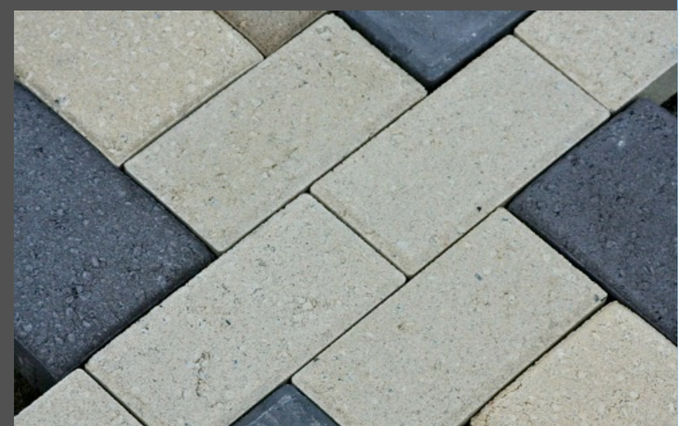
Utilization of CO_2 in High Performance Building and Infrastructure Products

DE-FE0004222

DOE NETL Carbon Storage
Pittsburgh, PA
August 18-20, 2015



Solidia Cement^{TM} Chemistry

Solidia Technologies

Oxide	Portland Cement (wt.%)	Solidia Cement (wt.%) *example*
CaO	60 - 67	43
SiO_2	17 - 25	45
Al_2O_3	3 - 8	6
Fe_2O_3	0.5 – 6.0	2.5
MgO	0.5-4.0	2.0
Alkali-oxide (Na, K)	0.3 – 1.2	1.0

Mineral phases $CaSiO_3$ and $Ca_3Si_2O_7$ will react with CO_2

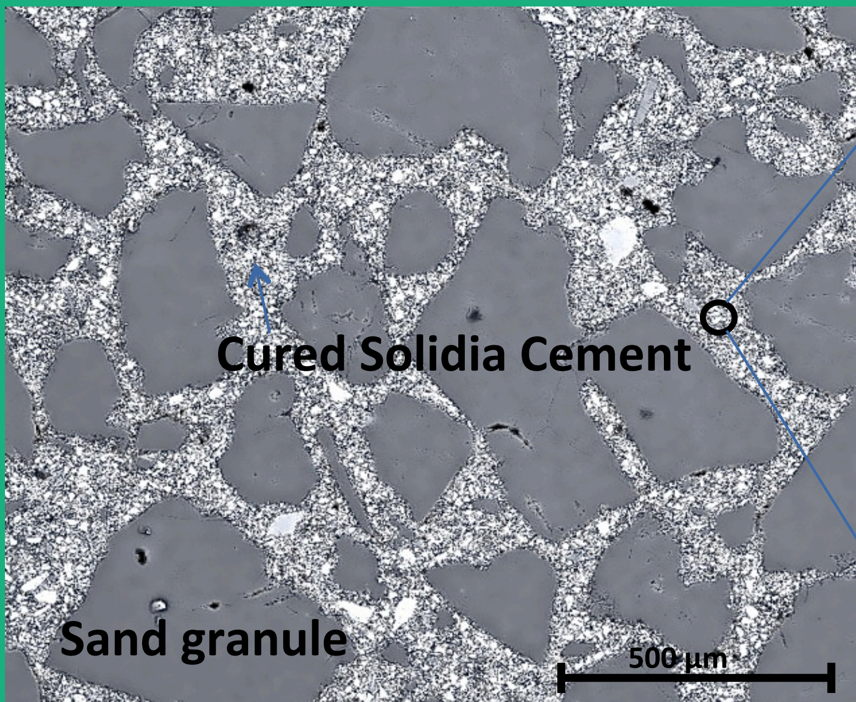
Solidia Cement is a *low-lime alternative* to ordinary Portland cement

CO_2-Curing of Solidia Concrete™

Solidia Technologies

$$CaSiO_3 + CO_2(g) \rightarrow CaCO_3 + SiO_2$$

Solidia Concrete™



Solidia Cement™

$CaCO_3$ in Solidia Concrete acts in a manner similar to that of C-S-H gel in Portland cement concrete

CO_2 Footprint Comparison

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Portland Cement Concrete vs. Solidia Concrete

