DEPARTMENT OF ECOLOGY
State of Washington

EITE Industries Advisory Group

Meeting 3: November 14, 2024

Introductions

Ecology staff

- Jihan Grettenberger – Facilitator
- Adrian Young – Cap-and-Invest Industrial Policy Lead
- Andrew Hayes – Cap-and-Invest Policy Section Manager

Meeting reminders

- Meetings are open to the public and recorded
- Advisory Group members will appear as “Panelists” in the Zoom meeting
- Members of the public will appear as “Attendees”
- Attendees may unmute and provide comment in the public comment portion of the meeting
- Meeting materials and summary notes will be published on the Advisory Group webpage

Purpose of EITE Industries Advisory Group (IAG)

- Composed of 23 members representing EITE Industries within Cap-and-Invest Program
- Provide input on a report to the Legislature related to the allocation of no-cost allowances to EITEs from 2035 to 2050.
- Ecology will use input to inform its report to the legislature, in tandem with input from other interested parties.
- Further information available on Ecology's website.

Timeline: report and advisory groups

Phase 1:
Aug–Dec 2024

Collect information, discuss technical issues, and identify factors affecting EITE allocation & decarbonization

EITE Industries AG

EITE Industry & Facility perspective

EITE Policy AG

Program & Statewide perspective

Break

Phase 2:
Mar–Aug 2025

Discuss and assess policy and technical considerations

Discuss draft policy recommendations for EITE allocation 2035-2050

EITE Industries AG

EITE Policy AG

Phase 3:
Sep–Nov 2025

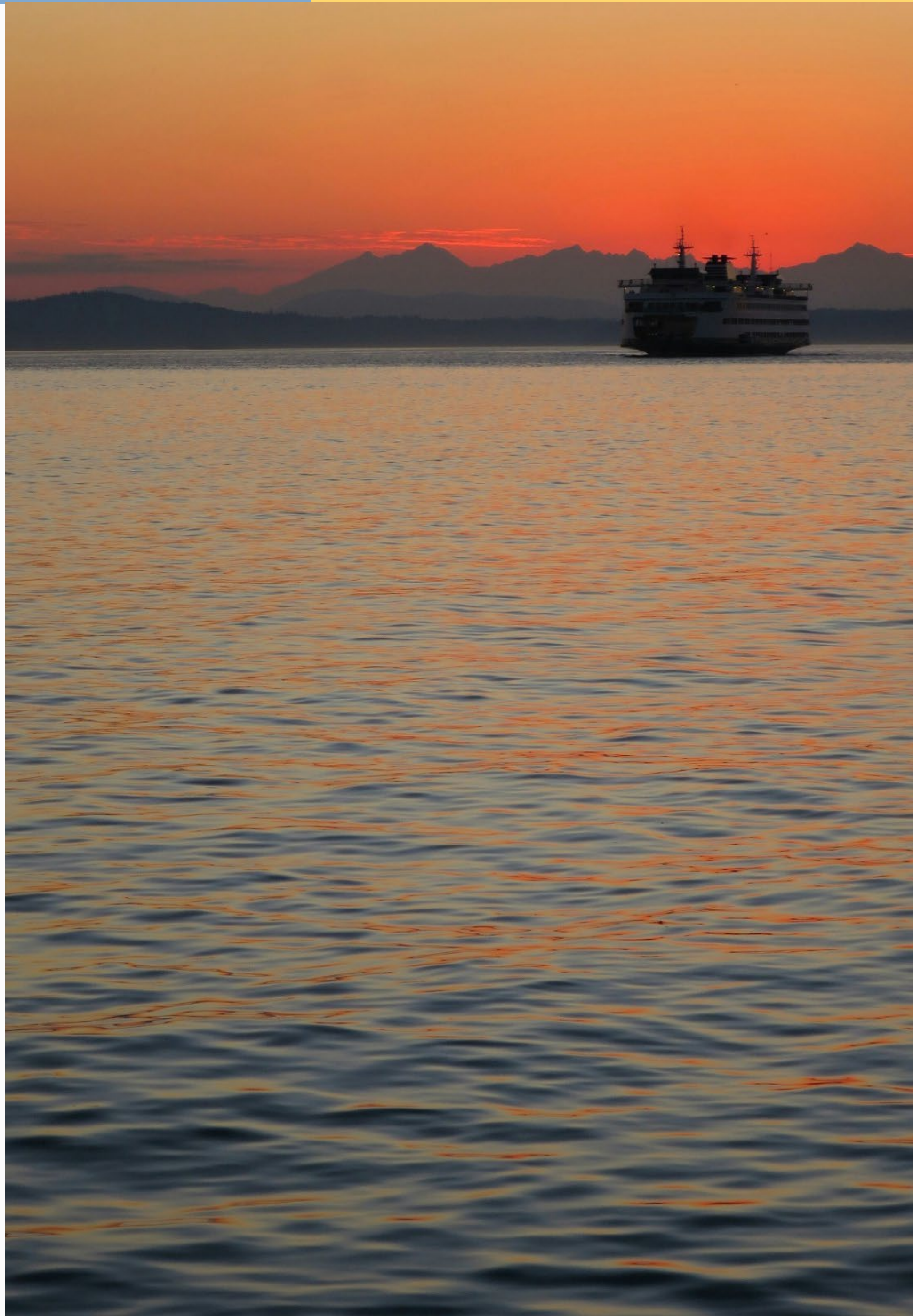
Ecology prepares final report for legislature

Report submitted to legislative committees

Other engagement opportunities: Tribes, EJ Council, overburdened communities

Agenda – Meeting #3

- Background and context: industrial decarbonization and the CCA
- Presentations:
  - Rocky Mountain Institute: Washington’s Industrial Opportunity
  - Renewable Thermal Collaborative: Buyer’s Perspectives on Decarbonization
  - Energy Innovation: Policies for Zero-Carbon Industry
- Discussion: Opportunities and Challenges for Decarbonization of EITEs in WA
- Open Discussion: Member topics/questions
- Wrap up and next steps
- Public comment opportunity



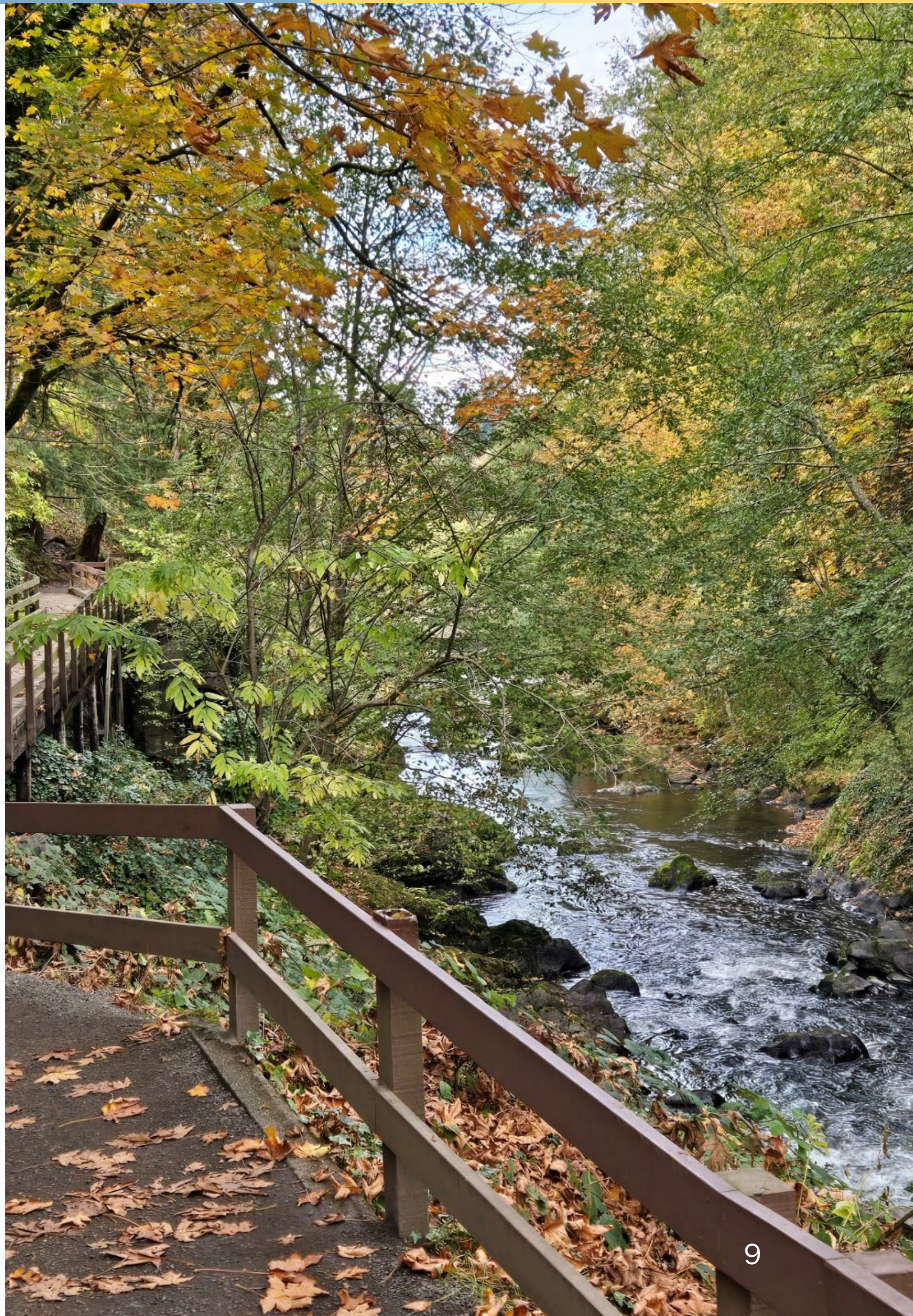
Industrial decarbonization and the CCA

Legislative intent of CCA

- Cap-and-Invest Program intended to work alongside other climate policies to help Washington achieve its statewide greenhouse gas emissions limits
- *"…Washington will position its economy, technology centers, financial institutions, and manufacturers to benefit from national and international efforts that must occur to reduce greenhouse gases…"* RCW 70A.65.005(6)
- *"The legislature further intend to encourage these [EITE] industries to continue to innovate, find new ways to be more energy efficient, use lower carbon products, and be positioned to be global leaders in a low carbon economy…."* RCW 70A.65.005(6)

CCA and EITE compliance pathways

- Legislature asked Ecology to identify compliance pathway for EITEs to achieve their proportionate share of greenhouse gas emissions limits (HB 1682)
- During 2022 legislative session EITEs raised concerns about the compliance pathway proposed by Ecology
- Ecology had identified a need to better understand potential decarbonization pathways for EITE in WA to better inform EITE allowance allocation for 2035-2050



Industrial decarbonization pathways

Department of Energy:

- Industrial Decarbonization Roadmap
- Pathways to Commercial Liftoff: Industrial Decarbonization
- Other liftoff reports

U.S. Climate Alliance:

- Enabling Industrial Decarbonization: A Policy Guidebook for U.S. States

- High-level pathways or ‘pillars’
  - Energy efficiency
  - Industrial electrification
  - Low-carbon fuels, feedstocks, and energy sources
  - Carbon capture, utilization, and storage
- Significant barriers to deployment and achievement of emissions reduction potential
- Suite of policies needed to overcome barriers and support effective deployment
- Need to understand what pathways look like for EITEs in WA and potential role of state policies

Questions?

Presentation: RMI

Washington State Industrial Decarbonization Pathways

November 14, 2024

AGENDA

RMI team

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About RMI

Transforming the global energy system to secure a clean, prosperous, zero-carbon future for all.

BY Targeting Key Sectors

- Electricity
- Buildings
- Transportation
- Industry

USING Powerful Market Catalysts

- Policy
- Technology
- Climate Aligned Finance
- Climate Intelligence
- Education & Capacity Building
- Communications

Project overview

The opportunity

Washington and its industrial partners can work together to secure industrial decarbonization commitments and investments

Washington has both ambitious climate goals – including reducing climate emissions 95% below 1990 levels by 2050 – and ambitious clean tech & job growth goals, like adding 300,000 manufacturing jobs between 2021 and 2031.

Most of Washington's large industrial facilities receive free allowances through 2034 to cover their emissions under the Cap-and-Invest Program.

Industries could leverage incentives within Cap-and-Invest alongside lucrative but expiring federal grants/incentives to reduce emissions. Federal support potentially totals $4 billion from 2023 through 2031.

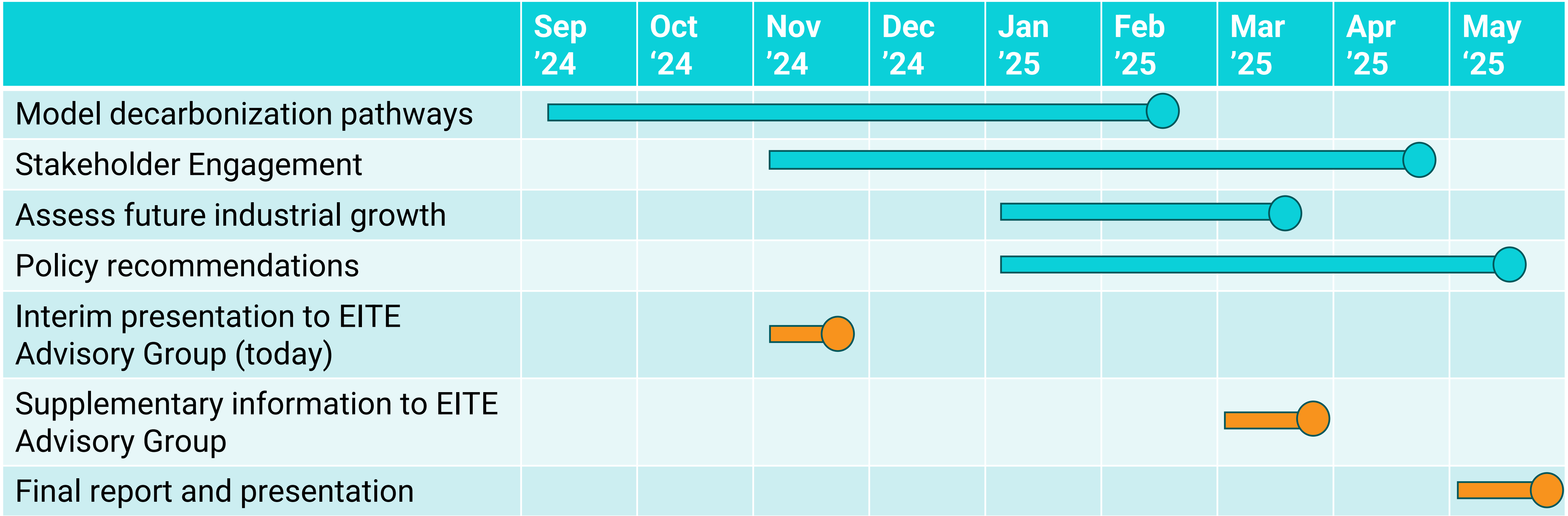
Objective

Establish a foundational analysis of decarbonization pathways for Washington's existing and future industry and explore market and policy opportunities to support industrial decarbonization and regional clean tech development.

Project scope

- Identify technical decarbonization pathways for existing EITE industries and manufacturing in Washington.
- Analyze the interaction between federal incentives and cap-and-invest program incentives and produce recommendations for the use of cap-and-invest allowances.
- Assess potential future industrial growth in Washington and the projected impact on greenhouse gas emissions, air pollution, and workforce.
- Engage with stakeholders to understand Washington’s industries’ barriers to decarbonization and preferences for future investments.

Project timeline



Stakeholder engagement

- We want to ensure our study reflects the current industrial decarbonization landscape in Washington as accurately as possible and are therefore looking to interview stakeholders and advocates across the industry arena.
- As EITE Advisory Group and EITE industry members, your on-the-ground experience with decarbonization will be helpful as we study realistic and implementable decarbonization solutions.

Interviews

We are looking to interview industry members and other stakeholders about implementation costs, technical results, and other helpful inclusions or considerations.

We want to make sure our study reflects the current landscape as accurately as possible, and as part of that, we want to identify any policy, knowledge, or financing gaps or other constraints.

As EITE Advisory Group members, you represent industries that are not only critical to Washington's economy, but also to the discussion of how to achieve Washington's climate goals.

Issues in focus

- What we're looking for: Industry's input is invaluable as we develop a robust and realistic analysis of how industries can continue to decarbonize while navigating the economy and policy challenges of the current landscape.
- These interviews will provide critical perspectives on:
  - How you see efforts like cap-and-invest and state climate goals impacting your operations, cost, and long-term planning;
  - The technical and financial challenges and opportunities you face in decarbonizing;
  - What types of support or policy adjustments would make further decarbonization most feasible and cost-effective for your sector.

Baseline Industrial Emissions

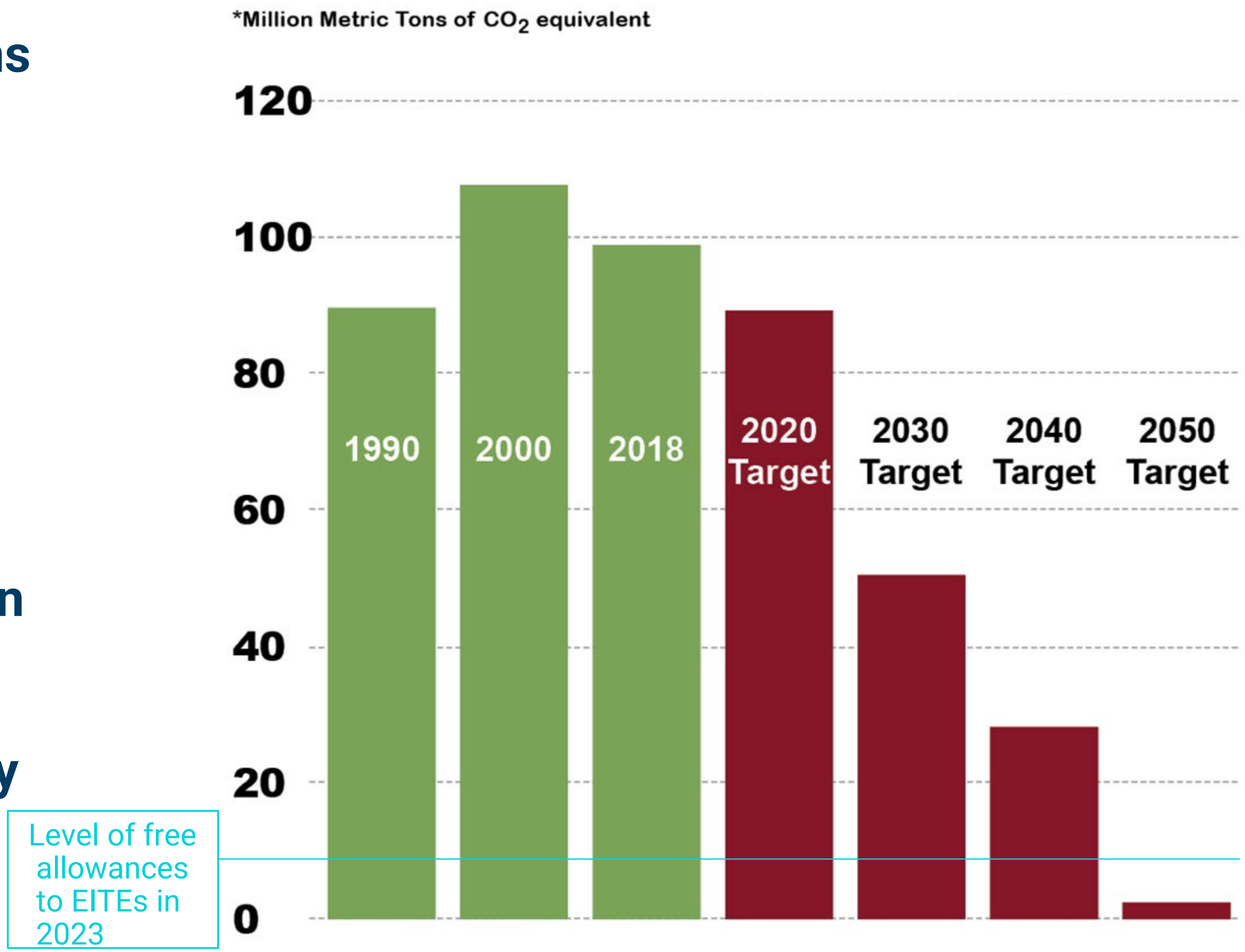
Climate emissions and reduction targets

Washington Greenhouse Gas Emissions Goals

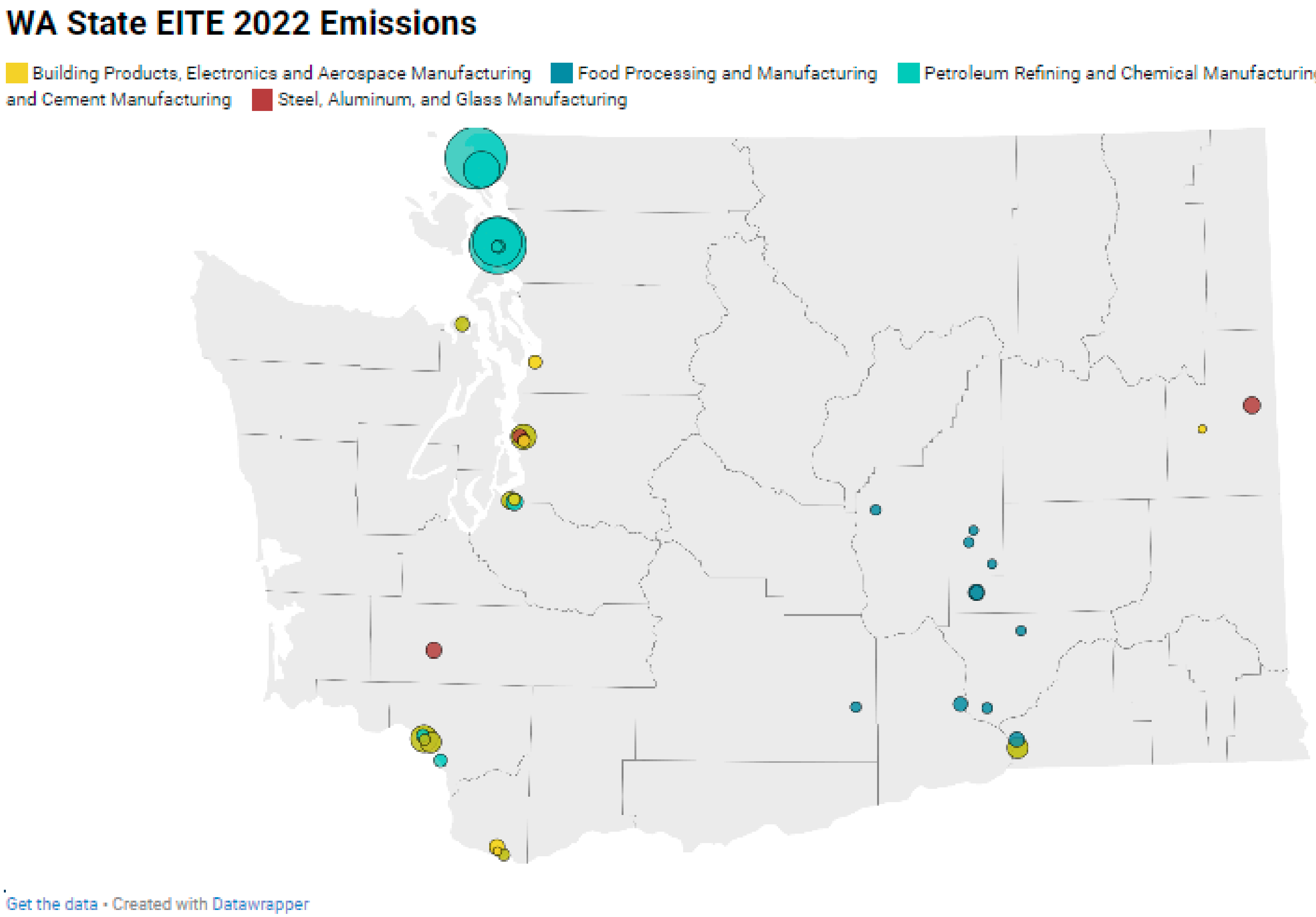
- **45% below 1990 levels by 2030**
- **70% below 1990 levels by 2040**
- **95% below 1990 levels with net zero emissions by 2050**

