Cover Page

Project Title: SEM TECH - Ion Exchange Electrolysis Continuous Mining

SEM TECH: Salt Electro Mining Technology

CMU: Continuous Mining Unit CRU: Continuous Refining Unit

Specific NOFO Topic: Rowow, LLC's proposed project directly addresses Innovative Critical Minerals Recovery. We are in full alignment with DOE's technology development areas, 2. Mining and Processing and 3. Equipment and Productivity. We will build upon previous successful mining waste processing demonstrations, confirming the efficacy of our ion exchange technology and methods. These are referenced throughout our response. The proposed technology is currently at TRL 5, and Rowow will scale to TRL 7 or greater under our award from DoE.

Technical and Business Point of Contact: Mr. Robert Karas, Rowow, LLC (OWNER) will serve as Project Director and will be the POC for all questions and issues concerning this submission and during the performance of work under the award. He may be reached directly by email at irowow@gmail.com and by phone at (407) 724-8687.

The Project Team: Mr. Robert Karas, Project Director, will be directly responsible for overall project management, primarily focusing on the fundamental research, material processing, and deliverables under the award.

Project Locations: All mining material will be processed at a new location to be determined.

Proposed Federal Funding: The overall project funding is $12,799,424. We propose a 36-month performance period with a projected start date of 07/01/2026 and an end date of 06/30/2029.

Senior/Key Personnel and other Covered Individuals: As Project Director and the developer of our technology and methods, Mr. Robert Karas will perform all materials processing and extraction.

Statement Regarding Confidentiality: Due to the project's open source stance and nature, a request for confidentiality is not required. The ultimate objective of this project is to establish a novel industry that can achieve economic competitiveness through further advancements. The only technology that has not been disclosed is the ion exchange membrane; its planned release will be open-sourced.

Statement Regarding AI Use: AI assisted in formatting and editing to match DOE verbiage.

Project Overview Background

The project began in November 2023, leveraging prior work on low-cost ion exchange membranes originally developed for redox flow battery applications. After Richard Ebanks introduced gold-bearing ore for evaluation, initial bench-scale testing used aqua regia to digest the precious metals. Recovering metals through traditional reduction and precipitation proved difficult and posed issues. Electrolysis enabled the successful plating of gold powder, but the acid cost (notably nitric acid) and process requirements (heated, stirred solutions) demonstrated that aqua regia-based digestion would be difficult to scale economically for mining applications.

Subsequent research identified sodium chlorates and sodium hypochlorites as practical alternative oxidizers with established use in platinum group metal recovery. Because these oxidizers can be generated cost-effectively via saltwater electrolysis, Rowow LLC developed a test-scale, electrochemically driven process that demonstrated controlled precious metal extraction from rock samples. This work evolved into a continuous, closed-loop extraction and recovery architecture in which key acids (e.g., hydrochloric acid and chlorate oxidizers) are generated in situ using electricity and brine, reducing dependence on externally supplied chemicals. This integrated process platform is designated under SEM TECH as the Continuous Mining Unit (CMU).

Early scale-up trials processed larger ore quantities and consistently produced concentrated mixed-metal powders. Follow-on refining confirmed rhodium recovery and indicated the presence of additional platinum group metals, which substantially increased downstream separation complexity under conventional refining workflows. Over approximately one year, the team sought domestic analytical, refining, and off-take capabilities but identified limited U.S. capacity for a platinum group and rare earth overall. In parallel, development was constrained by limited in-house analytical methods until funding allowed for a dedicated laboratory and the procurement of XRF analytical capability (Rigaku NEX DE), accelerating iteration and validation.

Within the following year, funding by mining firms interested in SEM TECH, accelerated construction and the development of multiple electrolysis-based mining unit variants, and new ion exchange membrane manufacturing methods were established. In parallel, the Continuous Refining Unit (CRU) expanded SEM TECH's operating modes through straightforward changes to solution chemistry and electrode types. Recent efforts also discovered related electro-separation approaches, including electrodialysis and a multi-cell configuration that enable single-stage elemental separation. Collectively, these outcomes provide a strong technical foundation to advance SEM TECH as a scalable, closed-loop platform for domestic recovery of precious, platinum group, rare earth, and other critical elements from diverse feedstocks, including mining waste and low-grade ores.