	Portland Cement Concrete	Solidia Concrete	Note
a. CO_2 emitted/t of cement made	0.81 t	0.56 t	0.25 t of CO_2 emissions avoided at cement plant
b. CO_2 captured/t of cement used	0.00 t	0.25 t	0.25 t of CO_2 captured at concrete plant
c. Total CO_2 footprint/t of cement used (a-b)	0.81 t	0.31 t	0.50 t of CO_2 "saved"

DE-FE0004222 Program Status

Technical Evaluation (Task 3.0)	→ Complete 6/2014
Demonstration of Solidia Cement Produced at Commercial Cement Plant (Subtask 4.1)	→ Complete 12/2014
Demonstration of Solidia Concrete Utility in Commercial Concrete Products (Subtask 4.2)	→ Complete 6/2015
Implement CO_2-Curing At Commercial Concrete Plant (Subtask 4.3)	→ **In Progress**

Description of Concrete Curing System

Company: Paver and Block Manufacturer #2
Plant Location: New Jersey
Cement Usage: 25,000 t/yr
Target Product: Vibro-cast Concrete Pavers

Curing System consists of 18 bays:

Each bay;

- 5 ft. x 17 ft. x 75 ft.
- 240 boards
- 25 to 60 t concrete

Construction

- Roll down doors
- Sheet metal walls
- ***Not sealed***

No internal ducting

Concrete Plant Conversion Process

- Gas Flow and Distribution Within the Curing Bay
- Bay Preparation and Sealing
- Ductwork Design and Installation
- Door Fabrication and Installation
- Gas Conditioning System
- Other Site Preparation
- Carbon Footprint Calculation

Gas Flow Distribution Within the Bay

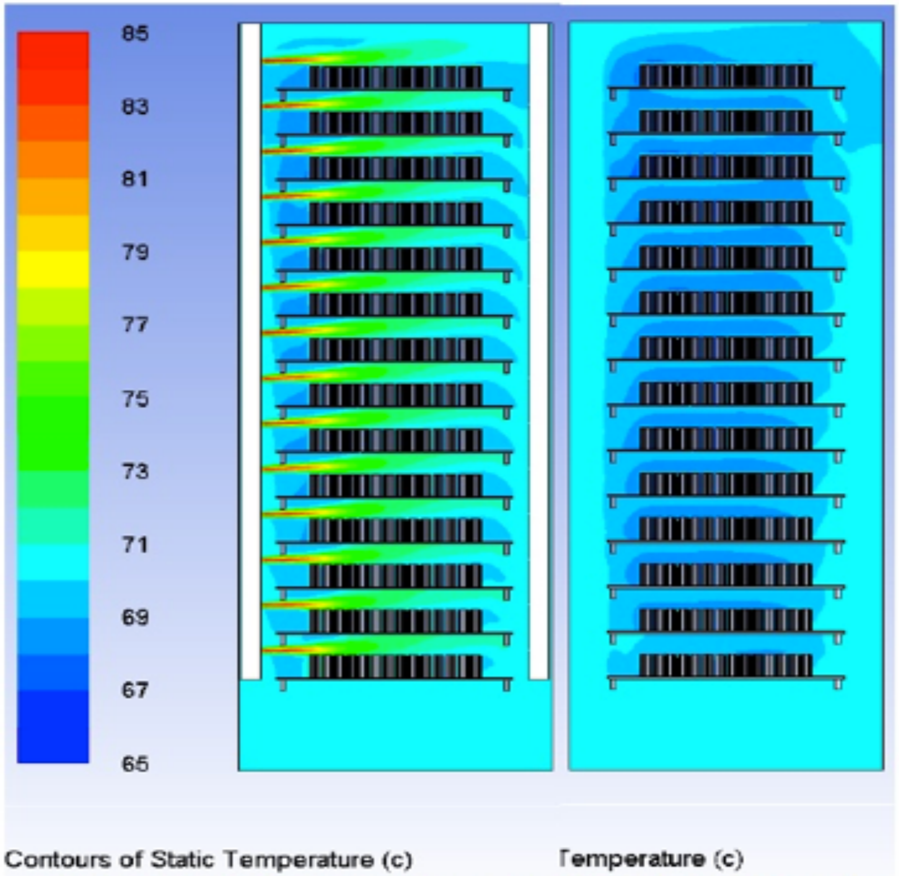


Figure 11 – Contours of Temperature on Jet Centerlines (left) and 30cm off centerline (right) with Outlet Manifold (°C)

Objective:

Achieve uniform temperature, relative humidity and CO_2 concentration throughout curing bay.

