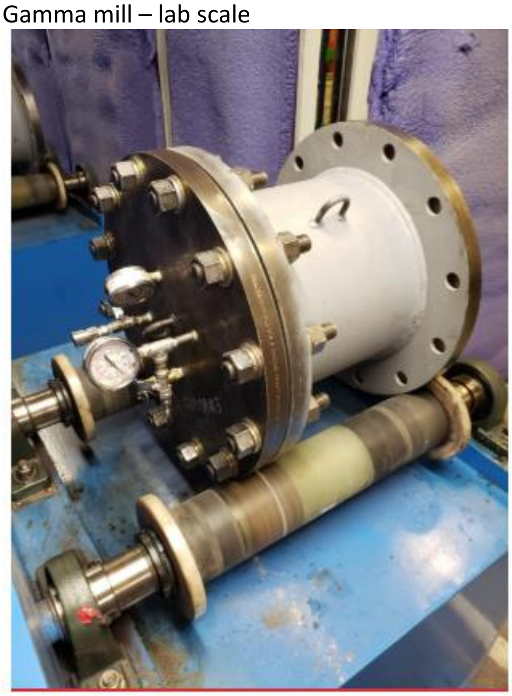
FINAL OUTCOMES REPORT (CONFIDENTIAL)

1.0 PROJECT INFORMATION

1. ERA PROJECT ID #	CS0162297
2. CALL / ROUND	Accelerating CCS Technologies- Round 4
3. PROJECT TITLE	Direct Carbon Conversion of Chemically Enhance Supplementary Cementitious Materials for Building Construction
4. COMPANY NAME	Carbon Upcycling Technologies inc.
5. PROJECT TYPE (R&D, Development, Demonstration, Implementation)	R&D
6. LOCATION (primary location the project took place by address, land description, or GPS coordinates)	Unit 20-6280 76th Ave SE Calgary, AB T2C 5N5 and National Renewable Energy Laboratory (NREL): 15013 Denver West Parkway, Golden, CO 80401
7. PROJECT START DATE	May 1st 2023
8. PROJECT COMPLETION DATE	September 30, 2025
9. TECHNOLOGY READINESS LEVEL (TRL) AT PROJECT INITIATION	3
10. TRL AT PROJECT COMPLETION	6
11. JOBS CREATED	15 – for this project alone
12. GHG EMISSIONS REDUCED (Project-level: annual, cumulatively by 2030 and by 2050)	none project level. 120,000 T of CO2 emissions reduced Projected 2030 in AB and Canada, by 2050: 2,910,000
13. TOTAL ERA FUNDING	$600,000
14. TOTAL PROJECT VALUE	$1,200,000
15. ERA PROJECT ADVISOR	Mizanul Mizan

16. SUBMISSION DATE	December 1st ,2025
17. KEY PROJECT CONTACT NAME AND EMAIL	Ana Aday PhD. Ana.Aday@nrel.gov Jennifer Kingsbury jennifer.kingsbury@carbonupcycling.com
18. QUOTE (why was ERA a pivotal funder for this project? How did ERA funding help advance on the TRL scale? Etc.)	Our novel technology reduces the carbon footprint of cement, sequesters carbon, and improves concrete performance. With Carbon Upcycling, cement producers can now create a superior product using local industrial byproducts and natural materials and reduce carbon dioxide emissions at the same time. ERA has allowed Carbon Upcycling to test a variety of new industrial byproducts to determine their suitability as cement product.
19. NOTABLE COMMUNICATIONS	Upcoming publication in the ACI Journal on the results of this project
20. IMAGE (please insert or link a photo capturing the technology for ERA publications)	Gamma mill – lab scale 

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5.0 EXECUTIVE SUMMARY

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As Canada and Alberta moves away from coal power plants and traditional steel production methods, the supply of common materials used as SCMs in cement is dwindling. This leads to higher costs and supply chain challenges. Alberta's efforts to reduce steel production emissions, particularly the shift to electric-arc furnaces (EAF), are already reducing the availability of traditional SCMs. As a result, cement producers may have to more on clinker, the carbon-heavy ingredient in cement, or face the high costs and emissions of importing SCMs from distant sources such as Turkey and Italy. This is not only an environmentally costly option but also expensive because of the high transportation and logistics costs involved.

This project addresses this problem by turning a local byproduct from steel production in Alberta and Canada into a locally-sourced cement replacement. The steel byproduct, known as Blast Oxygen Furnace (BOF) and EAF slag, normally does not capture CO_2, but CU's process "activates" it, allowing it to bond with CO_2. The CO_2 captured from the cement plant's emissions is then permanently stored in the slag, turning it into a carbon sink. The result is a low-carbon, durable alternative to clinker, reducing concrete's carbon footprint by up to 30%. This innovation also keeps BOF and EAF slags out of landfills, cuts down on waste, and strengthens local supply chains by reducing the need to import materials.

To address this need for new, local, and readily available supplementary cementitious materials (SCMs) to enter the market, a trans-national consortium was created between Carbon Upcycling Technologies (CU), a Canadian carbon utilization company and the National Renewable Energy Laboratory (NREL), which the US Department of Energy funds. In this project, NREL and Carbon Upcycling are partnering to develop and demonstrate a framework to assess various SCMs available in North America, including byproducts SCMs from high-emitting industries such as steel and mining for their suitability as SCMs. CU has developed a proprietary Mechanically Assisted Chemical Exfoliation (MACE) process that can take a variety of feedstocks and high or low-purity CO_2 from direct air capture or point sources) as inputs to provide enhanced carbonated SCMs for use in concrete, thereby improving strength and increasing alkali- silica and sulfate resistance of the resulting concrete. The activities undertaken in this project will help the consortium members evaluate the suitability of these SCMs as inputs in the MACE process and develop ideal processing conditions for the CO_2 enhancement of these SCMs

The project will lead the determination of CO_2 uptake in our SCMs for greenhouse gas emissions for future commercial use. Directly, CU's process captures CO_2 and sequesters it into the slag. Indirectly, partially replacing clinker with this CO_2-enhanced material further reduces the carbon footprint of cement. Each tonne of this material replaces a tonne of cement, avoiding approximately 800 kg of CO_2 emissions. This leads to an estimated 25,000 tonnes of CO_2 savings per year. At full scale, the total CO_2 reduction will reach 28,000 tonnes annually.

CU's technology offers a cost-effective, scalable solution for the cement industry as it transitions to greener cement options. The project supports the Global Cement and Concrete Association's goals for net-zero emissions by demonstrating the potential of BOF slag as a sustainable alternative to traditional SCMs, contributing significantly to the reduction of CO_2 emissions. By integrating CO_2 capture into the cement-making process, this project offers a pathway to decarbonize one of the world's most carbon-intensive industries.

6.0 PROJECT DESCRIPTION

6.1 INTRODUCTION

CU's MACE process is a patented technique capable of processing a variety of feedstocks by exposing them to CO_2 of varying purities, ranging from flue gas (5%) captured from a cement plant to high purity CO_2 (~99%). This process produces carbonated and activated supplementary cementitious materials for use in concrete. MACE is a low-energy exfoliation process that operates at ambient temperature and low pressure. The exfoliation process generates solids with high specific surface area, increased porosity and chemically active sites facilitating CO_2 adsorption and mineral carbonation. These attributes contribute to enhanced amorphous content and improved pozzolanic behavior, or at the very least, ensure stable physical CO_2 adsorption. The process is designed to promote both physical and chemical adsorption of CO_2 onto the SCM surfaces, ensuring that the adsorbed CO_2 remains stable and is only released at temperatures exceeding 400 °C. During operation, materials and bearings are placed inside the canister of the grinding mill, which is then securely and impermeably sealed. Next, flue gas is supplied to the chamber after which the gas port is sealed. The grinding mill is then rotated on rollers to undergo the mechanochemical activation process for 48 hours.

