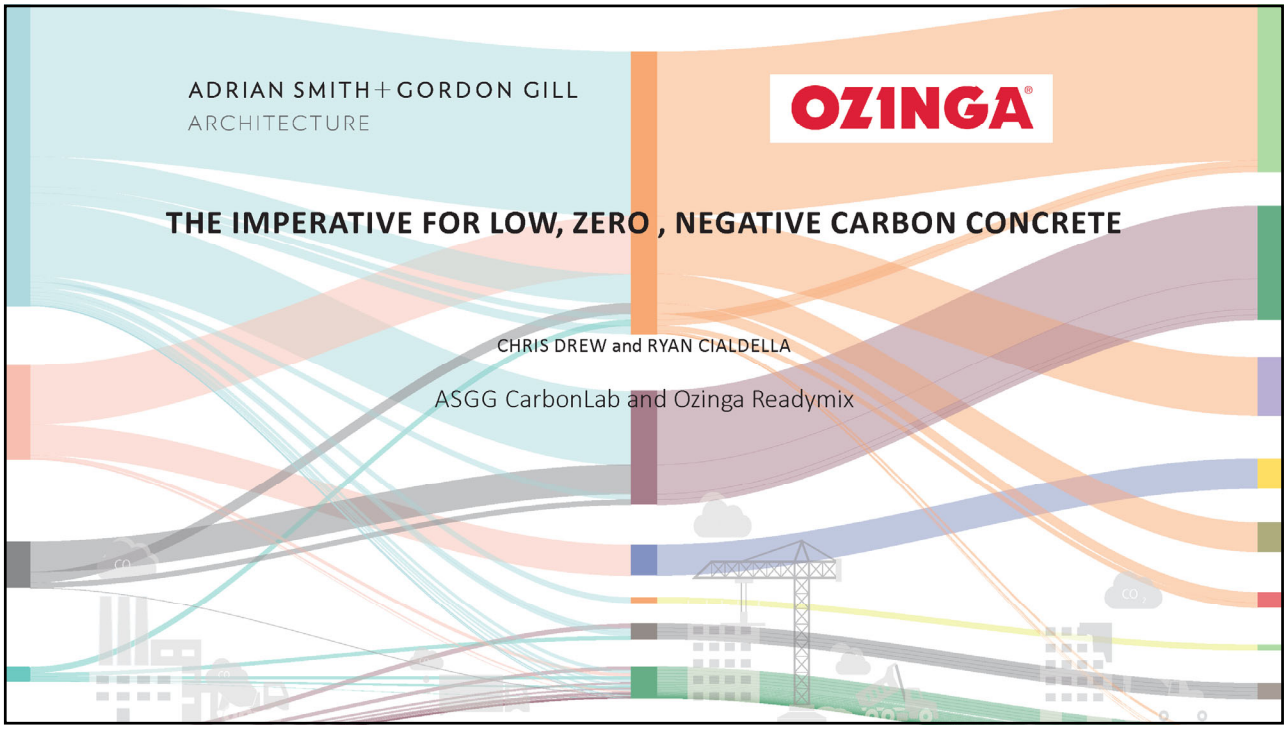
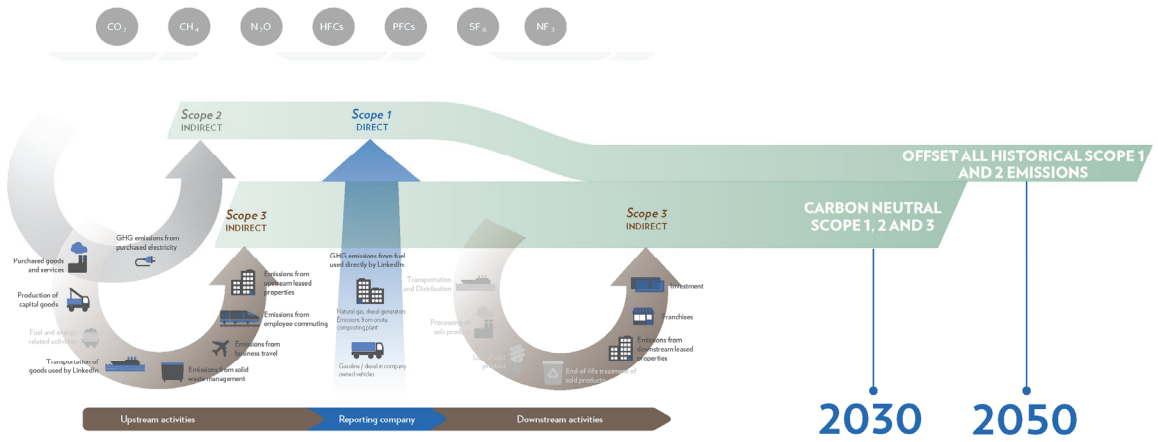


GLOBAL CARBON REPORTING



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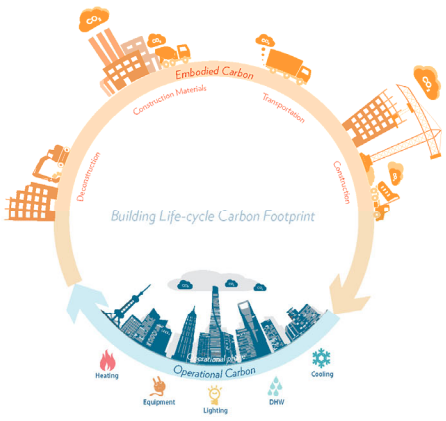
WHAT IS LIFE-CYCLE CARBON FOOTPRINT?

Embodied Carbon + Operational Carbon = Life-cycle Carbon

Embodied carbon counts as 20%-50% of the building's whole life-cycle emissions.



GREENHOUSE GAS	GWP (CO_2 EQUIVALENT)
CARBON DIOXIDE (CO_2)	1
METHANE (CH_4)	25
NITROUS OXIDE (N_2O)	298
HYDROFLUOROCARBONS (HFCs)	675-14,800 (r410a=2,088)
PERFLUOROCARBONS (PFCs)	7,390-13,300
SULPHUR HEXAFLUORIDE (SF_6)	22,800

OPERATIONAL CARBON

GHG emissions generated through operating a building. Includes direct emissions from fuel combustion and indirect emissions from electricity generation. Reported as kg or tons CO_2e.

