# DE-FE0032248

# Black River Net-Zero Lime Kiln & Carbon Removal Facility

PI: Deborah Jelen

Presented By: Kathy Fagundo, Program Manager
Electricore, Inc.

Nick Papanicolaou, Decarbonization Manager
Carmeuse Americas

Acknowledgement
This material is based upon work supported by the Department of Energy under Award Number DE-FE0032248.

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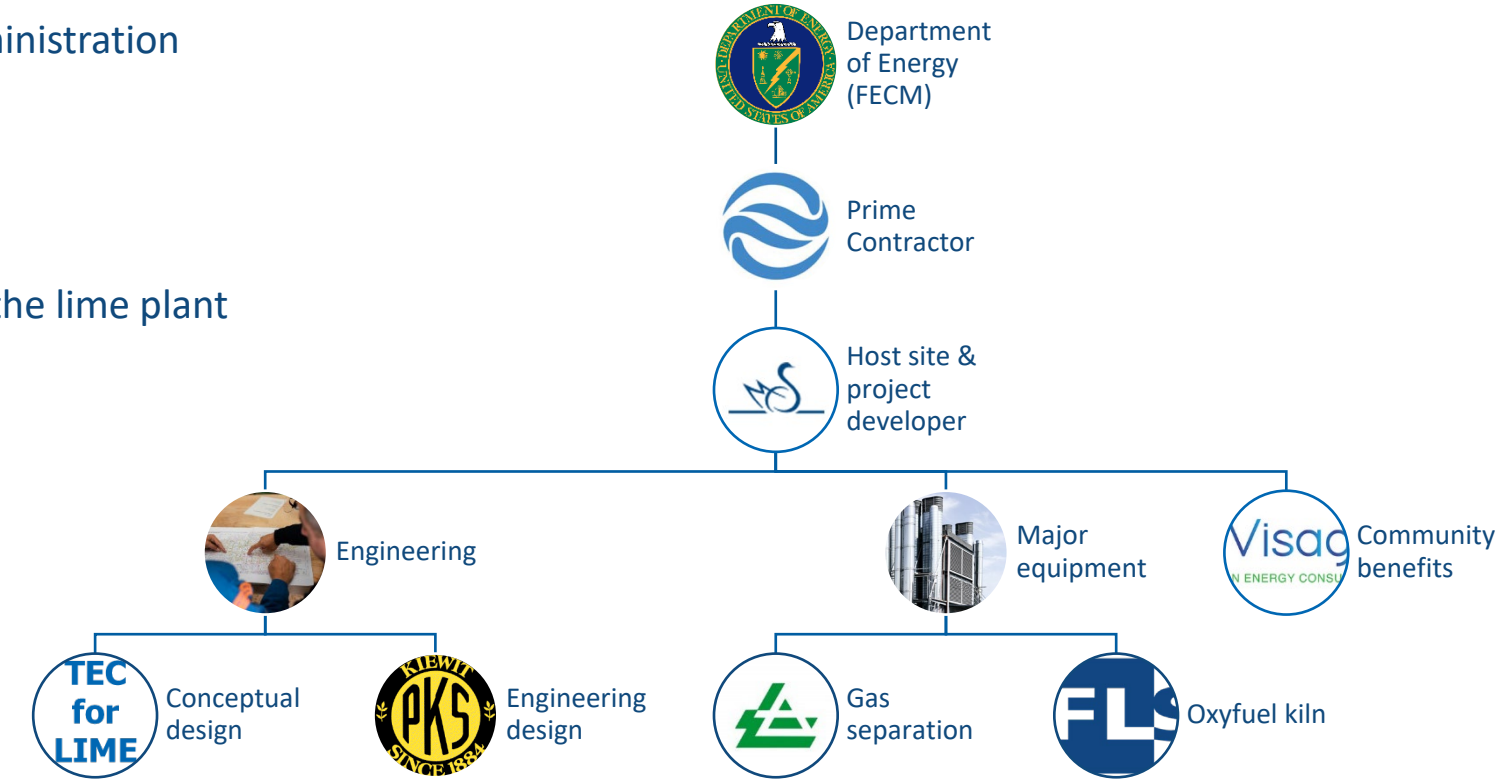
# Project Overview