U.S. Greenhouse Gas Emissions Goals

- **50-52% reduction from 2005 levels in economy-wide net greenhouse gas pollution in 2030**
- **Net zero greenhouse gas pollution by 2050**

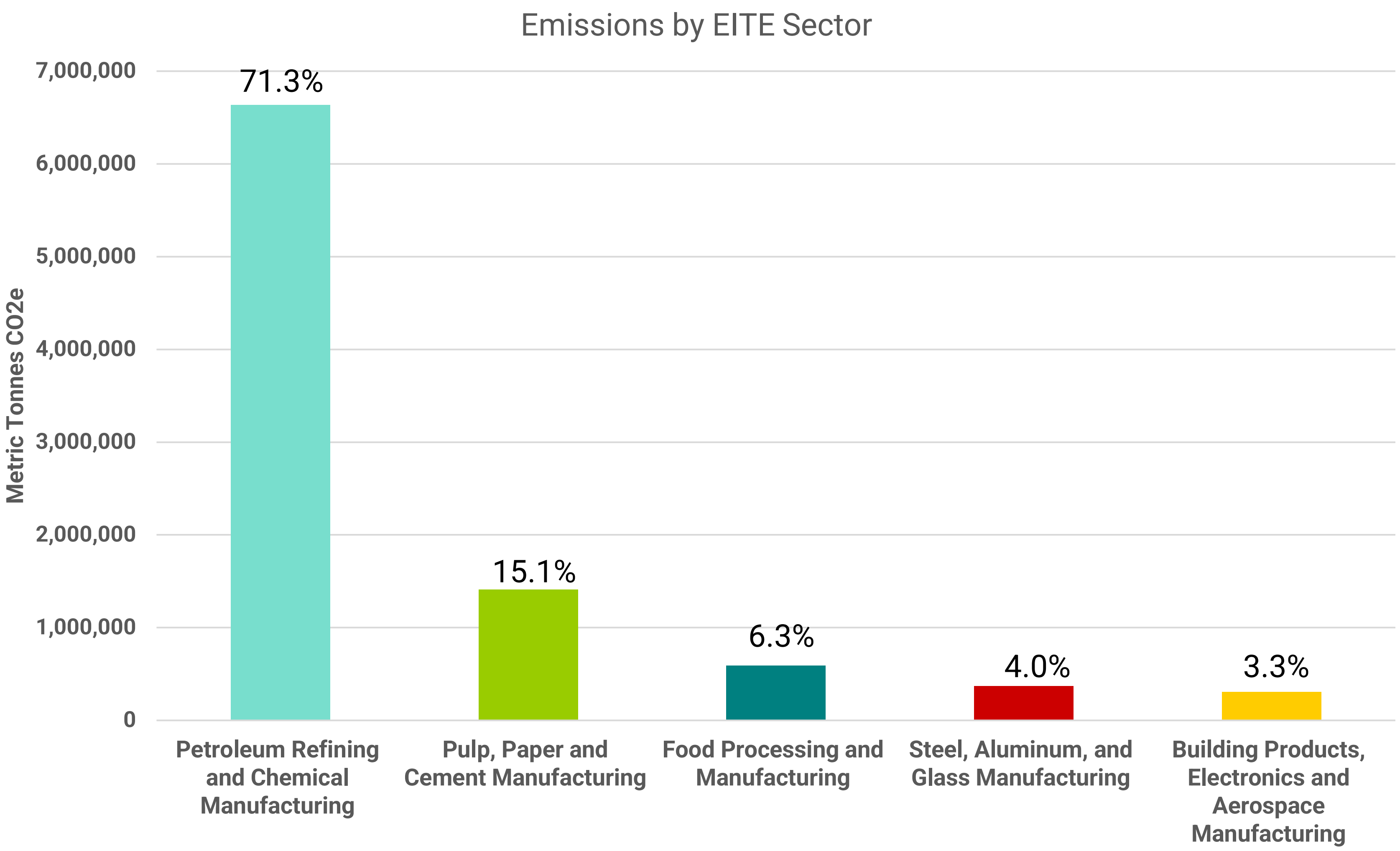


EITE Facilities are clustered in specific regions



Link to map: https://www.datawrapper.de/_/6V95j/

Emissions concentration across sectors



EPA Flight 2022 emissions data

Industrial Decarbonization Incentives

Recent federal legislation has opened new opportunities for industrial decarbonization

Since the 2021 passage of Washington's Climate Commitment Act establishing the Cap & Invest program* there have been major changes to federal policy:

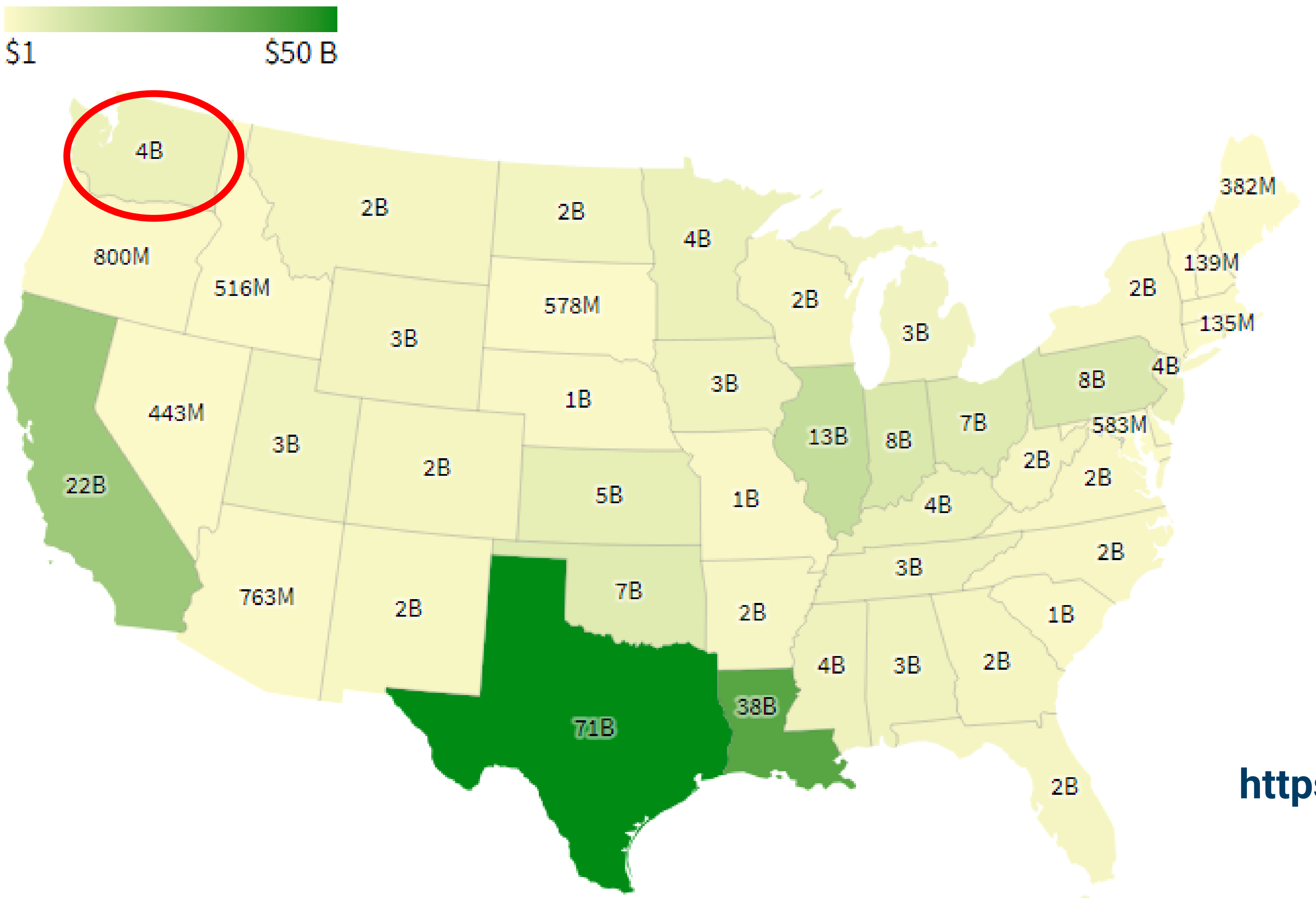
- **2021 Infrastructure Investment and Jobs Act (also called the Bipartisan Infrastructure Law)**
- **2022 CHIPS and Science Act**
- **2022 Inflation Reduction Act**

Updated programs, expanded programs, new programs, more funding, more tax credits – *a lot to keep track of!*

In general, new federal incentives and programs expire prior to 2035, some much sooner.

*C&I Program affirmed by voters in 2024 election on Initiative 2117

Industry Sector Potential IRA Funding from 2023-2031 (USD)



According to RMI's Full Potential scenario, the contiguous U.S. can receive $255 billion in IRA funding for industry sector projects.

https://rmi.org/bring-in-the-billions/

Decarbonizing Industry Resource Tool (DIRT)

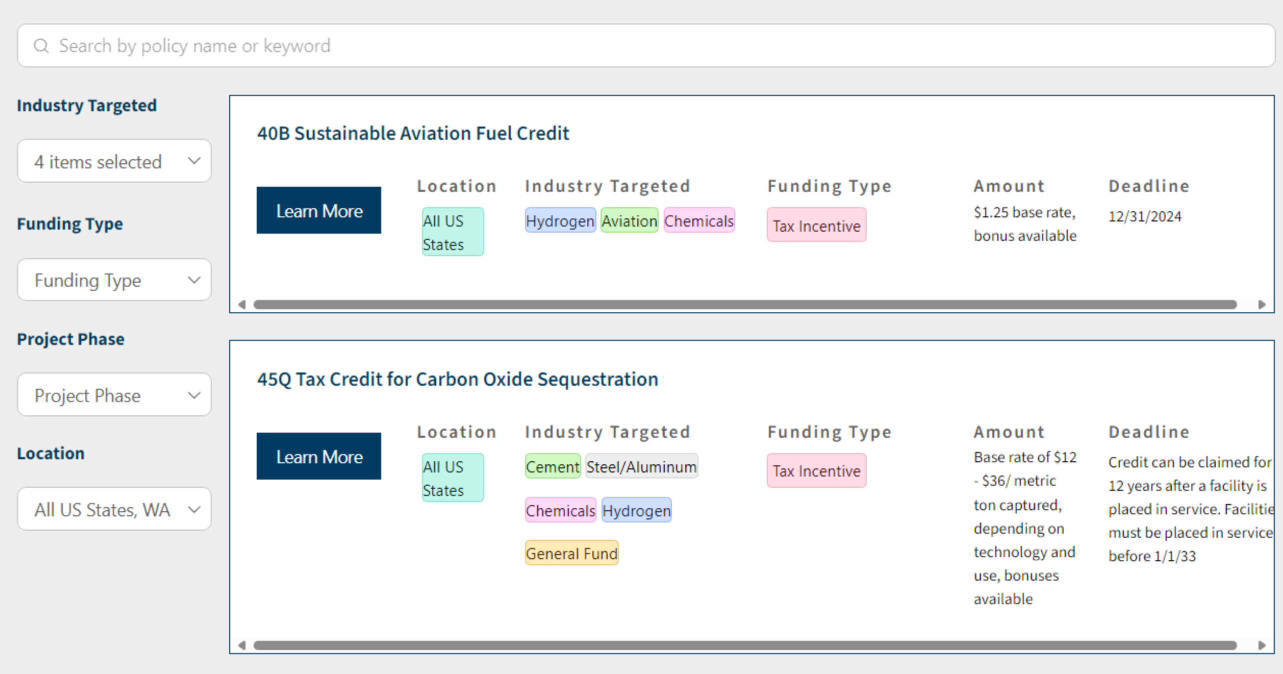
Get the DIRT on industrial decarbonization incentives

https://rmi.org/decarbonizing-industry-resource-tool-dirt/

Financial incentives categorized by industry

- Cement
- Steel
- Aluminum
- Chemicals
- Batteries
- Trucking
- Shipping
- Aviation
- Hydrogen

Includes details on amount, deadlines, stackability, and links to government information pages.



Top Programs for EITEs in Washington

In brief, not exhaustive.

Name of Program	Primary Sectors	Timing
45V Clean Hydrogen Production Tax Credit	Refining, Cement, Metals	Facilities must be placed in service by end of 2032
45Q Tax Credit for Carbon Oxide Sequestration	Refining, Cement, Metals	Facilities must be placed in service by end of 2032
45X Advanced Manufacturing Production Credit	Manufacturing	Through 2032
Various tax credits for Sustainable Aviation Fuel and other alternative fuels	Refining, Chemicals	Through 2027
Clean Electricity Production Tax Credit + Clean Electricity Investment Tax Credit	Electricity	Through 2032 or later
48C Advanced Energy Project Credit	Cross-sector	Second round recently closed
Industrial Demonstration Program	Cross-sector	Deadline 9/30/2026
Title 17 Clean Energy Financing	Cross-sector	Deadline 9/30/2026
Energy Infrastructure Reinvestment	Refining	Deadline 9/30/2026
Washington's Hard-to-Decarbonize Sector Grants	Cross-sector	Rolling

45V Clean Hydrogen Production Tax Credit

- For the production of low lifecycle emission hydrogen.
- Applies to Refining, Cement, Metals, and potentially other industries.
- Tiered credit, value of the credit is determined by the level of lifecycle emissions per kg of H2, with a maximum amount of $3/kg H2.
- Facilities must be placed in service by 12/31/2032.
- Use clean hydrogen to replace existing uses of grey hydrogen, and use for decarbonizing other processes.

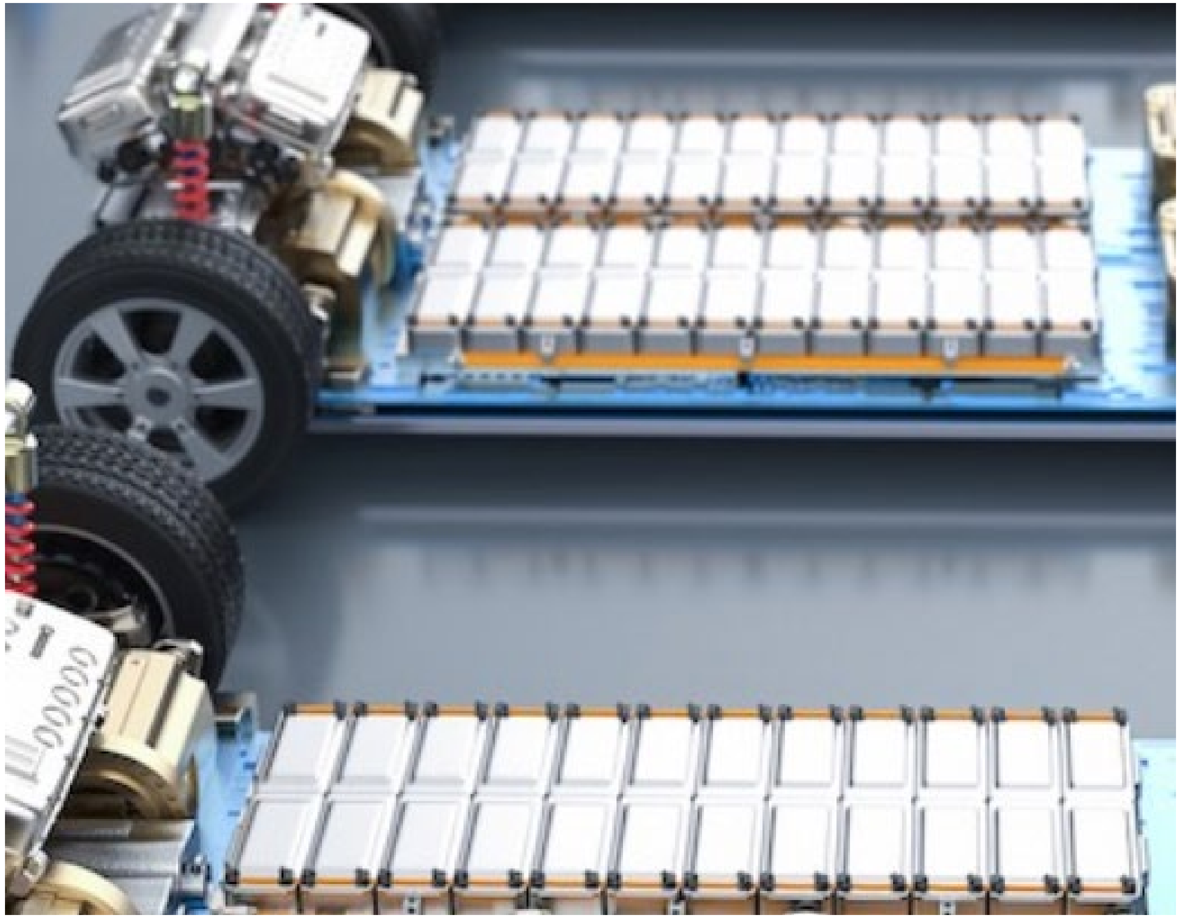
https://www.irs.gov/credits-deductions/clean-hydrogen-production-credit

45Q Tax Credit for Carbon Oxide Sequestration

- For facilities capturing and storing carbon.
- Applies to Refining, Pulp & Paper, Cement, Metals, and potentially any facilities with large point sources of carbon emissions
- Base rate of $12 - $36/ metric ton captured, depending on technology and use, with bonuses available.
- Facilities must be placed in service by 12/31/2032.

https://www.irs.gov/instructions/i8933

45X Advanced Manufacturing Production Credit



- For the production of components within the solar, wind, and battery supply chain including thermal batteries and “non-cell” batteries, as well as the processing and refining of critical minerals.
- Applies to parts of the manufacturing sector.
- The amount of the tax credits depends upon the qualified component.

https://www.federalregister.gov/documents/2024/10/28/2024-24840/advanced-manufacturing-production-credit

Various tax credits for Sustainable Aviation Fuel and other alternative fuels

- **Relevant for refineries, biofuel producers, and chemical facilities.**
- **40B Sustainable Aviation Fuel Credit. Expires 12/31/2024.**
- **Extension of 40A Tax Credits for Biodiesel and Renewable Diesel and Mixtures. Expires 12/31/2024.**
- **Extension of Tax Credits for Alternative Fuels. Expires 12/31/2024.**
- **45Z Clean Fuel Production Credit. Replaces the above, begins 1/1/2025 and expires 12/31/2027.**
    - Worth $0.20 - $1.75 per gallon of fuel depending on emissions factor.

https://www.irs.gov/credits-deductions/businesses/sustainable-aviation-fuel-credit https://www.irs.gov/businesses/small-businesses-self-employed/fuel-tax-credits https://www.irs.gov/credits-deductions/clean-fuel-production-credit

Clean Electricity Production Tax Credit + Clean Electricity Investment Tax Credit

- Do not directly fund industrial emissions reduction.
- For industrial facilities looking to electrify processes it is worth considering also building on-site electricity generation and storage. With the usage of the federal tax credits this could be more cost effective than grid electricity in some cases.
- PTC: 0.3 cents/kwh for large facilities, 1.5 cents/kwh for small facilities, bonuses available for domestic content and siting in an energy community
- ITC: 6% of investment, 30% if meeting prevailing wage requirements, 50% if meeting domestic content requirement and located in an energy community.
- Both PTC and ITC phase out after 2032 or when U.S. greenhouse gas emissions from electricity are 25% of 2022 emissions or lower.

https://www.irs.gov/credits-deductions/clean-electricity-production-credit https://www.irs.gov/credits-deductions/clean-electricity-investment-credit

48C Advanced Energy Project Credit

- **Can apply to many industries**
- **Worth up to 30% of a qualifying investment:**
  - Clean Energy Manufacturing and Recycling Projects
  - Greenhouse Gas Emission Reduction Projects
  - Critical Material Projects
- **A tax credit that operates more like a $6 billion competitive grant program, allocated in two waves.**
  - Second round applications were due October 2024.

https://www.energy.gov/infrastructure/qualifying-advanced-energy-project-credit-48c-program

Industrial Demonstration Program

- $6.3 billion in total funding from DOE Office of Clean Energy Demonstrations.
- Funding projects that focus on the highest emitting and hardest to abate industries: iron and steel, cement and concrete, chemicals and refining, food and beverage, paper and forest products, aluminum, other energy-intensive manufacturing industries and cross-cutting technologies.
- Awards are being made on an ongoing basis

https://www.energy.gov/oced/industrial-demonstrations-program

Title 17 Clean Energy Financing

Innovative Energy, Innovative Supply Chain, and SEFI Loans from the DOE Loans Program Office

1. Innovative Energy loans support projects that will deploy a "new or significantly improved" energy technology.
2. Innovative Supply Chains loans support manufacture a "new or significantly improved" product (innovation can be in manufacturing process).
3. State Energy Financing Institution (SEFI) loans do not have an innovation component and are for augmenting state efforts to support clean energy projects.

