Onsite Energy Technical Assistance Partnerships
U.S. DEPARTMENT OF ENERGY
Midwest

Decarbonizing Thermal Energy through Onsite Energy

Agriculture Utilization Research Institute

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Onsite Energy Technical Assistance Partnerships (TAPs)

DOE's 10 regional Onsite Energy TAPs provide technical assistance to end users and other stakeholders about technology options for achieving clean energy objectives. Key services include:

Technical Assistance: Screen sites for opportunities to implement onsite energy technologies and provide advanced services to maximize economic impact and reduce risk from initial screening to installation to operation and maintenance.

End-User Engagement: Partner with organizations representing industrial and other large energy users to advance onsite energy as a cost-effective way to transition to a clean energy economy.

Stakeholder Engagement: Engage with strategic stakeholders, including utilities and policymakers, to identify and reduce barriers to onsite energy through fact-based, unbiased education.

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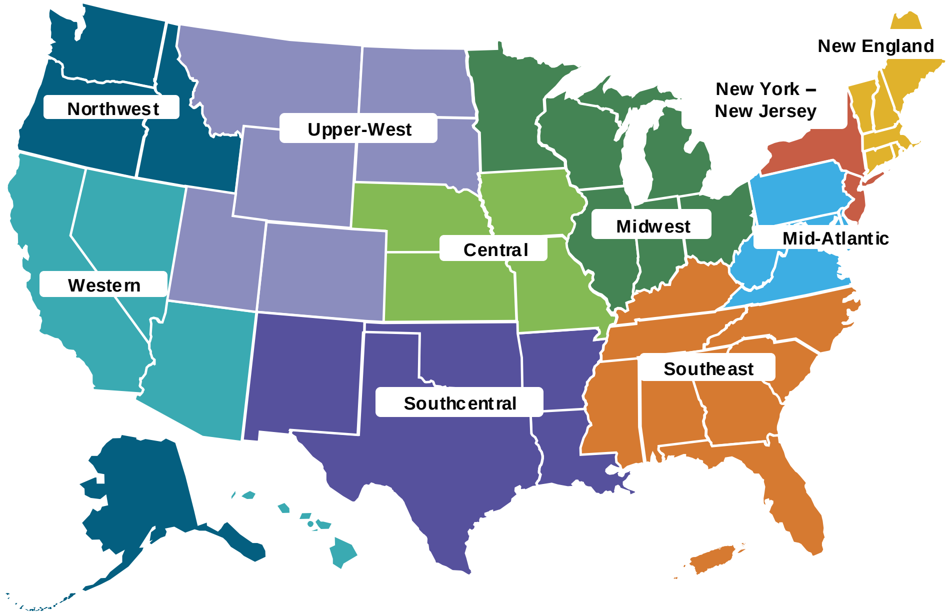
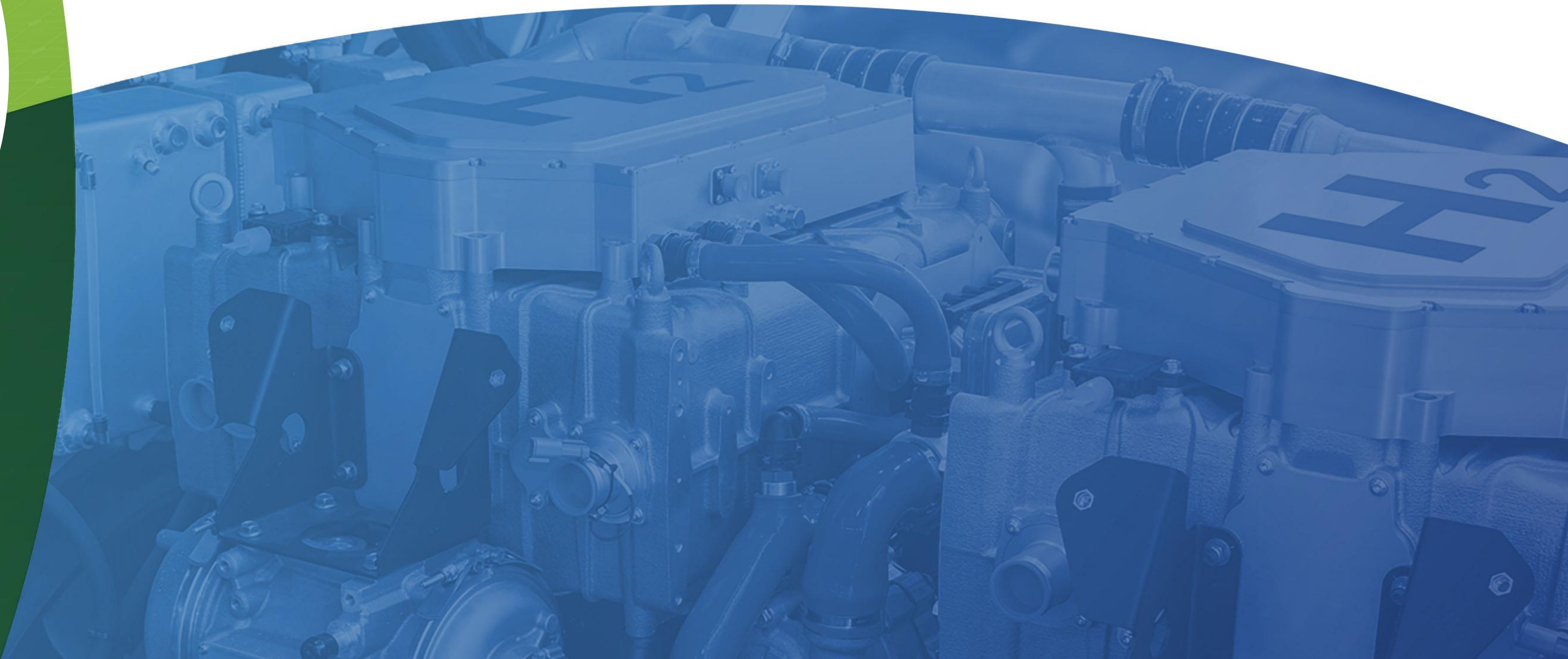


