

Training Day – Module 3B

Decarbonising non-electrifiable energy demand

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Poll # 1:

Which of these hard to decarbonise industries generates the most global emissions?

- ☐ Iron and steel
- ☐ Cement
- ☐ Pulp and paper
- ☐ Glass
- ☐ Chemicals
- ☐ Petrochemical Refining

What are Hard to Decarbonise Industries?



Hard to decarbonise or abate industries are those that:

- Require higher heat processes to produce materials
- Rely on fossil fuels, e.g., coal, natural gas, and oil to generate high heat
- Cannot rely solely on electricity to generate high temperatures
- Are globally competitive and sensitive to small increases in production costs

Hard to decarbonise industries are reliant on thermal processes to produce finished goods.

- **Lower temperatures ($< 150^{\circ}\text{C}$ / $< 300^{\circ}\text{F}$):** Food, beverages, paper, pharmaceuticals, cleaning
- **Medium temperatures ($150 - 400^{\circ}\text{C}$ / $300 - 750^{\circ}\text{F}$):** Chemicals, polymer production, casting, materials production
- **Higher temperatures ($>400^{\circ}\text{C}$ / $>750^{\circ}\text{F}$):** Steel, cement, glass, ceramics, petrochemical refining

Petrochemical Refining

- Requires heat rates higher than 400° C for distillation, cracking, and reforming processes
- Energy feedstocks include natural gas, coal, and fuel oil, used for steam production, and heating boilers and furnaces.
- Electricity is used for mechanical, non-thermal purposes.



Petrochemical Refining – Lowering emissions

- Hydrogen, including green hydrogen, is an alternative feedstock to reduce energy intensity and emissions
- Biomass and renewable energy sources reduce emissions for electricity uses
- Waste gases from refining processes can be captured and stored, or used to produce lower emitting fuels

Iron and Steel Production

Production uses two methods for high thermal heat:

- Blast furnace–basic oxygen furnace method relies on coal and coke for 90 percent of energy to process ore into metals
- Electric arc furnace method relies on electricity to process scrap metal into new materials, using half the energy



Iron and Steel Production – Lowering emissions

- Electrification and use of renewable energy can reduce energy intensity of production
- Hydrogen-based steelmaking can be used to produce high heat for BF-BPF processes

Cement is produced in two stages:

- **Clinker production** requires heating raw materials to over $1,450^{\circ}\text{C}$ in rotary kilns
 - Feedstocks include coal, pet coke, and natural gas
- **Grinding and milling** of clinker, gypsum and other materials, and other mechanical processes
 - Energy source is mainly electricity.



Cement Production – Lowering emissions

Biomass: wood chips, rice husks, and agricultural residues

Waste-derived fuels: refuse-derived fuel, solid recovered fuel, used tires, and sewage sludge

Renewable fuels: biofuels, clean natural gas

Green hydrogen: produced from renewable electricity for future decarbonization

Pulp and Paper Production

Pulp and paper production includes several steps, which require different energy intensity:

- Chipping logs, pulping, refining, forming sheets, drying and finishing.
- Pulping and drying require the highest heat, using coal, oil, natural gas and black liquor
- Other processes use electricity.



Pulp and Paper Production – Lowering emissions

- Thermal processes: black liquor uses pulping byproducts, replacing fossil fuels, reducing emissions
- Electric processes: renewable energy sources to offset fossil fuels

Glass Production

Glass manufacturing requires temperatures above 1500 °C to melt raw materials

- Primary fuels include natural gas and oil.
- Electricity powers motors, pumps and other mechanical processes

Some plants use electricity or hybrid systems to fuel glass furnaces, reducing energy intensity.



Glass Production – Lowering emissions

Hydrogen and green hydrogen – replacing fossil fuels

Oxy-fuel burners – Using 100% oxygen Increases combustion efficiency and reduces emissions

Hybrid furnaces – Combining electric and fuel heating

High cullet content – increasing cullet by 10% can cut energy use by ~2–3%

Heat recovery systems – Capturing exhaust heat to preheat combustion air or raw materials

Chemical Production

Chemical production uses both process heating and energy feedstocks, relying on natural gas, oil, and coal, and electricity

Natural gas is the dominant feedstock and energy source for many chemicals, including **ammonia** and **methane**



Chemical Production – Lowering emissions

Bioenergy: Biomass or other renewable feedstocks (e.g., municipal solid waste, starch, lignin) to produce chemicals or fuels

Alternative feedstocks: (CO₂, water, biomass, recycled plastics)

Renewable energy integration: (solar, wind)

Energy efficiency: (process optimization, heat recovery, advanced catalysts)

Food and Beverage Production



Food and Beverage production uses different energy resources for several processes:

- **Process Heat:** natural gas or waste heat steam production
- **Refrigeration and freezing:** electricity
- **Drying and baking:** Steam, hot air or ovens using electricity



Food and Beverage Production - Lowering emissions



- Renewable energy for electrical uses
- Bioenergy for high process heating

Decarbonisation Barriers:

Heat intensity

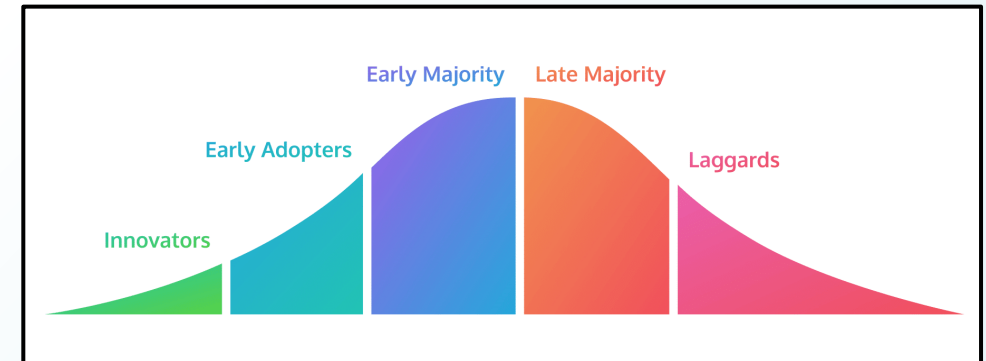
Can renewable energy and electrification work for high heat industries? If not, what are lower emission options ?

- Hydrogen, specifically green hydrogen
- Biofuels and waste byproducts
- Concentrated solar facilities
- Future: Technology development

Decarbonisation Barriers: Market and Adoption Barriers

Adoption of new technologies and processes follows the pattern of the innovation or product adoption curve

- Commercialization/supply chain
- Lower cost
- Reduced risk



Any change in use of resources and feedstocks in industrial processes and power will require initial investment, and evaluation of cost differential and cost effectiveness of the investment.

- ROI of lowest cost abatement solution must be clear and worth the cost of the change
- Value of change must occur over time

Adoption of laws and policies can incentivize or deter the adoption of industry decarbonization

- **Example #1:** Cap and trade and carbon taxes create incentives for investment and to reduce emissions
- **Example #2:** Changes in government leadership can creating instability in investment and markets

Government and private funding, supportive policies, and coordination across sectors will help.

Technology Innovation Required

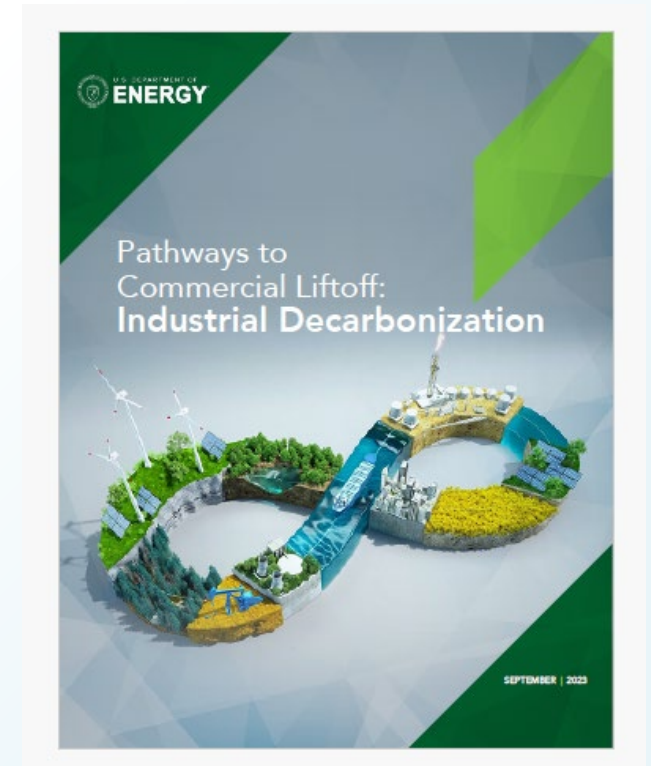


To move beyond the innovator and early adopter stage, research and development at the government, industry and company level will be necessary.

- Support and development in US Biden Administration - Lift Off Reports, Loan Program Office and funding
- EPRI and GTI Low Carbon Resources Initiative – industry funded research and development of low carbon fuels

Pathways to Commercial Liftoff: Industrial Decarbonization

- Focuses on eight industrial sectors, providing options
- Uses Marginal Abatement Cost Curve Analysis to identify the lowest cost abatement solution for each ton of emissions across the eight sectors
- Identifies need for government policies and private investment.



The Low-Carbon Resources Initiative (LCRI) will focus on large-scale deployment to 2030 and beyond.

Fundamental advances in a variety of low-carbon electric generation technologies and low-carbon chemical energy carriers - such as clean hydrogen, bioenergy, and renewable natural gas - are needed to enable affordable pathways to economy-wide decarbonization.



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With the information you have heard this afternoon, what do you consider the most difficult barrier to industrial decarbonization globally?

- **Cost, funding**
- **Competitive pressure**
- **Supply chain, availability of resources (e.g., biofuels)**
- **Laws and Policies**
- **Market structures and incentives**
- **Commercialization**



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