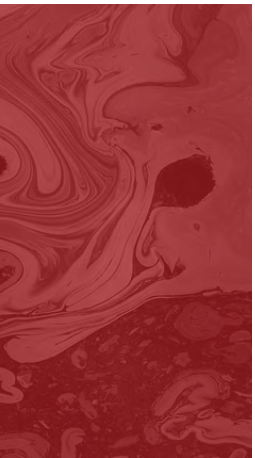
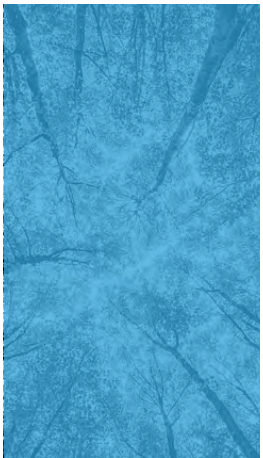
Food & Beverage





3.7 Food & Beverage

The food and beverage manufacturing industry is a critical, $359 billion sector of the U.S. economy. The sector employs more than 1.7 million workers (14.6 percent of all U.S.

manufacturing employees) at over 36,000 food and beverage processing plants, owned by over 31,400 companies. With complex supply chains stretching all over the United States and throughout nearly every part of the economy, food and beverage manufacturing is diverse, dispersed, and challenging to regulate. [392]

Food and beverage manufacturing is also one of the largest GHG-emitting and energy-consuming industries in the United States. The sector emits around 96 MMT CO_2e/year (including emissions from offsite generation), with CHP, boilers, and process heating accounting for the most direct emissions. Over half (53 percent) of its emissions come from offsite electricity and steam generation (***Figure 28***). [393] Most energy consumed in food and beverage manufacturing (over 55 percent) is natural gas, with much of the rest coming from grid electricity (***Figure 29***). [394]

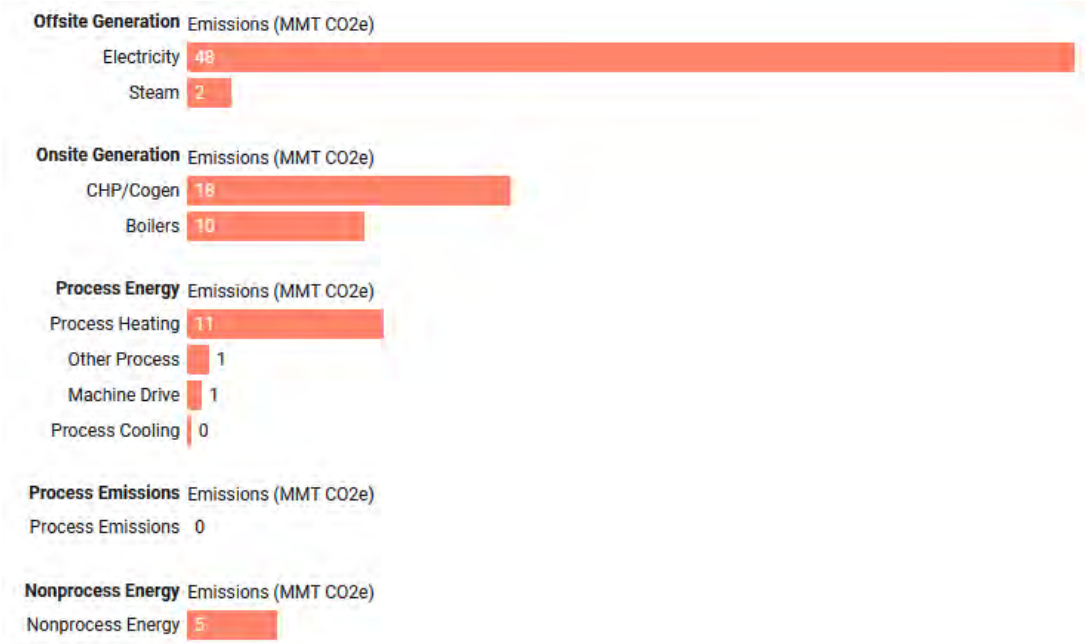


Figure 28: Food and beverage sector sources of GHG emissions in 2018, by major end use. Source: U.S. DOE, Manufacturing Energy and Carbon Footprint: Food and Beverage Sector.

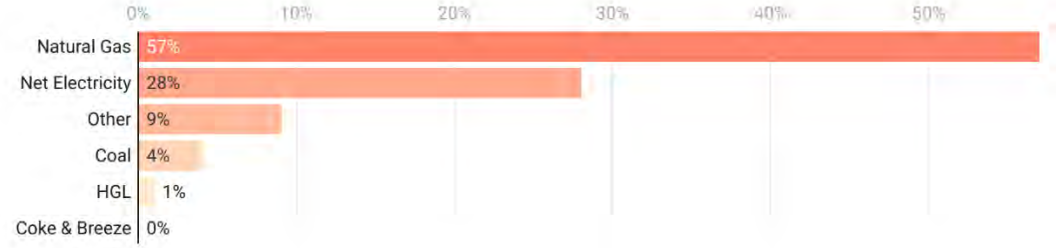
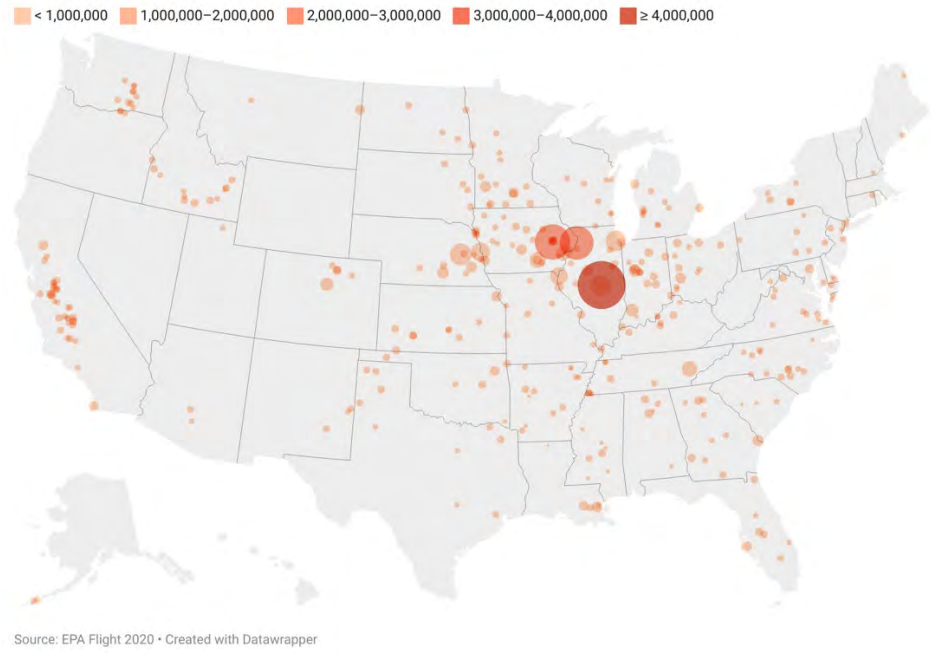


Figure 29: Food and beverage sector fuel and non-fuel uses of energy in 2018 (as a percentage of total trillion Btu). Source: U.S. EIA, MECS 2018, Table 1.2.

Food and beverage manufacturing is highly dispersed (***Figure 30***). [395] Most processing facilities are in the general proximity of major population centers, and/or close to material

sources in their supply chains.[396] Because of this, the GHG emissions associated with the transportation of these goods leads to higher embodied emissions. The states with the most food and beverage manufacturing plants in 2017 were California (5,731), followed by New York (2,573) and Texas (2,273), but the states with the facilities contributing the most GHG emissions differ (Iowa, Illinois, and Nebraska).



State	Total GHG Emissions	Facilities
IA	7,001,172	31
IL	6,461,579	16
NE	2,036,680	11
CA	1,668,320	42
IN	1,366,774	20
MN	798,979	15
TN	632,072	12
OH	606,993	11
KS	548,501	9
GA	543,162	12
ID	487,478	13

Figure 30: Location and total reported emissions (metric tons CO_2e) of food and beverage manufacturing plants in the United States (left). Top 10 states by total GHG emissions from food and beverage facilities (right table). Size and darkness of bubbles scale with level of emissions. Source: U.S. EPA, FLIGHT.

The top five food manufacturing companies in the United States by 2019 food and beverage sales have all established science-based sustainability and emissions reduction targets. For example:

- Nestle, which was responsible for 92 million tons of GHG emissions in 2018, is a signatory of the UN Business Ambition for 1.5°C pledge and plans to halve its emissions by 2030 and achieve net zero by 2050.[397]
- PepsiCo is committed to reducing scope 1 and 2 emissions by 75 percent and scope 3 emissions by 40 percent by 2030.[398]
- JBS has committed to achieving net-zero GHG emissions by 2040 and has also signed on to the UN Business Ambition pledge.[399]
- Tyson Foods is targeting net-zero GHG emissions by 2050.[400]
- Archer Daniels Midland intends to lower its GHG emissions by 25 percent and reduce energy intensity by 15 percent by 2035.[401]

Common approaches to reach these decarbonization goals include supporting regenerative agriculture practices, supply chain management, investing in carbon offsets, redesigning packaging to reduce waste, and conducting internal carbon prices pilots. However, these goals overlook many readily available opportunities for enhanced energy efficiency and process electrification.

On the agricultural side, better land use and fertilizer management, crop rotation, no-till practices, agroforestry, and precision agriculture can help reduce net GHG emissions and reduce waste. Another high-potential opportunity for with short-term savings includes food waste reduction, which translates directly to mitigated carbon dioxide emissions in the supply chain. Though difficult to achieve because of the diversity of supply chains, policies and programs aimed towards material efficiency, packaging redesigns, and recycling have the potential to make a meaningful difference. Information communication technologies can support automation and process optimization. Other opportunities include waste heat recovery, industrial heat pumps, and regulatory changes that provide greater flexibility for process innovation.

There are many examples of existing state-level policies or programs aimed at reducing emissions from food and beverage manufacturing. **New York** recently detailed the possibility for carbon capture utilization technologies to create savings in beverage carbonation, food freezing, chilling, and packaging, and in horticulture.[402] **Delaware** and **Maryland** both have statewide agricultural audit and implementation (incentives and training) programs that are aimed at promoting the uptake more-efficient agricultural practices and technologies to reduce energy use and waste.[403, 404] **Washington** state's *2021 Energy Strategy* indicates the potential for GHG reduction measures such as fuel-switching boilers, industrial heat pumps, alternative drying strategies, and ultraviolet or microwave pasteurization/sterilization to help decarbonize food and beverage manufacturing.[405]

Internationally, Canadian provinces Manitoba and Ontario have developed province-based initiatives towards reducing food waste while the EU has created a *Circular Economy Action Plan* that includes sections on packaging and recycling.[406, 407, 408] The EU has also investigated the potential of demand-side strategies such as public procurement of food to support the market for less-carbon-intensive food products as well as manufacturing processes that are responsible for less emissions.[409]

Decarbonization of the food and beverage sector will require enabling policies, programs, capital investments, and R&D to overcome barriers that include inadequate funding, health and safety scrutiny, few uses for waste heat, sector diversity, and geographic constraints. The barriers and policy connections are summarized in ***Table 14***.

Table 14: Decarbonization barriers in the food & beverage industry.