EMBODIED CARBON

The Greenhouse Gas (GHG) emissions from construction, maintenance, and demolition of a building. This includes emissions caused by extraction, manufacture, transportation, assembly, disassembly, and landfill. Reported as kg or tons CO_2e.

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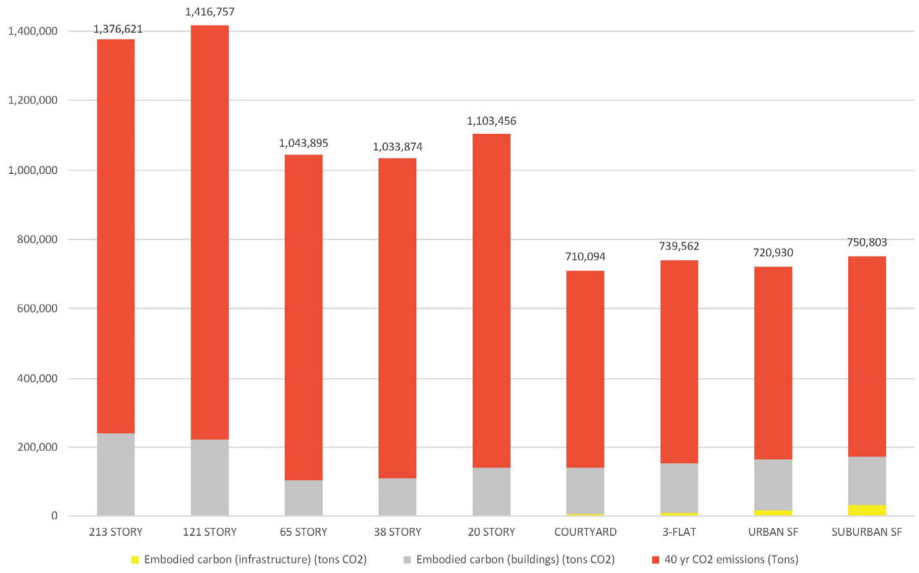
OPERATIONAL AND EMBODIED CARBON - TYPICAL



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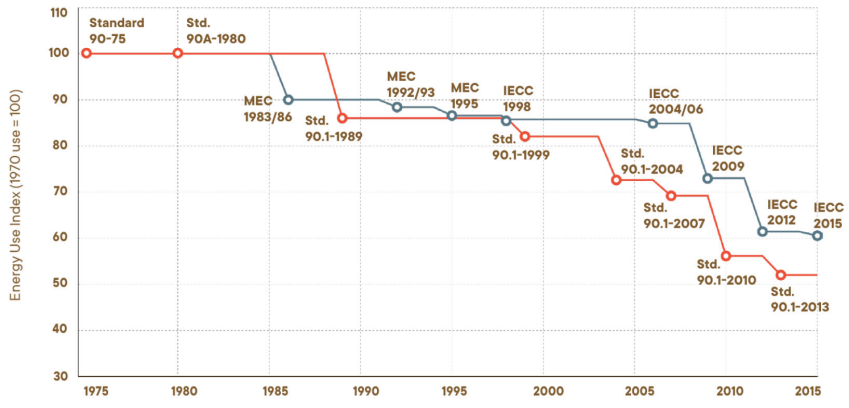
ENERGY EFFICIENCY



