U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Energy Storage for Manufacturing

Energy Storage for Manufacturing & Industrial Decarbonization Workshop

February 8-9, 2022

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manufacturing.energy.gov

Industry's Significant CO_2 Emissions

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

ACCOUNTS FOR

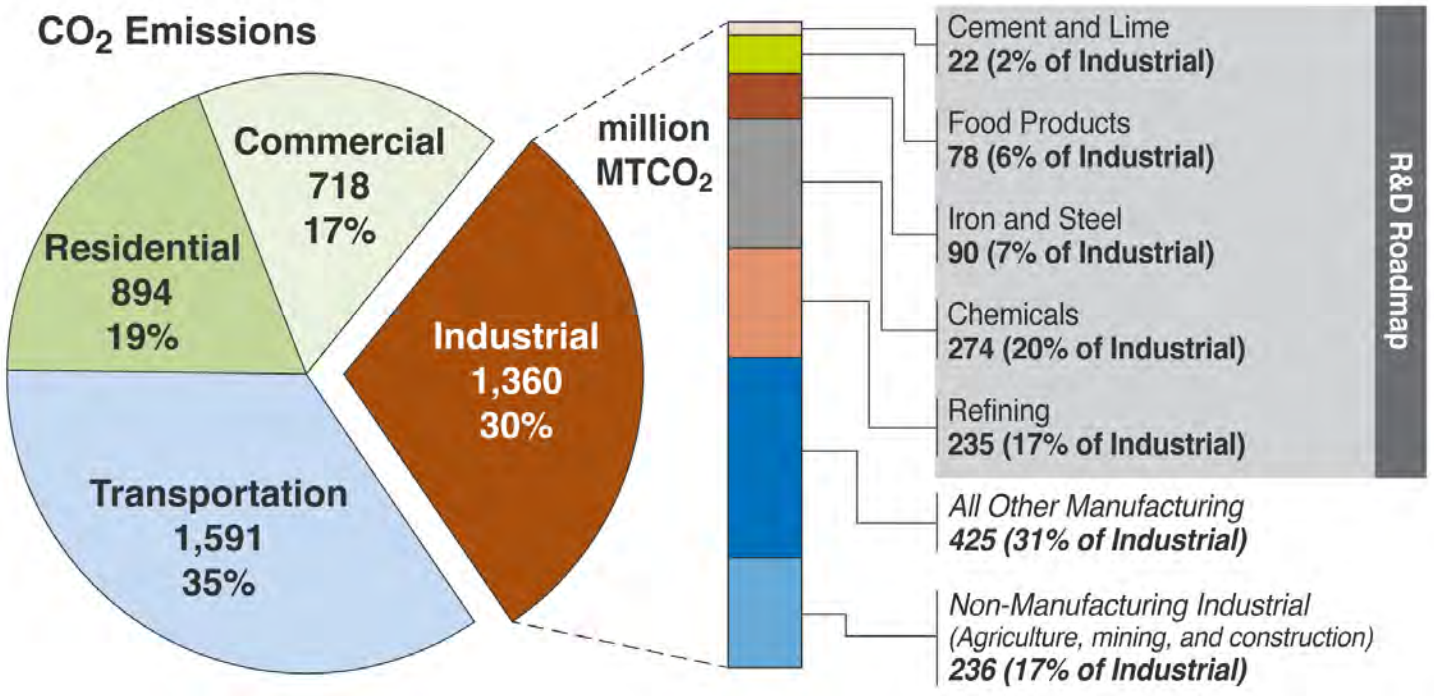
32% of the nation's primary energy use

28% of CO_2 emissions

Anticipated industrial sector energy demand growth of 30% by 2050 may result in a

