Technical Appendix

Background of Maryland GHG Emissions Reduction Policies and Targets

The Greenhouse Gas Reduction Act (GGRA) of 2009 required Maryland to reduce state-wide greenhouse gas (GHG) emissions by 25 percent from a 2006 baseline by 2020 while ensuring a positive impact on Maryland's economy, protecting manufacturing jobs, and creating new jobs in the State. The GGRA was reauthorized in 2016 to incorporate additional reporting and mid-course reaffirmation goals and set a new benchmark of a 40% emissions reduction from 2006 levels by 2030. The Climate Solutions Now Act of 2022 increased the ambition of Maryland state emission reduction targets, calling for a 60% gross reduction of GHGs from 2006 levels by 2031 and net-zero emissions by 2045. The emissions reduction target set by the Climate Solutions Now Act of 2022 is the most ambitious state target in the U.S.

The GGRA prohibits the state from requiring GHG emissions reductions from Maryland's manufacturing sector, causing a significant increase in costs to Maryland’s manufacturing sector, or directly causing the loss of existing jobs in the manufacturing sector unless required at the federal level or by existing state law. The General Assembly created a process to re-evaluate this provision based on an independent study of the economic impact of requiring greenhouse gas emissions reductions from the State's manufacturing sector, to be overseen by the Maryland Commission on Climate Change.

Definitions and Descriptions of Maryland Manufacturing

Definition of Manufacturing

Manufacturing is defined as activities falling within North American Industry Classification System (NAICS) codes 31-33 where possible in this analysis. When an activity is ambiguous or unknown, the categories “Industrial Fuel Use” and “Industrial Processes and Product Use” in the Maryland Greenhouse Gas Inventory are taken as the default boundaries because they form the legal basis for greenhouse gas reduction plans and the scope of this work.

Description of Manufacturing Activities in Maryland

There are 6,693 manufacturing facilities listed in the Maryland Manufacturing Directory. The geographical distribution of these facilities is shown in Supplementary Figure 1. The top 5 most common manufacturing activities in the Directory are given in Supplementary Table 1.

Supplementary Figure 1. Map of density of manufacturing facilities by zip code in Maryland. Data from Maryland Manufacturing Directory.
NAICS code | NAICS code description | Number of facilities
---|---|---
323111 | Commercial Printing (except Screen and Books) | 463
311811 | Retail Bakeries | 419
339999 | All Other Miscellaneous Manufacturing | 328
339950 | Sign Manufacturing | 277
337110 | Wood Kitchen Cabinet and Countertop Manufacturing | 262

*Supplementary Table 1.* Most common manufacturing activities by NAICS code in the Maryland Manufacturing Directory.

**Maryland Greenhouse Gas Emission Inventory**

The Maryland Greenhouse Gas Emission Inventory is publicly available for years 2006, 2011, 2014, and 2017. A draft version of the 2020 inventory was supplied by the Maryland Department of the Environment for this analysis. All emissions in the inventory are calculated based on a 100-year global warming potential (GWP).

**Historical Fuel Prices in Maryland**

![Real Energy Prices in Maryland](image)

*Supplementary Figure 2.* Real energy prices in Maryland for 2006-2020. Data from EIA and BLS.

Fuel prices in the industrial sector have fluctuated over time, but those fluctuations in prices do not correlate with similar fluctuations in GDP or employment (Figure 2), indicating that the sector is resilient to fuel price changes of this magnitude.
## Harmonization of Manufacturing Categories Across Figure 3 Datasets

