CO_2 UTILIZATION IN CONCRETE - REMOVALS & REDUCTIONS - CARBONCURE - U.S. PROJECT #1

Document Prepared by Carbonomics, LLC

Project Title	CO_2 UTILIZATION IN CONCRETE - REMOVALS & REDUCTIONS - CARBONCURE - U.S. PROJECT #1
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1 PROJECT DETAILS

1.1 Summary Description of the Project

This project activity will capture waste CO_2 which would have otherwise been emitted into the atmosphere, or atmospheric CO_2 which would otherwise be in the atmosphere, and utilize that gas as a feedstock in the production of concrete. These project activities reduce greenhouse gas (GHG) emissions by sequestering CO_2 via the production of concrete. This manufacturing process has the additional benefit of requiring less Portland cement, which further reduces emissions, because the cement production process is highly energy and carbon intensive. The project activity will take place at the location where the concrete is first manufactured (mixed with cement, water, aggregates, etc.). At its peak, this project activity will result in approximately 366,400 metric tons of CO_2 reduced over the crediting period, the average annual emission reductions being 52,342 tCO_2eq.

1.2 Sectoral Scope and Project Type

Sectoral Scopes 4 and 6. This activity will be a grouped project. Project Type is Construction.

1.3 Project Eligibility

This project meets all the criteria set out in the VCS Program Guide, the VCS Standard and the VM0043 methodology approved under the VCS program. The project will both capture and mineralize CO_2 into ready-mix concrete and reduce the amount of Portland Cement used in the concrete compared to the baseline. The project will yield both permanent CO_2 removals and reductions complies with all of the applicability criteria under VM0043. Section 2.1 of the VCS Standard (v4.2) lays out the scope of the VCS program, including the following:

1) The six Kyoto Protocol greenhouse gases (this project will reduce CO_2 as explained in Section 4 of this document)
2) Ozone-depleting substances (not applicable)
3) Project activities supported by a methodology approved under the VCS Program through the methodology approval process (this project will use VM0043 as explained in Section 3 of this document)
4) Project activities supported by a methodology approved under an approved GHG program (not applicable as this is using a Verra methodology)
5) Jurisdictional REDD+ programs and nested REDD+ projects as set out in the VCS Program document Jurisdictional and Nested REDD+ (not applicable)

1.4 Project Design

This project is designed to be a grouped project, and the first facilities included in the project are listed in Appendix II of this document.

☐ The project includes a single location or installation only

☐ The project includes multiple locations or project activity instances, but is not being developed as a grouped project

☒ The project is a grouped project

Eligibility Criteria

As a grouped project, additional facilities can be included as new project activity instances as long as these new facilities install CarbonCure equipment, have arrangements with CarbonCure to transfer the ownership rights of the VCUs to CarbonCure, and can confirm adherence both to the regulatory surplus requirement (additionality) as well as the relevant applicable requirements outlined in Section 3.2. There are 43 initial project instances in this grouped project. In addition, to initial project instances, and for all new instances they will meet the following criteria:

- Are subject to the baseline scenario determined in the project description, which in this case (as specified in VM0043) is the continuation of manufacturing concrete through traditional processes – not with the use of CO2 capture and utilization)
- Take place within the US (for the initial project instances these are listed in Appendix II and take place in Georgia, North Carolina & South Carolina).
- Be validated at the time of verification against the applicable set of eligibility criteria.
- Have a start date that is the same as or later than November 6, 2018.
- Be eligible for crediting from the start date of the instance through to the end of the project crediting period (only).
- The initial project instances in this PD, are using CarbonCure equipment, that meet all of these criteria. The baseline scenario is the manufacturing of non-CO2 injected concrete. The facilities are all in the US with a start date after Nov. 6, 2018. And the project was validated against this set of eligibility criteria.
- Comply with at least one complete set of eligibility criteria for the inclusion of new project activity instances.
- Be included in the monitoring report with sufficient technical, financial, geographic and all other relevant information to demonstrate compliance with the applicable eligibility criteria.
- Have evidence of project ownership for the relevant start date of each project activity instance.
- Not leave one VCS project and enroll in another VCS project instance.

Project Proponent

Organization name	CarbonCure Technologies Inc
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Title	Business Operations and Credit Inventory Manager, Carbon Finance

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1.5 Other Entities Involved in the Project

Organization name	Carbonomics, LLC
Role in the project	Consultant
Contact person	Seth Baruch
Title	President
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1.6 Ownership

The project activities are taking place at the facilities owned by different companies that are using CarbonCure's technologies, but all will have contractual agreements with CarbonCure to transfer ownership of VCUs generated at their facilities to CarbonCure. The VCS Standard says project ownership can be demonstrated by "property or contractual right in the plant, equipment or process that generates GHG emission reductions".

An example of the agreements that CarbonCure has with the various facilities owned by different companies is attached as Appendix I in this document.

1.7 Project Start Date

The project start date will be November 6, 2018

Note that the project start date is November 6, 2018 as this was the date CarbonCure equipment was installed at the facilities. However, there was an initial commissioning and data-gathering phase for the first project instances, which required some adjustments to the monitoring approach. Thus, to be conservative, CarbonCure did not start seeking credits until January 1, 2019.

1.8 Project Crediting Period

This project will use a 7-year crediting period that is twice renewable, which will start on November 6, 2018 up until November 5, 2025. CarbonCure plans to have multiple projects in the project boundary prior to the end of this initial 7-year crediting period of its twice renewable project (e.g. a separate project for new producers who join after November 5, 2023).

1.9 Project Scale and Estimated GHG Emission Reductions or Removals

The estimated annual GHG emission reductions/removals of the project are:

☐ <20,000 tCO2e/year

☒ 20,000 – 100,000 tCO_2e/year

☐ 100,001 – 1,000,000 tCO_2e/year

☐ >1,000,000 tCO_2e/year

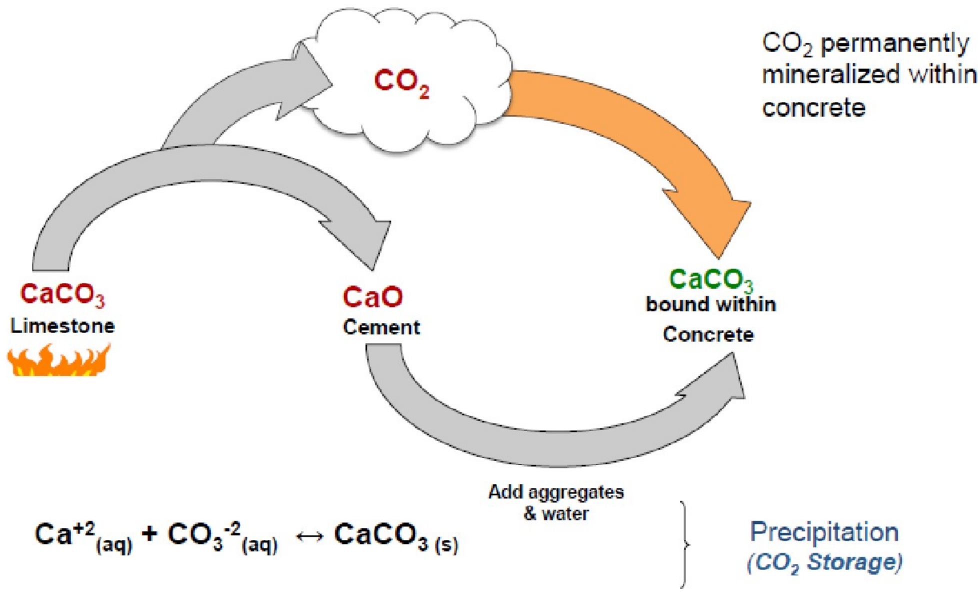
Project Scale	
Project	X
Large project	

Year	Estimated GHG emission reductions or removals (tCO_2e)
2018	1,400
2019	5,000
2020	10,000
2021	20,000
2022	30,000
2023	50,000
2024	100,000
2025	150,000
Total estimated ERs	366,400
Total number of crediting years	7
Annual Emissions	52,343

1.10 Description of the Project Activity

The project activity will consist of taking a conventional concrete manufacturing facility and adding equipment that will inject CO_2 into the concrete production process, mineralizing it into the concrete and permanently removing the CO_2. The intent of this project activity is to reduce emissions by producing a type of concrete that (a) sequesters CO_2 into the material itself, which has the additional benefit of (b) manufacturing a product that requires less Portland cement.

The sequestering of CO_2 lowers emissions by taking gas that would have otherwise been emitted (or would be in the atmosphere in the case of atmospheric CO_2 sources) and captures, compresses and transports it to a site where it can be embedded into the concrete itself. The concrete produced by the project will also require a lower amount of the cement, which further reduces emissions because cement production is highly energy and carbon intensive. A unit of cement not required as a result of the project activity thus results in lower emissions. The figure below represents this overall concept:



The expected lifetime of the CarbonCure CO2 injection equipment is approximately 15 years. This lifetime is based on the extensive research by the CarbonCure engineering team. Evidence was compiled from the relevant manufacturers and compared to current customer usage levels. The typical load for the equipment, as it is today, for Ready-Mix technology is an injection of 1 lb. of CO2 per yd3. On average, loads are about 8 yd3, and a ready-mix plant may produce up to 10 loads per hour. Thus, 80 lb of CO2 per hour or 640 lb of CO2 per day can be injected, assuming an 8-hour working day. CarbonCure expects to increase these figures over time.

1.11 Project Location

Appendix II lists all of the facilities where this project activity will be taking place at the time of project validation, the facilities are focused in and around Adairsville, Georgia, United States. However, as a grouped project, additional facilities will be included within the project boundary, which will cover the US.

1.12 Conditions Prior to Project Initiation

See Section 3.4 (Baseline Scenario).

1.13 Compliance with Laws, Statutes and Other Regulatory Frameworks

This project activity is in compliance with all local laws and other regulatory frameworks. All of the plants where the project is taking place are existing facilities, with all of their permits and approvals already in place. Thus, the project is introducing equipment that is retrofitted into existing facilities, with a small footprint, into these existing facilities. This equipment will inject CO2 into concrete, and the concrete producer will develop concrete mixes that use substantially less cement. The incremental level of activity – the different mixes and CO2 injection equipment – require no new compliance with any other statutes, laws or regulatory frameworks, beyond what these facilities currently have to comply with. All the concrete mixes developed as a result of this project activity will be ASTM certified.