https://betterbuildingssolutioncenter.energy.gov/onsite-energy/taps

Industrial Thermal Decarbonization: Challenges and Opportunities

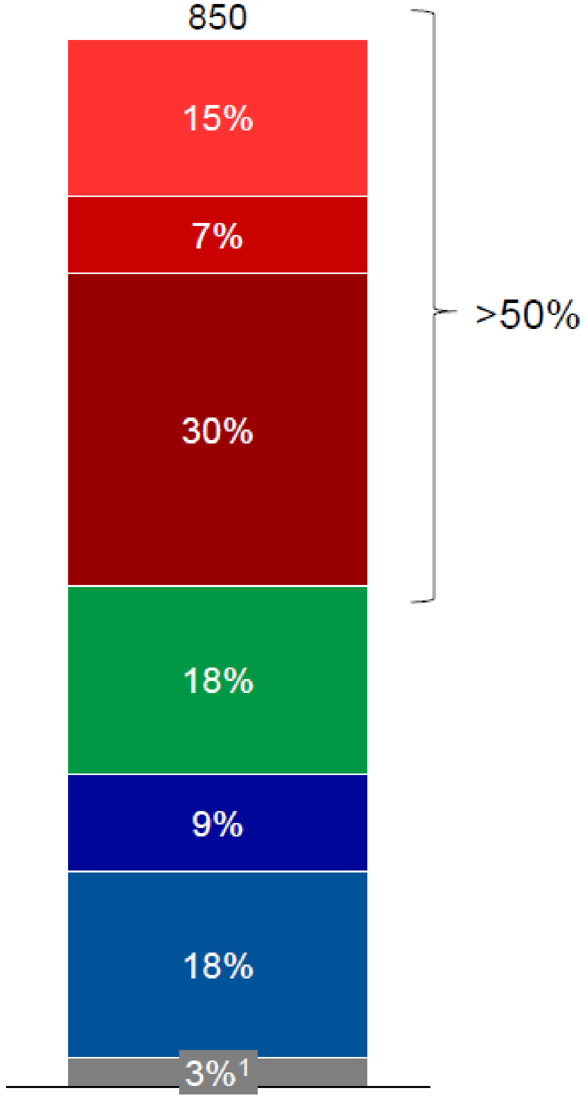


Breakdown of Industrial Sector Emissions

Majority of emissions in sectors of focus are from heat

Emissions source		Definition
Heat[3]	Low temp heat	Low heat (-30-200ºC) emissions, where heating is end-use
	Mid temp heat	Medium heat (200-400ºC) emissions, where heating is end-use
	High temp heat	High heat (400ºC+) emissions, where heating is end-use
Process	Process	Process-related emissions from chemical transformation of raw materials and fugitive emissions
Electricity	On-site power	Electricity emissions for power produced on-site
	Off-site power	Electricity emissions for power from the grid
Other	Other	Other emissions sources[1]

Emission breakdown, MT CO_2



Emissions from Industrials sector of focus[2]

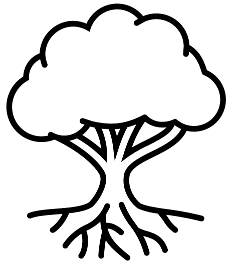
Notes: 1. Incl. electrochemical processes, refrigeration, and cooling for ethylene / propylene; cooling, heat loss for ammonia, fugitives or leakage emissions from NG processing, and quarry and logistics emissions (e.g., cement) | 2. Estimate based on available data
Source: 2018 EPA Flight, 2018 EERE Manufacturing Energy and Carbon Footprints report, 2022 IEDO Report, Energy Environ. Sci., 2020,13, 331-344, EIA, 2020 USGS, DOE Natural Gas Supply Chain report

Source: https://liftoff.energy.gov/wp-content/uploads/2023/09/20230918-Pathways-to-Commercial-Liftoff-Industrial-Decarb.pdf