15% CO_2 emissions increase

CO_2 Emissions By Sector



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

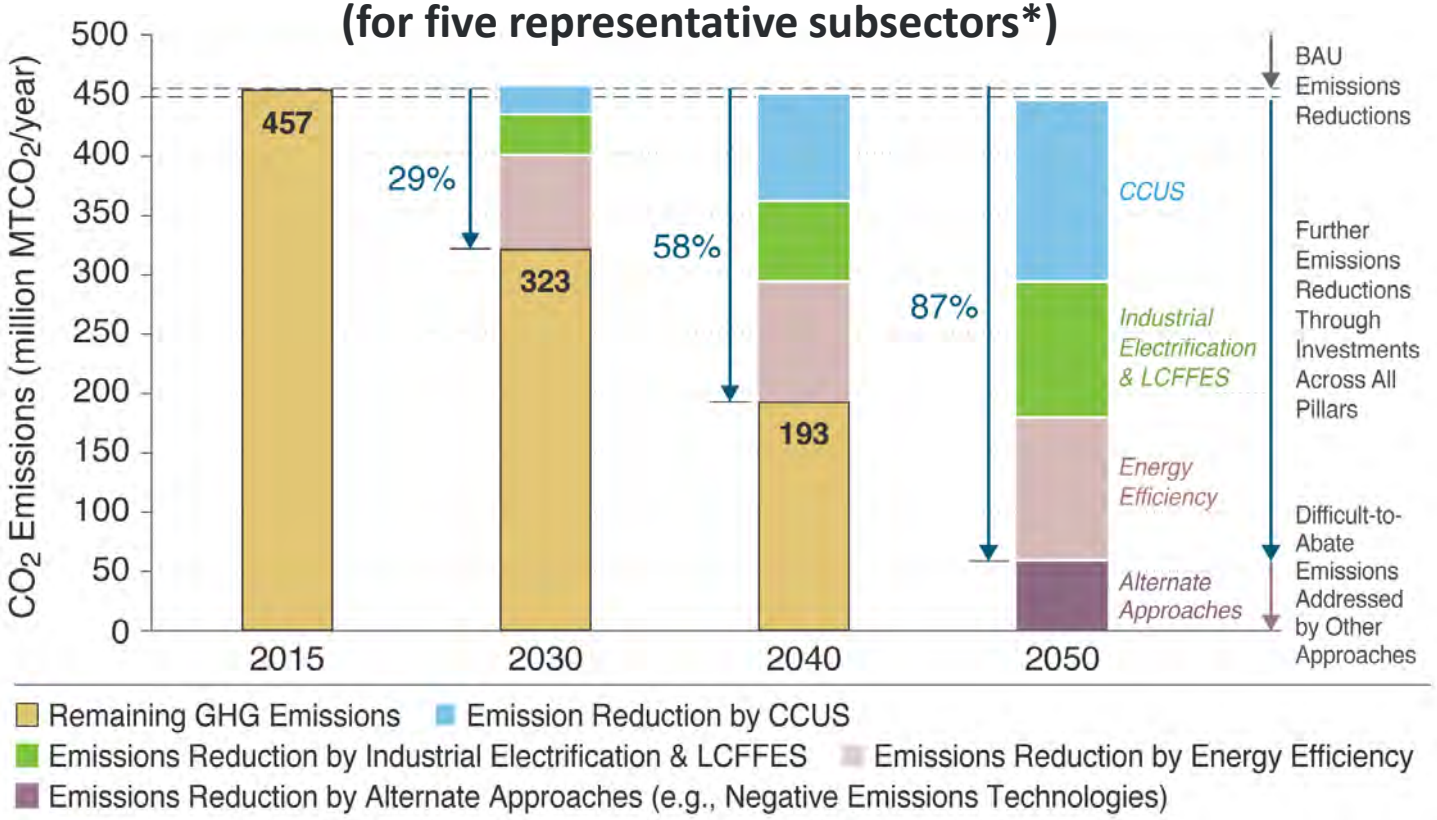
Industrial Decarbonization Roadmap identifies RD&D to achieve significant, economical greenhouse gas emission reductions by 2050.

EIA, *Annual Energy Outlook 2020 with Projections to 2050*.

2050 Industrial Emissions Reductions Potential

Near-Zero GHG Emissions Scenario

(for five representative subsectors*)



