Develop and test an integrated Acid Mine Drainage treatment and REE/CM extraction plant

USDOE Project DE FE00 31834

Project Leadership:

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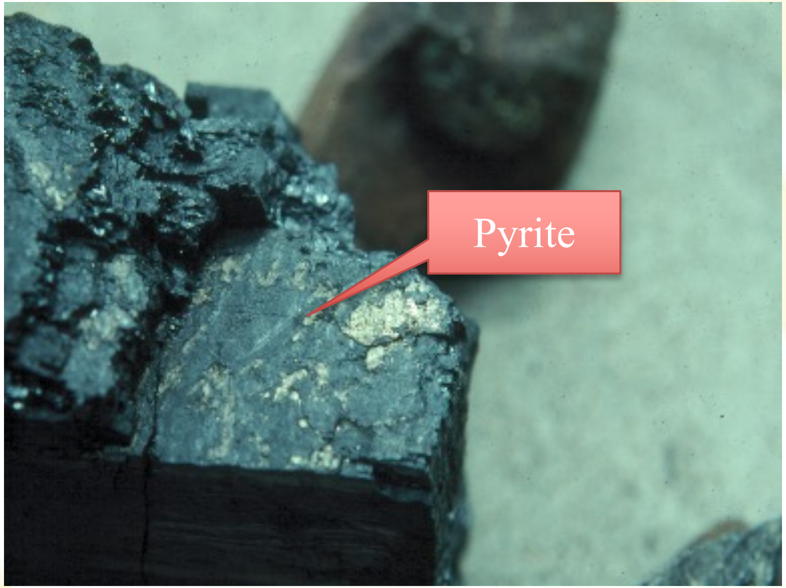
State:
WVDEP