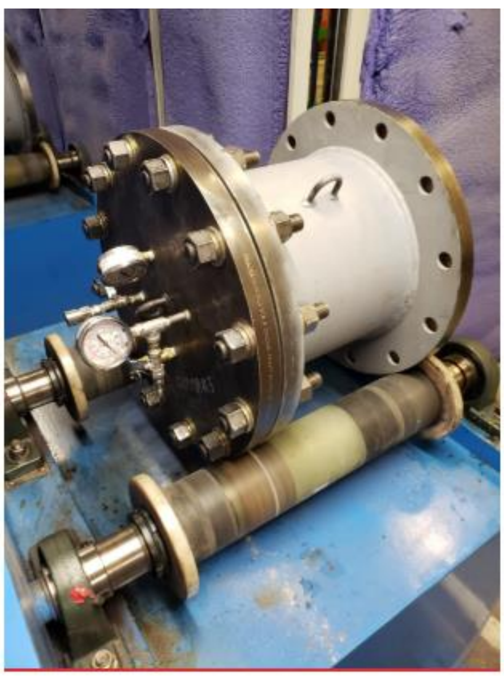

Figure 1: Carbon Upcycling's Gamma mill

6.2 BACKGROUND OF THE PROJECT

Concrete is the most utilized material produced by humankind and important to all aspects of society and yet is the source of 8% of all GHG emissions. This demand is driven by the critical role concrete plays in our infrastructure systems and is expected to grow in the coming decades due to the development of new infrastructure and maintenance of existing infrastructure for approaches that promote safer, resilient, and durable construction.

As Canada and Alberta moves away from coal power plants and traditional steel production methods, the supply of common materials used as SCMs in cement is dwindling. This leads to higher costs and supply chain challenges. Alberta's efforts to reduce steel production emissions, particularly the shift to electric-arc furnaces (EAF), are already reducing the availability of traditional SCMs. As a result, cement producers may have to more on clinker, the carbon-heavy ingredient in cement, or face the high costs and emissions of importing SCMs from distant sources such as Turkey and Italy. This is not only an environmentally costly option but also expensive because of the high transportation and logistics costs involved.

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6.3 PROJECT OBJECTIVES

There are four project objectives:

- Determine the low-value waste products and mineralizable resources that are currently available in North America that can be unlocked for use as SCMs through literature review by NREL
- Determine the efficacy of CO_2 sequestration and enhanced cementitious reactivity of a range of low-grade feedstocks
- Build a MACE reactor to process 10-50 kilos per sample
- Identify an ideal pilot location and feedstock material for follow-up work

6.4 PERFORMANCE/SUCCESS METRICS IDENTIFIED IN THE CONTRIBUTION AGREEMENT

Table 1: Success Metrics Identified in the Contribution Agreement

Success Metric	Project Target	Project Achievement	Explanation
Demonstrate direct CO_2 conversion to enhanced SCM **by weight** **(CO_2/kg)**	10% - this number cannot be measured by %, see explanation. Instead use **CO_2**/kg units instead.	The Total Carbon Content can be assumed as representative of the CO_2 uptake of the samples given the significant amount of amorphous material. Basalt: very little BOF slag:104.14 g/kg SCM EAF slag: 108.3g/kg SCM Waste glass: very little Ni-Cu mine tailings: 51.5 g/kg SCM	The total carbon content (TC) in pre-MACE and post-MACE samples was determined using ultimate analysis where the sample is combusted using pure O_2 stream to oxidize C, H and N to CO_2, and NOx respectively. The resulting CO_2 and H_2O compounds are quantified with an IR (infrared radiation) Cell signal. Mine tailings, EAF and BOF slags showed a clear indication of carbonation. The waste glass and basalt samples resulted in very low degree of carbonation after undergoing MACE process. The CO_2 uptake in MACE-treated samples were calculated based on the increment in the total carbon content assuming the increase in carbon content is only from carbonation.
Net CO_2 reduction of concrete with enhanced SCM	20%	18% average	The 5 different materials had a range and using 25% replacement of concrete Basalt: 19% BOF slag:19% EAF slag: 18% Waste glass: 18% Ni-Cu mine tailings: 16%
$/ton (feedstock)	~100/ton	$60/ton	Based on TEA on the top 2 chosen materials: EAF and BOF slag: $60/ton Did not do for the rest of the materials

6.5 PROJECT CHANGES

No changes from our partner, NREL and their tasks.

Carbon Upcycling had several changes throughout the project primarily through the staff and corporate organization structure. CU during this project transitioned from a start up company of 15 FTE and funding from primarily from non -dilutive government grantsto a small company of over 40 FTE and a successful USD 23M Series A round. This explosion of staff and funding increase meant:

- Move the R&D team and purchase lab facilities and equipment at our HQ at Unit 20-6280 76th Ave SE, Calgary, AB from the ACCTC site at Shepherd (Calgary)
- It became evident with NREL's experience and a full lab in the USA and CU's need to have our own equipment to test our own material and validate NREL's results (as part of the learnings by our team) rather than outsourcing meant that there were more equipment and materials/supplies than anticipated.
- Expanded the R&D team significantly along with an R&D Manager and an Executive team (COO and CRO) and a finance team of 2 FTE, instead if just 1 PT bookkeeper.
- As part of the growth and this project, CU transitioned from a Google Cloud platform to Microsoft Office 365 to have increased cybersecurity, increased employee collaboration and access to more available apps like Power BI to reflect the increasing growth and complexity of the company.

Actual changes to the project were minimal. The biggest change was to extend the project by 3 months from June 30th, 2025, to September 30th, 2025 to have more time for CU do the Technological and Economic Analysis (TEA) and the partners to find a suitable location for the commercial pours of the concrete.

6.6 TECHNOLOGY RISKS

Technical risks and challenges of the proposed project primarily concern product performance, chemical variability in the feedstock, and carbon capture effectiveness.

Table 2: Risks identified

The selected SCMs may not meet performance expectations.	Technical	H	CU will utilize experience with a variety of previously investigated feedstocks to determine the optimized conditions to achieve acceptable performance. CU will utilize its research networks, particularly in the field of surface chemistry, analytical characterization, cementitious material investigation, etc to identify technical pathways to improve baseline feedstock performance.

The proposed SCM feedstocks are linked to other industrial sectors, and the feedstock availability and pricing is subject to change. The required scale (material supply) of the proposed SCMs to make a dent in global concrete industry carbon emissions is very large.	Economical	L	A sensitivity analysis will be utilized in the techno-economic report to account for potential changes in the feedstock price as a result of material scarcity or other economic factors. Higher emphasis will be placed on materials sourced from industries with high production volumes and rising annualized growth rates.
The use of industrial byproducts in cement blends is heavily regulated by standards. Acceptance of new material constituents in a cement blend can be a multi-year process involving various cement standards. Relevant specifications - BS EN 197-1:2011.	Commercial	M	CU will utilize accelerated tests (ex. 14-day accelerated alkali-silica reactivity test) to provide a high level of confidence on the outcome of the regulatory tests prior to undergoing the lengthy specified test regime. There is still hesitation to procure sustainable/carbonated building materials due to a lack of proven track record in the field.
The concrete industry is well-established and conservative with adoption of new materials and processes. Any approach to decarbonize the industry must be aligned with industry needs, goals, and standards.	Commercial	M	The NREL and CU team have strong relationships with well-established players in the concrete industry. For example, CEMEX, a major concrete multinational, is an investor in CU. This is just one such example. We will rely on these relationships to guide R&D activities, ensuring materials are developed with industry needs and standards in mind.

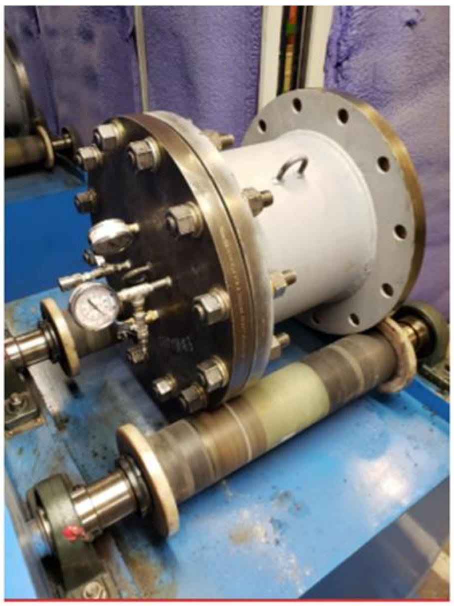
All the above risks were mitigated except for the commercial risk with cement standards. We recognized it but really understand the impact of it.