AIA 2030™

U.S. GREEN BUILDING COUNCIL USGBC

Passivhaus Institut

GREEN GLOBES

BREEAM®

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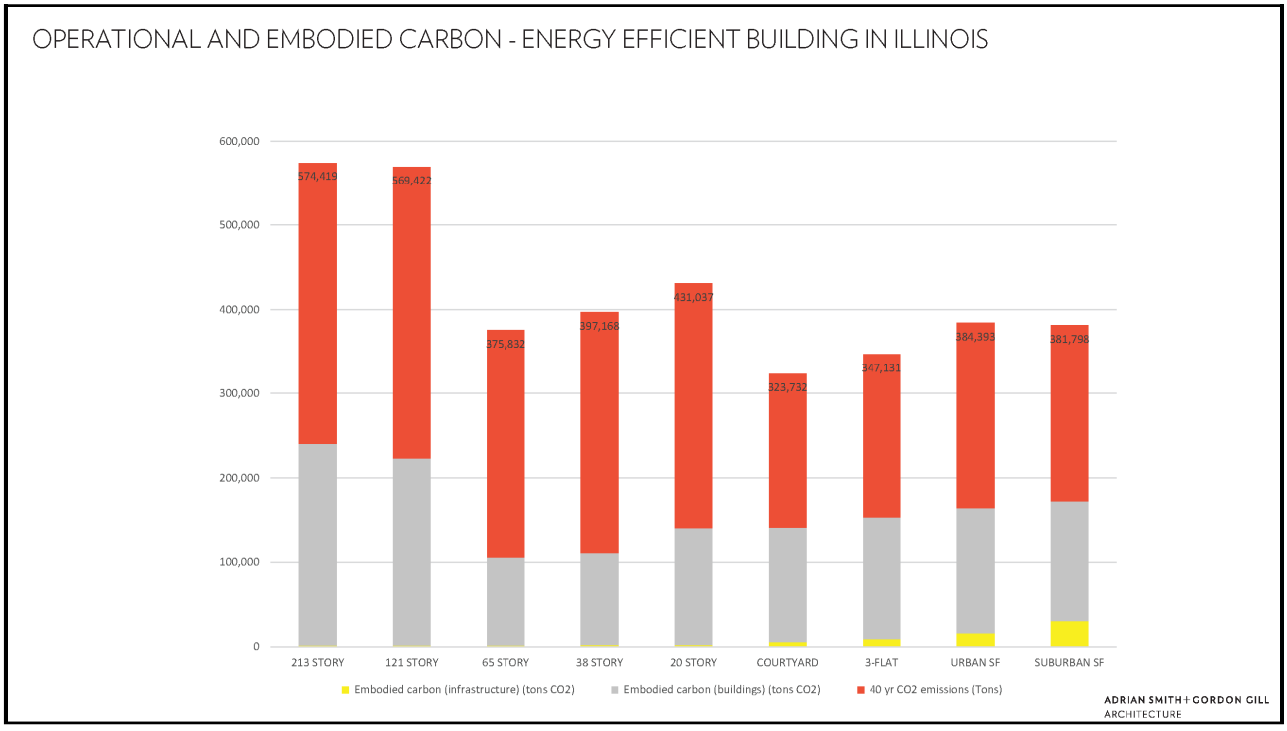
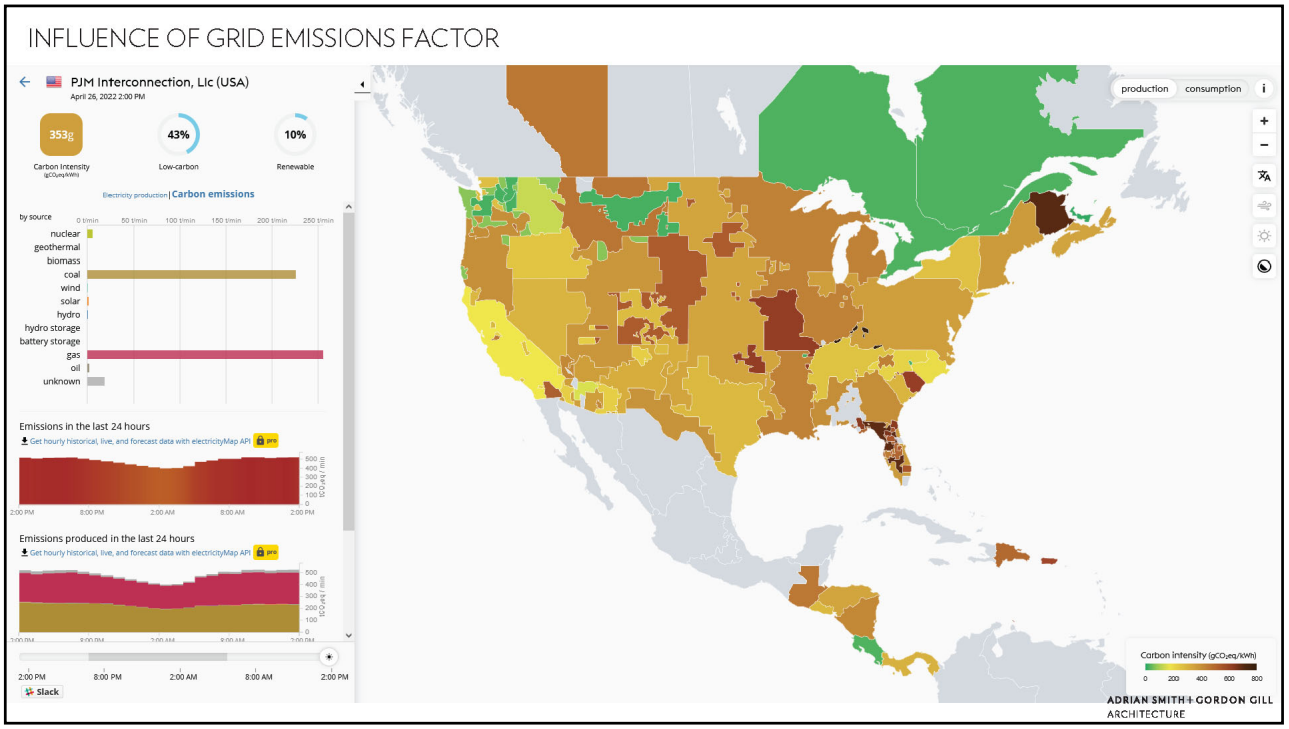
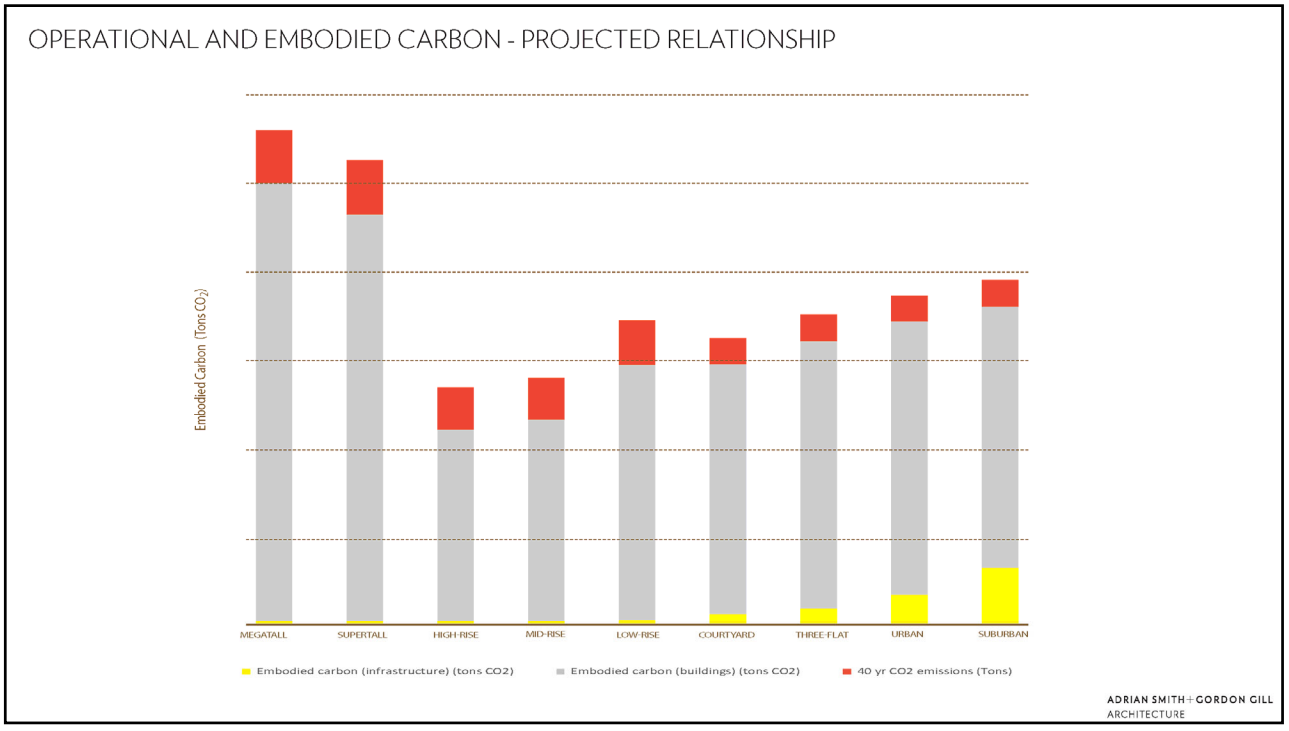
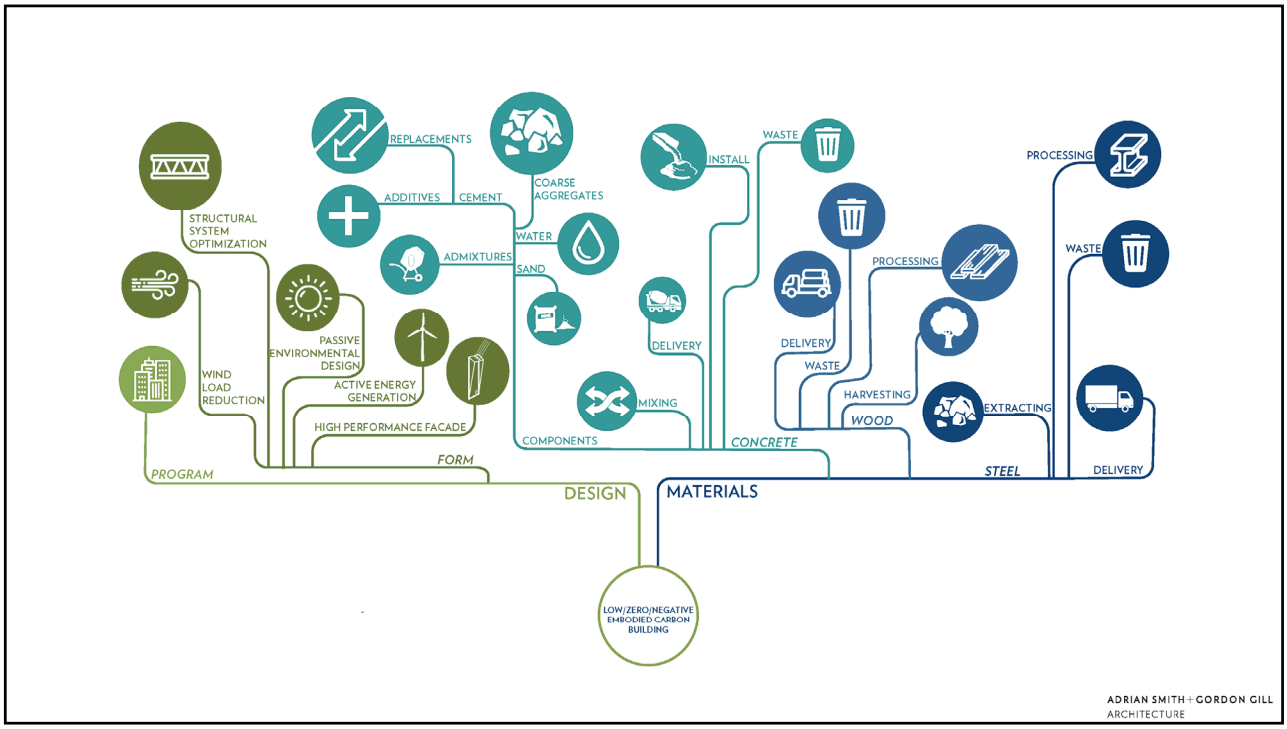
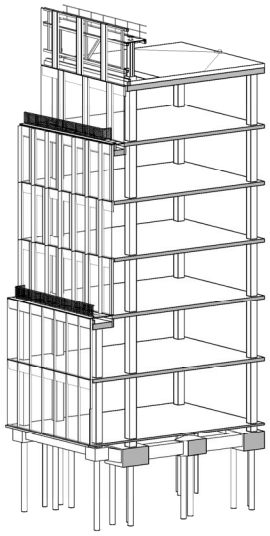