<table>
<thead>
<tr>
<th>Category</th>
<th>Energy Consumption</th>
<th>Number of Firms</th>
<th>Real GDP</th>
<th>Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Manufacturing Energy Consumption Survey, 100 MD Manufacturing Directory 101</td>
<td>MD Manufacturing Directory 101</td>
<td>Bureau of Economic Analysis 5</td>
<td>Bureau of Economic Analysis 5</td>
</tr>
<tr>
<td>Chemicals</td>
<td>NAICS code 324-325</td>
<td>NAICS code 324-325</td>
<td>Chemicals manufacturing, Petroleum and coal products manufacturing</td>
<td>Chemicals manufacturing, Petroleum and coal products manufacturing</td>
</tr>
<tr>
<td>Food Processing</td>
<td>NAICS code 311-312, No code but Self-description with “food”</td>
<td>NAICS code 311, No code but Self-description with “food”</td>
<td>Food and beverage and tobacco product manufacturing</td>
<td>Food manufacturing, Beverage and tobacco product manufacturing</td>
</tr>
<tr>
<td>Furniture and Related Products</td>
<td>NAICS code 337</td>
<td>NAICS code 337</td>
<td>Furniture and related product manufacturing</td>
<td>Furniture and related product manufacturing</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>NAICS code 339</td>
<td>NAICS code 339</td>
<td>Miscellaneous manufacturing</td>
<td>Miscellaneous manufacturing</td>
</tr>
<tr>
<td>Nonmetallic Mineral Products</td>
<td>NAICS code 327</td>
<td>NAICS code 327</td>
<td>Nonmetallic mineral product manufacturing</td>
<td>Nonmetallic mineral product manufacturing</td>
</tr>
<tr>
<td>Printing and Related Support</td>
<td>NAICS code 323</td>
<td>NAICS code 323</td>
<td>Printing and related support activities</td>
<td>Printing and related support activities</td>
</tr>
</tbody>
</table>
### Calculation of Cement Emissions Reductions (Figure 8) and Costs (Table 1)

#### OPC to PLC Switch

Abatement potential from transitioning from OPC to PLC cement manufacturing at the Hagerstown facility was calculated using a 10% industry default emissions reduction coefficient. The industry default emissions reduction coefficient was multiplied by Hagerstown's total process CO$_2$ emissions in 2020 to calculate the abatement potential. Union Bridge provided an abatement potential estimate of 7% from OPC to PLC switching at the Union Bridge facility that was used instead of the industry default.

\[
0.10 \times Total\ Emissions = Abated\ tCO_2\ at\ Hagerstown
\]

\[
0.7 \times Total\ Emissions = Abated\ tCO_2\ at\ Union\ Bridge
\]

Switching from OPC to PLC is estimated to reduce costs by between $10 to $30 per ton of CO$_2$. The range of savings from switching from OPC to PLC were calculated by multiplying the total CO$_2$ emissions by either $10 or $30.

\[
$ saved\ per\ tCO_2 \times Abated\ tCO_2 = Annualized\ savings
\]

### Supplementary Table 2. Explanation of categories and data sources for Figure 3.

<table>
<thead>
<tr>
<th>Category</th>
<th>NAICS Code(s)</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NAICS code 321-322</td>
<td>Paper manufacturing, Wood product manufacturing</td>
</tr>
<tr>
<td>Other</td>
<td>All other NAICS codes 31-33 not listed in this table.</td>
<td>Primary metal manufacturing, Fabricated metal product manufacturing, Machinery manufacturing, Electrical equipment, appliance, and component manufacturing, Textile mills, Textile product mills, Apparel manufacturing, Leather and allied product manufacturing, Plastics and rubber products manufacturing</td>
</tr>
<tr>
<td>Transportation Equipment</td>
<td>NAICS code 336</td>
<td>Motor vehicles, bodies and trailers, and parts manufacturing Other Transportation Equipment</td>
</tr>
<tr>
<td></td>
<td>NAICS code 336</td>
<td>Motor vehicles, bodies and trailers, and parts manufacturing Other Transportation Equipment</td>
</tr>
</tbody>
</table>
Coal to Natural Gas

The EIA estimates a 44.7% emissions reduction coefficient for the transition from coal to natural gas.\textsuperscript{27} Abatement potential for the coal to natural gas transition at the Union Bridge facility was calculated by multiplying the 44.7% emissions reduction coefficient by Union Bridge's total coal CO\textsubscript{2} emissions in 2020.

\[ 0.447 \times \text{Total Coal Emissions} = \text{Abated tCO}_2 \]