INDUSTRIAL THERMAL ENERGY

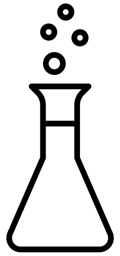
Thermal processes and systems are essential and pervasive in industry, but every major industrial subsector uses heat in different ways…

drying
paper, batteries

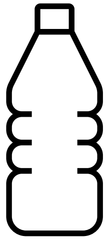


steam
pasteurization of food & beverage

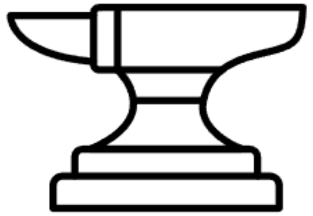
distillation
high purity chemicals



melting
formed plastics, semiconductors



smelting
iron, copper, aluminum



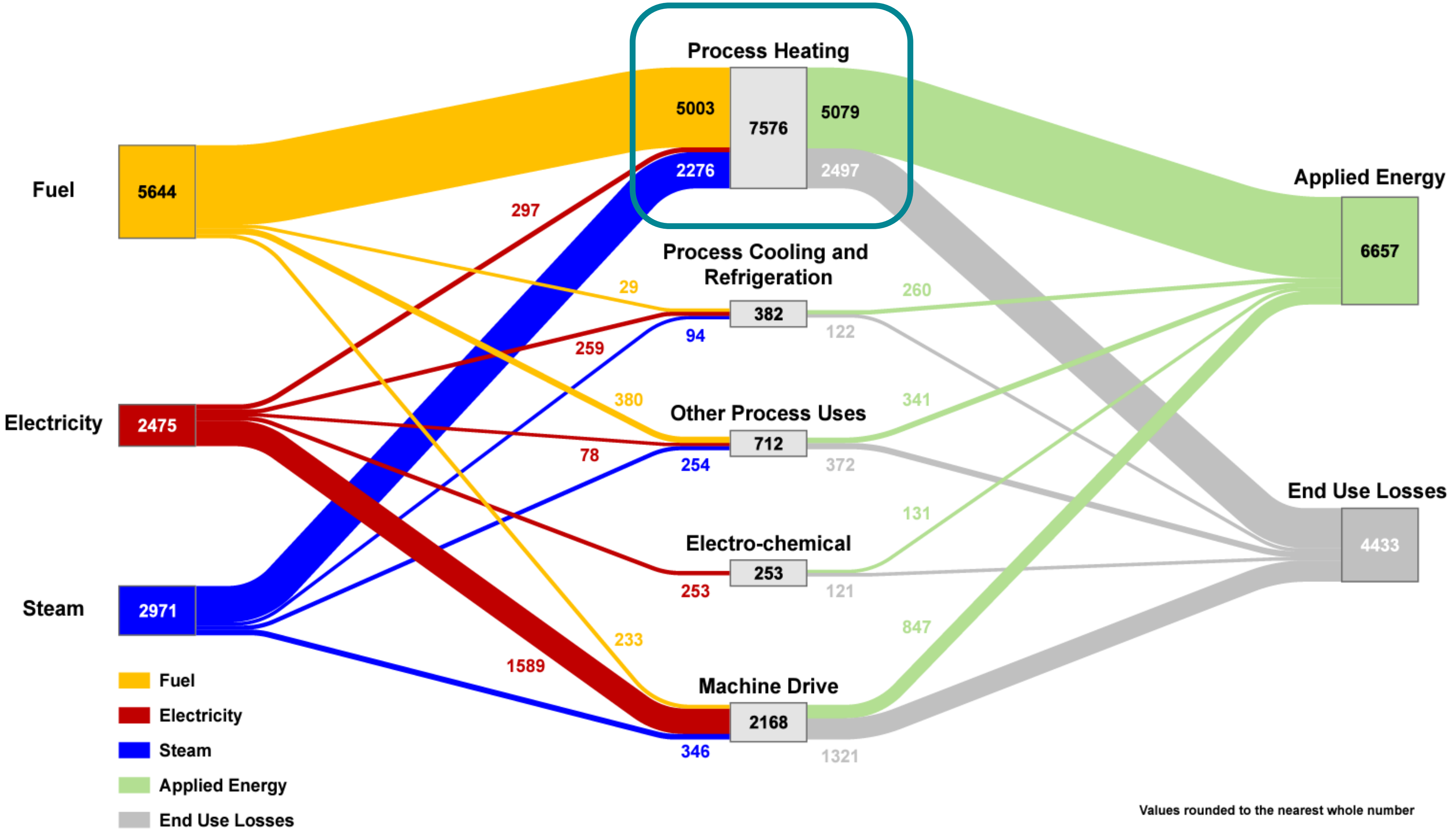
calcining
cement, lime

<100ºC **Process Temperatures Needed** >800ºC

Source: US DOE

PROCESS HEATING IS THE LARGEST SINGLE SOURCE OF ENERGY LOSS IN MANUFACTURING

U.S. Manufacturing Process Energy (TBtu), 2018



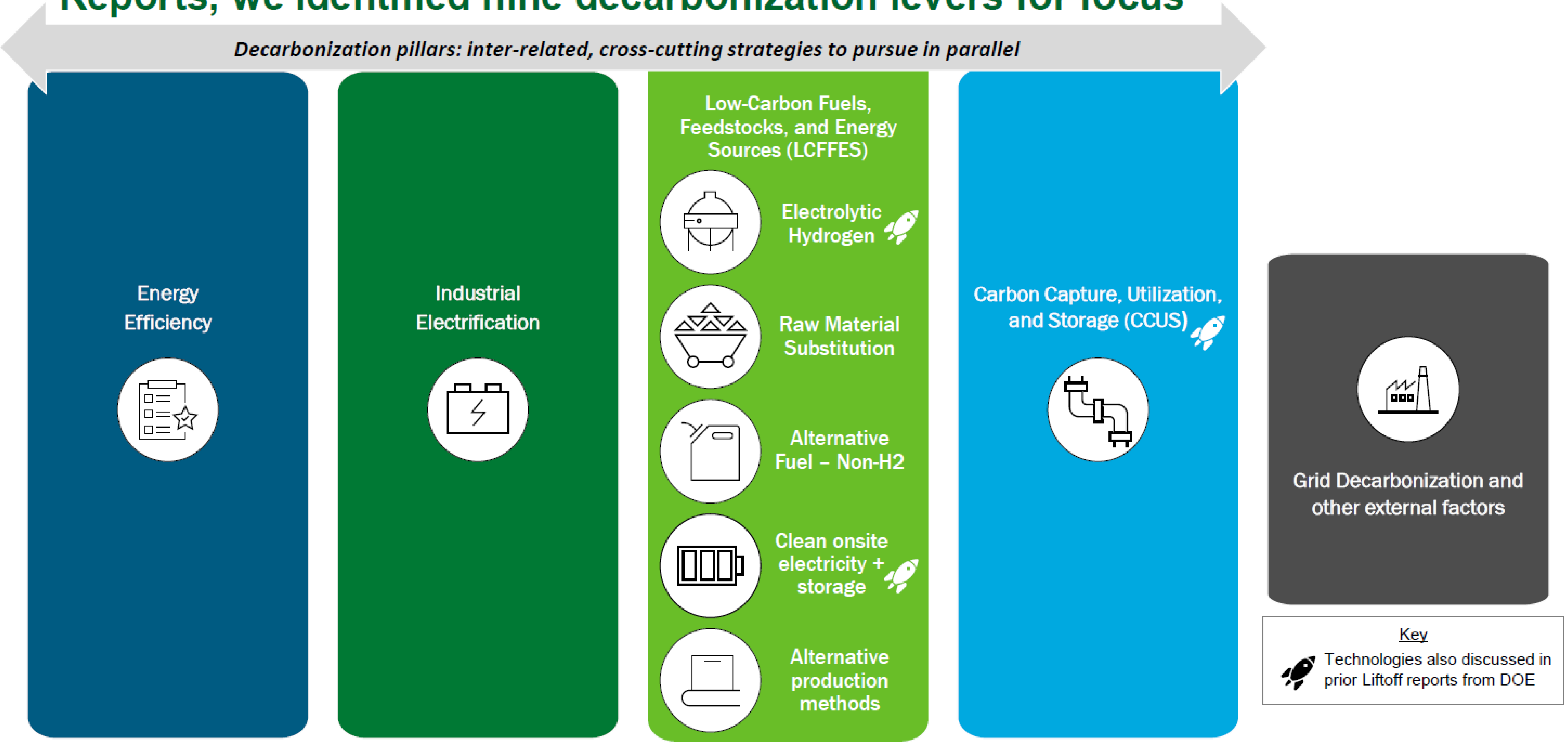
- **~1/3rd of process heating energy is lost!**

https://www.energy.gov/eere/iedo/2018-manufacturing-static-energy-sankey-diagrams

