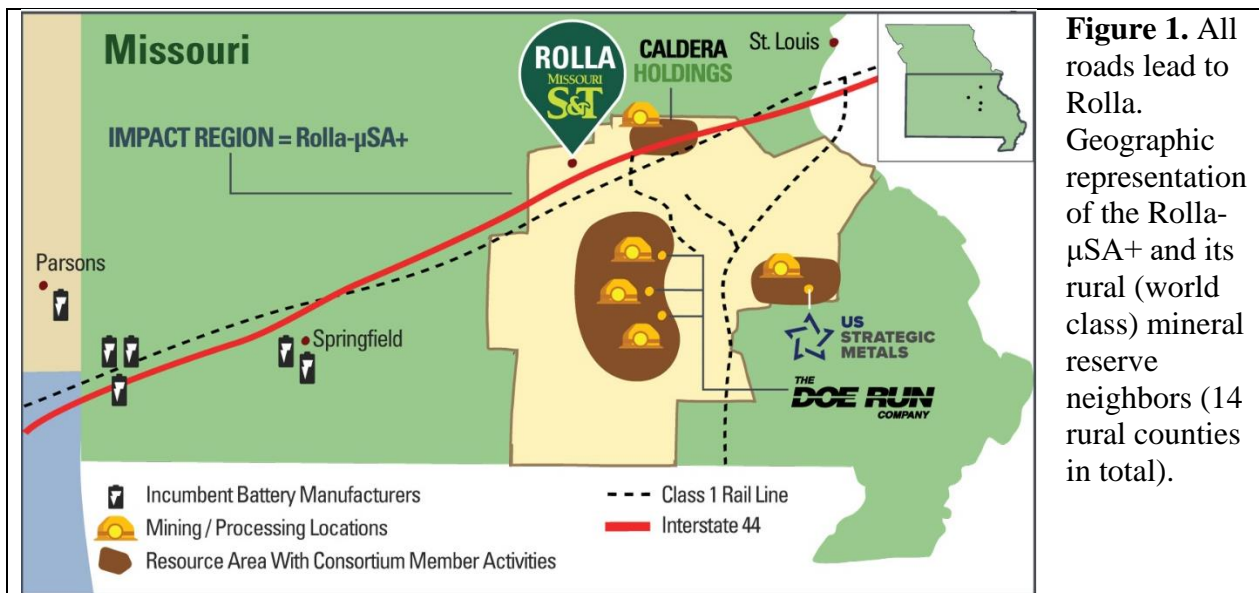


Executive Summary

Critical Minerals, Critical Materials and Critical Goods form the core segments of the vertically integrated Critical Supply Chain. Control and profitable operation of the vertically integrated segments underpin US national and economic security and our ability to be competitive in advanced energy technology (KFTA #9). In 2022, the US had a net import reliance on 38 of the 50 USGS recognized Critical Minerals, with 26 dominated by China. This proposal seeks to articulate why and present solutions as to how the Rolla, MO Micropolitan Statistical Area, and the surrounding mineral-rich rural areas (Rolla- μ SA+ – Figure 1) can meet the downstream US advanced energy products manufacturers demand through unlocking the extraction, refining, and displacement of more than 30% of the cobalt and nickel imported today.¹ The Missouri University of Science and Technology (S&T), internationally recognized for its mineral and refining expertise and intimate connection with the incumbent large mineral extraction corporations, Dept. of Energy Critical Materials Institute, and State partners, will lead the Critical Minerals and Materials for Advanced Energy (CM2AE) Consortium. Missouri has committed nearly \$100M for the development of an advanced manufacturing prototyping facility and \$16M to support critical mineral development. We estimate the Rolla, Missouri tech hub can spur \$40B in economic activity,² induce >6,000 good paying jobs³ to impoverished communities in our state, and help advance the United States’ global competitiveness in advanced energy manufacturing by 2033.



I. Technology-based Potential of the Region for Global Competitiveness

The United States’ critical materials problem reduces to two direct issues: (1) we are not extracting enough of the critical minerals; and (2) we do not have the processing capacity to convert the minerals into materials that are necessary for advanced energy or critical goods products. The Rolla- μ SA+ has unique expertise in hydrometallurgical refining expertise and capacity, led by S&T and found throughout the Doe Run, US Strategic Metals (USSM), and Caldera Holdings corporations. The Rolla- μ SA+ hub will create an eco-system to translate this expertise into new enterprises based on intellectual property facilitated by the consortium.