The one risk that was much more impactful was not getting the standards such as ASTM (American Standards and Canadian Standards Association for cement standards for our demonstration pours for MS#6. These are very long and a comprehensive reviewed. For both CU and NREL actual small-scale demonstration pours like sidewalks was not possible because these novel SCMs materials were not certified under current concrete standards such as CSA and ASTM. No cement company wants to take the risk of a commercial pour without that certification. This is why we went with the paver route to meet our objective

7.0 PROJECT WORK COMPLETED AND OUTCOMES

7.1 METHODOLOGY

For CU, the primary experimental methodology is the use of our mills and our carbonator. Prior to the mechano-activation, CU sends the pre-treated materials to undergo a series of testing such as XRD, XRF and SEM to determine the chemical and morphological characteristics of the material. TGA testing is done in-house. The MACE reactor, used for feedstock processing, is illustrated below.



During operation, materials and bearings are placed inside the canister of the grinding mill, which is then securely and impermeably sealed. Next, flue gas is supplied to the chamber under a patented process that has a specified low pressure, after which the gas port is sealed. The grinding mill is then rotated on rollers to undergo the mechanochemical activation process for 48 hours. Once that is completed, CU conducts a series of post-MACE testing to determine the changes of the morphological and chemical testing through third-party testing such as XRD, XRF, and SEM.

Samples are treated as received, except for the BOF and the EAF slag, which are milled prior to MACE treatments due to the large size of the pellets.

7.2 TECHNOLOGY DEVELOPMENT

The actual MACE technology development did not happen, but our suitable product identification for SCMs (end material) took huge leaps and bounds in understanding.

For our feedstock analysis TRL growth:

Slag such as EAF-BOF went from 5-7

Waste glass from 4-7

Mine tailings from 3-6

Basalt from 3-6

7.3 PROJECT ACHIEVEMENTS, RESULTS, AND ANALYSIS

The first step was a joint decision by CU and NREL to determine which materials to test based on literature review on appropriate chemistry for carbonation and geographic availability.

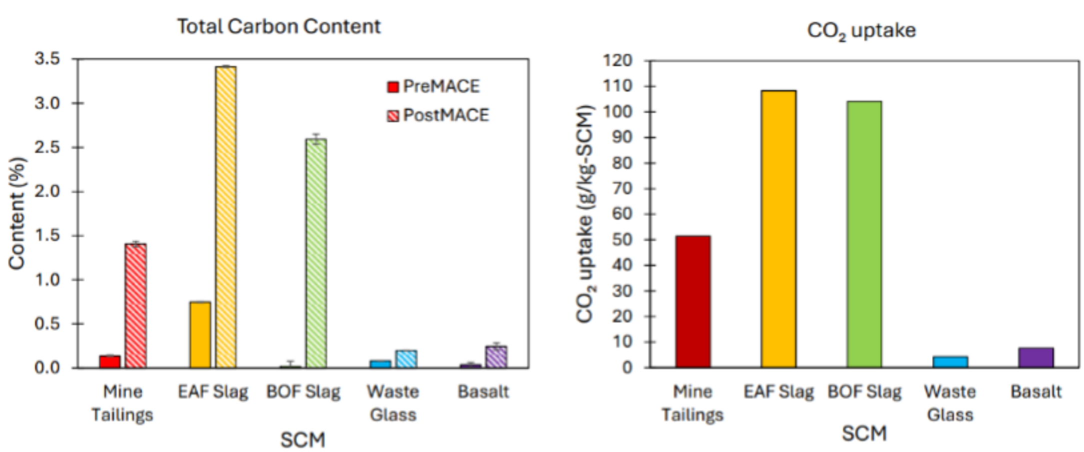
Table 5: Promising feedstock for carbon mineralization

Sample ID	Feedstock	Comments
1	Mine tailings	From Nickel-Copper mines in the the USA
2	EAF slag	Electric Arc Furnace Slag
3	BOF slag	Basic Oxygen Furnace Slag
4	Waste glass	Mixed recycled glass
5	Basalt	Powder suitable for landscaping

NREL procured the mine tailings and basalt. CU supplied EAF slag from Nucor, BOF slags from CRH and Stelco in Mississauga, and waste glass from the UK.

The highlights of the testing revealed for the direct CO_2 conversion of enhanced SCM by weight was:

Figure 2: Total carbon content of pre and post MACE samples (left) and CO_2 uptake in MACE treated samples (right)



The total carbon content (TC) in pre-MACE and post-MACE samples was determined using ultimate analysis where the sample is combusted using pure O_2 stream to oxidize C, H and N to CO_2, H2O and NOx respectively. The resulting CO_2 and H_2O compounds are quantified with an IR (infrared radiation) cell signal. The CO_2 uptake in MACE-treated samples was calculated based on the increment in the total carbon content assuming the increase in carbon content is only from carbonation. Total carbon content and CO_2 uptake of different materials are shown in Figure 2. As evident from the figure, BOF slag showed the second highest CO_2 uptake of ~104 g-CO_2/kg-slag.

The chemical composition of the EAF slag is very similar to that of the BOF slag, however SiO_2 and MgO content is higher in EAF slag as described in the XRF results. The CO_2 uptake was highest in case of EAF slag.

According to the total carbon content (Figure 2), the CO_2 uptake of mine tailing was ~51 kg/ton-slag, which is significantly lower than that of EAF and BOF slags. The lower CO_2 uptake can be explained by lower CaO content of the mine tailings considering that Mg-containing phases are also known to have slower rate of carbonation compared to Ca-containing phases.

The CO_2 uptake of waste glass with MACE treatment was negligible (~4 kg/ton-glass) and lowest among the materials selected for this study.

It is intriguing to note that the combined CaO and MgO content of basalt (15.1%) is very comparable to that of mine tailing (16.4%). In addition to the calcium and magnesium oxide content, the particle size distribution of MACE-treated basalt and mine tailing samples are also very similar. However, the CO_2 uptake of mine tailing was found to be about 7 times higher than basalt (Figure 5). The possible explanation for the lower extent of carbonation of basalt is the difference in mineralogical composition.

Our testing has shown that all the novel SCMs that have undergone post-MACE treatment have exhibited CO_2 sequestration. See Table 6 to illustrate the CO_2 uptake of the materials as SCMs.

Table 4: Emissions of concrete mixtures using a 25% replacement of SCMs.

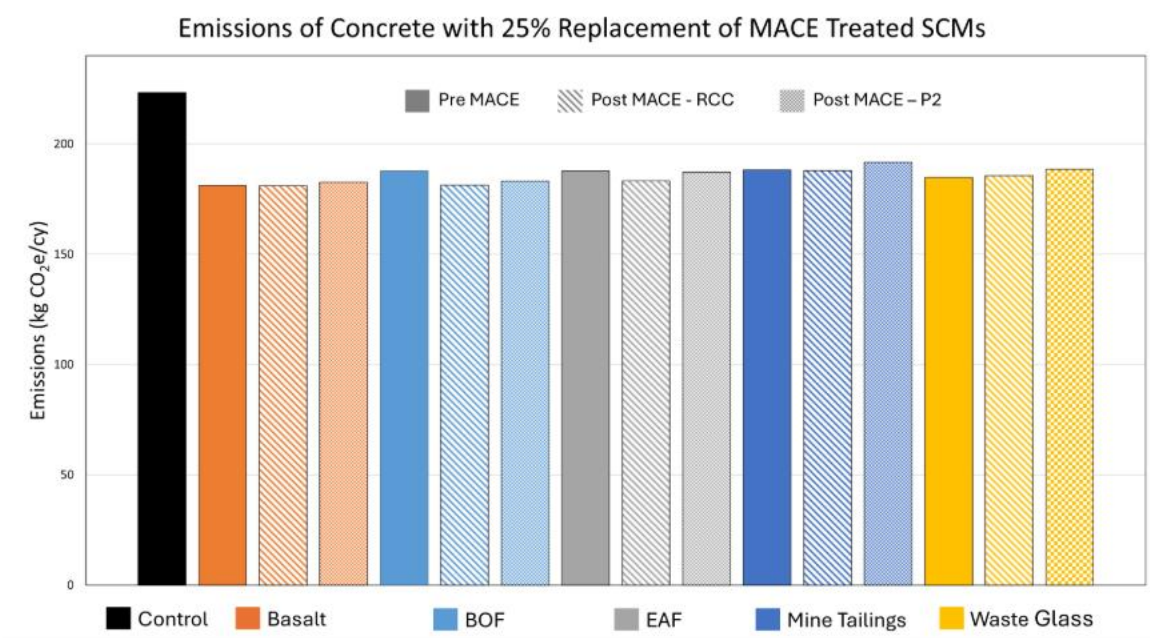
	Emissions (kg CO2e/cy)		
Mix	**Cradle-to Gate**	**CO_2 Sequestration**	**Total**
Control (no SCM)	223.30	0	223.30
Basalt Pre MACE	181.20	0	181.20
Basalt Post MACE - RCC	181.54	0.46	181.08
Basalt Post MACE - P2	183.21	0.46	182.75
BOF Pre MACE	187.69	0	187.69
BOF Post MACE - RCC	188.19	6.82	181.37
BOF Post MACE - P2	189.00	6.82	183.18
EAF NUC Pre MACE	187.77	0	187.77
EAF NUC Post MACE - RCC	190.42	7.09	183.32
EAF NUC Post MACE - P2	194.31	7.09	187.22