Challenge / Barrier	State Opportunities	Policy Connections
Health, safety, quality scrutiny of food and beverage products create additional costs and stipulations on process change	• These hurdles, while necessary, can be minimized by articulating benefits to supply chain partners, customers, regulators… of energy efficiency, low-carbon technologies, and getting buy-in for changes	• Workforce training and technical assistance for efficiency improvements • Address negative perceptions about process changes to food quality and show benefits to society, consumers, government, companies
Underutilized waste heat recovery opportunities	• Industrial heat pumps can provide significant GHG and energy savings in process heat and uses for waste heat	• Capital costs may have to be augmented to make heat pumps viable at scale • Industrial clusters can be encouraged to more effectively reuse waste heat, adopt low-

Challenge / Barrier	State Opportunities	Policy Connections
	• Industrial clusters can increase waste heat use • Energy management can help reduce energy/heat demand	carbon technologies, and update infrastructure • Support for SEM managers (especially SMM) while developing workforce
Capital costs associated with electrification	• Food and beverage is well suited for electrification because of high modularization of heating potential, low process heat	• Electricity: natural gas price disparity is an opportunity for incentives to spur electric technology adoption
Diversity of the sector, geographic distribution	• Industrial clusters can be a route to counter geographic disparity • Supply chain inefficiency is a major source of emissions	• States can revitalize industrial clusters as a locus for supply chain resiliency • RFIDs, supply chain transparency and optimization, EPDs, can aid transformation
Food waste is a huge source of ineffective embodied carbon	• Packaging redesign, recycling, material efficiency can significantly reduce waste and embodied emissions • Information and communication technologies (ICTs) can reduce food waste through sensors, optimization	• State mandates on plastic use recyclability of packaging, use of imperfect produce, and extended shelf lives can reduce food waste • R&D and incentives are needed to accelerate the proliferation of ICTs in food and beverage manufacturing
R&D needed to increase the feasibility of decarbonization technology options	• Smart manufacturing, beneficial electrification, low-carbon fuels, CCUS have the potential to reduce emissions significantly	• State funds leveraged with federal funds in R&D can help bridge the gap between innovative options and commercial viability

Roadmaps for the Food & Beverage Industry

- Decarbonization Roadmap for the EU Food Industry (2021)
- UK Roadmap for Food (2015)
- UK Roadmap for Food (Appendices) (2015)

REFERENCES

[1] Intergovernmental Panel on Climate Change, *Climate Change 2022: Mitigation of Climate Change | Summary for Policymakers*, 2022, https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf.
[2] U.S. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020*, 2022, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020.
[3] Ben King et al., *Taking Stock 2022: US Greenhouse Gas Emissions Outlook in an Uncertain World*, Rhodium Group, July 14, 2022, https://rhg.com/research/taking-stock-2022/.
[4] U.S. Energy Information Administration (EIA), "Energy Use in Industry," accessed September 8, 2022, https://www.eia.gov/energyexplained/use-of-energy/industry.php.
[5] U.S. EIA, "Six subsectors account for nearly 90% of manufacturing energy consumption," April 19, 2021, https://www.eia.gov/todayinenergy/detail.php?id=47596.
[6] U.S. Department of Energy (DOE), *Manufacturing Energy and Carbon Footprints (2018 MECS)*, 2021, https://www.energy.gov/eere/amo/manufacturing-energy-and-carbon-footprints-2018-mecs.
[7] U.S. DOE, *Industrial Decarbonization Roadmap,* September 2022, https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.
[8] Intergovernmental Panel on Climate Change, "The evidence is clear: the time for action is now. We can halve emissions by 2030," [Press Release] April 4, 2022, https://www.ipcc.ch/report/ar6/wg3/resources/press/press-release.
[9] Intergovernmental Panel on Climate Change, *Climate Change 2022*, 2022.
[10] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, 2022.
[11] U.S. EPA, "Greenhouse Gas Inventory Data Explorer," accessed September 8, 2022, https://cfpub.epa.gov/ghgdata/inventoryexplorer/index.html - allsectors/allsectors/allgas/econsect/all.
[12] U.S. EPA, "Greenhouse Gas Inventory Data Explorer," accessed September 8, 2022.
[13] U.S. EPA, "Sources of Greenhouse Gas Emissions: Industry Sector Emissions," accessed September 8, 2022, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions - industry.
[14] U.S. EIA, "Energy Use in Industry," accessed September 8, 2022, https://www.eia.gov/energyexplained/use-of-energy/industry.php.
[15] U.S. EIA, "Six subsectors account for nearly 90% of manufacturing energy consumption," 2021.
[16] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS)*, 2021.
[17] King, *Taking Stock 2022*, 2022.
[18] Andrew Reamer, "Industrial Decarbonization Priorities – DOE Seeks Information (by 2/28)," American Economic Association, January 28, 2022, https://www.aeaweb.org/forum/2335/industrial-decarbonization-priorities-seeks-information.
[19] United States Climate Alliance, accessed September 8, 2022, http://www.usclimatealliance.org/.
[20] U.S. DOE, *Industrial Decarbonization Roadmap,* September 2022.
[21] The White House Statements and Releases, "Fact Sheet: Biden-Harris Administration Rallies States, Cities, and Companies to Boost Clean American Manufacturing," [Press release] October 20, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/10/20/fact-sheet-biden-harris-administration-rallies-states-cities-and-companies-to-boost-clean-american-manufacturing/.
[22] International Energy Agency (IEA) et al., *Technology Roadmap: Energy and GHG Reductions in the Chemical Industry via Catalytic Processes*, 2013, https://www.iea.org/reports/technology-roadmap-energy-and-ghg-reductions-in-the-chemical-industry-via-catalytic-processes.
[23] Simon Moser and Horst Steinmüller, "RDI Roadmaps on Industrial Decarbonization," European Council for an Energy Efficient Economy, June 13, 2018, https://www.eceee.org/library/conference_proceedings/eceee_Industrial_Summer_Study/2018/1-policies-and-programmes-to-drive-transformation/rdi-roadmaps-on-industrial-decarbonization/.

[24] Manfred Fischedick et al., "Chapter 10: Industry," in *AR5 Climate Change 2014: Mitigation of Climate Change*, Working Group III, Intergovernmental Panel on Climate Change, 2014, https://www.ipcc.ch/report/ar5/wg3/.
[25] Eric Larson et al., *Net-Zero America: Potential Pathways, Infrastructure, and Impacts*, Princeton University, December 15, 2020, https://environmenthalfcentury.princeton.edu/sites/g/files/toruqf331/files/2020-12/Princeton_NZA_Interim_Report_15_Dec_2020_FINAL.pdf.
[26] Sarang D. Supekar and Steven J. Skerlos, "Market-Driven Emissions from Recovery of Carbon Dioxide Gas," *Environmental Science & Technology* 48, no. 24 (November 20, 2014): 14615–23, https://doi.org/10/f6t656.
[27] James Williams et al., "The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity," *Science* 335, no. 6064 (November 24, 2011): 53-59, http://www.sciencemag.org/content/335/6064/53.abstract.
[28] The National Academies of Sciences, Engineering, Medicine, "Industrial Efficiency," accessed September 8, 2022, http://needtoknow.nas.edu/energy/energy-efficiency/industrial-efficiency/.
[29] Takahiro Oki and Hugo Salamanca, "Driving Energy Efficiency in Heavy Industries: Global energy efficiency benchmarking in cement, iron & steel," IEA (International Energy Agency), March 17, 2021, https://www.iea.org/articles/driving-energy-efficiency-in-heavy-industries.
[30] U.S. Department of Energy (DOE), *Better Plants Progress Update Report: A Year of Innovation and Industrial Leadership*, 2020, https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/2020%20Better%20Plants%20Progress%20Update%20-%20FINAL.pdf.
[31] U.S. DOE, "Advanced Manufacturing: Waste Heat Resource Recovery Page," January 24, 2017, https://www.energy.gov/eere/amo/articles/waste-heat-recovery-resource-page.
[32] Amelia Elson, Rick Tidball, and Anne Hampson, *Waste Heat to Power Market Assessment*, ICF International, March 2015, https://info.ornl.gov/sites/publications/files/Pub52953.pdf.
[33] U.S. DOE, How Much Energy is a Gigawatt, 2022, https://www.energy.gov/eere/articles/how-much-power-1-gigawatt.
[34] U.S. DOE, "Advanced Manufacturing: Waste Heat Resource Recovery Page," accessed September 8, 2022, https://www.energy.gov/eere/amo/articles/waste-heat-recovery-resource-page.
[35] IEA, *Material Efficiency in Clean Energy Transitions*, 2019, https://www.iea.org/reports/material-efficiency-in-clean-energy-transitions.
[36] U.S. EIA, "Energy Use in Industry," accessed September 8, 2022, https://www.eia.gov/energyexplained/use-of-energy/industry.php.
[37] Aidan Tuohy and Niall Mac Dowell, *Increasing Electric Power System Flexibility: The Role of Industrial Electrification and Green Hydrogen Production*, Energy Systems Integration Group, January 2022, https://www.esig.energy/wp-content/uploads/2022/01/ESIG-Industrial-Elec-Hydrogen-report-2022.pdf.
[38] Ali Hasanbeigi et al., *Electrifying U.S. Industry: A Technology- and Process-Based Approach to Decarbonization*, Global Efficiency Intelligence, January 2021, https://www.globalefficiencyintel.com/electrifying-us-industry.
[39] E. Worrell, "Industrial Energy Use, Status and Trends," *Encyclopedia of the Anthropocene* 1 (November 29, 2017): 421-430, https://www.sciencedirect.com/science/article/pii/B9780128096659090455?via%3Dihub.
[40] Chris Battaile et al., "A review of technology and policy deep decarbonization pathway options for making energy-intensive industry production consistent with the Paris Agreement," *Journal of Cleaner Production* 187 (June 20, 2018): 960-973, https://www.sciencedirect.com/science/article/abs/pii/S0959652618307686?via%3Dihub.
[41] Mariësse van Sluisveld et al., *EU decarbonisation scenarios for industry*, ReInvent PROJECT NR 730053, July 4, 2018, https://static1.squarespace.com/static/59f0cb986957da5faf64971e/t/5b3fdf266d2a73e319355e0c/1530912585721/D4.2+EU+decarbonisation+scenarios+for+industry.pdf.
[42] U.S. DOE, *Industrial Decarbonization Roadmap,* September 2022.
[43] Ed Rightor, Paul Scheihing, Andrew Hoffmeister, Riyaz Papar, Industrial Heat Pumps; Electrifying Industry's Process Heat Supply, March 30, 2022, https://www.aceee.org/research-report/ie2201