ENERGY earthshots U.S. DEPARTMENT OF ENERGY

DOE Industrial Decarbonization Roadmap & Liftoff Report

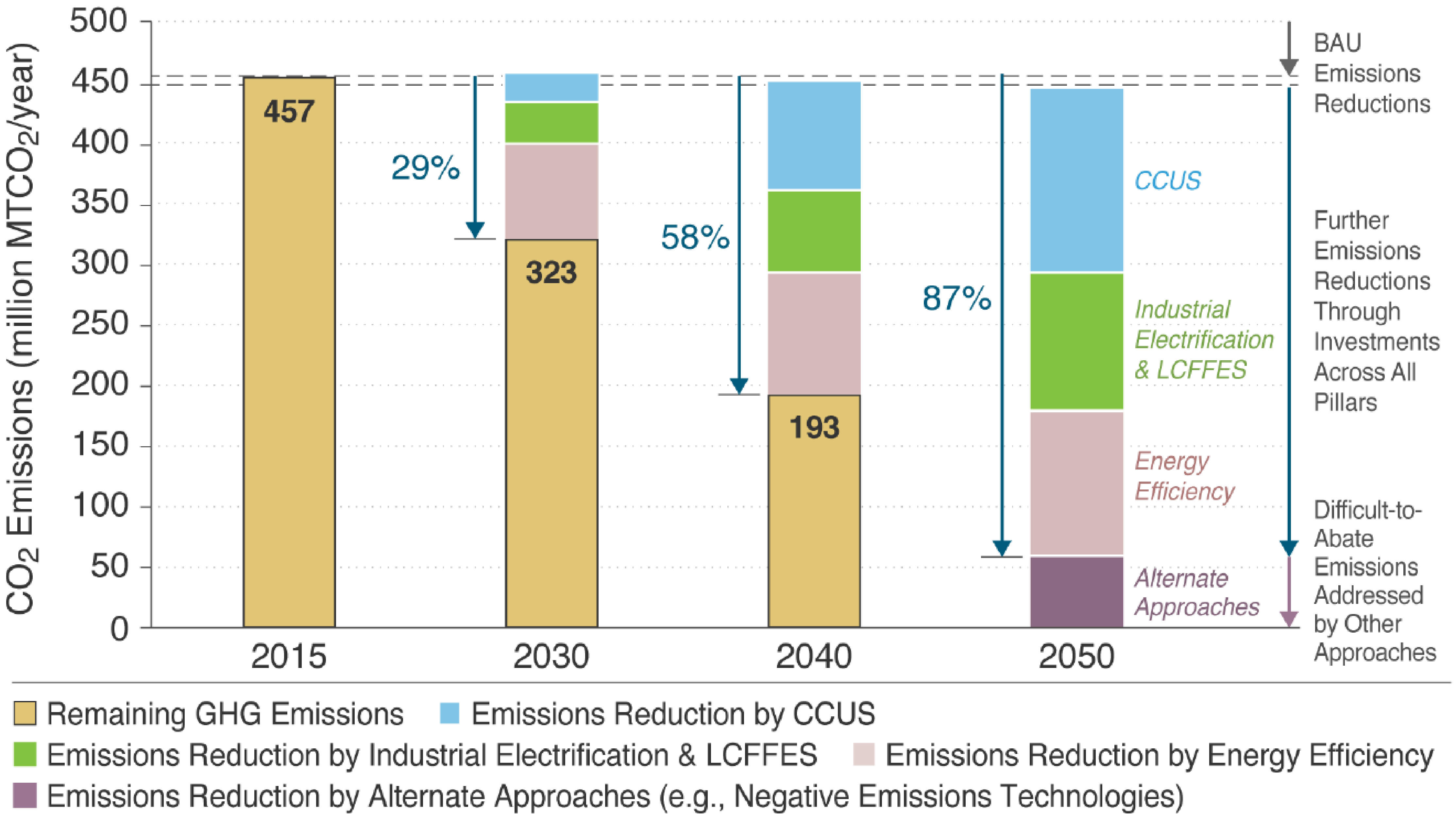
Based on DOE's Industrial Decarbonization Roadmap and prior Liftoff Reports, we identified nine decarbonization levers for focus



Notes: 1. For the purposes of this analysis, CCS includes reformation-based H2. Utilization is included in overall discussions; however, MACC analysis focuses on CCS due to limited expected market for utilization.

Source: https://liftoff.energy.gov/wp-content/uploads/2023/09/20230918-Pathways-to-Commercial-Liftoff-Industrial-Decarb.pdf

DOE Industrial Decarbonization Roadmap



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High Temperature Heat Deep Dive

NOT EXHAUSTIVE

Decision criteria	Chemicals	Refining	Iron & Steel[8]	Cement	Pulp & Paper	Aluminum	Glass
Highest heat requirement,[10] degrees	1,000ºC	800ºC	1,600ºC	1,450ºC	1,100ºC	1,000ºC	1,600ºC
High grade heat share of industry emissions[11]	11%	49%	73%	34%	7%	26%	47%
Most applicable technologies with implementation tradeoffs	Small modular nuclear reactor Electrification +TES Hydrogen[9] CCS	CCS Electrification +TES Hydrogen[9] Biofuels	Electrification CCS Hydrogen[9]	Biomass; waste fuels CCS Electrification +TES	Biofuels Electrification (BE)CCS	Hydrogen[9] CCS Electrification	Electrification CCS Biofuels Hydrogen[9]

Deployable | Demo | R&D / Pilot

Key challenges/tradeoffs[1]