Mine Tailings Pre MACE	188.31	0	188.31
Mine Tailings Post MACE - RCC	191.03	3.19	187.84
Mine Tailings Post MACE - P2	194.91	3.19	191.72
Waste Glass Pre MACE	184.73	0	184.73
Waste Glass Post MACE - RCC	185.8	0.28	185.56
Waste Glass Post MACE - P2	188.88	0.28	188.59

We used BOF and EAF as our examples for the TEA and LCA analysis due to its availability as a widespread industrial byproduct that considered waste, found globally – and not constrained geographically due to geology (ie basalt) and its ability to sequester significant amounts of carbon dioxide.

CU evaluated two potential MACE processes. The first is collocating the MACE reactor at the site of material production for a fully integrated Reactor Carbon Capture (RCC) system. The second process (P2) is to have a separate MACE plant within 100 miles of the material production where transportation is required for both the SCM and CO_2 before the MACE process. A preliminary LCA has been conducted for a concrete mixture containing the MACE treated SCMs under both scenarios to aid CU in the analysis of the proposed options.

Figure 3: Emissions of concrete mixes using a 25% replacement of SCMs. For each material, the pre-MACE, RCC MACE, and P2 MACE materials were evaluated.



However, another major conclusion from this LCA is that there is relatively little variation between the materials and within the material treatment options. This is because while the SCM is at a 25% replacement level for the cement, it is only a minor component of the total concrete mixture and so it can only contribute so much to the overall emission profile. One important distinction to highlight is that the mixtures using RCC MACE treated materials always have lower emissions than the respective P2 MACE treated materials. This is due to the extra transportation emissions that the P2 process requires as opposed to the colocation in the RCC process. Additionally, for the materials with the highest levels of sequestration potential (BOF slag and EAF slag), the total emissions are lower than the mixtures with the respective pre-MACE materials. This means that the sequestration gained by the MACE process is more than enough to cover the emissions that are generated because of the MACE process. This difference is magnified when comparing just the RCC process to the pre-MACE materials which reinforce the benefits of the RCC process from an LCA standpoint. Overall, this LCA provides an initial understanding of the relative Cradle-to-Grate embodied impacts of basalt, BOF slag, EAF slag, mine tailings, and waste glass.

Future LCA work will add to this analysis by refining the assumptions of energy requirements for the MACE process across all materials. Another detail to refine is that CU currently assumes the same CO_2 sequestration potential of a SCM regardless of the purity of CO_2 stream in the reactor. The RCC process would likely have a lower purity stream than the P2 process because it will be a flue gas stream as opposed to a high purity capture stream. This purity difference could impact the sequestration potential of the SCMs that were used for this analysis and could impact their relative overall impacts. Incorporating these factors into a future LCA would provide a more comprehensive understanding of the embodied CO_2 impacts of each material and would aid in the evaluation of materials for MACE processing. For the MACE reactor, the energy requirements were derived from an operational pilot plant at 75 kWh/ton of MACE-enhanced SCM produced. The same energy inputs were assumed for each SCM. As a refinement from previous versions of this LCA, a potential market for each material was established based on material availability and feasibility for CU to build a reactor in the region.

NREL and CU tested five materials as potential candidates for SCMs: Cu-Ni mine tailings, basalt, waste glass, Electric Arc Furnace (EAF) slag and Blast Oxygen Furnace (BOF) slag. CU and NREL chose BOF and EAF slag for concrete pours because of the positive initial testing that showed its potential as a novel SCM, its ability to scale up from a lab to commercial scale and to sequester CO_2 to decarbonize the steel industry globally. The TEA analysis will focus on both BOF and EAF slag.

TEA and $/ton feedstock analysis

The preliminary TEA revealed the following about mechanical-assisted chemical exfoliation (MACE) in comparison to other materials used in the production of SCM. Basalt demonstrated a positive MACE ability to sequester CO_2 in the R3 testing. With a 15% PLC replacement, it was able to meet the required compressive strength. Basalt, however, is limited geographically and heterogeneous, characterized by its unique rock chemistry and distinct properties. Mine tailings showed too much variability in particle size and strength testing due to the inherent heterogeneity of the geology of the rocks. Glass has the strongest compressive strength testing results, but CU has mixed results with waste glass's ability to sequester CO_2.

Given the internal evidence CU has gathered for other feedstocks, CU assumes that there are little to no differences in the carbon uptake potential of steel slag when using ~4% flue gas CO_2 with RCC versus ~99% CO_2 with sequential capture and conversion.

The estimated CAPEX for a MACE commercial facility with a 200,000 tpa capacity would be approximately $70M. This would equate to approximately 10% to 25% of the total production of an average cement plant.

The cost of MACE Reactive Carbon Capture (RCC) enhanced EAF and BOF slag SCM is competitive with existing, more carbon-intensive cement products with which it could replace.

The most significant factor in financial modelling is the electricity costs from the local grid to operate our reactors.

The methodology for completing the preliminary TEA is based on Carbon Upcycling's (CU) extensive experience in developing and implementing first-of-a-kind integrated MACE RCC pilot plants using its proprietary MACE technology. This experience includes constructing and operating a pilot-scale plant in Calgary, Alberta, which demonstrates TRL 8 productivity, converting 30 tonnes per day of coal fly ash into SCM. This facility is fully integrated with flue gas from natural gas combustion at a power plant. Additionally, CU is currently constructing another pilot project in Mississauga, Ontario, in collaboration with cement producer CRH, which will enhance slag from blast oxygen furnace (BOF) steel production to produce 32,000 tonnes per annum (tpa) of BOF slag SCM.

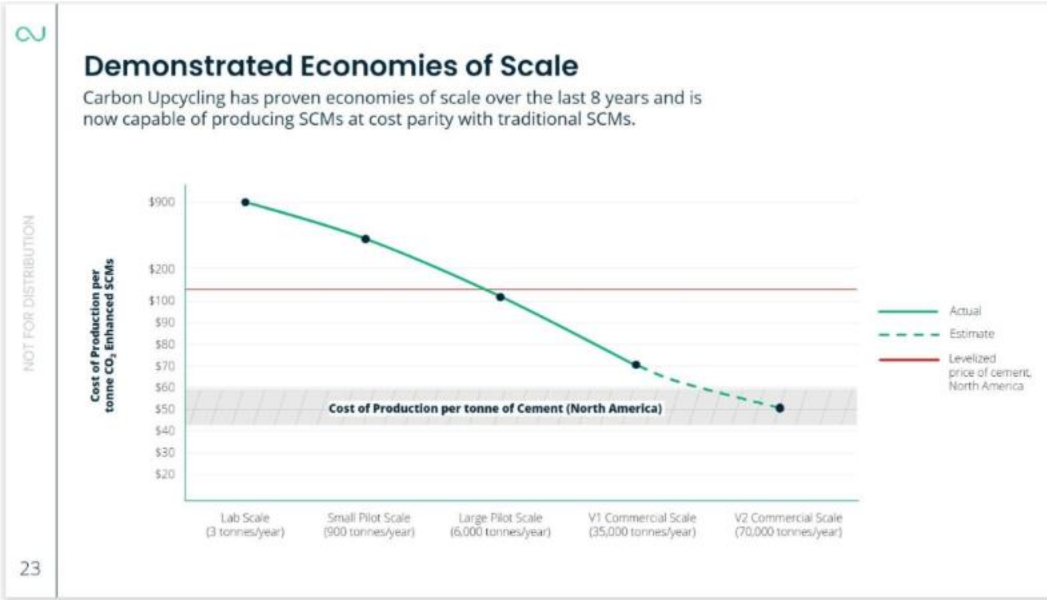
From these existing deployments, CU utilized the Mississauga facility as a Canadian template to extrapolate findings and prepare a preliminary financial model for a 128,000-tpa MACE plant designed to convert slag and other materials into SCM. For USA, CU is using a EAF steel plant near Chicago as a model. These models, along with the existing facilities, directly utilize on-site flue gas as a CO_2 source, aligning with the goal of on-site RCC for the creation of low-carbon SCMs. To further refine the TEA, CU has