[44] Tobias Naegler et al., "Quantification of the European Industrial Heat Demand by Branch and Temperature Level," *International Journal of Energy Research* 39, No. 15 (October 19, 2015): 2019–2030, https://onlinelibrary.wiley.com/doi/abs/10.1002/er.3436.
[45] Ed Rightor et al., "Industrial Heat Pumps; Electrifying Industry's Process Heat Supply", March 30, 2022.
[46] Ed Rightor et al., "Industrial Heat Pumps; Electrifying Industry's Process Heat Supply", March 30, 2022.
[47] Oliver Sartor, Chris Bataille, Decarbonizing Basic Materials in Europe: How Carbon Contracts for Differences Could Help Bring Breajkthrough Technologies to Market, IDDRI, 2019, https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Etude/201910-ST0619-CCfDs_0.pdf.
[48] Dan Starman, *Addressing the Cost of Electrification: Decarbonizing Heat for Energy Intensive Sectors*, Cornwall Insight, February 2022, https://www.cornwall-insight.com/wp-content/uploads/2022/02/Addressing-the-costs-of-electrification__final.pdf.
[49] U.S. EIA, "Energy Use in Industry," accessed September 8, 2022.
[50] Gregory P. Thiel and Addison K. Stark, "To decarbonize industry, we must decarbonize heat," *Joule* 5, Issue 3 (March 17, 2021): 531-550, https://www.sciencedirect.com/science/article/pii/S2542435120305754#bib46.
[51] Green Car Congress, "CF Industries to Build Green Ammonia Plant in Louisiana," November 6, 2020, https://www.greencarcongress.com/2020/11/20201106-cf.html.
[52] J. van de Loosdrecht and J.W. Niemantsverdriet, "Synthesis Gas Chemistry and Synthetic Fuels,"
in *Chemical Energy Storage* ed. R. Schloegl (Berlin: De Gruyter, 2013), https://www.syngaschem.com/the-chemistry/.
[53] Leigh Krietsch Boerner, "Industrial ammonia production emits more CO_2 than any other chemical-making reaction. Chemists want to change that," *Chemical & Engineering News,* June 15, 2019, https://cen.acs.org/environment/green-chemistry/Industrial-ammonia-production-emits-CO2/97/i24.
[54] National Grid, "The hydrogen colour spectrum," accessed September 8, 2022, https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum.
https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum
[55] Sara Baldwin, Dan Esposito, and Hadley Tallackson, "Assessing the Viability of Hydrogen Proposals: Considerations for State and Utility Regulators and Policymakers," Energy Innovation, 2022, https://energyinnovation.org/wp-content/uploads/2022/03/Assessing-the-Viability-of-Hydrogen-Proposals.pdf.
[56] U.S. DOE, *Industrial Decarbonization Roadmap,* September 2022.
[57] IEA, *CCUS in Clean Energy Transitions: A New Era for CCUS*, accessed September 8, 2022, https://www.iea.org/reports/ccus-in-clean-energy-transitions/a-new-era-for-ccus.
[58] Carbon Leadership Forum, "What is a Buy Clean Policy?," accessed September 8, 2022, https://carbonleadershipforum.org/what-is-a-buy-clean-policy/.
[59] BlueGreen Alliance, "Buy Clean," accessed September 8, 2022, https://www.bluegreenalliance.org/site/buy-clean/.
[60] Ali Hasanbeigi, Dinah Shi, and Navdeep Bhadbhade, *Federal Buy Clean for Cement and Steel: Policy Design and Impact on Industrial Emissions and Competitiveness*, Global Efficiency Intelligence, September 2021, https://www.globalefficiencyintel.com/federal-buy-clean-for-cement-and-steel.
[61] Tuohy, *Increasing Electric Power System Flexibility*, 2022.
[62] Tessa Weiss and Thomas Koch Blank, "Hydrogen Reality Check: We Need Hydrogen — But Not for Everything," RMI, June 27, 2022, https://rmi.org/we-need-hydrogen-but-not-for-everything/.
[63] Igor Alexeyevich Bashmakov and Lars J. Nilsson, "Chapter 11: Industry," in *Climate Change, 2022: Mitigation of Climate Change, Sixth Assessment*, Working Group III, Intergovernmental Panel on Climate Change (2022): Figure 11.13, 2022, https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_Chapter11.pdf.
[64] Tamaryn Brown et al., "Reducing CO2 Emissions from Heavy Industry: A Review of Technologies and Considerations for Policy Makers," Imperial College, Grantham Institute for Climate Change, 2012: Figure 8, https://perma.cc/6MDH-LPVZ.
[65] U.S. DOE, *Industrial Decarbonization Roadmap,* September 2022

[66] National Association of Manufacturers (NAM), "2019 United States Manufacturing Facts," accessed September 8, 2022, https://www.nam.org/state-manufacturing-data/2019-united-states-manufacturing-facts/.
[67] HB21-1266 Environmental Justice Disproportionate Impacted Community, Colorado General Assembly, 2021, http://leg.colorado.gov/bills/hb21-1266.
[68] State of Massachusetts, *Massachusetts Clean Energy and Climate Plan for 2025 and 2030*, June 30, 2022, https://www.mass.gov/doc/clean-energy-and-climate-plan-for-2025-and-2030/download.
[69] State of Maine, Governor's Office of Innovation and the Future, "Industrial Innovation Task Force," accessed September 8, 2022, https://www.maine.gov/future/initiatives/climate/climate-council/industrial-task-force.
[70] SB-596 Greenhouse gases: cement sector: net-zero emissions strategy, State of California, September 23, 2021, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB596.
[71] Climate Initiatives Task Force, *Louisiana Climate Action Plan*, February 2022, https://gov.louisiana.gov/assets/docs/CCI-Task-force/CAP/Climate_Action_Plan_FINAL_3.pdf.
[72] Michigan Department of Environment, Great Lakes, and Energy, *MI Healthy Climate Plan*, April 2022, https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Offices/OCE/MI-Healthy-Climate-Plan.pdf.
[73] State of Washington, "E. Industrial Transformation and Workforce Development," in *Washington 2021 State Energy Strategy* (2021): 84-113, https://www.commerce.wa.gov/wp-content/uploads/2021/01/WA_2021SES_Chapter-E-Industry.pdf.
[74] Wisconsin Office of Sustainability and Clean Energy, Great Plains Institute, and Slipstream, *State of Wisconsin Clean Energy Plan*, April 2022, https://osce.wi.gov/Documents/SOW-CleanEnergyPlan2022.pdf.
[75] California Air Resources Board, *Draft 22 Scoping Plan Update*, May 10, 2022, https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp.pdf.
[76] State of Minnesota, *Minnesota's Climate Action Framework [Draft]*, January 2021, https://climate.state.mn.us/sites/climate-action/files/2022-01/Climate Action Framework Draft_2.pdf.
[77] State of New York, *New York State Climate Action Council Draft Scoping Plan*, December 30, 2021, https://climate.ny.gov/-/media/Project/Climate/Files/Draft-Scoping-Plan.pdf.
[78] State of Michigan, Department of Environment, Great Lakes, and Energy, *Council on Climate Solutions: Workgroup Recommendations*, October 2021, https://www.michigan.gov/egle/about/Groups/Council-on-Climate-Solutions/Workgroup-Recommendations.
[79] State of Maine, "Industrial Innovation Task Force," accessed September 8, 2022.
[80] SB 5910 - 2021-22: Accelerating the availability and use of renewable hydrogen in Washington state, Washington State Legislature, June 9, 2022, https://app.leg.wa.gov/billsummary?BillNumber=5910&Year=2021&Initiative=false - documentSection.
[81] Bill Status of SB3613: Hydrogen Economy Task Force, Illinois General Assembly, June 10, 2022, https://ilga.gov/legislation/billstatus.asp?DocNum=3613&GAID=16&GA=102&DocTypeID=SB&LegID=138580&SessionID=110&SpecSess=.
[82] State of Colorado Energy Office, *Opportunities for Low-Carbon Hydrogen in Colorado: A Roadmap*, October 2021, https://drive.google.com/file/d/1wV2Xq1COF0BY77X_OSvkNSMKgPNeMfcU/view.
[83] State of New Mexico Economic Development Department et al., *Defining and Envisioning a Clean Hydrogen Hub for New Mexico*, January 2022, https://www.env.nm.gov/wp-content/uploads/2022/01/Defining-and-Envisioning-a-Clean-Hydrogen-Hub-for-NM.pdf.
[84] Oregon Department of Energy, "Renewable Hydrogen Study," accessed September 8, 2022, https://www.oregon.gov/energy/energy-oregon/Pages/rh2.aspx.
[85] State of Colorado, *Carbon Capture, Utilization, and Storage (CCUS) Task Force Subcommittee Recommendations*, February 2022, https://www.mines.edu/carboncapture/wp-content/uploads/sites/365/2022/02/Task-Force-Recommendations-Final.pdf.
[86] Carbon Leadership Forum, "Policy Resource: Buy Clean Buy Fair Washington Pilot Study," accessed September 8, 2022, https://carbonleadershipforum.org/bcbf-project/.
[87] HF 6: A bill for an act relating to commerce; establishing a biennial budget for Department of Commerce,

Public Utilities Commission, and energy activities; Minnesota Legislature, June 26, 2021, https://www.revisor.mn.gov/bills/text.php?number=HF6&type=bill&version=1&session=ls92&session_year=2021&session_number=1.
[88] Energy Policy Solutions, "Research and Development Support," accessed September 8, 2022, https://energypolicy.solutions/energy-policy-design/research-and-development/.
[89] Jeffrey Rissman et al., "Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070," *Applied Energy* 266 (May 15, 2020): 114848, https://www.sciencedirect.com/science/article/pii/S0306261920303603?via%3Dihub#s0155.
[90] California Energy Commission, "California's Clean Energy Research Program Funds $1 Billion of Innovative Projects, Attracts $7.8 Billion in Private Investment," [Press release] May 19, 2022, https://www.energy.ca.gov/news/2022-05/californias-clean-energy-research-program-funds-1-billion-innovative-projects?utm_medium=email&utm_source=govdelivery.
[91] Maine Technology Institute, "The Maine Clean Energy Innovation Challenge," accessed September 8, 2022, https://www.mainetechnology.org/mti-impact/the-maine-clean-energy-innovation-challenge/.
[92] Massachusetts Clean Energy Center, "InnovateMass," accessed September 8, 2022, https://www.masscec.com/program/innovatemass.
[93] Massachusetts Clean Energy Center, "IncubateMass," accessed September 8, 2022, https://www.masscec.com/program/incubatemass.
[94] Lawrence Technological University, "EGLE awards Centrepolis Accelerator $1.55M to advance cleantech, sustainability," [News release] July 26, 2021, https://www.ltu.edu/news/?_from=/entrepreneurship/index.asp&_opt=detail&_cid=3aea92d0-b56a-434b-b893-a1f55e57fb95.
[95] Minnesota Commerce Department, "Applied Research and Development," accessed September 8, 2022, https://mn.gov/commerce/industries/energy/utilities/cip/applied-research-development/.
[96] New York State Energy Research and Development Authority (NYSERDA), "NYSERDA Supports Business and Technology Growth Essentials," accessed September 8, 2022, https://www.nyserda.ny.gov/Partners-and-Investors/Clean-Energy-Startups/NYSERDA-Supports-Growth-Essentials.
[97] NYSERDA, "Governor Cuomo Announces $10 Million to Establish the Carbontech Development Initiative,"
," [Press release] April 7, 2021, https://www.nyserda.ny.gov/About/Newsroom/2021-Announcements/2021-04-07-Governor-Cuomo-Announces-10-Million-to-Establish-the-Carbontech-Development-Initiative.
[98] U.S. DOE, *Industrial Decarbonization Roadmap,* September 2022.
[99] New York State, "Climate Action Council Draft Scoping Plan," accessed September 8, 2022, https://climate.ny.gov/-/media/Project/Climate/Files/Draft-Scoping-Plan.pdf.
[100] Nadher Sobhani, *Decarbonizing the U.S. Industrial Sector: Regional, economic, and technical realities*, Niskenan Center, 2021, https://www.niskanencenter.org/wp-content/uploads/2021/04/Sobhani-Decarbonizing-the-Industrial-Sector.pdf.
[101] Rissman, "Technologies and policies to decarbonize global industry," 2020.
[102] California Air Resources Board, "Cap-and-Trade Program," accessed September 8, 2022, https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/about.
[103] State of Washington Department of Ecology, "Climate Commitment Act (CCA)," accessed September 8, 2022, https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Climate-Commitment-Act.
[104] The Regional Greenhouse Gas Initiative, an Initiative of Eastern States of the US, "Welcome," accessed September 8, 2022, https://www.rggi.org/?msclkid=365364a3afa211ecb13c7f1d3910c9d4.
[105] State of Oregon, "Climate Protection Program," accessed September 8, 2022, https://www.oregon.gov/deq/ghgp/cpp/Pages/default.aspx.
[106] The World Bank, "Carbon Pricing Dashboard," accessed September 8, 2022, https://carbonpricingdashboard.worldbank.org/map_data.
[107] Hawai'i State Energy Office, *Carbon Pricing Assessment for Hawai'i: Economic and Greenhouse Gas Impacts*, April 23, 2021, https://energy.hawaii.gov/wp-content/uploads/2021/04/HawaiiCarbonPricingStudy_Final_Apr2021.pdf.