LPO loans often have lower interest rates than traditional financing, and the LPO tailors loans to the specific detail of each project. A broad range of projects can be financed through Title 17.

No max loan size. Loan guarantees need to be designated for Conditional Commitment by September 30, 2026.

https://www.energy.gov/lpo/title-17-clean-energy-financing

Energy Infrastructure Reinvestment

From the DOE Loans Program Office

- Provide financing for projects that retool, repower, repurpose or replace energy infrastructure that has ceased operations or projects that reduce operational emissions of existing energy infrastructure in energy communities.
- Notably applicable to refineries
- Time constraint: loan authority only goes through September 2026

Washington's Hard-to-Decarbonize Sector Grants

- Grant program to fund projects that aim to reduce emissions in hard-to-decarbonize sectors, including iron, steel, aluminum, cement, concrete, glass, pulp and paper, food and beverage, wood and building products, aerospace, electronics, chemicals, and heavy-duty transportation.
- Grant recipients must anticipate being able to reduce greenhouse gas emissions in Washington by or before 2030.
- Contact Washington Department of Commerce for details on next round of funding; $20 million was awarded in most recent round.

Contact Washington Department of Commerce. Contract Portal – Washington State Department of Commerce

Question for EITE Committee Members…

Which of these incentives has your company pursued or will pursue?

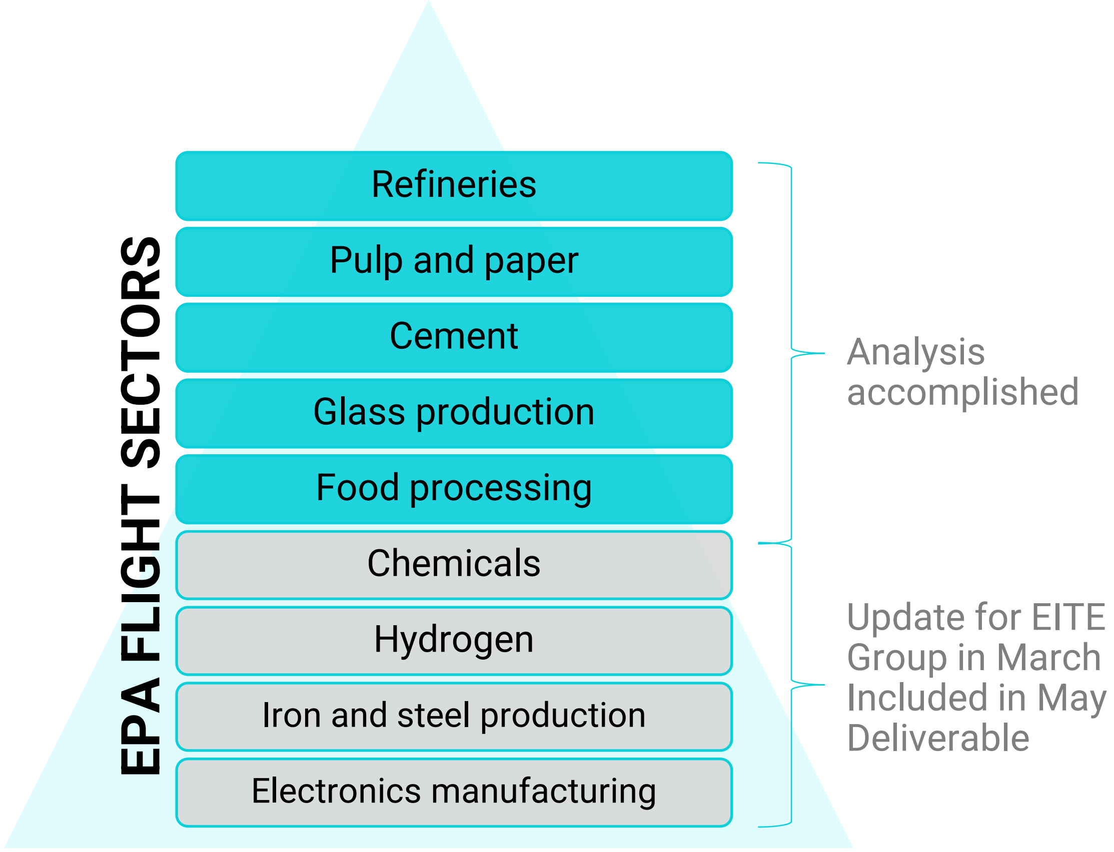
45V Clean Hydrogen Production Tax Credit
45Q Tax Credit for Carbon Oxide Sequestration
45X Advanced Manufacturing Production Credit
Various tax credits for Sustainable Aviation Fuel and other alternative fuels
Clean Electricity Production Tax Credit + Clean Electricity Investment Tax Credit
48C Advanced Energy Project Credit
Industrial Demonstration Program
Title 17 Clean Energy Financing
Energy Infrastructure Reinvestment
Washington's Hard-to-Decarbonize Sector Grants

Sector-specific decarbonization pathways

Refineries, cement, pulp and paper, glass, and food processing

Overview of analysis and next steps

- **Analysis to date:**
  - Narrative explanation of existing and applicable to each sector technical interventions
  - Sequence and time to implement interventions
  - Projected impact of annual GHG emissions for each sector, based on EPA FLIGHT data (2022)
  - Cost estimates
  - Existing examples of interventions
- **Next steps:**
  - Analyze remaining sectors (update to EITE group in March)
  - Projected change in criteria and hazardous air pollutants (final deliverable in May)**
  - Change in electricity and/or fuel consumption (final deliverable in May)**
  - Recommendations for policies to support decarbonization (final deliverable in May)**
  - Refined costs and GHG reduction estimates based on interactions with industry



Cross-cutting technical interventions

Energy efficiency

- Near term decarbonization solution that does not require substantial changes to industrial processes
- Includes improvements in system efficiencies, process yield, and recovery of thermal energy; expansion of energy management practices; and increased implementation of smart manufacturing strategies.

Electrification

- Electrification, particularly of thermal processes, provides an opportunity to leverage decarbonized electricity sources and reduce industrial emissions from onsite combustion of fossil fuels.
- Includes electrification of process heat (e.g., heat pumps) or electrification of hydrogen production for industrial process use.

Low Carbon Fuels and Hydrogen

- Decarbonizing industrial processes with low-carbon fuels is effective in areas where electrification is challenging due to high temperature needs or the chemical nature of the processes.
- Includes use of biogenic fuels (biomass or biogas) or waste fuels (like municipal solid waste (MSW) or tire-derived fuel and green hydrogen.

Carbon Capture

- Implementing CC(U)S technologies allows industries to capture CO_2 emissions for storage or conversion into valuable products. Critical component for deep decarbonization.
- Current costs and technological considerations push the technology towards long-term horizon.

Refineries

Key decarbonization technologies

Overview of existing technologies

Immediate — 1-3 years — 5-10 years

Reduce rates

Includes adjusting production rates - lowers emissions without capital investment. Requires strategic rate reductions to minimize fuel usage while still meeting demand.

Less fugitive emissions & flaring

Includes methane leaks and routine flaring reduction with enhanced Leak Detection and Repair (LDAR) and flare gas system upgrades that help cut fugitive emissions. Also purchase of low-leak oil and gas inputs certified under recent MiQ standards

Biorefinery

Includes conversion of smaller refineries to produce biofuels like Sustainable Aviation Fuel (SAF). Ideal for lower-capacity sites like U.S. Oil/PAR Pacific in Tacoma.

Naphtha/Coker Shutdowns

Shutting down processing units reduces emissions as gasoline demand drops. Naphtha can be repurposed as a high-sulfur feedstock for other industries, preserving some product value.

Electrification

Replacing fossil fuel-based systems with electric technologies, focusing primarily on process heating (e.g., heaters, boilers, and steam generation).

Green Hydrogen

Production of green hydrogen via electrolysis. Can be eligible for 45V tax credits. Especially impactful at larger sites like BP Cherry Point.

Fluid Catalytic Cracking Waste Gas Carbon Capture

Captures CO_2 from FCC waste gas, potentially converting it to methanol. Eligible for 45Q tax credits, this method provides a bridge to cleaner production options - particularly relevant in the long-term.

REFINERIES

Pathways and emissions reduction potential

5 refineries with cumulative 6.4 MMt CO_2e p.a., modeled emission reductions of 40%

Low-Hanging Fruits: Fugitive emission reduction and naphtha/coker shutdowns are prioritized early due to their low costs and high readiness. Biorefineries are a lucrative option for smaller facilities.

Scalable Technologies: Electrification of boilers is sequenced as grid decarbonization advances, making renewable electricity more accessible.

Capital-Intensive Projects: Green hydrogen and CCU are pushed further down the timeline to align with declining technology costs and increasing incentives.

CCU for FCC units needs to start operations in 2036 to take advantage of the 45Q tax credits. This is a longer-term solution due to the high costs and technological complexity of capturing and converting concentrated CO_2 streams into methanol.

Source: RMI research

Cost estimates and Technological Readiness Level (TRL)

Low, medium, and high CapEx interventions

Low Capex Interventions

- **Less Fugitive/Flaring**
  - **Capex**: $15-62.5 million
- **Reduce Rates**
  - **Capex**: $0 (but potential revenue loss, pending market conditions)
- **Naphtha/Coker Shutdowns**
  - **Capex**: $0 (but potential revenue loss, pending market conditions)

Medium Capex Interventions

- **Electrify Boilers**
  - **Capex**: $10-80 million ($20 ml for 20 MW) | **Incentives**: ITC (with Renewable Integration)
- **Green Hydrogen**
  - **Capex**: $23.72-130 million (10-50 MW) | **Incentives**: 45V Tax Credit | **TRL**: 6-7 (Pilot and demonstration)

High Capex Interventions

- **Biorefinery**
  - **Capex**: $175-500 million | **Incentives**: RFS Credits (Renewable Fuel Standard) | **TRL**: 7-8 (Commercialization phase)
- **FCC Waste Gas CCU**
  - **Capex**: $100-400 million | **Incentives**: 45Q Tax Credit | **TRL**: 6-8 (Pilot to Early Deployment)

Source: Marginal abatement cost based on DOE Pathways to Commercial Liftoff: Industrial Decarbonization

Case study: Marathon Dickinson (ND)

Refinery to biodiesel, CCUS under evaluation

- **Location**: Stark County, North Dakota
  Conversion: From crude oil refinery to renewable diesel **due to financial struggles** of the refinery in **2020** with a **$500 million** investment.
  Wind Power Addition: **Five 2.3 MW wind turbines** to be installed by **One Energy Enterprises LLC** in **2022**; - **$24 million** investment.
- **Economic Impact**:
  - **100 full-time jobs** and **20 contractors**.
  - **$19 million** in local wages annually.
  - **$2.1 million** in property taxes and additional **$940,000** from wind project.
  - **$5000 scholarships to 5 students** pursuing career in STEM yearly
- **Renewable Diesel Production**:
  - Producing **12,000 barrels/day**.
  - Feedstock: **3 million acres of corn** and **1.5 million acres of soy**.
  - Distributed to **California** by rail, meeting **low-carbon fuel standards**.
- **Environmental Benefits**:
  - Wind power will supply up to **45%** of facility electricity, reducing carbon intensity and increasing competitiveness in low-carbon markets.
- **In 2023 received $2.5ml funding for CCUS from DOE**

Technology selection criteria

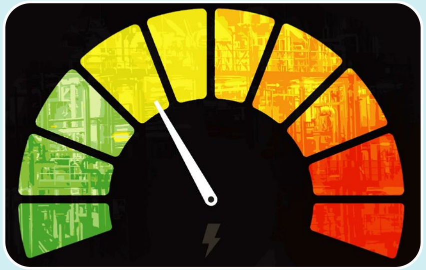
Technology	Technology Readiness Level	Cost Considerations	Emission Reduction Potential (facility level p.a.)	Overall Implementation Timeline
Biorefinery	High	Moderate to high initial capital	50-90%	Immediate – mid -term, for small scale
Less Fugitive/Flaring	High	Low to moderate (leak detection and flare systems)	5-10%	Immediate, low reduction
Naphtha Shutdowns	High	Low capital, involves production losses	10-20%	Immediate, but revenue loss
Electrify Boilers	Medium to High	High initial costs for electrification	20-30%	Mid-term
Electrify Cokers	Low	High due to specialized electrification needs	25%	Mid-term
Green Hydrogen Integration	Medium	Very high (hydrogen production & infrastructure)	20%	Mid-to-long term, scaling, challenges
FCC Waste Gas CCU	Low to Medium	High capital & operational costs, potential revenue from methanol	10-20%	Long-term, tech uncertainty
Reduce Production Rates	High	Low capital, reduced revenue from lower production	10-15%	Immediate, but revenue reduction & low reduction

Pulp and Paper

Key decarbonization technologies

Overview of existing technologies

Immediate | 1-3 years | 5-10 years



Energy Efficiency/Waste Heat Recovery

Improving energy efficiency, particularly in steam systems, represents a significant immediate opportunity for emissions reductions and cost savings. Other technologies include advanced process control (APC) systems, enzyme-assisted refining and impulse drying.

Electrification

Includes electrification of the auxiliary boilers for production of steam used in the pulp mills and paper production processes, especially relevant for non-integrated paper mills.

Low Carbon Fuels and Hydrogen

The most probable source for Low Carbon Fuels (LCFs) for this subsector are forest residues, sawmill chips or pellets. LCFs particularly relevant for integrated and pulping mills due continued access to biomass. Green hydrogen can be used as a cleaner fuel for steam generation

Black Liquor Gasification/ Biorefinery

Converting black liquor into syngas for generating electricity and steam more efficiently or using it in biorefineries for biofuels and hydrogen production. In combination with CCUS contribute to negative emissions.

Carbon Capture Utilization Storage

Applied to address CO_2 emissions that are not easily avoided, such as those from boilers that burn biomass residue leftover after pulping, and from lime kilns used in the Kraft chemical recovery process.

Pathways and emissions reduction potential

13 pulp and paper mills, with cumulative 6 MMT CO_2e, ~84% of which are biogenic CO_2

Low-Hanging Fruits: Advanced monitoring systems, **electrification**, and waste-heat recovery help enhance operational efficiency and reduce emissions from various processes in the short run.

Large-scale solution: Black Liquor Gasification, LCS and **WHR** are particularly effective for integrated mills because of their inherent large-scale energy demands, significant production of black liquor, and access to biomass.

Capital-Intensive Projects: Capture technologies, while more costly and still in pilot stage, offer a potential solution for residual emissions that cannot be mitigated through other measures. Amine-Based Post-Combustion Capture is most suitable for PPI.

CCU for FCC units needs to start operations in 2036 to take advantage of the 45Q tax credits. This is a longer-term solution due to the high costs and technological complexity of capturing and converting concentrated CO_2 streams into methanol.

Source: EPA FLIGHT (2022), RMI research

Cost estimates and Technological Readiness Level (TRL)

Low, medium, and high CapEx interventions

Low Capex Technologies

- **Energy Efficiency and WHR**
  - **Capex**: $1.5-$15 million (lower bound for WHR from the ventilation air of the drying section and used for heating of the facilities – upper bound combination of several measures) | **Incentive:** Section 179D tax deductions, Federal 48C tax credits

Medium Capex Technologies

- **Low-Carbon Fuels (LCF)**
  - **Capex**: $15-$25 million | TRL 6-8 | **Incentive:** IRA production tax credits for biofuels and hydrogen
- **Electrification:**
  - **Capex**: $30-$60 million | **Incentive**: 48C

High Capex Technologies

- **Carbon Capture Utilization and Storage (CCUS)**
  - **Capex**: $100-$350* million | TRL 6-7 | **Incentive**: 45Q tax credit
- **Black Liquor Gasification**
  - **Capex**: $150-$400M* million | TRL 6-7 | **Incentive:** Biofuel-related tax credits under the IRA

Source: Marginal abatement cost based on DOE Pathways to Commercial Liftoff: Industrial Decarbonization

PULP AND PAPER

Case-study: Pilot at Vicksburg Containerboard Mill (MS)

Carbon Capture Funding opportunity

Funding overview:

- **Program**: Part of DOE's Carbon Capture Large-Scale Pilot Projects, led by the Office of Clean Energy Demonstrations (OCED)
- **Funding**: Phase 1 awarded **$4.3M of a potential $88M federal cost share**

Project Details

- **Location**: International Paper's Vicksburg Containerboard Mill, Redwood, MS
- **Lead Partners**: RTI International with International Paper, SLB, and Amazon
- **Objective**: Capture 120,000 metric tons of CO_2 annually, achieving a 90% capture efficiency—equivalent to emissions from ~28,000 cars
- **Technology**: RTI's Non-Aqueous Solvent (NAS) technology, which requires less energy and lowers operating costs compared to traditional methods

Economic and Community Impact

- **Local Benefits**: Approximately 90 temporary construction jobs and workforce development initiatives
- **Community Engagement**: Establishing a network, collecting community feedback, and exploring local philanthropic opportunities
- **Phase 1 Scope (18-21 months)**

Current state:

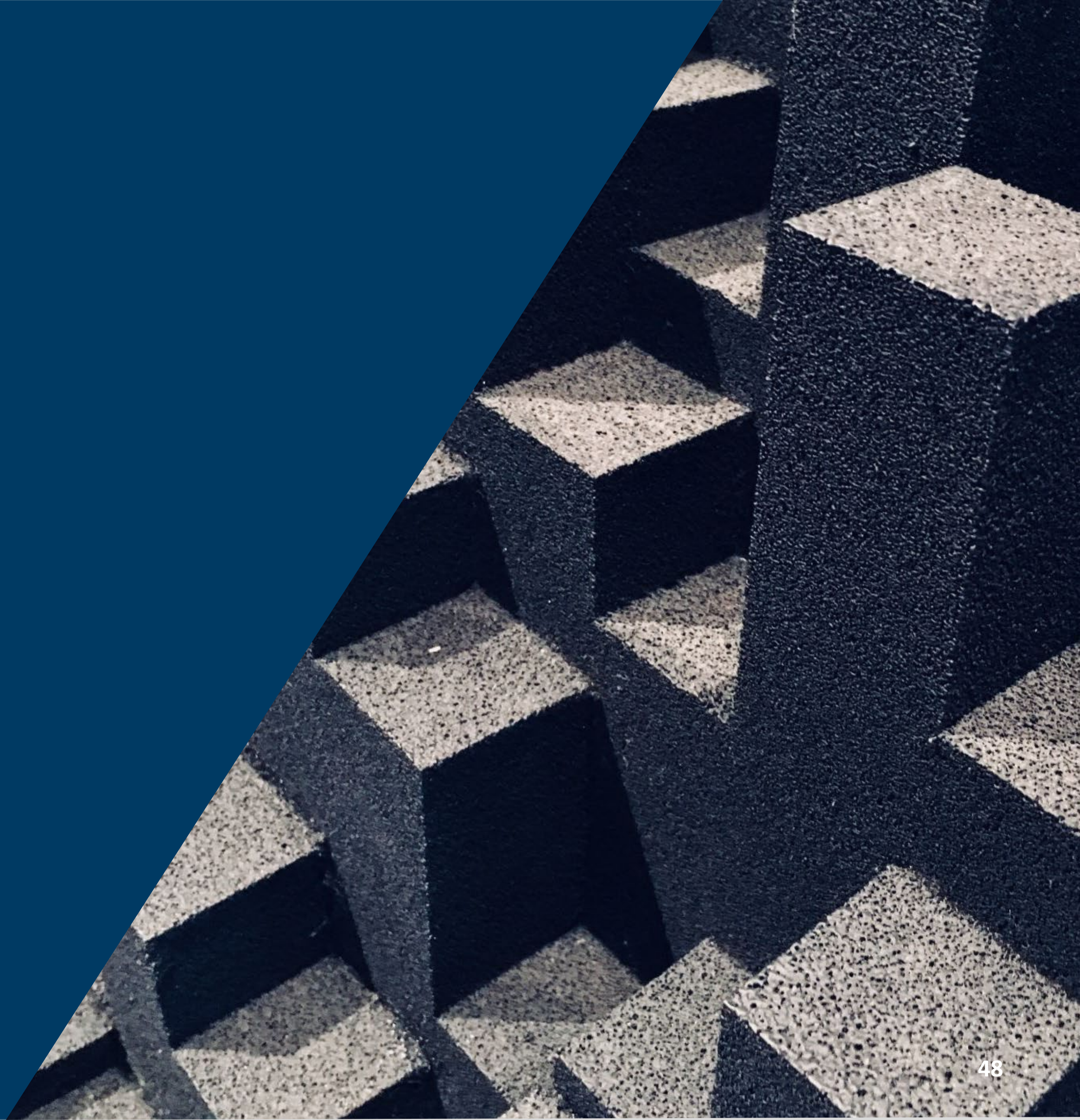
- **FEED Study**: Engineering design and feasibility assessment for carbon capture integration
- **Preparatory Actions**: System component testing, workforce planning, and input on environmental review