LIFECYCLE ANALYSIS- TYPICAL OFFICE BUILDING



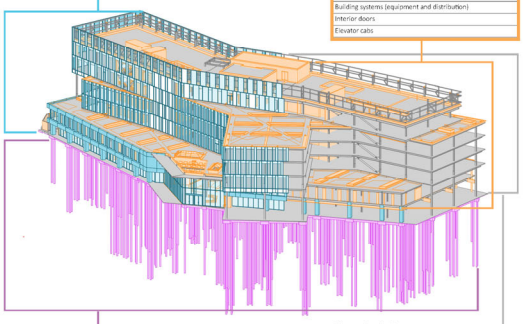
Lifecycle Assessment Material Boundaries

Exterior Wall

Components	*Materials*
Included	*Included*
Curtain Wall Panels	Glazing
Storefront System	Aluminum Mullions
Precast Panels	Aluminum Panels
Shading Fins	Insulation
	Precast Concrete
Excluded	
Embed Plates	
Fin Additional Support	
Gaskets or Sealants	
Exterior doors	

Interior Partitions

Components	*Materials*
Included	*Included*
Interior GWB Walls	Gypsum board
Interior Shafts	Aluminum studs
Interior Storefront	Ceramic Tile
Roof planters	Insulation
	Cement Plaster
	Shaft liners
	Glazing
	Aluminum Mullions
	Precast Concrete
Excluded	
Tenant fitout (inc. toilet rooms and furniture)	
Building systems (equipment and distribution)	
Interior doors	
Elevator cabs	



Foundations

Components	*Materials*
Included	*Included*
Slab on Grade	Concrete
Grade beams	Steel Rebar
Piles	
Excluded	
Infrastructure requirements (cranes, telecommunications, etc)	

Above Grade Structure

Components	*Materials*
Included	*Included*
Columns	Concrete
Beams	Steel
Slabs	Steel Rebar
BRBF (diagonal bracing)	Fireproofing
Roof Parapet	Metal Deck
Excluded	
Stairs	

