Critical Minerals

Systems Analysis Tasks

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U.S. Department of Energy
National Energy Technology Laboratory
Resource Sustainability Project Review Meeting

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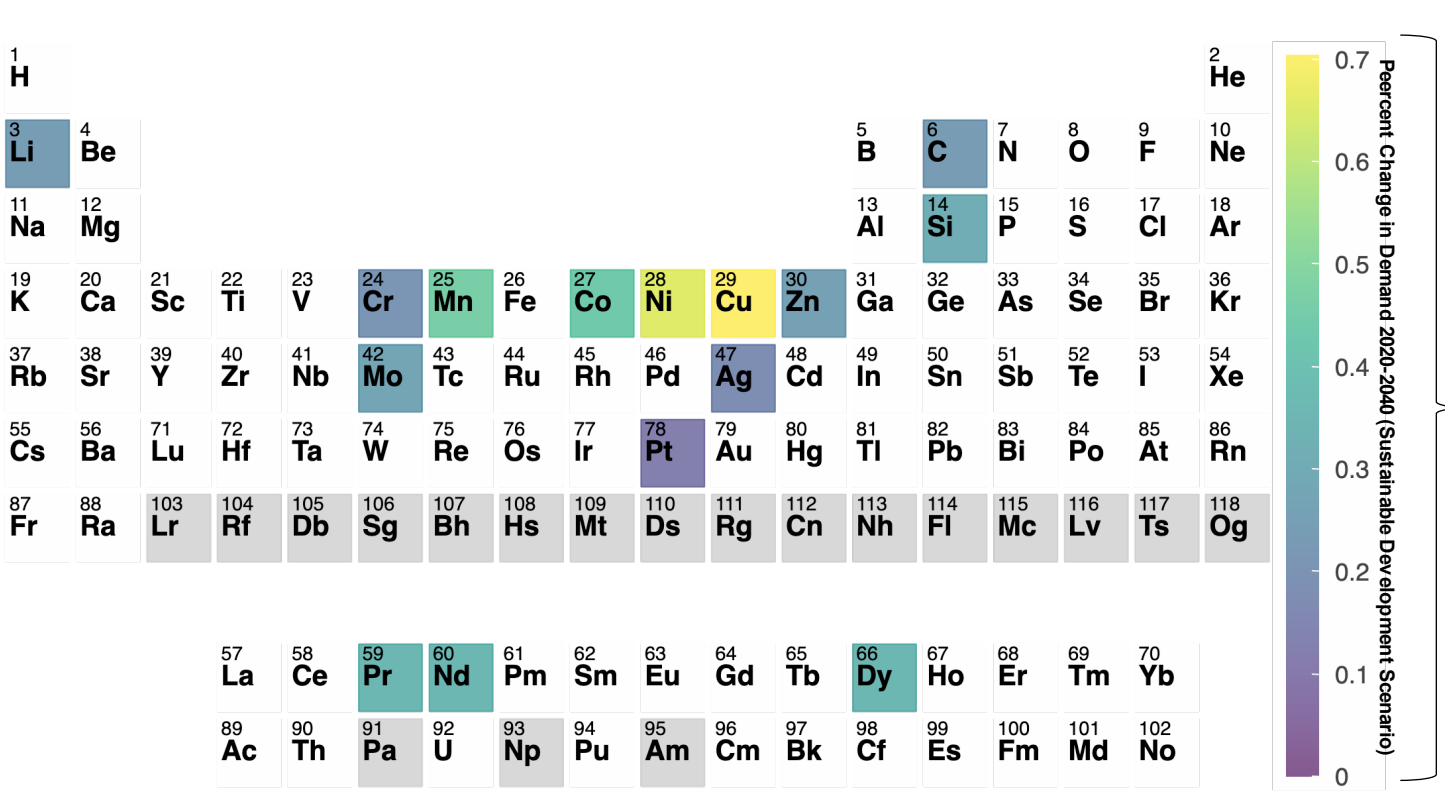
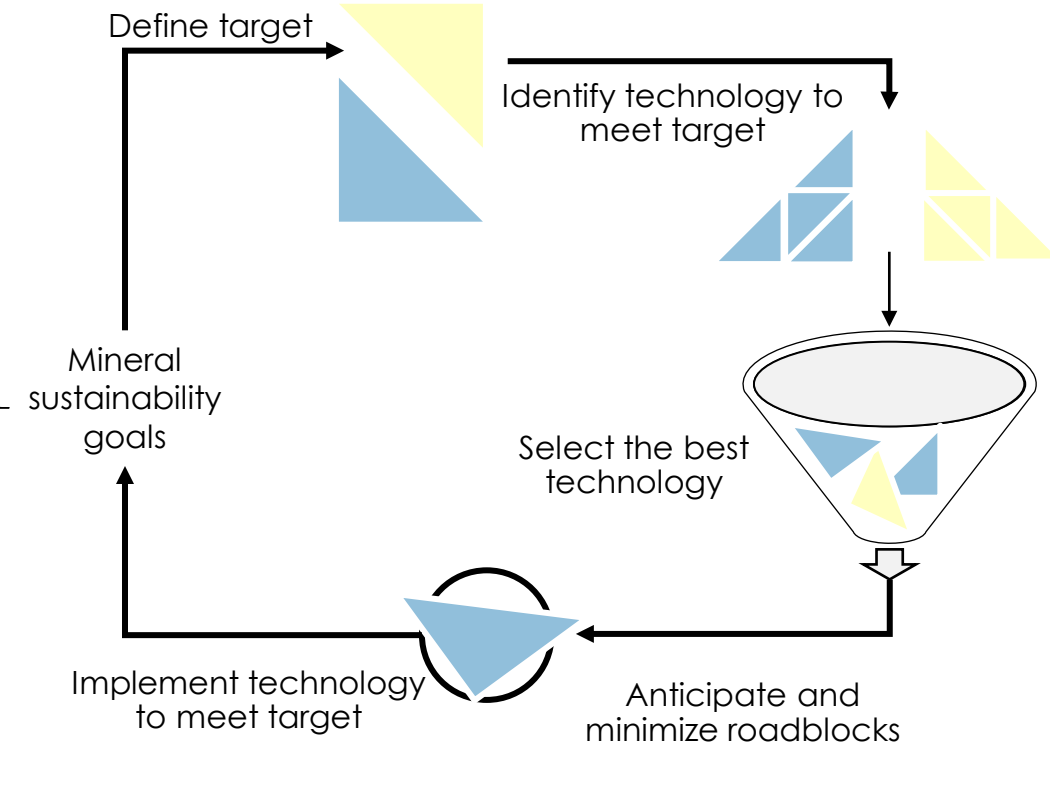
Legal Disclaimer