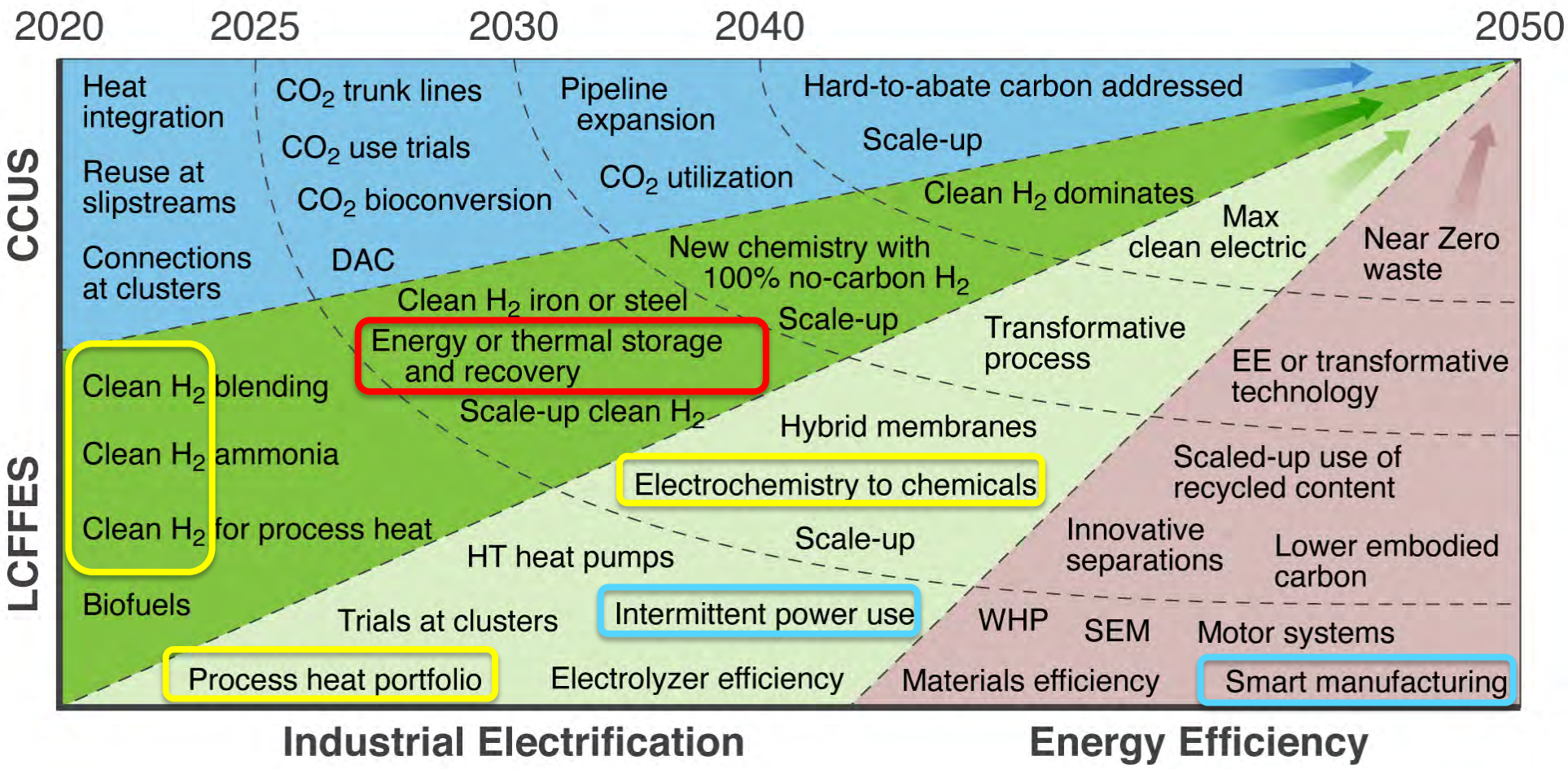
Industrial decarbonization pillars: Energy efficiency; industrial electrification and low-carbon fuels, feedstocks, and energy sources (LCFFES); and carbon capture, utilization, and storage (CCUS)

Pillars of industrial decarbonization:

- Energy efficiency
- Industrial electrification
- Low carbon fuels, feedstocks, and energy sources
- Carbon capture, utilization and storage

***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



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

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.