1.14 Participation under Other GHG Programs

1.14.1 Projects Registered (or seeking registration) under Other GHG Program(s)

This project has not been registered, nor is CarbonCure seeking registration, under any other GHG programs.

1.14.2 Projects Rejected by Other GHG Programs

This project has not been rejected by any other GHG program.

1.15 Other Forms of Credit

1.15.1 Emissions Trading Programs and Other Binding Limits

Does the project reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowance trading?

☐ Yes ☒ No

This project is not currently reducing GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowance trading or GHG compliance program.

1.15.2 Other Forms of Environmental Credit

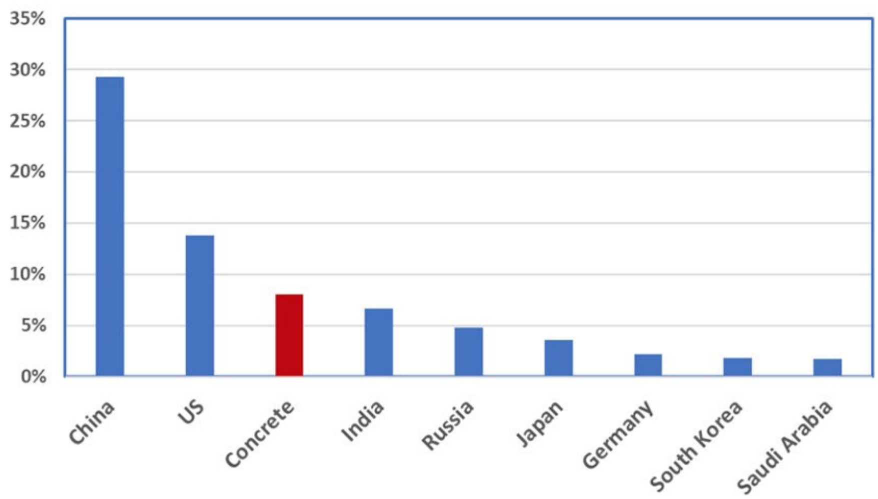
Has the project sought or received another form of GHG-related credit, including renewable energy certificates?

☐ Yes ☒ No

This project has not sought or received any other form of GHG-related environmental credit and is not currently eligible to participate in any other such programs.

1.16 Sustainable Development Contributions

Concrete is the most widely used man-made material in existence. The single largest ingredient in concrete is Portland Cement, and it has a massive carbon footprint. Cement is the source of about 8% of the world's CO2 emissions. If the cement industry were a country, it would be the third largest emitter in the world - behind China and the US[1]. To the extent that the concrete sector can be decarbonized, it will make a major contribution to sustainable development.



1.17 Additional Information Relevant to the Project

Leakage management

As stated in Section 8.3 of VM0043, no sources of potential leakage can be identified.

Commercial Sensitive Information

Commercially sensitive information includes information such as mix design details, CO_2 details (location, provider, source), contract language used by CarbonCure to prove ownership of credits (Appendix I) as well as the names and locations of facilities CarbonCure partners with (Appendix II, and where otherwise specified in Monitoring Reports). All commercially sensitive information will be disclosed to the VVB as needed and as it can be provided.

Further Information

N/A.

2 SAFEGUARDS

2.1 No Net Harm

There are no negative environmental impacts associated with this project. This project is taking place at existing concrete manufacturing facilities, so no new facilities are being constructed that could potentially have environmental impacts, and the equipment used to capture CO2 is modular and can be retrofitted directly into the existing facility.

2.2 Local Stakeholder Consultation

This project activity is taking place in facilities that already exist and for which environmental impacts have already been incurred. The specific project activity only involves the use of different mixes of concrete which were going to be used commercially regardless of CarbonCure and the placement on-site at the facility of CO_2 injection equipment. These incremental impacts are negligible compared to the facilities themselves. There will be no additional air or water impacts as a result of this GHG reduction project and no incremental impacts in the community. As a result, no stakeholder consultation is required.

2.3 Environmental Impact

For the reasons described in Section 2.1, no environmental impact statement was required for this specific GHG-reducing activity.

2.4 Public Comments

No public comments were received.

2.5 AFOLU-Specific Safeguards

This section is not applicable.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

VM0043, Methodology for CO_2 Utilization in Concrete Production, V.1

3.2 Applicability of Methodology

This project meets all of the eligibility criteria under VM0043, as indicated below (italics indicate how this particular project meets that specific criterion:

1. Project activities must manufacture concrete using CO_2 as a feedstock in the production process, through a process that requires lower amounts of cement as compared to concrete production processes that do not use CO_2 as a feedstock. *Facilities where CarbonCure equipment will be installed provide a concrete product that uses CO_2 as a feedstock – using technology developed by CarbonCure – to cure the CO_2 with the concrete and reduce its carbon footprint.*

2. The concrete produced by the project activity must have the same performance (e.g., compressive strength) as the baseline concrete that would have otherwise been used in the absence of the project. *CarbonCure and its concrete producer partners will manufacture concrete that meets all ASTM standards, which is a requirement in order to use that concrete in the market. ASTM's cement and concrete standards are instrumental in the evaluation and testing of concrete, cement, and aggregates. Concrete can have different properties depending upon the mixture that is used in creating it, which contains cement, chemical admixtures, and aggregates. These ingredients are mixed with water to create concrete which is used as a*

primary construction material in buildings. These cement and concrete standards allow laboratories all over the world to test and evaluate concrete mixtures to ensure their strength and safety. These standards help to identify the various properties of concrete including strength, elasticity, hardness, and workability.

3. Project activities must produce a concrete material that will be used and sold in the commercial market. *All facilities within the project boundary will deploy its concrete products in the market for their customers. Evidence of the sale of concrete products – which are produced as a result of the project activity – will be provided to the VVB as an attestation or similar proof to confirm applicability.*

4. Project activities may use supplementary cementitious materials in cement and concrete. *This project activity may include concrete production that uses SCMs.*

5. The use of recycled concrete is not eligible in either the baseline or project scenario. *To be clear, it is possible that concrete mixes in both the baseline and project scenarios could contain gravel or other material that originally came from concrete that was at end-of-life and ground up for use as an additive. This is often done in the industry and can happen in the baseline and project scenario. In some cases, the origin of gravel may not be known. That said, the producers will not be adding any additional recycled concrete in the project scenario. This confirmation can be provided to the VVB as an attestation or similar proof to confirm that there is no use of recycled concrete in the project scenario.*

6. This methodology is limited to the production of ready-mix concrete, as opposed to pre-cast molds. *CarbonCure's equipment will be injected into ready-mix concrete only, which can be demonstrated during project validation as the only projects included within the project boundary are ready-mix companies.*

7. Project proponents must source their CO_2 only from sources where the CO_2 would have otherwise been emitted to the atmosphere, for example from industrial sources, or from atmospheric CO_2 such as biogenic and Direct Air Capture sources. *CarbonCure will identify the sources of CO_2 to ensure applicability – and provide evidence to the VVB by providing the following:*

- *The location or locations from where the CO_2 is captured and processed*
- *Confirmation that the CO_2 is not coming from a geological well or CO_2 that was previously geologically sequestered, is captured as part of another process and is therefore a waste product or is atmospheric CO_2.*

As noted above, this information can be commercially sensitive, and thus will be provided directly to the VVB. If CarbonCure is unable to provide the VVB with sufficient proof, it will not receive emissions reductions from the sequestered CO_2. If CarbonCure is unable to fulfill this applicability criteria, only emission reductions based on the reduction in cement usage can be counted.

8. Project proponents must note if CO_2 is sourced from an emissions source that is regulated by a cap-and-trade program. If CO_2 is obtained from such a source, the project proponent must review the facility's emissions reporting to regulators to ensure it is not reducing its emissions

output based on the amount of CO_2 captured and supplied to the project activity. Alternatively, the project proponent can receive an attestation from the facility that it is not reporting lower emissions due to the capture of CO_2 for the project activity. If such reporting is not available or an attestation cannot be provided, the project activity must not count emissions reductions for the sequestering of CO_2 into concrete (although emission reductions can still be counted for the reduction in cement usage). *CarbonCure will identify the sources of CO2 to ensure these sources are coming from locations where no cap-and-trade program exists, and if they are regulated by a cap-and-trade program, ensure its not reporting the emissions reduction from the CO2 captured for the project activities – and provide this evidence to the VVB. In the case of the initial validation, the projects are located in Georgia, North Carolina and South Carolina, which does not have a cap-and-trade program.*

3.3 Project Boundary

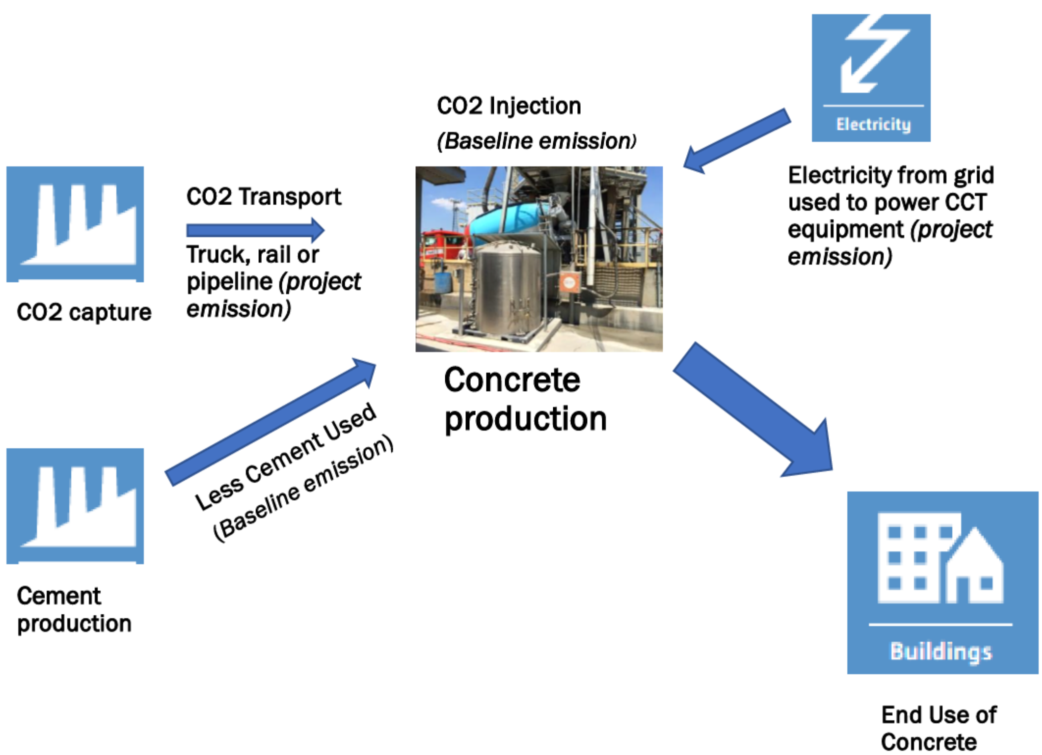
The project boundary and relevant GHG sources, sinks and reservoirs for the project and baseline scenarios are provided below:

Source		Gas	Included?	Justification/Explanation
Baseline	Captured CO_2	CO_2	Yes	CO_2 is the main gas that can be captured by carbon capture and utilization technology
		CH_4	N/A	Only CO_2 captured and sequestered into concrete is considered for this methodology
		N_2O	N/A	Only CO_2 captured and sequestered into concrete is considered for this methodology
		Other	N/A	Other GHGs (HFCs, PFCs, SF_6) are not used in this process.
	GHGs from cement production, including calcination	CO_2	Yes	The use and combustion of fossil fuels is a significant source of emissions from the production of cement. Note that CO_2 process emissions also occur as a by-product of the calcination process, where a calcium or magnesium carbonate such as limestone is heated with clay to form clinker (primarily calcium oxide) and CO_2. The heat required for the calcination process is typically

				supplied from the combustion of fossil fuels, resulting in the emission of further CO_2
		CH_4	No	Excluded for simplicity, emissions are considered negligible.
		N_2O	No	Excluded for simplicity, emissions are considered negligible.
		Other	N/A	Other GHGs (HFCs, PFCs, SF_6) are not used in this process.
Project	GHGs from the project facility	CO_2	Yes	Electricity, combusted natural gas or liquid/solid fuels are the primary energy sources that would be used to power a facility manufacturing concrete material. CO_2 is the primary emission from that combustion. This relates only to the incremental increase use of equipment needed to sequester the CO_2, not the entire facility itself, if that facility existed prior to the project but without the CO_2-sequestering equipment.
		CH_4	No	Excluded for simplicity, emissions are considered negligible.
		N_2O	No	Excluded for simplicity, emissions are considered negligible.
		Other	N/A	Other GHGs (HFCs, PFCs, SF_6) are not used in this process.
	GHGs from cement production	CO_2	Yes	Note that CO_2 process emissions also occur as a by-product of the calcination process, where a calcium or magnesium carbonate such as limestone is heated with clay to form clinker (primarily calcium oxide) and CO_2. The heat required for the calcination process is typically supplied from the combustion of fossil fuels, resulting in the emission of further CO_2
		CH_4	No	Excluded for simplicity, emissions are considered negligible.

		N_2O	No	Excluded for simplicity, emissions are considered negligible.
		Other	N/A	Other GHGs (HFCs, PFCs, SF_6) are not used in this process.
	GHGs from capturing, compressing and transporting CO_2	CO_2	Yes	Main GHG associated with the electricity requirements and fossil fuel usage associated with processing waste CO_2. Note also that the default factors for transportation emissions (tCO_2e/tonne-mile) includes all GHGs from transportation.
		CH_4	No	Excluded for simplicity, emissions are considered negligible.
		N_2O	No	Excluded for simplicity, emissions are considered negligible.
		Other	N/A	Other GHGs (HFCs, PFCs, SF_6) are not used in this process.

Also provided is a diagram of the project boundary, showing the physical locations of the various installations or management activities taking place as part of the project activity based on the description provided in Section 1.8.



3.4 Baseline Scenario

The baseline scenario is the continuation of manufacturing concrete through traditional processes (i.e., not through the use of CO_2 capture and utilization technology). This is specified as the baseline scenario in VM0043.

3.5 Additionality

VM0043 uses an activity method for the demonstration of additionality.

Step 1: Regulatory Surplus: There is currently no law or regulation requiring production of low-carbon cement and/or use of CO_2 injection technology in the project bounds, however several policies have been introduced that would permit or encourage, but not require the use of CO_2 injection technology. This is the case within the jurisdictions where the first instances (Appendix II) will be validated. Evidence of this is provided by CarbonCure's senior policy director, who engages in regulatory conversations and manages a subscription to a software platform that enables the user to monitor when any policy is proposed that includes language around carbon utilization in concrete. The platform is FiscalNote: https://app.fiscalnote.com/. This platform is frequently checked. At the time of this writing, there is only one jurisdiction which has a mandate which compels the use of CO_2 injection into ready-mix concrete in the United States in Honolulu HI (18-283) for municipal projects. The database can be shown to the VVB upon validation. When additional instances are included in the grouped project, regulatory surplus will also be confirmed for these facilities.

Step 2: Positive List: This project is on the positive list of VM0043 as it meets all of the applicability criteria listed in the methodology.

3.6 Methodology Deviations

This project will have multiple deviations from VM0043. The CarbonCure equipment itself does use electricity, and VM0043 requires direct metering or use of utility bills to quantify the amount of this electricity. However, the actual amounts used are very small and difficult to meter individually. Thus, CarbonCure will provide to the VVB an alternative method. This involves direct metering of a portion of CarbonCure devices and coming up with a conservative estimate, based on a representative sample of direct measurements, of kWhs used per unit of CO_2 injected into the concrete.

More specifically, CarbonCure has undertaken a number of tests at different concrete production facilities. These tests were conducted at the five separate concrete production facilities. These tests were conducted at facilities in diverse locations, representing different variables that could potentially account for different levels of electricity usage, such as climate.

Measurements for system energy/power usage breakdown were based on the phases of injection, including idle periods. The calculations show two examples using the peak power consumption to provide a conservative energy usage profile to avoid undercalculating: 1) all days - assuming the system is on 24/7 with no days off and 2) days used - assuming the system only had power the days it was used. The power consumption was calculated during an injection (peak power usage) by measuring the voltage supplied and the current of each enclosure separately. The current measurement was completed with an electrical line splitter to multiply the current value by 10X which was reported and corrected for. The results are provided in the table below:

Max energy usage per day using 117 W measurement during injection										
	Producer 1		Producer 2		Producer 3		Producer 4		Producer 5	
Max Energy usage per day	2.808	kWh	2.808	kWh	2.808	kWh	2.808	kWh	2.808	kWh
Energy per kg CO_2/Day (days used)	0.0711	kWh	0.0302	kWh	0.0954	kWh	0.0276	kWh	0.0817	kWh
Energy per kg CO_2/Day (all days)	0.0995	kWh	0.0432	kWh	0.1316	kWh	0.0350	kWh	0.1221	kWh

To be conservative, CarbonCure will use the highest of the numbers across all the projects, representing the highest potential level of project emissions associated with electricity usage. The testing above indicates that the highest value is 0.1316 kWhs of electricity per kg of CO2 injected into the process. CarbonCure believes this is an accurate, and conservative way to estimate electricity usage. CarbonCure does not believe these numbers will change throughout the year based on the type of equipment used.

As concrete producers can have many different mix designs with the same or similar compressive strength performance, CarbonCure has aggregated mix designs into CarbonCure Mix Designs based on various industry standard criteria and application. These are outlined in Appendix III of the Project Description. Carboncure Mix Designs are used in addition to the below deviations.

An additional deviation has been made to Equation 3 in the VM0043 methodology. As concrete producers can have many different mix designs which are similar in performance, the number of tests required to compare individual baseline and project mix designs to determine the cement cut is not practically feasible given the quantity or necessary given the similarities in mix design performance. As a result, CarbonCure will: a) conduct the testing (in accordance with the testing procedure listed in Appendix II of VM0043) for baseline and project CarbonCure Mix Designs that comprise 50% or more of the production volume; b) for the CarbonCure Mix Designs that this testing was conducted for, use the results of the testing data to quantify the cement cut; c) for the CarbonCure Mix Designs that this testing was not conducted for, CarbonCure will use the average cement cut from (b) (that is, the CarbonCure Mix Designs that conducted the testing) and apply a 1 standard deviation deduction to ensure conservatism. This approach provides a robust, accurate and conservative approach that is also practically feasible.

Similarly, a deviation is applied to the requirement for compressive strength tests. As outlined in VM0043 compressive strength tests are required to assess that the strength of concrete remains the same or greater than the baseline scenario. These tests are performed to provide evidence of strength to producers and concrete producers then go on to sell their concrete commercially. As concrete producers can have many different mix designs which are similar in performance and compressive strength, the number of tests required to compare individual baseline and project mix designs to determine the compressive strength is not practically feasible given the quantity or necessary given the similarities in mix design performance and compressive strength. As a result, CarbonCure will conduct the testing at the producer or in a lab (in accordance with the testing procedure listed in Appendix II of VM0043) for baseline and project CarbonCure Mix Designs that comprise 50% or more of the production volume, ensuring a robust, accurate and conservative approach that is also practically feasible.

Moreover, a slight adjustment to the calculation of the emissions associated with the processing of CO_2 has been made; Equation 12 in the VM0043 methodology. The value of injected CO_2 into concrete is used here rather than the value of total CO_2 transported to a facility, as the emission reduction calculation is done on a Ticket level based on each truck load of concrete, rather than as the total value transported to a facility. This change is made as CarbonCure does not receive any information around the total CO_2 transported to facilities. Evidence can be provided to VVBs that total CO_2 transported is injected into concrete as facilities do use CO_2 for other purposes.

For conservative purposes, CarbonCure treats instances where the CO2 source of plants has not yet been identified (CO2 suppliers can keep this information confidential) the same as it would if the CO2 source were a geological well. In these instances, CarbonCure includes an added_emissions_tonnes value for the portion of the injected CO2 that is not mineralized.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

Emissions in the baseline scenario are associated with two components. The first component is the emissions associated with the production of Portland cement. The second component is the emissions from the CO2 that are captured and sequestered in the concrete produced by the project activity.

$$BE_y = BE_{ACU,y} + BE_{CO2,cap,y}$$

Where:

BE_y = Baseline emissions in a given year (y) (tCO2)

$BE_{ACU,y}$ = Emissions from the production of Portland cement that would have been used in the absence of the project activity (avoided cement usage) (tCO_2e) in year y

$BE_{CO2,cap,y}$ = Emissions from the capture of CO_2 (tCO_2e) in year y

Component 1: Avoided Cement Emissions (BEACU):

The first component of the baseline emissions calculation is the displacement of conventional cement production by the project activity. These baseline emissions are calculated in the equation below. The amount of displacement is calculated by determining the quantity of cement that would have been used in the absence of the project and multiplying that by the emissions factor of the cement.