Critical Minerals: role of systems analysis





Critical Minerals EY23 Field Work Proposal

System Analysis Scope

Critical Minerals Resource Data (Task 9)	Gabe Creason 
Life Cycle Analysis (Task 22)	Michelle Krynock  Shirley Sam  Tyler Davis 
Markets Analysis (Task 23)	Gavin Pickenpaugh  Jack Suter 
Techno-Economic Assessment (Task 25)	Alison Fritz  Chad Able  Tommy Schmitt 

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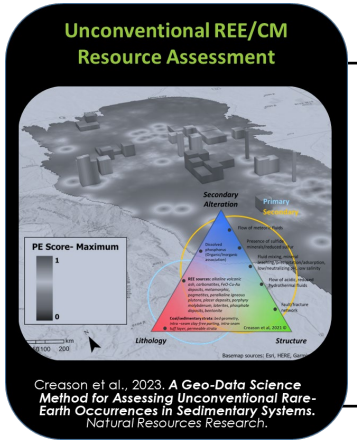
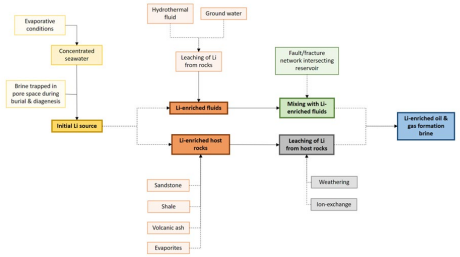
Critical Minerals Resource Data (Task 9)

