Industrial emissions: the forgotten climate wedge

2018 U.S. GHG emissions vs. FY20 DOE clean energy RD&D funding

- Agriculture: 10%
- Transportation: 29%
- Buildings: 12%
- Industry: 22%
- Electricity generation: 27%

DOE Portfolio, by Sector, FY 2020
- Transportation: 16%
- Science/Crosscutting: 25%
- Agriculture: 1%
- Buildings: 6%
- Industry: 6%
- Electricity: 46%

Source: Sivaram, Cunliff, Hart, Friedmann, and Sandalow (2020)
Why are emissions from heavy industry hard to abate?

Challenge #1: High-temperature heat for industrial processes relies on fossil fuel combustion

Challenge #2: “Process emissions” from chemical transformations cannot be eliminated by switching to clean energy

Calcination: \[ \text{CaCO}_3 + \text{heat} \rightarrow \text{CaO} + \text{CO}_2 \]
Goals for Session 1: Crosscutting Topics

- What are the most critical cross-cutting research, development, and demonstration (RD&D) priorities in high-temperature systems to meet climate targets and advance manufacturing competitiveness?
  - Electrification for heating, electrochemical processes
  - Clean hydrogen as feedstock, reductant, or fuel

- What are the tradeoffs between electrification and hydrogen?
# Greening High-Temperature Manufacturing: Agenda

(Wednesday, January 27, 10AM to 1PM EST)

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<th>Topic</th>
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<td>Welcome &amp; Introduction</td>
<td>Colin Cunliff</td>
<td>10:00 to 10:05 AM</td>
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<td><strong>Session 1: Cross-cutting Topics</strong></td>
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<tr>
<td>Electrification</td>
<td>Ali Hasanbeigi</td>
<td>10:05 to 10:20 AM</td>
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<td>Hydrogen industrial applications</td>
<td>Mark Ruth</td>
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<td>H2 vs electrification tradeoffs</td>
<td>Mark Johnson</td>
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<td>Response + discussion</td>
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<td><strong>5 min break</strong></td>
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<td><strong>Session 2: Sectoral Topics</strong></td>
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<td>Hydrogen production</td>
<td>Everett Anderson</td>
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<td>Chemicals</td>
<td>Karthish Manthiram</td>
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<td>Iron &amp; Steel</td>
<td>Marlene Arens</td>
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<td>Cement</td>
<td>Maria Juenger</td>
<td>12:15 to 12:30 PM</td>
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<td>Response + discussion</td>
<td>all participants</td>
<td>12:30 to 1:00 PM</td>
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Cross-cutting priorities for clean manufacturing RD&D: Topics for discussion

1. RD&D priorities for:
   - industrial applications of hydrogen (ignore H2 production)
   - electrification of heat (> 150°C)
   - other options (novel processes, CSP)

2. How mature is each approach? Where *(what innovation stage)* should government invest? What program structure?

3. What *innovation targets* should a federal RD&D program pursue?

4. What *other policies* would complement RD&D investments?
5 min break
Resume at 11:25
Sectoral priorities for clean manufacturing RD&D: Topics for discussion

1. RD&D priorities for:
   - hydrogen production (e.g. roll-to-roll electrolyzer manufacturing)
   - chemicals production (e.g. novel electrochemical processes, resistive heating)
   - iron & steel (hydrogen-DRI, direct electrolysis)
   - cement (SCMs, kiln electrification, CCS)

2. How mature is each approach? Where (what innovation stage) should government invest? What program structure?

3. What innovation targets should a federal RD&D program pursue?

4. What other policies would complement RD&D investments?
What other federal policies would complement federal RD&D investments?

- Tax incentives for manufacturers or investors
- Contracts for differences
- Loans or loan guarantees for manufacturers
- Regulatory reform
- Codes and standards
- Government procurement of end products (through GSA, DOD, DOT, USACE)
- Workforce development
At what innovation stage should government invest? What RD&D investments are most useful?

- Publicly-funded, investigator-initiated basic research?
- Publicly-funded, targeted applied R&D at labs and universities?
- Cost-shared pilot-scale facilities run by public agencies?
- Cost-shared commercial-scale demo projects carried out by manufacturers?
- Publicly-supported, industry-led manufacturing consortia that focus on targeted challenges/sectors (e.g. roll-to-roll manufacturing of electrolyzers)?