Recovery and Refining of Rare Earth Elements from Lignite Mine Wastes

NETL Resource Sustainability Meeting – April 3rd, 2024

Presenter: Nolan Theaker

Overview

- Project Team
- Technology Background
- Opportunity Highlights
- FEED Progress
- Technical and CBP Progress
- Remaining Work
- Disclaimers
- Questions

Project Team

Organization	Role/Competency
UND	Technology provider, process engineering, project management/coordination
Rare Earth Salts	REE/CM separations and metallization lead, host site and preliminary owner/operator
Microbeam Technologies, Inc.	Technology provider for mine waste feedstock analysis/sorting and Ge/Ga separations
Barr/McCarl's	FEED study lead, NEPA and permitting lead
WSP	Wastewater treatment/disposal lead, including NEPA and permitting
North American Coal	Host site provider (Falkirk Mine)
Rainbow Energy	Host site provider (Coal Creek Station)
BNI Coal	Host site provider (Center Mine)
Minnkota	Host site provider (Milton R. Young Station)
AmeriCarbon	Potential owner of the ND REE concentrate plants & offtake for REE-extracted lignite mine waste byproduct
Envergex LLC	Greenhouse gas lifecycle analysis and process modeling
Dennis James Consulting	Technical consultant - mining
MLJ Consulting	Commercial consultant
Odney	Community Benefits Plan development and implementation consultant
U.S. DOE / NDIC	Project sponsors: DOE $8M; NDIC $2M

Also on the Team – North Dakota

- Legislative and Governmental Support
  - Strong interest in removing barriers for growth
  - State loan and grant programs
  - 57-39.2-04.21 – Tax Exemptions
- Industrial Support
  - Essentially the entire lignite industry – mines and power
  - Long-term commitments to lignite power plants - CCUS
- Community Support
  - REE/CM improves long-term sustainability of the industry, jobs and economic impact

Technology Background

REE in Lignite

- REEs found typically bound in the organic form, somewhat in minerals
  - Higher in value than standard LREE-concentrated mineral forms, lower than the weathered clays
- As per NDGS findings, weathering from paleosols a likely concentration mechanism