- Award Period: 7/27/2023 through 01/26/2025
- Project Funding
  - Total Funding: $1,875,000
  - Federal Funding: $1,500,000
  - Cost Share Funding: $375,000
- DOE-NETL Team
  - Project Manager: Sai Gollakota
  - Contracting Officer: Lisa A. Kuzniar
  - Award Administrator: Davina Reed
- Project Objective

  Execute and complete the initial design of a commercial-scale, oxyfuel fired flash calciner lime kiln with carbon capture system that:
  - separates $CO_2$ with 95% capture efficiency from process flue gas streams;
  - utilizes sustainably sourced biomass (SSB) alone or in combination with natural gas;
  - maximizes utilization of SSB (up to 90% thermal substitution);
  - captures and permanently sequesters 400,000 metric tonne per year (TPY) of $CO_2$ producing a net zero product and net negative emissions from operations

# Project Partners

- **Electricore:** Prime Contractor and program administration
- **Carmeuse:** Host site and project developer
- **Carmeuse Technologies**: Conceptual design of the lime plant and technical advisor
- **Kiewit:** EPC partner
- **FLSmidth**: Oxyfuel kiln design
- **Air Products:** Air separation and $CO_2$ purification unit design
- **Visage Energy:** Community benefits



# Carmeuse has ambitious GHG reduction Targets: Carbon neutral for our scope 1 emissions by 2050

Pathways to Decarbonization

- Efficiency Improvements / Asset Modernization
- Low Carbon Alternative Fuels
- Carbon Capture, Utilization and Sequestration

The Black River Net Zero Pre-Feed Study seeks to better understand the feasibility of implementing these pathways with a new modern Oxy-fired Gas Suspension Flash Calciner, utilizing low carbon fuels and sequestering CO2 emissions within known onsite geological storage