$BE_{ACU,y} = \sum I\ [Q_{cement,i,b,y}\ x\ EF_{cement}]$

Where:

$BE_{ACU,y}$	= Emissions from the production of Portland cement that would have been used in the absence of the project (tCO_2e) in year y
$Q_{cement,i,b,y}$	= Quantity of Portland cement that would have been used in the baseline for concrete produced using a project mix design *i* in year y (metric tonnes). In instances where available the mix_level_cement_cut is used, otherwise the corporation_level_cement_cut value is used. This is explained further and examples given in Appendix IV of VM0043.
EF_{cement}	= Emissions factor of Portland cement production (tCO_2e/metric tonne of cement)

There are three options for determining the emissions factor. For this project, CarbonCure will select Option 2 to determine the emissions factor of the cement – the use of Environmental Product Declarations or EPDs, which ultimately results in a more conservative cement emissions factor due to the 12% discount. The reason is that different producers procure cement from different cement plants, and it's not practical or feasible to collect emissions data from each, across such a large geography. In addition, the quantities purchased vary from year to year, along with the quantities from each cement production facility. All of the plants in the initial project will be using type I/II cement from Holcim– Holly Hill, which currently have a GHG intensity of 889 kg of CO_2 equivalent per tonne of cement or type III from Holcim Holly Hill which has a GHG intensity of 902 kg of CO_2 equivalent per tonne of cement. There are instances where the industry average value of 1,040 or 922 kg of CO_2 is also used. The EPD and relevant documentation for industry average values will be made available to the VVB upon project validation. Note that this EPD does not include the 12% discount that, per the requirements of VM0043, will be applied to project developers using Option 2. This discount is accounted for in the accompanying spreadsheet used to provide an ex-ante estimation of emission reductions throughout the crediting period.

Component 2: Captured CO_2 ($BECO_2$,cap): There are two options for determining the amount of CO_2 captured and mineralized in the concrete: Option 1: Testing to Determine Quantity of CO_2 Stored in the Concrete or Option 2: Using a Default Mineralization Efficiency Factor. *This project will use Option 2, which assumes that 60% of the CO_2 injected into the concrete is actually mineralized.*

$BE_{CO2,cap,y} = Q_{CO2,meter,y}\ x\ 0.60$

Where:

$Q_{CO2,meter,y}$ = Amount of CO2 injected in year y into the concrete production process, as determined by a flow meter (tCO2) at the project activity location.

0.60 = Conservative default for the quantity of CO2 that is mineralized into the concrete

4.2 Project Emissions

Like baseline emissions, project emissions include the emissions associated with the production of Portland cement used in the project activity concrete, which should be less than cement used in the baseline concrete. Project emissions include any additional electricity or fossil fuels used at the concrete manufacturing facility used by the CO2 injection equipment, as well as the emissions from the processing and transport of the CO2. Project emissions are calculated for every truck load of concrete that is poured (these are referred to as ‘Tickets’ in the concrete industry). Tickets for the same plant are rolled up and aggregated into a tCO2e GHG emission reduction or removal, and further combined by year. For all formulas noted below note that calculations are first done on the Ticket level. Then, all Tickets that were generated in a given year are aggregated.

Project emissions in year y of the project crediting period will be expressed as below, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PE_y = PE_{cement,y} + PE_{elec,y} + PE_{ffc,y} + PE_{CO2,y} + PE_{added\_emissions\_tonnes}$$

Where

PE_y = Project emissions in year y (tCO_2e)

$PE_{cement,y}$ = Emissions from the production of cement used at the project facility in year y (tCO_2e)

$PE_{elec,y}$ = Emissions from the incremental use of electricity by the CO_2 injection equipment at the project facility in year y (tCO_2e)

$PE_{ffc,y}$ = Emissions from the incremental combustion of fossil fuels by the CO_2 injection equipment at the project facility in year y (tCO_2e)

$PE_{CO2,y}$ = Emissions associated with the capture, compression and transport of CO_2 to the location where it will be sequestered in concrete in year y (tCO_2e).

$PE_{added\_emissions\_tonnes}$ = Emissions associated with CO2 source *where it is not known*, this applies the entire portion of q_CO2_meter at the project facility for the relevant facilities where CO2 is not known

The project emissions from the amount of cement used at the project facility are calculated as follows, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$pE_{cement,y} = \sum i \; Q_{cement,i,p,y} \; x \; eF_{cement}$$

Where:

$pE_{cement,y}$ = Emissions from the amount of cement used at the project facility in year y (tCO_2e)

$Q_{cement,i,p,y}$ = Quantity of Portland cement used in the project for concrete produced using a project mix design *i* in year y (metric tonnes)

eF_{cement} = Emissions for the Portland cement used in the project (tCO_2eq/metric tonne of). The same option as described in Section 4.1 will be used.

For this project, CarbonCure will not be using any additional fossil fuels, such as natural gas, beyond what it would use in the absence of this project activity. There will be a slightly elevated usage in electricity from the CO2 injection equipment itself, but it will be quite small. It will not be directly metered, but CarbonCure will provide an estimation as to how much electricity is typically used per quantity of CO2 injected, as outlined in Section 3.6.

The project emissions from the use of electricity at the project facility are calculated as follows, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PE_{elec,y} = Q_{elec,y} \times EF_{elec}$$

Where:

$PE_{elec,y}$ = Emissions from the use of electricity at the project facility in year y (tCO_2e)

$Q_{elec,y}$ = Quantity of electricity used by the CO_2 equipment from the grid in year y used to power the equipment needed to operate the project activity in year y (MWH)

EF_{elec} = Emissions intensity of the electricity (tCO_2/MWH)

The project emissions from the capture, compression and transport of CO2 to the facilities will use the second of the two options in VM0043 – the use of a default of 200 kWhs per tonne of CO2 used in the process. The injected CO2 into concrete is used here rather than the value of total CO2 transported to a facility, as the emission reduction calculation is done on a Ticket level based on each truck load of concrete that is poured. Note that for this project, transportation of C02 will likely be done via truck transportation and not by the use of pipelines., Thus a second component to project emissions for truck related transport is outlined below. To convert the 200 kWh/tonne to GHG emissions, CarbonCure will use the eFelec at the facility where the CO2 is processed, using the latest US EPA eGrid emission factors.

Emissions Associated with the Processing of CO_2 are illustrated below, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PE_{CO2,processing,t} = Q_{CO2,meter,t} X\ 200\ kWh/tonne\ X\ EF_{elec}$$

$Q_{CO2,meter,y}$ = Amount of CO2 injected in ticket t and aggregated for that year into the concrete production process, as determined by a flow meter (tCO2) at the project activity location.

EF_{elec} = Emissions intensity of the electricity (tCO_2/MWh)

Emissions Associated with the Transport of CO_2 are illustrated below, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PE_{CO2,transport,y} = \sum i\ (Q_{CO2,injected,y,i}\ x\ miles\ transported_{,I}\ x\ EF\ CO2\ i)$$

$PE_{CO2,transport,y}$ = Project emissions associated with the transport of CO_2 per ticket in year y (tCO_2e).

QCO2,injected,y,i = Amount of CO2 procured from a source in year y and injected into concrete by mode i. (tCO2)

EF $_{CO2\ i}$ = CO_2 emission factor for mode i (barge, rail, or truck), (tonne/tonne-mile).

Transport Mode	Emissions in mtCO_2/tonne-mile
Rail	0.0000231
Waterborne	0.000044
Truck	0.00023–- until March 2020 0.000223 – March 2020 – April 2021 0.000233 – April 2021 onwards
Air	0.00139

For this project, CO_2 will be transported by truck, and thus the 0.00023, 0.000223 and 0.000233 figure will be used based on the year that the credit is generated.

4.3 Leakage

No leakage needs to be considered in this project.

4.4 Net GHG Emission Reductions and Removals

Net GHG emission reductions and removals are calculated as follows, note that all calculations first occur on a Ticket level and are then aggregated for a given year. Due to the nature of the concrete industry, calculations for emission reductions and removals occur for every given truck load of concrete 'Tickets'. This is the case for all baseline and project calculations. All the Tickets for a given year are added together to calculate net GHG emissions reductions and removals. CarbonCure Technologies will provide a ER spreadsheet to their VVB so that all calculations can be traced accordingly.

$$ER_y = BE_y - PE_y$$

Where:

ER_Y = Net GHG emissions reductions and removals in year y (tCO_2e)

BE_Y = Baseline emissions in year y (tCO_2e)

PE_y = Project emissions in year y (tCO_2e)

See attached spreadsheet for more detail:

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2018	28,000	26,600	0	1,400

2019	100,000	95,000	0	5,000
2020	200,000	190,000	0	10,000
2021	400,000	380,000	0	20,000
2022	600,000	570,000	0	30,000
2023	1,000,000	950,000	0	50,000
2024	2,000,000	1,900,000	0	100,000
2025	3,000,000	2,850,000	0	150,000
TOTAL	7,328,000	6,961,600	0	366,400

5 MONITORING

5.1 Data and Parameters Available at Validation

Data / Parameter	EFcement
Data unit	$tCO2e/t$ of cement
Description	Emission factor for the production of Portland cement
Source of data	Project proponent and/or cement production facilities
Value applied	889 kgCO2e/t of cement, 901 kgCO2e/t of cement, 922 kgCO2e/t of cement or 1,040 kgCO2e/t but this will vary as more facilities are added to the project
Justification of choice of data or description of measurement methods and procedures applied	Option 2 is being used because Option 1 – Plant Specific Data – is not practical in this case, since producers will source cement from many different plants and in varying quantities from year to year. The plants in the initial project will be using a combination of the industry average for the emission factor of cement that is 1,040 kg of CO2 equivalent per tonne of cement for any time before 2021-03-12 or 922 kg of CO2 equivalent per tonne of cement for any time period where credits are generated after this date. Similarly, for the plants in the initial project, the value for type I/II cement from Holcim - Holly Hill, which has a GHG intensity of 889 kg of CO2 equivalent per tonne of cement is also used or the value for type III which has a GHG intensity of 902 kg of CO2 equivalent per tonne of cement. The EPD and Industry Average documentation will be made available to the VVB upon project validation. Similarly, for the plants in the initial project, the value for industry averages may change based on the year of credit generation. Note that this number does not include the 12% discount for use of Option 2 (EPDs) and this discount is accounted for separately in the accompanying spreadsheet.
Purpose of Data	Calculation of baseline and project emissions, because the use of cement occurs in both the baseline and project scenarios.
Comments	N/A