Source: https://www.amazon.science/blog/decarbonizing-paper-packaging

Technology selection criteria

Technology	Technology Readiness Level	Cost Considerations	Emission Reduction Potential (facility level p.a.)	Overall Implementation Timeline
Low-Carbon Fuels (LCFs)	Medium to High	Moderate to High initial capital	25-50%	Immediate to Mid-term
Electrification	Medium to High	Moderate to High initial costs for electrification	15-30%	Mid-term
Waste Heat Recovery (WHR)	High	Moderate initial capital	10-15%	Immediate
Energy Efficiency	High	Low to Moderate initial capital cost	15-20%	Immediate
Carbon Capture Utilization & Storage	Low to Medium	High capital & operational costs	50-90%	Long-term
Black Liquor Gasification/Biorefinery	Low to Medium	High initial capital	30-50%	Mid-term to Long-term

Cement

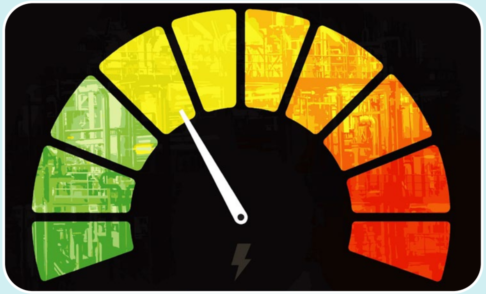


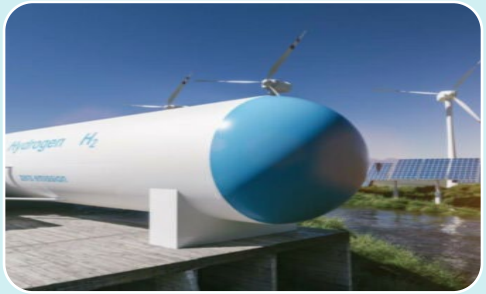
CEMENT

Key decarbonization technologies

Overview of existing technologies

Immediate | **1-3 years** | **5-10 years**





Supplementary cementitious materials (SCMs)

Include materials like fly ash, steel blast furnace slag, or calcined clays that partially replace Portland cement during the blending or grinding phase. Given Washington's access to local sources of fly ash and other SCMs, this substitution can be implemented effectively to lower overall carbon intensity.

Energy Efficiency/ Waste Heat Recovery (WHR)

EE applicable at all stages of production - upgrading process control systems to improve kiln operation stability, reducing fuel consumption, and using more efficient grinding systems to reduce energy use during the finish milling process. WHR can be applied during clinker cooling and the kiln phases to capture excess heat and convert it into usable energy.

Low Carbon Fuels

Include alternative fuels, such as biomass or waste-derived fuels, that can be used to reduce the carbon footprint of the high-heat requirements of cement manufacturing.

Carbon Capture Utilization and Storage

Can be implemented during the kiln phase to capture carbon dioxide generated during the production of clinker.

Pathways and emissions reduction potential

Majority of emissions (~88%) happen in the clinker production (35% energy, 53% process) phase

- **1 clinker production facility with yearly emissions ~ 0.315 Mt CO_2e;**

Low-Hanging Fruits: SCMs and energy efficiency can be applied in short term. SCMs offer substantial reduction in emission with the lowest cost.

Scalable Technologies: Alternative fuels and WHR can be applied in the medium term and require more capital.

Capital-Intensive Projects: CCUS pushed further down the timeline to align with declining technology costs and increasing incentives.

Source: EPA FLIGHT (2022), RMI research

Cost estimates and Technological Readiness Level (TRL)

Low, medium, and high CapEx interventions

Low Capex Technologies

- **Energy Efficiency**
  - **Capex**: $10-$50 million | **Incentive:** Section 179D tax deductions and state-level incentives can further offset costs
- **SCMs**
  - **Capex:** $10-$50 million | **Incentive:** If installing clay calciner, DOE industrial demonstrations program

Medium Capex Technologies

- **Low-Carbon Fuels (LCFs)**
  - **Capex**: $100-$150 million | TRL 6-8 | **Incentive:** IRA production tax credits for biofuels and hydrogen
- **Waste Heat Recovery (WHR)**
  - **Capex**: $20-$70 million | **Incentive:** Federal 48C tax credits

High Capex Technologies

- **Carbon Capture and Storage (CCS)**
  - **Capex**: $200-$400 million | TRL 6-7 | **Incentive**: 45Q tax credit

Source: Marginal abatement cost based on DOE Pathways to Commercial Liftoff: Industrial Decarbonization

Case study: Fortera Redding (CA)

Carbon Capture & Mineralization

Overview

- **Location**: Redding, California, co-located with CalPortland's cement plant. Fully operational as of April 2024.
- **Significance**: First industrial-scale CO_2 mineralization facility for cement production in North America, reducing emissions by 70% compared to traditional cement.
- **Funding & Incentives**: The plant has benefited from tax credits and incentives under the Inflation Reduction Act (IRA), including 45Q tax credits for carbon capture, which improve project economics and enhance competitiveness.

Key Features

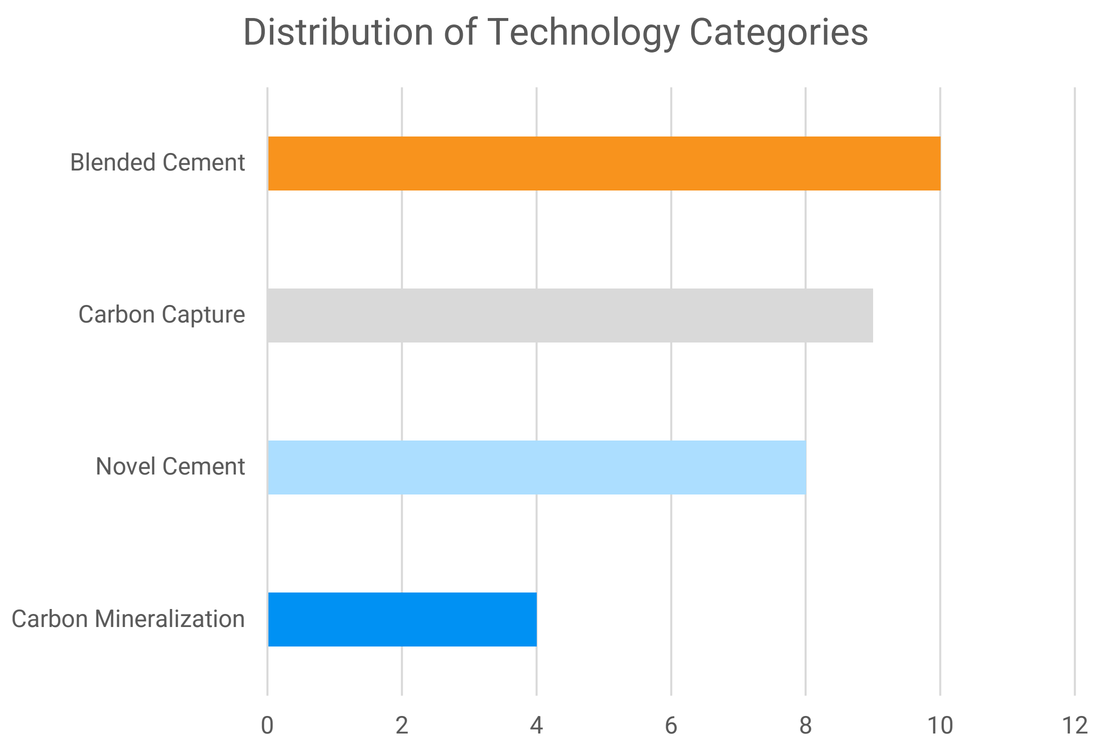
- **ReCarb® Technology**: A bolt-on solution integrating with existing cement infrastructure, minimizing capital costs and enabling rapid scalability.
- **Carbon Capture & Mineralization**: Captures CO_2 emissions directly from cement production, permanently sequestering 6,600 tons of CO_2 annually and producing 15,000 tons of ReAct® green cement.
- **Increased Output**: Produces one ton of green cement per ton of limestone, reducing raw material loss and lowering energy requirements with reduced kiln temperatures.

Economic Impacts

- **Cost-Effective Production**: Utilizes existing infrastructure, reducing capital expenditure compared to building new facilities.
- **Lower Production Costs**: Reduces material loss and energy consumption, enhancing cost efficiency and offering a competitive price point for ReAct® cement.
- **Job Creation**: Supports local jobs and contributes to the green economy by investing in low-carbon cement production.

Overview of US-based cement decarbonization projects

DOE data on 33 projects in the USD, 20 pilots



- **Mean Funding Amount**: $67.7 million
- **Minimum Cost**: $1.5 million
- **Maximum Cost**: $508.7 million
- **Top states:**
  - Texas (TX), California (CA), Colorado (CO): each with 4 projects

Technology selection criteria

Technology	Technology Readiness Level	Cost Considerations	Emission Reduction Potential (facility level p.a.)	Overall Implementation Timeline
SCMs (supplementary cementitious materials)	High	Low	4-40%	Immediate
Alternative fuels	Medium	Medium	40%	Immediate to Mid-term
Energy efficiency	High	Low	5-20%	Immediate
Carbon management (CCUS)	Low	High	40-90%	Long-term solution
Waste heat recovery (WHR)	High	Low to Medium	10-20%	Mid- to Long-term solution

Glass Production

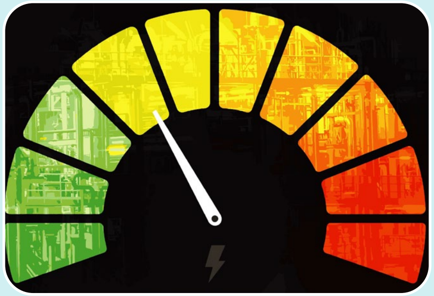
Key decarbonization technologies

Overview of existing technologies

Immediate → **1-3 years** → **5 -10 years**

Material Efficiency and Recycling

Includes increasing the use of recycled glass (cullet), which has a lower melting temperature compared to raw materials, thus requiring less process heat. Utilizing cullet also avoids both energy-related and process CO_2 emissions.



Energy Efficiency/ Waste Heat Recovery

Efficiency measures, such as the use of oxyfuel furnaces, reduce energy consumption by optimizing combustion in the glass melting process - widely applied in the U.S. due to low capital cost and ease of retrofit, used alongside with WHR from the exhaust gases for preheating the combustion air.

Electrification

Includes electrifying specific heating processes using electric melting furnace technologies, such as submerged electrodes, microwaves, and plasma.

Low Carbon Fuels / Hydrogen

Replacing fossil fuels with low-carbon alternatives, such as biogas, synthetic methane, biomass, or green hydrogen. This substitution can provide the high temperatures needed for melting glass materials while significantly reducing carbon emissions

Carbon Capture Utilization and Storage

CCUS technologies to capture and store CO_2 emissions from the melting process. This pathway has potential, but its feasibility for the glass industry remains uncertain due to challenges such as the presence of acidic compounds and high cost.

Pathways and emissions reduction potential

60% to 85% of the energy required for glass production, and the associated emissions, are attributed to the melting process.

2 facilities with 0.106 Mt CO_2

Low-Hanging Fruits: Energy efficiency measures and raw material substitution (increased cullet use) are the most cost-effective, providing immediate emissions reductions with lower investment.

Capital-Intensive Projects: LCFs, Green hydrogen and electrification are pushed further down the timeline to align with declining technology costs and increasing incentives. Hybrid/Electric furnace projects receive significant funding in the Industrial Demonstrations Program (IDP), led by DOE's Office of Clean Energy Demonstrations (OCED)

CCUS. This is a longer-term solution due to the high costs and technological complexity particularly given the size of facilities in WA. Feasibility for the glass industry remains uncertain due to challenges such as the presence of acidic compounds and lower CO_2 concentrations in flue gases.

Source: FLIGHT EPA (2022), RMI research

Cost estimates and Technological Readiness Level (TRL)

Low, medium, and high CapEx interventions

Low Capex Technologies

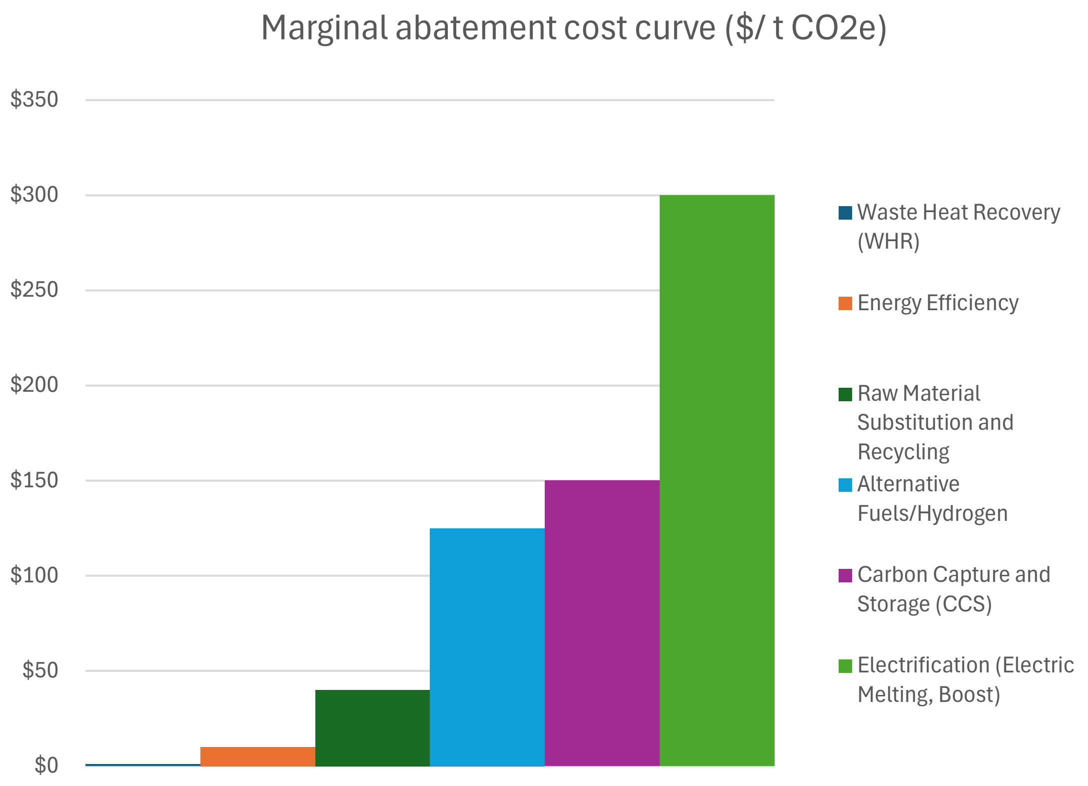
- **Energy Efficiency Improvements**
  - **Capex**: $1-2 million total
- **Waste Heat Recovery (WHR)**
  - **Capex**: $2-4 million total
- **Raw Material Substitution and Recycling**
  - **Capex**: $1.5-3 million total

Medium Capex Technologies

- **Electrification (Electric Boosting & Partial Electrification)**
  - **Capex**: 60-150 million total| **TRL**: 7-8 (Pilot stage for large-scale glass furnaces)| **Incentives**: Production Tax Credit (PTC), Clean Energy Tax Credits, funding under 48C (Advanced Energy Project Credit)
- **Alternative Fuels/Hydrogen Blending**
  - **Capex**: $6-60* million total.| **TRL**: 6-7 (Development/Pilot stage) | **Incentives**: 45V

High Capex Technologies

- **Full Electrification or Hydrogen Fuel Conversion**
  - **Capex**: 80-200* million total **TRL**: 6-7 (Development/Pilot stage)| **Incentives**: 45V, Advanced Manufacturing Tax Credits
- **Carbon Capture Utilization Storage (CCUS)**
  - **Capex**: $100-350* million total | **TRL**: 6 (Early Development stage - Pilot)| **Incentives**: 45Q



Source: Marginal abatement cost based on DOE Pathways to Commercial Liftoff: Industrial Decarbonization.

GLASS PRODUCTION

Case study: Gallo Glass (CA)

Hybrid Furnace Project Funding

Objective: Decarbonize Gallo Glass's production process by constructing a hybrid glass furnace, shifting the primary energy source from natural gas to electricity, with a target energy mix of 80% electricity and 20% natural gas.

Funding:

- **California Energy Commission (CEC):** $5M through INDIGO Program for state cost-share.
- **US Department of Energy (DOE):** $75M federal funding.
- **Gallo Glass:** $70M match funding.

Key Benefits:

- **Environmental Impact:** Significant reduction in greenhouse gas emissions and increased energy efficiency at the Modesto facility, the largest glass container production site in the U.S.
- **Community Impact:**
  - **Recycling Program:** New community-focused glass recycling initiative to enhance environmental benefits across the supply chain.
  - **Workforce Development:** Expansion of apprenticeship programs and training for both new (102 projected) and existing employees (741 current staff).

Timeline:

- **Operational Start Date:** Projected by 2028.

Technology selection criteria

Technology	Technology Readiness Level	Cost Considerations	Emission Reduction Potential (facility level p.a.)	Overall Implementation Timeline
Alternative fuels/Hydrogen	Low to Medium	Medium to High, high uncertainty of existing estimates	30-60%	Long-term solution
Electrification (electric melting, electric boost)	Medium to High	High	20-40%	Mid-term solution
Waste Heat Recovery	High	Low	10-15%	Mit-term solution
Energy efficiency	High	Low	10-20%	Immediate solution
Carbon Capture and Storage	Low to Medium	High, high uncertainty of existing estimates	30-80*%	Long-term solution
Raw material substitution and recycling	High	Low	12-25%	Immediate solution

* Large uncertainty for emission reduction at this level

Food Processing

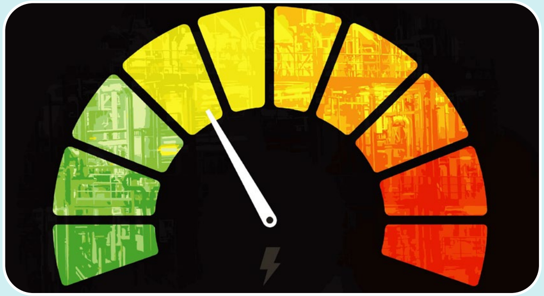
FOOD PROCESSING

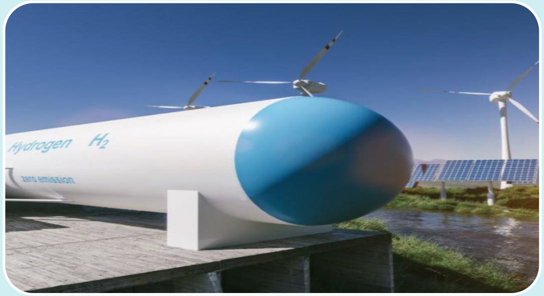
Key decarbonization technologies

Overview for key technologies based on example of potato processing

Immediate

3-5 years





Material Efficiency

Includes optimizing the use of raw materials, reducing waste, and maximizing product yield, e.g., reducing waste in peeling (steam pealing, optical peeling control systems), sorting, and blanching (counter-flow) steps can significantly cut energy use and emissions.

Energy Efficiency/Waste Heat Recovery

Incudes efficient lighting, chillers, freezers, fryers with advanced control systems, variable speed drives for washing and peeling processing. Heat recovery from fryers, water vapors, steam peelers can be used to e.g., pre-heat blanching water, air or heating.

Electrification

Involves replacing gas-fired boilers or fryers with electric ones. Heat pumps can be used to electrify the provision of low- to medium-temperature (up to 200°C) heat for preheating and drying.

Low Carbon Fuels/ Hydrogen

Includes switching from conventional fossil fuels to low carbon alternatives, such as biogas, biomethane, or renewable natural gas for high-temperature processes (e.g.,frying, roasting, drying). Hydrogen can also be used as a fuel for steam boilers and burners, replacing natural gas.

Pathways and emissions reduction potential

10 facilities, with cumulative 0.59 Mt CO2e emissions

Dominant sub-sector – potato processing

Low-Hanging Fruits: combination of material efficiency, WHR and energy efficiency offer quick gains in emission reduction with minimal investment and short payback period with minimal disruptions to existing operations.