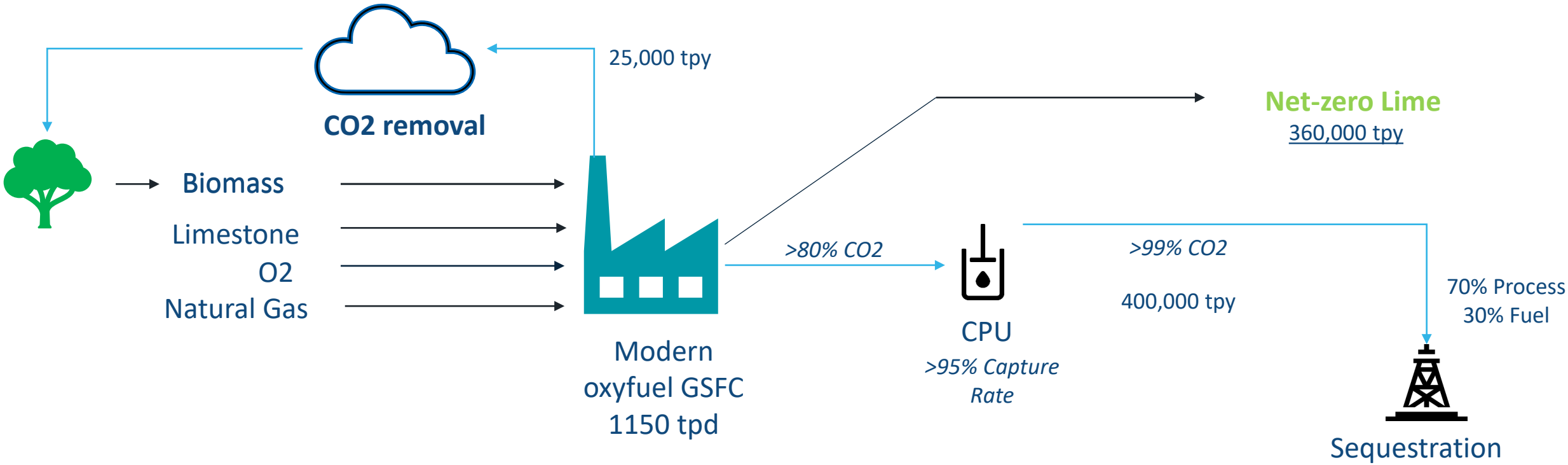
# Site Selection

**Carmeuse Black River Plant in Butler, KY**

- **5 kilns, 3 long rotary kilns, 2 pre-heater rotary kilns**
- **Favorable geology for on-site carbon sequestration within the Mt Simon formation**
- **Ability to ship via truck, rail and marine distribution to market**
- **Raw material reserves**

**This project considers the installation of a 1150 tpd Gas Suspension Flash Calciner to replace capacity from the 3 long rotary kilns currently in operation.**

# Technology Overview




Oxyfuel Gas Suspension Flash Calciner design operates with pure oxygen for combustion avoiding nitrogen from air in the process, the $CO_2$ in flue gases exit the GSFC at >80% vol.(dry) and are concentrated and purified to >99% in the CPU for sequestration

The capture and sequestration of the biogenic $CO_2$ from biomass fuels allows for net negative emissions (BECCS) where the Lime production facility operates as a carbon removal facility

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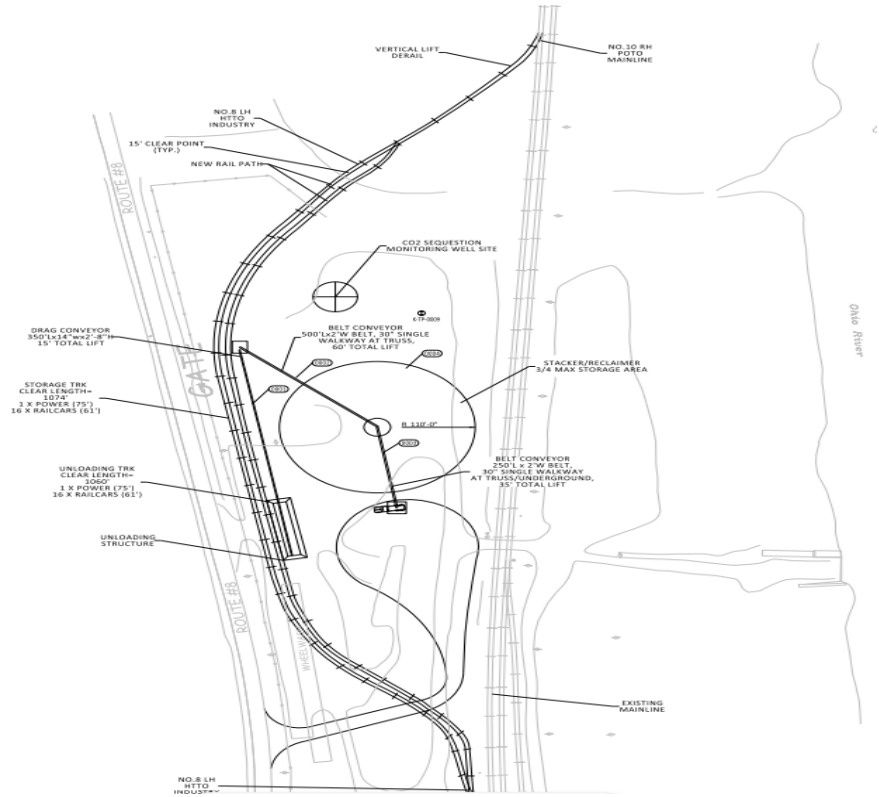
# Sustainably Sourced Biomass

