

# Identifying Alternative Supplementary Cementitious Materials for California's Construction Industry

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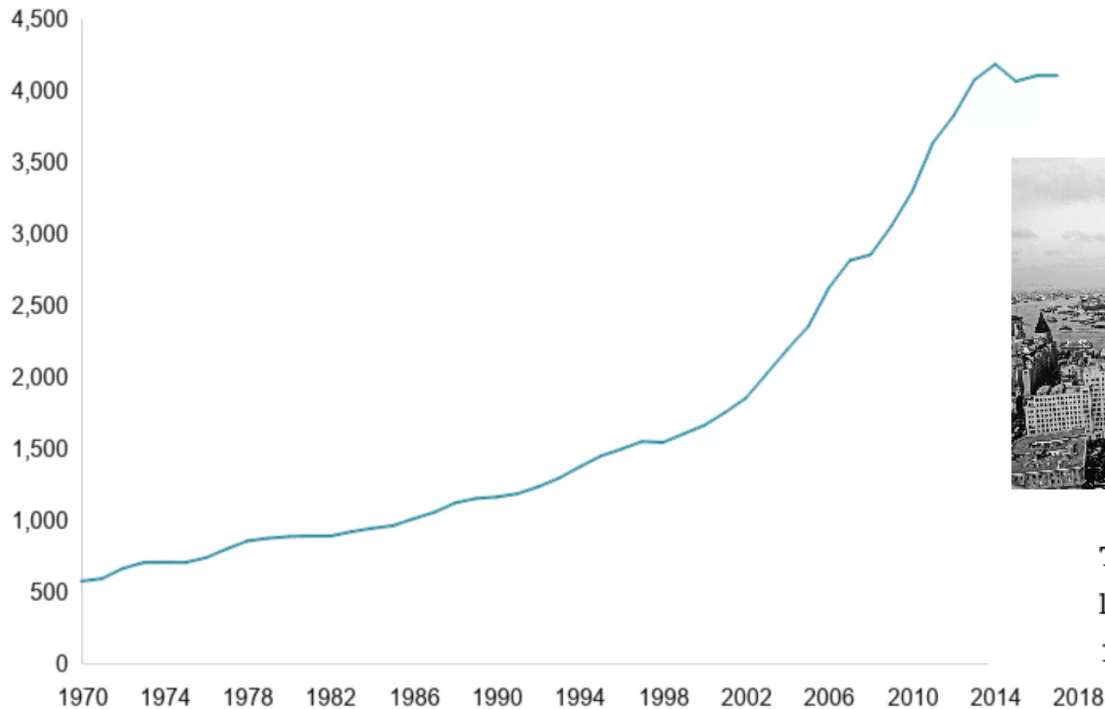
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# Global Cement Demand Projection

- Cement responsible for ~8% of anthropogenic CO<sub>2</sub> emissions
- Global cement production risen sharply but leveling off

Monteiro et al.  
(2017)

Millions of metric tonnes



These two photos capture what growth looks like—for better and for worse. Shanghai in 1987 (left) and 2013 (right). Gates (2021)