Challenge:

Bay interior is divided into 14 distinct levels by solid boards bearing concrete parts.

Approach:

- Construct computational fluid dynamic (CFD) model of fully loaded bay interior
- Define interior duct and inlet design
- Defines blower, heat exchanger capacity

Bay Preparation and Sealing

Objective:

Prevent CO_2 leakage during CO_2-curing.

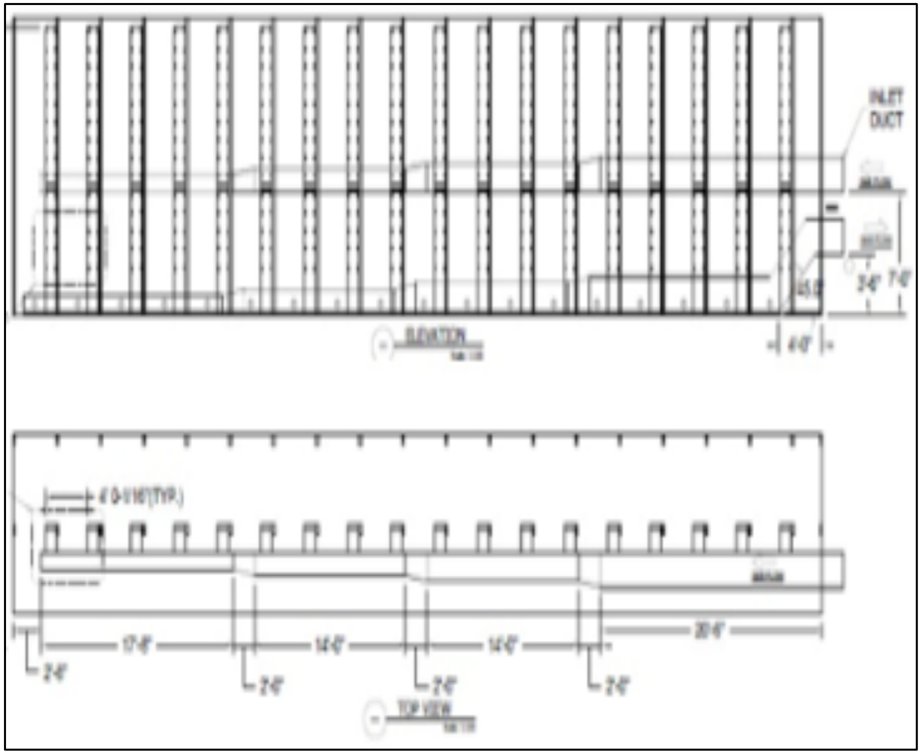
Challenge:

Bay walls are constructed from sheet metal / fiberboard panels, and contain multiple ports.

Approach:

- Seal large gaps
- Coat bay interior
- With material that is impermeable to CO_2