collaborated with several steel and cement plants, which provided technical information about their plants, operations, and products. These collaborations yielded additional crucial information needed to develop a comprehensive preliminary TEA for a variety of different feedstocks and potential sites.
The proposed 200,000 tpa MACE plant demonstrates the scalability and efficiency of this technology. Based on extrapolations from existing facilities, this plant would require approximately 10 MWh of connected load for CO_2-mediated milling, which exfoliates the feedstock and creates chemically active sites for CO_2 binding. This process activates the SCM and permanently sequesters some CO_2, resulting in a product that's immediately ready for use in cement and concrete applications. A typical commercial plant's projected footprint is estimated to be at most 12,140 m2 (130,680 ft^2) accommodating all necessary equipment, including material conveyors, vertical roller mills, dust collectors, carbonation reactors, and associated infrastructure.

Water requirements for the MACE plant are expected to be minimal, as the process primarily utilizes semi-dry solid-gas chemistry to produce SCM from raw feedstock. Any input water for MACE conversion is supplied in the humidity of flue gases resulting from combustion.

The proposed 200,000 tpa integrated MACE RCC plant is expected to produce EAF/BOF slag SCM at a competitive cost of around $60 per tonne, leveraging economies of scale (see Figure 4). This price point makes the product cost-competitive with existing domestic SCMs and clinker. The only cost associated with the product featuring an on-site MACE RCC system is the electrical cost to operate the mill. CU would have abundant and 'free' CO2 from the plant's flue gas stack and EAF slag, since both materials are integrated directly into the steel mill facility. Notably, there would be no green premium for MACE-enhanced EAF or BOF slag SCM.

Figure 4: Economies of Scale



8.0 LESSONS LEARNED

8.1 CHALLENGES

As part of the down selected materials, Municipal Waste Solids Incinerator Ash (MWSI) was chosen in MS#1 for its chemical characteristics. However, acquiring such material from sources in North America has proved challenging and posed a challenge for acquiring materials on a scale. Most reported MWSI ash in literature is sourced from Asia, which is out of the scope of the MACE project. Hence, the project partners decided to pivot from investigating MWSI to basalt (e.g., mafic, silicate minerals rich in magnesium and iron). Basalt rock formations are currently used to sequester CO_2 in geological formations and are present in large quantities in North America.

Another challenge that was unforeseen was the wear and tear of our laboratory scaled bench top mills due to the mechanical rotation on roller to grind the material down to a specific particle size to make it more reactive to CO_2. One mill completely broke apart and needed to be replaced for this project.

Another minor technical challenge was the move from ACCTC to the HQ for the R&D lab facilities. This new facility has given us some unexpected expenses that were unforeseen. Since we are not "hooked" up to a natural gas driven electrical plant with a flue gas to conduct our experiments for CO_2 uptake in our feedstocks, we must order canisters of CO_2 to mimic flue gas conditions and hook them to our benchtop MACE reactors with hoses and valves.

In M#6, for both CU and NREL actual small-scale demonstration pours like sidewalks was not possible because these novel SCMs materials were not certified under current concrete standards such as CSA and ASTM. No cement company wants to take the risk of a commercial pour without that certification. This is why the partners went with the paver route to meet our objective.

8.2 PRACTICAL LEARNINGS

First – CU realized that the different material behaved very differently and each sample had different results. We needed to do several results pre- and post-MACE to establish a "normal" range of the samples. This meant several runs to establish a baseline range for pre- and post-MACE testing.

Compiling the concrete test results made an interesting case for both LCA and TEA analysis. Initial indications are that they can meet the cement standards. The biggest barrier from this to reality is to get CSA and ASTM standards. Right now, none of these products can be commercially manufactured as they need to be certified by ASTM and CSA and that can take up to 6 months to a year. Getting ASTM and CSA standards for novel SCM needs to be baked into our commercialization timeframes and planning. Right now, none of these products can be commercially manufactured as they need to be certified by ASTM and CSA. For entirely new material that have never been used in cement it can take years. The steps are:

- 5 years of testing for data
- Put in mini ballot (recommendation)
- Ballot goes to all members (ie CSA or ASTM)
- If approved, then standard publication

To gain certification, CU has a staff member that is part of the ASTM c01 and c09 committees. This allows to us to participate in ASTM standards and work with other members to put forward a ballot. For instance, there is another company that wants to use EAF slag and CU is working with them to put forth a ballot for EAF slag so we can have EAF certified SCMs. Canadian standards for cement are modelled after the ASTM standards.

8.3 ORGANIZATIONAL LEARNINGS

CU has an excellent R&D staff along with our partnership with NREL has given us valuable insight into novel SCMs materials. There needs to be a better tie between R&D and BD to achieve commercial/marketable usage of SCMs.

See section 8.2 as specific example of learnings how we can bridge R&D to BD to commercialization.

This project really built our R&D team and really refined the processes for testing, analysis, validation and closure.

8.4 HIGHLIGHTS

Working with NREL was a highlight. They were fantastic partners who were easy to collaborate, share knowledge, and kept a scientific rigour to our testing processes.

MS#1: It was interesting to go through all the literature (NREL) and then to illustrate the availably geographically in literature and on Power BI to show cement plant locations in relation to the sites such as steel plants and mines to demonstrate how readily available the feedstock are in North America. It was a valuable exercise to demonstrate how early research can focus our future efforts in time and planning.

MS#5: The final tests that NREL and CU conducted showed that some materials exhibited better performance than others. Some showed better carbon sequestration, others showed showed better strength. Some materials are readily available, and others were difficult to acquire. It was hard choosing the two best materials. We chose BOF and EAF slag. Both had good strength and CO_2 uptake and readily available in Canada and USA.

Getting the pavers from NREL and then conducting our own tests to on our brand-new SAI (strength activity index) machine in MS#6 was the final highlight.

9.0 GHG BENEFITS

9.1 PROJECT BASELINE EMISSIONS

none

9.2 PROJECT EMISSIONS

none

9.3 EMISSIONS REDUCTION IMPACT

- *Please summarize the direct and indirect emission reduction impact in the following table –*

Year	Baseline Emissions @Year (tCO2e)	Project Emissions @Year (tCO2e)	Estimated Annual Production (if applicable)	Unit of Production	Emissions Reduction @Year (tCO2e)
2023					
2024					
2025					
2026					
2027					
2028					
2029					
2030					
2031-2040				kg CO2e	
2041-2050				kg CO2e	

Our testing has shown that all of the novel SCMs that have undergone post-MACE treatment have exhibited CO_2 sequestration. In the previous milestone, we used BOF and EAF as our examples for the TEA and LCA analysis due to its availability as a widespread industrial byproduct that considered waste, found globally – and not constrained geographically due to geology (ie basalt) and its ability to sequester carbon dioxide. See Table 6 to illustrate the CO_2 uptake of the materials.

Table 4 Emissions of concrete mixtures using a 25% replacement of SCMs.