Gabe Creason



Adapting the Unconventional REE/CM Resource Assessment Method for Local-Scale Application



Geospatial AI/ML-Driven Pattern Discovery to Identify Prospective Unconventional CM Resources

Adapting the Unconventional REE/CM Resource Assessment Method for Local-Scale Application

Objective

- Add capability to the NETL-RIC URC resource assessment method (Creason et al., 2023) to support local scale evaluation and quantification of in-place CM resource potential at sites for which higher resolution data are available.

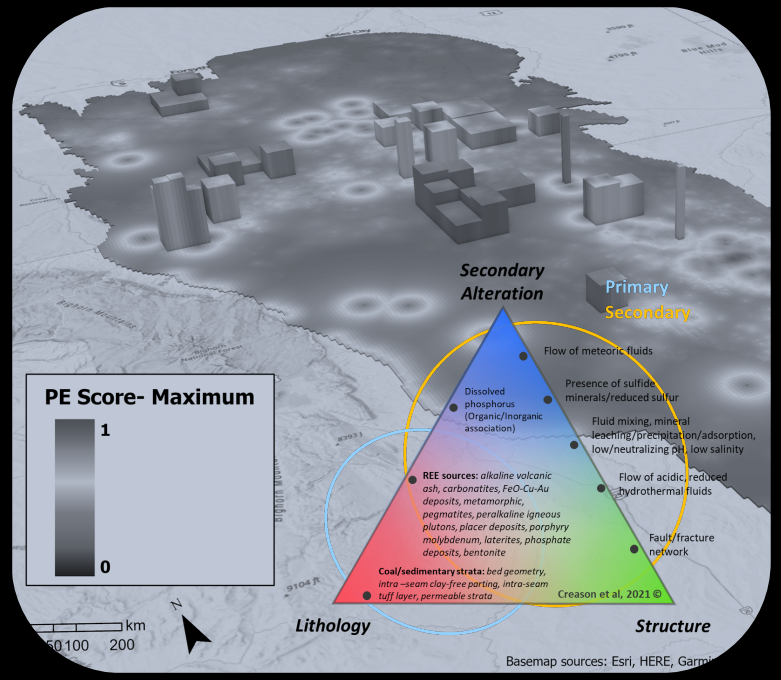
Approach

- Establish new analytical approaches for three-dimensional analysis and characterization
- Incorporate additional data types into assessment
- Demonstration with case study

Outcome

- Accelerate TRL maturation of several NETL AI and software R&D REE/CM systems by demonstrating a commercial-scale test case and supporting the Minerals Sustainability Program interest in establishing a commercially viable domestic supply of REE and CMs.

Unconventional REE/CM Resource Assessment



Creason et al., 2023. ***A Geo-Data Science Method for Assessing Unconventional Rare-Earth Occurrences in Sedimentary Systems.*** *Natural Resources Research.*

Geospatial AI/ML-Driven Pattern Discovery to Identify Prospective Unconventional CM Resources