Energy conversion & storage in the industrial sector

Direct

Indirect

Ancillary

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

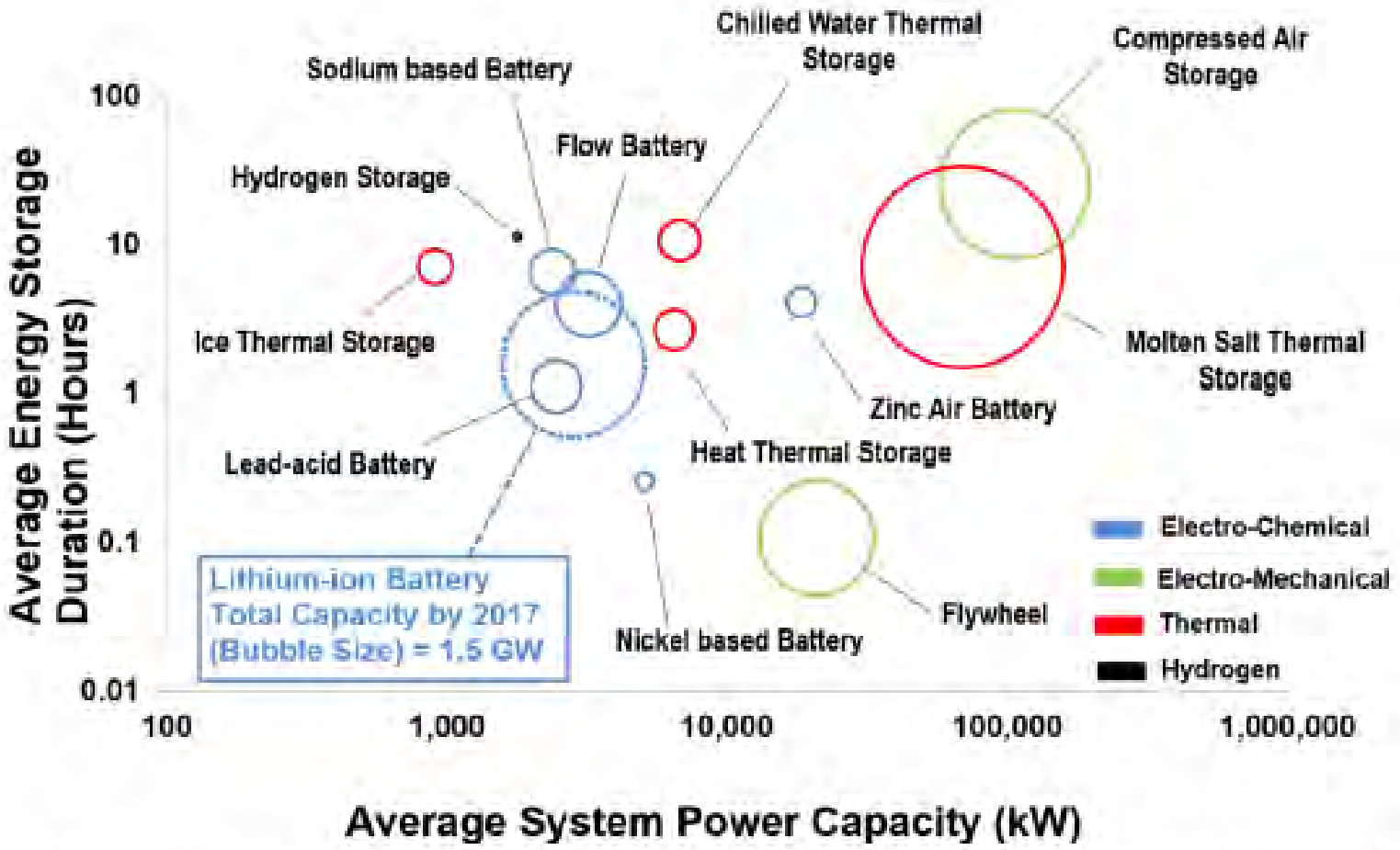


Figure 1. Average characteristics of energy storage systems built worldwide between 1958 and 2017, by technology, from the DOE Energy Storage Database (2018), sample size = 1,041 (pumped hydro not shown because of its very large global capacity)

Fu, Ran, Timothy W. Remo, and Robert M. Margolis. *2018 US Utility-Scale Photovoltaics-Plus-Energy Storage System Costs Benchmark*. No. NREL/TP-6A20-71714. National Renewable Energy Lab.(NREL), Golden, CO (United States), 2018. https://www.nrel.gov/docs/fy19osti/71714.pdf

ENERGY STORAGE GRAND CHALLENGE
U.S. DEPARTMENT OF ENERGY

ENERGY STORAGE TECHNOLOGIES

GOALS	Load Response Short	Load Response Mid	Load Response Long	Black Start Capable	Power Quality	Reliable	Robust	Long Lifetime	Scalable	Compact	Safe	Efficient	Flexible	Modular
Electrochemical	●	●●●	●●●	●●●	●	●●	●●	●	●	●●	●	●	●	●●●
Electro-mechanical	●●●	●●●	●●	●●●	●	●	●●	●●●	○	○	●●	●●●	●	○
Chemical	○	●●	●●	●	○	○	○	●●	●●●	●	○	●	●	●
Thermal	○	●●	●●	○	○	●	○	●	●●●	○	○	●	○	○
Flexible Buildings	○	●	●	○	●	●	●	●●	○	○	●●●	●●	●●	●●●
Flexible Generation	●●	●●	●●	●	●●●	○	○	●●	●	○	●●●	●●	●●●	●