Capital-Intensive Projects: Low Carbon Fuels, and electrification require more upfront investment and offer considerable emissions reductions. Green hydrogen and electric boilers for steam generation might become attractive in the future with declining costs of hydrogen

CCU: currently considered economically challenging in the food sector

Source: EPA FLIGHT (2022), RMI research

Cost estimates and Technological Readiness Level (TRL)

Low, medium, and high CapEx interventions

Low Capex Technologies

- **Energy Efficiency Improvements**
  - **Capex**: $100.000 - 2 million total
- **Waste Heat Recovery (WHR)**
  - **Capex**: $1-5 million total
- **Material Efficiency**
  - **Capex**: $1.5-3 million total

Medium Capex Technologies

- **Electrification**
  - **Capex**: 2-20 million total | **TRL**: 7-8 | **Incentives**: Production Tax Credit (PTC), Clean Energy Tax Credits, funding under 48C (Advanced Energy Project Credit)
- **Alternative Fuels/Hydrogen**
  - **Capex**: $10-80* million total | **TRL**: 7-8 | **Incentives**: 45V

High Capex Technologies

- **Carbon Capture and Storage (CCS)**
  - **Capex**: $100-250* million total | **TRL**: 6 (Early Development stage - Pilot)| **Incentives**: 45Q

Source: Marginal abatement cost based on DOE Pathways to Commercial Liftoff: Industrial Decarbonization

FOOD PROCESSING

Case study: Moses Lake Biogas Project – J.R. Simplot Company

Waste-to-biogas

- **Overview:**
  - **Location:** Moses Lake, WA
  - **Purpose:** Convert potato waste into biogas for plant energy needs
  - **Technology:** Anaerobic digester, unique boiler fuel mix with bio, hydrogen, and natural gases
- **Project Timeline & Costs:**
  - **Development Start:** Early 2000s
  - **Completion:** 2013
  - **Estimated Cost:** $10M - $25M (typical for similar projects e.g., Stantec)
- **Key Benefits:**
  - **Carbon Reduction:** Lowers fossil fuel use and emissions
  - **Cost Savings:** $800K saved in irrigation via wastewater reuse, reduced energy costs
  - **Resource Efficiency:** Potato waste into biogas; starch recovery for paper manufacturing
- **Community Impact:**
  - **Sustainability Leader:** Sets a standard for waste-to-energy in agriculture
  - **Supports Local Farmers:** Reused wastewater aids in crop irrigation

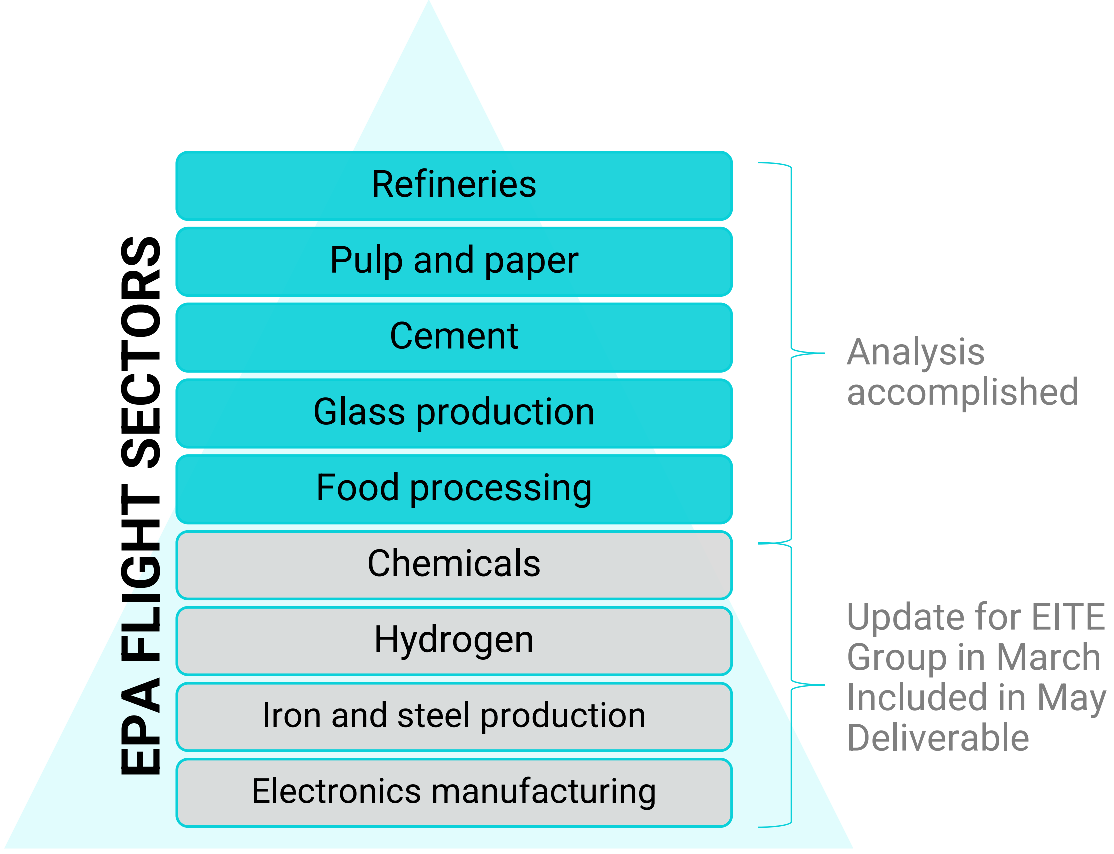
Technology selection criteria

Technology	Technology Readiness Level	Cost Considerations	Emission Reduction Potential (facility level p.a.)	Overall Implementation Timeline
Energy Efficiency	High	Low	10-25%	Immediate solution
Waste Heat Recovery (WHR)	High	Low to Medium	5-15%	Immediate solution
Material Efficiency	High	Low	3-10%	Immediate solution
Electrification	Medium to High	Medium	20-30%	Mid-term solution
Low Carbon Fuels (e.g.. biomass in boilers)	Medium	Medium to High	20-50%	Mid- to Long-term solution
Hydrogen	Medium	High	30-60%	Long-term solution, at the moment not feasible
CCS	Low	High	60-90%	Currently, not feasible

Next Steps

Next steps

- **Analysis to date:**
  - Narrative explanation of existing and applicable to each sector technical interventions
  - Sequence and time to implement interventions
  - Projected impact of annual GHG emissions for each sector, based on EPA FLIGHT data (2022)
  - Cost estimates
  - Existing examples of interventions
- **Next steps:**
  - **Analyze remaining sectors (update to EITE group in March)**
  - **Projected change in criteria and hazardous air pollutants (final deliverable in May)****
  - **Change in electricity and/or fuel consumption (final deliverable in May)****
  - **Recommendations for policies to support decarbonization (final deliverable in May)****
  - **Refined costs and GHG reduction estimates based on interactions with industry**



Upcoming outreach for interviews

We will be in touch with members of this EITE Industries Advisory Group via **email** in the coming weeks

We will also be reaching out to members of the EITE Policy Advisory Group

RMI

Questions?

Contact for follow-ups:
dveysey@rmi.org

Presentation: Renewable Thermal Collaborative

RTC Overview

Renewable Thermal Collaborative
November 2024

The Renewable Thermal Collaborative

The RTC is the only global, buyer-led coalition focused on decarbonizing thermal energy with renewables.

We focus across the intersecting issues of **technology**, **market development**, and **policy**.

RTC Members (buy-side) and Solution Providers are invited to participate in multiple RTC workstreams to:

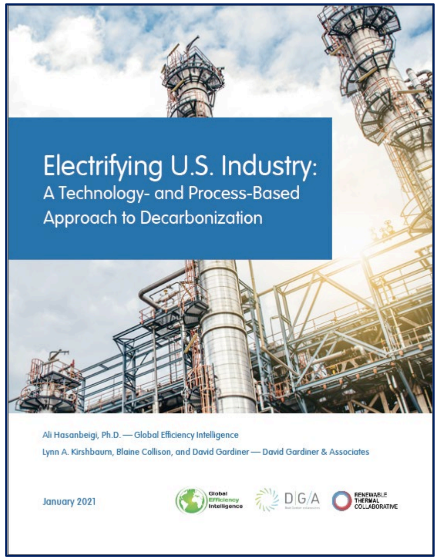
- Identify and address barriers;
- Accelerate solutions;
- Implement projects and policies.

Facilitated by:

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

D|G/A David Gardiner and Associates

WWF



RTC Members

RTC Solutions Providers

ABSOLICON SOLAR COLLECTORS
acceleware
AIRTHIUM
Ambient Fuels
ANTORA
ARCHAEA ENERGY
Armstrong
ATMOSZERO
BIOENERGY DEVCO
Blue Delta Energy
BRENMILLER
CALIBRANT ENERGY
CEBA Clean Energy Buyers Association
COHO an ERM Group company
DCO Energy
ECHOGEN power systems
ELECTRIFIED THERMAL SOLUTIONS
ELSTOR
engie
FERVO ENERGY
FORBES MARSHALL
GEA
GENERATE
Heliogen
HYDROGEN TECHNOLOGIES
KARMAN
KYO THERM investing in clean energy
LUMENION GREEN ENERGY 24/7
M-RETS Renewable Thermal
MAGALDI dependable energy storage
NEXTera ENERGY RESOURCES
NOVO HYDROGEN
nyle thermal
PILLER Blowers & Compressors
PURPOSE ENERGY
RONDO
SCALE MICROGRIDS
skyven technologies
SoCalGas A Sempra Energy utility
Solar UV Solutions
SJI
spirax sarco
StormFisher HYDROGEN
TC Energy
TES
THERMAL ENERGY INTERNATIONAL
THERMON
TRIO
clean energy ahead TURBODEN
TWIN EAGLE
VANGUARD RENEWABLES
VEOLIA
verse
VILTER by COPELAND
WES Wilson Engineering Services Energy • Environment • Enterprise

What We Do

Workstreams

- Members, Solutions Providers, and select experts convened to identify barriers and execute solutions in:
    - Industrial Electrification & Industrial Heat Pump Alliance
    - Solar Thermal
    - Renewable Natural Gas (RNG)
    - Green Hydrogen
    - Thermal Storage
    - Greenhouse Gas (GHG) Accounting
    - Policy
        - Currently focused on U.S. federal policy
        - Will expand to targeted states

Member & Solutions Provider Convenings

- Monthly Community Calls
- Annual Partnership Workshops
- Annual Summit in Washington, D.C.
    - Sept. 30-Oct 1, 2024
    - October 16-17, 2025

Buyers' Challenges

To decarbonize thermal / Scope 1 emissions, buyers need to:

1. Sort which technologies go where, in what order (sites and technologies);
2. identify out with whom to partner (suppliers, operators, etc.);
3. Figure out how to pay for it, and;
4. Understand any policy drivers / risks / opportunities that may be relevant.

And they have to turn these answers into multi-year, implementable plans that support the core businesses and meet any (and all) corporate goals.

Lessons Learned

Technology

- Technology is a ”yes, and…” conversation.
- Simultaneous, multi-tech, integrated deployment is the <only> path to scale.
- Electrification, solar thermal, thermal storage, heat pumps, biomethane, green hydrogen all have a role to play.

Markets

- Third-party finance is essential; the RE market is an important example; Heat as a Service / Energy as a Service
- Pre-commercial convening and collaboration are powerful.
    - Monthly Community Calls
    - Annual Partnership Workshops
    - Annual Summit in Washington, D.C.

Policy

- Policy is essential; national and sub-national.
- IRA is an impactful step forward, but more to be done.
- State policy @ industrial/thermal decarb is still mostly pending in the U.S.

RTC Publications and Resources

Publications:

Renewable Thermal Vision:
https://www.renewablethermal.org/vision/

Case Studies:
https://www.renewablethermal.org/category/publications/case-studies/

Food & Beverage Sector:
https://www.renewablethermal.org/food-and-bev/

Chemical Sector: https://www.renewablethermal.org/chemical-sector-assessment/

Technology Action Plans: Electrification, Solar Thermal, Thermal Energy Storage, Green Hydrogen (RNG Action Plan upcoming)

RTC Justice40 Opportunity Assessment brief:
https://www.renewablethermal.org/rtc-justice40-opportunity-assessment/

Tools:

Policy Finder:
https://www.renewablethermal.org/policy-finder/

Partner Locator:
https://www.renewablethermal.org/partner/

Heat Pump Decision Support Tools:
https://www.renewablethermal.org/heat-pump-decision-support-tools/

State Electrification Report:
https://www.renewablethermal.org/state-electrification-report/

Communications:

Monthly newsletter:
https://www.renewablethermal.org/contact-us/

LinkedIn:
https://www.linkedin.com/company/renewable-thermal-collaborative/

Questions?

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Executive Director

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202-669-5950

Sign up for our newsletter at renewablethermal.org

Follow us on LinkedIn

Presentation: Energy Innovation

Policies to Decarbonize Industry

For Washington State

Jeffrey Rissman
Senior Director, Industry

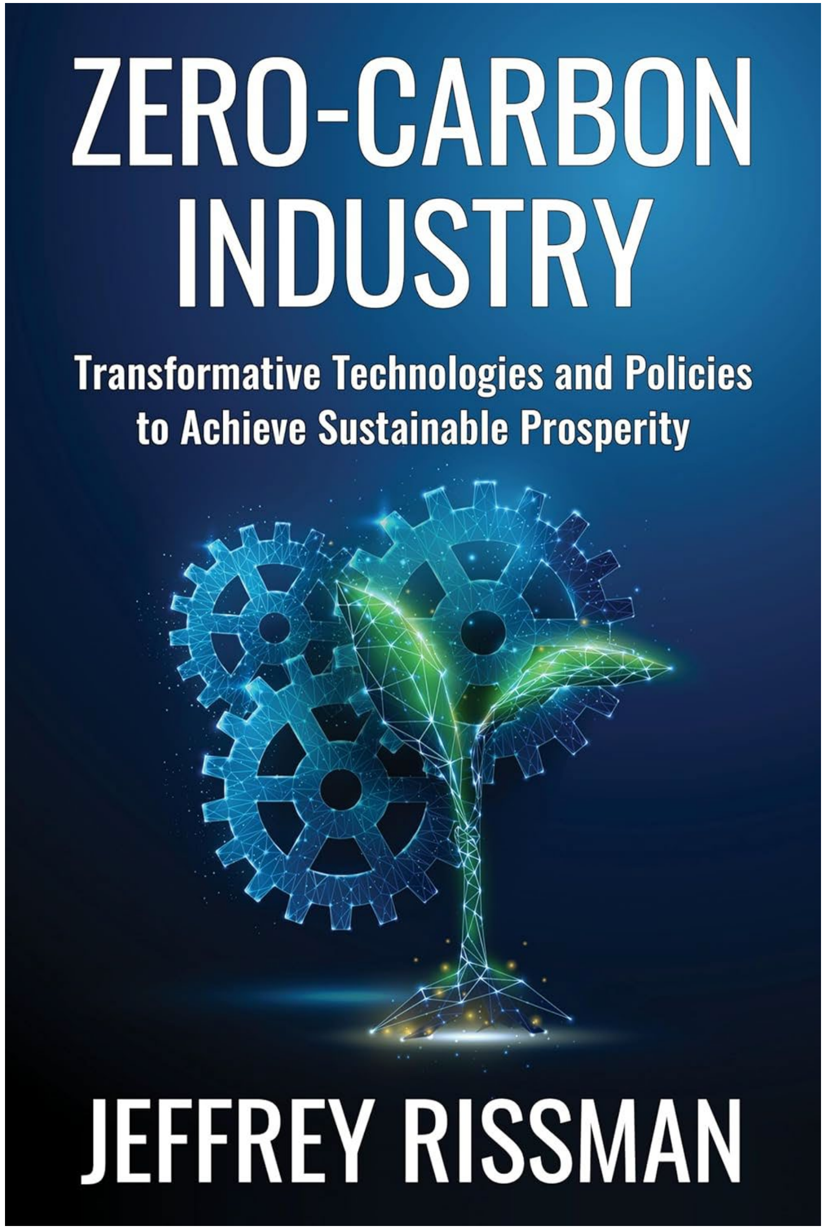
ENERGY INNOVATION
POLICY & TECHNOLOGY LLC

Zero-Carbon Industry

- Roadmap for understanding emissions and energy use of the global industrial sector
- The key technologies that can bring industrial GHG emissions to zero
- The policy framework to help commercialize these technologies and deliver them at scale

Book published by

COLUMBIA UNIVERSITY PRESS



Introduction: What is *Zero-Carbon Industry?*

<u>The Largest GHG-Emitting Industries</u>

1. Iron and Steel
2. Chemicals
3. Cement and Concrete

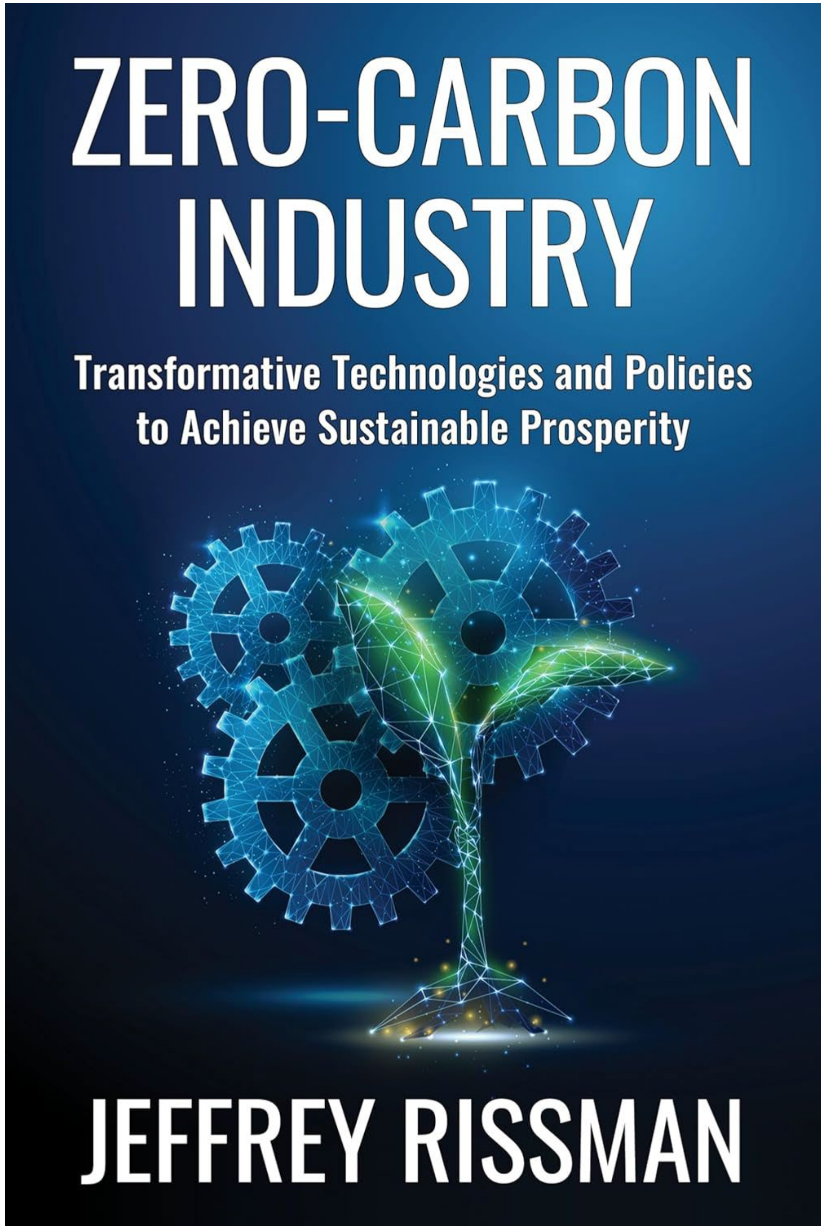
<u>Technologies</u>

4. Energy Efficiency
5. Material Efficiency, Material Substitution, and Circular Economy
6. Electrification
7. Hydrogen and Other Renewable Fuels
8. Carbon Capture and Use or Storage

<u>Policies</u>

9. Carbon Pricing and Other Financial Policies
10. Standards and Green Public Procurement
11. R&D Support, Disclosure & Labeling, and Circular Economy Policies
12. Equity and Human Development

Conclusion: A Roadmap to Clean Industry

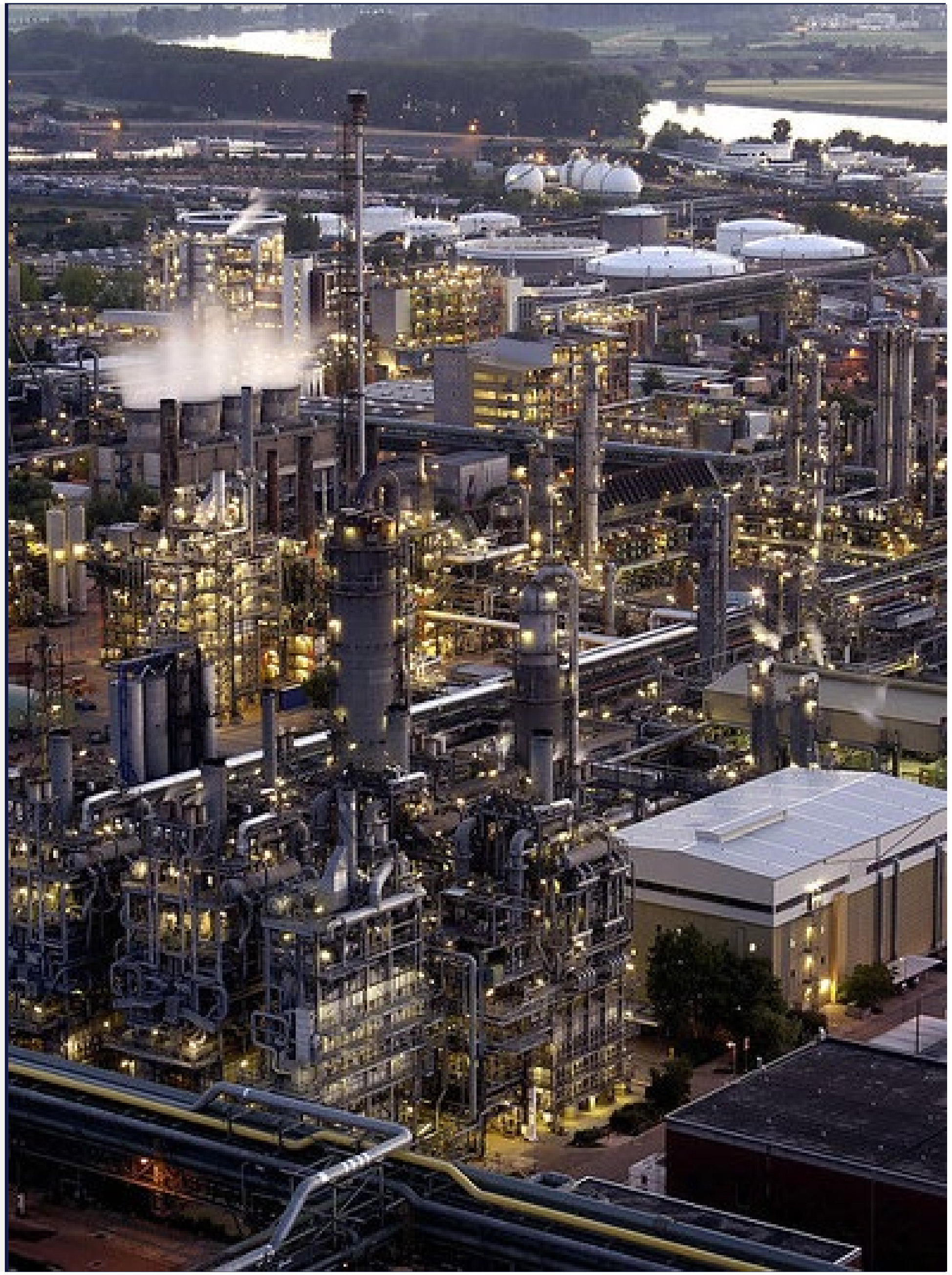


Carbon Pricing and Other Financial Policies

ENERGY INNOVATION
POLICY & TECHNOLOGY LLC

Why Financial Policies?