Missouri has a clear and distinct advantage with known mineral resources of cobalt (>150,000 mt), nickel (>200,000 mt) and rare earth elements (REE) (72,000-mt w/ 9,000-mt as Nd₂O₃).⁴ In 2022,

US mine production for Co was just 800 mt.⁵ Additional known advanced energy minerals that have been economically feasible to mine historically in the Rolla-μSA+ include Ga, Ge, Pb, Zn, Cu and Sn; these additional minerals are important as co-products and improve the economic feasibility of Co, Ni, or REE extraction and refining.

If the known mineral reserves were put to use Missouri would capture 100% of the Co demand for battery manufacturing.⁶ Further, if the estimated mineral resources of Missouri were extracted, the Rolla-μSA+ would be the majority global supplier of Co and Ni.

However, it is the advanced hydrometallurgical expertise and processing capacity potential, along with existing approved permits, and willing investors (e.g., Great Plains Partners Venture Group) that make the Rolla-μSA+ globally competitive. We estimate this market potential to be worth more than \$40B in aggregate over the next 10 years.²

In addition, the facility and expertise developed out of this work will draw ore from each corner of the US to develop custom hydrometallurgical-hybrid processes for their regional economies and sustainable practices that reduce emissions. Additionally, due to the robust barge, rail and truck infrastructure of the Rolla-μSA+, it is also economically feasible to process internationally sourced concentrates at full-scale. Rolla-μSA+ will create a true eco-system for developing hydrometallurgical technology to support advanced energy manufacturing.

II. Role of the Private Sector

Doe Run, US Strategic Metals, and Caldera Holdings will collaborate with S&T to do empirical testing and simulation work to reduce the cost and time to scale up their proprietary hydrometallurgical processes. These private sector collaborators have committed to use the S&T scaling facility for process flowsheet development and collaborate with S&T experts to perform techno-economic-analysis using the developed flowsheets. The facility will also be open to expanding new partnerships. Each corporation will also provide statistics and requirements for workforce personnel that S&T will use to drive curriculum changes and new degree programs, certificate offerings, and K-12 engagement.

These private sector partners provide unique value to the consortium because they will (1) use the scaling facility to develop process flowsheets and receive formal techno-economic feasibility analysis; (2) finance requirements beyond the EDA investment and/or custom equipment for the scaling facility; (3) provide clear technical requirements and workforce requests for the processed critical materials; (4) co-share in the exploration and development costs and human resources of proving additional mineral reserves; and (5) serve as integral partners in the prosperity and sustainability of underserved mining communities. In each case, the private sector consortium members essential to each of the above needs has signed a letter of commitment (see addenda).

On the downstream side, the private sector regional battery manufacturing corporations have made commitments to purchase materials from the full-scale precursor cathode active material (P-CAM) and CAM manufacturers if the requirements/specifications and volume delivery schedules are met. These agreements are important to buying down investor risk. There are also several producers and customers in the microelectronics industry that are very interested in developing partnerships.

III. Regional Coordination & Partnerships

The CM2AE is a group of interconnected non-metro rural areas tied to the Rolla-μSA+. S&T has a long history of partnering with regional organizations, including Missouri Department of Natural Resources, Missouri Enterprise, and Missouri Chamber of Commerce.

Fourteen counties south and southeast of Rolla have a high employment concentration in mining and are the focus for this tech hub application. These counties are highly rural (most with $\leq 25,000$ people) and include Carter, Crawford, Dent, Howell, Iron, Madison, Oregon, Phelps, Reynolds, Shannon, St. Francois, Ste. Genevieve, Texas, and Washington (yellow shaded area in Figure 1). These counties have enough middle-skill labor to meet the needs of the tech hub. There are 8,919 production workers, 5,176 installation, maintenance and repair occupations, and 4,093 construction and extraction occupations. If we extend the geography to Franklin and Jefferson counties in southern metro St. Louis, the number of occupations grows to 17,578, 9,900, and 9,345, respectively. In the 14-county area, the mean annual wage of these occupations is \$34,141, \$42,023, and \$44,405, respectively (in the original 14-county area).⁷

The Missouri Association of Council of Governments (MACOG) will help the consortium engage with these counties by bringing the relevant Economic Development Districts (EDDs) to strategy discussions. These EDDs include the Meramec Regional Planning Commission, Ozark Foothills Regional Planning Commission, South Central Ozark Council of Governments, and Southeast Missouri Regional Planning and Economic Development Commission. Missouri's Department of Economic Development (DED) has a long history of partnering with EDDs including through its community development block grants, broadband development, and statewide Comprehensive Economic Development Strategy (CEDS) efforts.