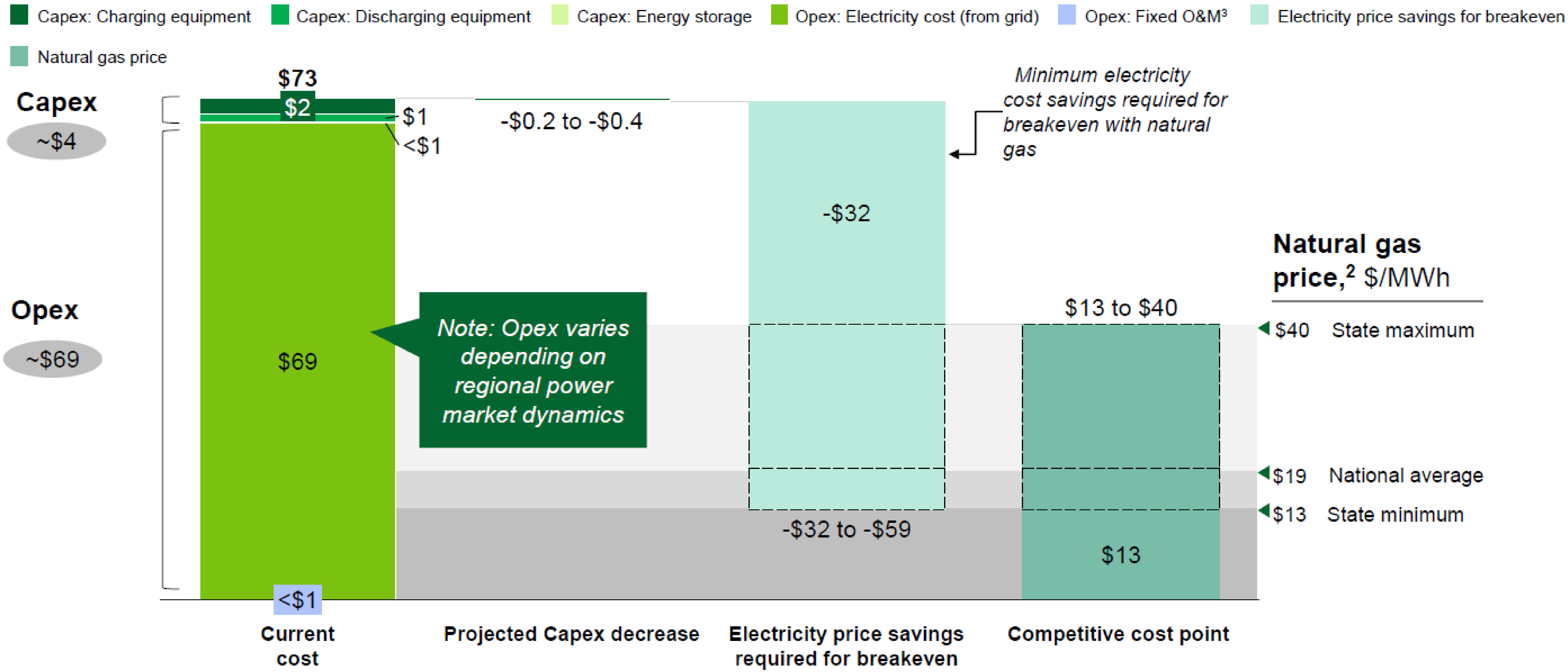
- High opex cost
- High capex cost
- Operational challenges[2]
- Retrofit challenges[3]
- Product limitations[4]
- Access to low carbon electricity [5]
- Supply challenges[6]

Notes: 1. Highest priority challenges/tradeoffs for each technology in each sector listed in figure. Other challenges could apply but may not be as critical a decision factor for industry | 2. Operational challenges refer to difficulty in meeting the heat or other technical requirements for the process with the decarbonization technology. For example, the use of biomass in cement presents operational challenges as it has a lower heat value than fossil fuels and therefore cannot replace 100% of fuel and reach sufficient temperatures | 3. Retrofit challenges are difficulty in implementing the decarbonization technology. For example, the number of emissions sources in refining and chemicals is a retrofit challenge for CCS as emissions sources could need to be rerouted to combine multiple streams to be captured within the facility | 4. Product quality challenges refer to when the decarbonization technology impacts the quality of the product being produced. For example, EAF produces steel that does not meet technical requirements for some end-uses (e.g., automotive)| 5. Refers to challenges in accessing sufficient low carbon electricity either from the grid or onsite | 6. Supply challenges arise when the decarbonization technology relies on an input that has a limited or localized supply chain. For example, access to biomethane for use in melting glass will depend on the location of the glass production and if there is availability of sufficient biomethane within range | 7. High temperature (HT) | 8. Weighted average of in-scope subsegments | 9. Assumes purchase of electrolytic hydrogen. Production of electrolytic hydrogen has its own set of challenges (e.g., access to low carbon electricity for electrolytic hydrogen) | 10. The general maximum heat requirement for current processes; excludes a consideration of new processes | 11. High temperature heat emissions data is estimated from this combination of sources.

Source: https://liftoff.energy.gov/wp-content/uploads/2023/09/20230918-Pathways-to-Commercial-Liftoff-Industrial-Decarb.pdf

Case study on heat decarbonization through thermal energy storage

Cost components of high temperature thermal energy storage (TES),[1] $/MWh of thermal energy delivered **ILLUSTRATIVE**