Objective

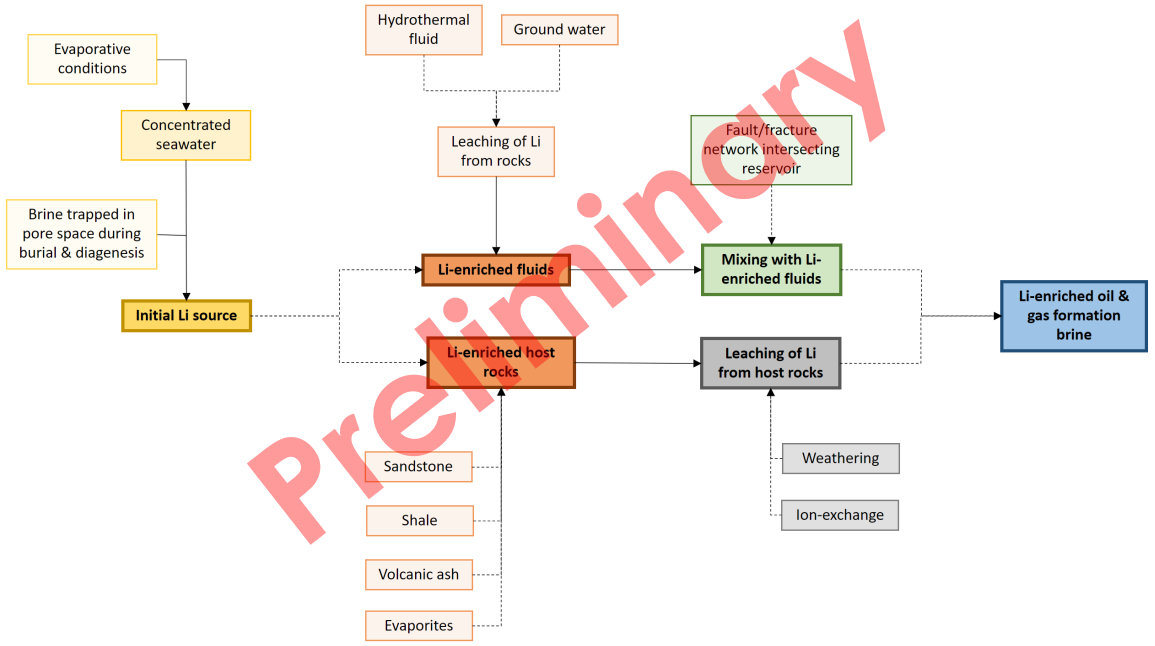
- Establish a new approach to identify and evaluate unconventional sources of additional critical minerals (e.g., lithium and other priority minerals)

Approach

- Develop a geospatial AI/ML-driven geochemical pattern discovery approach using geochemical and geophysical data
- Aggregate the current state of knowledge of systematic nature of CM accumulation (lithium) in geologic deposits
- Integrate that knowledge into the geologic processes-based framework of URC assessment method

Outcome

- Outputs from CM-specific geologic processes and geochemical modeling approaches will be integrated to provide new analytical tools for assessing unconventional CM resource potential in domestic sedimentary basins



Conceptualization of the geologic system relating to lithium enrichment in oil field brines.

Critical Minerals EY23 Field Work Proposal

System Analysis Scope

Life Cycle Analysis (Task 22)

Michelle Krynock

Shirley Sam

Tyler Davis

Critical Minerals LCA Toolkit

Fly Ash Environmental Assessment of Alternative Actions

ISO Technical Advisory Group (TAG) 298 Working Group 5: Environmentally Sustainable CM Mining, Separation, and Processing Guidance

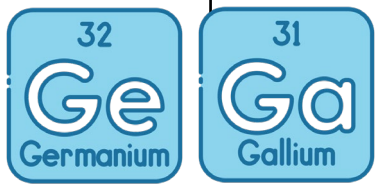
Critical Minerals EY23 Field Work Proposal

System Analysis Scope

Markets Analysis (Task 23)

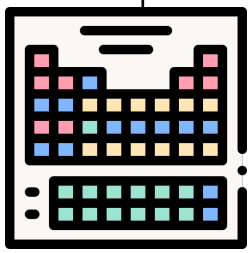
Gavin Pickenpaugh

Jack Suter



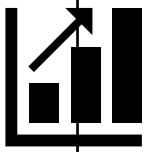
Source: Bearicons

Evaluation of market data for Gallium (Ga) and Germanium (Ge)



Source: Freepik

Updates to REE embedded demand database



Production and cost targets for REE

Embedded Demand of Ga and Ge

Objective

- Ga and Ge are critical to the energy transition.
- Supply of Ga and Ge is not secure due to export controls by competing nations.
- It is critical to understand U.S. reliance on imports containing these materials that are not currently measured.