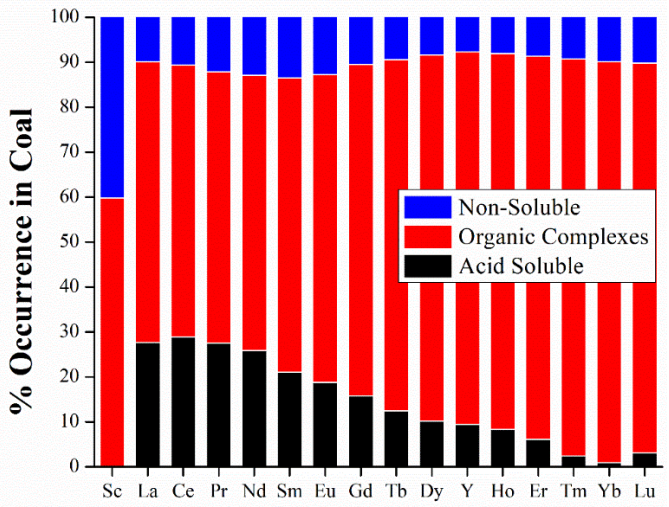

Image credit: CEMRI Data

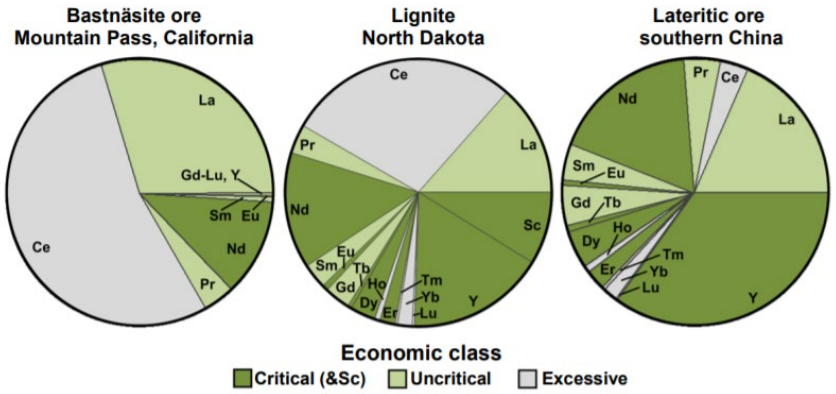

Image credit: ND Geologic Survey

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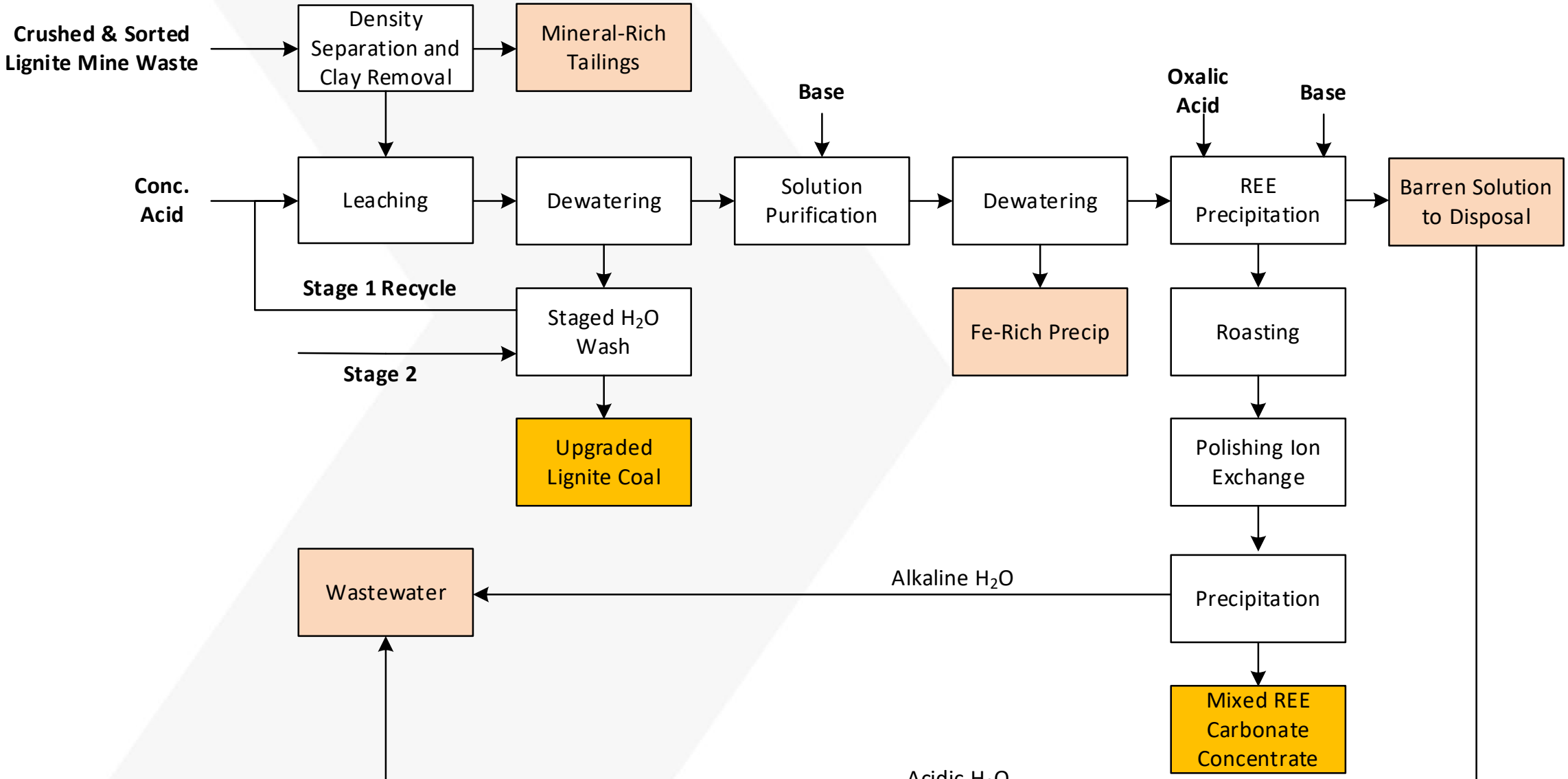
Flow Diagram of UND's Mixed Rare Earth Concentrate (MREC) Process