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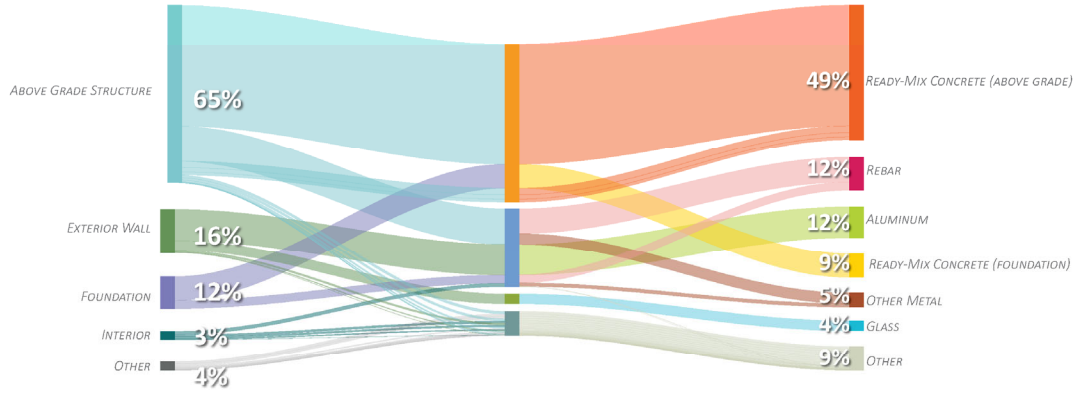
EMBODIED CARBON- TYPICAL CONCRETE BUILDING

EMBODIED CARBON BREAKDOWN BY MATERIAL



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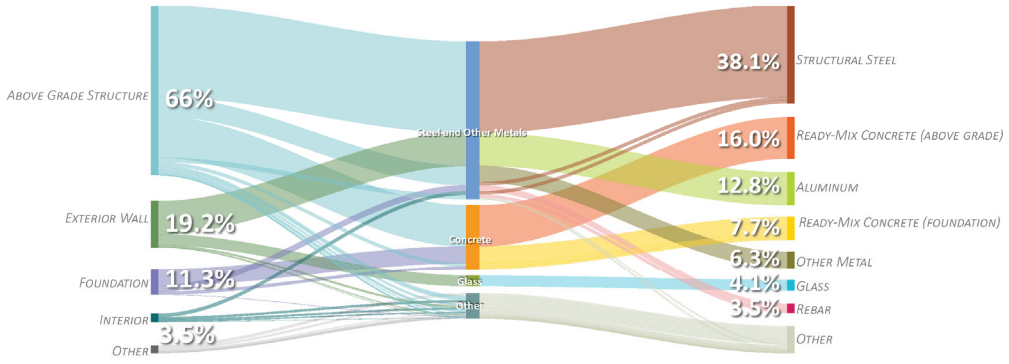
EMBODIED CARBON- TYPICAL STEEL FRAMED BUILDING

EMBODIED CARBON BREAKDOWN BY MATERIAL



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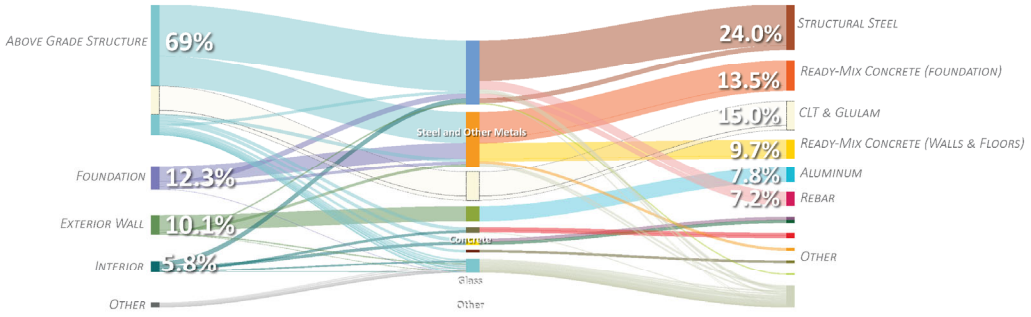
EMBODIED CARBON- TYPICAL HYBRID BUILDING

EMBODIED CARBON BREAKDOWN BY MATERIAL



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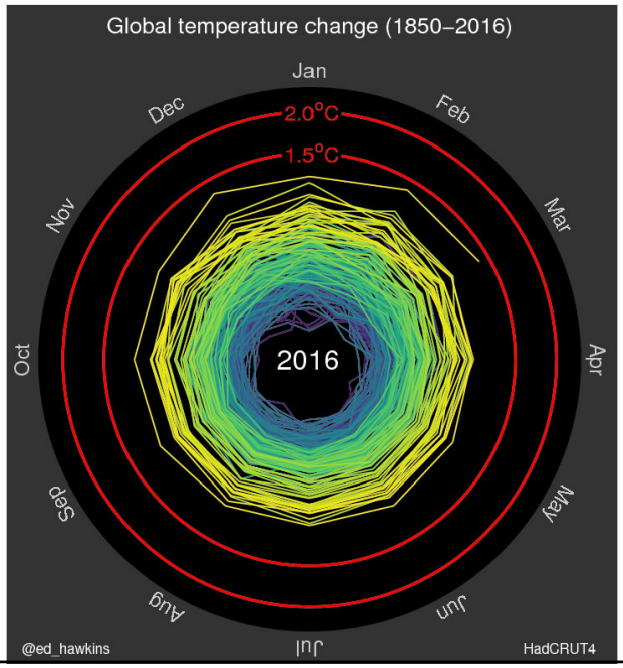
GLOBAL WARMING IS AN IMMEDIATE ISSUE