[108] RGGI (Regional Greenhouse Gas Initiative), *The Investment of RGGI Proceeds in 2019,* 2021, https://www.rggi.org/sites/default/files/Uploads/Proceeds/RGGI_Proceeds_Report_2019.pdf.
[109] NYSERDA, "Regional Greenhouse Gas Initiative (RGGI) Reports," accessed September 8, 2022, https://www.nyserda.ny.gov/About/Publications/Program-Planning-Status-and-Evaluation-Reports/RGGI-Reports.
[110] California Climate Investments, "Food Production Investment Program," accessed November 4, 2022, https://www.caclimateinvestments.ca.gov/fpip.
[111] New Jersey Department of Environmental Protection, New Jersey Board of Public Utilities, and New Jersey Economic Development Authority, *Regional Greenhouse Gas Initiative Strategic Funding Plan: Years 2020 through 2022,* accessed April 22, 2022, https://www.nj.gov/rggi/docs/rggi-strategic-funding-plan.pdf.
[112] Center for Climate and Energy Solutions, "Carbon Border Adjustments," accessed September 8, 2022, https://www.c2es.org/content/carbon-border-adjustments/.
[113] State of Washington Department of Ecology, "Emissions Intensive Trade Exposed industries (EITEs)," accessed September 8, 2022, https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Climate-Commitment-Act/Emissions-Intensive-Trade-Exposed-industries#:~:text=EITE%20facilities%20are%20core%20industries,global%20competition%20for%20their%20products.
[114] W. Acworth et al., *Carbon Leakage and Deep Decarbonization*, International Carbon Action Partnership, October 2020, https://icapcarbonaction.com/system/files/document/icap_carbonleakagedeepdecarbonization_fullreport.pdf.
[115] Erin Campbell, Anne McDarris, and William Pizer, *Border Carbon Adjustments 101*, Resources for the Future, November 10, 2021, https://www.rff.org/publications/explainers/border-carbon-adjustments-101/.
[116] Chris Kardish et al., *Carbon Border Adjustments: Considerations for Policymakers*, Center for Climate and Energy Solutions, June 2022, https://www.c2es.org/wp-content/uploads/2022/06/carbon-border-adjustments-considerations-for-policymakers.pdf
[117] Darien Shanske, "State-Level Carbon Taxes and the Dormant Commerce Clause: Can Formulary Apportionment Save the World?" *Chapman Law Review* 18, September 27, 2014, https://www.chapman.edu/law/_files/publications/CLR-18-darien-shanske.pdf.
[118] David Gamage and Darien Shanske, "Why a State-Level Carbon Tax Can Include Border Adjustments," in *Articles by Maurer Faculty* (2017): 2549, https://www.repository.law.indiana.edu/cgi/viewcontent.cgi?article=3549&context=facpub#:~:text=Border%20tax%20adjustments%20are%20crucial,intensive%20products%20such%20as%20concrete.
[119] Energy Policy Solutions, "Economic Signals," accessed September 8, 2022, https://energypolicy.solutions/energy-policy-design/economic-signals/.
[120] State of Massachusetts, Department of Energy Resources, "Rebates/Incentives for your business or institution," accessed September 8, 2022, https://www.mass.gov/guides/massachusetts-energy-rebates-incentives - -rebates/incentives-for-your-business-or-institution-.
[121] New Jersey's Clean Energy Program, "Large Energy Users," accessed September 8, 2022, https://www.njcleanenergy.com/leup.
[122] Focus on Energy, Wisconsin, "Large Energy Users," accessed September 8, 2022, https://dev.focusonenergy.com/business/large-energy-users.
[123] NYSERDA, "On-site Energy Manager Program," accessed September 8, 2022, https://www.nyserda.ny.gov/All-Programs/On-Site-Energy-Manager.
[124] California Climate Investments, "Food Production Investment Program," accessed September 8, 2022, https://www.caclimateinvestments.ca.gov/fpip.
[125] Colorado Energy Office, "Clean Air Program (CAP) Grants," accessed September 8, 2022.
[126] State of Delaware, Department of Natural Resources and Environmental Control (DNREC), "E2I: Energy Efficiency Industrial," accessed September 8, 2022, https://dnrec.alpha.delaware.gov/climate-coastal-energy/efficiency/industrial/.

[127] Maryland Energy Administration, "FY22 Commercial, Industrial & Agricultural Grant Program," accessed September 8, 2022, https://energy.maryland.gov/business/Pages/incentives/empowermdcigp.aspx.
[128] Efficiency Maine, "Commercial and Industrial (C&I) Custom Program," accessed September 8, 2022, https://www.efficiencymaine.com/at-work/commercial-industrial-custom-program/.
[129] Mississippi Office of Energy, "Natural resources in Mississippi," accessed September 8, 2022, https://mississippi.org/community-resources/office-energy/.
[130] NYSERDA, "Commercial & Industrial (C&I) Carbon Challenge," accessed September 8, 2022, https://www.nyserda.ny.gov/All-Programs/CI-Carbon-Challenge.
[131] Minnesota Commerce Department, "Conservation Improvement Program," accessed September 8, 2022, https://mn.gov/commerce/industries/energy/utilities/cip/.
[132] Energy Trust of Oregon, "Industry," accessed September 8, 2022, https://www.energytrust.org/programs/industry/.
[133] State of Delaware DNREC, "Energy Efficiency Investment Fund," accessed September 8, 2022, https://dnrec.alpha.delaware.gov/climate-coastal-energy/efficiency/energy-efficiency-investment-fund/.
[134] Minnesota Commerce Department, "Financial Assistance," accessed September 8, 2022, https://mn.gov/commerce/industries/energy/financial-assistance/.
[135] Tennessee Department of Environment and Conservation, "Energy Efficiency and Renewable Energy Loan Program," accessed September 8, 2022, https://www.tn.gov/environment/program-areas/energy/state-energy-office--seo-/programs-projects/programs-and-projects/clean-energy-financing/clean-energy-financing/energy-efficiency-and-renewable-energy-loan-program.html. https://www.tn.gov/environment/program-areas/energy/state-energy-office--seo-/programs-projects/programs-and-projects/clean-energy-financing/clean-energy-financing/energy-efficiency-and-renewable-energy-loan-program.html
[136] New York State Solar Program, "Commercial Solar Incentives and Financing," accessed September 8, 2022, https://www.nyserda.ny.gov/All-Programs/NY-Sun/Solar-for-Your-Business/Financial-Support/Incentives-and-Financing.
[137] New Hampshire Public Utilities Commission, "Commercial & Industrial (C&I) Solar Incentive Program," accessed September 8, 2022, https://www.puc.nh.gov/Sustainable Energy/RenewableEnergyRebates-CI.html.
[138] Efficiency Maine, "Commercial and Industrial (C&I) Custom Program," accessed September 8, 2022, https://www.efficiencymaine.com/at-work/commercial-industrial-custom-program/.
[139] Massachusetts Department of Energy Resources, "Rebates/Incentives for your business or institution," accessed September 8, 2022, https://www.mass.gov/guides/massachusetts-energy-rebates-incentives - -rebates/incentives-for-your-business-or-institution-.
[140] MN Commerce Department, "Financial Assistance," accessed September 8, 2022.
[141] Colorado Energy Office, "Clean Air Program (CAP) Grants," accessed September 8, 2022, https://energyoffice.colorado.gov/clean-energy-programs/industrial-decarbonization-resources/clean-air-program-cap-grants.
[142] NYSERDA, "Commercial & Industrial (C&I) Carbon Challenge," accessed September 8, 2022.
[143] SB 5910 - 2021-22, Washington State Legislature, 2022.
[144] Colorado Energy Office, "Clean Air Program (CAP) Grants," accessed September 8, 2022.
[145] NYSERDA "Commercial & Industrial (C&I) Carbon Challenge," accessed September 8, 2022.
[146] Colorado Energy Office, "Clean Air Program (CAP) Grants," accessed September 8, 2022.
[147] NYSERDA "Commercial & Industrial (C&I) Carbon Challenge," accessed September 8, 2022
[148] Bill S3091 ScaScaSa (3R), New Jersey Legislature, November 8, 2021, https://www.njleg.state.nj.us/bill-search/2020/S3091.
[149] SB22-051: Policies To Reduce Emissions From Built Environment, Colorado General Assembly, 2022, http://leg.colorado.gov/bills/SB22-051.
[150] HB 4139: Relating to reductions of greenhouse gas emissions in the state's transportation system; and prescribing an effective date, Oregon State Legislature, 2022, https://olis.oregonlegislature.gov/liz/2022R1/Measures/Overview/HB4139.
[151] Rightor, E, Srinivasan, P., Elliott, RN., *Reimagining Program Design at DOE to Accelerate Transformative Industrial Technology Development at Scale*, White Paper, ACEEE, April 2022, https://www.aceee.org/white-paper/2022/04/reimagining-program-design-doe

[152] Delaware Sustainable Energy Authority (DESEU), "Energize Delaware," accessed September 8, 2022, https://www.energizedelaware.org/energize-delaware/deseu/.
[153] American Green Bank Consortium (AGBC) and Coalition for Green Capital (CGC). *Green Banks in the United States: 2021 U.S. Green Bank Annual Industry Report*, May 2021, https://greenbankconsortium.org/annual-industry-report.
[154] Climate Initiatives Task Force, *Louisiana Climate Action Plan*, 2022.
[155] Michigan Department of Environment, Great Lakes, and Energy, *MI Healthy Climate Plan*, 2022.
[156] State of Washington, "E. Industrial Transformation and Workforce Development," 2021.
[157] National Association of State Energy Officials (NASEO), *Carbon Capture, Utilization, and Storage: Overview and Considerations for State Planning*, accessed September 8, 2022, https://naseo.org/data/sites/1/documents/publications/CCUS Report Final.pdf.
[158] Regional Carbon Capture Deployment Initiative, *Policy Approaches & Best Practices: State-Level Action to Support Economywide Deployment of Carbon Capture,* accessed September 8, 2022, https://carboncaptureready.betterenergy.org/wp-content/uploads/2020/03/Carbon-Capture-Ready-Best-Practices.pdf.
[159] Matt Bright, "The Inflation Reduction Act creates a whole new market for carbon capture," Clean Air Task Force, August 22, 2022, https://www.catf.us/2022/08/the-inflation-reduction-act-creates-a-whole-new-market-for-carbon-capture/.
[160] Carbon Leadership Forum, "Guidance on Embodied Carbon Disclosure," accessed September 8, 2022, https://carbonleadershipforum.org/guidance-on-embodied-carbon-disclosure/.
[161] John Milko, *We Can't Cut What We Can't Count: Using Environmental Product Declarations to Measure and Reduce Embodied Carbon*, Third Way, October 15, 2021, https://www.thirdway.org/report/we-cant-cut-what-we-cant-count-using-environmental-product-declarations-to-measure-and-reduce-embodied-carbon.
[162] State of Washington, "E. Industrial Transformation and Workforce Development," 2021.
[163] Energy Policy Solutions, "Performance Standards," accessed September 8, 2022, https://energypolicy.solutions/energy-policy-design/performance-standards/.
[164] Rissman, "Technologies and policies to decarbonize global industry," 2020: 6.3.
[165] U.S. EPA, "Air Quality - National Summary," accessed September 8, 2022, https://www.epa.gov/air-trends/air-quality-national-summary.
[166] U.S. DOE, "New Study: Renewable Energy for State Renewable Portfolio Standards Yield Sizable Benefits," [Press release] January 7, 2016, https://www.energy.gov/eere/articles/new-study-renewable-energy-state-renewable-portfolio-standards-yield-sizable-benefits.
[167] Alan Krupnick, *Federal Climate Policy 105: The Industrial Sector*, Resources for the Future, March 31, 2021, https://www.rff.org/publications/explainers/federal-climate-policy-105-the-industrial-sector/.
[168] Krupnick, *Federal Climate Policy 105*, 2021.
[169] Rissman, "Technologies and policies to decarbonize global industry," 2020.
[170] Colorado Department of Public Health and Environment, "Greenhouse Gas Emissions and Energy Management for Manufacturing in Colorado," accessed September 8, 2022, https://cdphe.colorado.gov/greenhouse-gas-emissions-and-energy-management-for-manufacturing-in-colorado.
[171] State of Oregon, "Climate Protection Program," accessed September 8, 2022, https://www.oregon.gov/deq/ghgp/cpp/Pages/default.aspx.
[172] Climate Initiatives Task Force, *Louisiana Climate Action Plan*, 2022.
[173] Massachusetts Department of Environmental Protection, "Waste Ban Regulations & Policies," accessed September 8, 2022, https://www.mass.gov/guides/massdep-waste-disposal-bans#-waste-ban-regulations-&-policies-.
[174] House Bill 1541: An Act To Support and Improve Municipal Recycling Programs and Save Taxpayer Money, State of Maine, July 2, 2021, https://legiscan.com/ME/bill/LD1541/2021.
[175] Allyn Stern and Nicole Waxman, "Maine Becomes First State to Sign Extended Producer Responsibility Law for Packaging, Other States with Plastics and Packaging Bills May Follow Shortly," *National Law Review* XII, No. 251 (July 14, 2021), https://www.natlawreview.com/article/maine-becomes-first-state-to-sign-extended-producer-responsibility-law-packaging.
[176] SB 582: Relating to modernizing Oregon's recycling system, Oregon State Legislature, accessed September 8, 2022, https://olis.oregonlegislature.gov/liz/2021R1/Measures/Overview/SB582.

