Resource Assessment of Industrial Wastes for CO_2 Mineralization

FECM 23 (08/29/2023)

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PI: Dr. Johannes van der Watt (University of North Dakota)

Project Manager: Johnathan Moore

UNIVERSITY OF NORTH DAKOTA

COLLEGE OF ENGINEERING & MINES

PROJECT PARTICIPANTS

University of North Dakota

- Energy and Minerals Innovation Center (EMIC)
- Dept. of Civil Engineering
- Dept. of Geography
- Dept. of Chemical Engineering

Envergex, LLC (Sub-awardee)

Industry Supporters – Residue Providers

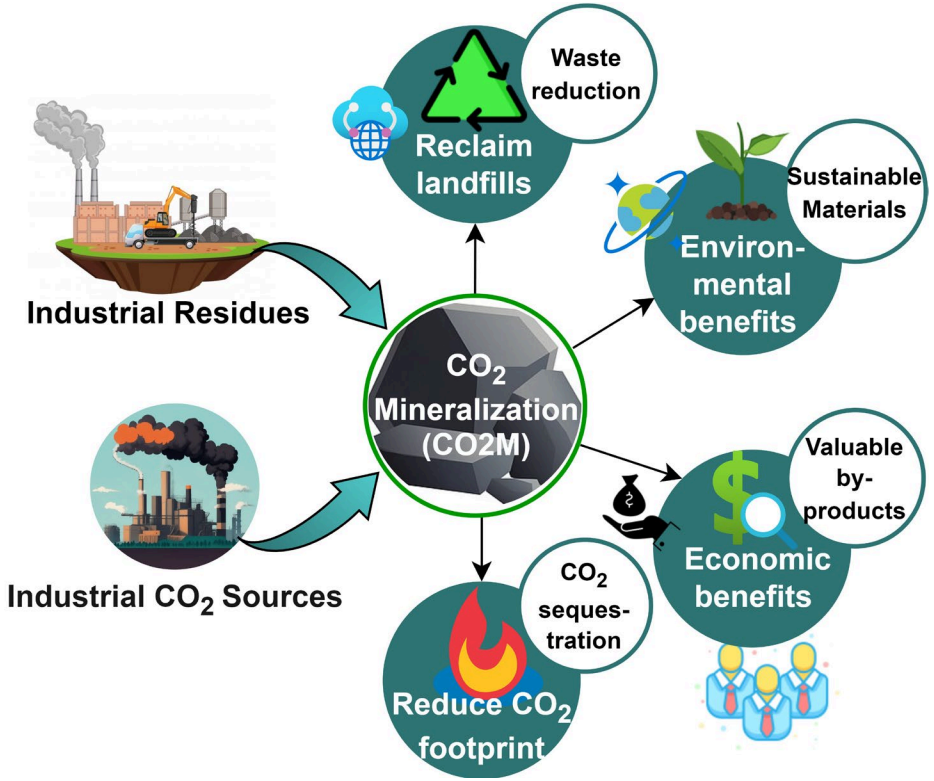
PROJECT SUMMARY

Opportunity: Industrial residues often underutilized – potential for use other than disposal

Goal: Use residues to capture CO_2 – beneficially alter composition for value-added secondary use

Solution approach:

- Identify industrial residues with carbonation potential
- Characterize chemical and physical properties
- Test CO_2 Mineralization
- Assess benefits of treatment
- Quantify environmental/economic performance