Data / Parameter	EFCO2,i
Data unit	Tonne of CO2 per tonne-mile
Description	Emission factor for mode of transport.
Source of data	See table in Section 8 from EPA Center for Corporate Climate Leadership
Value applied	0.00023–- until March 2020 0.000223 – March 2020 – April 2021 0.000233 – April 2021 onwards These values will vary as additional verifications are completed and the credit period year changes.
Justification of choice of data or description of measurement methods and procedures applied	This is an accurate and simplified default for considering the emission factors of different modes of transport.
Purpose of Data	Calculation of project emissions.
Comments	N/A

Data / Parameter	Default factor for amount of energy required to capture, treat and compress a tonne of CO2
Data unit	kWh/tonne
Description	Default factor for amount of energy required to capture, treat and compress a tonne of CO2
Source of data	See Appendix V of VM0043
Value applied	200 kWh/tonne of CO2 processed
Justification of choice of data or description of measurement methods and procedures applied	See Appendix V of VM0043
Purpose of Data	To provide an option for determining project emissions from capturing CO2 if that information is not available from the CO2 supplier.
Comments	

Data / Parameter	Default efficiency of mineralization
Data unit	Ratio
Description	Amount of CO_2 injected into the process that gets mineralized into the concrete.
Source of data	See Appendix VI
Value applied	0.60
Justification of choice of data or description of measurement methods and procedures applied	See Appendix VI of VM0043
Purpose of Data	In some cases, one concrete manufacturer may be producing too many mix designs for the testing to be feasible or practical. In this case, project proponents must use a default based on the percentage of CO2 injected into the process (as determined by a meter) and actually mineralized.

Comments	This parameter indicates the *efficiency of mineralization*. There have been tests done on this efficiency as outlined in Appendix V of VM0043. These tests show quite a range of results in terms of the efficiency of the uptake of CO_2 into the concrete, and there appears to be little correlation between the efficiency of mineralization and the percent dosing of CO_2. However, the lowest test result is at 76%, meaning that three-quarters of the CO_2 that is injected into the process actually gets mineralized into the concrete. At a conservative default, the assumed efficiency of mineralization will be set at 60%.

5.2 Data and Parameters Monitored

Data / Parameter:	$Q_{cement,i,p,y}$
Data unit:	Tonne
Description:	Quantity of Portland cement used in the project for concrete produced using a project mix design *i* in year y.
Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	Use standard weighing procedures to determine mass of cement used to produce concrete over the course of year Y.
Frequency of monitoring/recording:	Measured continuously.
Value applied	The values applied will vary based on each CarbonCure mix design for a given facility. As this is a grouped facility with multiple facilities and hundreds of mix designs this data is provided directly to the VVB upon validation.
Monitoring equipment	Scales
QA/QC procedures to be applied:	Note that frequency of calibration is based on DOT laws based on which region facilities are in the USA. As this is a grouped project various calibration frequency will be applied to different project instances. For the first project instance the GDOT requires calibration to occur every 6-months. With calibration certificates available for verification.
Purpose of data:	Calculation of baseline and project emissions.
Calculation method:	N/A

Comments:	N/A

Data / Parameter:	$q_{Cement,b,i,test\ n}$
Data unit:	Tonne
Description:	Quantity of Portland cement used to prepare baseline compressive strength test specimen n for concrete produced using a mix design that results in a concrete of equivalent compressive strength to project mix design *i.*
Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	See Appendix II of VM0043
Frequency of monitoring/recording:	Once per project crediting period for the Corporation's (or Division's) CarbonCure Mix Designs that comprise 50% or more of the product volume.
Value applied	The values applied will vary based on each CarbonCure mix design for a given facility. As this is a grouped facility with multiple facilities and hundreds of mix designs this data is provided directly to the VVB upon validation.
Monitoring equipment	Scales
QA/QC procedures to be applied:	See Appendix II of VM0043
Purpose of data:	Calculation of baseline emissions by comparing the amount of cement in the project activity concrete and the amount of cement that would be required in the baseline concrete.
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$q_{Cement,p,i,test\ n}$
Data unit:	Tonne
Description:	Quantity of Portland cement used to prepare project compressive strength test specimen n for concrete produced using project mix design *i*

Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	See Appendix II of VM0043
Frequency of monitoring/recording:	Once per project crediting period for the Corporation's (or Division's) CarbonCure Mix Designs that comprise 50% or more of the product volume.
Value applied	The values applied will vary based on each CarbonCure mix design for a given facility. As this is a grouped facility with multiple facilities and hundreds of mix designs this data is provided directly to the VVB upon validation.
Monitoring equipment	Scales
QA/QC procedures to be applied:	See Appendix II of VM0043
Purpose of data:	Calculation of baseline emissions by comparing the amount of cement in the project activity concrete and the amount of cement that would be required in the baseline concrete.
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$Q_{CO2,meter,y}$
Data unit:	Tonne
Description:	Amount of CO_2 injected in year *y* to produce concrete, as determined by a flow meter.
Source of data:	CarbonCure
Description of measurement methods and procedures to be applied:	The use of calibrated flow meters. Calibration is conducted according to the equipment manufacturer's specifications (FUTEK), once a year. The amount of CO_2 must be metered before entering the production process and must be subject to standard calibration and QA/QC procedures for the measurement of critical data variables.
Frequency of monitoring/recording:	Data must be monitored continuously and recorded on at least a daily basis.

Value applied	For the first crediting period the values applied are listed below. As additional verifications are completed these values will vary. 2019 – 51.1 2020 – 129.7 2021 – 255.8
Monitoring equipment	Flow meter
QA/QC procedures to be applied:	Calibration of meters will take place once per year.
Purpose of data:	Calculation of baseline emissions when measuring how much CO_2 was injected into the concrete and for project emissions when determining emissions from processing.
Calculation method:	N/A
Comments:	Project proponents may use a mass-flow meter to measure mass of CO_2. The meter is embedded into the CarbonCure equipment.

Data / Parameter:	$Q_{Concrete,i,p,y}$
Data unit:	Tonne
Description:	Quantity of concrete produced by the project for project mix design *i* in year y.
Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	Standard procedures to weigh concrete product, standard industry practice for all concrete suppliers.
Frequency of monitoring/recording:	Continuous
Value applied	The values applied will vary based on each CarbonCure mix design for a given facility. As this is a grouped facility with multiple facilities and hundreds of mix designs this data is provided directly to the VVB upon validation.
Monitoring equipment	Scales

QA/QC procedures to be applied:	Standard procedures to ensure accuracy of weighing methods, including manufacturer-recommended calibrations for measuring devices, which will be every three months. Project proponents will keep clear records of all concrete produced and used at construction sites, which can be presented to the validation/verification body.
Purpose of data:	Calculation of baseline emissions
Calculation method:	N/A
Comments:	CarbonCure will list for each producer the number of mix designs that will be considered for emission reduction calculations and the approximate percentage those mix designs comprise of the entire facility's production. This information will be provided to the VVB.

Data / Parameter:	$Q_{elec,y}$
Data unit:	MWh
Description:	Quantity of incremental, additional electricity from the grid in year y used to power the equipment needed to operate the project activity in year y (MWH)
Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	See Section 3.6
Frequency of monitoring/recording:	See Section 3.6
Value applied	For the first crediting period the values applied are listed below. As additional verifications are completed these values will vary. 2019 – 6.7 2020 – 17.1 2021 – 33.7
Monitoring equipment	Electricity meter
QA/QC procedures to be applied:	N/A as defaults will be used as described in Section 3.6.
Purpose of data:	Calculation of project emissions

Calculation method:	N/A
Comments:	N/A

Data / Parameter:	EF_{elec}
Data unit:	tCO_2e/MWH
Description:	Emission intensity of electricity used to transport CO_2 and at the project facility.
Source of data:	US EPA eGrid
Description of measurement methods and procedures to be applied:	eGrid emissions factor published by the US Environmental Protection Agency for the US sub-region where the facility is located (latest available information) may be used. This will be used for determining the emissions intensity of the 200 kWh/ton default. Note that these may vary depending on the year of credit generation.
Frequency of monitoring/recording:	Annual
Value applied	For the first project these values are SRSO, SRVC & SRTV. For SRSO these values are: 1027.93 lb/MVh, 969.16 lb/MVh, 949.7 lb/MVh. For SRVC these values are: 743.33 lb/MVh, 675.42 lb/MVh, 623.11 lb/MVh. For SRTV these values are: 1031.54 lb/MVh, 860.18 lb/MVh, 834.18 lb/MVh. Taking into account the region and year that the credit was generated in. Depending on the region and year of credit generation these values may vary for all future projects.
Monitoring equipment	NA
QA/QC procedures to be applied:	NA
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	Miles transported in year y by mode *i*
Data unit:	Miles
Description:	Miles of shipped CO_2 to the project site by mode *i*.

Source of data:	CO_2 supplier, transporter and CarbonCure
Description of measurement methods and procedures to be applied:	The company supplying or transporting the CO_2 should provide data to project proponents about the total number of tonnes delivered and total miles driven to the final destination. If the exact location of where each canister/tank of CO_2 was filled cannot be precisely determined by the CO_2 supplier, a reasonable and conservative estimate will be provided based on ALL locations where the particular CO_2 supplier is obtaining its gas. Suppliers may obtain CO_2 from multiple sources, and this may be difficult to track. However, if the supplier knew that the furthest location away was X miles, and that is the maximum, that number could be used for all CO_2 because it would be the most conservative.
Frequency of monitoring/recording:	Annual
Value applied	The values applied will vary for each facility, as this is a grouped project there will be a large number of facilities and as a result values are provided to the VVB for each given verification.
Monitoring equipment	Google maps or odometers
QA/QC procedures to be applied:	Records from CO_2 supplier or transporter should be available at project verification.
Purpose of data:	Calculation of project emissions.
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$Q_{CO2,supplied,t,i}$
Data unit:	Tonne
Description:	Amount of CO2 injected in ticket t into the concrete production process, as determined by a flow meter (tCO2) at the project activity location. This value is then rolled up for a given year where relevant.
Equations	12
Source of data:	Amount of CO2 injected into a ticket, and aggregated for a given year where relevant.