[177] SB-54 Solid waste: reporting, packaging, and plastic food service ware, California State Legislature, June 30, 2022, https://leginfo.legislature.ca.gov/faces/billHistoryClient.xhtml?bill_id=202120220SB54.
[178] Stern, "Maine Becomes First State to Sign Extended Producer Responsibility Law for Packaging," 2021.
[179] California Air Resources Board, "Low Carbon Fuel Standard," accessed September 8, 2022, https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/about.
[180] State of Oregon, "Oregon Clean Fuels Program," accessed September 8, 2022, https://www.oregon.gov/deq/ghgp/cfp/Pages/default.aspx.
[181] State of Washington, Department of Ecology, "Clean Fuel Standard," accessed September 8, 2022, https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Clean-Fuel-Standard.
[182] Peter Connors et al., *Review of Federal, State, and Regional Tax Strategies and Opportunities for CO2-EOR-Storage and the CCUS Value Chain*, for U.S. DOE, September 21, 2020, https://www.fticonsulting.com/~/media/Files/us-files/insights/reports/2020/sep/carbon-capture-utilization-storage.pdf.
[183] Regional Carbon Capture Deployment Initiative, *Policy Approaches & Best Practices*, 2022.
[184] NASEO, *Carbon Capture, Utilization, and Storage*, accessed September 8, 2022.
[185] House Bill 4491, West Virginia Legislature, March 1, 2022, http://www.wvlegislature.gov/Bill_Status/bills_text.cfm?billdoc=HB4491%20SUB%20ENR.htm&yr=2022&sesstype=RS&i=4491.
[186] State of California, "Carbon Capture and Sequestration Protocol Under the Low Carbon Fuel Standard," accessed September 8, 2022, https://ww2.arb.ca.gov/resources/documents/carbon-capture-and-sequestration-protocol-under-low-carbon-fuel-standard.
[187] State of California, "Buy Clean California Act," accessed September 8, 2022, https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act.
[188] HB21-1303: Global Warming Potential For Public Project Materials, Colorado General Assembly, July 6, 2021, https://leg.colorado.gov/bills/HB21-1303.
[189] Rissman, "Technologies and policies to decarbonize global industry," 2020.
[190] House Select Committee on the Climate Crisis, *Solving the Climate Crisis: The Congressional Action Plan for a Clean Energy Economy and a Healthy, Resilient, and Just America*, June 2020, https://climatecrisis.house.gov/sites/climatecrisis.house.gov/files/Climate Crisis Action Plan.pdf.
[191] State of Massachusetts, "Baker-Polito Administration Releases Final 2030 Solid Waste Master Plan," [Press release], October 18, 2021, https://www.mass.gov/news/baker-polito-administration-releases-final-2030-solid-waste-master-plan.
[192] Renewable Thermal Collaborative, *Low-Carbon Renewable Thermal Technology Solutions: Policies to Support Development and Deployment*, February 2021, https://www.renewablethermal.org/wp-content/uploads/2018/06/Low-Carbon-Renewable-Thermal-Technology-Solutions-3.1.21.pdf.
[193] House Select Committee on the Climate Crisis, *Solving the Climate Crisis*, 2020.
[194] New Hampshire Public Utilities Commission, "Class I Thermal Renewable Energy Certificate Program," accessed September 8, 2022, https://www.puc.nh.gov/Sustainable Energy/Class I Thermal Renewable Energy.html.
[195] State of Massachusetts, "APS Renewable Thermal Statement of Qualification Application," accessed September 8, 2022, https://www.mass.gov/guides/aps-renewable-thermal-statement-of-qualification-application.
[196] Wisconsin Office of Sustainability and Clean Energy, *State of Wisconsin Clean Energy Plan*, 2022.
[197] Anne Austin et al., "State-Level Permitting Primacy May Boost Carbon Capture and Storage," Pillsbury, August 11, 2021, https://www.pillsburylaw.com/en/news-and-insights/state-level-permitting-primacy-carbon-capture-and-storage.html.
[198] U.S. EPA, "Class VI - Wells used for Geologic Sequestration of Carbon Dioxide," accessed September 8, 2022, https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-carbon-dioxide.
[199] Austin, "State-Level Permitting Primacy May Boost Carbon Capture and Storage," 2021.

[200] U.S. EPA, "Underground Injection Control Primacy Status for States, Territories, and Tribes," accessed September 8, 2022, https://www.epa.gov/uic/underground-injection-control-primacy-status-states-territories-and-tribes.
[201] Ruth Ivory-Moore, *Pore Space Rights – U.S. Overview*, Global CCS Institute, May 2022, https://www.globalccsinstitute.com/wp-content/uploads/2022/05/Brief-Pore-Space-Rights-5.25.pdf.
[202] Breakthrough Energy, *U.S. Federal Manufacturing Policies from the Climate Policy Playbook*, February 2021, https://www.breakthroughenergy.org/~/Media/Files/BEV/Playbooks/Federal/Manufacturing/USFedManuComplete.pdf.
[203] Ben King, *Clean Products Standard: A New Approach to Industrial Decarbonization*, Rhodium Group, December 9, 2020, https://rhg.com/research/clean-products-standard-industrial-decarbonization/.
[204] World Resources Institute (WRI) *Toward a Tradable Low-Carbon Cement Standard: Policy Design Considerations for the United States*, March 25, 2021, https://www.wri.org/research/toward-tradable-low-carbon-cement-standard-policy-design-considerations-united-states.
[205] WRI, *Toward a Tradable Low-Carbon Cement Standard*, 2021.
[206] Webley Bowles et al., *Lifecycle GHG Impacts in Building Codes*, New Buildings Institute (NBI), January 2022, https://newbuildings.org/wp-content/uploads/2022/02/NBI_LI1.pdf.
[207] Bowles, *Lifecycle GHG Impacts in Building Codes*, 2022.
[208] Rissman, "Technologies and policies to decarbonize global industry," 2020.
[209] Carbon Leadership Forum (CLF), "Carbon Policy Toolkit," accessed September 8, 2022, https://carbonleadershipforum.org/clf-policy-toolkit/.
[210] Energy Policy Solutions, "Supporting Policies," accessed September 8, 2022, https://energypolicy.solutions/energy-policy-design/supporting-policies/.
[211] CLF, "What is a buy clean policy?" accessed September 8, 2022.
[212] CLF, *Buy Clean Buy Fair Washington Project Progress Report,* December 27, 2021, https://carbonleadershipforum.org/wp-content/uploads/2022/04/UW-CLF-SEEP-BCBF-Progress-Report-2021-12-27.pdf.
[213] State of California, "Buy Clean California Act," accessed September 8, 2022.
[214] HB21-1303, Colorado, 2021.
[215] Bill S3091, New Jersey, 2021.
[216] SB 542A: Relates to provisions in state procurement contracts involving the use of low embodied carbon concrete, New York State, December 22, 2021, https://www.nysenate.gov/legislation/bills/2021/S542.
[217] HB 4139, Oregon, 2022.
[218] HF 6, Minnesota, 2021.
[219] Substitute House Bill 1080, State of Washington, May 18, 2021, https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Session Laws/House/1080-S.SL.pdf?q=20211005131326.
[220] Climate Solutions Now Act of 2022, State of Maryland, June 1, 2022, https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/SB0528?ys=2022RS.
[221] Climate Initiatives Task Force, *Louisiana Climate Action Plan*, 2022.
[222] Michigan Department of Environment, Great Lakes, and Energy, *MI Healthy Climate Plan*, 2022.
[223] Wisconsin Office of Sustainability and Clean Energy, *State of Wisconsin Clean Energy Plan*, 2022.
[224] CLF, "Carbon Policy Toolkit," accessed September 8, 2022.
[225] Milko, *We Can't Cut What We Can't Count*, 2021.
[226] U.S. Office of Energy Efficiency and Renewable Energy, "Data-Driven, Strategic Energy Management: State and Local Solution Center," accessed September 8, 2022, https://www.energy.gov/eere/slsc/data-driven-strategic-energy-management.
[227] Andrew Whitlock, Ed Rightor, and Andrew Hoffmeister, *Canadian Strategic Energy Management Market Study*, ACEEE, November 1, 2021, https://www.aceee.org/research-report/ie2102.
[228] Energy Trust of Oregon, "Industrial Strategic Energy Management," accessed September 8, 2022, https://www.energytrust.org/industry-agriculture/industry-strategic-energy-management/.
[229] Colorado Energy Office, "Industrial Strategic Energy Management," accessed September 8, 2022, https://energyoffice.colorado.gov/clean-energy-programs/industrial-strategic-energy-management.

