Energy Storage for Manufacturing & Industrial Decarbonization Workshop
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manufacturing.energy.gov
Industry’s Significant CO₂ Emissions

Industrial sector is comprised of manufacturing | agriculture | mining | construction

ACCOUNTS FOR

32% of the nation’s primary energy use

28% of CO₂ emissions

Anticipated industrial sector energy demand growth of 30% by 2050 may result in a 15% CO₂ emissions increase

Technological advances in manufacturing will be critical to enabling decarbonization for other sectors.

Industrial Decarbonization Roadmap identifies RD&D to achieve significant, economical greenhouse gas emission reductions by 2050.

EIA, Annual Energy Outlook 2020 with Projections to 2050.

Source: Industrial Decarbonization Roadmap
2050 Industrial Emissions Reductions Potential

Near-Zero GHG Emissions Scenario
(for five representative subsectors*)

Pillars of industrial decarbonization:
- Energy efficiency
- Industrial electrification
- Low carbon fuels, feedstocks, and energy sources
- Carbon capture, utilization and storage

Industrial decarbonization pillars: Energy efficiency; industrial electrification and low-carbon fuels, feedstocks, and energy sources (LCFFES); and carbon capture, utilization, and storage (CCUS)

*Subsectors included in Roadmap analysis: Iron & Steel, Chemicals, Food & Beverage, Petroleum Refining, and Cement. (Near zero GHG scenario, excluding feedstocks. Source: DOE Industrial Decarbonization Roadmap, forthcoming)
Multiple Pillars of Decarbonization Must be Pursued in Parallel

Technical opportunities across a range of Technology Readiness Levels (TRLs)

- **Lower TRLs**: Investments in early-stage low carbon technologies will be needed soon to ensure future market viability.
- **Higher TRLs**: Prompt investments are essential to lower adoption hurdles and rapidly scale later-stage technologies.

Landscape of major RD&D investment opportunities for industrial decarbonization between now and 2050.

**LCFFES** = Low Cost Fuels, Feedstocks, and Energy Sources; **CCUS** = Carbon Capture Utilization and Storage

Source: Industrial Decarbonization Roadmap
What energy conversion & storage systems characteristics are needed for the industrial sector between now and mid-century?

## ESGC Roadmap:

https://www.energy.gov/energy-storage-grand-challenge/energy-storage-grand-challenge
Thermal opportunity

Process Heating in the manufacturing sector: 7.2 Quads

- Approximately 2.5 Quad opportunity in process heating alone

Investments in Industrial Decarbonization Technologies

Innovative Metals Processing

Improve the energy and carbon footprint of metals production, including through increased recycling of scrap, co-products, and process gasses.
- Direct electrolysis
- Alternative reductants
- Electrochemical recovery
- Selective separations

Efficiency Improvements in Chemical Manufacturing

Develop catalytic processes to optimize conversion rates & selectivity.

H2@ Scale and Hydrogen Shot ($1/1Kg clean H2 in 1 decade).

One-step electrochemical ethylene production from CO₂

Thermal Process Intensification

Develop low thermal budget technologies + low-carbon energy sources.
Flexible manufacturing facilities

NEW CONCEPT
- Flexible CHP system provides electricity and thermal energy for plant processes and operations
- Flexible CHP system provides additional generating capacity when grid demand increases and/or renewable resources are not available. Flexible CHP also can provide other services, such as frequency regulation, to keep the grid stable.

TODAY’S ELECTRIC GRID
- Power system serves residential, commercial, and industrial loads, and interconnects with a growing number of intermittent renewable energy resources.
What does the intersection of energy storage and the industrial sector look like going forward?

Highly efficient, productive, flexible and resilient manufacturing operations, systems and facilities.

Robust, dynamic, adaptable energy conversion & storage.

Advanced sensors, controls, platforms, & modeling of fundamental unit operations.

Industrial facilities as virtual batteries - potential to augment or offset carbon management needs. (Negawatt-hours)

*Example of optimized transport network for economy-wide carbon capture and storage.*

The circular dots show the types of CO₂ emitting sources, including several industrial categories, and triangles showing two classes of storage locations. Source: Abramson, McFarlane, and Brown (2020)
Thank You!

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