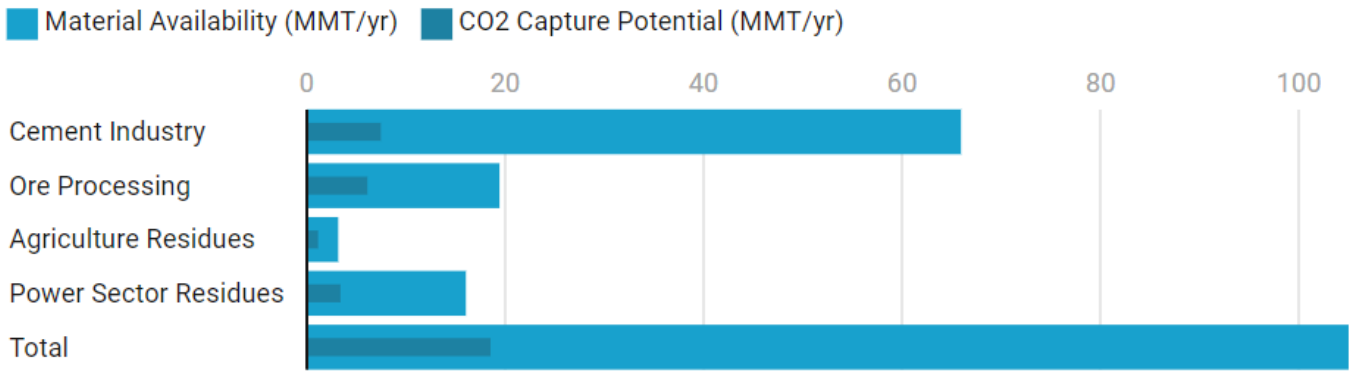


BACKGROUND

Enabling CO_2 Mineralization using Industrial Residues

- **CO_2 Mineralization Potential**
  - No single resource available for DOE's 20 MMT CO_2 capture goal
  - Industrial residues = Potential reactive minerals
  - Can reduce residues & liabilities
  - Enhancing material value
  - Enhance commercial potential

U.S. industrial residue production and CO_2 mineralization potential



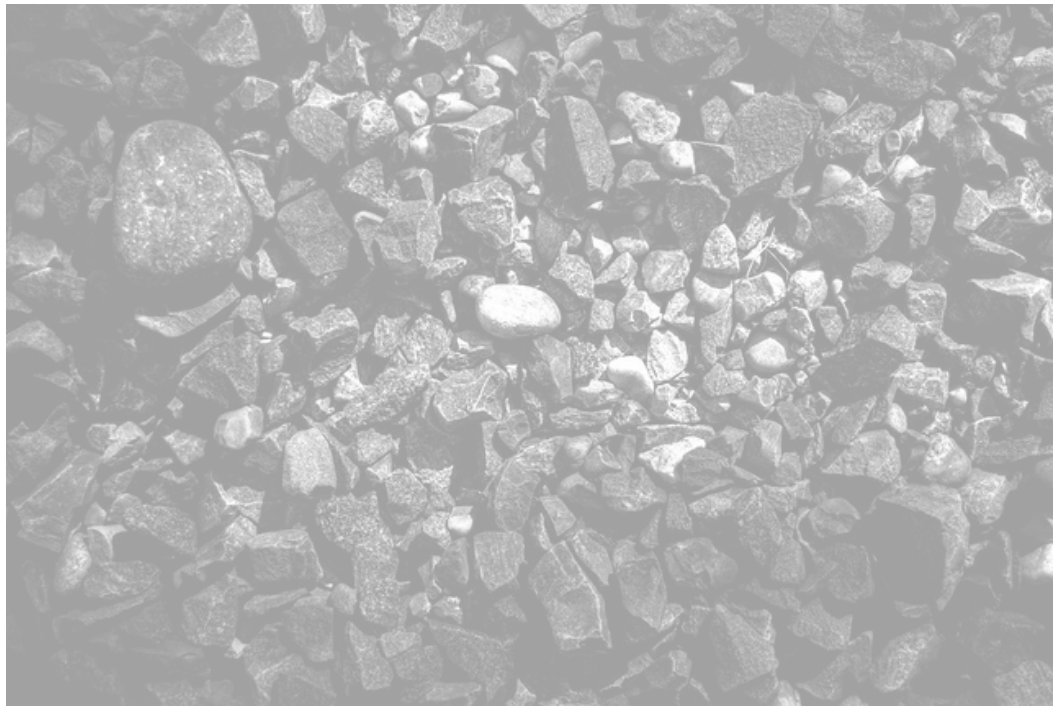
BACKGROUND

Heterogeneity Challenge

- Variability in properties, locations, & availability of residues
- Necessitates database & assessment tool/benchmark
- No two processes alike