## 2” wood chips (processed from railroad ties) delivered via rail

### Biomass Rail Unloading and Storage



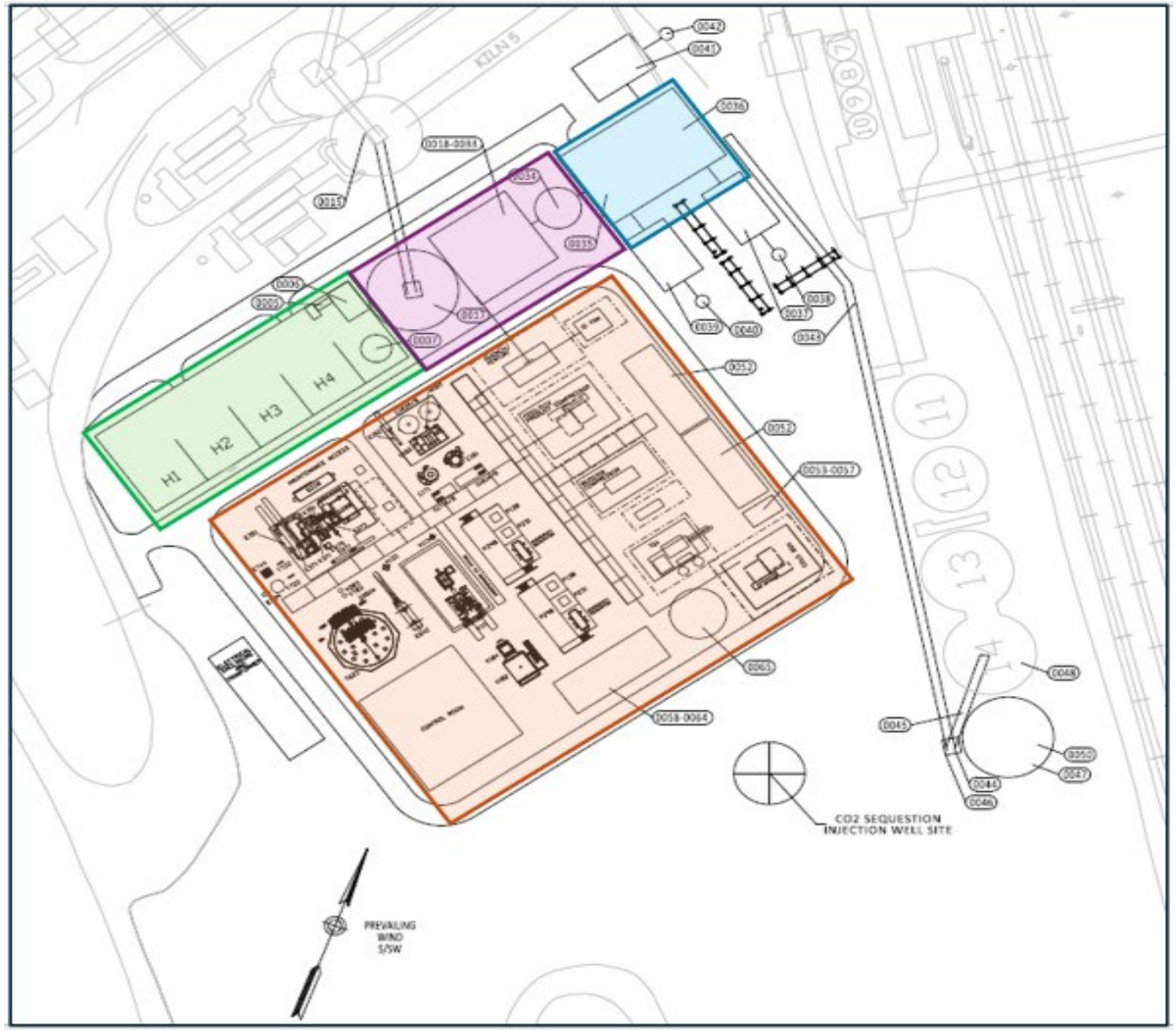

# Plot Plan

Biomass Processing

Limestone Storage & milling

Gas Suspension Flash Calciner

ASU / CPU, WSAC, Water Tower, Emergency Generators

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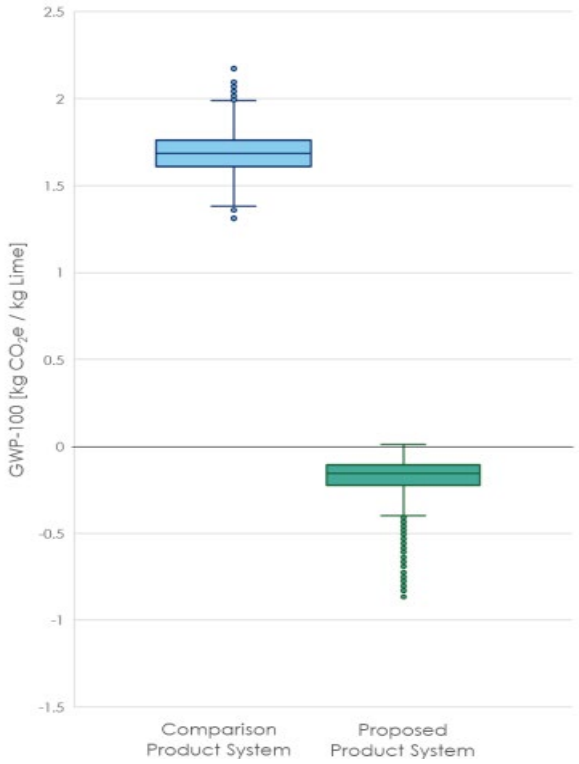