Ductwork Design and Installation

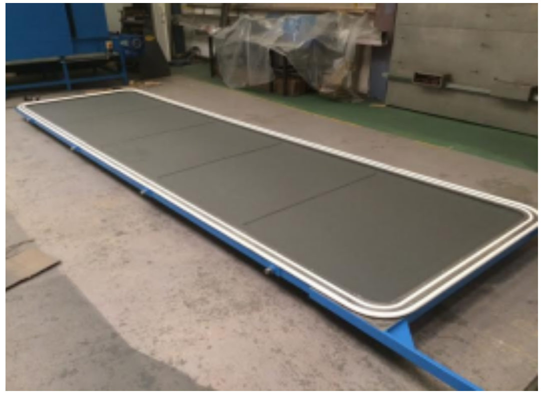


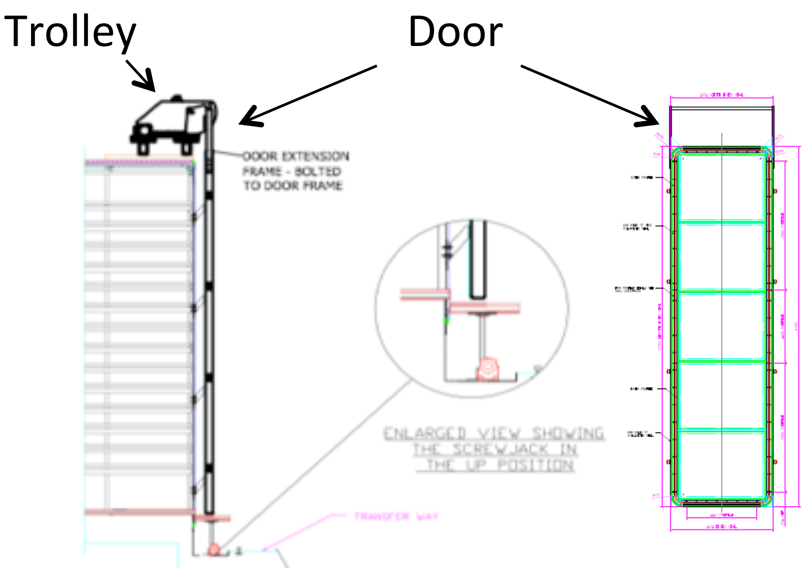
Ducts fabricated from sheet steel as per CFD design

Door Fabrication and Installation

Trolley on Rails

Door





Objective:

Replace roll-down door with solid metal door to prevent CO_2 leakage.

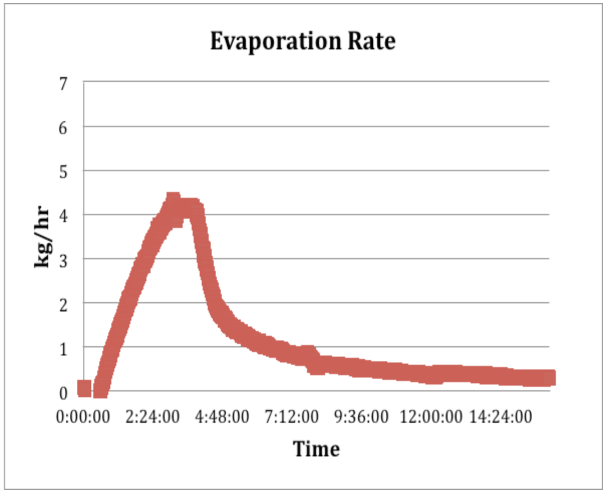
Challenge:

Concrete is placed within curing bays by robotic loading mechanism, limiting access to bay front.

Approach:

- Store doors in magazine mounted aside bays.
- Move and lower door onto bay front via trolley mechanism.

Gas Conditioning System



Heat Exchanger, Condenser

CO_2 Addition, Heater, Blower,

Objective:

Feed warm, dry CO_2 into curing bay and recondition wet CO_2 exiting curing bay.

Challenge:

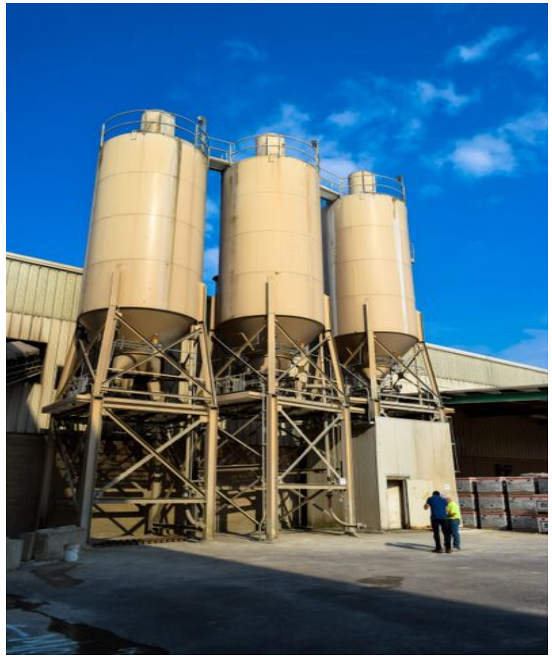
Low cost, energy efficient system to achieve the above. Dehumidify at high rates early in process

Approach:

- Cross flow heat exchanger, water cooled chiller (to store energy from exit gas, dehumidify gas, and recapture energy prior to heater/blower)
- Electrical or gas fired heater
- High capacity blower

