**Project Overview: A Scalable Process for Upcycling Carbon Dioxide (CO₂) and Coal Combustion Residues into Construction Products**

**Overall Project Performance Dates:** 1/1/2019 - 12/31/2020

**Project Participants:** UCLA; Susteon Inc.

**Overall Project Objectives:**

- **Upcycle industrial wastes and CO₂** – Produce low-carbon CO₂ Concrete products from coal combustion residues, flue gas CO₂, and low-grade waste heat

- **System design** – Produce data supporting heat and mass balances for design of a “bolt-on” CO₂ mineralization system at coal-fired power plants

- **Field test CO₂ processing system** – Fabricate and field test a CO₂ mineralization system to consume about 100 kg of CO₂ per day from coal-fired flue gas

**Project Funding Profile (20.31% Cost Share)**

<table>
<thead>
<tr>
<th>Gov't Share</th>
<th>Cost Share</th>
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</thead>
<tbody>
<tr>
<td>UCLA</td>
<td>$1,200,000</td>
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<tr>
<td>Susteon Inc</td>
<td>$300,000</td>
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<tr>
<td><strong>Total ($)</strong></td>
<td><strong>$1,500,000</strong></td>
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Technology Background: Low-carbon cementation by CO₂ mineralization

1. **Raw materials**
   - Ca/Mg(OH)₂
   - Filler
   - Aggregate
   - Water

2. **Carbonic system**
   - Ca(OH)₂ + CO₂ → CaCO₃ + H₂O
   - Green body forming
   - Fresh block
   - CO₂ mineralization
   - Gas stream
   - CO₂-lean gas
   - Concrete products
   - Concrete masonry units

3. **Compressive strength**
   - 24-h Compressive Strength (MPa)
   - Dry-cast
   - Relative Humidity, RH (%)
   - Reaction Time, t (h)

4. **Demonstration of alpha prototype system**
   - Preliminary LCA:
   - ~ 65% CO₂ emissions reduction relative to conventional CMU

**Technology Background:**
Low-carbon cementation by CO₂ mineralization

**CO₂ mineralization kinetics**

**Concrete masonry units**

**Compressive strength**
Technical Approach/Project Scope: Experimentation, system design, fabrication, and field tests

- **Experimental design and work plan:** Acquiring bench-scale data describing CO₂ mineralization reaction and product performance in relation to composition and processing (temperature, relative humidity, flow rates)
- Process design informed by data → system design and fabrication → field testing at host site → analysis/scaling

Key project milestones

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
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<tbody>
<tr>
<td>9/30/19</td>
<td>Completed bench-scale experiments for design inputs</td>
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<tr>
<td>12/26/19</td>
<td>Completed process design and bid specification</td>
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<tr>
<td>6/23/20</td>
<td>System fabricated and FATs passed</td>
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<tr>
<td>9/21/20</td>
<td>System installed and commissioned at host site</td>
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<tr>
<td>12/31/20</td>
<td>Completed field testing of CO₂Concrete system at host site</td>
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<tr>
<td>12/31/20</td>
<td>Completed design scaling, techno-economic analysis, and lifecycle analysis</td>
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Key project success criteria (at project completion):

- CO₂Concrete formulations demonstrate CO₂ uptake between 0.05 to 0.50 g CO₂/ g reactant and compressive strength > 13.8 MPa for hollow-core block applications
- Field testing demonstrates 50 to 90% CO₂ utilization efficiency using real flue gas at host site
- CO₂Concrete produced has a lifecycle footprint that is > 25% smaller than OPC concrete of equal performance