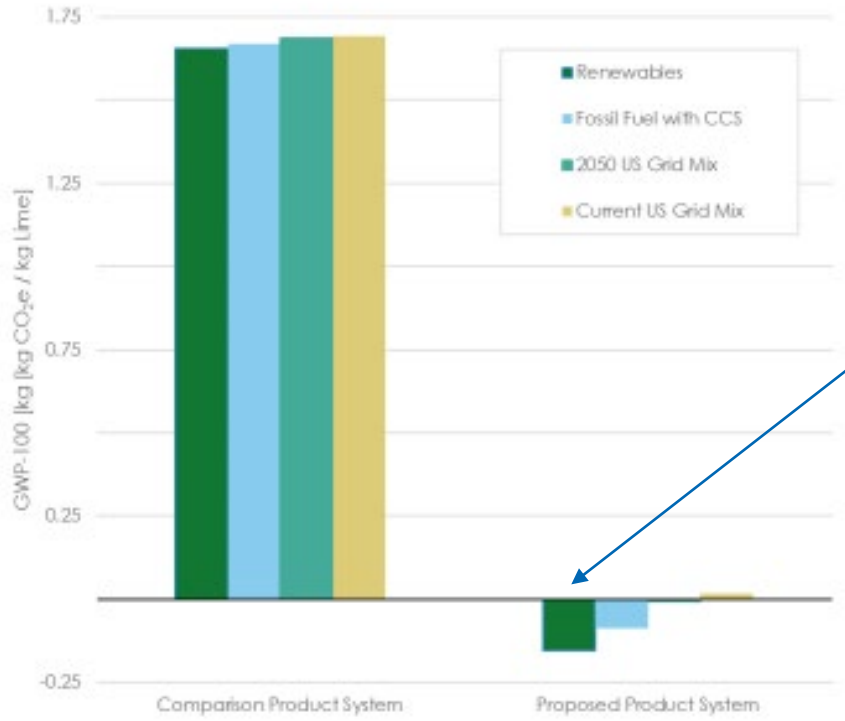
# Preliminary LCA – Emissions Reductions

## Monte Carlo simulation of Comparison and Proposed System GWP




## GWP of Comparison and Proposed Systems under four electricity scenarios




TEA to assume procurement of Green Renewable Electricity achieving the negative emissions and accounting for the Scope 1 -> Scope 2 transition.