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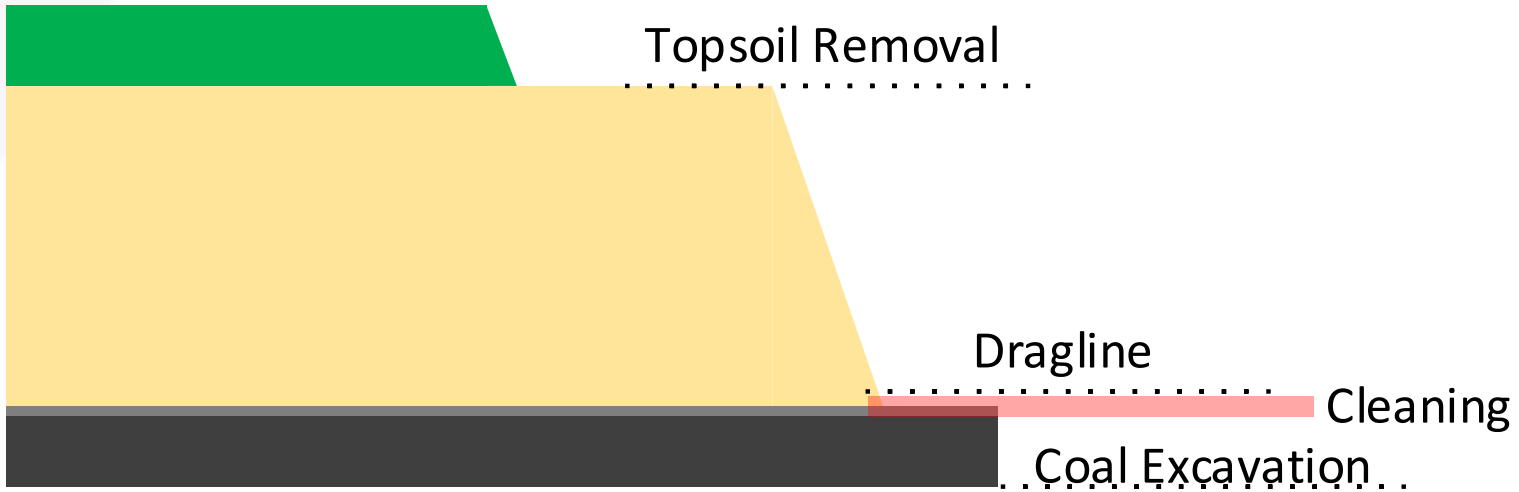
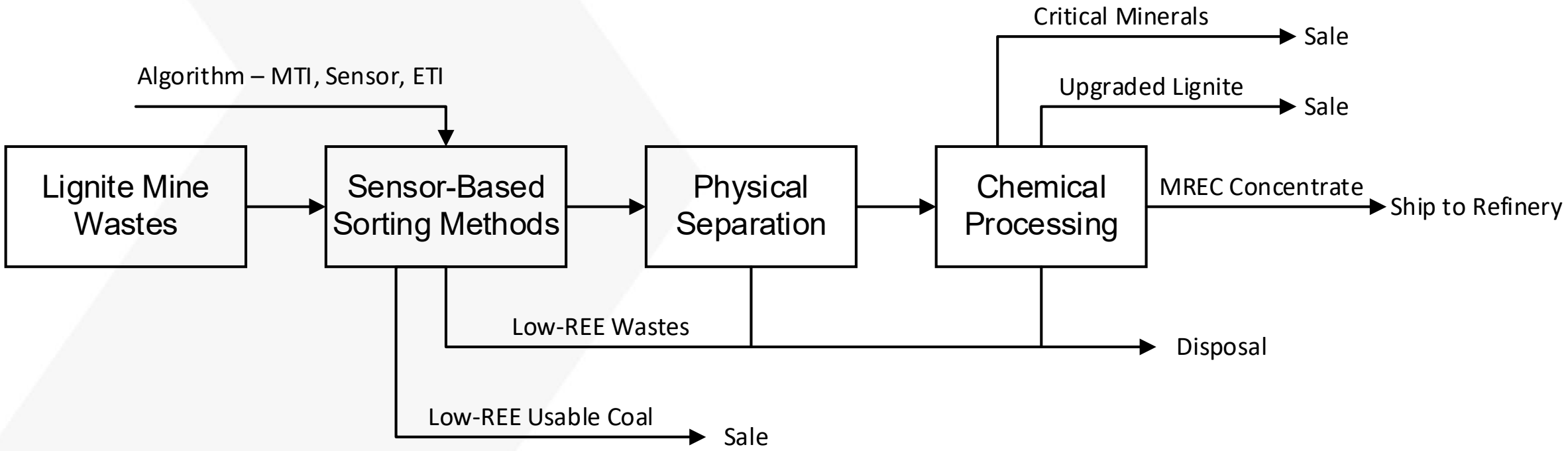
Lignite Mining – Mine Cleanings

- During mining of lignite, the dragline mining bench doesn't mine completely to the coal layer – avoiding losses
  - Thin section of overburden mixed with a thin section of coal – the topmost material, is removed separately and wasted
  - Coal is typically has higher ash – less suitable for combustion purposes in-ground



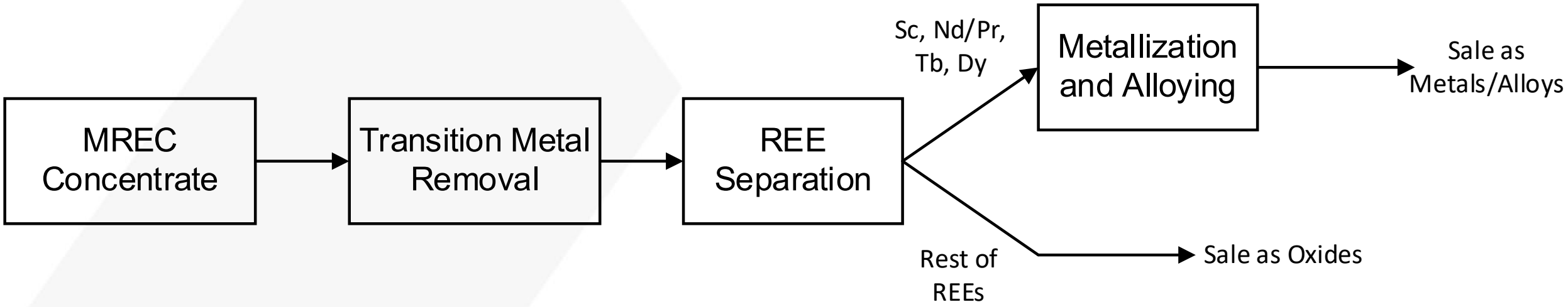
Overall Technology Concept

- Two plant sites to make minimum of 1 MTPD – use best resources of both



Overall Technology Concept (cont.)