Based on the updated 2025 list of 60 critical minerals, SEM TECH is capable of extracting all but 4 minerals. 53 of those elements can be extracted and concentrated by SEM TECH in a single leaching solution. Please see our supporting documents for a full listing. SEM TECH is not designed to directly extract Barite, Fluorspar, Metallurgical Coal, and Graphite because these are primarily recovered as native mineral/compound resources rather than as extractable dissolved elemental species. Synthetic pure Fluorspar (CaF_2) may be created from elements extracted by SEM TECH. The remaining 3 elements (Silicon, Titanium, and Tungsten), can be extracted by

SEM TECH utilizing the same components in the Continuous Mining Unit (CMU), only requiring a slight modification to which leaching solution is being utilized.

Finally, rough lab scale testing showed promising potential in the cost to process through the technology. These numbers are rough approximations and do not reflect a long term continuous operation (finalized under the scope of this project). Field sourced mining waste solution was processed at a cost of less than $5 a cubic yard, and 1 ton of ore was determined to cost $50-400 extracting its critical minerals. The feasibility section details more.

Project Goal

Under this award, Rowow, LLC will execute a three-goal program to scale a fully functional, closed-loop Continuous Refining Unit (CRU) capable of recovering precious metals and rare earth elements at throughput levels relevant to pilot-scale operations. The integrated system is designed to advance DOE resource recovery objectives while materially reducing waste generation and the environmental impacts associated with conventional mining and refining practices.

Goal 1 – Facility Relocation and Operational Readiness: Relocate and commission operations at an industrial facility with the utilities, permitting posture, and physical capacity required to execute the project tasks and establishing the long-term project vision necessary to and sustain DOE-aligned activities after project completion.

Goal 2 – SEM TECH R&D and System Engineering: Complete targeted research, component optimization, and end-to-end system engineering for SEM TECH, including design maturation of critical subcomponents and parts, while maintaining project objectives for closed-loop operation, high recovery efficiency, manufacturability, and scalable deployment.

Goal 3 – Prototype Build and Field Demonstration to TRL 7 or Higher: Develop and integrate SEM TECH within the Continuous Mining Unit (CMU) and CRU architectures to a full prototype configuration that meets TRL 7 performance and validation criteria (or higher), including processing of material from or at representative field test sites across multiple mine types and feedstocks.

Rowow will validate its proprietary ion-exchange membrane formulation, electrode architectures, and associated manufacturing processes to confirm performance and durability within SEM TECH and the CMU closed-loop configuration. The project will quantify recovery yields, energy and chemical consumption, alongside accurate waste reduction calculations to demonstrate that the proposed electrolysis-based recovery approach can deliver economic and environmental advantages not readily achievable with conventional alternatives at comparable simplicity, yields, and cost. The work plan defines the technical pathway, milestones, and test protocols required to advance the CRU from TRL 5 through TRL 6 to TRL 7, supported by fully documented test results. By the end of the period of performance, Rowow will have a functional metals and rare earth recovery process operating on-site, and the final report to DOE will document measured recovery performance, environmental benefits, and techno-economic viability of the SEM TECH for domestic resource recovery.

DOE Impact

An award from the U.S. Department of Energy would provide a material acceleration to

Rowow's development and validation pathway. The project is positioned at a key inflection point in SEM TECH and its component's final testing and scale-up. The proposed scope will build on prior technical results to advance the current TRL 5 system to TRL 7 or above through integrated prototype operation and field-relevant validation. Scale-up under this award will (i) further substantiate the performance and repeatability of SEM TECH, (ii) increase recovered metals and rare earth element yields through higher-throughput operation, and (iii) generate quantitative techno-economic data to support commercialization planning. To date, project progress has been primarily supported through internal resources, which has constrained the pace and breadth of development as system complexity and testing requirements have increased.

During 2025, Rowow received limited private-sector support through engagements with mining companies to conduct research activities and small-scale mine waste processing tests. These demonstrations were successful and are documented in the application. Targeted funding materially improved progress by enabling the acquisition of critical analytical capability and facility resources allowing for new feedstocks to be tested. The proposed project will extend this foundation through controlled and repeatable tests to full prototype and production-relevant operation, establishing SEM TECH's overall capacity, along with subcomponent efficiency, durability/longevity, and manufacturing scalability while expanding the range of recoverable metals and rare earth elements. Absent DOE support, the capital and operational requirements to achieve production-scale validation and the associated data package are not achievable within a reasonable timeframe through independent funding alone.