- Modified NETL CO2U openLCA LCI Database with project LCA and sensitivity/uncertainty analysis
- Completed NETL CO2U openLCA Results Contribution Tool

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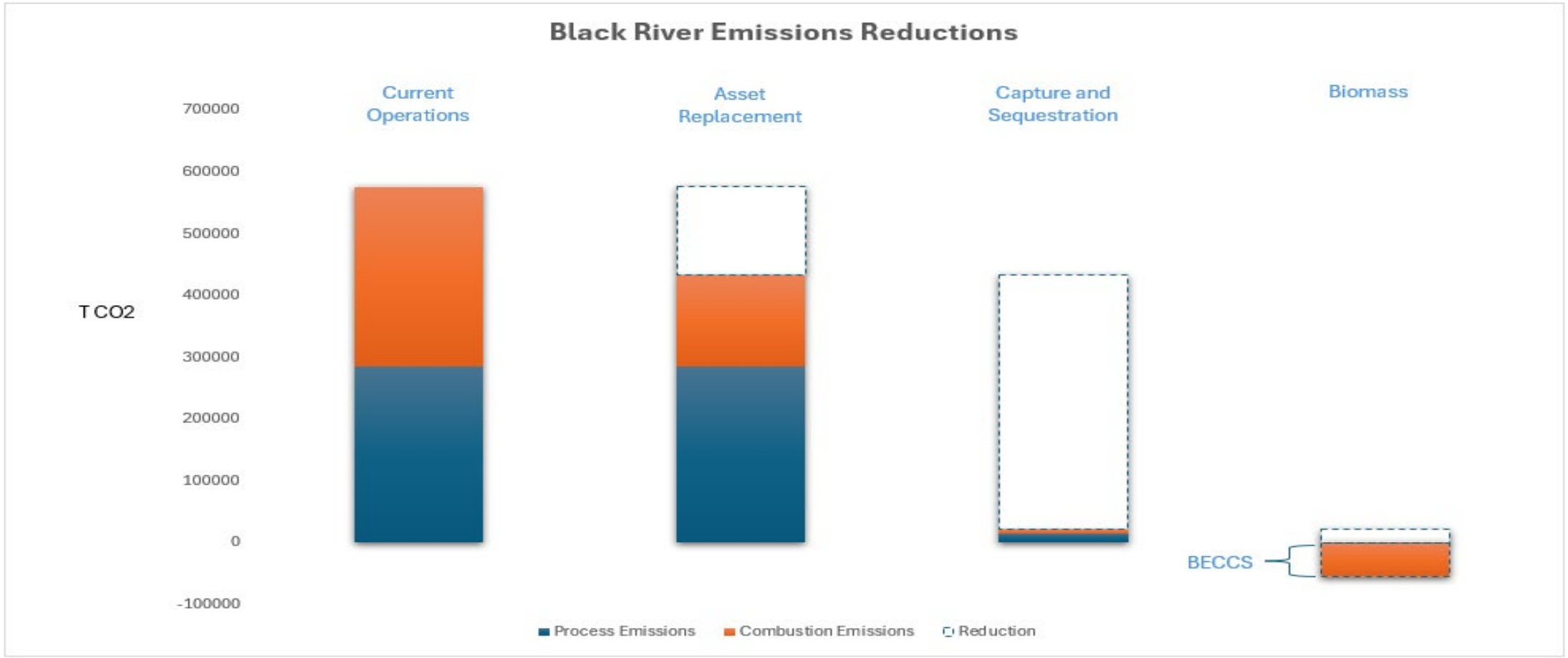
# Net Zero Lime Kiln and Carbon Removal Facility (BECCS)

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# Decarbonized Summary Comparison

## Decarbonized Net Zero Lime - KPI Comparison

| Comparison Unit | Unit | Current | Proposed | variance | Notes: |
|---|---|---|---|---|---|
| Installed Power | MW | 5 | 25 | 20 | 5X, ASU / CPU make up 70% of incremental load |
| Specific Power Consumption | kwh / T lime | 56 | 420 | 364 | 7.5 X, TEA to consider green renewable electricity price premium via PPA or other |
| Fuel Consumption | mmbtu / T lime | 9.3 | 4.8 | -4.5 | 0.5 X |
| CO2 specific emission | T CO2 / T lime | 1.6 | -0.15 | -1.75 | With renewable green electricity |
| Headcount | # of Employee's | 25 | 76 | 46 | 3.0 X |