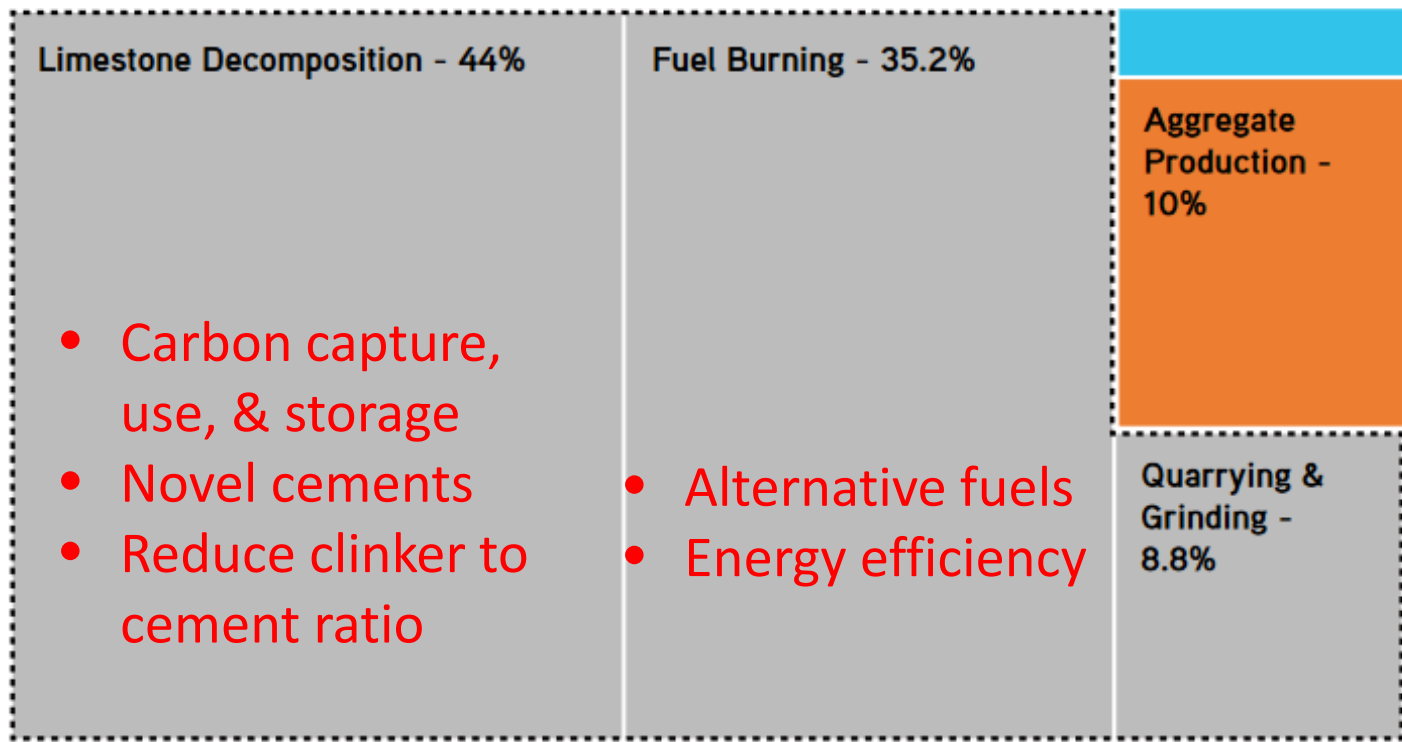
Note: Figures for 2016 and 2017 are estimates

Source: USGS

BBC

# Decarbonization Opportunities

 = Cement Production Processes



Batching,  
Mixing, &  
Delivery - 2%

# Supplementary Cementitious Materials

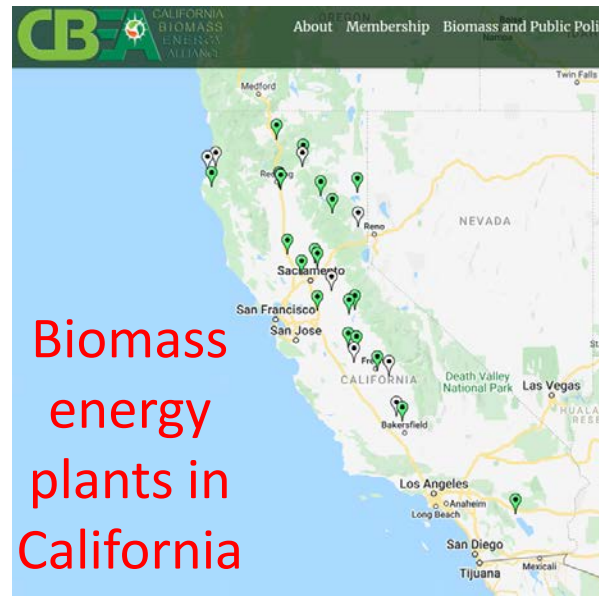
- Ashes from industrial wastes
- Fly ash (most common)
  - Domestic supplies of fly ash diminishing
  - California second leading cement-consuming state (USGS 2022)
  - Sources of fly ash in Utah, Arizona, Colorado, New Mexico and other countries
- Steel slag (GGBFS)
  - Little steel making in the US
  - GGBFS mainly imported
- Looking at biomass ashes and biochars