- All REE/CM products have interested parties in the quantities projected



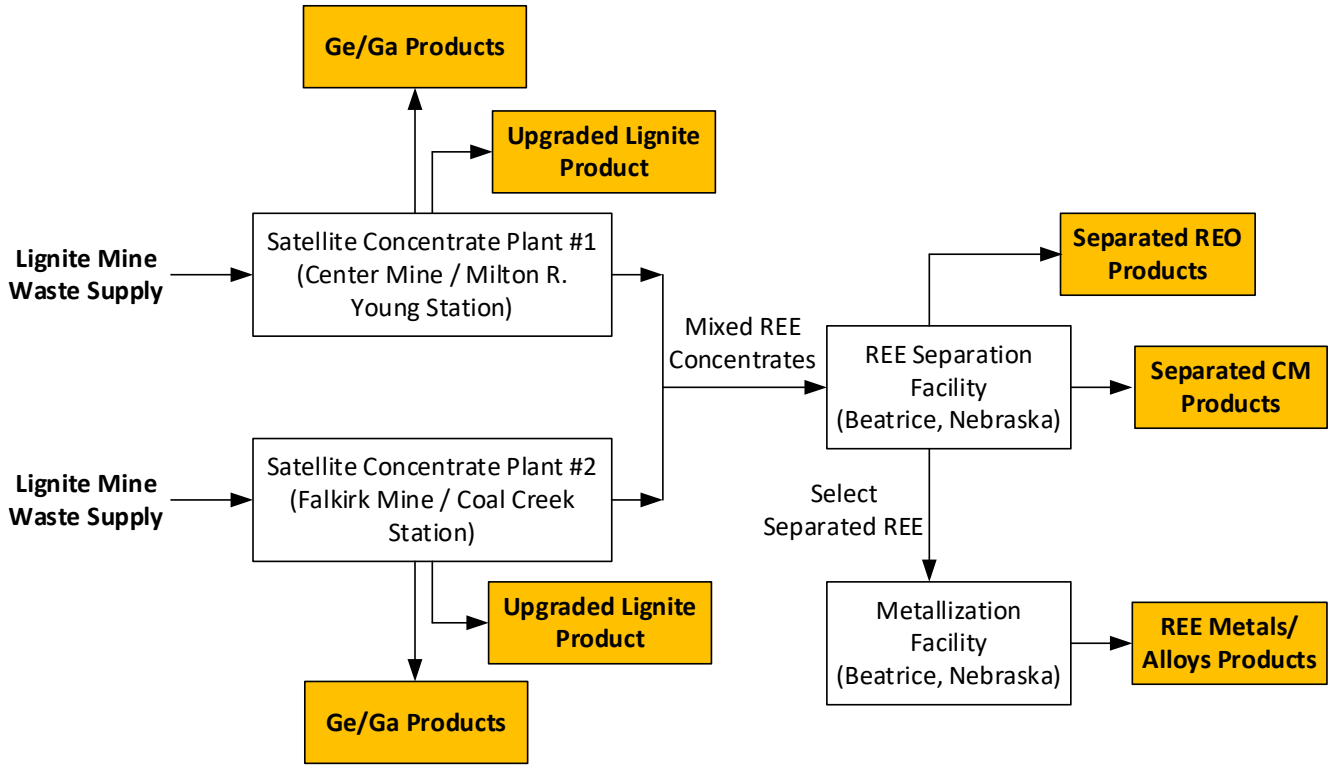
Upgraded Lignite Market Options

- Upgrading process – stripping out organic-bound ions
  - Overall coal ash does not significantly change, BUT
  - Organic-based ash drastically reduced
- Fuel Effects
  - Na essentially eliminated (>90% is organic bound)
- Carbon product feedstocks
  - Organic framework is highly purified, and highly functionalized
    - Functionalization allows for strengthened bonding, purity allows for high-purity applications (graphite)

Project Background

Project Structure & Objectives

1. Quantify project jobs and workforce needs and address
2. Ensure project provides meaningful benefits to surrounding communities, including stakeholder engagement
3. Develop all requisite permit applications and receive NEPA approval
4. Develop AACE Class 3 FEED study for a concentrate, refining, and metallization facility
5. Perform limited R&D to de-risk certain technology subsystems
6. Develop business plan and secure Phase 2 financing