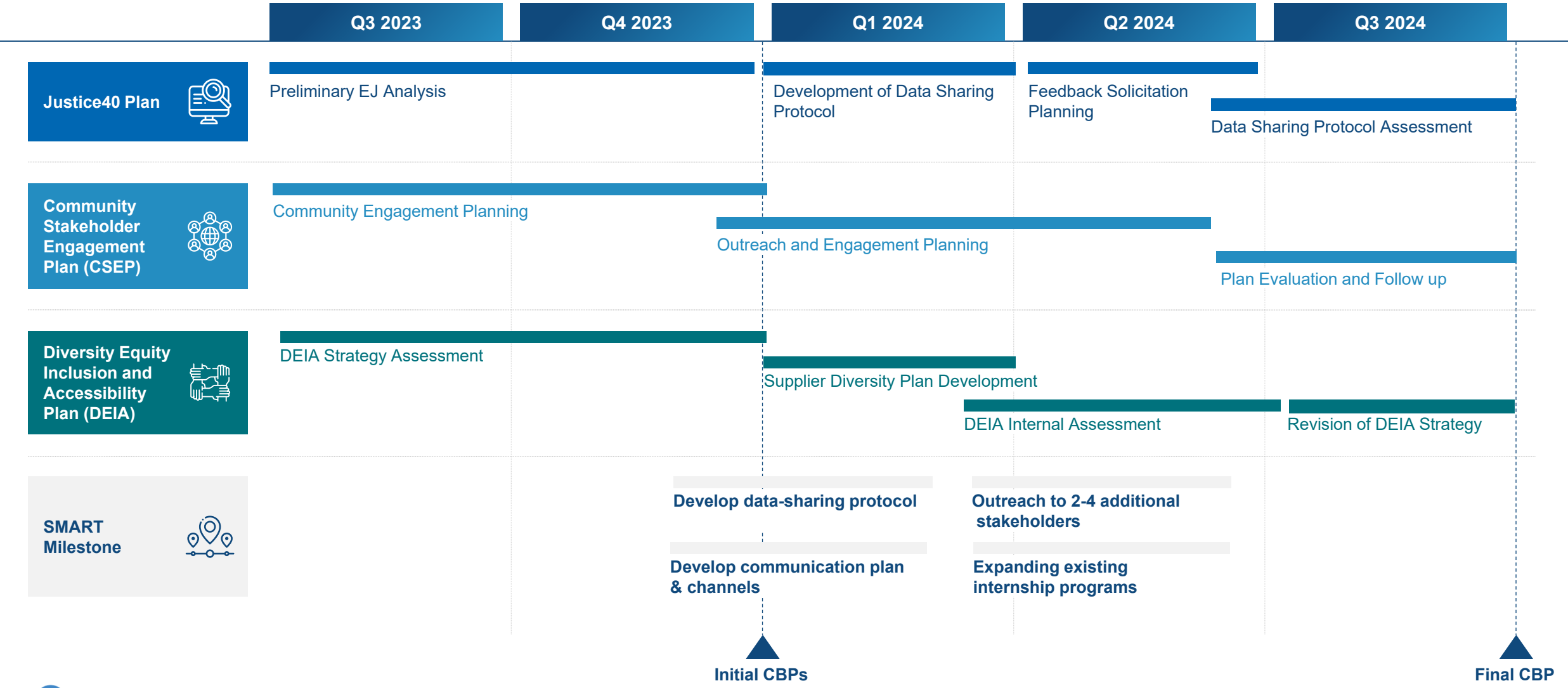
# Lessons Learned

- Wastewater treatment of impurities has significant impact to CapEx / OpEx.
  - Impurities derived from Direct Contact Cooler / CPU effluent of Flue Gas Condensates
  - Waste water treatment considers  water recycle to maximum feasible extent driven by current permitting requirements
- Green premium on net zero $CO_2$ products not yet mature
- Wash column for acid gas removal was required despite oxy-fuel combustion, derivative of biomass selection
- AP CPU + Membrane system benefits overall system performance
  - Increases capture rate from approx. 95% to >99%
  - Reduces overall system $O_2$ consumption by 5 to 10% through recycle