[230] NYSERDA, "Strategic Energy Management Program," accessed September 8, 2022, https://www.nyserda.ny.gov/All-Programs/Strategic-Energy-Management.
[231] Climate Initiatives Task Force, *Louisiana Climate Action Plan*, 2022.
[232] State of Washington, "E. Industrial Transformation and Workforce Development," 2021.
[233] Wisconsin Office of Sustainability and Clean Energy, *State of Wisconsin Clean Energy Plan*, 2022.
[234] NYSERDA, "Flexible Technical Assistance (Flex Tech) Program," accessed September 8, 2022, https://www.nyserda.ny.gov/All-Programs/FlexTech-Program.
[235] State of Washington, Department of Ecology, "Efficiency services for manufacturing and industrial facilities," accessed September 8, 2022, https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Toxics-reduction-assistance/Efficiency-services-for-manufacturing-industries.
[236] Efficiency Maine, "Commercial and Industrial (C&I) Custom Program," accessed September 8, 2022.
[237] Energy Trust of Oregon, "Industry," accessed September 8, 2022.
[238] Focus on Energy, Wisconsin, "Large Energy Users," accessed September 8, 2022, https://dev.focusonenergy.com/business/large-energy-users.
[239] U.S. EPA, "Recommendations of Specifications, Standards, and Ecolabels for Federal Purchasing," accessed September 8, 2022, https://www.epa.gov/greenerproducts/recommendations-specifications-standards-and-ecolabels-federal-purchasing.
[240] Energy Star, "Registry of Energy Star Certified Buildings and Plants," accessed September 8, 2022, https://www.energystar.gov/buildings/certified_buildings_and_plants.
[241] CLF, "Guidance on Embodied Carbon Disclosure," accessed September 8, 2022.
[242] Oregon Concrete and Aggregate Providers, "Oregon Concrete EPDs," accessed September 8, 2022, https://www.ocapa.net/index.php?option=com_content&view=article&id=247:oregon-concrete-epds&catid=20:site-content&Itemid=201s - epdresources.
[243] Climate Initiatives Task Force, *Louisiana Climate Action Plan*, 2022.
[244] Wisconsin Office of Sustainability and Clean Energy, *State of Wisconsin Clean Energy Plan*, 2022.
[245] U.S. EPA, "Learn About the Greenhouse Gas Reporting Program (GHGRP)," accessed September 8, 2022, https://www.epa.gov/ghgreporting/learn-about-greenhouse-gas-reporting-program-ghgrp.
[246] U.S. EIA, "Manufacturing Energy Consumption Survey (MECS): 2018 MECS Survey Data 2018," accessed September 8, 2022, https://www.eia.gov/consumption/manufacturing/data/2018/ - r14.
[247] National Renewable Energy Laboratory (NREL), "2018 Industrial Energy Data Book," November 14, 2019, https://data.nrel.gov/submissions/122.
[248] California Air Resources Board, "Mandatory Greenhouse Gas Emissions Reporting," accessed September 8, 2022, https://ww2.arb.ca.gov/our-work/programs/mandatory-greenhouse-gas-emissions-reporting/about.
[249] California Air Resources Board, *Reporting Guidance for Determining Rule Applicability for California's Mandatory GHG Reporting Program*, February 1, 2019, https://www.arb.ca.gov/cc/reporting/ghg-rep/guidance/applicability-general.pdf.
[250] https://drive.google.com/file/d/18jS7Aq193ZPVb46EVZDnDEyeZBZfJ6kG/view
[251] Climate Initiatives Task Force, *Louisiana Climate Action Plan*, 2022.
[252] New York State, *Climate Action Council Draft Scoping Plan*, 2021.
[253] State of Washington, "E. Industrial Transformation and Workforce Development," 2021.
[254] Ihab Mikati et al., "Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status," *American Journal of Public Health* 108, no. 4, (March 7, 2018): 480-485, https://ajph.aphapublications.org/doi/10.2105/AJPH.2017.304297.
[255] Apte, J. S., Chambliss, S. E., Tessum, C. W., Marshall, J.D. "A Method to Prioritize Sources for Reducing High PM2.5 Exposures in Environmental Justice Communities in California." California Air Resources Board and California Environmental Protection Agency, November 21, 2019, https://ww2.arb.ca.gov/sites/default/files/classic/research/apr/past/17rd006.pdf.
[256] Lauren Zeise et al., *Impacts of Greenhouse Gas Emission Limits Within Disadvantaged Communities: Progress Towards Reducing Inequities*, California Office of Environmental Health

Hazard Assessment, February 2022, https://oehha.ca.gov/media/downloads/environmental-justice/impactsofghgpoliciesreport020322.pdf.
[257] Ed Rightor, "U.S. Can Cut Emissions by Helping Transform Industrial Clusters," ACEEE, July 15, 2021, https://www.aceee.org/blog-post/2021/07/us-can-cut-emissions-helping-transform-industrial-clusters.
[258] Mika Naumanen, European Panorama of Clusters and Industrial Change, European Union, 2019, https://single-market-economy.ec.europa.eu/industry/strategy_en
[259] Julio Friedmann, Mahak Agrawal, and Amar Bhardwaj, "Evaluating Net-Zero Industrial Hubs in the United States: A Case Study of Houston," Columbia | SIPA: Center on Global Energy Policy, June 30, 2021, https://www.energypolicy.columbia.edu/research/report/evaluating-net-zero-industrial-hubs-united-states-case-study-houston.
[260] Elizabeth Abramson, Emma Thomley, and Dane McFarlane, *An Atlas of Carbon and Hydrogen Hubs for United States Decarbonization*, Great Plains Institute, February 2022, https://scripts.betterenergy.org/CarbonCaptureReady/GPI_Carbon_and_Hydrogen_Hubs_Atlas.pdf .
[261] Friedmann, *Evaluating Net-Zero Industrial Hubs in the United States*, 2021.
[262] Port of Rotterdam, "Energy Transition: Towards a CO2 Neutral Port," accessed September 8, 2022, https://www.portofrotterdam.com/en/port-future/energy-transition.
[263] Port of Seattle, "Seattle City Light Explores Renewable Hydrogen Fuel at the Port with Department of Energy Awards," [Press release] November 9, 2021, https://www.portseattle.org/news/seattle-city-light-explores-renewable-hydrogen-fuel-port-department-energy-awards.
[264] Friedmann, *Evaluating Net-Zero Industrial Hubs in the United States*, 2021.
[265] Baton Rouge Area Chamber, "Grön Fuels' $9.2 Billion Carbon Negative Renewable Fuel Complex Achieves Major Milestone with Air Permit Approval," [Press release] April 22, 2021, wire.com/news-releases/gron-fuels-9-2-billion-carbon-negative-renewable-fuel-complex-achieves-major-milestone-with-air-permhttps://www.prnewsit-approval-301275389.html
[266] The Port of Los Angeles, "Port of Los Angeles Rolls out Hydrogen Fuel Cell Electric Freight Demonstration," [Press release] June 7, 2021, https://www.portoflosangeles.org/references/2021-news-releases/news_060721_zanzeff.
[267] Maria Gallucci, "https://www.canarymedia.com/articles/sea-transport/3 -ways -the -new -climate -law -will -help -clean -up -dirty US -us-ports," *Canary Media*, August 23, 2022, https://www.canarymedia.com/articles/sea-transport/3-ways-the-new-climate-law-will-help-clean-up-dirty-us-ports.
[268] U.S. Climate Alliance, "U.S. Climate Alliance States Commit to New High-Impact Actions to Achieve Climate Goals and Go Further, Faster, Together," [Press release] November 7, 2021, https://www.usclimatealliance.org/publications/2021/11/7/us-climate-alliance-states-commit-to-new-high-impact-actions-to-achieve-climate-goals-and-go-further-faster-together.
[269] The White House, "Fact Sheet: Biden-Harris Administration Advances Cleaner Industrial Sector to Reduce Emissions and Reinvigorate American Manufacturing," [News release] February 15, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/15/fact-sheet-biden-harris-administration-advances-cleaner-industrial-sector-to-reduce-emissions-and-reinvigorate-american-manufacturing/.
[270] State of New Mexico Office of the Governor, "New Mexico, coalition of mountain west states sign MOU to develop a regional clean hydrogen hub," [Press release] February 24, 2022, https://www.governor.state.nm.us/2022/02/24/new-mexico-coalition-of-mountain-west-states-sign-mou-to-develop-a-regional-clean-hydrogen-hub/.
[271] New York State, "Governor Hochul Announces Multi-State Agreement Signed with Major Hydrogen Ecosystem Partners to Propose a Regional Clean Energy Hydrogen Hub," [Press release] March 24, 2022, https://www.governor.ny.gov/news/governor-hochul-announces-multi-state-agreement-signed-major-hydrogen-ecosystem-partners.
[272] State of Louisiana Office of the Governor, "Louisiana, Oklahoma, and Arkansas Announce Hydrogen Partnership," [Press release] March 10, 2022, https://gov.louisiana.gov/index.cfm/newsroom/detail/3587.
[273] U.S. DOE Office of Policy, *The Inflation Reduction Act Drives Significant Emissions Reductions and Positions America to Reach Our Climate Goals*, August https://www.energy.gov/sites/default/files/2022, https://www.energy.gov/sites/default/files/2022-

08/8.18%20InflationReductionAct_Factsheet_Final.pdf. -
08/8.18%20InflationReductionAct_Factsheet_Final.pdf
[274] Intergovernmental Panel on Climate Change, *Climate Change 2022*, 2022.
[275] U.K. Government, *Industrial Decarbonisation Strategy*, March 2021, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970229/Industrial_Decarbonisation_Strategy_March_2021.pdf.
[276] European Commission, *Updating the 2020 New Industrial Strategy: Building a stronger single market for Europe's recovery, European industrial strategy*, 2021, https://ec.europa.eu/info/sites/default/files/communication-industrial-strategy-update-2020_en.pdf.
[277] Japan's Ministry of Economy, Trade, and Industry (METI), "Japan's Roadmap to 'Beyond-Zero' Carbon" accessed September 8, 2022, https://www.meti.go.jp/english/policy/energy_environment/global_warming/roadmap/.
[278] U.K. Research and Innovation (UKRI), "Industrial decarbonisation challenge," accessed September 8, 2022, https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/clean-growth/industrial-decarbonisation-challenge/.
[279] EIC, "European Industrial Cluster: Connecting the European Industry," accessed September 8, 2022, https://industrialcluster.eu/en/home/.
[280] European Commission, "Public-private partnerships in energy," accessed September 8, 2022, https://ec.europa.eu/info/research-and-innovation/research-area/energy-research-and-innovation/public-private-partnerships-energy_en.
[281] European Clusters Alliance, *Industrial Clusters for an innovative and competitive Europe*, Debruary 2021, https://clustersalliance.eu/-cms/wp-content/uploads/2021/02/20200102-ECA-Position-Paper-v15.pdf.
[282] European Commission, "European Observatory for Clusters and Industrial Change," accessed September 8, 2022, https://ec.europa.eu/growth/industry/strategy/industrial-cluster-policy/observatory_en.
[283] European Commission, "What is the Innovation Fund?," accessed September 8, 2022, https://ec.europa.eu/clima/eu-action/funding-climate-action/innovation-fund/policy-development_en.
[284] Alberta Government, *Climate Change Innovation and Technology Framework 2017*, 2017, https://open.alberta.ca/dataset/59ff9a2e-da93-4f8e-8c91-e8610ad4c1d2/resource/222449d1-60d9-49d6-a47c-4086c350ea25/download/climate-change-innovation-and-technology-framework-2017.pdf
[285] David Goldstein and Peter Therkelsen, "A Structure for Incentivizing Greater Achievements in Strategic Energy Management," Natural Resources Defense Council, Lawrence Berkeley National Lab, 2017, https://www.aceee.org/files/proceedings/2017/data/polopoly_fs/1.3687931.1501159107!/fileserver/file/790291/filename/0036_0053_000022.pdf.
[286] King, *Clean Products Standard*, 2020.
[287] Washington Utilities and Transportation Commission, "Clean Energy Transformation Act," accessed September 8, 2022, https://www.utc.wa.gov/regulated-industries/utilities/energy/conservation-and-renewable-energy-overview/clean-energy-transformation-act.
[288] Ed Rightor et al., "Industrial Heat Pumps; Electrifying Industry's Process Heat Supply", March 30, 2022.
[289] Sobhani, *Decarbonizing the U.S. Industrial Sector*, 2021.
[290] Baldwin, "Assessing the Viability of Hydrogen Proposals," 2022, https://energyinnovation.org/wp-content/uploads/2022/03/Assessing-the-Viability-of-Hydrogen-Proposals.pdf.
[291] Ilissa B. Ocko and Steven P. Hamburg, "Climate consequences of hydrogen emissions," *Atmospheric Chemistry and Physics* 22, No. 14, (July 20, 2022): 9349–9368, https://acp.copernicus.org/articles/22/9349/2022/.
[292] Science-based Targets, "Ambitious Corporate Climate Action," accessed September 8, 2022, https://sciencebasedtargets.org/.
[293] Ben King et al., *Clean Products Standard: A New Approach to Industrial Decarbonization*, Rhodium Group, December 9, 2020, https://rhg.com/wp-content/uploads/2020/12/Clean-Products-Standard-A-New-Approach-to-Industrial-Decarbonization.pdf.