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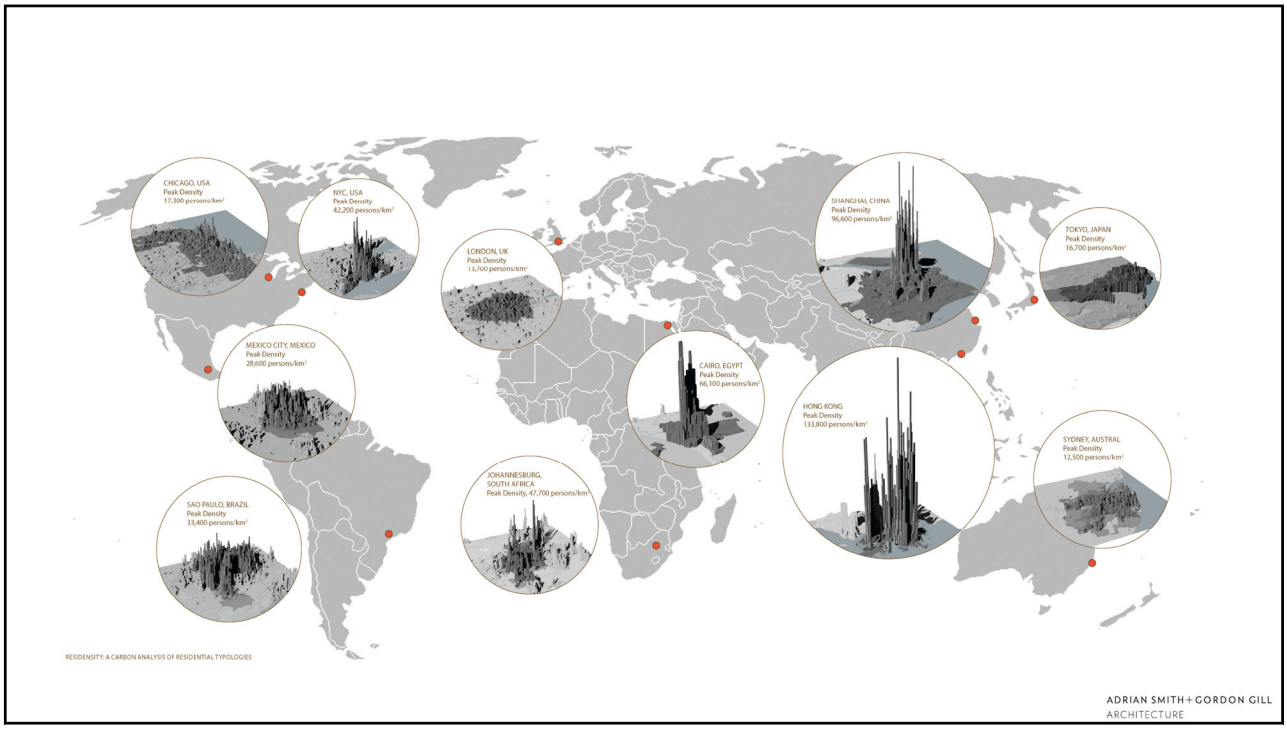
CHICAGO, USA
Peak Density
17,300 persons/km²
NYC, USA
Peak Density
42,200 persons/km²
LONDON, UK
Peak Density
13,700 persons/km²
SHANGHAI CHINA
Peak Density
96,600 persons/km²
TOKYO, JAPAN
Peak Density
16,700 persons/km²
MEXICO CITY, MEXICO
Peak Density
28,600 persons/km²
CAIRO, EGYPT
Peak Density
66,100 persons/km²
HONG KONG
Peak Density
133,800 persons/km²
SYDNEY, AUSTRAL
Peak Density
12,500 persons/km²
SAO PAULO, BRAZIL
Peak Density
33,400 persons/km²
JOHANNESBURG,
SOUTH AFRICA
Peak Density, 47,700 persons/km²
RESIDENSITY: A CARBON ANALYSIS OF RESIDENTIAL TYPOLOGIES
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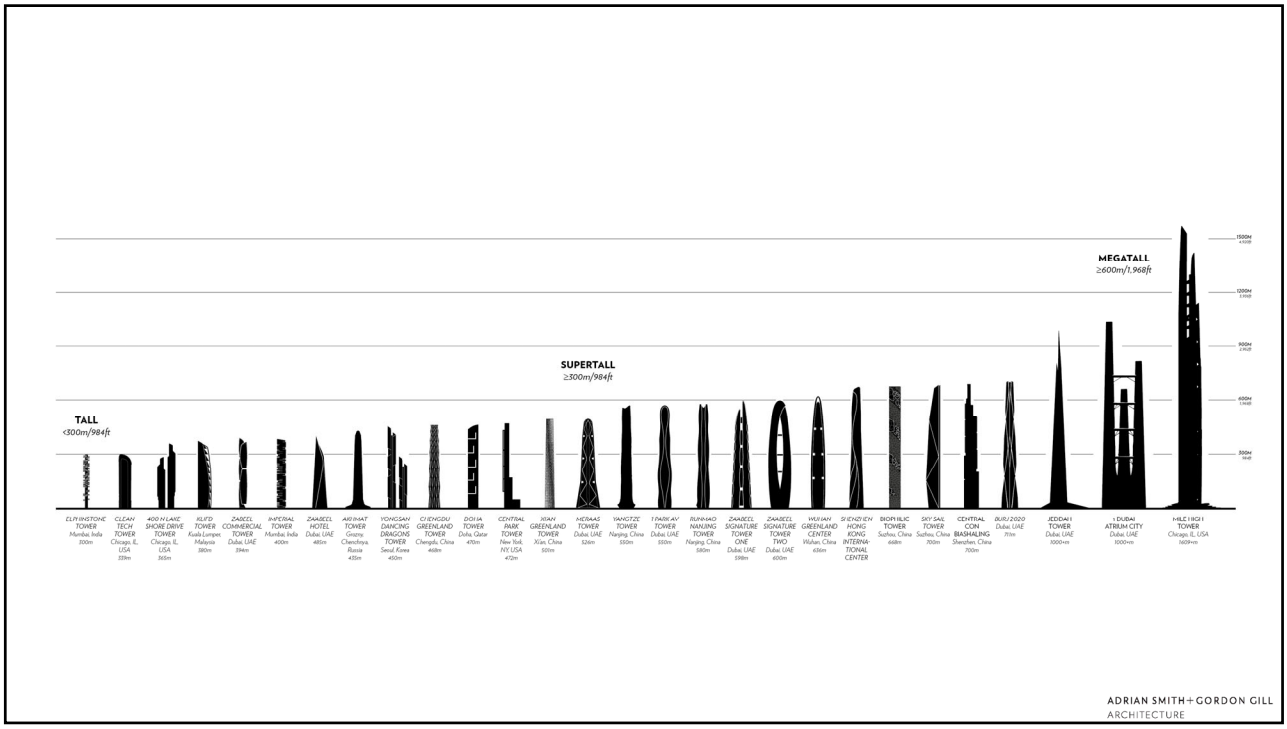
TALL
<300m/984ft
SUPERTALL
≥300m/984ft
MEGATALL
≥600m/1,968ft
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EMBODIED CARBON - CENTRAL PARK TOWER, NY