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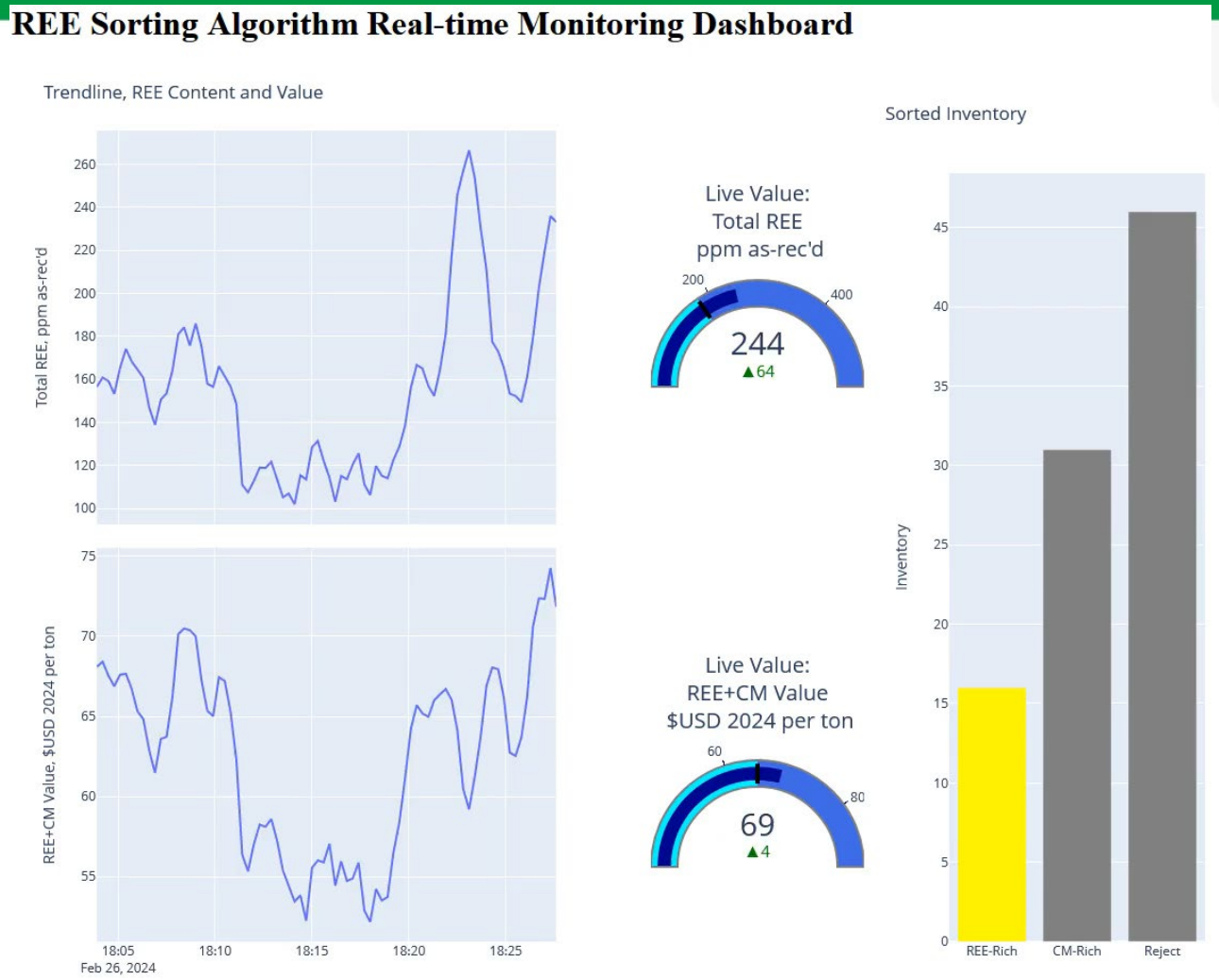
Scope of Work

- Task 1: Project Management and Planning
- Task 2: Community Benefits Plan
- Task 3: NEPA Requirements
- Task 4: Permits for Construction and Operation
- Task 5: AACE Class 3 FEED Study
- Task 6: Circuit De-Risking Research
  - 4 Subtasks – Ore sorting, wastewater management, piloting feedstocks, metals cell development
- Task 7: Financing and Business Plan Development and Implementation

Technical and CBP Progress

REE On-Line Sorting and Analysis

- Field Test performed to de-risk REE sorting algorithm
- Demonstrated REE measurement and sorting system on online (moving-belt) coal data using MTI's neural network to predict and sort REE+CM
- Algorithm sorts incoming coal into REE-rich, CM-Rich, and Reject streams
- Validation of predicted vs. actual REE+CM is in progress



Overburden Separation from REE-Rich Lignite

- Samples taken from both Falkirk Mine (Underwood, ND) and Center Mine (Center, ND) analyzed for washability and clay separation
  - Preliminary data shows ~30-40% clay in existing cleanings streams, 60-70% lignites
  - Streams of >90% clay materials can be produced using blade mills and other size-based classification
    - Reduces load on physical separation tails handling
    - Detailed physical separation testing by vendors underway for performance guidelines
- Tailings produced non-hazardous, although wet clays