The Missouri Chamber, whose Chamber Federation includes 200 local Missouri chambers of commerce, will also help ensure the consortium engages with local businesses in the Rolla area as well as in the surrounding rural communities.

The State of Missouri has also committed nearly \$100M for the development of an advanced manufacturing prototyping facility and \$16M to support critical mineral development, as well as tens of millions of dollars in workforce development tools and local infrastructure.

IV. Equity & Diversity

The 14-county region including Rolla and mining-heavy areas to the south and east will benefit greatly from the economic impact spurred by the CM2AE consortium. These areas have a much higher poverty rate than other communities, 18.3% compared to the Missouri average of 12.8%. They are also growing jobs (3.6% to 8%) and GDP (4.2% to 9.2%) at less than half the rate of the Missouri average.⁸

Missouri's Workforce Development Board will ensure Missourians in the tech hub communities gain access to the good jobs resulting from critical minerals and materials economic activity. The Workforce Development Board will leverage its job center network, especially facilities in Rolla, West Plains, and Park Hills to assist Missourians facing barriers to employment. Mineral Area College, a community college with five locations in the focused region, will train and help young people in the region's rural areas discover lucrative mining and refining career opportunities.

The CM2AE consortium members represent the diversity of stakeholders in Rolla and the rural communities to the south and east. Stakeholders represent academia, the private sector, state government, economic development, and local officials. We believe that MACOG's participation, in particular, will ensure that local community interests are understood and acted upon.

Of considerable note is the inequity experienced in the impoverished rural communities surrounding the mining operations in terms of the job availability, reskilling capacity, pay differential and access to broadband and healthcare. CM2AE is committed to ensuring benefits

from the tech hub will be shared equitably. CM2AE will work with Mineral Area College (MAC), and Ozarks Technical Community College, to provide reskilling and training for the newly created jobs, promote local procurement for commercial projects within the Tech Hub, and ensure broad consultation with the rural communities. Diversity in mines, owners, leaders, producers and stakeholders is essential to the sustainability and resilience of the economies which will benefit from this work.

V. Composition and Capacity of the Regional Workforce

Mining, processing, and CAM production to scale to 300,000 metric tons of material per year into lithium-ion, primary-lead-acid batteries and more, starting from the Rolla-μSA+, requires workers to perform that work (production operators), maintain the equipment, engineers to adjust the process, plant managers to sustain floor operations, hazardous materials safety training specialists to meet compliance/regulations, and more. In total, more than 500 Standard Occupational Classification types by detailed occupation are required to meet the critical minerals → critical materials → critical goods part of the supply chain toward lithium-ion battery manufacturing alone. Historical averages from vertically integrated European and East-Asian manufacturers in the same field show that the hourly positions will be four times the salaried positions. To meet just the lithium-ion battery supply chain manufacturing needs will require an estimated 6,000 direct, indirect and induced jobs at full capacity, with at least 3,500 new workers, and 300 lost through attrition during the building phase. Of these 3,800 new workers, 3,000 will be high school graduate, certificate and/or associate degree holders, and 10% with non-STEM 4-yr degrees. The remaining 800 will be 60% (480) engineers, 20% supervisory and the balance to high level support functions.⁹

Thanks to Missouri S&T, Missouri is a mecca for mining and metallurgical engineering and geology talent. Missouri had more 2021 program completions (certificate through PhD) in mineral and mining engineering than any other state in the country. And Missouri produces more than double the program completions in geological and geophysical engineering than the next closest state, Colorado. In fact, Missouri had 60 Masters- and PhD-level geological and geophysical engineering program completions in 2021, compared to 28 in second-place Colorado.¹⁰

S&T has several programs aimed at recruiting engineering talent to the school as well as retaining the talent in Missouri after they graduate. These include a dedicated recruiter for the programs in the mining area, active recruitment activities including summer camps for teachers and experimental mine tours for K-12 students in the area, higher than average departmental scholarships, and collaboration with consortium partners to offer internships and hiring in Missouri. There is enough skilled labor, as discussed earlier, to meet the needs of the tech hub.