Budget

Category	Year 1	Year 2	Year 3	Total
Lead Researcher Team Salary	$300,000	$300,000	$300,000	$900,000
Administrative Team Salary (Indirect Cost)	$150,000	$150,000	$150,000	$450,000
Accounting/Office (Indirect Cost)	$50,000	$50,000	$50,000	$150,000
Labor/Employees (4)	$250,000	$250,000	$250,000	$750,000
Chemists/Technicians (2-3)	$200,000	$200,000	$200,000	$600,000
Chemical Engineer (1)	$180,000	$180,000	$180,000	$540,000
Purchasing new ICP-MS	$450,000	$0	$0	$450,000
Purchasing new WD-XRF	$350,000	$0	$0	$350,000
Manufacturing Equipment	$0	$400,000	$500,000	$900,000
Injection Molding Equipment	$0	$0	$700,000	$700,000
Vacuum Filtration Equipment	$0	$200,000	$0	$200,000
Safety Equipment	$180,000	$0	$0	$180,000
Supplies/materials/chemicals	$50,000	$200,000	$200,000	$450,000
600 Tons of ORE	$2,699,424	$0	$0	$2,699,424
Property	$2,500,000	$0	$0	$2,500,000
Third party analysis services	$50,000	$50,000	$50,000	$150,000
Facility modifications	$75,000	$25,000	$50,000	$150,000
Travel/Insurance/Utilities/Misc (Fringe Benefits)	$160,000	$260,000	$260,000	$680,000
Cost Share				
Federal Total				

Total	$7,644,424	$2,265,000	$2,890,000	$12,799,424

Indirect/fringe costs, totaling $1,280,000, less than 15% of the total allowed ($1,919,913.60)

Technical Description, Innovation, and Impact

Relevance and Outcomes

Rowow's SEM TECH platform is enabled by a proprietary ion-exchange membrane formulation and manufacturing process that yields membranes with tunable transport properties suitable for multiple cell configurations. In the current mining configuration, the membrane functions as a cation exchange separator that preferentially transports positively charged ions while rejecting anions. Under an applied electric field, this selective ion transport sustains charge balance and establishes a stable electrochemical potential gradient across the separator, enabling controlled migration of target cations while maintaining separation of acidic and alkaline environments.

The membrane is produced from a novel polymer recipe using consumer grade available precursor materials, resulting in a substantially lower cost alternative to conventional commercial ion exchange membranes. As a representative comparison, commercial membranes are approximately $100 for a sheet[1], whereas Rowow's membranes are produced for less than $1 for the same area. Beyond cost, the membrane is designed to provide improved resistance to fouling and acid attack, while supporting configurable ion transport behavior tailored to specific process chemistries.

Prior research has demonstrated ion exchange membrane approaches for acid and mineral recovery[2]. However, broad commercial adoption in mining applications has been limited by high membrane cost and performance degradation in harsh varying solutions. A low cost process compatible membrane is therefore a key enabling element for an economically viable continuous electrochemical recovery system aligned with DOE objectives.

SEM TECH applies this membrane enabled electrochemical architecture to the extraction, recovery, and treatment of metals from ores and mining waste streams to support domestic industries requiring a critical mineral supply. The system drives targeted redox transformations electrochemically by operating at controlled electro voltage potentials selected near relevant thermodynamic thresholds, reducing dependence on bulk chemical reagents and improving process efficiency relative to conventional chemical methods for comparable or superior transformations. The platform is designed to accommodate broad dissolved metal chemistries, enabling recovery of heavy metals into a concentrated mixed-metal powder suitable for downstream refining through additional SEM TECH continuous refining units or established industrial processing pathways.

Selectivity for separation and refinement can be further tuned through the combined selection of electrolyte/acid solution, electrode materials, and operating potentials, enabling staged recovery and purification from mixed concentrates. The program objective is an integrated closed loop electrochemical process from extraction through concentration and refinement to purified elemental products or industrial ready materials that minimizes consumable usage and eliminates generation of toxic waste streams.

[1] https://www.aliexpress.us/item/3256804341058677.html?channel=twinner
[2] https://www.sciencedirect.com/science/article/pii/S2468227624004526

Feasibility

A substantial body of peer reviewed research has established the technical basis and recovery potential of ion-exchange membrane electrolysis systems for metal and acid recovery. However, membrane cost and fouling in aggressive, mixed ion solutions have historically been prohibitive for broad deployment at scale. When appropriately engineered and operated at controlled electrochemical potentials, membrane enabled electrodeposition can achieve very high recovery and selectivity. For example, a recent electromembrane reactor study treating a real copper electrorefining effluent reported complete antimony recovery (100%) and near complete recovery of bismuth (95%) and copper (90%) after 4 hours under galvanostatic operation. The study further showed that membrane separators improve current efficiency while regenerating the chlorine separately for further acid reuse[3].