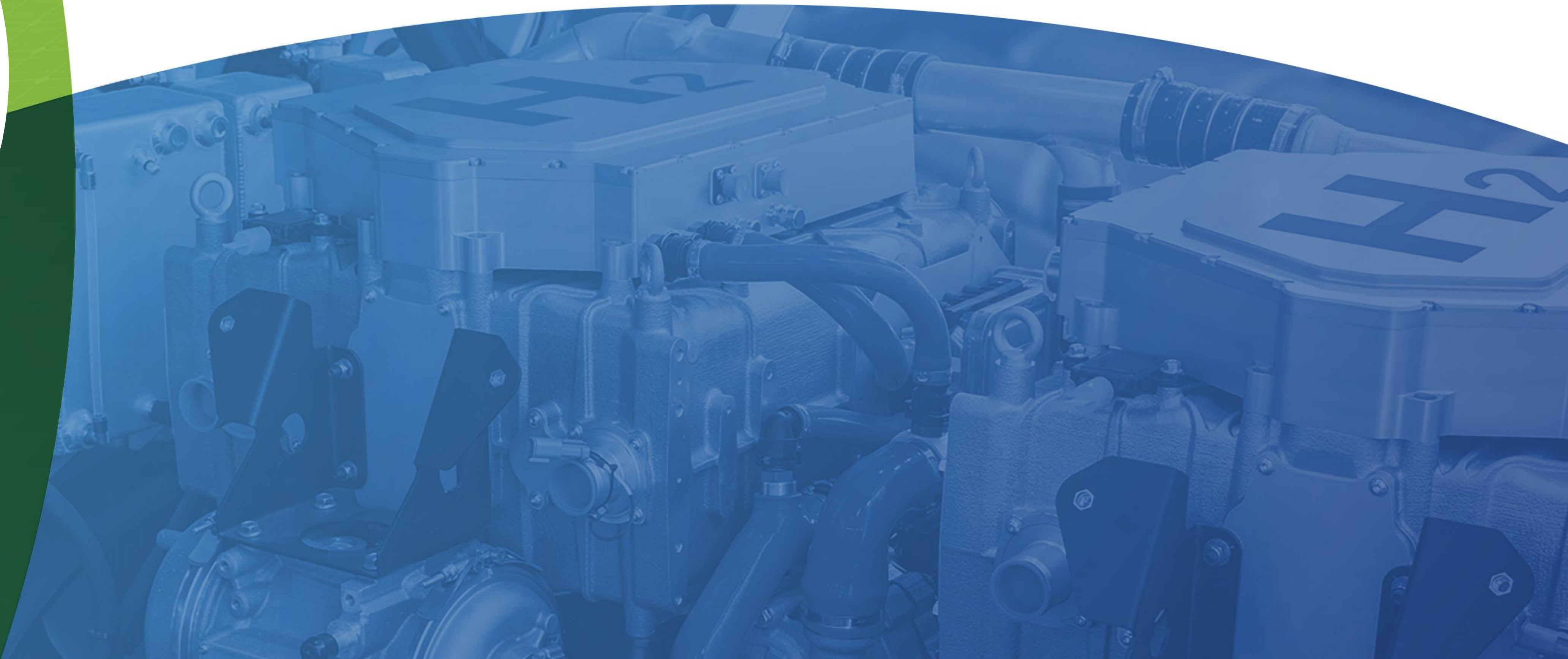
Notes: Electricity price in comparison to fossil fuel is the largest determinant of TES's economic viability | 1. Capex figures are based on anonymized industry data from LDES council members; technology agnostic, assumes 16h storage, 8h charging, 365 cycles per year, 8% WACC, 30-year lifetime, and 5,840 MWh heat discharge per year | 2. EIA annual Natural Gas Prices: Industrial (2021); minimum represents the lowest (West Virginia) and highest (Delaware) annual natural gas price by state; note that the natural gas price doesn't include a small efficiency loss from combustion | 3. Assumes that fixed O&M cost is 2% of capex, in line with similar energy technologies; no data is available from the LDES council
Source: LDES Council, EIA Monthly Electric Power Industry Report

Source: https://liftoff.energy.gov/wp-content/uploads/2023/09/20230918-Pathways-to-Commercial-Liftoff-Industrial-Decarb.pdf

Onsite Energy in the Industrial Decarbonization Roadmap

Energy Efficiency	Industrial Electrification	Low-Carbon Fuels, Feedstocks, and Energy Sources (LCFFES)	Carbon Capture, Utilization, and Storage (CCUS)
Energy efficiency advancements minimize industrial energy demand, directly reducing the GHG emissions associated with fossil fuel combustion.	Industrial process technologies that utilize electricity for energy, rather than combusting fossil fuels directly, enable the sector to leverage advancements in low-carbon electricity from both grid and onsite generation sources.	Substitution of low- and no-carbon fuels and feedstocks for fossil fuels can further reduce combustion-associated emissions for industrial processes.	This multi-component strategy for mitigating difficult-to-abate emissions involves capturing generated CO2 before it can enter the atmosphere; utilizing captured CO2 whenever possible; and storing captured CO2 long-term to avoid atmospheric release.
Onsite Energy Technologies/Applications			
Combined Heat and Power Waste Heat to Power Thermal Storage	Heat Pumps (air source, ground source, industrial) Solar Wind Battery/Electric Storage Thermal Storage	Combined Heat and Power Anaerobic Digestion Waste Heat to Power	All Combustion based Generation