Industry Needs

- Guidelines for CO_2 mineralization technologies
- R&D tools



PROJECT OBJECTIVES

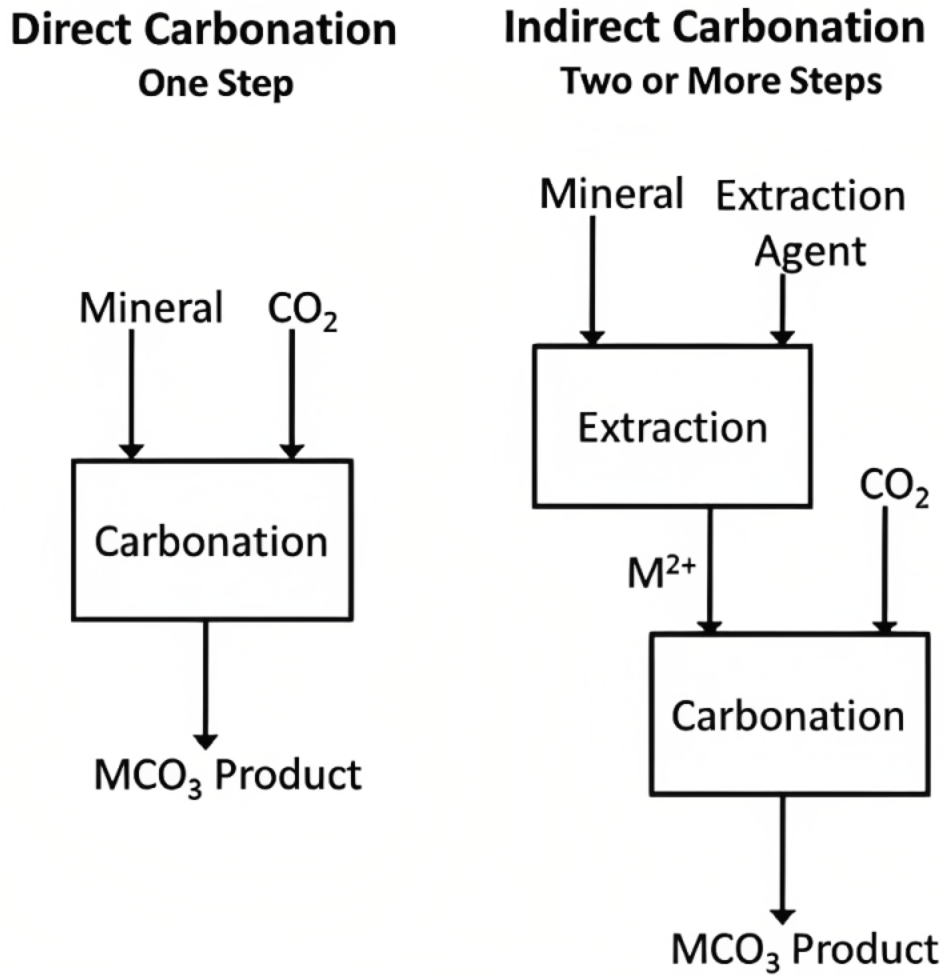
Identify & quantify usable resources for CO_2 capture

- Map resource locations
- Develop CO_2 Mineralization (CO2M) processes
- Tap into existing infrastructure (CO_2 resources)
- Beneficiate residues (identify users)
- Quantify process viability environmental & economic benefits/disadvantages

TECHNICAL APPROACH

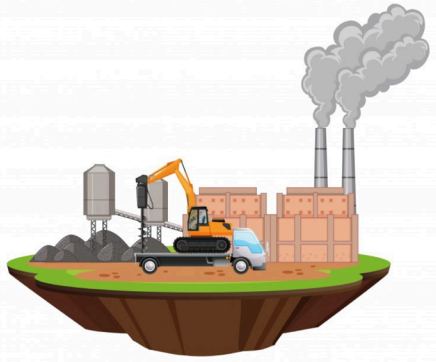
CO_2 Mineralization (CO2M)

- E.g. Wollastonite reaction with CO_2:
- $CaSiO_3 + CO_2 = CaCO_3 + SiO_2$
- Carbonation advantage: Captured CO_2 does not require deep geologic disposal
- Nature's example: Weathering reactions
- But, kinetic & mass transfer limitations
- Processes impractical for ex-situ point-source capture
- Key approach: Proprietary enhancement – orders of magnitude improvement



TECHNICAL APPROACH

- Reiterative approach
  - Collect,
  - Characterize
  - Test
  - Characterize
  - Refine
- Select promising routes
- Evaluate feasibility