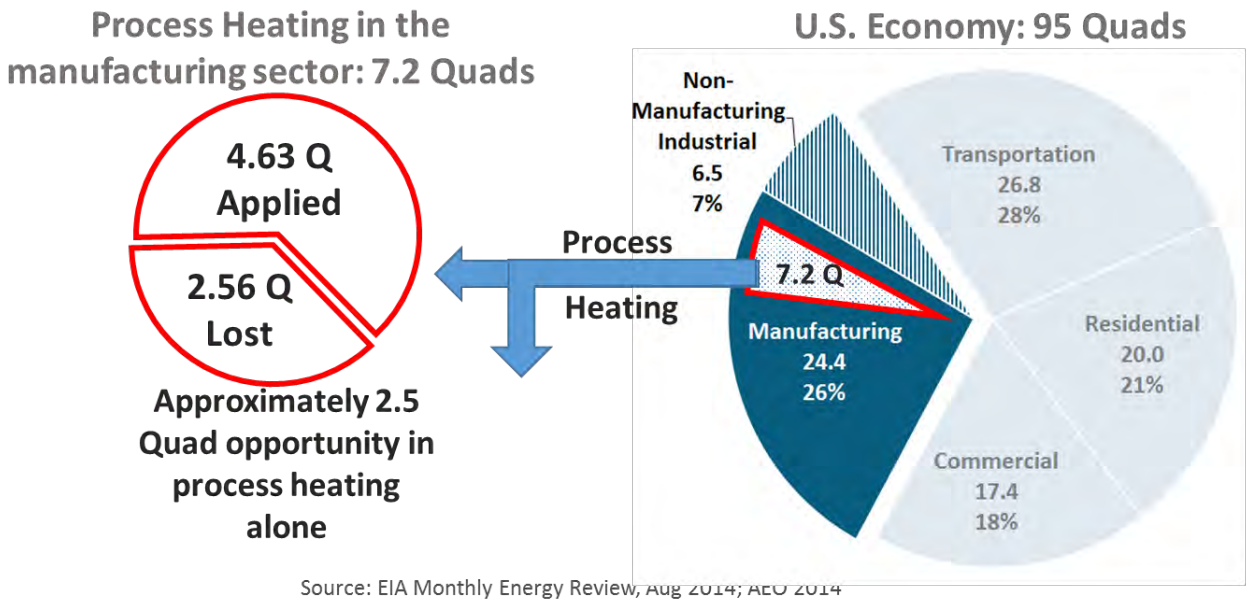
BIDIRECTIONAL

○ Technology is less likely to achieve performance goal

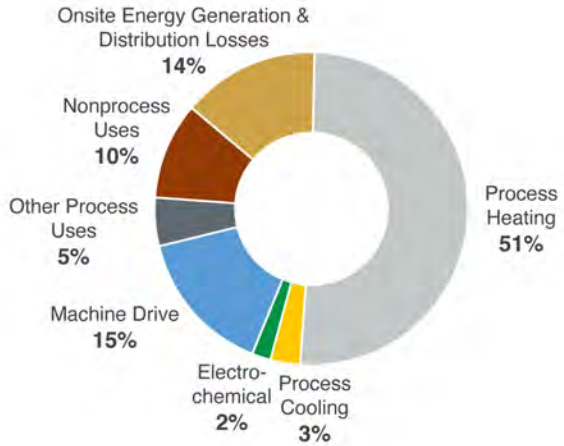
● Technology is more likely to achieve performance goal

ESGC Roadmap :
https://www.energy.gov/energy-storage-grand-challenge/energy-storage-grand-challenge