- **Some cost-effective decarbonization opportunities exist today, particularly in energy- and material-efficiency**
- **But the transition to zero-carbon industry would be slow and incomplete without policy support**
- **Financial policies change the landscape in which firms operate, facilitating and rewarding low-carbon production while making businesses pay for harms caused by their pollution.**
  - *Well-designed policy produces a competitive landscape where business decisions that optimize profit **also** result in lower GHG emissions, co-benefits such as public health improvements and job creation, and improved social equity*



Carbon Pricing Effect Mechanisms

- Carbon pricing reduces emissions through three broad mechanisms:
  - *Technology switching*
  - *Demand reduction*
  - *Smart use of carbon pricing revenues*
- Which entities end up shouldering carbon pricing costs – policy design considerations

Since Washington State already has a cap-and-invest system, we're going to skip most of the policy design aspects today, but I list them here so you can see what is in the book.

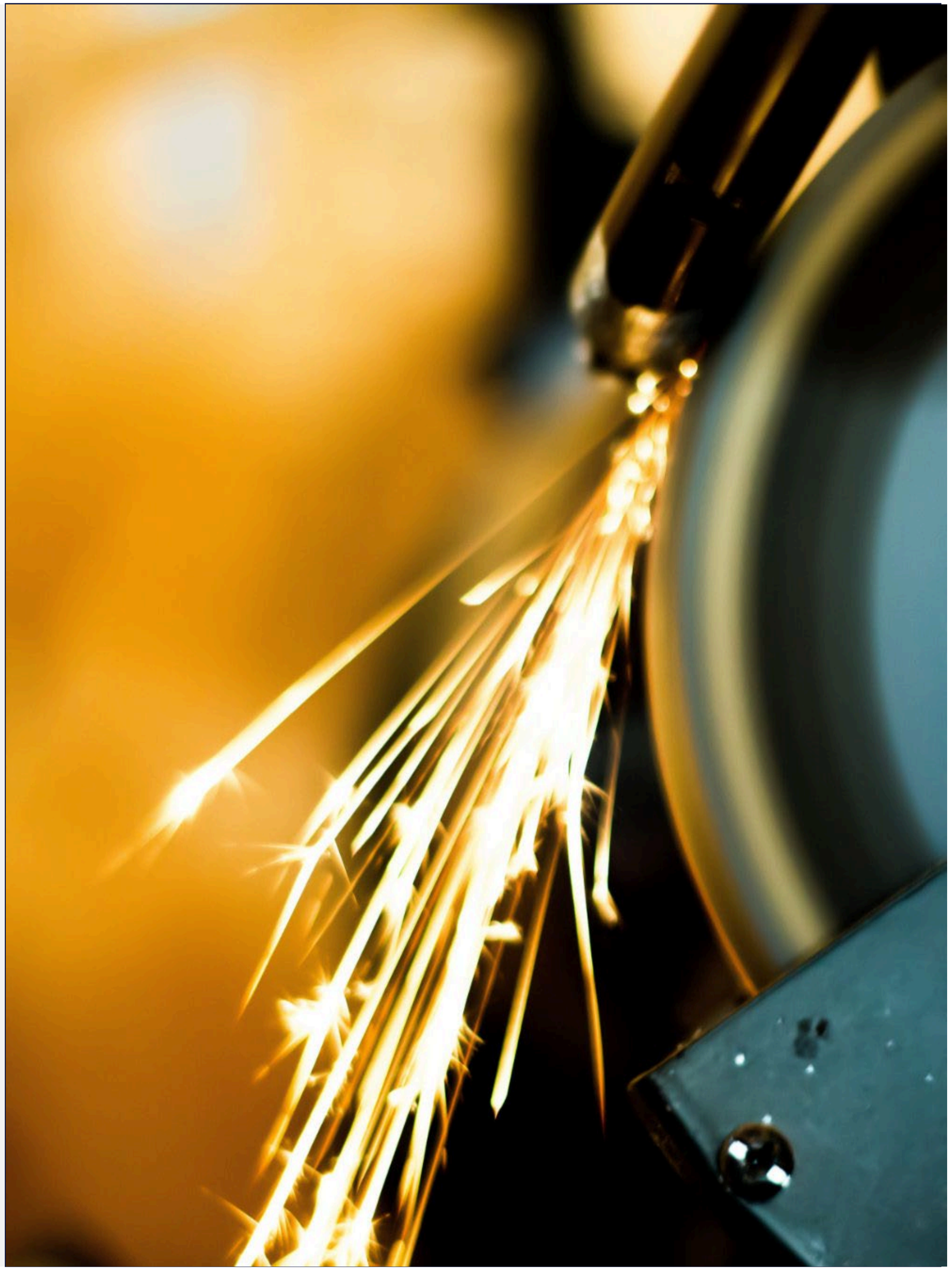
Carbon Pricing Design Considerations

- Carbon tax or cap-and-trade
- Scope of coverage
- Banking of permits
- Carbon offsets
- Linking jurisdictions
- Industrial competitiveness, leakage, and border adjustments

Since Washington State already has a cap-and-invest system, we're going to skip most of the policy design aspects today, but I list them here so you can see what is in the book.

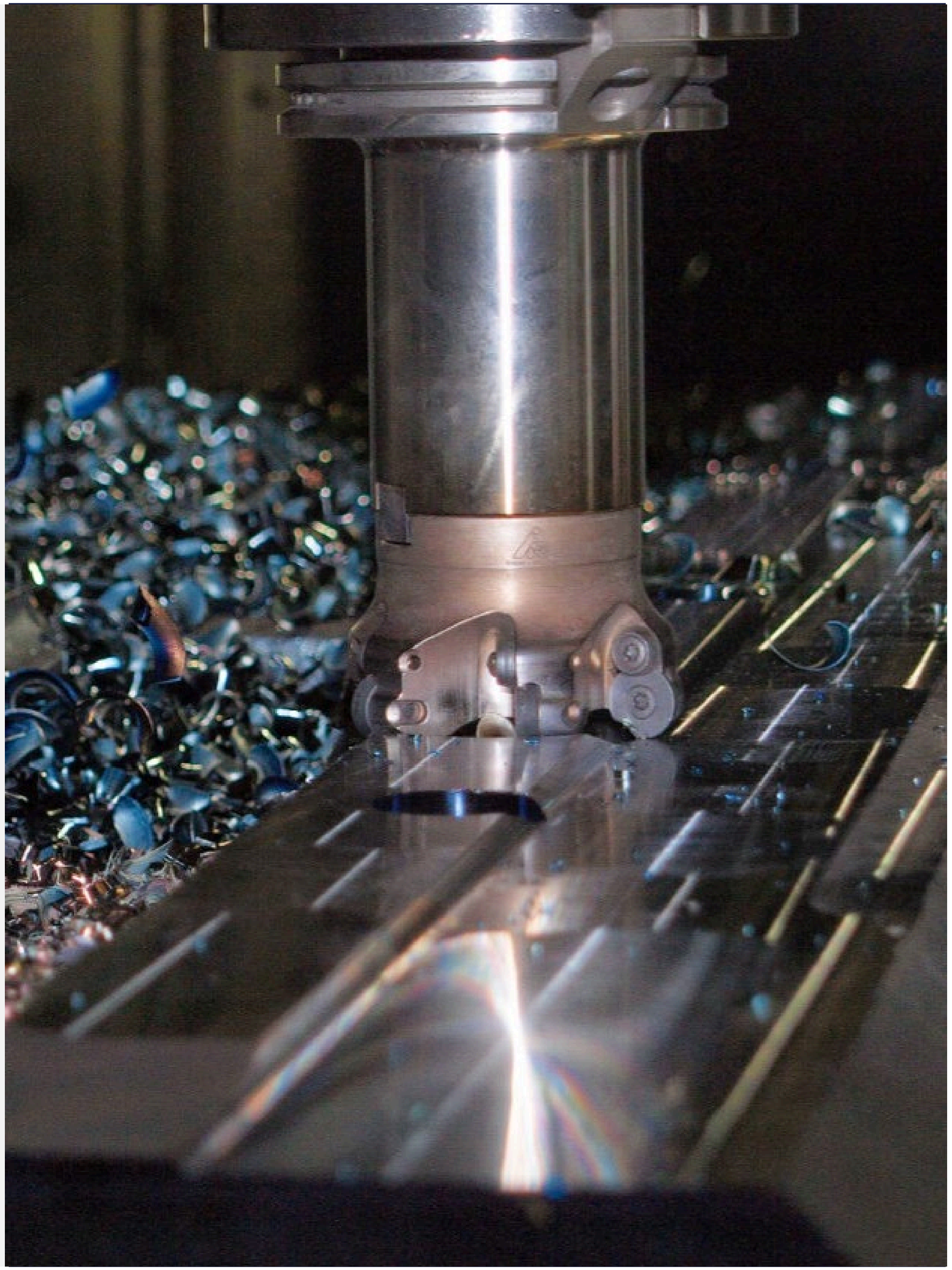
Leakage

- **A frequent concern is whether industrial carbon pricing will reduce the competitiveness of domestic industries relative to foreign manufacturers or cause *leakage*, domestic industries shifting production to countries with weaker environmental rules.**
- **Limiting leakage is worthwhile because a high leakage rate negatively affects domestic jobs and production while reducing carbon pricing's emissions abatement.**
- **Estimating leakage risk is very challenging. Studies estimates vary widely (i.e., 0% - 40%).**
  - *Timeframe affects leakage estimates, because it is difficult to quickly move production abroad.*
  - *With increasing trend toward climate policy, moving production abroad is no guarantee of escaping regulation long-term.*



Border Adjustments

- **Border adjustments may be the most powerful mechanism to reduce leakage**
- **Goods imported from jurisdictions with weaker carbon pricing are taxed according to the embodied emissions in the imported goods and the difference in tax rates.**
  - *This avoids giving advantage to goods imported from places with poor environmental protections.*
- **Domestic firms that export to jurisdictions with weak or absent carbon pricing are given a carbon tax rebate based on the difference in tax rates domestically and in the export market.**
  - *This prevents carbon pricing from putting domestic manufacturers at a disadvantage when exporting their products.*

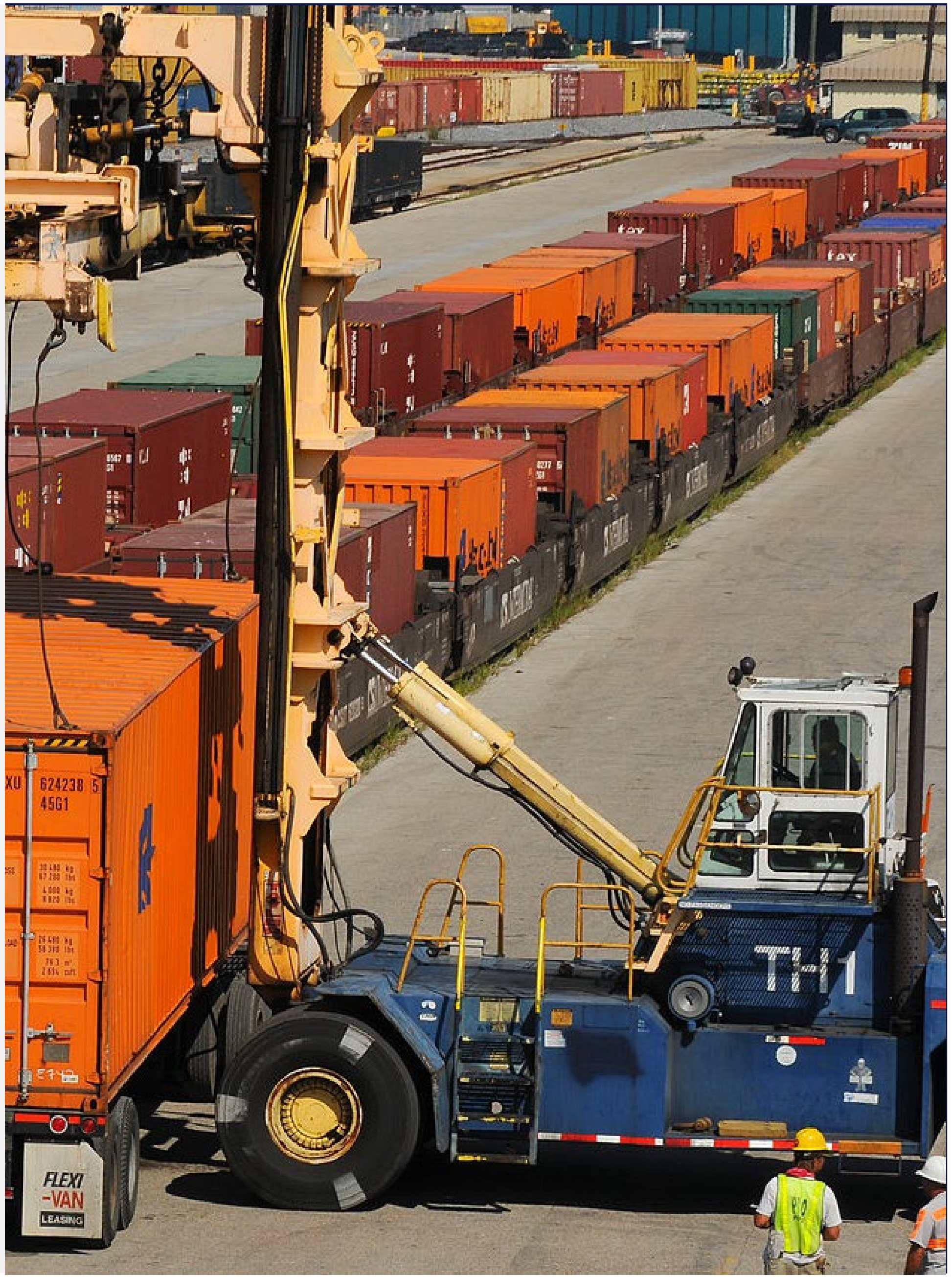


U.S. State Substitutes for Border Adjustments

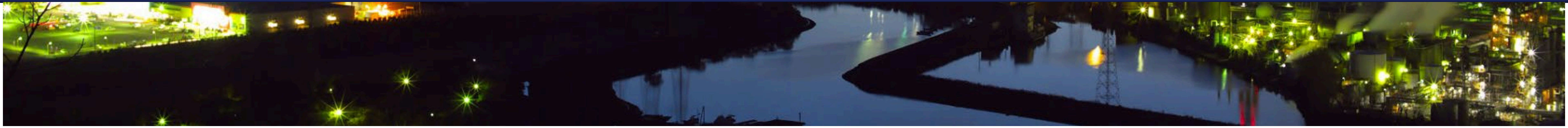
- **U.S. states may not have the legal authority to implement traditional border adjustments, as Congress has the right to regulate interstate commerce**
- **However, it may be possible to achieve a similar effect through state-level policies**
  - *For instance, a state sales tax based on a product's carbon intensity would apply to all goods sold in the state, even if manufactured in another U.S. state, and would not apply to goods exported from the state.*
  - *Many states already have sales taxes and have the right to set sales tax rates. Setting those rates based on carbon intensity is novel but might fall within existing legal authority.*

Financial Incentives to Limit Leakage

- **Free allocation of emissions permits**
  - *Limits leakage but can dampen the incentive to decarbonize.*
  - *Therefore, it is best paired with a known phase-out schedule, so manufacturers have a reason to invest in cleaner processes and technologies.*
- **Instead of free emissions permits, provide subsidies to domestic manufacturers that are linked to positive traits the government wishes to encourage.**
  - *For example, subsidies may be based on a firm's production, the number of high-quality jobs the firm provides, etc. A manufacturer that performs well on these metrics might stand to gain from the carbon pricing policy from day 1, while a company that performs poorly will see costs increase.*
- **Or directly subsidize clean manufacturing technologies or clean energy (discussed later)**



Green Banks and Lending Mechanisms

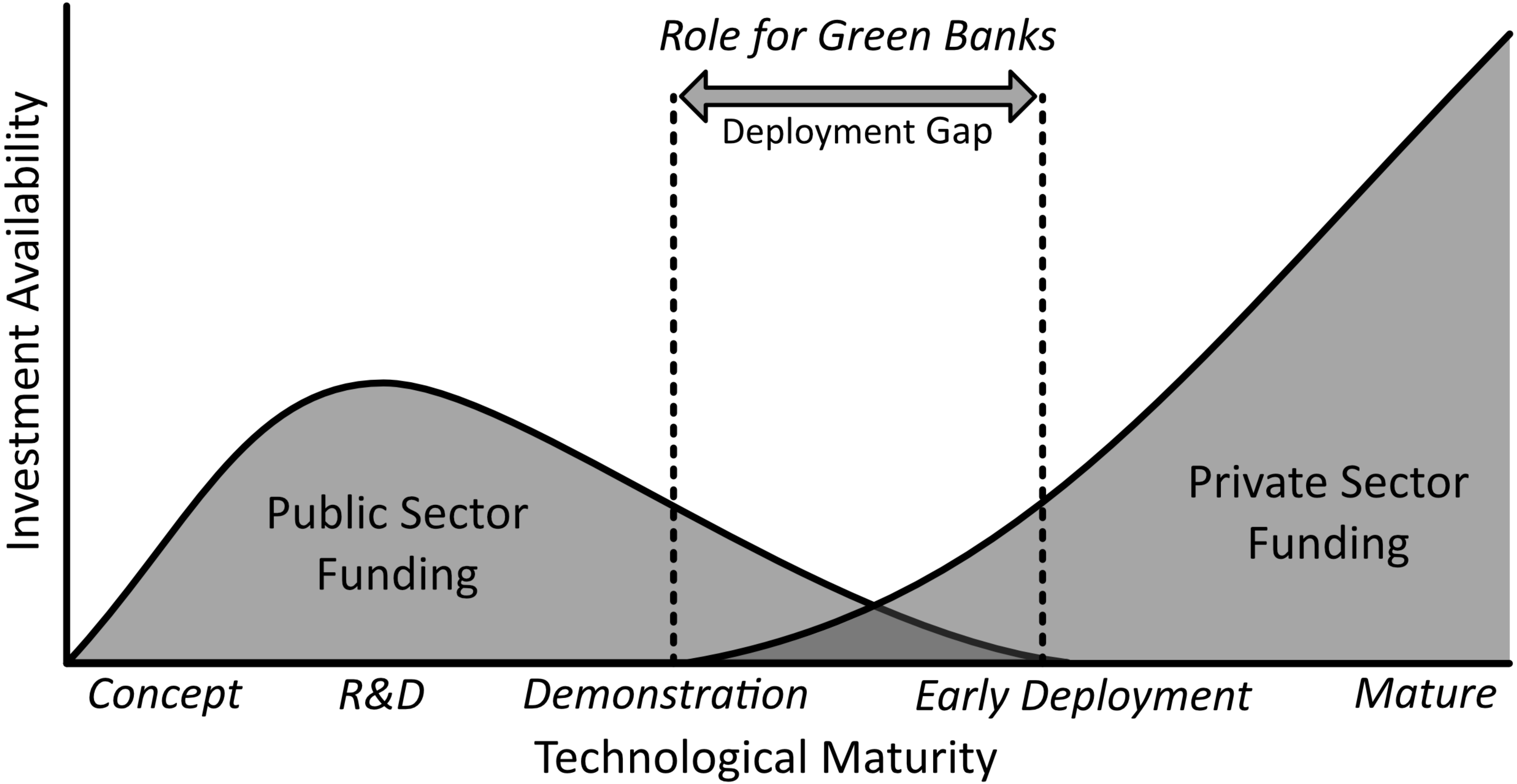


Green Bank Key Features

- **A green bank strives to operate as a revolving fund, a self-sustaining fund where repaid principal and interest on loans are used to finance new loans to other recipients.**
  - *This allows the green bank to be capitalized once and then to operate in perpetuity. This makes revolving funds more politically durable than programs that require ongoing government appropriations.*
- **A green bank seeks to partner with private capital, using public money to generate private investment in qualifying green projects.**
  - *This enables the green bank to direct far more money to qualifying projects than would be possible using government resources alone.*
  - *For example, from 2012-2021, the Connecticut Green Bank mobilized $1.85 billion in private investment using just $288 million in green bank funds, a leverage ratio of **7.4 to 1**.*