Onsite Energy TAP Technical Assistance



Onsite TAP Services Across Project Development Phases

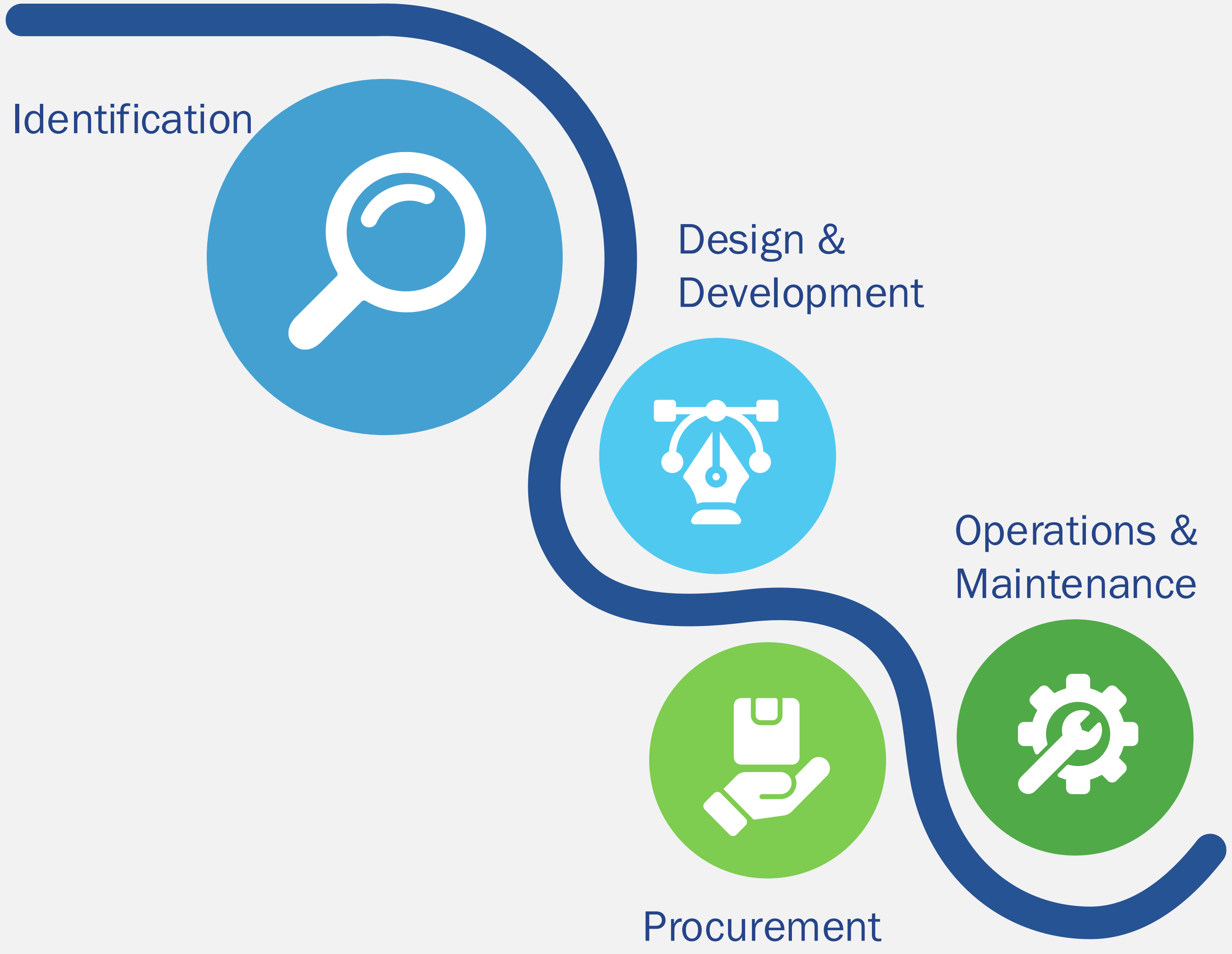
Identification
- Operational goals
- Portfolio analysis
- Technology screening
- Economic analysis
- Regulatory review

Design & Development
- Planning
- Equipment options
- Equipment siting
- Third-party reviews
- Utility rate analysis

Procurement
- Specifications review
- Finance identification
- Permitting support

Operations & Maintenance
- Measurement & verification
- Optimizing performance
- Reporting

Technical Assistance Touchpoints



Getting Started: How to Work with Your Onsite Energy TAP

Contact Your Regional TAP

Contact the Onsite Energy TAP in your region to start exploring onsite energy opportunities.

Discuss Site Characteristics, Goals, Objectives

Meet with the Onsite Energy TAP to discuss preliminary interest in onsite energy and learn about the facility's needs and energy-related goals.

Collect Site Data

Work with the Onsite Energy TAP to collect data needed to perform technical assistance (e.g., facility size, operations, electric and gas usage, etc.).

Conduct Analysis

Onsite Energy TAP works with technical analysis team to perform initial screenings for multi-technology options or advanced analysis to support project installations.

Review Results

When the results are ready, meet with your Onsite Energy TAP to review and discuss next steps (e.g., options worth further analysis or additional support available)

Summary

- Industrial Thermal Decarbonization presents many challenges but also opportunities
- Onsite Energy technologies can play a significant role in industrial decarbonization
- The US DOE Onsite Energy TAP provides no-cost technical assistance to help your facility explore decarbonized solutions

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