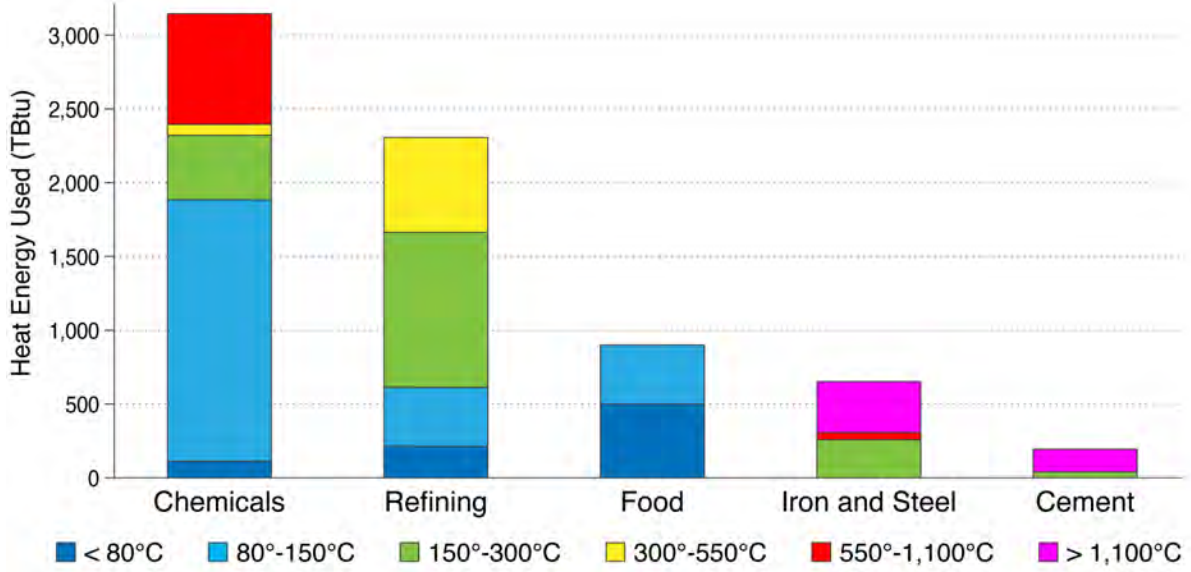
Thermal opportunity



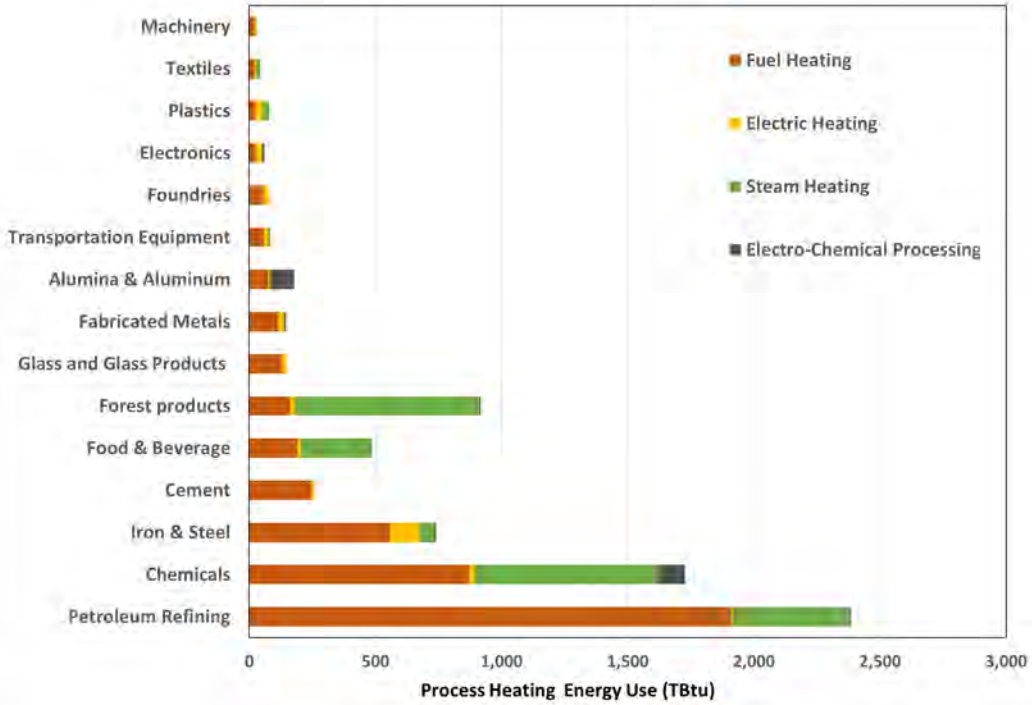
Source: EIA Monthly Energy Review, Aug 2014; AEO 2014



Onsite manufacturing energy end-use facilities in the U.S. in 2018 by end-use.
2018 Manufacturing Energy Consumption Survey (MECS) data.