Target Projects / Technologies

- **Green banks aim to support projects that struggle to attract affordable private-sector financing, for instance, because the technology is too new.**
- **However, green banks only fund projects that can be accomplished using available technology**
  - *Green banks require a financial return with acceptable risk and in a reasonable time frame to attract private capital and ensure the green bank can continue to make new loans.*
- **Thus, green banks are best suited to overcoming a gap where clean technology is available, but financing or cost barriers hamper its deployment.**


Role for Green Banks
Deployment Gap
Investment Availability
Public Sector Funding
Private Sector Funding
Concept
R&D
Demonstration
Early Deployment
Mature
Technological Maturity

Subsidies and Tax Credits

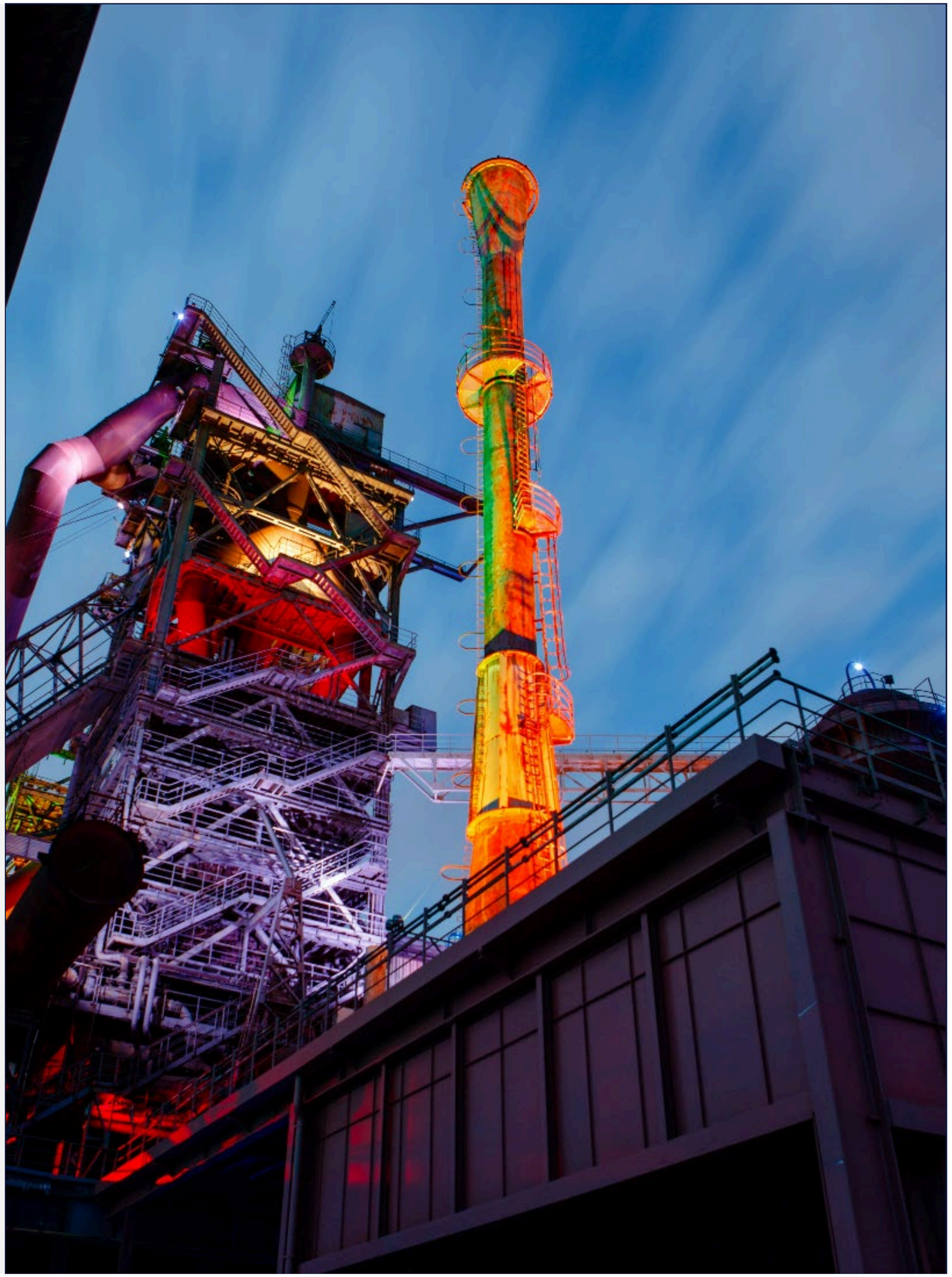
- **Forms of cost-sharing where the government provides money (or reduces tax liability) for businesses that undertake specific investments or activities.**
- **Unlike loans from a green bank or private lender, a company need not pay back subsidies or tax credits.**
  - *Therefore, these policies are a good fit for earlier-stage projects and technologies that are unlikely to be able to achieve financial returns and repay loans in a timeframe acceptable to a creditor.*

Subsidy Design for Industry

- Subsidizing green industrial equipment
- Subsidizing manufacturers' use of clean energy
- Subsidizing clean production of output products

Subsidizing Green Industrial Equipment

- **Can be the least-expensive approach for government**
  - *For example, over a typical industrial boiler's lifetime, fuel represents 96% of costs, while capital is 3%.*
- **Can expand the market for green equipment, driving down their costs.**
- **Can be difficult to make technology-neutral because the government must specify which types of equipment are eligible for subsidies**

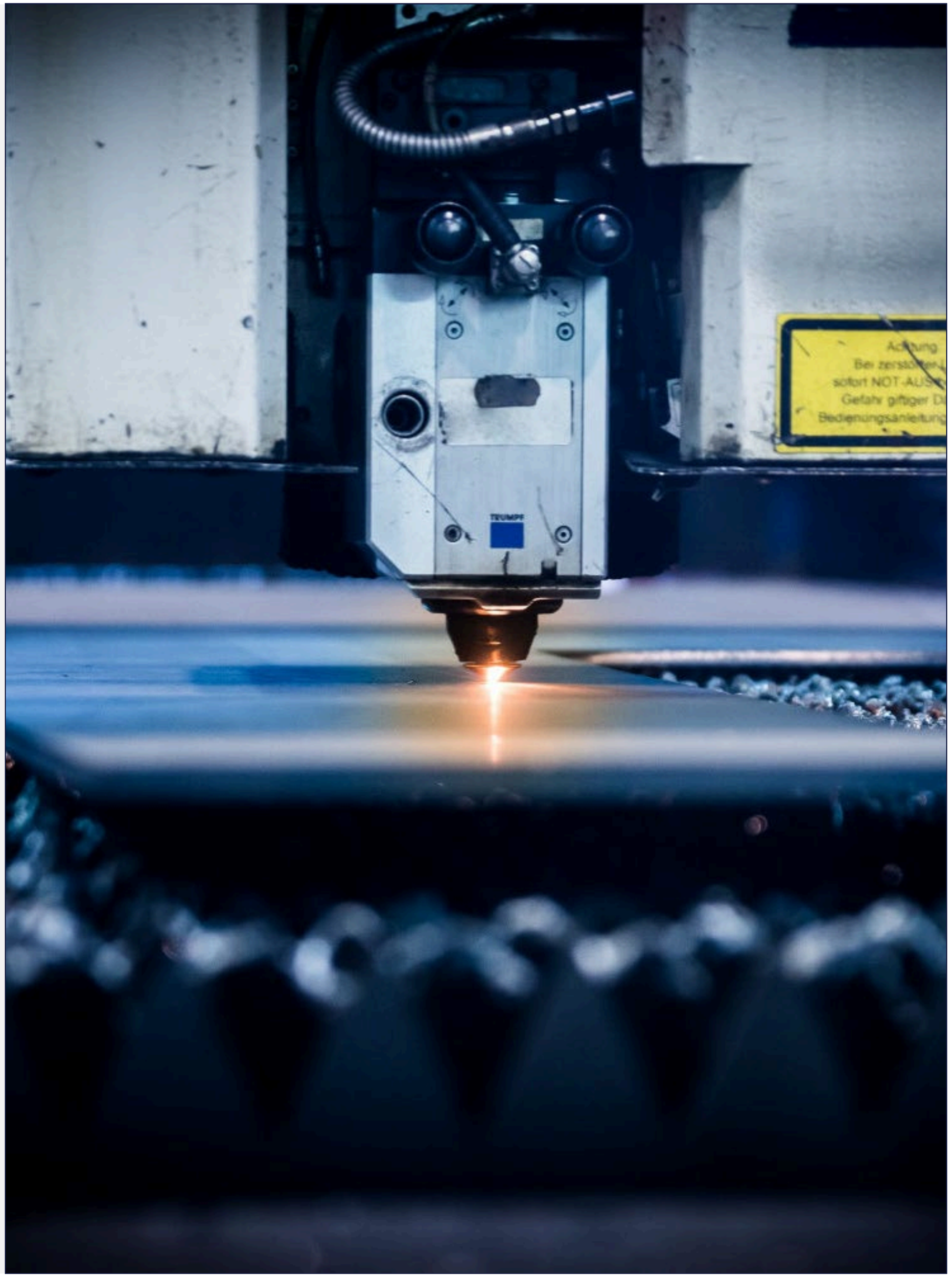


Subsidizing Manufacturers’ Use of Clean Energy

- **Can help remedy cost discrepancies between clean and dirty energy sources**
  - *Like carbon pricing, it helps correct for externalities*
  - *However, a subsidy can be much more targeted than a carbon tax (for example, limited to particular fuels used by specific industries), helping to limit its costs, and it may be politically easier to enact.*
- **But fails to incentivize strategies that reduce energy use, particularly energy efficiency, material efficiency, material substitution, and circular economy measures.**

Subsidizing Clean Production of Output Products

- **The most technology-neutral approach, allowing a broad range of compliance options**
  - *Though they don’t reward circular economy measures that reduce product demand, like longevity and repairability*
- **May help to increase output in targeted industries**
  - *Can help support industries to meet other policy objectives, such as those providing jobs in disadvantaged communities*
- **Cost savings might be passed on to consumers**
- **Can be challenging to pick units to fairly measure production for goods that are not homogenous materials, like TV sets (different sizes, features, etc.)**



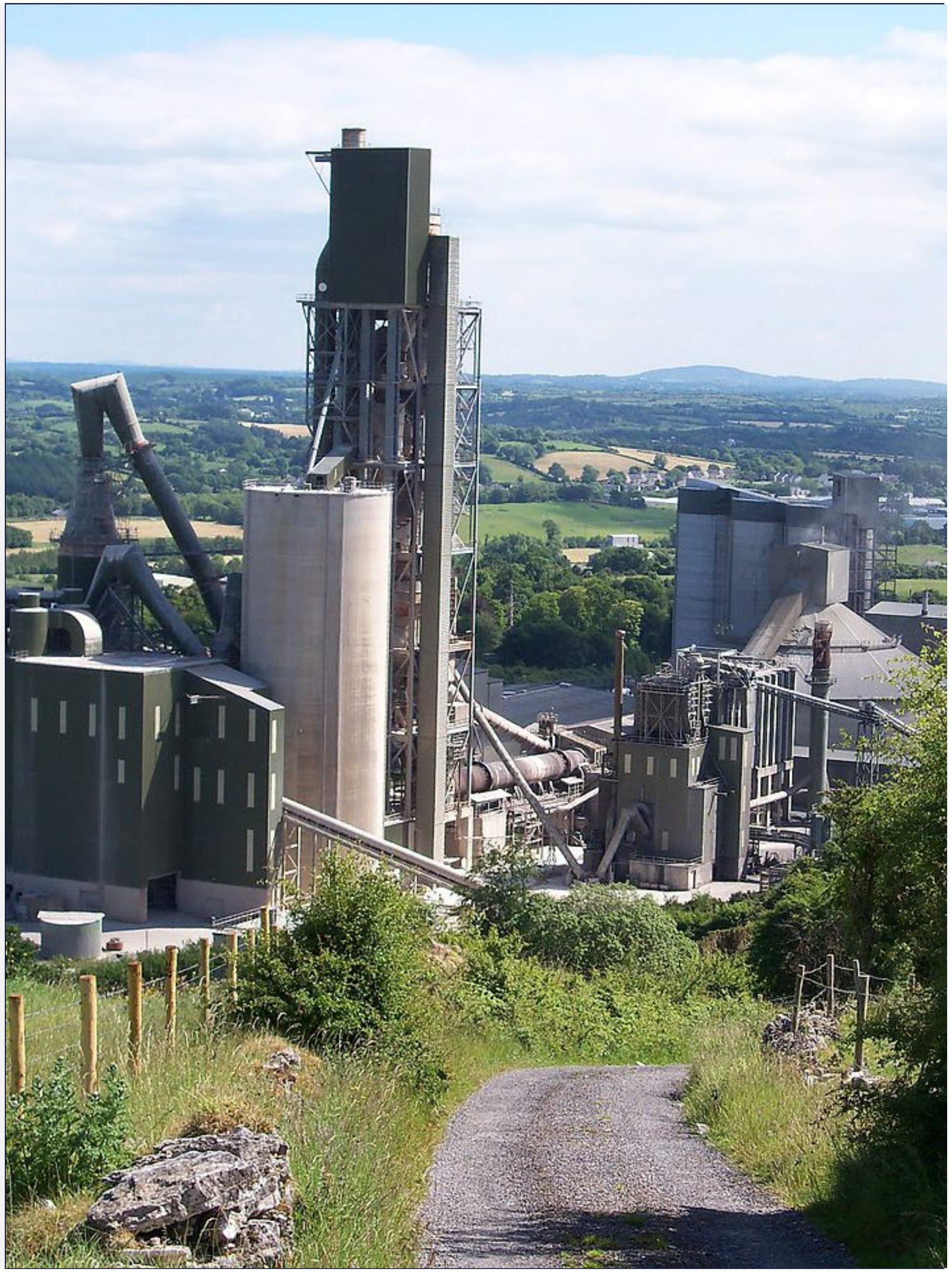
Equipment Fees,
Rebates, and Feebates

Fees, Rebates, Feebates

- **A fee** is a sales tax applied to equipment that fails to meet an efficiency or emissions intensity threshold.
  - *The fee should escalate based on the degree to which the equipment falls below the threshold.*
- **A rebate** is the opposite of a fee: government pays buyers of equipment that exceeds an efficiency or emissions intensity threshold.
  - *Rebates should escalate with the degree to which equipment exceeds the threshold, up to a maximum value for zero-emissions equipment.*
- **A feebate** combines a fee and a rebate in a single policy.
  - *The level of efficiency or emissions intensity that incurs neither a fee nor a rebate is called the pivot point. A feebate can be a cost-effective policy for government, as fee revenues can be used to fund rebates.*

Best For Relatively Mature Technologies

- Since these policies rely on the existence of a range of equipment choices from different manufacturers, they are not well-suited to support early-stage technologies or first-of-a-kind demonstration projects.
- They are ideal for driving improvement of relatively mature technologies.
- **Build in Improvement:** The threshold or pivot point for these policies should tighten over time to provide incentive for continuous improvement and the development of cleaner industrial technologies.



Energy Efficiency and Emissions Standards

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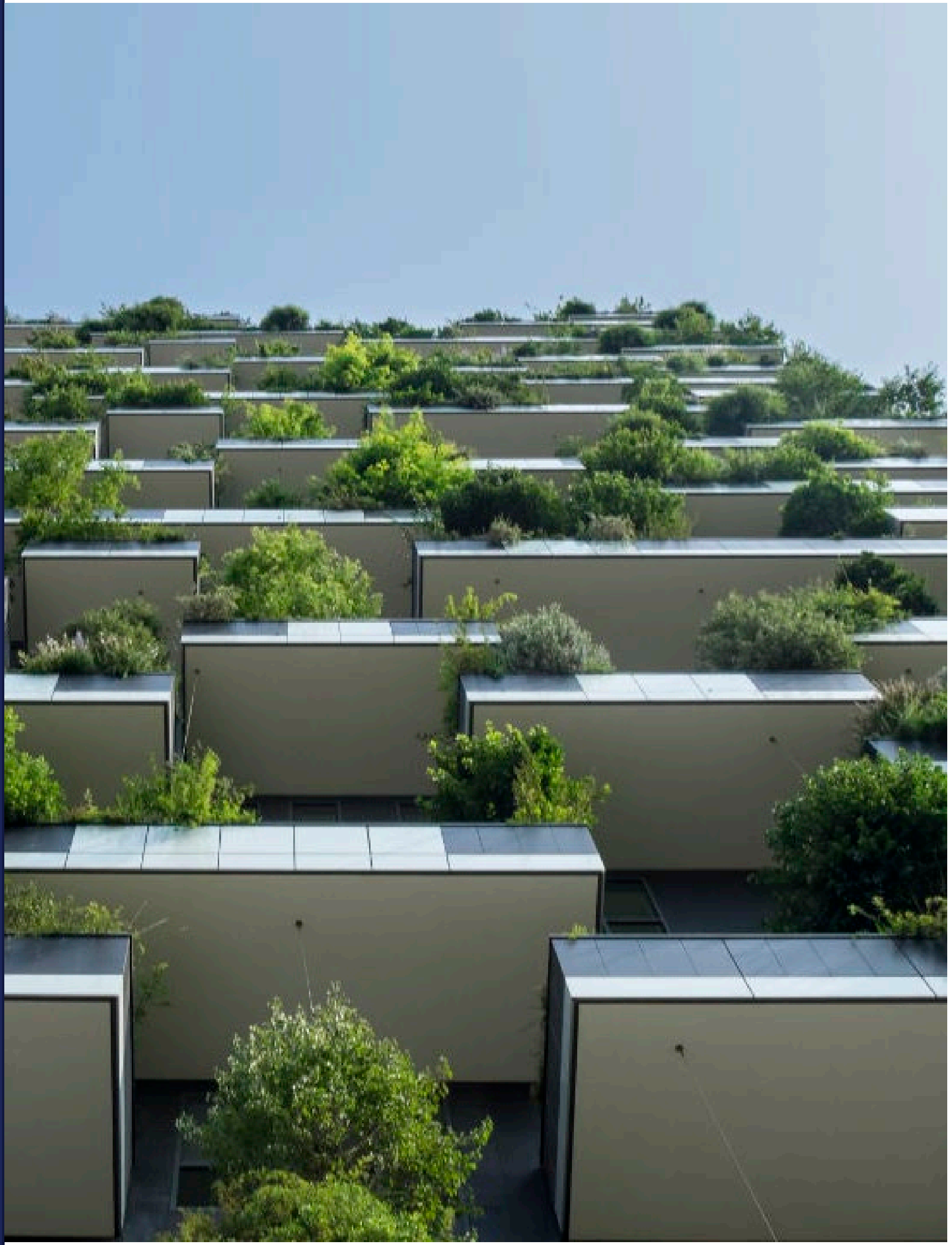
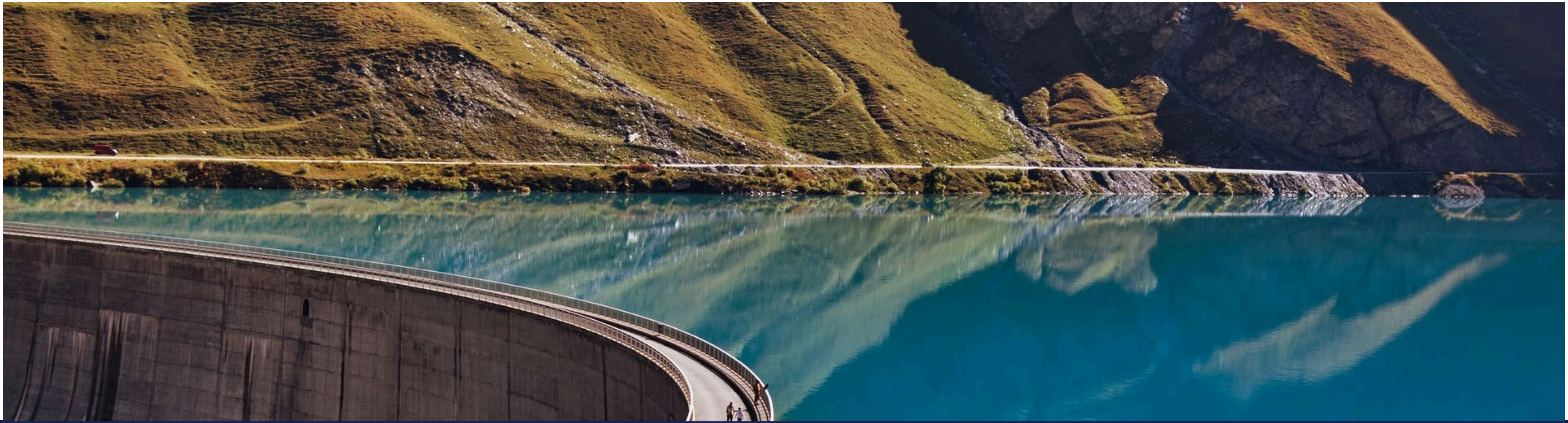