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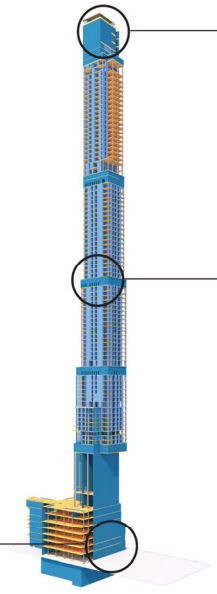
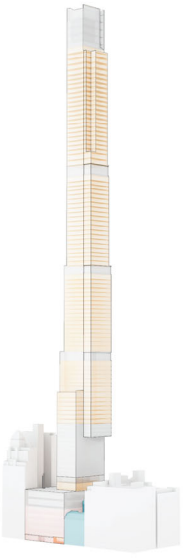
EMBODIED CARBON - DESIGN ESTIMATE

CENTRAL PARK TOWER
New York City, NY



STRUCTURE DIAGRAM



PROGRAM MASSING

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SECOND TO WATER, CONCRETE IS THE MOST WIDELY USED MATERIAL ON EARTH

Approximately 10 billion tons of concrete are produced each year - thats more than 19,000 tons / minute - enough to fill 1060 ready mix trucks and the ready-mix concrete market is set to exceed $600 billion by 2025.

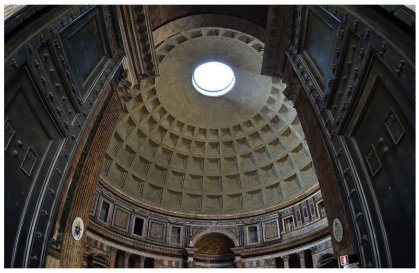
Concrete has been used since at least as early as the first millennium BC and was used extensively by the Romans who used quicklime, volcanic ash and pumice.

Concrete is manufactured from cement, sand, aggregate and water. Additives are used to alter the properties of it.

Portland cement (named after the stone found on the Island of Portland in England) was patented in 1824 and is the most widely used cement.

Cement clinker is made by heating limestone and clay to 1,450 °C in a cement kiln. The clinker is then ground, along with a small amount of gypsum, to a fine powder.

Over time, the set cement (calcium hydroxide) absorbs CO_2 to become calcium carbonate.



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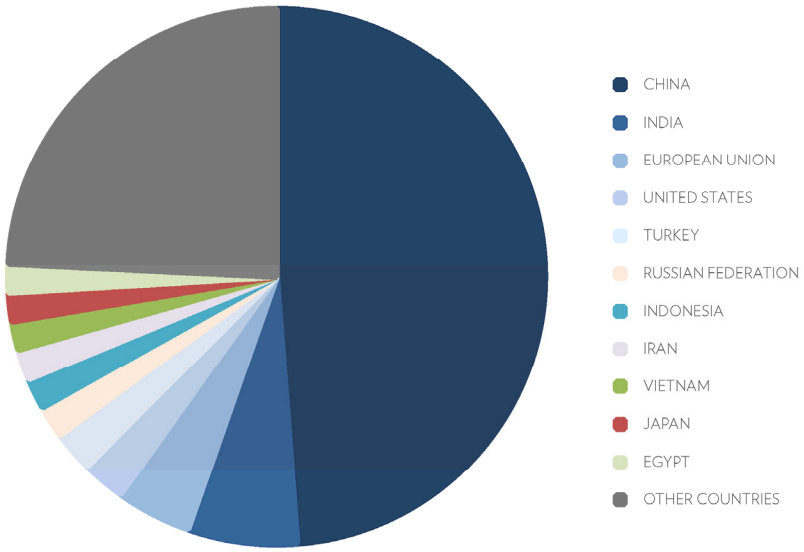
CO_2 EMISSIONS FROM CEMENT PRODUCTION 2015

IF THE CEMENT INDUSTRY WAS A COUNTRY IT WOULD HAVE THE THIRD HIGHEST EMISSIONS BEHIND THE USA AND CHINA

CHINA	733
INDIA	99
EUROPEAN UNION	68
UNITED STATES	39
TURKEY	37
RUSSIAN FEDERATION	29
INDONESIA	28
IRAN	28
VIETNAM	26
JAPAN	26
EGYPT	26
OTHER COUNTRIES	364
GLOBAL TOTAL	1435

Units in million metric tons



SOURCE:
Olivier, J., Janssens-Maenhout, G., Muntean, M. and Peters, J. (2016), Trends in global CO2 emissions: 2016 Report, The Hague: PBL Netherlands Environmental Assessment Agency, http://edgar.jrc.ec.europa.eu/news_docs/jrc-2016-trends-in-global-co2-emissions-2016-report-103425.pdf

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Low – Zero – Negative Concrete Research Project

- Objectives and Goals
- Stakeholders
- Process

Emissions Reduction Strategies

- Environmental Product Declarations
- Cement Reduction & Blends
- Emerging Technologies
- Admixtures
- Aggregates
- Collaboration

Environmental Product Declarations

- Global Warming Potential – GWP
- Baseline
  - Production vs Industry Standard
- Product Specific

OZINGA

EPD
ENVIRONMENTAL PRODUCT DECLARATION

READY MIX CONCRETE PRODUCED BY:

OZINGA READY MIX CONCRETE

FACILITY: Dekalb
STRENGTH: 4000 psi @ 28 days
MIX NAME: CSP4KAE

IMPACT INDICATOR		PER YD3	PER M3
Climate Change	kg CO_2e	172.70	225.89
Ozone Depletion	kg CFC11e	7.44E-06	9.73E-06
Acidification	kg SO2e	0.77	1.01
Eutrophication	kg NE	0.27	0.35
SFP (Smog)	kg O3e	15.63	20.44
Non-renew. energy	MJ, NCV	1,311.52	1,715.47