Description of measurement methods and procedures to be applied:	Telemetry system installed onsite at producer plant that measures exact quantity of CO2 injected into concrete.
Frequency of monitoring/recording:	Annual
Value applied	For the first crediting period the values applied are listed below (with tickets aggregated up into years). As additional verifications are completed these values will vary. 2019 – 51.1 2020 – 129.7 2021 – 255.8
Monitoring equipment	N/A
QA/QC procedures to be applied:	N/A
Purpose of data:	Determination of project emissions associated with transporting CO_2 to the project site.
Calculation method:	N/A
Comments:	The *CO2 <u>supplied</u> to the facility* is here assumed to equal the total amount of CO2 injected into concrete. CarbonCure has confirmed this by running numerous tests to compare total CO2 injected into concrete with total value of CO2 transported to a facility, this will be available upon request to the VVB. Additionally, where requested CarbonCure will provide proof that producers are not using CO2 except for CarbonCure operations. The deviation noted here is included in the deviation section, and simply takes into account the feasibility of acquiring CO2 sales records for all facilities. Project proponents must demonstrate that the captured CO_2 is coming from a waste source where the gas would – in the absence of the project activity – be emitted. The project proponent should obtain an attestation from the supplier of the CO_2 or provide other evidence that the captured CO_2 would have otherwise been emitted.

5.3 Monitoring Plan

The Monitoring Plan will comprise of the following elements:

1. Quantity of Concrete produced: The cornerstone of any concrete producer's business is producing ready-mix concrete and bringing it to job sites. As such, the company is well acquainted with the method to quantify both the volume of concrete (in cubic yards) as well as mass (in tons). The producer will measure their concrete production by scales used as standard industry practice in the concrete industry. The scales in the plants are measured by weight to achieve the volume desired, and the companies generally have QC software that allows the company to convert the volumes to mass/weight. The scales are calibrated by a third party at least once per year. Calibration reports at all facilities will be made available to the VVB upon request. Quantities of concrete produced will be provided by CarbonCure Mix Design, with weighing records specified by CarbonCure Mix Design (see below).

2. Amount of cement that concrete would have otherwise been required: The producer will be able to determine the cement content in the project activity concrete by the amount of cement mixed in. Most producers have a well-established way to precisely measure the cement content of their concrete. However, an important component of this part of the monitoring plan is establishing how much cement would have otherwise been used. To do this, CarbonCure and the producers will do the following
    a. Define CarbonCure Mix Designs: For each Corporation, CarbonCure will provide, in a database made available to the VVB, a listing of each CarbonCure Mix Design that the Corporation's facilities will produce. If the same CarbonCure Mix Design is used at multiple facilities for the Corporation, that will be indicated. CarbonCure will indicate which CarbonCure Mix Design was used, based on its criteria (design strength (psi), cement type (e.g., type I/II), % SCMs, blend of aggregates (e.g. coarse+fine), strength enhancing admixtures (e.g. Xseed)) - and provide a specific identification number for that CarbonCure Mix Design. New CarbonCure Mix Designs can be added over time by a Corporation, and that information will be provided to the verifier upon each verification. The defined CarbonCure Mix Designs can be found in the Appendix III of this document.
    b. VM0043 requires that the baseline and project samples have an equivalent level of compressive strength, and CarbonCure and the individual producer will conduct these tests for at least three baseline and three project samples for the CarbonCure Mix Designs that comprise 50% or more of production. The process for conducting these tests is provided in Appendix III of this document. These tests will take place at a lab or across the Coproration's plants (unless the same mix is used across multiple sites, in which case the testing procedure has to be done only once), and the results for each CarbonCure Mix Design will be sent to CarbonCure and archived in a central database that will be made available to the

VVB. CarbonCure Mix designs can yield slightly different compressive strength results based on test results. As a result, if multiple tests are conducted on the same CarbonCure Mix Design then an average of all tests is taken to determine the cement reduction of the CarbonCure Mix design. As concrete producers can have many different mix designs which are similar in performance, mix designs will be aggregated into CarbonCure Mix Designs based on their criteria (design strength (psi), cement type (e.g., type I/II), % SCMs, blend of aggregates (e.g. coarse+fine), strength enhancing admixtures (e.g. Xseed)), resulting in multiple mix designs leveraging the same compressive strength testing. To ensure an approach that is robust, accurate and conservative but also practically feasible, CarbonCure will conduct this testing for the CarbonCure Mix Designs that comprise 50% or more of production. The VVB will also be allowed to visit any of the project sites and review any of the tests (within the monitoring report 2-year period), testing procedures and the personnel who conducted them. This testing data will be archived for a period of two years after each monitoring report.

c. For each CarbonCure Mix Design, CarbonCure and the producer will develop a baseline mix – an equivalent concrete product that would be used for the same application but which would not have included any of the technologies or materials from the project activity. In other words, the reference concrete product is what would have been produced in the baseline scenario, using previous levels of cement. These reference amounts will contain the baseline levels of cement which are integral to determining the cement cuts. To determine the value of cement cuts, the difference between the baseline and project scenarios is used. CarbonCure will arrive at these amounts by one of two ways: 1) for the CarbonCure Mix Designs that this testing noted above was conducted for, use the results of the testing data to quantify the cement cut; or 2) for the CarbonCure Mix Designs that this testing was not conducted for, CarbonCure will use the average cement cut from (1) but apply a 1 standard deviation deduction to ensure conservatism.

3. Quantity of CO_2 used:

   a. CO_2 injection will be used to further reduce the amount of cement content required. This element of the Monitoring Plan will require CarbonCure to measure, through a flow meter, the amount of CO_2 that is injected into the process. This will happen at each site. The flow meter data will be provided by site, but it will not be necessary to measure the CO_2 flow by mix design because the CO_2 injected is determined in aggregate. However, that data will be exported by each site on a daily basis, into a centralized data management that will be maintained by CarbonCure at its headquarters.
   b. Transport-related emissions must also be taken into account. CarbonCure will have a system that accounts for how much CO_2 is delivered to each site – and exactly how far that site is from the source. This is important because this data parameter is measured in tonne-miles. For example, if a shipment of 10 tons of CO_2 is

shipped to a facility that is 84 miles away from the CO_2 source, the central system will record 840 tonne-miles (10*84). CarbonCure will know exactly how many tons of CO_2 will get delivered to each site and will know exactly how many miles that site is from the CO_2 source. Thus tonne-miles can be easily calculated. The central CarbonCure team will keep track of CO_2 sales to each facility throughout the project year and will convert that to tonne-miles on a monthly basis. This will be cross checked by CO_2 supply sale records to each facility, which can be spot-checked by the verifier.

c. Calibration for the equipment that measures the amount of CO2 injected into the concrete mix will occur during the course of the project. Each CarbonCure system is calibrated by comparing the metered CO2 via a flow model versus the weight change from a CO2 tank that is on four load cells in the CarbonCure manufacturing facility. The data from the calibration is aggregated to confirm that the flow model is +/-5% of what the load cells have sensed. Calibration is completed once before the equipment is deployed to facilities. Additional calibration can be done based on the performance of the equipment.

4. Quantity of cement actually used: In its normal course of business, every concrete producer tracks – at every one of its facilities – both the cement content of its concrete and everything else – water, aggregates, etc., which go into every truck before it goes to a job site. Each component of the concrete is weighed separately before it is mixed. All of this weight data is archived, so the producer will know how much cement went into each unit of concrete that is sent to each customer location. The demonstration of this data management system will be provided upon project validation, and a verifier will be able to randomly spot check individual records (eg: quantity of cement mixed with Concrete Project Design X on Day Y, which went in a truck to Job Site Z).
5. All other calculations: CarbonCure has retained Carbonomics to assist with data management, monitoring reports, and overall assistance with assuring the yield of carbon offsets. Carbonomics will work with CarbonCure to prepare data in accordance with this Project Description and VM0043 and complete monitoring reports prior to each verification. As such, Carbonomics will be able to monitor for changing parameters, such as updated eGrid factors.

In instances of non-conformity, the below actions will be taken to ensure that the data is monitored and calculated accurately.

Points of Vulnerability and QA/QC: Most of the data required for this project are handled as a matter of course for concrete producers and CarbonCure, such as concrete quantities and cement purchases – essentially normal supply chain management and product sales. The potential weak points relate to transferring that data from each of the facilities to a centralized database that will be reviewed by a VVB. Again, the key data includes:

- List of CarbonCure Mix Designs and justification for specifying a specific mix design within the CarbonCure Mix Designs

- Developing a reference baseline sample and measuring the compressive strength of that sample and the project sample for the CarbonCure Mix Designs that comprise 50% or more of production
- Concrete produced, delineated by CarbonCure Mix Design
- Cement quantities actually used
- CO_2 usage, transport, and electricity consumption of the CO_2 injection equipment

These are not a large number of data variables but if they occur across many facilities and multiple mix designs, there is potential for human error. The following QA/QC procedures will be put in place:

- CarbonCure has built in quality assurance into their Technical Services team that uses standard operating procedures to capture baseline data. A data management system will be established to transfer data for all key parameters to the overall project manager at CarbonCure for this activity. Frequent double checking of the data that gets exported to the central management system will take place, as will a system to automatically flag anomalies if, for example, there are unexplained data swings – outside of established parameters – that would indicate an error.

- Cross-checks will take place, such as what the central database says for CO_2 deliveries and comparing that to invoices from the CO_2 supplier. And if the flow meter data from CarbonCure differs substantially from CO_2 purchase records at a specific site, the central team will be able to spot it. In cases when data differences cannot be reconciled, CarbonCure will use the data that leads to the more conservative estimation of emission reductions.
- The central CarbonCure team will also make sure that key records related to the measurement equipment itself are archived and available, particularly calibration reports for meters and other key measurement devices. All calibration will take place in accordance with the recommendations of the measurement device manufacturer. A list of measurement devices at each site will be provided to the VVB upon project validation.