Approach

- Determine what products imported into the U.S. include Ga and Ge.
- Estimate the Ga and Ge contained in these products.
- Calculate the total imports of these products.

Outcome

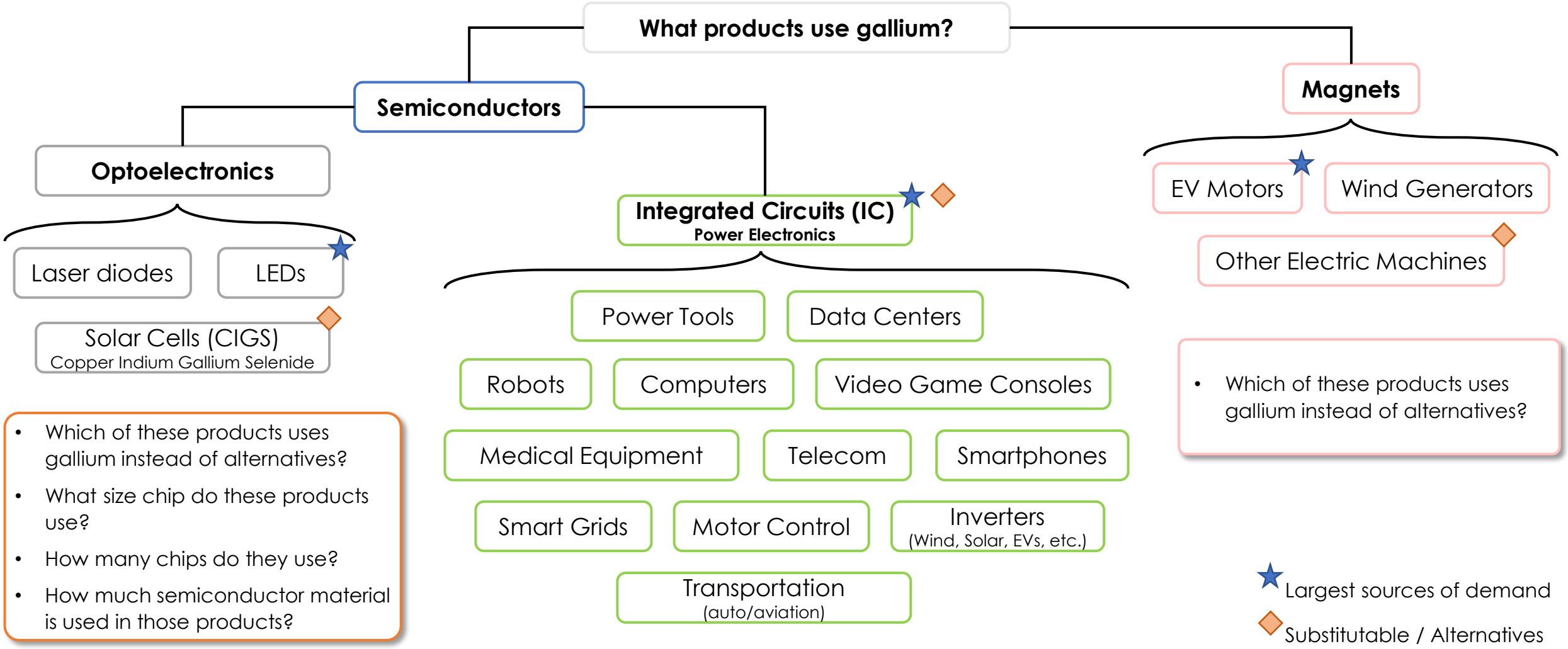
- Establish the embedded demand of Ga and Ge in imports to the U.S.