Based on in house results and process rationale, Rowow expects that continuous operation can support >99% recovery for many target critical metals (including rare earths, precious metals, and heavy metals), recognizing electrochemical systems are typically operated to maintain trace residual dissolved metals to maintain above dynamic equilibrium for stable mass transfer rather than forcing complete depletion in a single batch step.

Rowow has resolved the primary cost barrier through a novel recipe and manufacturing method and has demonstrated membrane efficacy under harsh, mixed chemistry conditions, establishing a defensible baseline for SEM TECH industrial feasibility. Remaining work focuses on final optimization and design to validate upper performance limits, allowing for economical utilization of the membrane and supporting components (e.g., electrodes, electrolyte chemistry, cell flow configuration, and controls) at scale. Field engagement with multiple mines and representative materials has further matured Rowow's understanding of real world constraints, including feed variability, operational robustness requirements, and deployment considerations.

SEM TECH ion-exchange electrolysis units have been tested in-house on raw mining ore, tailings, and other provided materials, demonstrating the capability to process diverse feedstocks under harsh conditions, including direct processing of high sulfide ore. In additional demonstrations, ore previously treated via mercury amalgamation was processed through the electrolysis system, showing the extraction of toxic heavy metals and recovery of remaining precious metals (e.g., gold and platinum) and other rare earth elements, while producing non-toxic tailings. Energy consumption (calculated with a large margin of error) was estimated at 300-2,200 kWh to fully leach and recover critical minerals from one ton of ore, corresponding to approximately $50-$400/ton. This power demand is consistent with a standard 100-amp residential service supporting a 1 ton/day unit. Ore and waste-stream processing cost were strongly influenced by variabilities such as sulfide and calcium content, which increased time and energy requirements to react with constituents, regenerate/maintain the required acidic conditions, and initiate effective "bleaching" conditions capable of dissolving precious metals. These outcomes indicate strong technical potential and favorable preliminary economics even with early, non-optimized electrolysis cells, and they define clear pathways for improvement under the proposed project scope.

The expected physical footprint for a continuous mining unit is modest, approximately

[3] https://www.sciencedirect.com/science/article/pii/S1383586625011839

50-300 ft² to process one ton per day with the vacuum filtration drum representing the largest single footprint element. The electrolysis cell stack itself occupies only a few square feet at that throughput. Scaling is not constrained, moreover, efficiency is expected to improve with scale through better integration and reduced relative losses. Overall, the infrastructure required to operate SEM TECH CMU and CRU systems is minimal and does not require specialty site modifications.

Mining waste liquids have also been processed, resulting in precipitation ("crashing out") of dissolved heavy metals into a filterable solid. In a representative case, the observed processing energy was <33 kWh (approximately $5 in electricity) to process 255 gallons of mining liquid waste.

From an operational standpoint, SEM TECH relies on straightforward process controls (e.g. conductivity and current density monitoring), enabling rapid training and simplified operation. Safety requirements are minimized through appropriate enclosures, ventilation, and leak detection. Routine inspections and maintenance of seals and fittings remain standard practice. In the unlikely event of a major gas leak, the presence of a strong chlorine odor provides an additional detectability cue. Fundamentally, SEM TECH is designed for operation without requiring specialized higher education, supporting scalable workforce adoption and rapid deployment across sites.

Innovation and Impacts

The enabling innovation is Rowow's ion-exchange membrane. Simplified recipes and scalable manufacturing approaches provide a practical pathway to utilization in electrochemical processes that have not been economically attainable with conventional commercial membranes. Complementing the membrane is a unique flow design implemented as a continuous, closed loop process, where electrolyte solution is transferred from the cathode compartment to the anode side. This differs from typical ion exchange electrolysis arrangements and has demonstrated strong performance for continuous cycling and stable operation. These typical configurations such as fully divided, stationary cells remain valuable for specific use cases such as liquid mine waste treatment and acid regeneration. However, the integrated flow approach provides a more effective architecture for continuous closed loop processing.

The projected impact to the mining sector is significant. Mine wastes can be reprocessed economically to regenerate acids and electrochemically reduce dissolved species, enabling recovery of critical minerals and heavy metals into a collectable product stream. Following heavy metals removal, the remaining solution can be electrochemically neutralized to a disposal ready condition, substantially reducing pollutant release and long term environmental liabilities.

Pilot scale demonstrations across multiple cell configurations will establish operating envelopes and deployment options, enabling both overall process redesign and incremental integration into existing mining and refining workflows. In either pathway, SEM TECH is positioned to improve recovery efficiency, increase yields, and eliminate toxic waste generation through closed loop electrochemical processing.