The cost to transition from coal to natural gas was calculated by adding annualized infrastructure costs and annualized fuel costs. Union Bridge estimates that installing natural gas infrastructure, including the 28 mile natural gas pipeline, will cost $50 million. A range of annualized infrastructure costs were calculated by dividing the $50 million in infrastructure costs by a 12 and 22 year lifespan representing a potential switch to net-zero fuels by 2040 and continual use of the pipeline through 2050 respectively. Fuel costs were calculated by subtracting the annual cost of coal consumed at Union Bridge from the annual cost of natural gas to replace coal. The annual cost of coal at Union Bridge was calculated by multiplying the cost per ton of coal in 2020 by the total tons of coal consumed in 2020.\textsuperscript{30} The cost to replace coal with natural gas was calculated by dividing the cost of natural gas per MMBtu by the cost of coal per MMBtu and then multiplying that quotient by the annual cost of coal in 2020.\textsuperscript{38}

\[
\frac{\text{Cost per ton of coal}}{\text{tons of coal}} = \text{Annualized cost of coal} \\
\frac{\$50,000,000}{\text{Pipeline lifetime in years}} = \text{Annualized infrastructure costs} \\
\left(\frac{\text{Cost of natural gas per MMBtu}}{\text{Cost of coal per MMBtu}}\right) \times \text{Annualized cost of coal} = \text{Annualized cost of NG} \\
\text{Annualized cost of NG} - \text{Annualized cost of coal} = \text{Annualized cost to switch fuels} \\
\text{Annualized infrastructure cost} + \text{Annualized cost to switch fuels} = \text{Annualized cost to switch to NG} 
\]

Coal to RDF Mix

Literature estimates suggest a 35% emissions reduction coefficient for the transition from coal to a RDF mix.\textsuperscript{33} The Hagerstown facility intends to transition up to 43% of their fuel mix from coal to a RDF mix over a 3 to 5 year period. Abatement potential for the coal to RDF mix transition at the Hagerstown facility was calculated by multiplying the 35% emissions reduction coefficient by the 43% transition coefficient and then by Hagerstown's total coal CO\textsubscript{2} emissions in 2020.

\[ \text{Emissions Reduction Coefficient} \times \text{Percent of fuel to be switched} \times \text{Total Coal Emissions} = \text{Abated tCO}_2 \]

Transitioning from coal to a RDF mix is estimated to cost between $0 to $100 per ton of CO\textsubscript{2}.\textsuperscript{34} The cost to transition from coal to a RDF mix at the Hagerstown facility was calculated by multiplying the tons of CO\textsubscript{2} abated by the transition by either $0 or $100.

\[ \$ \text{per tCO}_2 \times \text{Abated tCO}_2 = \text{Annualized cost for coal to RDF switch} \]

Natural Gas/RDF to Net-Zero Fuel Mix

The transition from either natural gas or a coal and RDF fuel mix to a net-zero fuel mix is assumed to totally eliminate the remaining fuel emissions at each facility. Abatement potential at the Union Bridge and Hagerstown facilities was calculated by subtracting the abatement potentials of the fuel-switching transitions at each facility from each facility's total coal CO\textsubscript{2} emissions in 2020.

\[ \text{Total Coal Emissions} - \text{Prior Fuel Switching Abatement Potential} = \text{Abated tCO}_2 \]
The cost for each facility to transition to a net-zero fuel mix was calculated based on the net-zero fuel mix demonstrated by HeidelbergCement at the Ribblesdale, UK cement facility. The Ribblesdale net-zero fuel mix consisted of 39% gray hydrogen (placeholder for green hydrogen), 12% meat and bone meal, and 49% glycerin. The cost of green hydrogen was calculated both with and without the $3 per kg hydrogen PTC offered through the IRA under section 45V. The range of costs for green hydrogen without the IRA PTC are $2.00 to $3.40 per kg. We assume full compliance with the prevailing wages and apprenticeship requirements of the IRA PTC. With the $3 green hydrogen IRA PTC, the cost per kg drops to between -$1.00 and $0.40. The range of costs for green hydrogen were converted from the price per kg to the price per ton, totaling $707.60 to $1,202.93 per ton without the IRA PTC and totaling -$353.80 to $141.52 with the IRA PTC. Meat and bone meal cost $198.50 per ton in May 2020 and glycerin cost $726.29 per tonne in 2019. The cost of glycerin was converted from cost per tonne to cost per ton, totaling $658.88 per ton. The cost per ton for each component was multiplied by their percentage make-up of the fuel mix to find the cost per ton of the complete fuel mix. The cost per ton of the net-zero fuel mix was calculated to form four separate values by using the high and low range of hydrogen under both the inclusion and exclusion of the IRA PTC hydrogen credits.