Standards' Niche

- **Standards are good at:**
  - *overcoming market barriers, information gaps, split incentives*
  - *removing poorly performing products from the market*
  - *incentivizing R&D to reduce the cost of manufacturing standard-compliant products*
- **Standards are less good at:**
  - *promoting the development of cutting-edge products that greatly exceed the standard*
    - A subsidy that scales with performance gives larger rewards to better-performing technologies, creating an incentive to produce innovative, top-tier products
  - *helping firms pay for new equipment or clean energy*
- **Standards and financial policies work best together.**

Design Principles for Standards

- Build In Continuous Improvement
- Keep Standards Simple and Outcome-Focused
- Encompass the Whole Market
- Create Tradable, Sales-Weighted Standards
- Consider Three-Scope Standards to Reduce Supply Chain Emissions



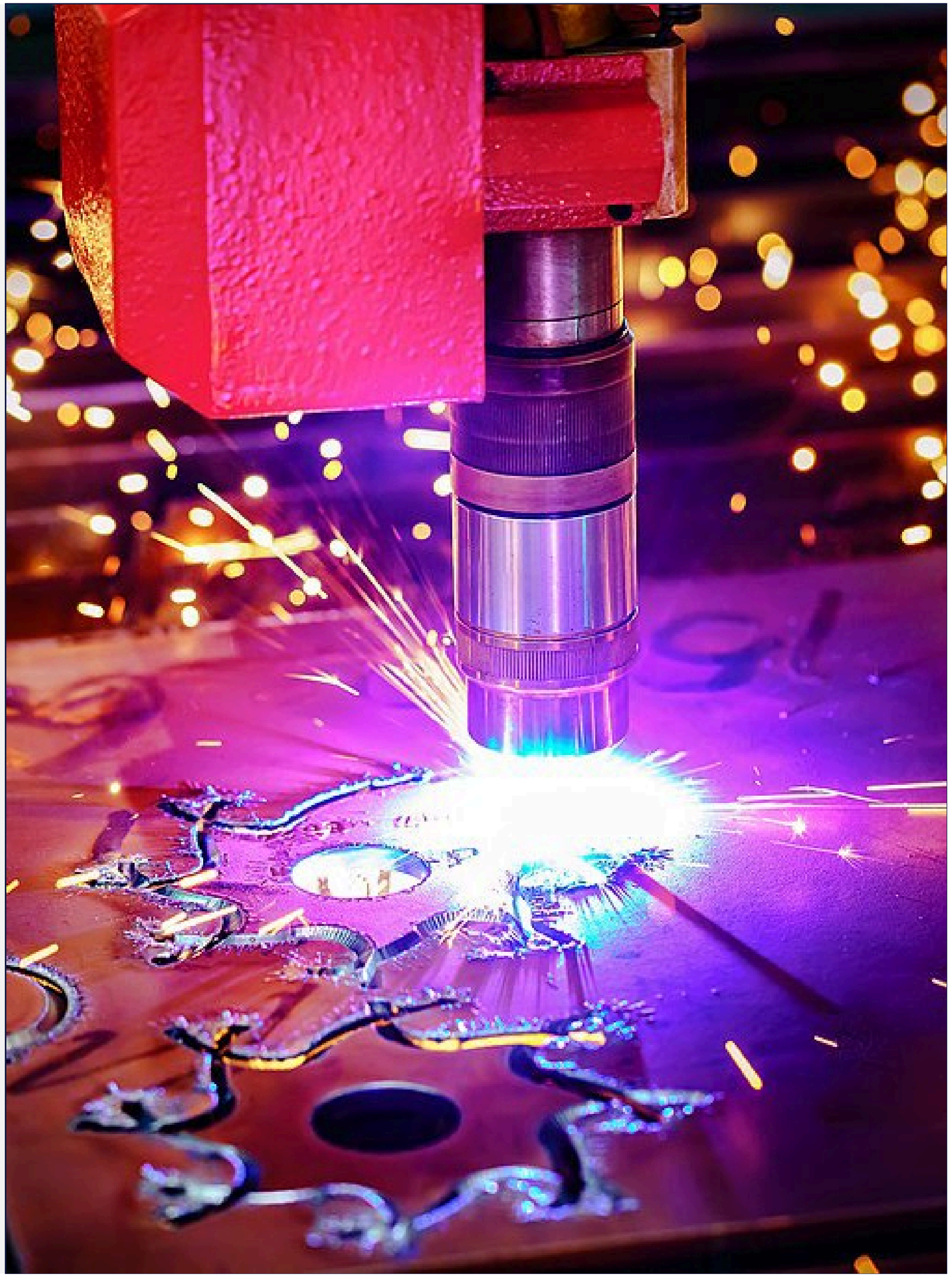
Green Public Procurement (GPP)

About Green Public Procurement

- **A green public procurement (GPP) program establishes an emissions intensity standard for goods purchased or funded by the government.**
- **Effectively, a GPP program segments the market, with a weaker standard (or no standard) determining which products may be sold to private sector buyers and a more stringent standard for products sold to government.**
- **GPP programs need not be limited to government-owned facilities. They may also encompass projects that accept government money.**
  - *U.S. states and cities routinely offer private firms subsidies worth hundreds of millions or billions of dollars in return for new capital investment.*

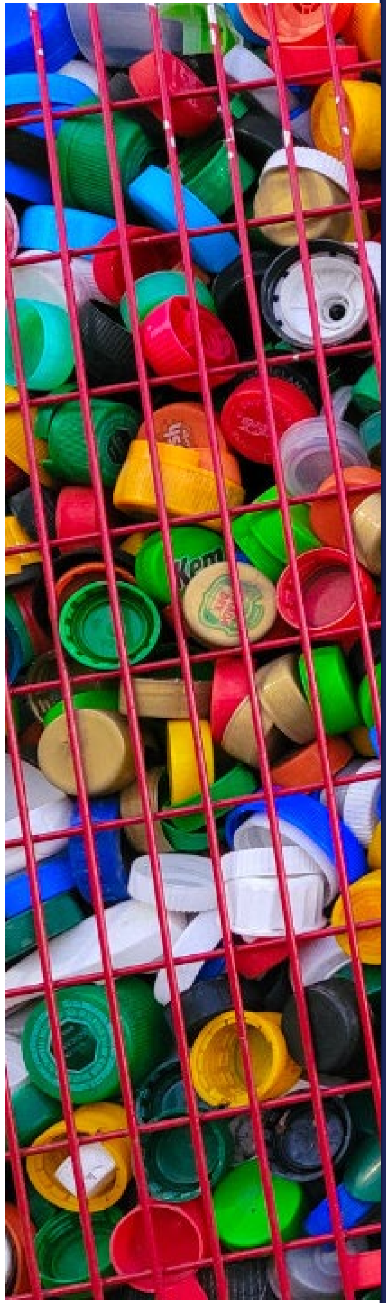
Government Purchasing Power

- **Public procurement accounts for an average of 12% of GDP in OECD countries and up to 30% in many developing countries.**
  - *Examples: roads, bridges, civic buildings, military equipment, public transit vehicles, medical and lab equipment, computers, etc.*
  - *Therefore, government procurement is a large and lucrative market that is attractive to many suppliers.*
- **If government is willing to pay more for low-emissions products, public procurement can serve as a starter market that allows novel, clean manufacturing processes to scale up.**
  - *This enables manufacturers to drive down their costs through returns-to-scale and learning-by-doing, helping clean products to subsequently break into the private sector market*



Carve-Outs

- **Products and materials made via the most innovative, zero-emissions processes will initially be available in limited quantities.**
  - *Therefore, it may not be possible for government to satisfy its demand by sourcing these products exclusively.*
  - *However, a weaker standard that is achievable by more manufacturers might not provide a market for the very cleanest technologies.*
- **To remedy this issue, a GPP may include carve-outs for products that achieve exceptionally high performance (i.e., near-zero emissions) and have limited market availability or high costs.**
  - *Essentially two tier GPP system, with a higher threshold for a certain percentage of government purchases and a lower threshold for the remainder*



R&D, Disclosure, Labeling, and Circular Economy Policies

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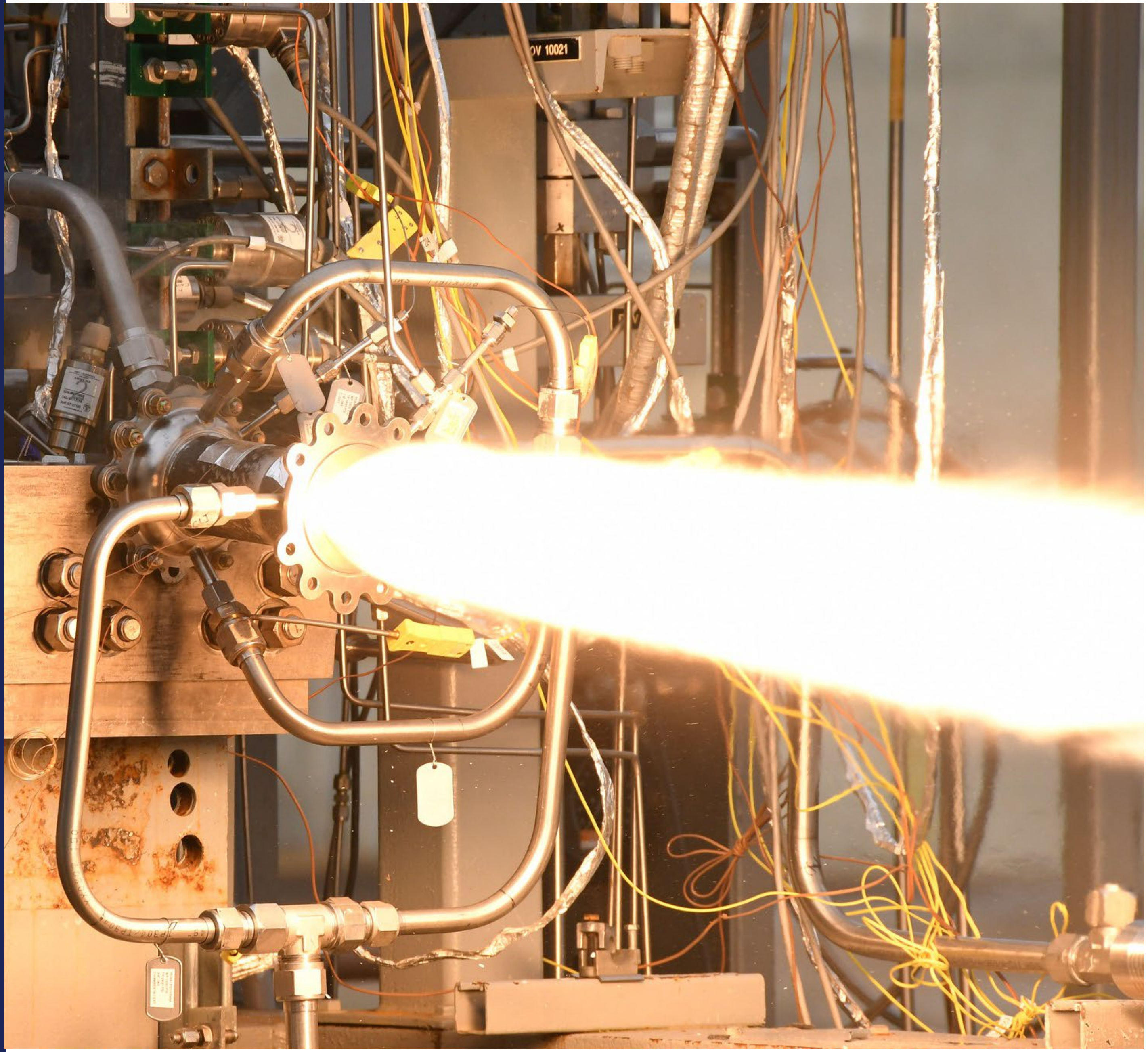
R&D Support Mechanisms

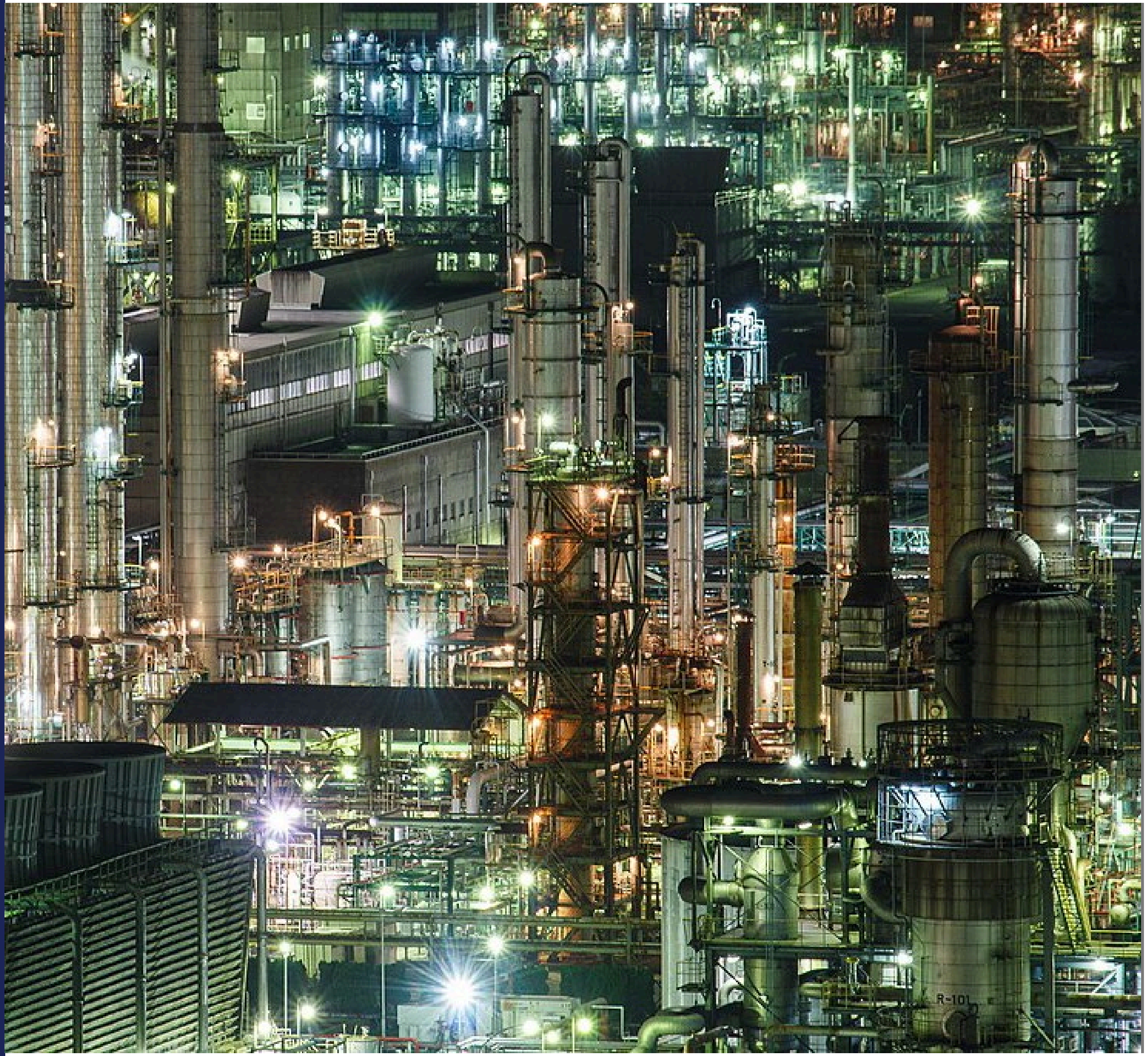
- Government laboratories
- Research partnerships
- Independent research organizations
- Grants and contract research
- Coordination of research efforts
- Access to STEM talent
- Smart patent protections

Emissions Disclosure and Labeling



Circular Economy Policies

- Right-to-repair
- Extended Producer Responsibility
- Increase demand for recycled materials
- Prohibit destroying excess inventory and returns
- Disposable item and packaging restrictions
- Recycling availability and requirements



Thank You

Jeffrey Rissman

Senior Director, Industry

Find out more and get a 20% off discount code at:
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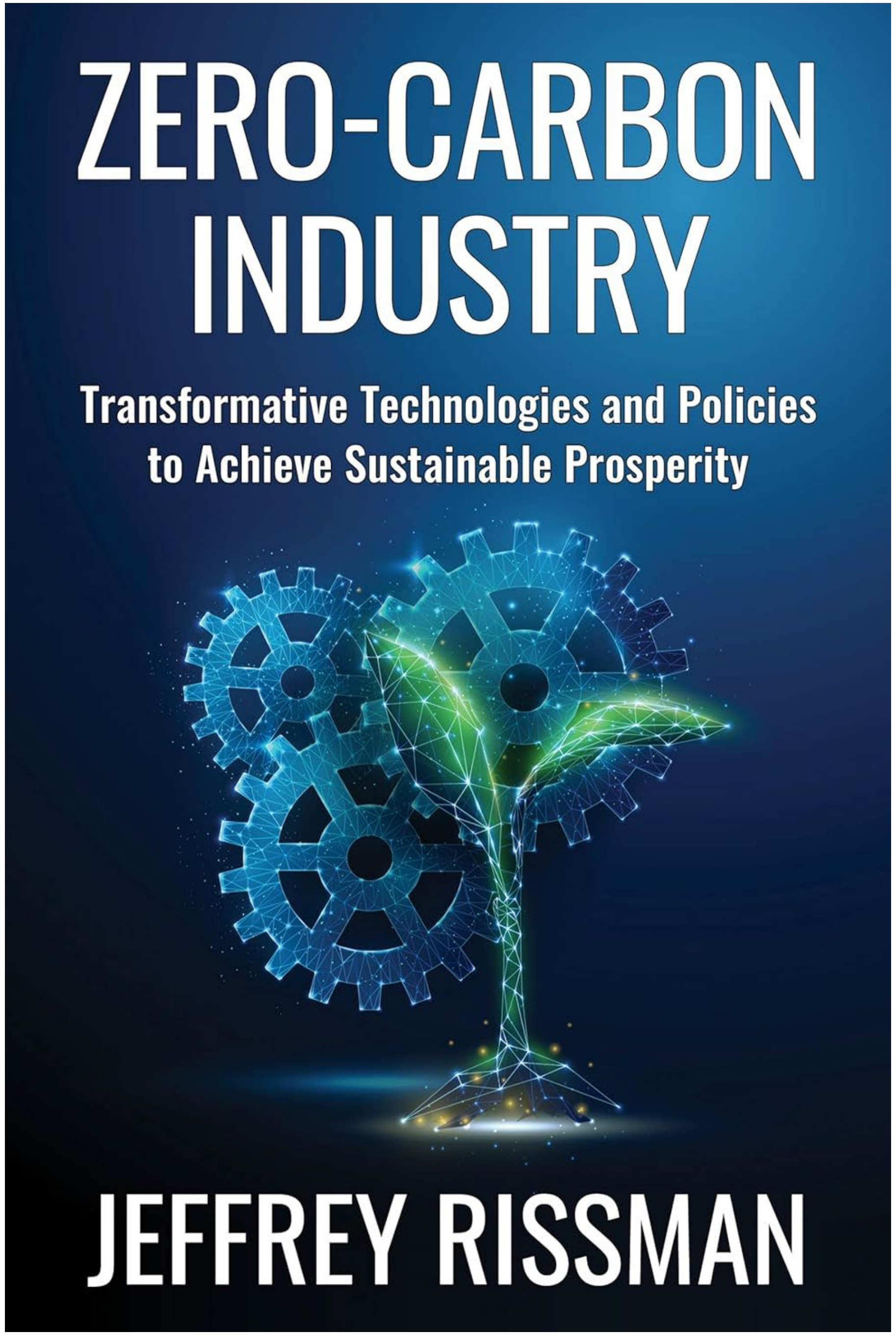

Discussion

Opportunities and Challenges for Decarbonization of EITEs in WA

Discussion Questions

1. Do the industrial decarbonization pathways outlined in today's presentations align with how EITEs are considering these issues? If not, what is missing?
2. What are the specific challenges and opportunities for deploying decarbonization pathways for EITEs in WA?
3. Which additional policies or strategies might enable implementation of these decarbonization pathways?
4. What other issues or information regarding industrial decarbonization should be considered in our report?

Open Discussion

Questions or Topics Proposed by Members

Next steps

Meeting #4: Dec, 19, 9 a.m.-12:00 p.m. PST.

- Topic: GHG emission baselines and benchmarks for EITE facilities
  - Presenters to be confirmed.
- EITE Policy Advisory Group meetings:
  1. Nov. 13
  2. Dec. 12
- RMI reaching out to arrange interviews

Public comment opportunity

Guidelines for providing public comment

- Up to two minutes per person
- Host will unmute you and begin timer
- Please keep the comments related to EITEs and the report to the Legislature
- Ecology will not respond to comments in this meeting
- To submit written comments, use our digital comment platform
- Please use “raise hand” button to indicate that you wish to provide a comment

DEPARTMENT OF ECOLOGY
State of Washington

Thank you!

If you have additional questions or comments, please send them to:

Adrian Young
Cap-and-Invest Industrial Policy Lead
CCAEITEIndustries@ecy.wa.gov