Workplan

Project Objectives

The project's overall goal is to advance the SEM TECH Ion Exchange Electrolysis Continuous Mining and Refining system from a Technology Readiness Level (TRL) of 5 to TRL 7 or above.

The three primary objectives to achieve the goal are to procure the required facility for the project's overall scope, fully test and validate SEM TECH, and scale SEM TECH for use in a closed loop Continuous Mining Unit (CMU) and Continuous Refining Unit (CRU) capable of extracting and refining heavy metals, precious metals, rare earth elements, and other critical minerals from diverse feedstocks.

Key objectives throughout the project include:

- Validating system performance and generating credible technical and economic data for successful commercialization.
- Design SEM TECH from domestically sourceable materials to be utilized in manufacturing.
- Establishing a proving ground facility for testing, demonstrations, and future proving groundwork with the DOE.
- Finalizing and optimizing core components such as membranes, electrodes, and electrolysis modules.
- Prioritizing high recovery yields, low processing costs, and fully closed loop operation with no toxic waste.

Expected Outcomes are:

- Scaled, in house production from domestically sourced materials of all key SEM TECH components (membranes, electrodes, overall electrolysis cells).
- A fully functional critical minerals extraction and refining technology that is globally competitive and strengthens the U.S. mining supply chain.
- A final facility capable of producing and supporting complete SEM TECH systems for testing of ore and feedstocks for rapid deployment at mine sites.
- Establish SEM TECH potential in utilization for domestic mining and refining sites, playing a key role in securing U.S. critical mineral supplies, by providing the key technology and educational resources.

Technical Scope Summary

The project is organized into three work scope and budget periods.

Budget Period 1 (Facility Acquisition and Setup): Rowow will identify and acquire an operations facility that is fully permitted and located within an industrially zoned area. Activities will include relocation, commissioning, and interior modifications to support all project operations. Safety planning will be a primary focus throughout, including the design and installation of safety controls such as monitoring systems, training, and containment measures. We will procure key analytical instrumentation to support research and verification needs, including a wavelength dispersive XRF spectrometer and an ICP-MS, along with associated cleanroom and facility buildouts required for installation and operation of the equipment. This will be completed within one year. In parallel with facility buildout, the project may conduct initial bench scale testing to confirm membrane performance, cell chemistry, and flow configurations.

Budget Period 2 (Prototype Development and TRL Advancement): The project will advance SEM TECH from TRL 5 to TRL 6, by validating a pilot scale system in relevant environments. Primary efforts will focus on procuring or manufacturing a continuous vacuum filtration drum to enable a prototype scale testing for continuous operation. Fabrication of the filtration drum will be performed in house or through qualified subcontractors, based on schedule and capability. Prototype testing on ores and representative materials will be conducted to evaluate technical performance and economic feasibility, resulting in detailed technical and cost analyses to inform potential mining industry deployment. This will include coordination with DOE and partner institutions for validation of produced materials for a third party review of SEM TECH analytical results.

Budget Period 3 (Pilot Demonstration and Scale-Up Preparation): The final period will advance SEM TECH to TRL 7 or higher through integrated demonstration within the Continuous Mining Unit (CMU) and Closed-Loop Refining Unit (CRU) in a relevant operational environment. The scope will emphasize scale up planning and costs for manufacturing the electrolysis units and associated components, including electrodes, ion-exchange membranes, and required auxiliary equipment (including filtration equipment, as decided from prior period). Contingent on successful results from Budget Periods 1 and 2, Rowow will validate, optimize, and document SEM TECH performance under conditions representative of real world applications.

WBS Structure

Budget Period 1 (Year 1): Facility Acquisition, Setup, and Foundational Readiness

Purpose: Establish an industrially zoned, permitted operations facility, implement safety controls, and stand up analytical capability (WD-XRF+ICP-MS) to support SEM TECH verification.

1.0 Budget Period 1 - Facility & Laboratory Readiness

Task 1.1 - Project management

1.1.1 Project Management Plan.
1.1.2 Technology Maturation Plan.
1.1.3 Project Summary Data Sheet.
1.1.4 Data Management and Sharing Plan.
1.1.5 Critical Minerals Collaborative Participation.

Task 1.2 - Facility identification, acquisition, and critical mineral material planning.

1.2.1 Identify potential locations.
1.2.2 Execute lease/purchase.
1.2.3 Plan for material transportation.
Go/No-Go #1: Facility secured within schedule/budget and suitable for long term objectives.