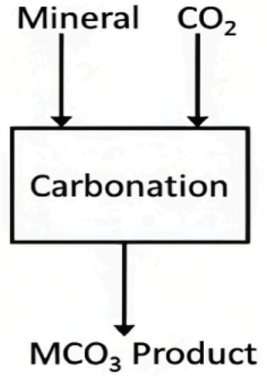


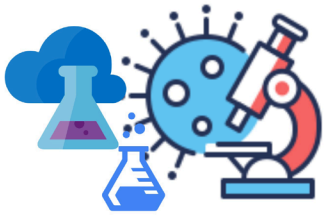
Residue procurement

Residue Characterization

- Compositional analysis
- XRF
- XRD
- ICP-MS
- PSD

Industrial residues





Lab-scale testing

Direct mineralization testing

- **LCA and TEA for CO2 Mineralization**
- **GIS Model**
- **Processing schemes**
- **Process Flow Diagrams**

Mineralization Assessment Tool Development

Product Characterization

- Compositional analysis
- XRF
- XRD
- ICP-MS
- PSD

Product testing

- Cement replacement
- ASTM testing standards

Mineralized Product Characterization and Evaluation

PROJECT STRUCTURE

Task 1.0 - Project Management and Planning

- Project management plan (PMP)
- Community benefits plan (CBP)

Task 2.0 - Characterization of Industrial Residues

- Subtask 2.1 - Residue Procurement
- Subtask 2.2 - Residue Characterization
  - Compositional analysis: Ash, Moisture, LOI, and pH
  - Elemental analysis
  - Mineralogy
  - Particle Size Distribution
  - Grindability

Industrial residues

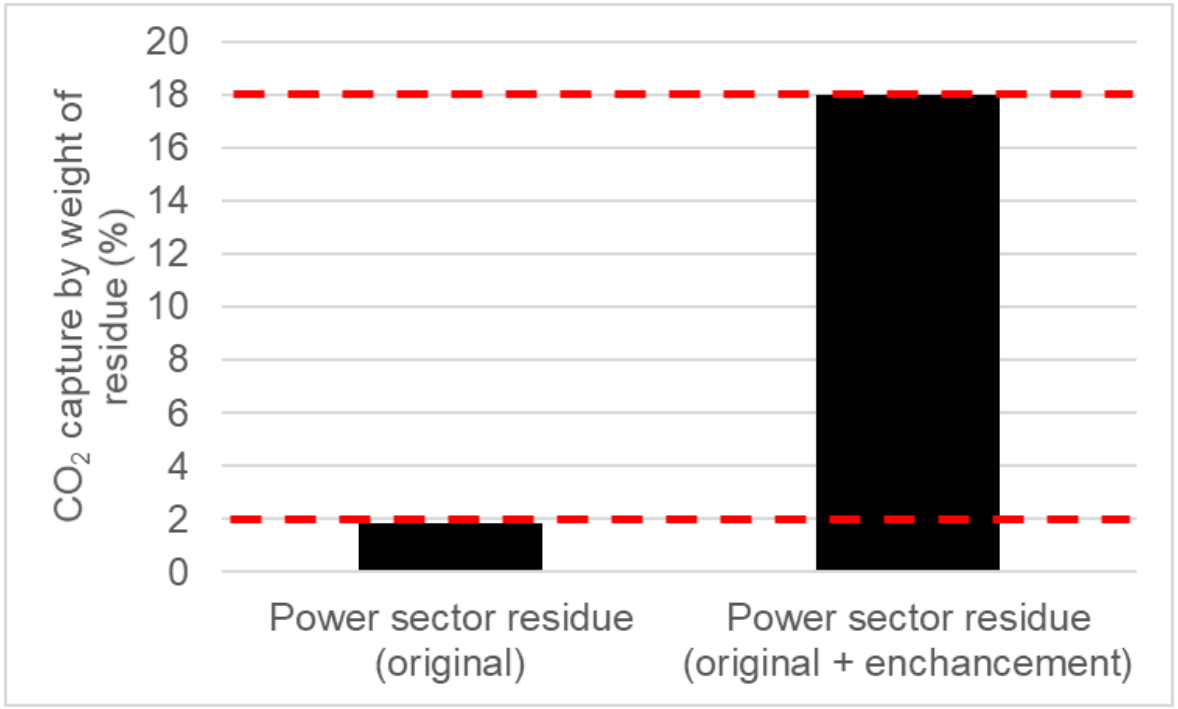
PROJECT STRUCTURE

Task 3.0 - Ex-situ Direct Mineralization Testing

- Lab scale: Semi-batch testing
- CO_2 uptake
- Theoretical vs actual carbonation
- Parametric study