Source: The Aluminum Association

Source: WellPCB

Embedded Gallium: Bauxite to completed packaging and integration with circuit board

Identifying total demand of gallium embedded within all products consumed in the US in 2022



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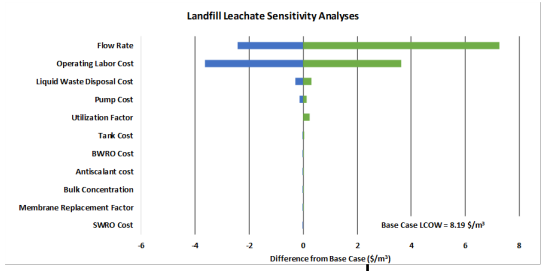
Techno-Economic Assessment (Task 25)

Alison Fritz

Chad Able

Tommy Schmitt



Treatment and Critical Mineral Recovery Baseline for Leachate and Produced Waters

CO-DART
CONSTITUENT DATA REPLACEMENT TOOL

Machine Learning Approaches for Energy Wastewater Characterization

Machine Learning Approaches for Energy Wastewater Characterization

NATIONAL ENERGY TECHNOLOGY LABORATORY

Objective

- Articulating more complete distributions of CMs in produced water and leachate allows for greater resolution in techno-economic analyses

Approach

- Gathered CM composition data from the Electric Power Research Institute Combustion Product Information (CPInfo) database, and NEWTS US Geological Survey (USGS) produced water data set.
- Performed modeling work in Python, leveraging the scikit-learn machine learning algorithms to build independent models for each constituent