Task 1.3 - Facility buildout, safety systems, and operational commissioning

1.3.1 Safety controls.
1.3.2 Commission work areas.

Task 1.4 - Analytical laboratory buildout and instrumentation commissioning

1.4.1 Procure analytical equipment.
1.4.2 Validate analytical equipment.

Task 1.5 - Initial bench scale confirmation and baseline operating envelope

1.5.1 Bench scale membrane performance.

1.5.2 Define baseline KPIs and test protocols.

Budget Period 2 (Year 2): Prototype Development & TRL Advancement (TRL 5 > TRL 6)

Purpose: Build the prototype scale continuous operation capability (including a continuous vacuum filtration drum), then demonstrate and validate stable closed-loop performance, recovery efficiency, and waste/byproduct outcomes.

2.0 Budget Period 2 - Prototype Development & TRL 6 Validation

Task 2.1 - Prototype engineering

2.1.1 Develop prototype architecture for CMU/CRU operation.

2.1.2 Establish test matrix and third-party validation.

Task 2.2 - Continuous vacuum filtration drum fabrication/procurement

2.2.1 Procure or manufacture a continuous vacuum filtration.

2.2.2 Integrate filtration with CMU.

Task 2.3 - Continuous operation: chemical losses and ion buildup control

2.3.1 Quantify chemical losses/solution.

2.3.2 Develop required solutions to losses.

Go/No-Go #2A: Demonstrate continuous operation with minimal intervention to maintain solution chemistry.

Task 2.4 - Recovery efficiency testing and independent validation

2.4.1 Use ICP-MS and WDXRF to quantify overall recovery.

Go/No-Go #2B: For target minerals, outperform existing methods via higher recovery and/or economically viable processing of lower-grade feedstocks at competitive cost.

Task 2.5 - Byproduct and waste identification

2.5.1 Identify byproducts generated and solutions.

Go/No-Go #2C: If byproducts cannot be utilized, confirm no toxic/hazardous liquid/solid residues requiring offsite disposal beyond standard compliant handling.

Task 2.6 - TRL 6 evidence package and prototype performance report

2.6.1 Produce documented test results supporting TRL 6 readiness.

Budget Period 3 (Year 3): Pilot Demonstration & Scale Up (TRL 6 → TRL 7+)

Purpose: Demonstrate closed loop CMU+CRU prototype operation in a relevant environment with stable process control. Validate durability and economics. Produce a scale up manufacturing plan for SEM TECH and its components.

3.0 Budget Period 3 - Pilot Demonstration, Durability, and Scale-Up

Task 3.1 - Integrated CMU+CRU pilot prototype build and commissioning

3.1.1 Build a full prototype configuration supporting TRL 7.

Task 3.2 - Pilot-scale testing in relevant operational environments

3.2.1 Conduct sustained runs.

3.2.2 Process multiple feedstocks.

Go/No-Go #3A: Demonstrate integrated CMU+CRU operation in a relevant environment for sustained run with stable process control.

Task 3.3 - Component durability, maintenance intervals, and operating economics

3.3.1 Validate service life and replacement intervals.

3.3.2 Perform cost/benefit analysis.

Go/No-Go #3B: Demonstrate projected operating economics are profitable over expected component lifetimes/replacement cycles.

Task 3.4 - Manufacturing scale-up plan and cost model

3.4.1 Develop a bottoms-up manufacturing cost model.

Go/No-Go #3C: Show credible path to scaled production costs supporting target unit production at scale.

Task 3.5 - Final reporting and end-of-project goal achievement

3.5.1 Finalize complete data package.

3.5.2 Deliver TRL 7+ final report.

End-of-Project SMART Goals

By the end of the project period, Rowow will achieve SEM TECH at TRL 7 or higher by demonstrating SEM TECH utilization in the Continuous Mining Unit's (CMU) and Continuous Refining Unit's (CRU) operation.

1. **Pilot demonstration evidence (TRL 7+)**
    - Complete an integrated CMU+CRU pilot run in a relevant environment showing stable process control (flow and electrochemical operating parameters) and repeatable operation documented in test reports.
2. **Independent validation of recovery performance**
    - Provide product/feed analytical results using **ICP-MS and WD-XRF** and confirm key results via a DOE designated third-party laboratory, establishing defensible recovery calculations for target materials.
3. **Closed-loop environmental outcome**
    - Characterize byproducts and demonstrate either viable co-products or confirm that processing does not create toxic wastes requiring offsite disposal beyond compliant handling, consistent with the closed-loop objective.
4. **Durability + economics + scale-up readiness**
    - Validate service life expectations for serviceable/critical components. Complete a cost-benefit analysis demonstrating a profitable end product production pathway versus consumables and operating costs. Deliver a manufacturing scale up plan/cost model for electrolysis units and key components.