Industry:
Rockwell Automation
TenCate Corporation
L3 Eng

ACID MINE DRAINAGE: AMD

1. H_2SO_4 leaches REE from shale
2. REEs precipitate with $Fe(OH)_3$

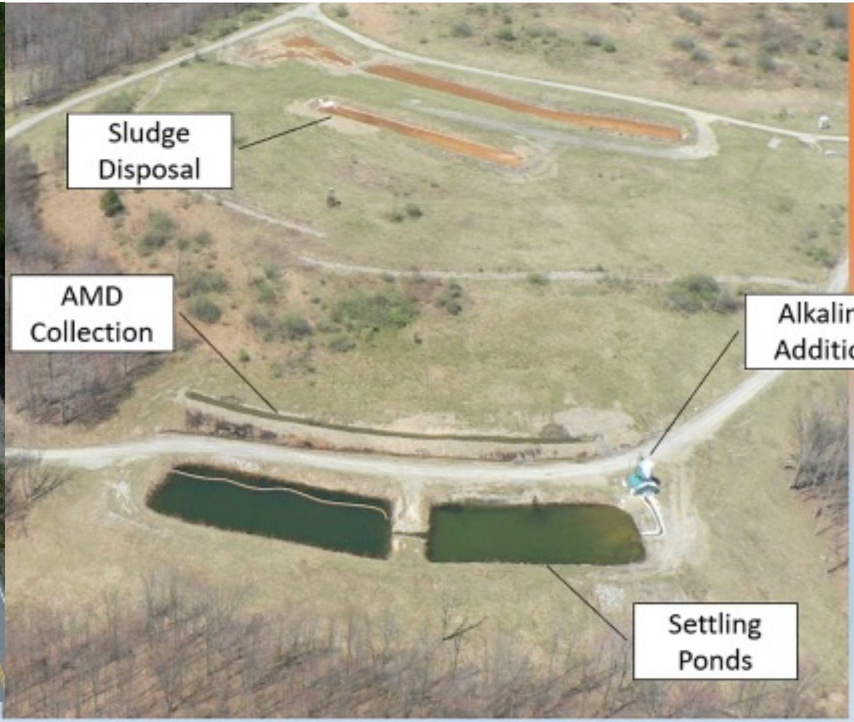
Pyrite + O_2 + H_2O = Fe^{2+} + H_2SO_4



$Fe^{2+} + O_2 + OH^- = Fe(OH)_3$

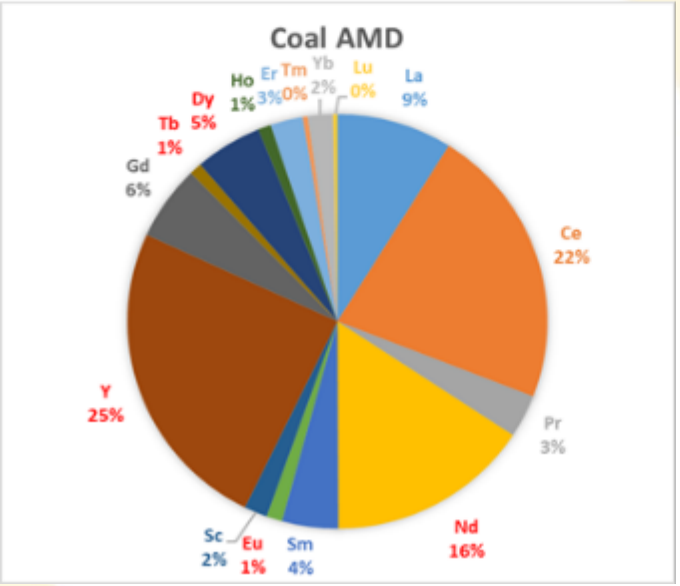
AMD treatment includes capture, neutralization and sludge management