Mineralization example

- Example: Power sector residues
- Enhancement changes performance
- High carbonation potential



Power Sector Residue Mineralization

PROJECT STRUCTURE

Task 4.0 - Mineralized Product Characterization and Evaluation

- Subtask 4.1 - Product Characterization
  - Compositional analysis: Ash, Moisture, LOI & pH
  - Mineralogy & Microstructure
  - Leachability (landfilled material – better/worse)

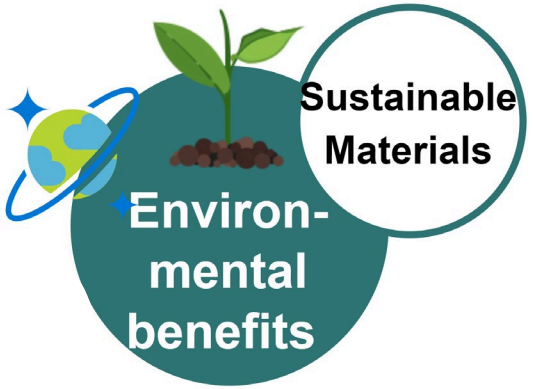
- Subtask 4.2 - Product Performance Testing
  - E.g., ASTM C618 and ASTM C989 standard specification
  - Perform screening analyses
  - E.g., aggregate/cement replacement

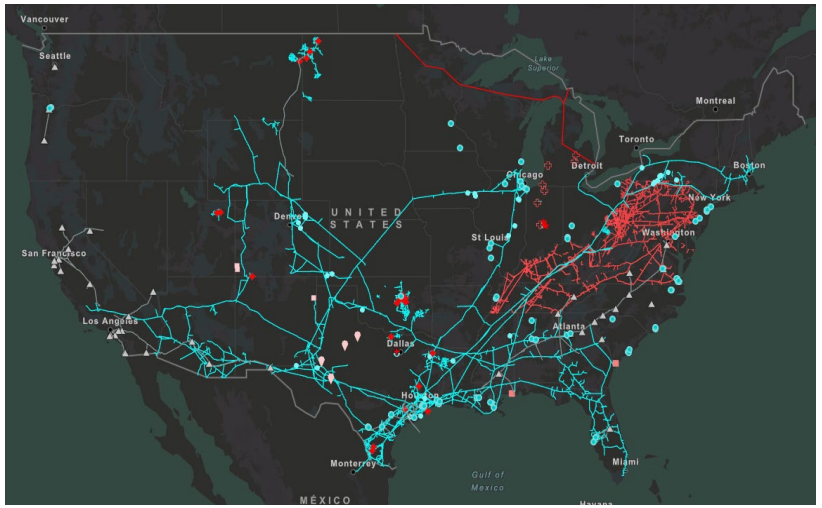
PROJECT STRUCTURE

Task 5.0 - Mineralization Assessment Tool Development

- Subtask 5.1 – Lifecycle Assessment for CO_2 Mineralization
  - LCA will follow ISO 14040-14044
  - SimaPro 9.1 software

- Subtask 5.2 – Geographical Information System (GIS) Model
  - Model will be designed using GIS software package ArcGIS Pro