Remaining Items

- Piloting of Feedstocks
  - Current piloting schedule using lignite mine cleanings as feedstock, process able to handle residual clay materials easily
  - Specific piloting of Underwood & Center feedstocks planned for April/May (pending weather, pilot availability)

- Low-cost, environmentally-friendly metallization testing underway, with focused goals on Nd/Pr alloy (and direct master alloys) and Sc metals

Community Benefits Plan Progress

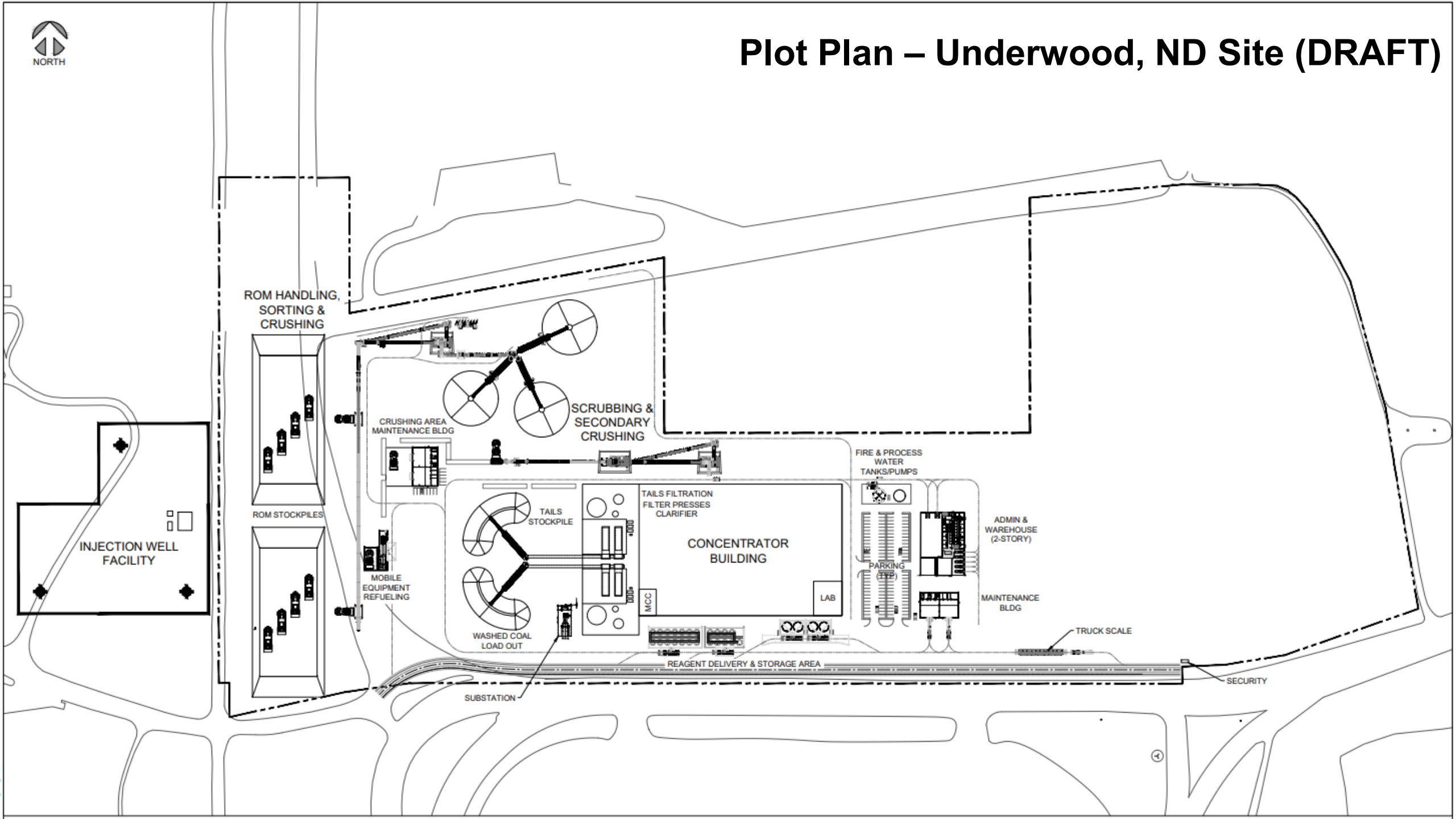
- Identified and have met/planned to meet with key community stakeholders in all affected communities (including outside of host site areas).
  - Some economic development opportunities and initiatives underway for recruitment, housing, and training of requisite workforce
  - Outreach activities planned including in-person, mail, print, radio, and web-based engagement strategies with rural, economically distressed communities surrounding sites
- Engagement with ND Building and Trades Unions for defining roles in project deployment