A very simplified sketch of the overall data management system can be illustrated in the table below:

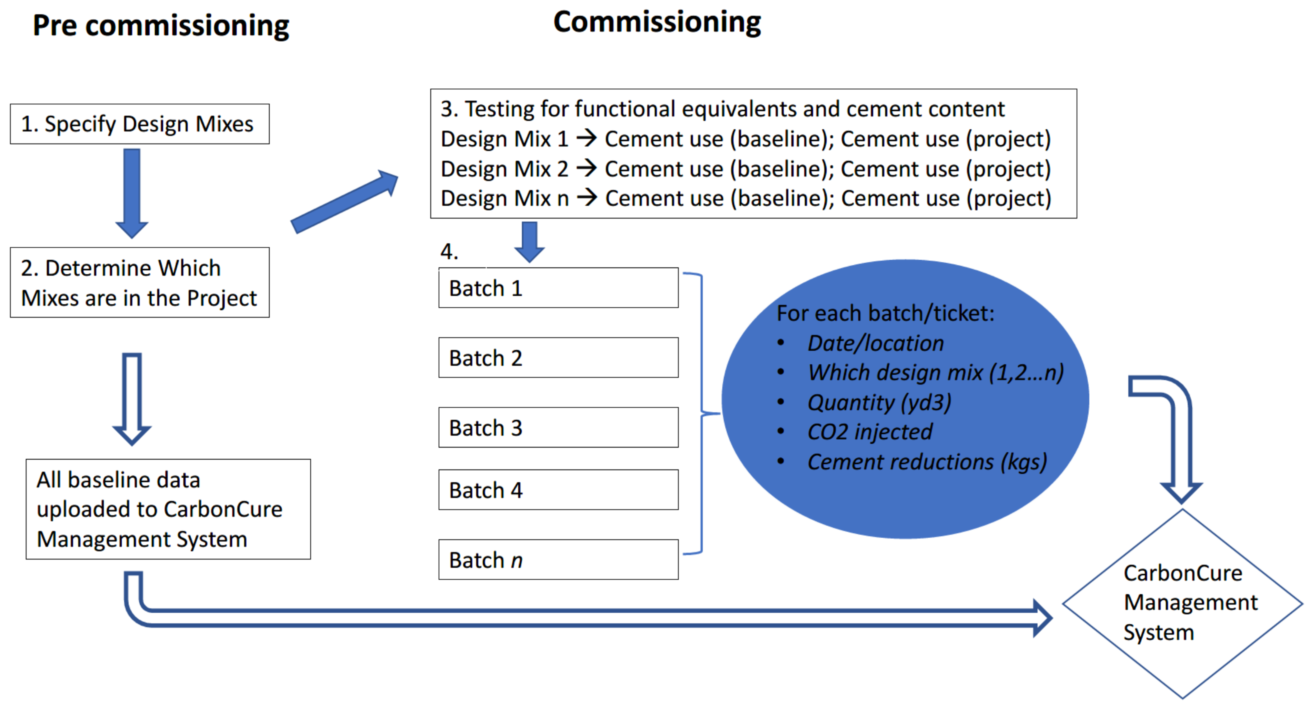
Parameter	Site 1	Site 2	Site n
CarbonCure Mix Design 1..n (list each CarbonCure Mix Design separately)			
Baseline test results 1, 2, 3 (based on its CarbonCure Mix Design)			
Project test results 1, 2, 3 (based on its CarbonCure Mix Design)			

Quantity of concrete produced by CarbonCure Mix Design 1…n over period X			
Quantity of CO_2 shipped (tons) over period X			
Distance between site and CO_2 source			
Quantity of CO_2 from flow meter			
Estimated amount of electricity used over period X			
EF of grid at site n			
List of measurement devices 1…n			
Latest calibration report for measurement devices 1…n			

CarbonCure has a system in place already with its producers to collect this data through a web portal, which is uploaded to a centralized data management system operated at CarbonCure's headquarters.

When a new facility installs CarbonCure equipment today, the site goes through a pre-commissioning phase, where baseline mix designs are identified and cataloged with the amount of cement, SCMs, etc. included in the design. From there, CarbonCure determines the materiality of each mix design. CarbonCure plans to just focus on the mix designs that make up the majority of the facility's production will be part of the offset project as some mix designs may simply be too small a percentage of a site's production to be worth all the testing. Based on the producer's actual production, CarbonCure may revisit a site after the pre-commssioning phase to complete additional strength testing.

In the commissioning phase, CarbonCure runs trials on these primary mix designs to determine the maximum amount of cement reduction that can take place. After full installation, CarbonCure is then able to track each batch that is produced and goes into a truck on its way to the construction site. This batch data, including the date and location of where the concrete went, is uploaded to the CarbonCure management system. The vast majority of concrete producers have this entire process – from mixing the ingredients to weighing the concrete prior to going into the truck to tracking to the final destination – automated, and thus CSV data can automatically be sent to CarbonCure, without any real human intervention. CarbonCure can track each batch, what mix design it is, what amount of cement is in that batch, etc.



Organization

Various teams at CarbonCure are dedicated to the data collection, processing and storage of credit data. These teams have various levels of expertise in their field, and work in parallel with one another.

All engineering and technical teams work under the SVP of Engineering. The research team works under the SVP of Technical Development. The Carbon Finance team works under the Senior Director of Carbon Finance.

- The Technical Services team at CarbonCure work closely with concrete producers to perform relevant QA/QC tests as well as supporting producers to collect various. This is a trained and skilled team of engineers that are highly familiar with the concrete industry.
- The Software Engineering team works to process the credit data based on the VM0043 methodologies calculation and stores it accordingly. This team follows a typical structure of a Software company, all with high fluency in data engineering and management.
- The Research team performs all relevant calibration monitoring and reporting. This is a team of Engineers that have numerous years of experience in the concrete innovation sphere.
- The Carbon Finance team – and individuals – Casey Leist, Ingy El Kafrawy – will be responsible for leading the monitoring period with various groups within the CarbonCure team. This team has experience in the carbon credit space and the nuances of monitoring, reporting and validation.

APPENDIX I. Proof of Ownership

[redacted]

4. **TRADEABLE ENVIRONMENTAL CREDITS.**

4.1 If Tradeable Environmental Credits are generated as a result of this Agreement ("**Applicable Credit(s)**") the Parties agree that they are the property of CarbonCure. [redacted]

(ee) "**Tradeable Environmental Credits**" means any potentially tradeable environmental attributes (including carbon and other credits or offsets) generated from or in relation to CarbonCure Product generated from CarbonCure Technology (and not Excluded Technologies). Such Environmental Credits may be generated, for example and without limitation, as a result of (i) reduced use of cement and/or upstream emissions associated with the production of concrete resulting from use of CarbonCure Technology and/or (ii) from the permanent use and storage of CO2 in concrete created using CarbonCure Technology;

[redacted]

APPENDIX II. PROJECT LOCATIONS

Company	***Plant Name***	***Plant Address***	***Geodetic Coordinates***
Thomas	*Acworth*	*4324 Toonigh Road*	*34.05775, -84.63921*
Thomas	*Anderson*	*1307 GA-140*	*34.34829, -84.67877*
Thomas	*Alpharetta*	*695 Sims Industrial Blvd*	*34.05869, -84.30732*
Thomas	*Athens*	*1020 Winterville Road*	*33.95128, -83.34465*
Thomas	*Atlanta*	*1430 Marietta Blvd*	*33.79381, -84.43244*
Thomas	*Ben Hill*	*2454 Daniel Road Southwest*	*33.68738, -84.51531*
Thomas	*Buckhead*	*740 Lambert Dr.*	*33.81347, -84.36357*
Thomas	*Canton*	*190 Hickory St.*	*33.78296, -84.28439*
Thomas	*Cartersville*	*145 Paga Mine Road*	*34.13962, -84.77476*
Thomas	*Covington*	*7143 Wheat Street Northeast*	*33.60592, -83.84020*
Thomas	*Cumming*	*2009 Ronald Regan Blvd*	*34.15358, -84.14518*
Thomas	*Cumming West*	*4070 Canton Hwy*	*34.23846, -84.23883*

Thomas	*Dawsonville*	*382 Hightower Parkway*	*34.28167, -84.29820*
Thomas	*Doraville*	*2825 Humphries Way*	*33.92646, -84.25228*
Thomas	*Duluth*	*3955 Buford Highway*	*33.97804, -84.16268*
Thomas	*East Savannah*	*42 Forbes Road*	*32.07396, -81.04850*
Thomas	*Gainesville*	*3960 Thurmon Tanner Rd*	*34.21511, -83.88605*
Thomas	*Grayson*	*1095 Ozora Road*	*33.88992, -83.89598*
Thomas	*Hiram*	*1133 Rosedale Drive*	*43.67621, -79.38435*
Thomas	*Jasper*	*615 Gennett Drive*	*34.48621, -84.44749*
Thomas	*Jefferson*	*993 Academy Church Road*	*34.13912, -83.63213*
Thomas	*Kennesaw*	*951 Duncan Road*	*34.26099, -83.37158*
Thomas	*Lawrenceville*	*455 Maltbie Street*	*33.96361, -83.99994*
Thomas	*Lithonia*	*6963 Maddox Road*	*33.96275, -83.98744*
Thomas	*Savannah*	*1724 Old Dean Forest Road*	*32.08978, -81.19814*
Thomas	*Stockbridge*	*605 Rock Quarry Road*	*33.53112, -84.22354*

Thomas	*Suwanee*	*450 Woodward Way*	*43.66298, -79.36749*
Thomas	*Tucker*	*2201 Moon Street*	*33.84967, -84.22587*
Thomas	*Tyrone*	*185 Peggy Lane*	*33.49704, -84.58248*
Thomas	*Charlotte*	*3701 N.Graham Street*	*35.26784, -80.81737*
Thomas	*Fuquay Varina*	*140 Pamela Drive*	*36.04403, -78.77859*
Thomas	*Knightdale*	*507 Old Montague Lane*	*35.80120, -78.50535*
Thomas	*Morrisville*	*220 International Drive*	*35.83819, -78.82228*
Thomas	*West Street*	*1131 N.West Street*	*41.00035, -73.72858*
Thomas	*Anderson*	*124 Moats Fowler Rd.*	*34.50723, -82.75644*
Thomas	*Bluffton*	*28 Benton Field Road*	*43.70869, -79.47113*
Thomas	*Columbia*	*1701 Peeples Street*	*34.06334, -81.05313*
Thomas	*Conway West*	*3442 Mount Pisgah Cemetery Rd.*	*33.92041, -79.05240*
Thomas	*Fountain Inn*	*180 Industrial Boulevard*	*43.71060, -79.35487*
Thomas	*Greenville*	*719 Worley Road*	*34.88108, -82.338991*
Thomas	*Myrtle Beach*	*202 Yeager Avenue*	*33.79148, -78.99017*

Thomas	*N. Charleston*	*1067 Lincoln Avenue*	*33.79735, -79.02593*
Thomas	*Powdersville*	*105 Piedmont Road*	*33.70856, -78.92686*
Thomas	*Spartanburg-New Cut*	*520 State Rd 771*	*34.99167, -82.01308*

APPENDIX III. TESTING PROCEDURE & MIX DESIGN OVERVIEW

CarbonCure and the producers in the project boundary will implement a testing procedure (at either a lab or the Corporation's plants) that measures quantities of cement needed to produce concrete with equivalent compressive strength both with and without the project processes to establish a ratio of Project Scenario:Baseline Scenario cement use. The test batches will yield the same levels of compressive strength (or have the project-level mix have a greater strength than the baseline).