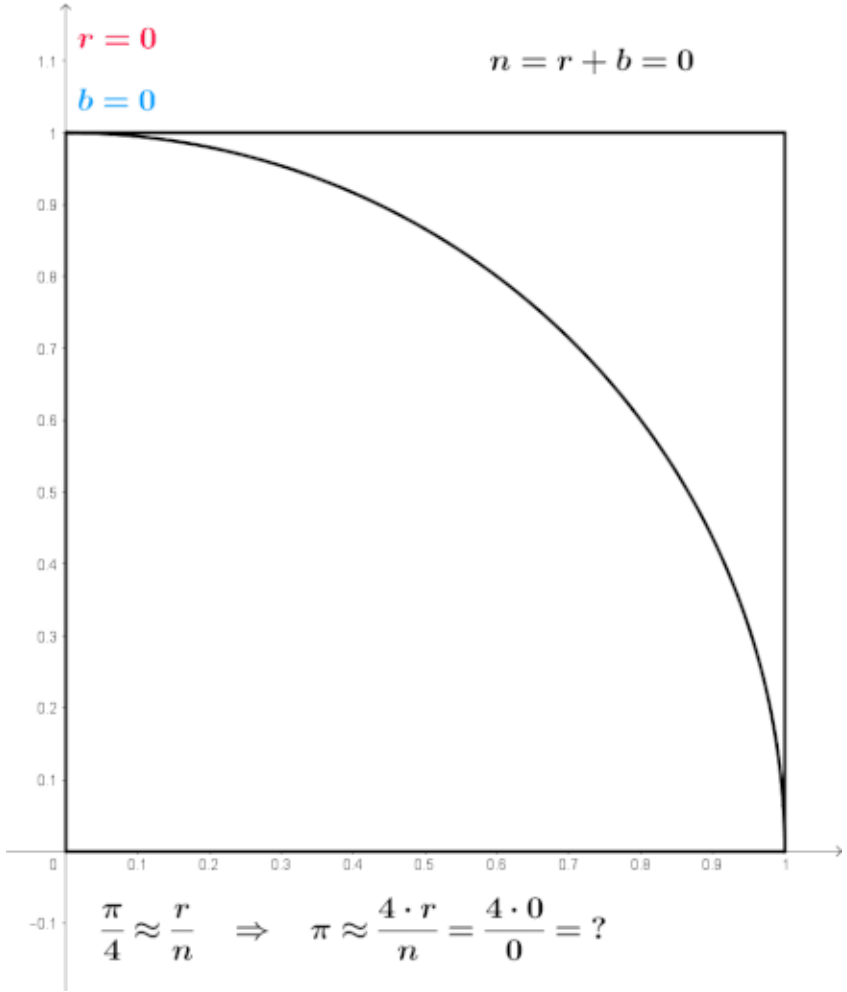
Outcome

- Created a Python tool: Constituent Data Replacement Tool (CoDaRT) with a graphical user interface to replace missing data in energy wastewater datasets
- Produced REE estimates in leachate using coal ash data

Graphical User Interface for CoDART

REEs in coal ash leachate estimated using CoDART data framework

- REE data is limited for leachate, but can be simulated using available data and methods
- Monte Carlo simulations were run to estimate the probability of REEs to be transferred from coal fly ash to leachate using REE data in coal fly ash, leaching ratios.



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Treatment and Byproduct Recovery Baseline for Leachate and Produced Waters

Objective

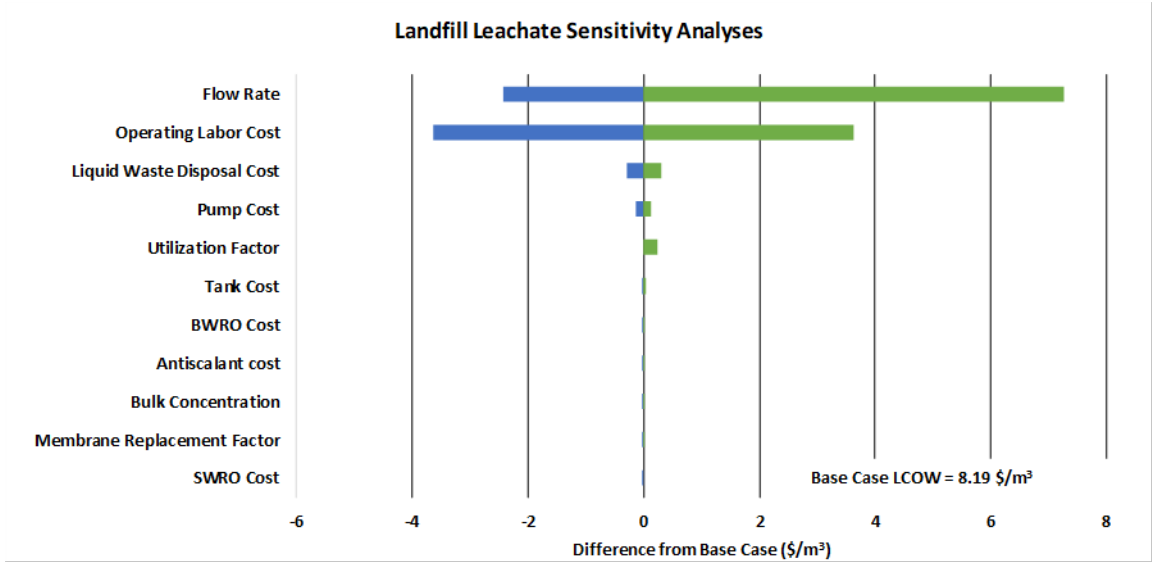
- The baseline cost of concentrating critical minerals during treatment of energy wastewaters can inform technology development and help build a domestic critical mineral supply.

Approach

- Modeled performance and cost of appropriate treatment and recovery systems for leachate and produced water in WaterTAP and OLI Studio and Flowsheet.
- Used CM market data available from the USGS for market value calculations.