# Project Scope

- Evaluation process:
  1. Chemical/physical characterization
  2. Pozzolanic reactivity testing
  3. Evaluation in concrete
    1. Strength
    2. Durability

# Biomass Energy Plants

- Fuel sources: Sawmill waste, forest management/cleanup biomass, agricultural (nuts shells, fruit pits), urban wood waste (used lumber,...)
- Rich in silica, calcium, and alumina provide potential pozzolanic reactivity



Company Name	City	County	Capacity (MW)	Ashes Prod. (tons/year)
DTE Energy Services	Woodland	Yolo	28	4 268
DTE Stockton LLC	Stockton	San Joaquin	50	48 730
Humboldt Redwood Company, LLC	Scotia	Humboldt	32.5	16 912
Mt Poso Cogeneration Co	Bakersfield	Kern	63.6	41 330
Sierra Pacific Industries Inc	Lincoln	Placer	19.2	11 251
Sierra Pacific Industries Inc	Sonora	Tuolumne	10.9	5 872
Sierra Pacific Industries Inc	Burney	Shasta	20	12 983
Wadham Energy LP	Williams	Colusa	29.1	19 587

# Agricultural Ashes/Biochars

- Rice hull ash (RHA): byproduct of bioenergy plants
  - Mainly  $\text{SiO}_2$
  - Reactivity depend on burning temperature
- Rice straw ash (RSA): metallic contaminants, potassium, limit complete combustion, thus, hinders widespread production of RSA



## Forestry Biochar

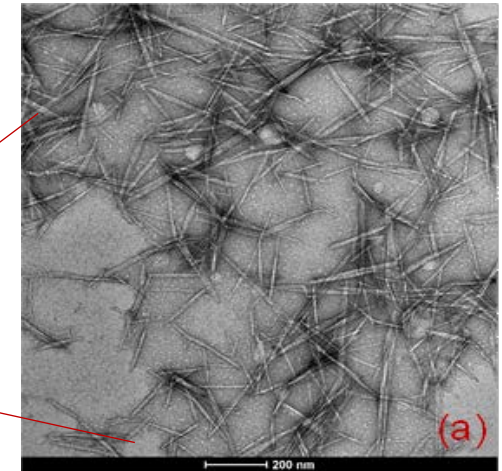
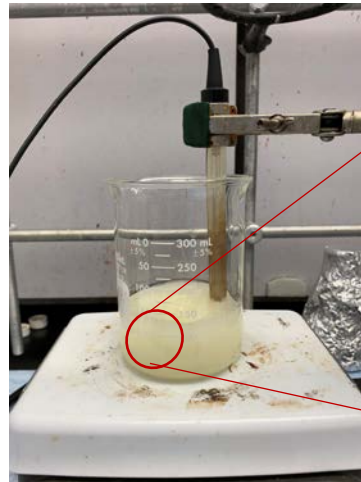
- Carbon sequestration in long lived infrastructure



Biochar made by pyrolysis of rice hulls (Glanris)

# Cellulose Nanomaterials

- Cellulose nanocrystals (CNCs): typically, by sulfuric acid hydrolysis: amorphous region is digested, and the crystalline region is intact
- Cellulose nanofibers (CNFs): tempo-oxidation or mechanical fibrillation
- Similar type of nanomaterials produced from chitin found in seafood waste
- CNC and CNF may provide
  - Internal curing functions/reduce shrinkage
  - Boost degree of hydration
  - Reinforcing mechanism
  - Stiffen C-S-H
- Our study:
  - Impact on workability, strength, cement reduction, compatibility with admixtures





# Thanks!

Please contact me to send samples:

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