Determining qCement,p,i,test n

qCement,p,i,test n will be determined by measuring the quantity of cement used to prepare project compressive strength test specimen *n* based on project mix design *i*, where the measurement of the quantity of cement and preparation, curing, and testing of the test specimen meet the requirements of the ASTM concrete standard test method for compressive strength relevant for the type of concrete in question[2]. For the applicable project mix design, a minimum of three batches will be tested and the three tests will be within 10% of each other in compressive strength for a given CarbonCure Mix Design. In all cases the number of batches and specimens tested will meet or exceed the requirements of the relevant ASTM standard test method.

This determination (for both qCement,b,I,test n and qCement,p,I,test n) will be done once during the project crediting period for the CarbonCure Mix Designs that comprise 50% or more of the Corporation's concrete production (it may also be done at the Division level of the Corporation).

Determining qCement,b,i,test n

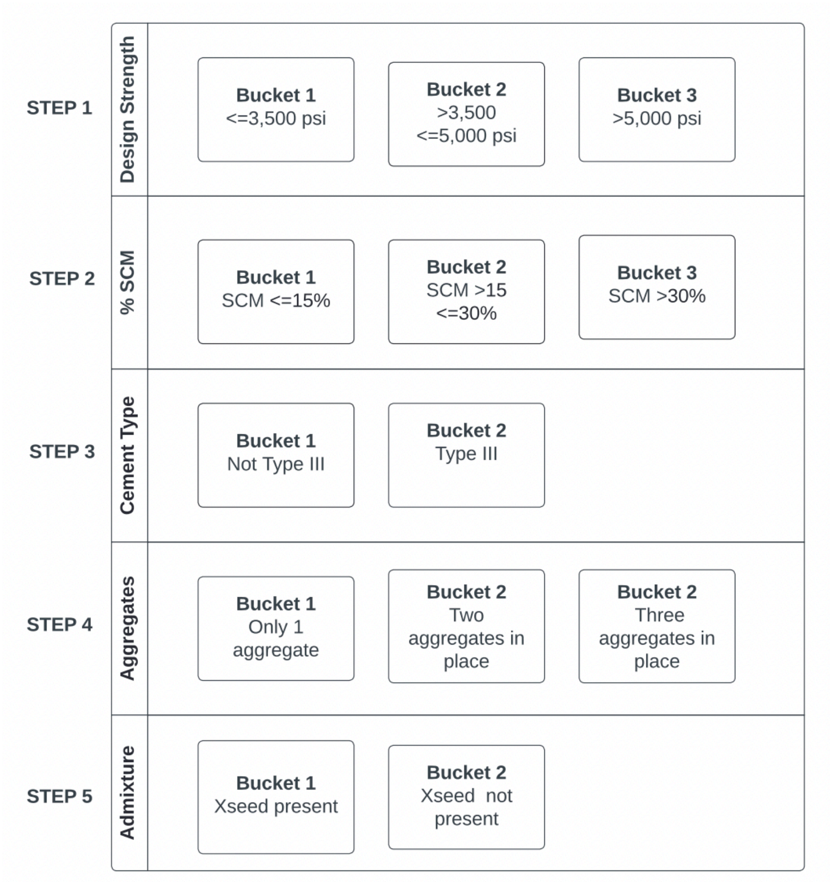
qCement,b,i,test n will be determined by measuring the quantity of cement used to prepare baseline compressive strength test specimen *n* based on a mix design that is intended to result in a concrete of equivalent compressive strength to project mix design *i*, where the measurement of the quantity and preparation, curing, and testing of the test specimens are identical to what is used for the determination of qCement,p,i,test n.

Test specimens will all be of the same volume, and equal to the volume of the specimens used to determine qCement,p,i,test n. The same number of specimens across the same number of batches as tested for qCement,p,i,test n will be tested. Baseline test specimens will have an average 28-day compressive strength that is equal to or less than the average 28-day compressive strength determined for the project test specimens used in determining qCement,p,i,test n. Where the average baseline test specimen compressive strength is greater than the average project test specimen compressive strength after completing at least three tests for a given mix design, the producer will conduct additional testing of either the project or baseline mix design (discarding an equivalent number of initial test specimen results for either the project or baseline as applicable) until the average project compressive strengths is equal to or greater than the baseline level strength.

CarbonCure Mix Designs

As concrete producers can have many different mix designs which are similar in performance, mix designs will be aggregated into CarbonCure Mix Designs based on their criteria (design strength (psi), cement type (e.g., type I/II), % SCMs, blend of aggregates (e.g. coarse+fine), strength enhancing admixtures (e.g. Xseed)), resulting in multiple mix designs leveraging the same compressive strength testing. This is used to determine the cement cuts, that is the difference between the baseline and project scenarios, specifically, CarbonCure will a) for the CarbonCure Mix Designs that this testing noted above was conducted for, use the results of the testing data to quantify the cement cut; or b) for the CarbonCure Mix Designs that this testing was not conducted for, Carboncure will use the average cement cut from (a) (that is, the CarbonCure Mix Designs that conducted the testing) but apply a 1 standard deviation deduction to ensure conservatism. For the calculations in step (a) (that is, the CarbonCure Mix Designs that conducted the testing), CarbonCure will calculate the values based on the averages demonstrated by the testing (e.g. if three tests were conducted for a given mix design and each respective test demonstrated a cement cut of 5.0%, 4.5% and 4.0%, CarbonCure would assume the average from these tests or 4.5%).

CarbonCure has a five step process for aggregating mixes into CarbonCure Mix Designs. This five step process results in a total of 108 possible unique combinations as demonstrated below.



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[2] See: *ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens Global - ACI 214R-11 Guide to Evaluation of Strength Test Results of Concrete Global - ACI 214.4R-10 Guide for Obtaining Cores and Interpreting Compressive Strength Results Europe EN 12390- 3:2019 Testing hardened concrete. Compressive strength of test specimen#*

The groupings and buckets in CarbonCure mix designs are based on the National Ready Mixed Concrete Association (NRMCA) benchmark report. The NRMCA is the leading industry association for ready-mix producers. They perform industry surveys that capture a statistically significant sample of ready-mix plants, the surveys provide the average distribution of plants and mixes that coincide with the buckets used to group mix families/CarbonCure mix designs. The report will be made available to a VVB upon request.

Additionally, CarbonCure has several industry experts attest to CarbonCure mix designs, their groupings as they relate to industry standards and their credibility within the concrete industry. These experts include the largest and most well established suppliers of concrete in the USA as well as technical advisors and mix design experts in the concrete space. These attestations will be made available to a VVB upon request.

Note on Required Average Compressive Strength (RACS): At the time of the writing of this PD, a revision to VM0043 is currently pending at Verra that would allow project proponents to use RACS as opposed to the currently-outlined testing procedure in VM0043. Should that amendment be approved by Verra, CarbonCure will use this as an additional approach under this project activity to determine functional equivalence at some or all of the sites within the project boundary.

APPENDIX IV. EXAMPLE OF MONITORING PROCEDURE

Example below for how CarbonCure would currently plan to provide the monitoring data for its first monitoring report for one Coproration's concrete production facilities that have installed CarbonCure equipment.

Step 1. CarbonCure will provide the quantity of concrete produced by the Corporation broken down by CarbonCure Mix Design. As concrete producers can have many different mix designs which are similar in performance, individual mixes will be aggregated into CarbonCure Mix Designs based on their criteria (design strength (psi), cement type (e.g. type I/II), % SCMs, blend of aggregates (e.g. coarse+fine), strength enhancing admixtures (e.g. Xseed)), resulting in multiple mix designs leveraging the same testing results. CarbonCure will conduct this testing for the CarbonCure Mix Designs that comprise 50% or more of the production volume (it may also be done at the Division level of the Corporation).

Step 2. For each CarbonCure Mix Design, CarbonCure will provide the quantity of cement that was actually used in the project concrete (lbs per cubic yard or another equivalent measure).

Step 3. For each CarbonCure Mix Design, CarbonCure will provide the quantity of cement that would have been used by the producer and the method for how this amount was determined.

Today, CarbonCure is determining this primarily one of two ways:

1. Based on the testing results for the CarbonCure Mix Designs (and relevant averages applied); or
2. Using a per-Corporation (or Division-level) estimate of the cement cut. This estimate is based on the average cement cut from the testing conducted for CarbonCure Mix Designs with a 1 standard deviation deduction to ensure conservatism.

Step 4. CarbonCure will provide the results of compressive strength tests on baseline and project concrete for the mix design families that comprise 50% or more of the Corporations production volume.

Step 5. CarbonCure will provide the GHG-intensity of the cement and how that's determined (e.g. EPD, etc.).

Step 6. CarbonCure will provide the quantity of CO_2 that was injected into the process.

Step 7. CarbonCure will provide the estimated or calculated amount of electricity used by the CarbonCure equipment.

Step 8. CarbonCure will provide the location of the plant (to determine the emissions factor of the grid)

For the first monitoring report, twenty-nine of the plants are in SRSO and 17 are in SRVC (and one in SRTV). Thus, it is easy to determine the grid emission factors. Below are some sample locations:

plant_name	**city**	**state**	**location**
East Savannah	Savannah	GA	32.0749111, -81.0523546
Adairsville	Adairsville	GA	34.1826958, -84.82844349
Fuquay Varina	Fuquay-Varina	NC	35.527721, -78.814765
West Street	Raleigh	NC	35.7953862, -78.6424783

Step 9. CarbonCure will provide the distance from where the CO_2 was captured/compressed and mode of transport. In instances where a portion of this data is not available, CarbonCure will provide an estimate based on the data it has and industry standards.