Mix	Emissions (kg CO2e/cy)		
	Cradle-to Gate	CO_2 Sequestration	Total
Control (no SCM)	223.30	0	223.30

Basalt Pre MACE	181.20	0	181.20
Basalt Post MACE - RCC	181.54	0.46	181.08
Basalt Post MACE - P2	183.21	0.46	182.75
BOF Pre MACE	187.69	0	187.69
BOF Post MACE - RCC	188.19	6.82	181.37
BOF Post MACE - P2	189.00	6.82	183.18
EAF NUC Pre MACE	187.77	0	187.77
EAF NUC Post MACE - RCC	190.42	7.09	183.32
EAF NUC Post MACE - P2	194.31	7.09	187.22
Mine Tailings Pre MACE	188.31	0	188.31
Mine Tailings Post MACE - RCC	191.03	3.19	187.84
Mine Tailings Post MACE - P2	194.91	3.19	191.72
Waste Glass Pre MACE	184.73	0	184.73
Waste Glass Post MACE - RCC	185.8	0.28	185.56
Waste Glass Post MACE - P2	188.88	0.28	188.59

Using the above numbers for EAF an BOF slag and selected Canadian site of Mississauga, Richmond BC and in-house use of AltaSteels's EAF, we can estimate the CO_2 emissions annually for each of the sites.

Mississauga utilizes BOF slag and will be operational in 2026. CU expects 30,000T of CO_2 reduced and 30,000 T of slag reduced from landfill. The scale of the plant is 32,000 tonnes per year of enhanced SCMs. That means from 2027-2050 that total CO_2 emissions reductions will be 720,000 T.

Richmond BC with a 120,000 TPA of enhanced EAF SCM per year will reduce 90,000 T /year of carbon dioxide starting in 2029. That means by 2050 that equates to 1,890,000 T of CO_2 emission reductions.

Lastly, if we use our 16,000 TPA at ACCTC for EAF from AltaSteel starting in 2030, that is 15,000T of CO_2 emissions reduction annually in Alberta. By 2050, that equates to 300,000 of CO2 reductions.

10.0 ENVIRONMENTAL, ECONOMIC, AND SOCIAL IMPACTS

10.1 OTHER ENVIRONMENTAL IMPACTS

Since CU's MACE technology is purely electrical driven, there are no additional GHG emissions, which mean no additional air contamination. Our technology also reduces the impact of industrial by-products that are often landfilled as there is currently no use such as EAF, BOF slags, mine tailings and waste glass. This has huge environmental impacts as waste such as mine tailings can contaminate water and soil due to leaching of heavy minerals and harming plants, animals and communities.

10.2 PROJECTED ECONOMIC IMPACT

The cement industry worldwide is prioritizing the use of Supplementary Cementitious Materials (SCMs) in concrete production and are directing substantial efforts toward securing reliable sources of traditional SCMs such as slag and fly ash. These materials have historically provided both economic and performance benefits to concrete mixtures; however, they face limited availability and rising prices.

With Alberta's coal power plants shutting down and its geological lack of natural pozzolans in the province, other sustainable sources of SCMs are strategically important to Alberta to explore for its construction industry. Alberta is already producing electric arc slag and will continue to create a material that can be used to develop local and cheap low-carbon cement. EAF slag is a strategically important feedstock for Carbon Upcycling as unlike conventional Blast Furnace slag, it is increasing in supply as steel plants switch operations to electrified processes. Importantly, EAF slag sequesters considerable CO_2 (up to 15% by mass) and enable coupling of the steel and cement industry within Alberta and globally.

This would allow Alberta to have local and cheap source of cement to strengthen its supply chain to execute the impending large scale projects in the province.

CU over the duration of this project's lifecycle has grown from 21 employees in Calgary to 43. CU grew from a startup into a SME over the time period. The growth of employees came from all departments such as engineering, R&D, operations, and at the executive level such as COO and CRO.

10.3 RESULTED INNOVATION CAPACITY

Carbon Upcycling's R&D team has shared knowledge with the University of Calgary with their Chemical Engineering department and with SAIT's Centre for Innovation and Research in Advanced Manufacturing and Materials department and to the Canadian Standards Association (CSA). Additionally, we are working with the City of Calgary to use our local low-carbon cement for concrete for infrastructure projects.

Carbon Upcycling increased the R&D team from 3 in 2023 to 8 in 2025.

10.4 SOCIAL IMPACT AND EDI OUTCOMES

As this was an R&D project, there was no direct impact on local communities, underserved communities, and/or indigenous groups.

During this project and not entirely unrelated, Carbon Upcycling became certified BCorp company in early 2024.

11.0 SCIENTIFIC ACHIEVEMENTS

1. 2023 ACT4 Knowledge Sharing Workshop (virtual presentation)
2. 2024 Clearwater Clean Energy Conference, Tampa, FL (in-person)
3. GEM Technical Presentation (in-person)
4. 2024 ACT & CETP Knowledge Sharing Workshop (virtual)
5. 2025 NREL Cement and Concrete workshop in-person (which CU attended)

Our results of this project will be published under the American Concrete Institute (ACI) Structural Journal. The paper will be titled: **Effect of Low-Value Alternative Supplementary Cementitious Materials on the Mechanical and Durability Performance of Concrete Mixtures**

Ryan Bourns, Jennifer Kingsbury and Sip Chen Liew are CU's contributors. It is planned to be published in December 2025.

12.0 POST-PROJECT STEPS

12.1 NEXT STEPS AND FOLLOW-UP PROJECTS

CU is currently constructing a world's FOAK pilot project in Mississauga, Ontario, in collaboration with cement producer CRH, which will enhance slag from blast oxygen furnace (BOF) steel production to produce 32,000 tonnes per annum (tpa) of BOF slag SCM.

CU's R&D team is continuing to understand and validate the EAF slag, mine tailings and basalt (ultra-mafic) material testing from a variety of sources to deepen the understanding of these material as novel SCMs.

Given the success of validating some novel SCMs, CU plans to test additional materials such as waste concrete and incinerator ash.

12.2 PARTNERSHIPS

Our cement industry connections are always looking for additional materials to test that are local and cheap and do not require imports. The need for cement for critical infrastructure in Canada and global has not changed. The fact that we can use steel slag that is a by-product and turn it to a SCM that meets or exceeds cement standards is compelling while having the added benefit of reducing GHG emissions on site. There are currently 15 cement plants across Canada, of which most are feasible sites and clients for CU's technology.

13.0 OVERALL CONCLUSIONS

CU and NREL joint project advanced the knowledge of what novel SCM's can be used in the cement and concrete industry in Alberta, Canada and the USA. The rigorous literature review on ideal chemistry and morphology for carbonation along with an intensive study of availability of the product allowed us to narrow down to five candidates:

1. Waste glass
2. Mine tailings
3. BOF slag
4. EAF slag
5. Basalt

After doing detailed testing of pre- and post MACE treatment both in cement and in concrete (mortar) testing for all five materials, it was determined that BOF and EAF slag were the two best candidates for the TEA and LCA analysis and to conduct small scale commercial pours.

This was due the abundance of steel mills in Canada and the USA and the fact that both EAF and BOF slag are typically landfilled as an industrial by-product and have no further use. Both EAF and BOF post-MACE testing demonstrated high carbonation uptake and exceeding strength and durability in cement standards.

The resulting GHG emissions reductions are speculative as this was not a commercial project, but both partners conducted a preliminary TEA and LCA report based on the projects' results to determine a hypothetical scenario of a full-scale commercial project in Alberta and abroad. The specifics can be found in sections 7.3 and 9.3.

14.0 COMMERCIALIZATION AND TECHNOLOGY TRANSFER PLAN

14.1 PROJECT COMMERCIALIZATION ADVANCEMENTS

Please see section 12.1

For gaps in commercialization please see section 8.2

14.2 PROJECT TECHNOLOGY ADVANCEMENTS

The results of this project have illustrated that EAF and BOF slag are to be pursued for commercialization projects in Canada. It has concretely (pun intended!) advanced our feedstocks that can be commercialized. In parallel, it allowed CU's BoD and senior executive to proceed with the Mississauga FOAK project construction (Q2 2025). This project intends to lead CU into addtional financing such as project financing and equity rounds to take the the company to another level to unlock high quality project pipeline with our industry partners.

Steel slag is now one of CU's most excting new feedstocks that we are commercializing.

14.3 PROJECT TRL ADVANCEMENTS

For our feedstock analysis TRL growth:

Slag such as EAF-BOF went from 5-7

Waste glass from 4-7

Mine tailings from 3-6

Basalt from 3-6

14.4 TECHNOLOGY PROVISION AND THIRD-PARTY VENDORS

CU's custom-made MACE reactors, both lab scale and commercial scale use common machine and electrical parts. Our associated facilities such as ducting for flue gas, filters, conveyor belts, heaters, bag houses at a commercial site such as a cement or a steel plant all use standard equipment that can be largely sourced in Canada.