Other Site Preparation

Concrete Pad for CO_2 Storage Tank



Dedicated Silo for Solidia Cement

Site / US CO_2 Footprint

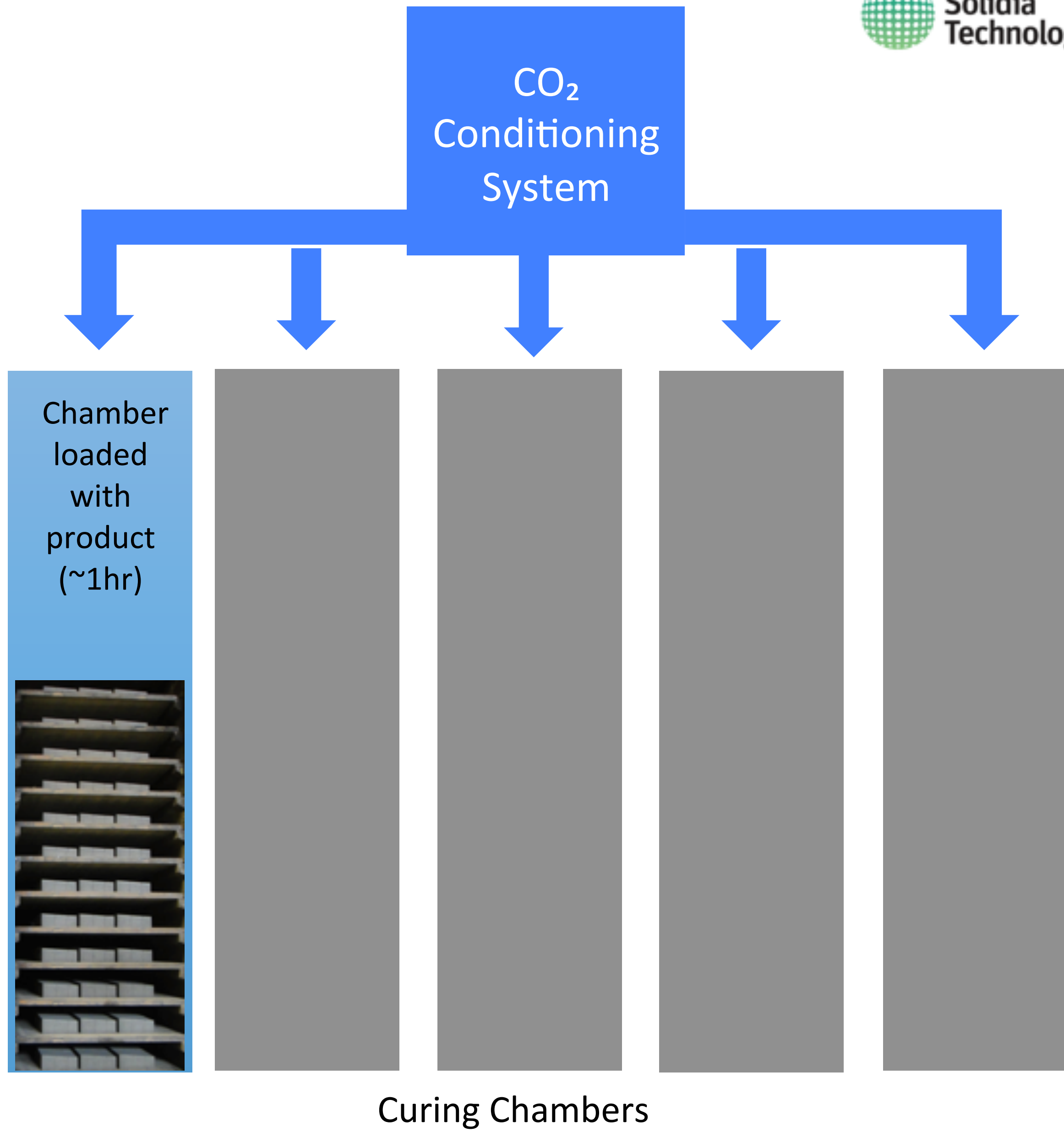
Plant Conversion	Tons of Portland Cement replaced by Solidia Cement	CO_2 "saved" per ton of cement	Total CO_2 "saved"	When
5% (1 bay)	1,250	0.50	625 t	2016
50%	12,500	0.50	6,250 t	2018
100%	25,000	0.50	12,500 t	2020