FEED Progress

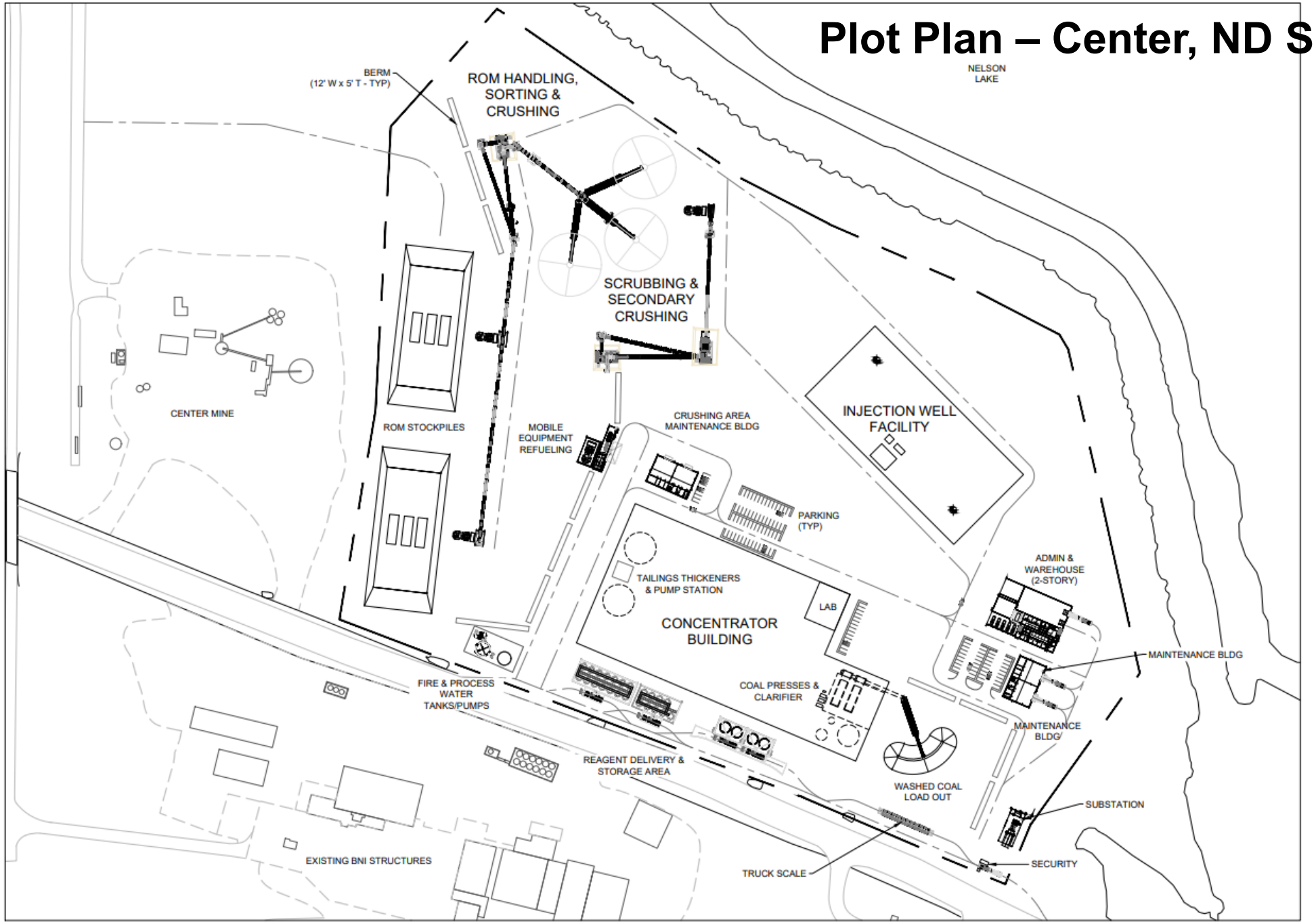
FEED Progress (By Discipline)

- Process Engineering – 90% complete
  - Flowsheets identified and fixed, P&IDs for all three facilities (Center & Underwood, ND; Beatrice, NE) near-complete
- Mechanical - >50% complete
  - Equipment identified and largely scoped pending OEM guidelines and specs
  - Includes layouts (drafts to be shown next of ND sites)
- Electrical – Underway with Equipment finalization occurring
- Civil, Structural initiated now layouts and plot plans are being finalized
- Costing to occur at end of FEED analysis

Plot Plan – Underwood, ND Site (DRAFT)



Plot Plan – Center, ND Site (DRAFT)



Planned Phase 2 Production

Element	Form	Minimum Purity	Annual Production
Didinium (Nd/Pr)	Alloy ingot	99.5%	57.8 tonnes
Terbium	Metal ingot	99.9%	2.9 tonnes
Dysprosium	Metal ingot	99.9%	11.6 tonnes
Scandium	Metal Ingot	99.9%	12.4 tonnes
Other REEs	Oxides	Variable	83.2 tonnes
Germanium Conc.	Oxide	99.9%	24.1 tonnes
Gallium Conc.	Oxide	99.9%	18.2 tonnes
Cobalt Concentrate	Oxide	98%	26.7 tonnes