Project Gantt Chart																
Start	7/1/2026				Year 1				Year 2				Year 3			
Length	12 Quarters															
ID	Task	Start	End	Days	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	BP1 - Facility	7/1/26	6/30/27	365												
1.1	Project management	7/1/26	7/31/26	31												
1.2	Facility identification, material acquisition plans	7/1/26	9/30/26	92												
GNG-1	◆ Go/No-Go #1	9/15/26	9/15/26	1												
1.3	Facility buildout, safety & commissioning	8/1/26	12/30/26	152												

1.4	Lab buildout & instrument commissioning	9/1/26	3/30/27	211
1.5	Bench scale confirmation	10/1/26	6/30/27	273
2	BP 2 - TRL 6	7/1/27	6/30/28	366
2.1	Prototype engineering	7/1/27	9/30/27	92
2.2	Continuous vacuum filtration drum	8/1/27	12/30/27	152
2.3	Continuous operation	10/1/27	3/30/28	182
GNG-2A	◆ Go/No-Go #2A	3/15/28	3/15/28	1
2.4	Efficiency testing & independent validation	12/1/27	5/30/28	182
GNG-2B	◆ Go/No-Go #2B	5/15/28	5/15/28	1
2.5	Byproduct & waste identification	12/1/27	4/30/28	152
GNG-2C	◆ Go/No-Go #2C	4/15/28	4/15/28	1
2.6	TRL 6 Report	4/1/28	6/30/28	91
3	BP 3 - TRL 7+	7/1/28	6/30/29	365
3.1	Pilot scale built	7/1/28	10/30/28	122
3.2	Pilot scale testing	10/1/28	4/30/29	212
GNG-3A	◆ Go/No-Go #3A	4/15/29	4/15/29	1
3.3	Components economics	12/1/28	5/30/29	181
GNG-3B	◆ Go/No-Go #3B	5/15/29	5/15/29	1
3.4	Manufacturing scale	1/1/29	6/30/29	181
GNG-3C	◆ Go/No-Go #3C	6/15/29	6/15/29	1
3.5	TRL 7+ package	5/1/29	6/30/29	61

Project Management

Overall approach

Rowow LLC will manage the work through a dedicated Project Team. The overall management framework is organized into three performance periods, each with defined tasks, subtasks, activities, milestones, and deliverables. Active communication and outreach to the DOE would be performed to best optimize and update the project's performance and planning.

Roles of each project team member

The project will be managed by the following Project Team:

Project Director (Mr. Robert Karas): Holds direct responsibility for overall project management, fundamental research, material processing, and completion of technical deliverables. Mr. Karas will lead execution across the workplan, maintain alignment to performance objectives, and ensure technical readiness at each stage gate.

Critical handoffs and interdependencies

The project will actively manage key interdependencies that can affect schedule, cost, and readiness.

Analytical capability & performance verification: Analytical characterization (XRF and ICP-MS) would be carefully managed with third party DOE designated labs to ensure material processing can meet project deadlines.

Prototype testing outcomes/scale-up decisions: Full scale prototype testing results will inform project team members of the technology's risk posture, resource allocation, and readiness to determine the proper path forward to integrate SEM TECH into industries.

Technical and management aspects of the management plan

Rowow LLC will manage the project using systems and controls aligned to DOE expectations.

Work planning and tracking: A methodical WBS driven approach to track scope, schedule, and deliverables by performance period to meet milestones and Go/No-Go decision points.

Financial and project management practices: Routine budget monitoring and cost tracking aligned to tasks and milestones, with attention to long lead time items.

Approach to project risk management

The project utilizes a cautious budget strategy, particularly in Performance Period 2, to address uncertainty and mitigate risks associated with unknown variables and costs that may arise during full scale prototype testing. The use of phased execution and Go/No-Go decision points limits exposure by preventing premature commitment to downstream activities before performance and readiness are verified. A network of potential candidates eliminates risks regarding a sufficient workforce.

Approach to permits, approvals, and compliance

Meeting with local government agencies early in the period of performance. Securing final permits for the selected facility. Initiating insurance and utility setup required for operations. Completing safety certification activities. Conducting an internal Environmental, Health, and Safety (EHS) review to confirm operational compliance and safe work practices prior to full operation.