- Startup at Paver and Block Manufacturer #2 scheduled for 9/2015
- If applied to all precast concrete in US…………
  - 20% of concrete production ~ 20 million tons of cement
  - ***~10 million tons of CO_2 can be "saved"***

Appendix

Full Plant Conversion

Operating Logic



Full Plant Conversion

Operating Logic

CO_2 Conditioning System

Curing ramp-up (~1hr)

Chamber loaded with product (~1hr)

Curing Chambers

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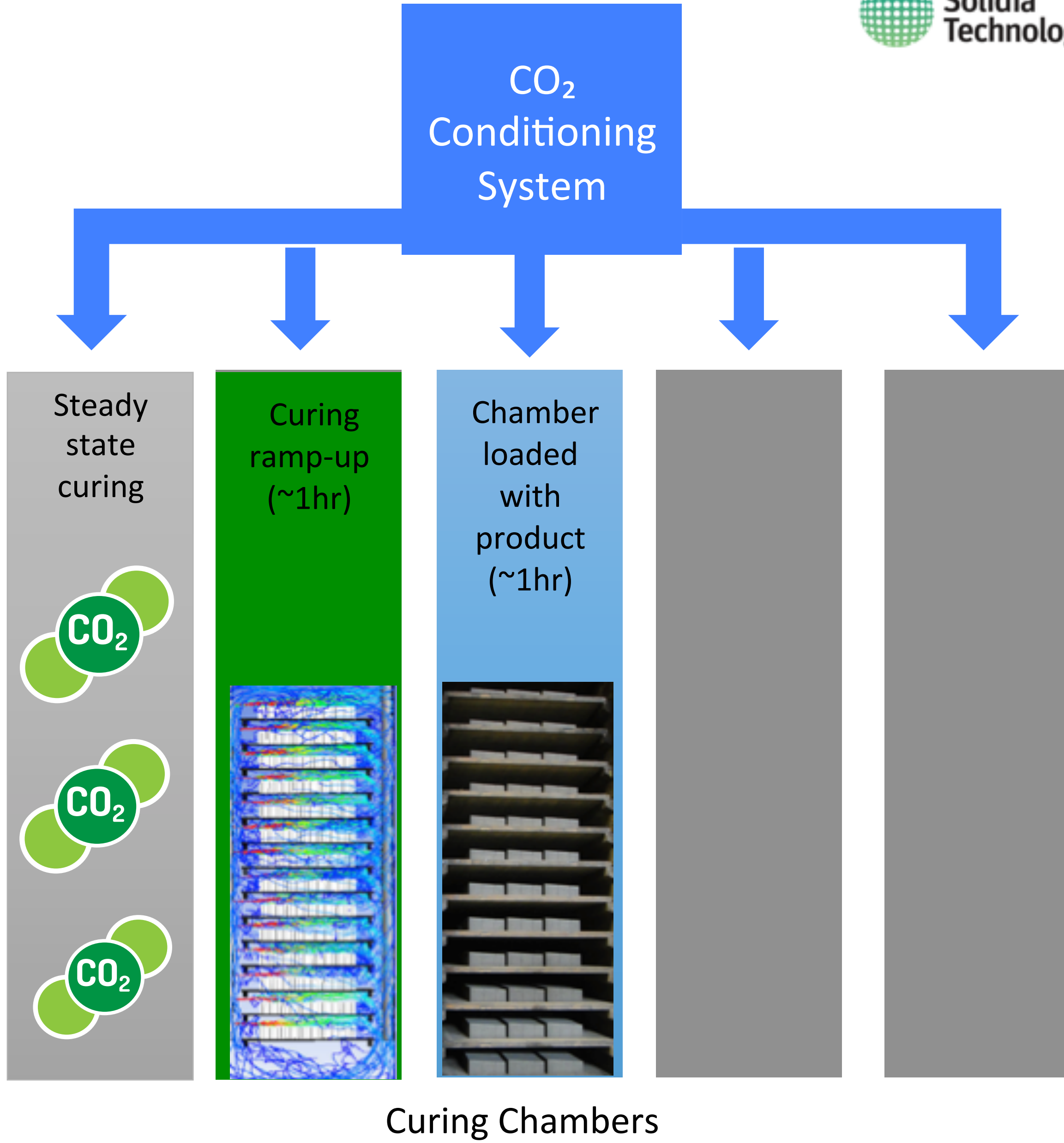
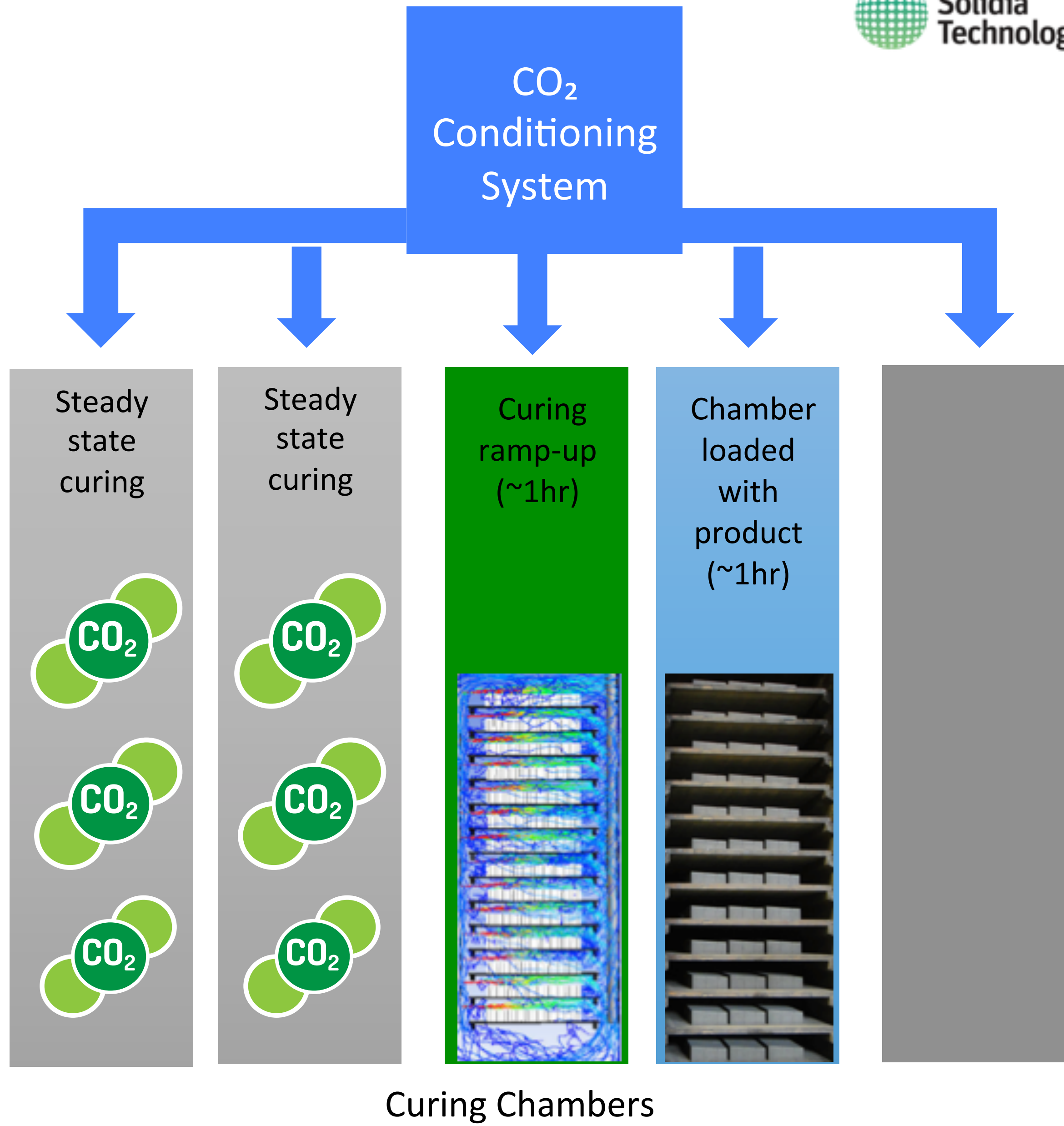
Full Plant Conversion

Operating Logic



Full Plant Conversion

Operating Logic



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Full Plant Conversion

Operating Logic

CO_2 Conditioning System

Empty Chamber and Reload	Steady state curing	Steady state curing	Curing ramp-up (~1hr)	Chamber loaded with product (~1hr)
	CO_2 CO_2 CO_2	CO_2 CO_2 CO_2		

Curing Chambers