# Plans for Future Testing / Development / Commercialization

- Oxy-fuel firing and the Carmeuse / FLS Gas Suspension Flash Calciner has promising technological advantages
  - Next step includes commercialization and deployment in a CCU project as an industrial demonstrator.
  - Identify synergies with GHG reduction potential in additional use cases
- Upon completion of final CapEX development (Class IV), review of significant cost drivers IE;
  - Biomass selection and associated impurities
    - Waste water treatment reduction
    - Acid gas removal reductions
    - Total LCA impacts from upstream treatment process of recycled railroad ties

# Community Benefits Plan Roadmap

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# Work Plan

| Task/ Subtask | Milestone Title & Description | Planned Completion Date | Actual Completion Date | Verification method |
|---|---|---|---|---|
| 1.0 | Kick-Off Meeting | 10/02/2023 | 10/02/2023 | Presentation File |
| 1.1 | Project Management Plan | 08/25/2023 | 08/25/2023 | Submitted PMP IAW Appendix G |
| 1.2.1 | Initial Technology Maturation Plan | 10/25/2023 | 10/25/2023 | Submitted TMP IAW Appendix J |
| 1.2.2 | Final Technology Maturation Plan | 10/29/2024 | | Submitted TMP IAW Appendix J |
| 1.3 | Workforce Readiness Plan | 10/29/2024 | | Submitted Workforce Readiness Plan IAW Appendix V |
| 1.4 | Data Management Plan | 07/27/2023 | 07/27/2023 | Submitted DMP IAW Appendix H |
| 2.2 | Preliminary Engineering Design Package | 01/23/2024 | 01/23/2024 | Submitted Preliminary Engineering Design Package |
| 2.3; 2.4; 2.5 | Final Engineering Design Package | 10/29/2024 | | Submitted Final Engineering Design Package |
| 2.6 | Project Cost Estimate | 10/29/2024 | | Submitted Project Cost Estimate IAW AACE Class 4 |
| 3.0 | Business Case Analysis (BCA) | 10/29/2024 | | Submitted Business Case Analysis (BCA) IAW Appendix S |
| 4.0 | Technology EH&S Risk Assessment | 10/29/2024 | | Submitted EH&S Analysis IAW Appendix R |
| 5.0.1 | Initial Life Cycle Analysis (LCA) | 11/24/2023 | 11/22/2024 | Submitted LCA IAW Appendix P |
| 5.0.2 | Final Life Cycle Analysis (LCA) | 10/29/2024 | | Submitted LCA IAW Appendix P |
| 6.0 | Environmental Justice Questionnaire | 10/29/2024 | | Submitted Environmental Justice Questionnaire IAW Appendix T |
| 7.0 | Economic Revitalization and Job Creation Outcomes Questionnaire | 10/29/2024 | | Submitted Economic Revitalization and Job Creation Outcomes Questionnaire IAW Appendix U |
| 8.0.1 | Initial Justice40 (J40) Initiative Plan | 11/24/2023 | 11/22/2024 | Submitted Justice40 (J40) Initiative Plan |
| 8.0.2 | Final Justice40 (J40) Initiative Plan | 10/29/2024 | | Submitted Justice40 (J40) Initiative Plan |
| 9.0.1 | Initial Community and Stakeholder Engagement Plan (CSEP) | 11/24/2023 | 11/22/2024 | Submitted Community and Stakeholder Engagement Plan (CSEP) |
| 9.0.2 | Final Community and Stakeholder Engagement Plan (CSEP) | 10/29/2024 | | Submitted Community and Stakeholder Engagement Plan (CSEP) |

# Success Criteria

| Budget Period | Date | Success Criteria |
|---|---|---|
| BP 1 | 1/26/2025 | • Initial engineering design completed for commercial-scale, advanced carbon capture system that separates $CO_2$ with at least 95% capture efficiency from process streams at an existing industrial lime facility<br>• All required deliverables are complete and acceptable |

# Thank You!


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