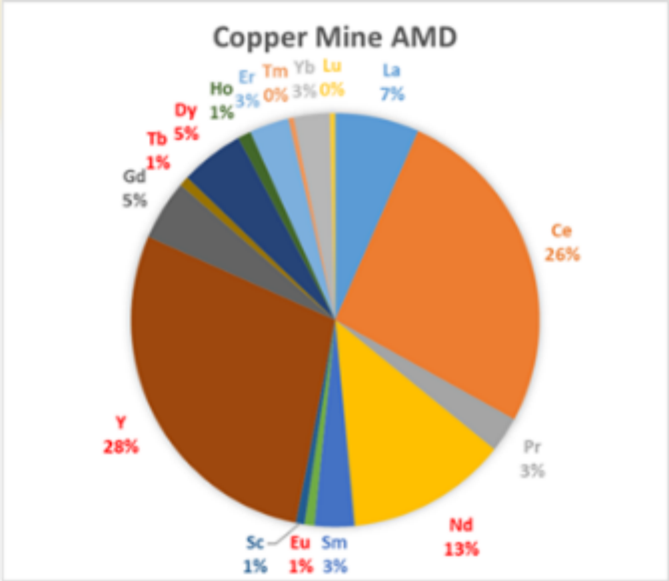
AMD TREATMENT SYSTEMS

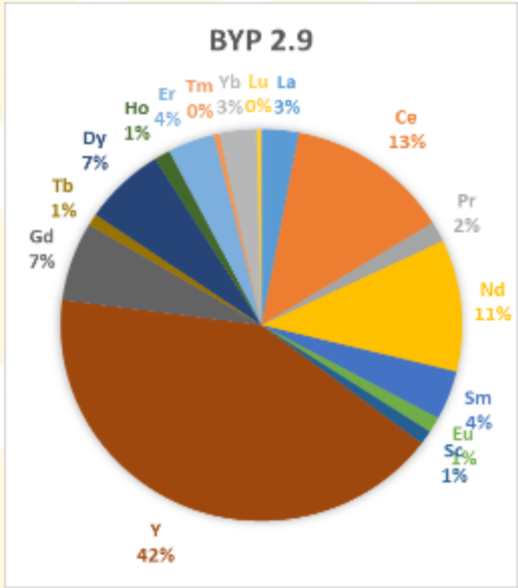


Passive vs. Active Acid Mine Drainage Treatment

Coal and Copper mine AMD samples have nearly identical REE distributions



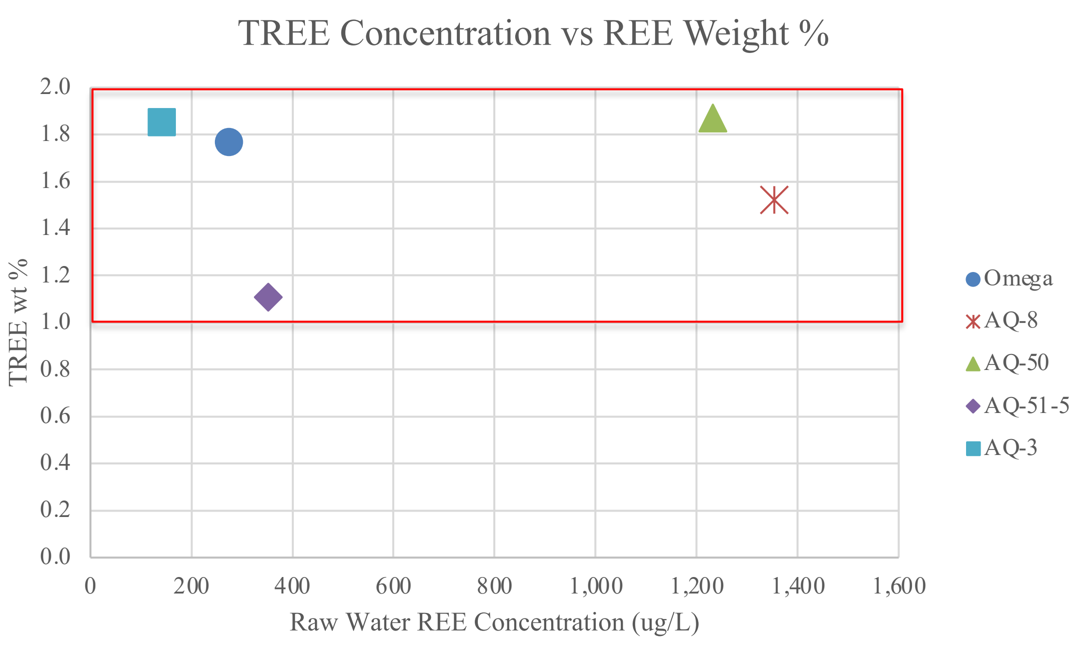




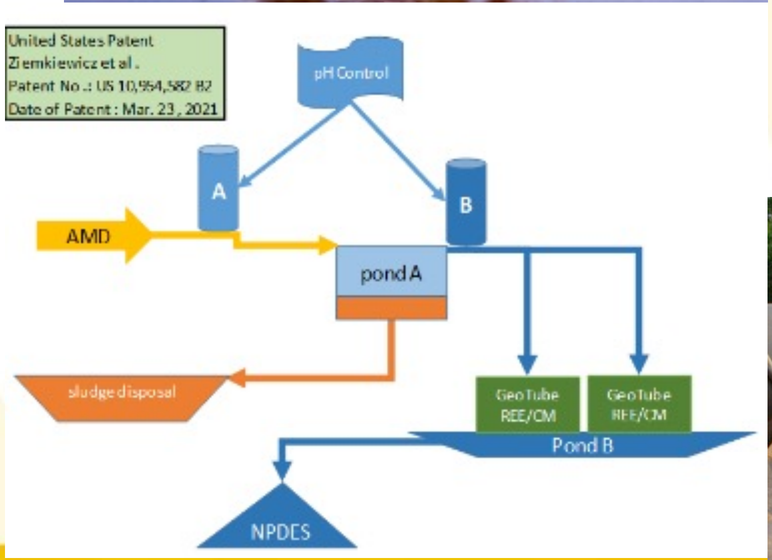
How Does Raw Water Quality Affect Grade?

Not at all:

Our process rejects most of the gangue then filters the residuals, resulting in a high degree of homogenization



AMD TREATMENT WITH REE/CM RECOVERY



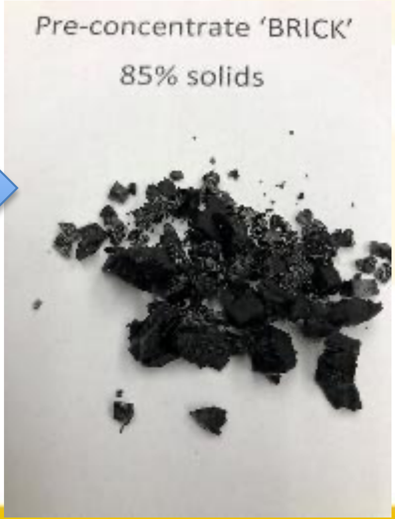
Process:

1. Generate pre-concentrate (brown floc)
2. Passively dewater to 85% solids (brick)
3. Transport to a central processing facility
4. Convert it to high-grade PLS (green), then MREO
5. Elemental oxide, reduction to metal