\( \text{$/ton green hydrogen } \times 0.39 + \text{$/ton MBM } \times 0.12 + \text{$/ton glycerin } \times 0.49 = \text{$/ton net zero fuel mix} \)

The annual cost to fully transition to a net-zero fuel mix at each facility was calculated by multiplying the cost of the net-zero fuel mix per ton by the number of tons needed to maintain the same Btu value at each facility and then subtracting the annual cost of the preceding fuel, either coal and RDF or natural gas, from the replacement cost. The volume of the net-zero fuel mix needed to replace coal at each facility was calculated by dividing the total Btu value of coal consumed in 2020 by the Btu per ton of the net-zero fuel mix. The Btu value of coal consumed in 2020 was calculated by multiplying the Btu per ton of coal by the total volume of coal consumed at each facility in 2020. The Btu value of the net-zero fuel mix was calculated by multiplying the Btu value per ton for each component and then again by the percentage of each component in the fuel-mix. Then the total Btu value of coal consumed in 2020 was divided by the Btu value of the net-zero fuel mix to find the number of tons of net-zero fuel mix needed to maintain the facility's Btu value. The annual cost to transition to a net-zero fuel mix at each facility was calculated by multiplying the cost per ton of the net-zero fuel mix by the number of tons needed to maintain the Btu and then by subtracting the annual cost of the preceding fuel.

\[
\text{Tons of coal consumed} \times \frac{\text{Btu/ton of coal}}{\text{Total Btu consumption}} = \text{Total Btu consumption} \\
\frac{0.39 \times \text{Btu}}{\text{ton of hydrogen}} + 0.12 \times \frac{\text{Btu}}{\text{ton of MBM}} + 0.49 \times \frac{\text{Btu}}{\text{ton of glycerin}} = \frac{\text{Btu}}{\text{ton net zero fuel mix}} \\

\text{Tons of net-zero fuel mix needed} = \frac{\text{Btu per ton of net zero fuel mix}}{\text{Btu/ton of net zero fuel mix}} \\
\text{Cost of preceding fuel} = \text{cost to switch to net zero fuel}
\]

CCUS

We assumed a 90% capture efficiency for the implementation of CCUS. Abatement potential was calculated by subtracting the sum of all preceding abatement potentials, including the OPC to PLC switch, either the coal to natural gas or coal to RDF mix fuel switch, and the transition to a net-zero fuel mix, from each facility’s total CO₂ emissions in 2020.

\[
0.9 \times (\text{Total Emissions} - \text{OPC to PLC} - \text{Fuel Switching} - \text{Net Zero Fuel Mix}) = \text{Abated tCO₂}
\]
The cost of CCUS was calculated both with and without including the 45Q tax credits that were expanded in the IRA to $85 per ton of CO_2 for capture and sequestration. We assume full compliance with the prevailing wage, hour, and apprenticeship requirements of the 45Q tax credits. The cost of CCUS implementation without 45Q credits ranges from $40 to $200 per ton of CO_2 captured with an additional $50 per ton of CO_2 to sequester geologically. The cost of CCUS implementation, including both sequestration costs and the 45Q credits, ranges between $5 and $165 per ton of CO_2. The cost to implement CCUS at the Union Bridge and Hagerstown facilities was calculated by multiplying the range of costs both with and without the 45Q credits by the total CO_2 abated by CCUS implementation.

\[ \text{Cost to implement CCUS} = \text{per tCO}_2 \times CCUS \text{ Abatement} \]

**Carbonation**

Literature estimates suggest that pre-demolition concrete can recapture between 7.6% to 24% of the emissions released during cement production over its lifetime through carbonation. We assume 10% of emissions are recaptured as a conservative lower bound. Abatement potential was calculated by multiplying the 10% recapture rate by the total CO_2 emissions at each facility in 2020.

\[ 0.1 \times \text{Total Emissions} = \text{Abated tCO}_2 \]

**Cement Timeline and Demand Projections**

The IEA estimates global demand for cement will grow between 12% and 23% between 2018 and 2050. In Figure 8, a median 17.5% linear increase in demand from 2018 levels was assumed, split between the 2031 and 2050 emissions timelines. We assumed a proportionate increase in emissions due to demand growth from 2020 levels. We assumed a 6% increase in demand growth and emissions between 2020 and 2031 and a 10% increase in demand growth and emissions from 2020 levels between 2031 and 2050. Due to this split in expected demand increase, the OPC to PLC switch and the initial fuel switching planned at each plant were applied separately to the demand increase in 2031 to 2050, which was not included in the 2020-2031 calculations. This separate calculation is represented in Figures 8a and 8b as reductions from “Previous measures.”