Remaining Work

Environmental

- Permits for ND

Agency	Permit/Authorization
U.S. Army Corps of Engineers	Section 404 Authorization (Nationwide Permit)
ND DEQ	Section 401 Water Quality Certification (issued for Nationwide Permit)
ND DEQ	Air Quality Permit to Construct
ND DEQ	Construction Stormwater General NDPES Permit (NDR11-0000)
ND DEQ	Industrial Stormwater General Permit (NDR05-0000)
ND Department of Water Resources	Water Appropriation Permit
ND DEQ	Class I (Underground Injection Control Program) Injection
U.S. EPA	Aquifer Exemption Request & Approval for Class I injection

- Pursuing Class 1 injection wells sites for ND sites
- Pursuing Environmental Assessment through NEPA

FEED

- Remaining Engineering work
  - Mechanical – equipment design and piping
  - Electrical – equipment needs, electrical intake locations
  - Civil/Structural – building and pad sizing, flood-plain considerations

- Capital and Operating cost estimates
  - Projected for planned feedstock quality over life of project

Business and Financing Plans

- Developing a project pro-forma based on projected costs and revenues
  - Including valuing coal and carbon products feedstock within sphere of plant
  - Anticipated time to first sale from construction (including finalization of off-take agreements and production quotas
- Business structure – ownership and operation
  - Planned companies for IP ownership and licensing, project development
- Intake/Offtake agreements

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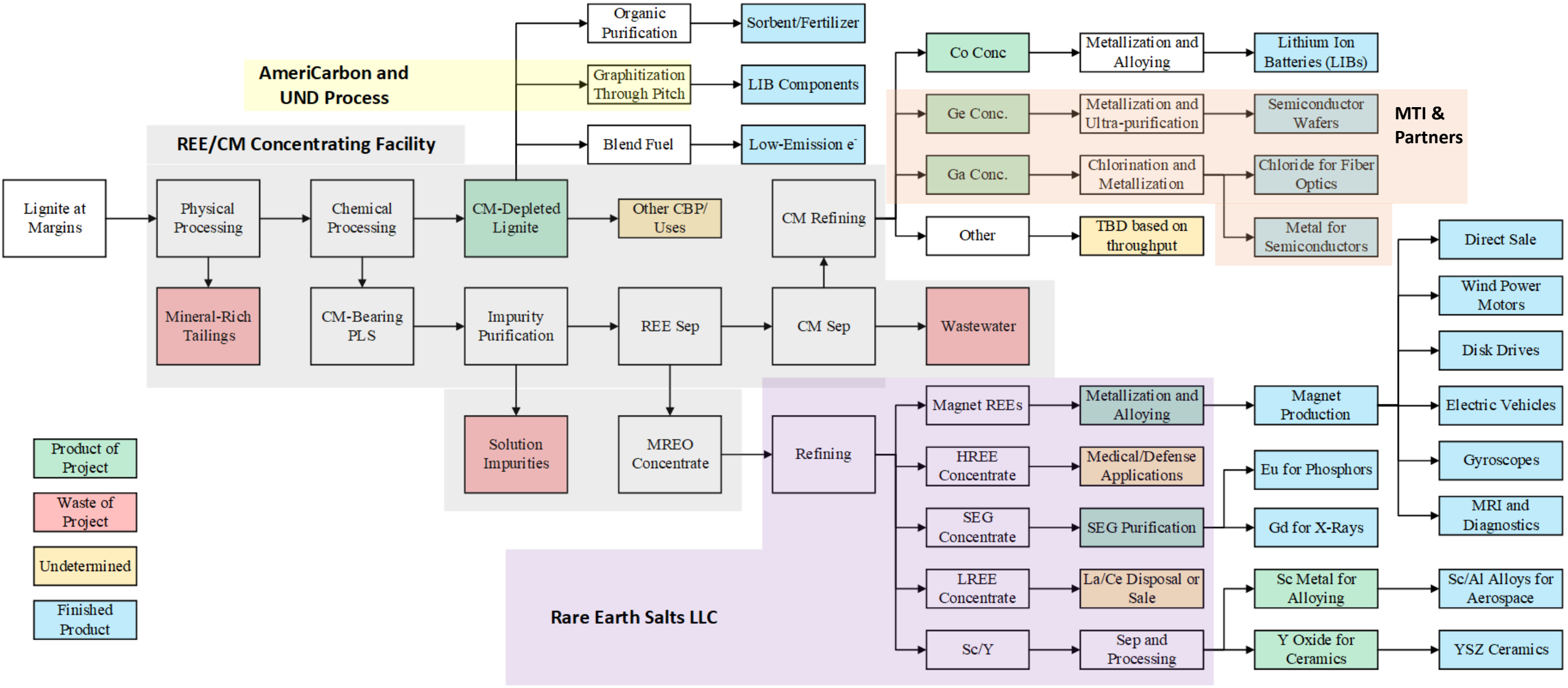
The opportunity if all comes together



Q&A

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