GENERAL INFORMATION

Declared Product	Ready-mixed concrete produced by Ozinga Ready Mix Concrete
Date of Issue	1/10/2022
Period of Validity	August 13th, 2025
EPD Holder	Ozinga Ready Mix Concrete, Inc. 19001 Old LaGrange Road, Ste 300 Mokena, IL 60448 www.ozinga.com
Program Operator	ASTM International 100 Bar Harbor Drive West Conshohocken, PA 19428-2959, USA
LCA and EPD Developer	Athena Sustainable Materials Institute 280 Albert Street, Suite 404 Ottawa, ON K1P 5G8, Canada
Core PCR	ISO 21930:2017 Sustainability in Building Construction - Environmental Declaration of Building Products
Sub-category PCR	NSF International Product Category Rule (PCR) for Concrete Version 1 (February 22, 2019), Verified by Thomas P. Gloria, Ph.D., Industrial Ecology Consultants

Athena Sustainable Materials Institute

Table E3-Great Lakes Midwest LCA Results (per cubic yard)

Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	197.04	216.41	257.59	309.58	326.96	385.62	402.59	447.19	491.54

PCA
America's Cement Manufacturers™

Environmental Product Declaration

Portland Cements
(per ASTM C150, ASTM C1157, AASHTO M 85 or CSA A3001)

ASTM INTERNATIONAL

Additional information regarding LCA methodology

Additional information regarding databases and impact methodologies used for conducting the LCA for this EPD can be found in the *LCA core model and database report* of the *U.S. version of WBCSD-CSI tool for EPDs of concrete and cement.*

Life cycle assessment results

The cradle-to-gate impacts of producing portland cement are presented in Table 4.

Table 4. Life cycle results for portland cement production.

Metric	Cradle-to-gate total per metric tonne of production	Unit
Environmental impact		
Global warming potential (100 years)	1040	kg CO2-eq.

ASTM C150 vs C595 vs C1157

Holcim

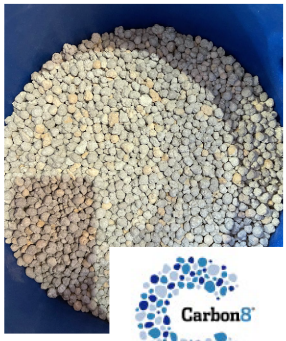
Environmental Product Declaration (EPD)
In accordance with ISO 14025 and 21930

Production stage EPD Results: Ste. Genevieve, MO – per Metric Tonne

Impact category and inventory indicators	Unit	Portland Type I/II Low Alkali ASTM C150
Global warming potential, GWP 100[1], AR5	kg CO_2 eq	748

Emerging Technologies

- CarbonCure
- Carbon8
- Blue Planet
- Carbon Upcycling
- University Studies
- Commercialization



Cement Reduction

- SCMs
  - Fly ash, slag, pumice, micro silica, metakaolin, ground glass
- Availability
- Cost

Admixtures/Aggregates

- Admixtures
  - High Range Water Reducers
  - Strength Enhancers
  - Accelerators
- Aggregates
  - Size
  - Hardness
  - Pumpability

Research Results

6500 psi @ 28 days < 100 kg/CO_2 per yard

- Concrete AI
- Mortar Lab
- Concrete Lab
- Plant Trials

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Life Cycle Impact Assessment		
Method and Indicators	TRACI 2.1 + Inventory metrics as specified in the NSF PCR	TRACI 2.1 + Inventory metrics as specified in the NSF PCR
Software	SimaPro v8.5 [9]	SimaPro v8.5 [9]

Table 4 shows the comparison of the NRMCA XXX Benchmark an the evaluated EPD for ready mixed concrete. It is shown that the environmental impact reductions in the category GWP is below 10%.

Table 4. Results comparison showing the NRMCA Benchmark and the evaluated EPD for ready mixed concrete.

Relevant Impact Categories for LEED			6000 psi	CSC RMX	% Change
Global Warming Potential	GWP	kg CO2e	326.96	66.39	-392.46%
Depletion potential of the stratospheric ozone	ODP	kg CFC11e	8.89E-06	1.91E-06	-364.35%
Acidification potential of soil and water	AP	kg SO2e	1.03	0.22	-360.69%
Eutrophication Potential	EP	kg Ne	0.45	0.11	-321.03%
Formation potential of tropospheric ozo	SFP	kg O3e	20.78	4.67	-345.06%
Non-renewable primary energy carrier used as energy	NRPRE	MJ, NCV	2145.44	426.22	-403.37%

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Benchmark Report:

LCA for Ready Mixed Concrete produced for Ozinga Ready Mixed Concrete

FACILITY:	Chicago Chinatown
STRENGTH:	3000 psi @ 28 days
MIX NAME:	ZERO Carbon

GENERAL INFORMATION	
Declared Product	Ready-mixed concrete produced by Ozinga Ready Mix Concrete
Date of Issue	May 3, 2022
Period of Validity	August 13, 2025
LCA Holder	19001 Old LaGrange Mokena, IL 60448
LCA and EPD Developer	Athena Sustainable 280 Albert Street, S Ottawa, ON K1P 5G
Core PCR	ISO 21930:2017 Sus Declaration of Build
Sub-category PCR	NSF International Pr Verified by Thomas

Table 4. Results comparison showing the NRMCA Benchmark and the evaluated EPD for ready mixed concrete.

Relevant Impact Categories for LEED			3000 psi	ZERO Carbon	% Change
Global Warming Potential	GWP	kg CO2e	216.41	-0.53	40849.36%
Depletion potential of the stratospheric ozone	ODP	kg CFC11e	6.09E-06	1.07E-06	-467.70%
Acidification potential of soil and water	AP	kg SO2e	0.74	0.32	-132.68%
Eutrophication Potential	EP	kg Ne	0.32	0.06	-397.27%
Formation potential of tropospheric ozo	SFP	kg O3e	14.81	7.88	-88.02%
Non-renewable primary energy carrier used as energy	NRPRE	MJ, NCV	1526.59	396.36	-285.15%

Collaboration

CO_2 REDUCTION OBJECTIVES

DAYS TO STRENGTH

DESIGN PROCESS

THANK YOU

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ARCHITECTURE