Pre-conc. TREE: 0.5%

0.1% solids

Brick TREE: 0.5-5.0%



Hi grade PLS

PLS TREE: 100-1,800 mg/L

MREO

MREO TREE: 90-99%

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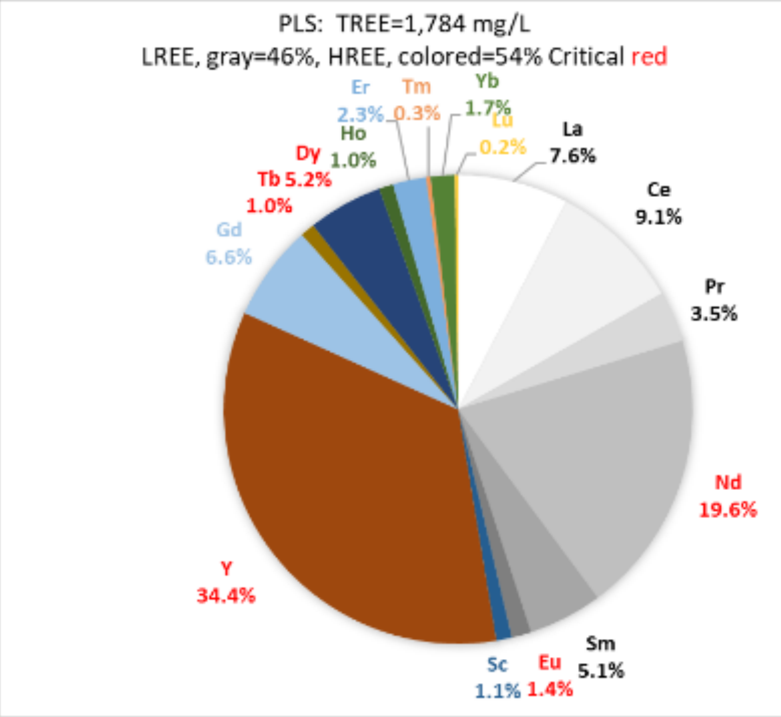
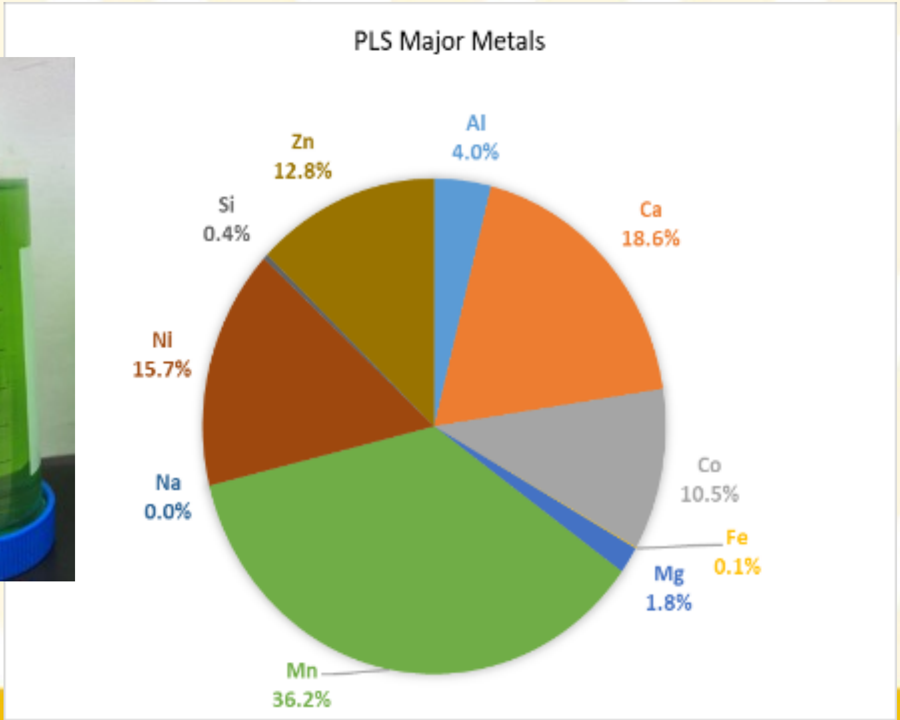
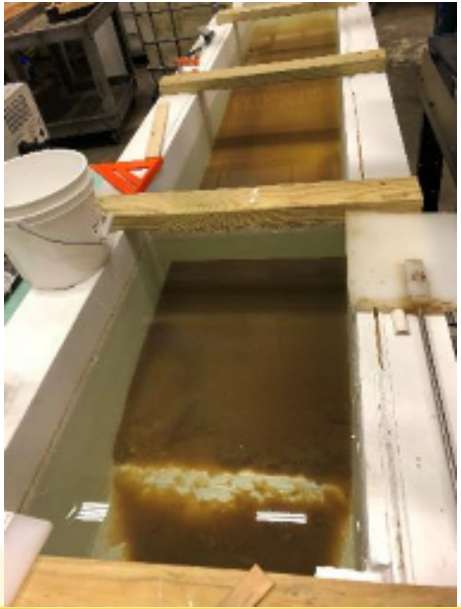
Recent PLS production: 1,784 mg TREE/L, 54% HREE almost no Al, Si