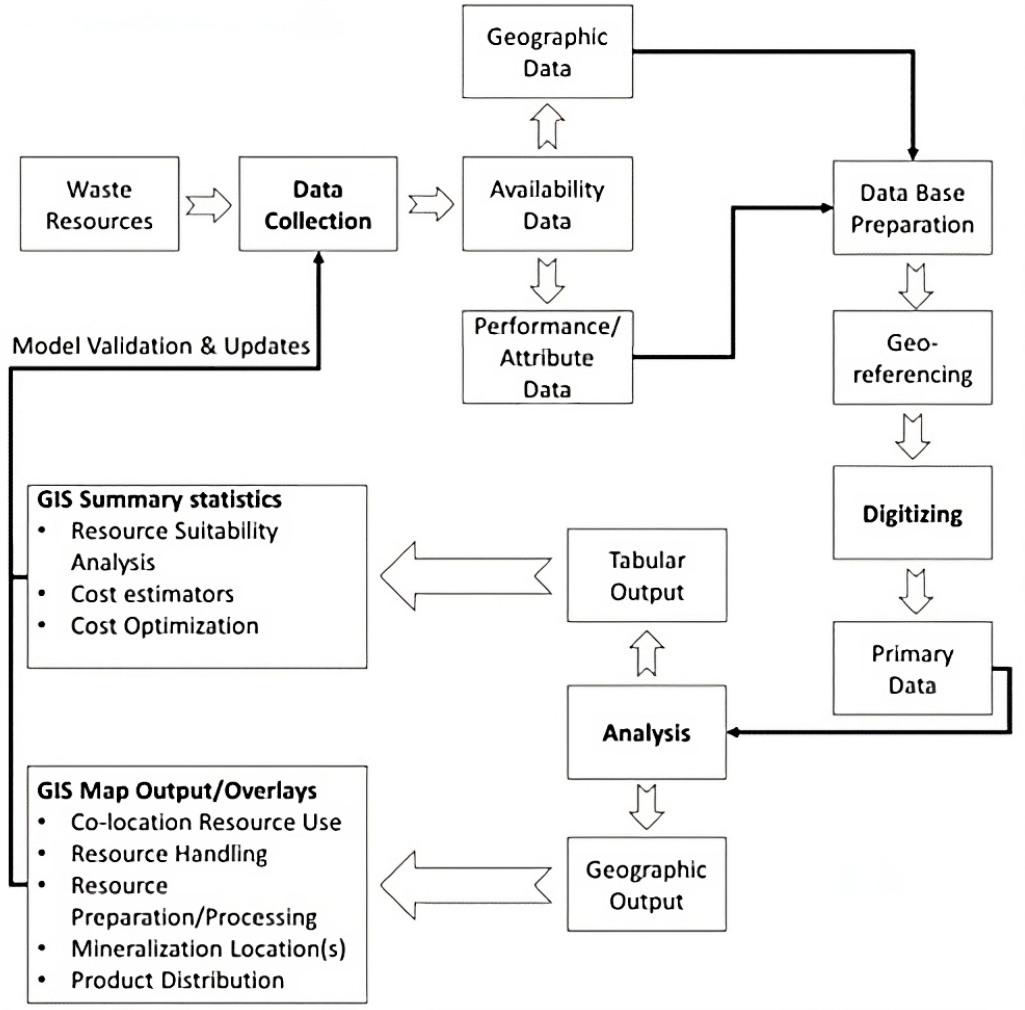




PROJECT STRUCTURE

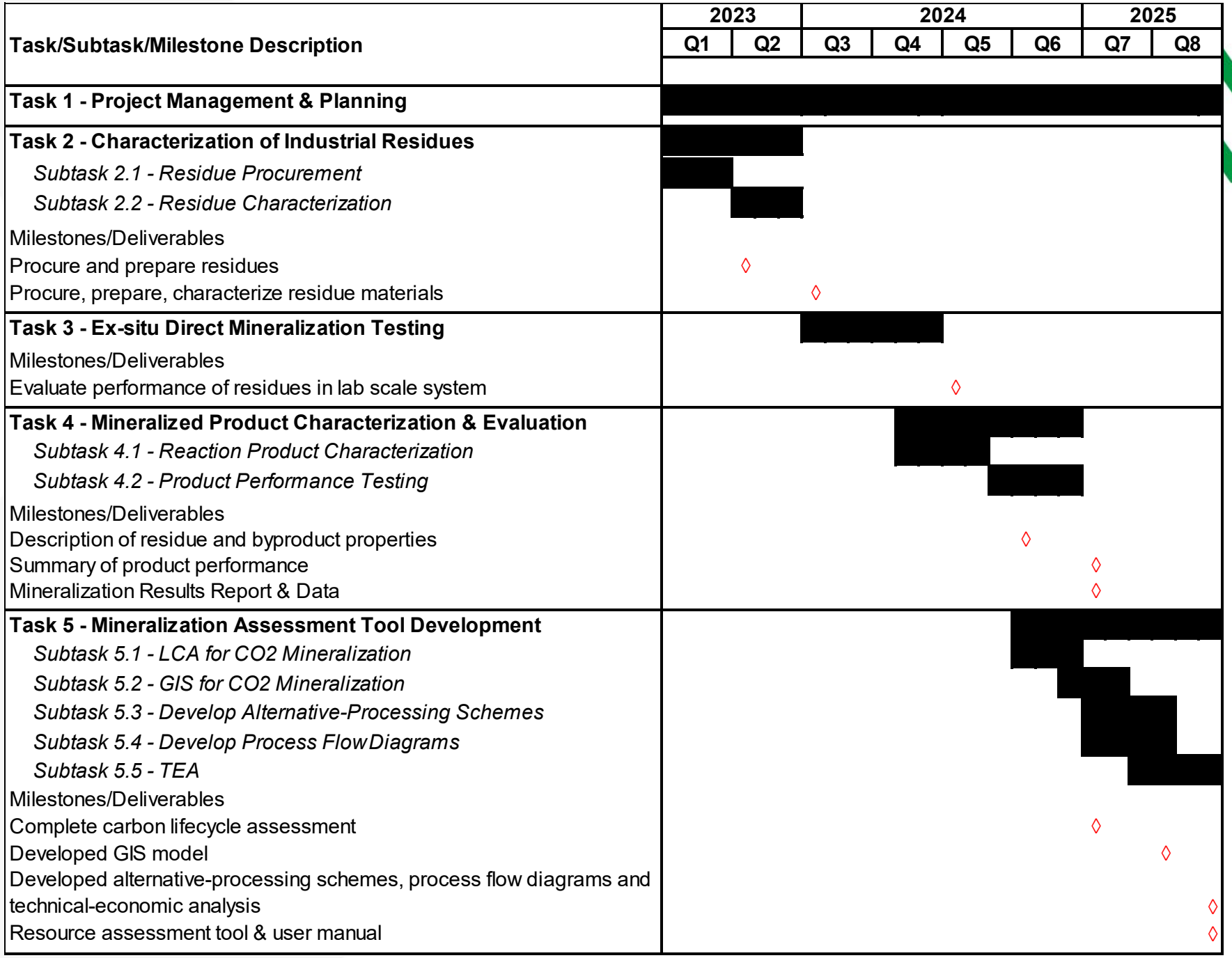
Task 5.0 - Mineralization Assessment Tool Development

- Subtask 5.3 – Develop Alternative-Processing Schemes
  - −Develop processing schemes (modeling software)
- Subtask 5.4 – Develop Process Flow Diagrams
  - −Coordinate with project supporters
- Subtask 5.5 – Technical and Economic Analysis
  - −Class V – Concept Screening (AACE Int.)