Distribution of process heat temperature ranges by industrial subsector in 2014.
Temperature ranges are in °C and heat use is in trillion Btu (TBtu). Data source: McMillan 2019



Investments in Industrial Decarbonization Technologies

Innovative Metals Processing

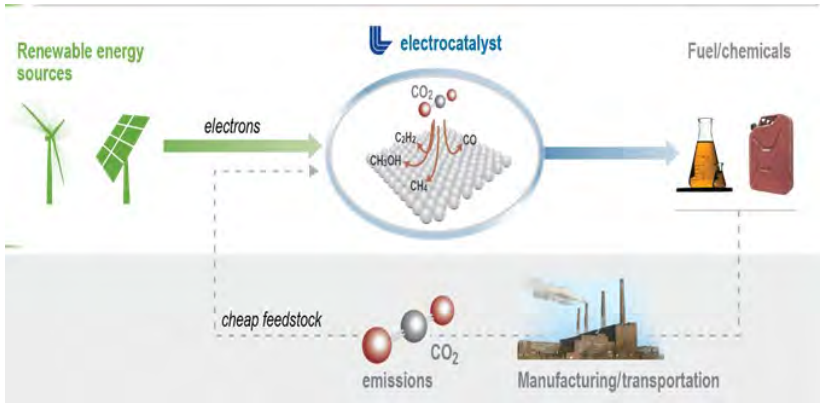
Improve the energy and carbon footprint of metals production, including through increased recycling of scrap, co-products, and process gasses.

- *Direct electrolysis*
- *Alternative reductants*
- *Electrochemical recovery*
- *Selective separations*

Flash ironmaking

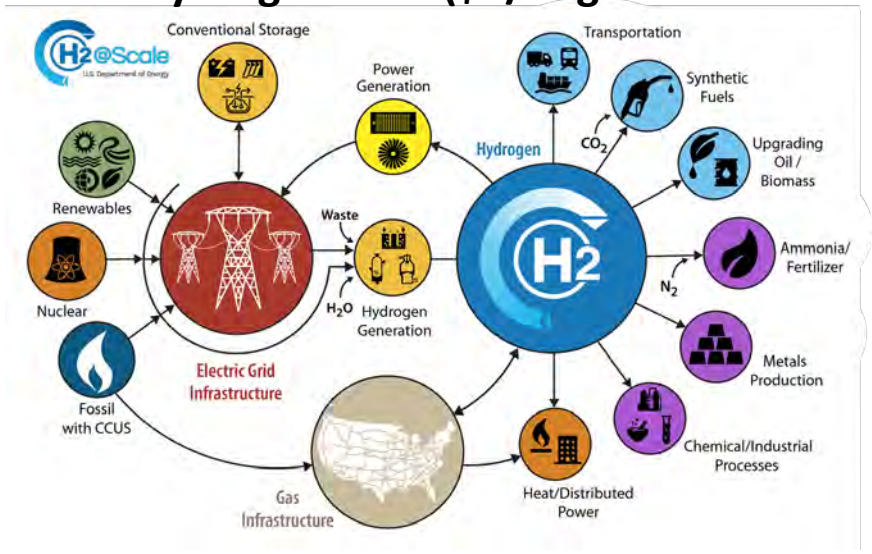
Efficiency Improvements in Chemical Manufacturing

Develop catalytic processes to optimize conversion rates & selectivity.



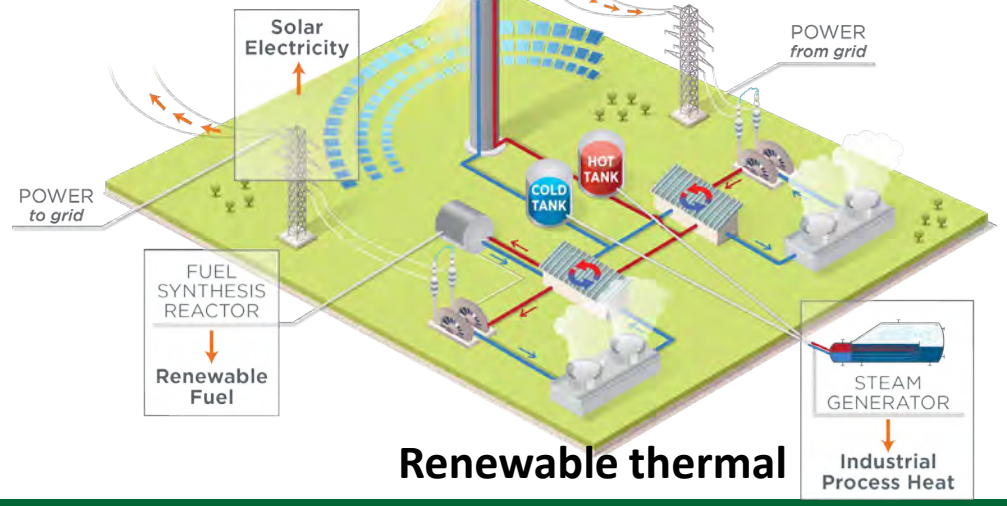
One-step electrochemical ethylene production from CO_2