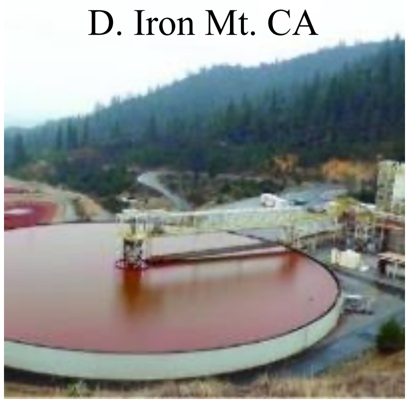


Project ETD67: Mt. Storm Pilot Plant

AMD treatment: Up to 1,000 gpm,
Production rate ~ 1 tpy each:
REE, Cobalt, Nickel.



Conceptual supply chain: Concentrates move to central processing facilities



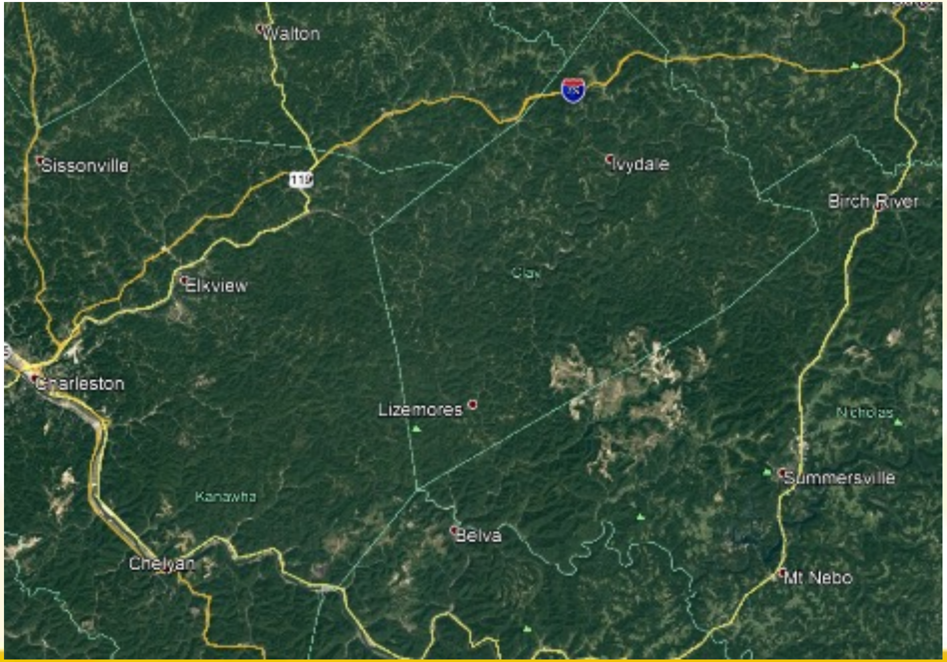
Potential source districts

A: Northern/Central APP
B: Southern APP/Illinois basin
C: Southern Rockies metal belt
D: Sierra metal belt
E: Northern Rockies metal belt
F: Minnesota iron range

Fola Site, Clay/Nicholas Co: 20 sq. miles, total property area

Big Branch Prep Plant site: 14 acres, Prep Plant Site

Dedicated rail to site 12 mi: Jct. w/N&S, CSX at Belva WV



Disadvantages of sourcing REE/CM from AMD

- Low concentrations
- Requires collection from many sites
- Need to manage upstream supply chain
- Quality control: moisture, grade