**Interviews with Cement Facility Representatives**

<table>
<thead>
<tr>
<th>IO1: Lehigh Hanson</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date:</strong> 07/15/2022</td>
</tr>
<tr>
<td><strong>Attendees:</strong> Adam Swercheck - North American Environmental Director at Lehigh Hanson, Kent Martin - Plant Manager at Union Bridge, Kurt Deery - Environmental Engineer at Union Bridge, David Perkins Vice President of Government Affairs and Communications at Lehigh Hanson, Mark Stewart - Climate Change Program Manager at MDE, Christopher Beck - Division Chief of Climate Change Program at MDE, John Artes - Engineer at MDE, Alexander Holt - Engineer at MDE, Matthew Helminiak - Commissioner of Labor and Industry at Maryland Department of Labor, James Rzepkowski - Acting Secretary of Labor at Maryland Department of Labor</td>
</tr>
</tbody>
</table>

**Abstract:** Lehigh Hanson and Union Bridge facility staff invited representatives from CGS, MDE, and the Department of Labor to tour the Union Bridge facility and to present and discuss Lehigh Hanson and Union Bridge’s goals and plans to decarbonize.
**Non-cement Fuel Usage Calculations and Category Harmonization**

*Allocation of Emissions in Figure 9*

Figure 9 was composed using both MD inventory data and GCAM data. The MD inventory contains the total carbon emissions from all major fuels, industry sources, and the carbon emissions from the cement industry, thus allowing for the separation of non-cement industry emissions from cement industry emissions. The GCAM data contains the energy consumption for major industries broken down by fuels. The GCAM data does not directly address emissions, but was used to estimate the percent allocation of fuel consumption between manufacturing and non-manufacturing industries.

*Timeline Assumptions for Mitigation Strategies in Figure 10*

The timeline for mitigation strategy is based on the availability of technologies and economic efficiency. Some sectors already show potential to increase profits, and reduce emissions by recycling or implementing more fuel-efficient contemporary technologies. Due to the economic efficiency and technology feasibility, energy efficiency and demand or material efficiency strategies are expected to be implemented in the first half of the 2020-2050 timeline.

On the other hand, the carbon capture and storage strategy are expected to be implemented in the second half of the 2020-2050 timeline. Although theoretically, the CCUS strategy has great potential for the Chemistry sector, the technologies for CCUS are not mature at the current stage. Because the availability time for CCUS is uncertain, assuming it will be implemented in the second half of the 2020-2050 timeline is more reliable.

The timeline of electrification and fuel switching strategies will be longer than demand and energy efficiency and implemented earlier than the CCUS strategy. Electrification and fuel switching strategies are already technologically feasible and continuously improving, so they can be implemented now, not in 2035 like the CCUS strategy. However, in many sectors, electrification and fuel switching strategies are not economically efficient, so these two strategies should be implemented at a slower pace, so the manufacturing sectors would have time to adjust themselves.

*Non-cement fuel use abatement cost calculations and sources*

The cost of non-cement fuel use abatement cost is based on the order of implementing reduction strategies. Studies indicate that the reduction strategies reduce emission by ratio, $7.38, 64$, so the emission reduction from
A specific strategy is based on emission amount when implemented. As there are totally 5 strategies, the final emission of strategy \( i \) is shown as follows:

\[
\text{Remaining emission} = \text{initial emission} \times \prod_{i=1}^{5} (1 - \text{strategy } i \text{ reduction})
\]

The reduction of specific strategy \( i \) in order \( j \) is as follows:

\[
\text{Emission reduction}_{i,j+1} = \text{initial emission}_j \times (\text{strategy } i \text{ reduction})
\]

To minimize the cost, we order the strategies based on their average costs, and thus the final costs of reduction is as follows:

\[
\text{Total emission reduction cost} = \sum_{i=1}^{5} \text{Emission reduction}_{i,j+1} \times \text{average reduction cost}_i
\]

The annualized reduction, on the other hand, assumes a linear reduction from year to year based on the effective reduction strategies.