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



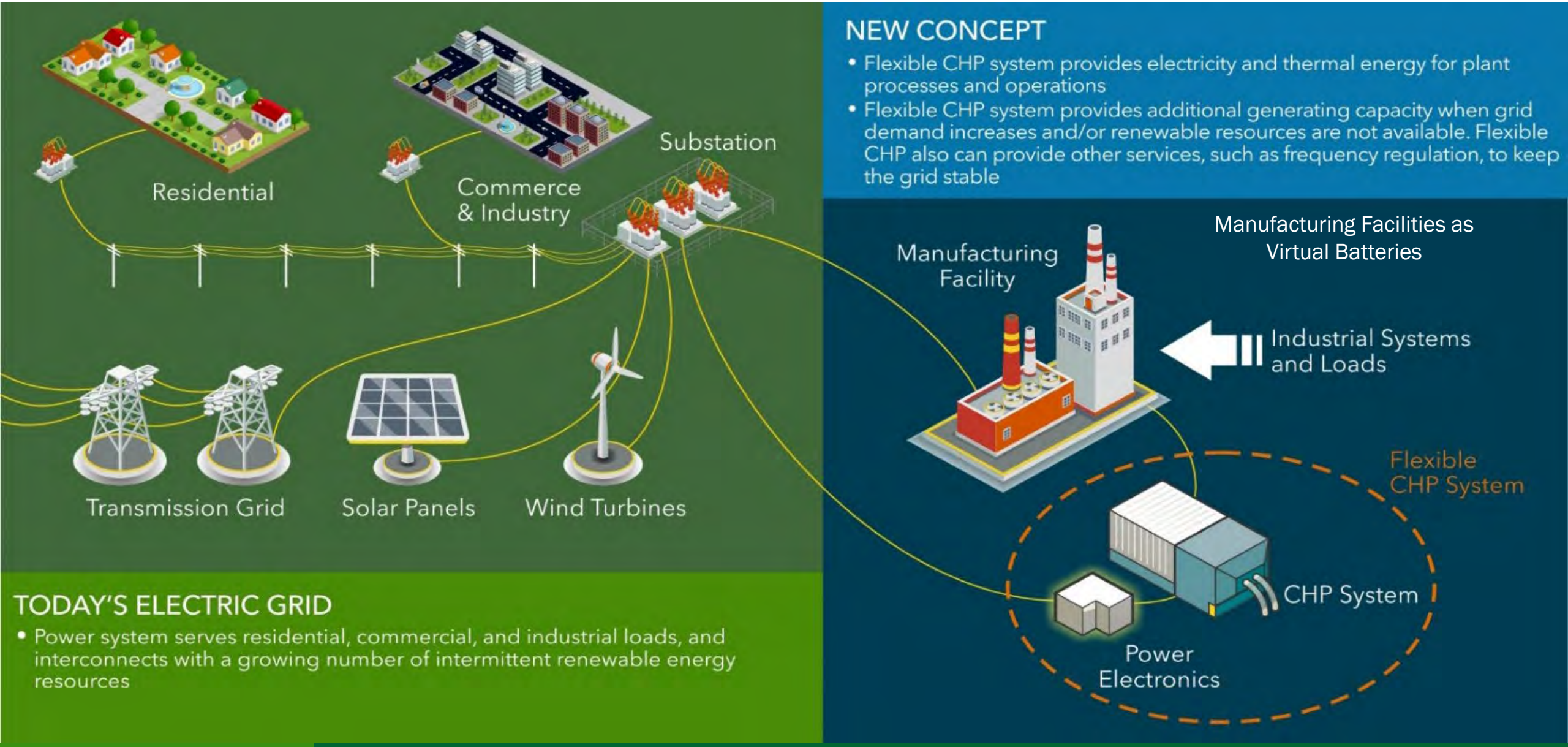
Thermal Process Intensification

Develop low thermal budget technologies + low-carbon energy sources.



Renewable thermal

Flexible manufacturing facilities



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.

EXAMPLE OF OPTIMIZED TRANSPORT NETWORK FOR ECONOMY-WIDE CARBON CAPTURE AND STORAGE.

The circular dots show the types of CO_2 emitting sources, including several industrial categories, and triangles showing two classes of storage locations. Source: Abramson, McFarlane, and Brown (2020)

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

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

Thank You!

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http://manufacturing.energy.gov