PROJECT SCHEDULE

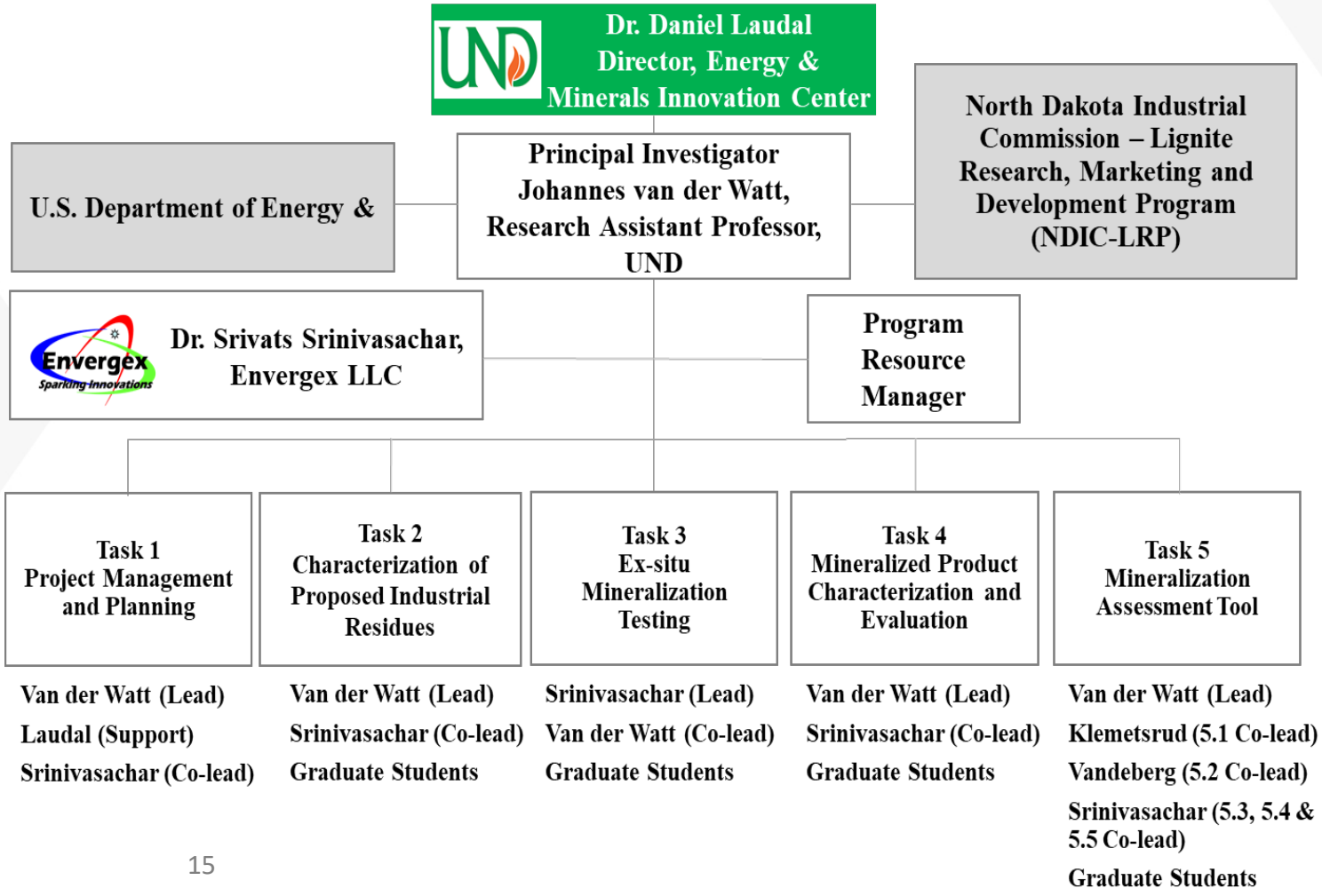
- Milestones & deliverables for each task
- Project update reports through quarterlies and final project report



PROJECT MANAGEMENT PLAN & RISK MANAGEMENT PLAN

Project Management Plan

- **Overview**
  - Project scope, objectives, & timeline
- **Organization**
  - Roles, responsibilities, & communication structure
- **Scope, Schedule, Cost**
  - Scope definition, change control, detailed schedule, & budgeting
- **Quality and Communication**
  - Quality standards, assurance, & stakeholder communication



PROJECT MANAGEMENT PLAN & RISK MANAGEMENT PLAN

Risk Management Plan

- **Assessment and Prioritization**
  - Evaluating risks - likelihood & impact
- **Mitigation and Contingency**
  - Strategies to reduce risks, contingency plans
- **Monitoring and Reporting**
  - Ongoing risk tracking, communication, & reporting
- **Documentation and Lessons Learned**
  - Maintaining risk register, learning from outcomes

PROJECT BUDGET

- DOE & North Dakota Industrial Commission (NDIC) Project
- DOE Funding & NDIC Cost Share
- NDIC: “Assessment of Lignite-Based Industrial Residues for Value-Added Product Creation through CO_2 Mineralization”
- National- & State-wide focus

Project	DOE	NDIC
Objective	Assess viability of using industrial wastes for CO_2 mineralization	Assess viability of beneficiating lignite-based residues using mineralization
Goal	Identify & quantify industrial residues applicable for CO_2 capture	Identify & quantify as well as remove contaminants hindering residue use as construction replacement material
Duration	• 24-months	
Budget	$ 1,000,000	$ 250,000 (cost-share)

DOE ACKNOWLEDGEMENT & DISCLAIMER

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END

- Thank you
- Questions?
- Contact details:

Dr. Johannes van der Watt

Office: (701) 777-5177

Email: johannes.vanderwatt@und.edu