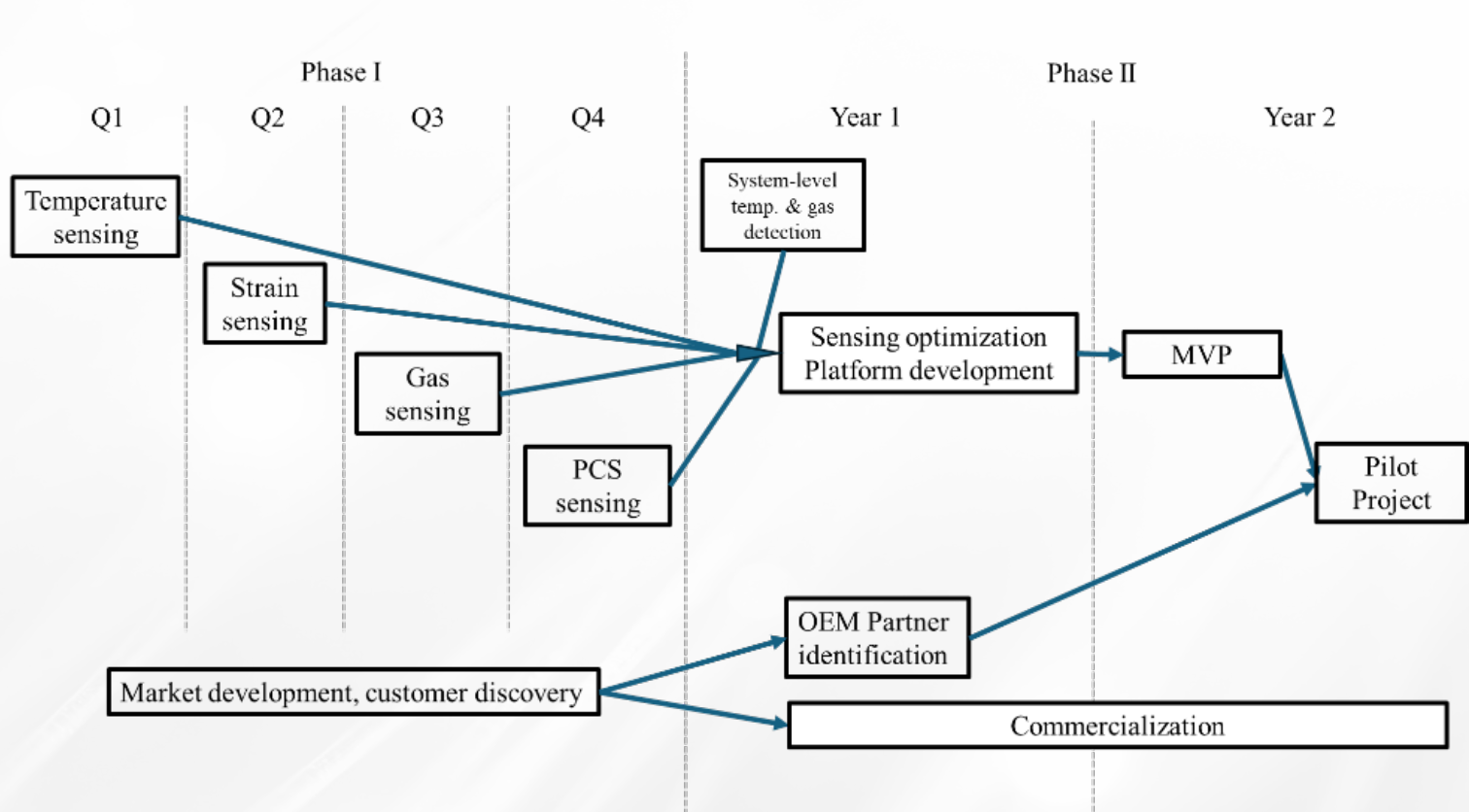
Task 4: Power conversion sensing development (August 2025 – December 2025)

- Milestone #4.1: Sensing interfaces between BMS and PCS benchmarked (June 2025)
- Milestone #4.2: Developed Phase II plan for coupling BMS and grid-tied inverter control (July 2025)

Task 5: Commercialization and market development (August 2024 – December 2025)

- ✓ Milestone #5.1: Market analysis of grid-scale energy storage and incumbent products/technology (October 2024)
- ✓ Milestone #5.2: Define initial technical product roadmap for MVP (January 2025)
- ✓ Milestone #5.3: Establish commercialization plan with market and financial projections (April 2025)
- Milestone #5.4: Finalize technical product roadmap for MVP and Phase II (September 2025)
- Milestone #5.5: OEM Partners Identified (December 2025)

Performance Plan



	Q1			Q2			Q3			Q4		
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Task 1	X	X	X									
Subtask 1.1	X											
Subtask 1.2	X											
Subtask 1.3	X	X	X									
Milestone 1.1	X											
Milestone 1.2	X											
Milestone 1.3			X									
Task 2				X	X	X						
Subtask 2.1				X								
Subtask 2.2				X								
Subtask 2.3				X	X	X						
Milestone 2.1				X								
Milestone 2.2				X								
Milestone 2.3						X						
Task 3							X	X	X			
Subtask 3.1							X					
Subtask 3.2							X					
Subtask 3.3							X	X	X			
Milestone 3.1							X					
Milestone 3.2							X					
Milestone 3.3									X			
Task 4										X	X	X
Subtask 4.1										X	X	
Subtask 4.2											X	X
Milestone 4.1											X	
Milestone 4.2												X
Task 5												
Subtask 5.1	X	X	X									
Subtask 5.2				X	X	X	X	X	X	X	X	X
Subtask 5.3	X	X	X	X	X	X	X	X	X	X	X	X
Subtask 5.4				X	X	X	X	X	X	X	X	X
Milestone 5.1			X									
Milestone 5.2						X						
Milestone 5.3									X			
Milestone 5.4												X
Milestone 5.5												X

Milestone #5.1: Market Analysis of Grid-Scale Energy Storage and Incumbent Technologies
Li-ion Battery Failure Timeline and Technology Alignment