Missouri One Start, a nationally recognized workforce training division within Missouri's Department of Economic Development has been in operation for >30 years and assisted over 1,000 companies and will play a key role in recruiting and training talent. Through a state-wide network of training professionals located within the community colleges and career technical centers, funding provided by Missouri One Start allows companies to customize training they need to ensure their workforce has the right skillset. Consortium member Doe Run participates in the Missouri One Start training program. The company received a training award to provide industry-specific training to upskill 300 existing workers with technical skills in areas such as metallurgy, instrumentation, welding, rigging, blueprints, and more. Missouri is also one of the top states in the nation for apprenticeships, which will also be a primary focus of talent development and training in this industry, to also include veteran programs.

Finally, the Missouri Workforce Development Board will leverage its programs, networks, and funding to help build a skilled workforce in alignment with CM2AE goals across all areas including building trades.

VI. Innovative ‘lab to market’ approaches

Cobalt (Co), Nickel (Ni) and Manganese (Mn) are critical minerals used to fabricate most commercial cathode active material (CAM) for lithium-ion batteries. Extraction of these metals from ore has historically used pyrometallurgy, whose separation efficiency, industrial scalability, and environmental challenges we discussed previously. On the other hand, CM2AE members have been developing advanced hydrometallurgical techniques that overcome the negative attributes of pyrometallurgical processing of Co, Ni, Cu, Mn, Pb, Zn, and rare earths from the region. The Missouri Dept. of Natural Resources, who has regulatory authority to oversee permitting, has issued current and valid air and water permits to Doe Run and USSM. **As of the date of this proposal, Missouri remains the only state with active permits to separate Co, Ni, Cu, Mn, Pb, Zn, Ga, Ge and rare earths (Nd, Pr, Dy, Tb) at an industrial scale within the US.**

This superior position on the separation market and control over sending material to the downstream full-scale plants for CAM processing and application to batteries is a key differentiator that secures global competitiveness. This is the amplification effect sought by the Regional Technology Innovation Hubs and which also impacts the additional KFTAs #1, 2, 3, 4 and 6 (note, the primary KFTA for this application is #9, Advanced Energy).

The lab-to-market innovation we seek here is primarily the scaling of hydrometallurgical and CAM manufacturing technologies. From a Technology Readiness Level (TRL) perspective, both parts of the process chain meet the prototype pilot scale in the use case or operational environment and as such meet the TRL-6 criteria. From a Manufacturing Readiness Level (MRL) perspective, when we bring these methods together, with new feedstocks that have varying concentrations of commodities and impurities, engineers have to design a unique process flow, causing a reversion in the MRL to a value of MRL-4 (i.e., capability to produce the technology in a laboratory environment). The scaling assessment we propose will advance these processes to an MRL-9 (i.e., low-rate production demonstrated; capability in place to begin full rate production).

The established relationship between state, local and private partners has already led to several policy changes around workforce development and diversity recruiting, which have also been funded at the state level. However, if additional changes are needed CM2AE is committed to working through them with appropriate consortium members.

VII. Impact on Economic and National Security of the Entire United States

Controlling the supply chain, from critical minerals to critical materials to critical goods, reduces our dependence on China, directly aligning with the findings and recommendation of the 100-day Review under Executive Order 14017, the securing of energy storage products; also defined under KFTA #9. From an intellectual property and trade secret view, the CM2AE has a head start on industrial scale hydrometallurgical and CAM precursor manufacturing that places it in a position of global leadership. We believe that the Rolla, MO Micropolitan Statistical Area and the surrounding, mineral-rich rural areas can unlock the extraction, refining and displacement of more than 30% of the cobalt and nickel imported today¹ that meet the downstream US advanced energy products manufacturers demand. “Reshoring” these critical materials is absolutely critical for our nation’s economic and national security.