[294] National Association of Manufacturers (NAM), "2019 U.S. Manufacturing Facts," accessed September 8, 2022, https://www.nam.org/state-manufacturing-data/2019-united-states-manufacturing-facts/.
[295] Ernst Worrell and Gale Boyd, "Bottom-up estimates of deep decarbonization of U.S. manufacturing in 2050,", *Journal of Cleaner Production* 330 (January 1, 2022): 129758, https://www.sciencedirect.com/science/article/pii/S0959652621039342.
[296] Worrell, "Bottom-up estimates of deep decarbonization of U.S. manufacturing in 2050," 2022.
[297] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS)*, 2021, https://www.energy.gov/eere/amo/manufacturing-energy-and-carbon-footprints-2018-mecs.
[298] U.S. EIA, *Manufacturing Energy Consumption Survey 2018: Table 5.2*, 2021, https://www.eia.gov/consumption/manufacturing/data/2018/pdf/Table5_2.pdf.
[299] Worrell, "Bottom-up estimates of deep decarbonization of U.S. manufacturing in 2050," 2022.
[300] Tuohy, *Increasing Electric Power System Flexibility*, 2022.
[301] U.S. Department of Homeland Security, CISA, "Chemical Sector Profile," accessed September 8, 2022, https://www.cisa.gov/sites/default/files/publications/Chemical-Sector-Profile_Final%20508.pdf.
[302] ACC, *2021 Guide to the Business of Chemistry*, August 12, 2021, https://www.americanchemistry.com/chemistry-in-america/data-industry-statistics/resources/2021-guide-to-the-business-of-chemistry.
[303] U.S. EIA, *Annual Energy Outlook 2021 with Projections to 2050*, January 29, 2020, https://www.eia.gov/outlooks/aeo/pdf/AEO2020 Full Report.pdf.
[304] U.S. EIA, *Manufacturing Energy Consumption Survey 2018: Table 1.2*, 2021, https://www.eia.gov/consumption/manufacturing/data/2018/pdf/Table1_2.pdf.
[305] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS): Chemicals*, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_chemicals_energy_carbon_footprint_0.pdf.
[306] U.S. EPA, Greenhouse Gas Reporting Program (GHGRP), "GHGRP Chemicals," accessed September 8, 2022, https://www.epa.gov/ghgreporting/ghgrp-chemicals.
[307] U.S. DOE, *Manufacturing Energy and Carbon Footprint | Sector: Chemicals*, 2010, https://www.energy.gov/sites/prod/files/2018/11/f57/2010_chemicals_energy_carbon_footprint.pdf.
[308] Colin McMillan and Mark Ruth, *Industrial Process Heat Demand Characterization*, NREL, July 5, 2015, https://data.nrel.gov/submissions/91.
[309] IEA, *Technology Roadmap: Energy and GHG Reductions in the Chemical Industry via Catalytic Processes*, 2013.
[310] U.S. EPA, "Facility Level Information on GreenHouse gases Tool (FLIGHT)," accessed September 8, 2022, https://ghgdata.epa.gov/ghgp/main.do.
[311] U.S. DOE, *Industrial Decarbonization Roadmap*, 2022.
[312] Arnout De Pee, et al., *Decarbonization of Industrial Sectors: The Next Frontier*, McKinsey and Company, June 2018, https://www.mckinsey.com/~/media/mckinsey/business functions/sustainability/our insights/how industry can move toward a low carbon future/decarbonization-of-industrial-sectors-the-next-frontier.pdf.
[313] IEA, *Technology Roadmap: Energy and GHG Reductions in the Chemical Industry via Catalytic Processes*, 2013.
[314] U.K. Department for Business, Energy & Industrial Strategy Chemicals Sector, *Industrial Decarbonization and Energy Efficiency Roadmap Action Plan*, October 2017, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/651230/chemicals-decarbonisation-action-plan.pdf.
[315] Ecofys and Berenschot, *Chemistry for Climate: Acting on the Need for Speed | Roadmap for the Dutch Chemical Industry Towards 2050*, VNCI, 2018. https://www.vnci.nl/Content/Files/file/Downloads/VNCI_Routekaart-2050.pdf
[316] VCI, *Working towards a GHG Neutral Chemical Industry in Germany*, 2019, https://www.vci.de/langfassungen/langfassungen-pdf/2019-10-09-greenhouse-gas-neutral-chemistry-is-technically-feasible.pdf.
[317] Science-Based Targets, "Companies Taking Action," accessed September 8, 2022, https://sciencebasedtargets.org/companies-taking-action.
[318] Craig Bettenhausen, "Chemical Firms Aim for More Ambitious Climate Goals," *Chemical and Engineering News* 99, No. 2 (January 11, 2021): 33, https://pubs.acs.org/doi/10.1021/cen-09902-cover2.

[319] Thomas Nonnast, "BASF Presents Roadmap to Carbon Neutrality," BASF, [News release] March 26, 2021, https://www.basf.com/global/en/media/news-releases/2021/03/p-21-166.html.
[320] Adam Duckett, "Dow Plans Zero Emissions Ethylene Complex," *The Chemical Engineer*, October 18, 2021, https://www.thechemicalengineer.com/news/dow-plans-zero-emissions-ethylene-complex/.
[321] "Dow and Shell Team up to Develop Electric Cracking Technology," Dow, [Press release] accessed September 8, 2022, https://corporate.dow.com/en-us/news/press-releases/dow-shell-electric-cracking-technology.html.
[322] ACC, "Shale Gas is Driving New Chemical Industry Investment in the U.S.," American Chemistry Council, August 11, 2022, https://www.americanchemistry.com/better-policy-regulation/energy/resources/shale-gas-is-driving-new-chemical-industry-investment-in-the-us.
[323] U.S. EIA, "Number and Capacity of Petroleum Refineries," accessed September 8, 2022, https://www.eia.gov/dnav/pet/PET_PNP_CAP1_A_(NA)_8D0_BPCD_A.htm.
[324] U.S. EIA, "Oil and Petroleum Products Explained," accessed September 8, 2022, https://www.eia.gov/https://www.eia.gov/energyexplained/oil-and-petroleum-products/.
[325] U.S. EIA, "U.S. Energy Facts Explained," accessed September 8, 2022, https://www.eia.gov/energyexplained/us-energy-facts/.
[326] U.S. Census Bureau, "2018-2020 Annual Survey of Manufacturers: ASM (Tables)," December 2021, https://www.census.gov/data/tables/time-series/econ/asm/2018-2020-asm.html.
[327] U.S. Bureau of Labor Statistics, *Employment for Manufacturing: Petroleum Refineries (NAICS 324110) in the United States*, retrieved from FRED, Federal Reserve Bank of St. Louis, August 15, 2022, https://fred.stlouisfed.org/series/IPUEN324110W200000000.
[328] U.S. EIA, *Manufacturing Energy Consumption Survey 2018: Table 1.2*, 2021.
[329] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS): Petroleum Refining*, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_petroleum_refining_energy_carbon_footprint.pdf.
[330] U.S. EPA, FLIGHT tool, accessed September 8, 2022.
[331] ExxonMobil, *Sustainability Report Highlights*, 2020, https://corporate.exxonmobil.com/-/media/Global/Files/sustainability-report/publication/Sustainability-Report.pdf.
[332] Motiva, *Fueling our World, 2020 Sustainability Report*, 2020, https://motiva.com/-/media/Files/About/2020-Sustainability-Report/FINAL-2020SustainabilityReport_2.ashx.
[333] Marathon Oil, "Emissions Management Committee," accessed September 8, 2022, https://www.marathonoil.com/sustainability/highlights/emissions-management-committee/.
[334] Valero Energy, "Environmental Stewardship," accessed September 8, 2022, https://www.valero.com/responsibility/environmental-stewardship.
[335] U.S. EIA, *International Energy Outlook | IEO2021 Issues in Focus: Energy Implications of Potential Iron- and Steel-Sector Decarbonization Pathways*, February 24, 2022, https://www.eia.gov/outlooks/ieo/IIF_industrial/.
[336] U.S. Geological Survey (USGS), "Iron and Steel Salient Statistics," January 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-iron-steel.pdf.
[337] USGS, "Minerals Yearbook - Metals and Minerals," accessed September 8, 2022, https://www.usgs.gov/centers/national-minerals-information-center/minerals-yearbook-metals-and-minerals.
[338] USGS, "Iron and Steel Salient Statistics," 2022.
[339] IEA, *Iron and Steel Technology Roadmap*, October 2020, https://www.iea.org/reports/iron-and-steel-technology-roadmap.
[340] U.S. EIA, *Manufacturing Energy Consumption Survey 2018: Table 1.2*, 2021.
[341] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS): Iron and Steel*, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_iron_steel_energy_carbon_footprint.pdf.
[342] U.S. EPA, FLIGHT tool, accessed September 8, 2022.
[343] ArcelorMittal, *Climate Action Report 2*, July 2021, https://corporate-media.arcelormittal.com/media/ob3lpdom/car_2.pdf.
[344] U.S. Steel (USS), *Roadmap to 2050*, accessed September 8, 2022, https://www.ussteel.com/roadmap-to-2050#:~:text=In%20April%202021%2C%20U.%20S.%20Steel,compared%20to%20a%202018%20baseline.