Milestone table

ID	Milestone	Target Date
1.1	Project formation and team structured	7/31/26
1.2	SMART: Facility required for project objectives acquired	9/30/26
1.3	Facility buildout and permitting	12/30/26
1.4	Lab buildout and instrument commissioning	3/30/27
2.1	Prototype engineered and built	9/30/27
2.2	SMART: Efficiency testing and independent validation	5/30/28
2.3	SMART: Byproduct and waste identification	4/30/28

2.4	SMART: TRL 6 achievement	6/30/28
3.1	Pilot scale engineered and built	10/30/28
3.2	SMART: Demonstrate processing in relevant environment	4/30/29
3.3	SMART: Component durability/maintenance analysis	5/30/29
3.4	SMART: TRL 7+ achievement	6/30/29

Project changes and how they will be handled

Project changes will be evaluated through the project's workplan and decision gates. Any change affecting scope, sequencing, cost, or deliverables will be evaluated and communicated with the DOE for impacts. Changes would prioritize on fitting to the overall project objectives.

Quality Assurance and Quality Control approach

The project will use analytical characterization (XRF and ICP-MS) to validate outputs and identify issues early. Careful sampling preparation and tracking through unique identifiers to maintain accuracy and traceability with storage in a secured location for more than 1 year after project completion.

Communications among project team members

Communications will be maintained through routine meetings between the Project Director, Business Administrator, and all respected company employees and project members supported by documented planning and tracking against the workplan. Communications practices will include regular check-ins tied to task progress, milestone readiness, and timely documentation of decisions, particularly at Go/No-Go points to ensure alignment, accountability, and continuity across all performance periods.

Technical Qualifications and Resources

Robert Karas serves as Project Director and brings a foundation in construction management, with prior roles spanning field engineer, foreman, and project manager. He previously led larger-scale infrastructure work, including management construction of the 26-story "Heron" apartment project in Tampa, where he oversaw field engineering, identified and resolved issues proactively, managed scheduling and material estimating, handled layout and planning, and produced a 3D model to support downstream planning and documentation. His work also involved frequent coordination with subcontractors and other firms while meeting architectural requirements, supported by detailed progress logs and multi-year scheduling to keep scope and deadlines on track. He later worked as a full-time drafter and project manager, leading estimating and bid work and producing build-ready blueprints and instructions and also developed hands-on experience modifying and repairing CNC machines, building expertise in advanced manufacturing and automation. Since leaving construction in January 2022, he has supported himself through farming while pursuing technical research projects documented publicly, including heavy equipment rebuilds, CNC builds, and work that progressed from redox flow batteries into chemistry, ion-exchange electrolysis, and mining applications.

SEM TECH is currently being developed at Rowow LLC's most recent facility: a 1,400-square-foot lab built by Robert in 2025 and designed specifically around SEM TECH's needs. The lab includes a CNC router table for electrolysis-cell manufacturing, a chemistry lab for sample prep and experimentation, a Rigaku NEX DE XRF spectrometer, ceramic kilns, a 12 kW induction heater, and related safety infrastructure (fumehoods/etc). While the space has enabled early core R&D, it is not large enough to support the full scope of planned work. Accordingly, a first-year priority is relocating to a larger facility, ideally an industrial site (already known/chosen) near rail access to support high-volume feedstock transport and expanded testing of incoming ore, as well as concentrate processing via CRU systems and CMU units deployed at mine sites. Robert's experience designing and constructing the existing lab, combined with his construction background, provides practical expertise for planning and building out a new facility aligned with the project's objectives. The R&D completed in the current lab has also clarified the operational limits and expansion requirements, enabling more realistic planning toward project goals. Over the past two years, Rowow LLC has iterated on multiple electrolysis unit designs (CMU and CRU) and worked with several client mines to evaluate workflow integration and commercialization pathways. This includes on-site coordination, ore transport logistics, extraction and concentration of critical minerals, concentrate refining, and engagement with commercial refining partners, collectively informing a detailed understanding of industry needs and constraints. Robert has worked full-time on the project for the past two years and intends to continue at that level. Richard has supported the effort since the beginning (including outreach and early sample development) and plans to transition into a full-time role to provide administrative and business support.

Finally, Rowow LLC intends to open-source the technology to accelerate adoption and ensure U.S. industries can implement SEM TECH in a highly optimized and rapid manner for critical mineral production. This would be supported through transparent documentation of progress/setbacks and broad dissemination through public channels such as websites and social media, helping shorten the learning curve and enabling commercial integration as project milestones are achieved.