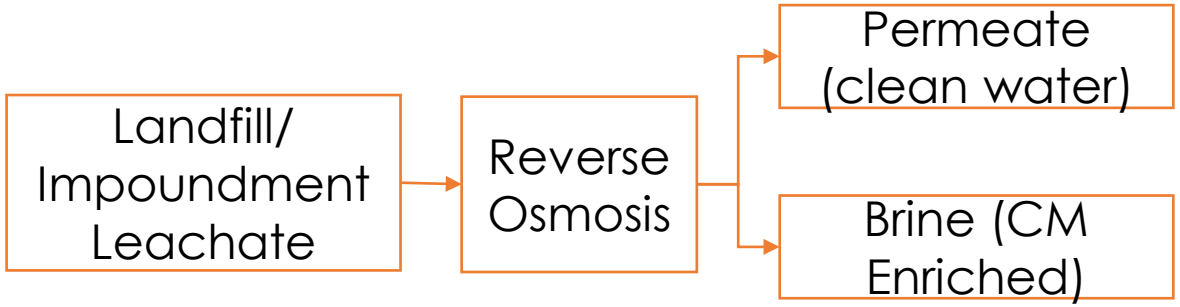
Outcome

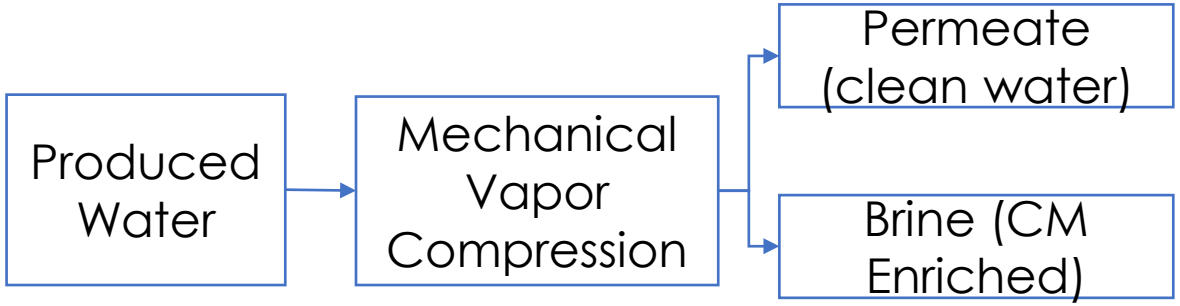
- Produced performance and cost estimates for a membrane system for landfill and impoundment leachate and a mechanical vapor compression (MVC) system for produced water
- Calculated expected market value of critical minerals in the resultant brine.



Leachate treatment and mineral concentration costs are most dependent on flow rate and labor.

Treatment and Byproduct Recovery Baseline for Leachate and Produced Waters





Feedstock	Value of Brine ($/m3 permeate)	Levelized Cost of Water ($2023/m^3)
Landfill Leachate	0.28	0.15-0.41
Impoundment Leachate	0.13	0.14– 0.39
Produced Water	15.44	3.00-6.51

Majority of value all brines is from lithium + magnesium

Preliminary results

Upcoming Public Products

TOOLS/SOFTWARE RELEASES

- NETL Critical Minerals LCA Guidance Toolkit
- "Machine Learning Approaches for Energy Wastewater Characterization" dataset completion tool.

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JOURNAL ARTICLES

- "Assessing Unconventional Rare-Earth Element Resource Potential in a Geologically Complex Sedimentary System: A Case Study from the Central Appalachian Basin (USA)". Justman, Creason, et al., in revision. Invited contribution to Special Issue in Applied Geochemistry.
- "Treatment and Byproduct Recovery Baseline for Leachate and Produced Waters". Able, Schmitt, Fritz et al.

Future directions

Current Expertise

- Geospatial AI/ML
- Process Systems Engineering
- Techno-economic Assessment
- Market Assessment
- Life Cycle Analysis

New Domains

- National Prospectus
- Supply Chain Network Model
- Justice40 Toolset

Existing Domains

- Inform R&D targets and project selection

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Thank you

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