[345] Stena Recycling, "The Value of Recycling Metals," accessed September 8, 2022, https://www.stenarecycling.com/insights/archive/the-value-of-recycling-metals/
[346] USGS, *Mineral Industry Survey: Cement in October 2021*, January 2022, https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/media/files/mis-202110-cemen.pdf.
[347] USGS, *Mineral Industry Survey: Cement in October 2021*, 2022.
[348] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS)*, 2021.
[349] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS): Cement*, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_cement_energy_carbon_footprint_0.pdf.
[350] PCA, *Environmental Product Declaration*, 2021.
[351] U.S. EPA, FLIGHT tool, accessed September 8, 2022.
[352] U.S. EIA, "Coal Explained: Coal Prices and Outlook," accessed September 8, 2022, https://www.eia.gov/energyexplained/coal/prices-and-outlook.php#:~:text=Coal%20explained%20Coal%20prices%20and%20outlook%201%20The,subbituminous%20%2414.01%204%20lignite%20%2419.86%205%20anthracite%20%24102.22.
[353] U.S. EPA, "Cement Kilns Burning Hazardous Waste as Supplemental Fuel: Guidance," accessed September 8, 2022, https://ordspub.epa.gov/ords/guideme_ext/f?p=guideme:gd:::::gd:dioxin_4_5_3.
[354] U.S. EIA, *Manufacturing Energy Consumption Survey 2018: Table 1.2*, 2021.
[355] U.S. EPA, *Carbon Intensity for the Cement Sector (2019)*, October 2021, https://www.epa.gov/system/files/documents/2021-10/cement-carbon-intensities-fact-sheet.pdf.
[356] Ernst Worrell et al., "Carbon Dioxide Emissions from the Global Cement Industry," *Annual Review of Energy and the Environment* 26, No. 1 (November 2001): 303-329, https://www.annualreviews.org/doi/full/10.1146/annurev.energy.26.1.303.
[357] IEA, *Cement: Not on Track*, November 2021, https://www.iea.org/reports/cement.
[358] USGS *Mineral Commodity Summary: Cement,* January 2021, https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-cement.pdf.
[359] Holcim, *Holcim's Net Zero Journey*, February 2022, https://www.holcim.com/sites/holcim/files/atoms/files/holcim_net_zero_journey_booklet.pdf.
[360] CEMEX, "Our 2030 Targets," https://www.cemex.com/sustainability/esg-reporting-center/our-2030-targets.
[361] HeidelbergCement, *Sustainability Report 2020*, June 14, 2021, https://www.heidelbergcement.com/en/pr-14-06-2021.
[362] U.S. DOE, *Bandwidth Study on Energy Use and Potential Energy Savings Opportunities in U.S. Glass Manufacturing*, September 2017, https://www.energy.gov/sites/default/files/2019/05/f62/Glass_bandwidth_study_2017.pdf.
[363] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS): Glass*, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_glass_energy_carbon_footprint.pdf.
[364] U.S. EIA, *Manufacturing Energy Consumption Survey 2018: Table 1.2*, 2021.
[365] U.S. EPA, FLIGHT tool, accessed September 8, 2022.
[366] Gentex Corporation, *Gentex Sustainability Report*, 2021, https://www.gentex.com/2021-Sustainability-Report.pdf.
[367] Pella, "Energy Efficiency," accessed September 8, 2022, https://www.pella.com/performance/energy-efficiency/.
[368] State of California, "Buy Clean California Act," accessed September 8, 2022.
[369] Colorado Energy Office, "Colorado adopts nation-leading policies to reduce GHG pollution from buildings," [Press release] June 8, 2021, https://energyoffice.colorado.gov/press-releases/colorado-adopts-nation-leading-policies-to-reduce-ghg-pollution-from-buildings.
[370] State of Delaware, DNREC, "E2I: Energy Efficiency Industrial," accessed September 8, 2022.
[371] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS): Forest Products*, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_forest_products_energy_carbon_footprint_0.pdf.
[372] USDA Research, Education and Economics Information System, Economic Analysis of the Forest Products Industry in the United States. 2013. https://portal.nifa.usda.gov/web/crisprojectpages/0231316-economic-analysis-of-the-forest-products-industry-in-the-united-states.html
[373] U.S. EPA, FLIGHT tool, accessed September 8, 2022.

[374] Matt Russell, "Economic contribution of forestry employees across US states," Arbor Analytics, December 12, 2020, https://arbor-analytics.com/post/economic-contribution-of-forestry-employees-across-us-states/.
[375] Alliance for Pulp and Paper Technology Innovation (APPTI), "Forest Products: Industry Overview," accessed September 8, 2022, https://www.appti.org/forest-products.html.
[376] U.S. EIA, *Manufacturing Energy Consumption Survey 2018: Table 1.2*, 2021.
[377] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS): Forest Products*, 2021.
[378] AF&PA, "Energy and the Environment," accessed September 8, 2022.
[379] AF&PA, "Energy and the Environment," accessed September 8, 2022.
[380] U.S. DOE "Forest Products Industry Profile: Advanced Manufacturing," accessed September 8, 2022, https://www.energy.gov/eere/amo/forest-products-industry-profile.
[381] U.S. EIA, "2018 MECS Release Schedule, Table 3.2 Fuel Consumption, 2018," and "Table 3.6 Selected Wood and Wood-Related Products in Fuel Consumption, 2018," 2021, https://www.eia.gov/consumption/manufacturing/data/2018/ - r1.
[382] U.S. EIA, Manufacturing Energy Consumption Survey 2018: Table 1.2, 2021.
[383] AF&PA, "Does Paper Actually Get Recycled?," accessed September 8, 2022, https://www.afandpa.org/priorities/recycling/does-paper-actually-get-recycled.
[384] U.S. DOE, Department of Energy Efficiency and Renewable Energy, *Pulp and Paper Industry Bandwidth Study*, June 2015, https://www.energy.gov/sites/default/files/2015/08/f26/pulp_and_paper_bandwidth_report.pdf.
[385] U.S. EPA, FLIGHT tool, accessed September 8, 2022.
[386] International Paper, *Vision 2030: Building a Better Future for People, the Planet and Our Company*, accessed September 8, 2022, https://www.internationalpaper.com/vision-2030.
[387] Kimberly Clark, *2020 Global Sustainability Report*, accessed September 8, 2022, https://www.kimberly-clark.com/-/media/kimberly/pdf/sustainability-reports/2020/k-c-2020-global-sustainability-report.pdf.
[388] Weyerhaeuser, "3 by 30 Impact Areas: Demonstrating Positive Impact," accessed September 8, 2022, https://www.weyerhaeuser.com/sustainability/3by30/?msclkid=7f8dd502b17c11ecaaa94d51e5dcb993.
[389] AF&PA, *Better Practices, Better Planet 2030: Sustainable Products For A Sustainable Future*, accessed September 8, 2022, https://www.afandpa.org/sites/default/files/2021-08/AFPA_BPBP2030_brochure_print_final.pdf.
[390] Government of the United Kingdom, *Pulp and Paper Industry Decarbonization Roadmap to 2050: Pulp and Paper,* March 2015, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/416673/Pulp_and_Paper_Report.pdf.
[391] Paul Griffin, Geoffrey Hammond, and Jonathan Norman, "Industrial decarbonisation of the pulp and paper sector: A UK perspective," *Applied Thermal Engineering* 134 (April 2018): 152-162, https://www.sciencedirect.com/science/article/pii/S1359431117358210?via%3Dihub.
[392] U.S. Department of Agriculture (USDA) Economic Research Service, "Manufacturing: Food and Beverage Manufacturing," accessed September 8, 2022: https://www.ers.usda.gov/topics/food-markets-prices/processing-marketing/manufacturing/.
[393] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS): Food and Beverage*, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_food_beverage_energy_carbon_footprint.pdf.
[394] U.S. EIA, *Manufacturing Energy Consumption Survey 2018: Table 1.2*, 2021.
[395] U.S. EPA, FLIGHT tool, accessed September 8, 2022.
[396] U.S. EPA, "Sector-Based Information and Resources – Agribusiness: Location of U.S. Facilities," accessed September 8, 2022, https://archive.epa.gov/sectors/web/html/map.html.
[397] Nestlé, "Focusing on regenerative agriculture and moving to renewable electricity, Nestlé redoubles efforts to combat climate change," [Press release] December 3, 2020, https://www.nestle.com/media/pressreleases/allpressreleases/nestle-efforts-combat-climate-change.
[398] Science Based Targets, "Case Study: PepsiCo," accessed September 8, 2022, https://sciencebasedtargets.org/companies-taking-action/case-studies/pepsico.

[399] JBS Foods, "JBS Makes Global Commitment to Achieve Net-Zero Greenhouse Gas Emissions by 2040," [Press release] March 23, 2021, https://jbsfoodsgroup.com/articles/jbs-makes-global-commitment-to-achieve-net-zero-greenhouse-gas-emissions-by-2040.
[400] Tyson, "Tyson Foods Targets 2050 to Achieve Net Zero Greenhouse Gas Emissions," [Press release] June 9, 2021, https://www.tysonfoods.com/news/news-releases/2021/6/tyson-foods-targets-2050-achieve-net-zero-greenhouse-gas-emissions.
[401] ADM (Archer Daniels Midland), "ADM Sets Scope 3 Emissions Reduction Target," [Press release] accessed September 8, 2022, https://www.adm.com/en-us/news/adm-stories/adm-sets-scope-3-emissions-reduction-target/.
[402] NYSERDA, *Potential for Carbon Capture, Utilization, and Storage Technologies in New York State*, July 2020, https://www.nyserda.ny.gov/-/media/Project/Nyserda/files/Publications/Research/Environmental/20-13-Carbon-Capture-Utilization-and-Storage-Technologies.pdf.
[403] Energize Delaware, *2018 Annual Report*, 2019, https://www.energizedelaware.org/wp-content/uploads/2019/12/DESEU_Annual_Report_2018_FINAL2.pdf.
[404] Maryland Energy Administration, "Kathleen A. P. Mathias Agriculture Energy Efficiency Program," accessed September 8, 2022, www.energy.maryland.gov/business/Pages/incentives/mathiasag.aspx.
[405] Washington State Department of Commerce, *Washington 2021 State Energy Strategy*, December 2020, https://www.commerce.wa.gov/wp-content/uploads/2020/12/Washington-2021-State-Energy-Strategy-December-2020.pdf.
[406] Manitoba Sustainable Development, "Made-in-Manitoba Climate and Green Plan," accessed September 8, 2022, https://www.gov.mb.ca/climateandgreenplan/index.html.
[407] Ontario Ministry of the Environment, Conservation and Parks, *Preserving and Protecting our Environment for Future Generations: A Made-in-Ontario Environment Plan*, 2018, https://prod-environmental-registry.s3.amazonaws.com/2018-11/EnvironmentPlan.pdf.
[408] European Commission, "A New Circular Economy Action Plan," November 3, 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN.
[409] European Commission, "Green Public Procurement," accessed September 8, 2022, https://ec.europa.eu/environment/gpp/index_en.htm.
[410] U.S. DOE, *Industrial Decarbonization Roadmap,* September 2022.
[411] Senate Committee on Energy and Natural Resources, *Energy Act of 2020 | Section-by-Section*, accessed September 8, 2022, https://www.energy.senate.gov/services/files/32B4E9F4-F13A-44F6-A0CA-E10B3392D47A.
[412] U.S. DOE, "DOE Announces $42.3 million and New Industry Partnerships to Decarbonize American Manufacturing," [Press release] July 29, 2021, https://www.energy.gov/articles/doe-announces-423-million-and-new-industry-partnerships-decarbonize-american-manufacturing.
[413] S.4355 - Clean Competition Act, U.S. Congress, June 7, 2022, https://www.congress.gov/bill/117th-congress/senate-bill/4355?q=%7B%22search%22%3A%5B%22whitehouse%22%2C%22whitehouse%22%5D%7D&s=4&r=3.
[414] U.S. General Services Administration (GSA), "GSA Lightens the Environmental Footprint of its Building Materials," [Press release] March 30, 2022, https://www.gsa.gov/about-us/newsroom/news-releases/gsa-lightens-the-environmental-footprint-of-its-building-materials-03302022.
[415] H.R. 4534 – 117th Congress (2021-2022): FAIR Transition and Competition Act, July 19, 2021, https://www.congress.gov/bill/117th-congress/house-bill/4534?s=1&r=9.
[416] The White House Statements and Releases, "Fact Sheet: Biden-Harris Administration Advances Cleaner Industrial Sector to Reduce Emissions and Reinvigorate American Manufacturing," [Press release] February 15, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/15/fact-sheet-biden-harris-administration-advances-cleaner-industrial-sector-to-reduce-emissions-and-reinvigorate-american-manufacturing/.
[417] Office of the Federal Chief Sustainability Officer, Federal Buy Clean Initiative, accessed September 15, 2022, https://www.sustainability.gov/buyclean/.
[418] U.S. DOE, *Manufacturing Energy and Carbon Footprints (2018 MECS),* 2021.
[419] U.S. DOE, "2018 Manufacturing Energy and Carbon Footprints: Definitions and Assumptions," March 2022, https://www.energy.gov/sites/default/files/2022-03/2018_mecs_footprint_definitions.pdf.