Harmonization of Manufacturing Categories for Figure 10 Datasets

<table>
<thead>
<tr>
<th>Global Change Analysis Model</th>
<th>Bureau of Economic Analysis</th>
<th>Manufacturing Energy Consumption Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>Chemical Petroleum and coal products</td>
<td>Ethyl Alcohol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Industrial Gases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nitrogenous Fertilizers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other Basic Inorganic Chemicals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other Petroleum and Coal Products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Petroleum Lubricating Oil and Grease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Petroleum Refineries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pharmaceutical Preparation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Photographic Film, Paper, Plate, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemicals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plastics Materials and Resins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pharmaceuticals and Medicines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemicals</td>
</tr>
<tr>
<td>Food Processing</td>
<td>Food</td>
<td>Animal Slaughtering and Processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beverages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dairy Product</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fruit and Vegetable Preserving and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specialty Food</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grain and Oilseed Milling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tobacco</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Other</td>
<td>Apparel Computer and electronic product Electrical Equipment, appliance, and component Fabricated Metal Product Furniture And Related Product Leather and Allied Products Machinery Miscellaneous Motor Vehicles, bodies and trailers, and parts Other Transportation Equipment Plastics and rubber products Primary Metal Textile Mills Textile Product Mills</td>
<td>Aircraft Artificial and Synthetic Fibers and Filaments Asphalt Paving Mixture and Block Asphalt Shingle and Coating Materials Automobiles Light Trucks and Utility Vehicles Aerospace Product and Parts Apparel Computer and Electronic Products Electrical Equip., Appliances, and Components Furniture and Related Products Leather and Allied Products Miscellaneous Plastics and rubber products Textile Mills Textile Product Mills Transportation Equipment</td>
</tr>
</tbody>
</table>

**Supplementary Table 3.** Categories used in Figure 10 to allocate emissions by manufacturing sector.
REFERENCES


(2) AN ACT Concerning Greenhouse Gas Emissions Reduction Act of 2009; Vol. CHAPTER 172 (Senate Bill 278).

(3) §2–1207 Article - Environment.

(4) Maryland Department of the Environment. Greenhouse Gas Emission Inventory.


(9) Facility Level Information on GreenHouse Gases Tool (FLIGHT), 2020.


(15) Lehigh Hanson. I01: Interview with Lehigh Hanson, 2022.


(26) ASTM. ASTM C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete; ASTM C618; ASTM International.


(49) Emission Categories Used to Calculate Compliance Obligations.

(50) Infrastructure Investment and Jobs Act.


(54) Doglio; DeBolt; Macri; Ormsby. Buy Clean Washington Act.
(55) Representative Dexter, Evans, Fahey, Grayber, Helm, Holvey, Hoy, Kropf, Moore-Green, Nelson, Noble, Nosse, Owens, Pham, Power, Reardon, Reynolds, Salinas, Sanchez, Williams, (Presession filed.). Relating to Reductions of Greenhouse Gas Emissions in the State’s Transportation System; and Prescribing an Effective Date.

(56) Senate Bill S542A.

(57) Ecklund; Hornstein. HF 2204.

(58) Greenstein, Linda R.; Singleton, Troy. Bill S3732 Sca (1R).


(60) Becker, J. Buy Clean California Act: Environmental Product Declarations: Concrete (2-Year).


(62) Urging All Cities to Consider Using Carbon Dioxide Mineralized Concrete for Future City Building and Infrastructure Projects Utilizing Concrete. usmayors.org. https://www.usmayors.org/the-conference/resolutions/?category=a0D4N00000FDDPaUAP&meeting=87th%20Annual%20Meeting.


(70) Scott, R. E. We Can Reshore Manufacturing Jobs, but Trump Hasn’t Done It: Trade Rebalancing, Infrastructure, and Climate Investments Could Create 17 Million Good Jobs and Rebuild the American Economy; Economic Policy Institute: Washington, DC, 2020.


(93) American Innovation and Manufacturing; Vol. 42 USC 7675.


(100) U.S. Bureau of Labor Statistics. CPI for All Urban Consumers (CPI-U); CUSR0000SA0; U.S. Bureau of Labor Statistics: Washington, DC.