CU has established a variety of trusted vendors to supply and deliver the equipment needed. Another key element in our commercialization is the need to develop relationships with trusted Engineering and Procurement Construction (EPCs) firms for the engineering design and the actual construction of our technology on-site. CU has been working with Unitech and they are now very familiar with our technology to create 3D models for FOAK project in Canada.

14.5 COMPETITIVE SCAN

CU faces several notable competitors in the carbon capture and utilization (CCU) space, particularly within the cement sector. Companies such as Solidia and TerraCO_2 are exploring low-carbon building materials through CO_2 utilization–Solidia via the production of stable carbonates and TerraCO_2 through vitrified, amorphous silicates. CarbonCure is a direct competitor in the ready-mix concrete sector. Its technology uses recycled CO_2 to improve the concrete manufacturing process and reduce the built environment's carbon footprint. By incorporating CO_2 in the curing process, CarbonCure reduces cement usage and allows for retrofitting of ready-mix operations, offering versatility and cost-effectiveness. While CarbonCure has established a presence in North America, its technology primarily targets the ready-mix and precast subsectors, which together make up roughly 15% of the concrete sector.

Other companies that reduce cement use in the concrete sector include Solidia, CarbonBuilt, and Carbicrete. However, these technologies are mainly applicable to the precast concrete subsector, and they share the challenge of needing CO_2 transport and purification. In contrast, Carbon Upcycling's technology is applicable to both the precast and ready-mix sectors, providing a broader market opportunity.

There are also a number of companies which are emerging in the technology space, but are quite far from reaching a level of technological maturity and market presence comparable to CU. CU continuously monitors the competitive landscape through quarterly patent landscaping and freedom-to-operate analyses, which includes a watch on 68 companies that show or have shown activity in this space.

14.6 MARKET AND END-USERS

CU serves the building materials sector, specifically cement plants and ready-mix concrete producers. CU's process creates economic value through carbon credits from point- source CO_2 capture and carbon-intensive clinker displacement. The initial target market for CO_2-enhanced SCMs will be ready-mix, precast concrete, and cement producers across the province, with builders and municipalities as end-users. CU will provide pre-blended cement products via its host partner such as a cement plant enabling adoption without supply chain disruptions. Revenue will be generated through a tolling arrangement with the host plant.

The global SCM market represents a significant and growing opportunity, with projections indicating an increase from $20.1 billion in 2020 to $39.9 billion by 2030, at a compound annual growth rate (CAGR) of 7.2%. With the construction industry's push towards decarbonization, using SCMs to reduce cement's carbon footprint is crucial, making a "business-as-usual" approach untenable. Traditional SCMs, such as fly ash and ground granulated blast-furnace slag, are well-established, but CU's innovation enables the use of other sub-families of these feedstock families, significantly enhancing their CO2 uptake and subsequently improving concrete performance while reducing the carbon intensity of the final product.

Total market

The serviceable addressable market (SAM) for Carbon Upcycling is primarily cement producers in North America and Europe, where the company has already initiated projects. The total amount of cement produced annually in the United States and Canada, including imports, was ~120 million tonnes in 2022. With the standard 30% replacement factor for SCMs in most ready-mix markets in North America, the demand for SCMs is estimated at 36 million tonnes, conservatively valuing the SCM market at USD 1.3 billion annually (assuming a market value of $50 per tonne of SCM). CU's Serviceable Obtainable Market would be to capture 3-5% of this demand for SCMs in North America by 2045, which equates to a USD 65M annual revenue market opportunity.

EAF

In the United States, there is a substantial demand for SCMs, driven by a gap between domestic cement consumption and production. With annual cement consumption reaching 120 million tonnes in 2022 and assuming a 30% replacement factor of ordinary Portland cement (OPC) with SCM in commercial concrete mixes, the projected demand for SCM approaches 32 million tonnes annually, valued at approximately $1.92 billion at a market price of $60 per tonne.

The availability of EAF slag as a feedstock for SCM production is considerable. In 2022, EAF processes accounted for about 70% of the 57 million tons of steel produced in the US. Total domestic slag sales were estimated at 17 million tons, with 51% of the total coming from steelmaking. This translates to approximately 6.2 million tons of EAF slag sold in 2022. Current spot prices for SCMs and OPC clinker in the domestic market range from $55 to $69 per tonne, with EAF slag priced at $60 per tonne.

BOF

As the steel industry decarbonizes, more BOF slag will be produced, which, when processed with CU's technology, can allow higher substitution of clinker and continued usage of a domestic feedstock that would otherwise be a waste product. The Great Lakes region is recognized for its potential in BOF slag production and legacy stockpiles, which can be substantial, particularly in remote steel mills. Ten steel plants produce BOF slag in the Great Lakes region. The total annual capacity is 41 million tons of steel.

There are currently 15 cement plants across Canada, of which most are feasible sites and clients for CU's technology. CU's MACE reactors could be integrated at each of these sites, with the scale of the installations depending on the client's needs and the local availability of BOF slag.

CU operates on a tolling model, generating primary income from its customers. However, CU is exploring the concept for larger 200,000 TPA projects to shift to a licensing model to accelerate technology scaling. Under this new strategy, the proposed 200,000-tpa MACE plant is projected to generate significant revenue, estimated at $20 million annually or $600 million over the reactor's 30-year lifespan. This transition in the business model aims to facilitate rapid expansion while maintaining a steady income stream from the MACE technology.

14.7 MARKETING

Carbon Upcycling has formed strategic partnerships with several cement and concrete giants, including CEMEX, CRH, Amrize, Imerys and TITAN Group. CU has formed strategic partnerships with steel companies like Nucor. CU markets with the cement industry and related associations such as the PCA (Portland Cement Association). CU attends several cement, concrete, advanced manufacturing and cleantech conferences and conventions throughout the year to keep our investors, industry partners, vendors, government and academia all appraised onf our R&D and engineering projects. CU also communicates externally through social media o keep our visibility high within our community and industry.

14.8 DISTRIBUTION

See section 14.4 and 14.5

14.9 TECHNOLOGY PROTECTION

CU has an extensive IP strategy and portfolio to protect our technology. Our Director of IP, Ben Brigou has been working with CU for the past eight years and is intimately familiar with our technology (MACE) and feedstocks and processes. We have 11 patents granted in 23 families. CU has an additional 93 patents pending.

In Canada, our mechanochemical process is published and our process involving COMPOSITIONS COMPRISING A MECHANOCHEMICALLY CARBOXYLATED MINERAL FILLER AND A CEMENT AND/OR ASPHALT BINDER is also protected . We have steel slag specific as pending in Canada.

The primary goal of CU’s IP strategy and activities is to enable CU’s most crucial short-term revenue drivers by ensuring CU is the only company in key jurisdictions, such as the USA, Canada and Europe, able to offer MACE™ treated products that are derived from essential feedstocks like ashes, slags, clays, natural pozzolans, and glass, where CU has conducted groundbreaking research and technological advancements. These products find applications in the cement and concrete industry, and MACE™ type continuous process plants show lower CAPEX and OPEX compared to rival grinding technologies for feedstocks.

CU relies primarily on a combination of patents and trade secrets to achieve this goal, thereby supporting our two-track, long-term business strategy: (i) building, owning, and operating MACE™ process plants, and (ii) licensing the process technology to partners.

A secondary goal of CU’s IP strategy is to create initial IP positions based on foundational, low TRL development work performed at CU. These initial IP positions ensure that technologies that potentially become long-term revenue drivers for CU are protected at an early stage.

Next to the patent portfolio, CU has developed a wealth of specific know-how around the MACE™ process, which may qualify for trade secret protection. CU strives to take all reasonable measures to protect such know-how through appropriate clauses in employment, contractor and external collaboration agreements, limiting information distribution on a need-to-know basis, managing IT and site access, and providing IP awareness training to employees.

CU, in collaboration with external counsel, actively monitors third-party patent publications quarterly to identify patent families that may be relevant to CU's freedom-to-operate. When threats to CU's operations are identified, further actions are taken, such as filing third-party observations on pending applications, monitoring the prosecution of pending applications, performing validity analysis, opposition, and/or designing around.