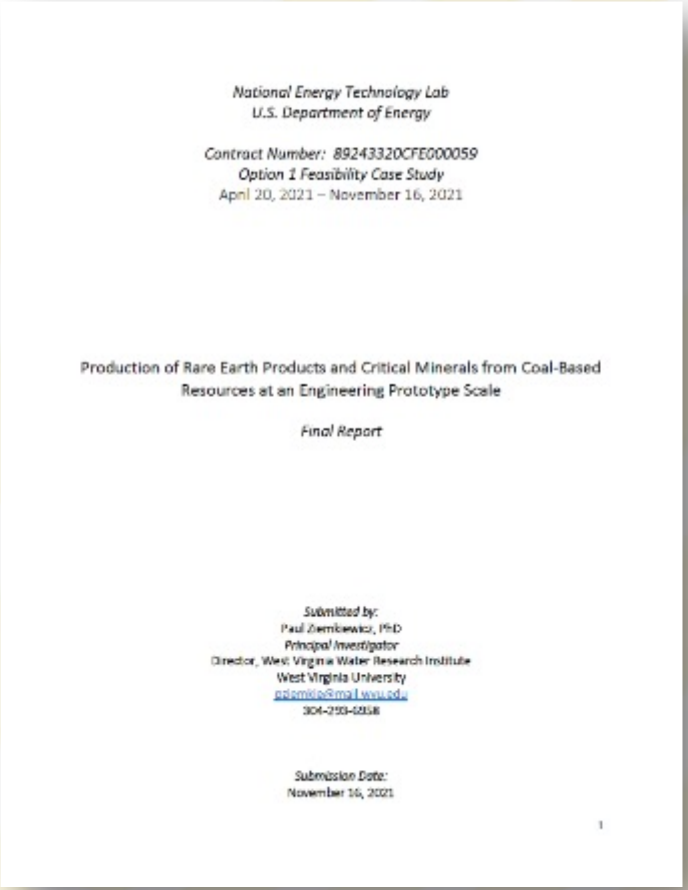
Advantages of sourcing REE/CM from AMD

- Already permitted sites, no delays due to permitting
- Easy to quantify yield, minimal exploration cost
- Environmentally beneficial, byproduct is clean water
- Solid wastes are RCRA subtitle D, non hazardous
- Distributes jobs and benefits across broad areas
- Incentivizes treatment of legacy AMD discharges
- Uniform feedstock, across mines and sectors
- Attractive economics
- No rads

Feasibility Study: FEL-2

<u>Key Components</u>

1. Resource estimate
2. Performance modeling/process engineering
3. Capital and operating cost estimate
4. Financial analysis
5. Risk analysis and technology gap analysis
6. Project execution plan
   – Interphase Test Work
   – FEL-3 Definitive Feasibility Study
   – Detailed Engineering
   – Project Execution


National Energy Technology Lab
U.S. Department of Energy

Contract Number: 89243320CFE000059
Option 1 Feasibility Case Study
April 20, 2021 – November 16, 2021

Production of Rare Earth Products and Critical Minerals from Coal-Based Resources at an Engineering Prototype Scale

Final Report

Submitted by:
Paul Ziemkiewicz, PhD
Principal Investigator
Director, West Virginia Water Research Institute
West Virginia University

Submission Date:
November 16, 2021

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Approach and Assumptions

- Techno-economic assessment was conducted to evaluate overall economic feasibility of the concept. Key components:
  - Revenue estimate
  - Capital cost estimate (Class IV, ±40%)
  - Operating cost estimate
  - Life cycle financial analysis
  - Sensitivity analysis
  - Monte Carlo simulation
- Results were recently published in a special edition of the *Minerals* journal.