CU also monitors third-party patent publications and general activity, as publicized in news articles and on websites, to identify potential infringers of CU IP and out-licensing opportunities

CU has recently reviewed the IP clauses in all its global employment and contractor agreement templates.

14.10 COST OF COMMERCIALIZATION

The primary cost is our MACE reactor. Our MACE reactor has been in development for a long time. This has been developed through many years and mainly via non-dilutive grants.

CU has successfully scaled its MACE technology from a lab concept to a fully operational pilot plant within 4 years of its first proof of concept runs. This scaling process involved upgrading from a 5-gram benchtop reactor to a 20-ton pilot reactor to process fly ash (see Figure 5) thanks to the XPRIZE project, which is 1,000,000X in scale. The estimated value of the non-dilutive Canadian funding since 2017 (XPRIZE) is about $3M to develop the MACE technology.

Figure 5: Scale growth of MACE reactors over time

CU has since created a commercial in-house 17,000 TPA to process fly ash at ACCTC, also through an ERA project!

Figure 6 : Commercial demonstration V2 – 2023 17,000 TPA (feedstock - fly ash)

CU from 2022 to present has been slowly taking some more advanced feedstocks such as fly ash into a commercial project. This technology transfer plan was developed over several stages such as Series A Funding, pilot project and initial revenue, then bridge funding to build FOAK projects complimented by additional non-dilutive funds. Once the FOAK project is built and producing enhanced SCMs, that is when CU has a steady revenue generation model.

To sum up:

Series A Funding and Growth

CU raised $36 million in Series A funding in 2023 and over $ 70MM in private & non-dilutive capital since 2014. These funds have supported significant operational expansion, R&D, and the growth of our intellectual property portfolio. CU has advanced its technologies and strengthened its competitive position as a leader in cement decarbonization. Our team has grown to 45 employees, with a focus on engineering, operations, and business development to ensure that we have the capabilities required for our ambitious growth plan.

Pilot Reactor and Revenue Generation

We are generating revenue from a pilot reactor in Calgary, Alberta. While this revenue is not material, it demonstrates our technology's commercial viability, confirms unit economics, and validates the process. Our partnership with a major ready-mix concrete producer underscores industrial players' confidence in our technology. The pilot project is key to scaling to a commercial level and provides data for future projects.

Financial Position and Capital Strategy

CU is debt-free, funding projects through equity and grants. This approach ensures financial stability while focusing on growth. Although we plan to incorporate debt to optimize capital costs, our priority is minimizing risk until projects generate revenue. CU was successful in securing a 18M bridge round financing primarily to support the Mississauga project and to continue strengthening the R&D lab and facilities in Calgary

Projected Revenue and Growth Milestones

With the completion of the CRH Mississauga project, we expect to generate $4 million in contracted annual revenue, providing financial resources to scale further. This milestone will validate our technology at a commercial level, create opportunities for future projects, and support our goal of expanding market presence.

Future

After successfully deploying this project in Canada, CU plans to develop a local center of excellence for low-carbon cement production in Alberta. This will scale technology deployment across the 130 cement plants owned by our strategic partners, and subsequently to the remaining 2600 cement plants world-wide. CU intends to raise a Series B round in 2027 to fund this centre and our future projects in Canada and USA. By 2050, CU aims to be the world's leading cement decarbonization company, enabling partners and customers to drastically reduce their emissions while offering a cost-competitive product to their infrastructure clients.

14.11 SHORT-TERM ACTIONS

Alberta's only steel plant, AltaSteel is already producing electric arc slag and will continue to create a material that can be used to develop local and cheap low-carbon cement. EAF slag is a strategically important feedstock for Carbon Upcycling as unlike conventional Blast Furnace slag, it is increasing in supply as steel plants switch operations to electrified processes. Importantly, EAF slag sequesters considerable CO_2 (up to 15% by mass) and enable coupling of the steel and cement industry within Alberta and globally. CU can utilize this product in house for Alberta's infrastructure projects that need concrete.

The ACT4 project work with BOF slag has directly shown that our work at Mississauga was validated. The project will use Carbon Upcycling's patented technology to permanently sequester CO_2 from the cement kiln and utilize it to transform locally produced industrial byproducts into high-quality, low-carbon supplementary cementitious materials (SCMs). Once operational in 2026, the facility will have the capacity to produce up to 30,000 tonnes of SCMs annually, directly contributing to Canada's climate and clean manufacturing goals.

Currently, the scope of Carbon Upcycling's FOAK (First-of-a-kind) project does not include the activation of EAF slag and is solely focused on the upcycling of BOF slag. Exploration of EAF slag as part of the Ash Grove project in Mississauga would be an important strategic initiative for Carbon Upcycling. ERA's support in an initiative to explore the activation of EAF slag would be a strategic benefit to Alberta and to CU's growth plans.

14.12 LONG-TERM COMMERCIALIZATION

Carbon Upcycling (CU) plans to utilize EAF slag to the USA since 70% of USA's steel plants are EAF slag. We have an LOI with a steel company to build a 120,000 TPA. CU anticipates that the project will be operational in 2028.

CU will continue to work with ultramafic rocks (ie basalt, serpentinite) for its potential for CO2 potential.

15.0 COMMUNICATIONS PLAN

15.1 KNOWLEDGE SHARING DURING PROJECT

In the USA, outreach activities for the MACE project outside of presentations, include high-level highlights and inclusion of the MACE project in the NREL portfolio of work on low carbon cement and concrete and CO2 mineralization (non-proprietary information is excluded). NREL often engages with other Department of Energy (DOE) offices and the MACE project is highlighted as an exemplary project with support from the DOE Fossil Energy and Carbon Management (FECM) portfolio. These audiences often include various stakeholders from the cement and concrete industry, chemical industry, and sustainable aviation fuels producers.

1.2023 ACT4 Knowledge Sharing Workshop (virtual presentation)

2. 2024 Clearwater Clean Energy Conference, Tampa, FL (in-person)

3. GEM Technical Presentation (in-person)

4. 2024 ACT & CETP Knowledge Sharing

5. 2025 NREL Cement and Concrete workshop in-person (which CU attended)

In Canada:

CU interfaces with the cement industry, particularly our investors such as CRH, Titan and CEMEX. CRH is also our partner for our FOAK BOF slag at a the cement plant at Mississauga Ont. The project will use Carbon Upcycling's patented technology to permanently sequester CO_2 from the cement kiln and utilize it to transform locally produced industrial byproducts into high-quality, low-carbon supplementary cementitious materials (SCMs). Once operational in 2026, the facility will have the capacity to produce up to 30,000 tonnes of SCMs annually, directly contributing to Canada's climate and clean manufacturing goals.

Workshop (virtual)

Knowledge sharing post project:

Our results of this project will be published under the American Concrete Institute (ACI) Structural Journal. The paper will be titled:

Effect of Low-Value Alternative Supplementary Cementitious Materials on the Mechanical and Durability Performance of Concrete Mixtures

Ryan Bourns, Jennifer Kingsbury and Sip Chen Liew are CU's contributors. It is planned to be published in December 2025

This project was foundational for our R&D team and created a lot of learnings for where CU should focus our efforts from a Business Development perspective. Because of this project, our FOAK Mississauga project (whose BOF slag we used) was given a FID to commence with construction. This is Canada.

Carbon Upcycling has a Communications, Lead who is passionate about the work we are doing and is communicating on a weekly basis in LinkedIn posts. Carbon Upcycling staff – including our C-Suite are also attending many conventions, conferences and workshops to enlighten government, industry and academia about our technology and the diversity of our feedstocks that can be utilized.

16.0 LITERATURE REVIEWED.

1An open database on global coal and metal mine production https://doi.org/10.1038/s41597-023-01965-y
2 An open database on global coal and metal mine production https://doi.org/10.1038/s41597-023-01965-y
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17.0 DEFINITIONS

XRD – X-ray Diffraction
XRF – X-ray Fluorescence
SEM – Scanning Electron Microscope
SCM – Supplementary Cementitious Materials
TGA – Thermogravimetric Analysis
ACCTC – Alberta Carbon Conversion Technology Centre
TEA – Techno-Economic Analysis
LCA – Life Cycle Analysis
CU – Carbon Upcycling
NREL – National Renewable Energy Lab (a USA Department of Energy funded National Lab)