West Virginia University

Approach and Assumptions

- Operational Configurations:
  - REO Facility
  - Complete Facility
  - REE, no Mischmetal
  - REE + Co, no Mischmetal
  - REE + Co + Mn, no Mischmetal
  - **CREE + Co + Mn, no Mischmetal**
- Price Scenarios
  - **September 2021 (feasibility study)**
  - December 2020 (conceptual study, NETL guidance)
  - Minimum 2014 – 2021
  - Maximum 2014 - 2021


minerals

MDPI

Article

A Fundamental Economic Assessment of Recovering Rare Earth Elements and Critical Minerals from Acid Mine Drainage Using a Network Sourcing Strategy

Keywords: techno-economic analysis; rare earth elements; acid mine drainage; solvent extraction; critical materials; cobalt; manganese

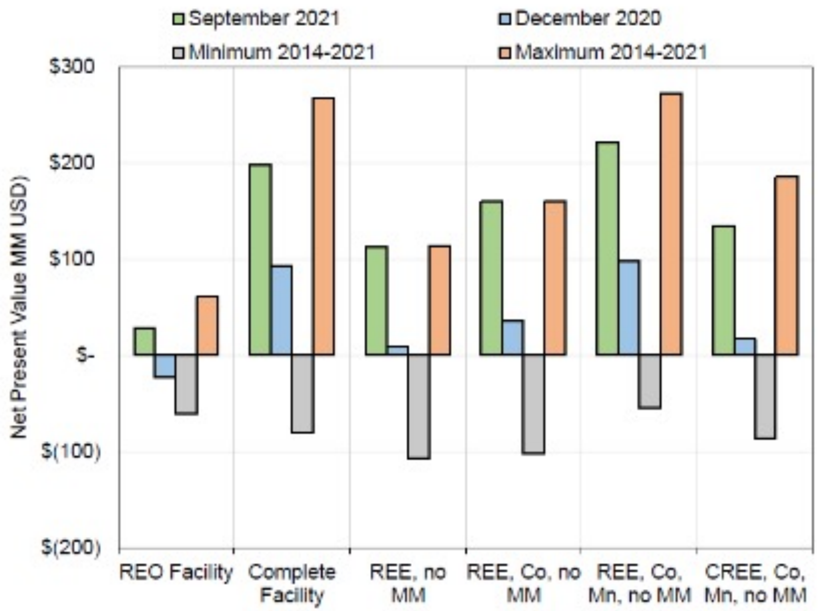
1. Introduction

Capital and Operating Cost Summary

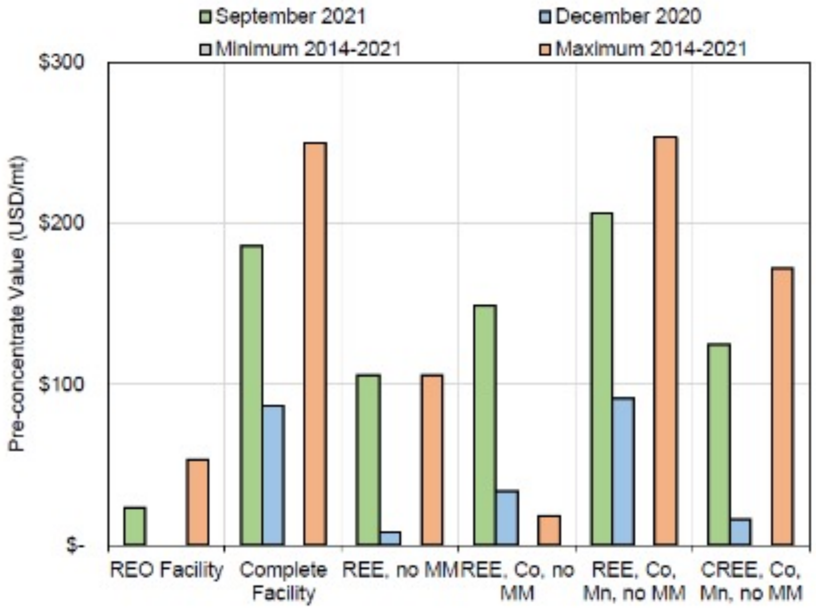
Revenues and Costs	Plant Configuration					
	REO Facility	Complete Facility	REE, no MM	REE + Co, no MM	REE + Co + Mn no MM	CREE + Co + Mn no MM
Revenues, Sept 2021 (MM USD)	$20.24	$70.46	$49.42	$58.59	$69.70	$56.58
Total Operating Cost (MM USD/year)	$14.62	$25.00	$21.14	$22.24	$24.41	$24.41
Capital Cost (MM USD)	$22.10	$185.81	$130.79	$148.60	$154.83	$142.20

Scenario Analysis Results

Net Present Value



PC Value at 10% ROR



Questions?

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