Low Temperature Workshop

February 3, 2021

Background: Production of chemicals, petrochemicals, refining, paper and food processing use about 4 exajoules (EJ) of primary energy at temperatures below 150 °C and 6 EJ at temperatures below 300 °C. More than half of this is used to produce chemicals and petrochemicals[1]. These industrial uses for low-temperature heat are in addition to the more than 18 EJ used to provide heating, cooling, refrigeration, drying for residential and commercial buildings[2]. Since climate policies are likely to motivate major changes in the production of fuels and chemicals now based almost entirely on fossil feedstocks, this workshop will focus primarily on the food processing and pulp and paper industries and their relation to technologies in buildings.

Currently, these low-temperature processes are mostly directly powered by fossil fuels -- typically natural gas in systems where capture and sequestration of CO_2 is not practical with known technology. A significant fraction of the energy used in papermaking, and food processing is used to remove water from materials, typically by adding enough energy to evaporate liquid. Both require enough energy to drive a phase change. Low-cost natural gas has meant that there has been little incentive for innovation in these technologies.

Climate policies and rapid technical advances in other fields, however, could lead to rapid change. Highly efficient heat pumps, including units able to provide heating to above 100 °C, and operate efficiently with heat sources below 0 °C would be particularly attractive. Many of these systems may be able offer process productivity advantages such as increased controllability, and safety. New approaches could also replace traditional refrigerant-driven heat pumps with devices using electrothermic or magnetic, while novel membrane technologies and heat exchangers could also improve process efficiency. Drying processes not using vapor-compression cycles are not limited by Carnot efficiency and ultrasound or pulsed-electric drying, novel separation membranes, and other innovations have the potential to provide large efficiency gains. Alternately, fossil fuels could be replaced with zero-energy synthetic fuel like hydrogen.

Technologies to reduce emissions associated with low-temperature thermal processes and water removal in buildings and industry will be critical for meeting global climate goals. Climate change and growing incomes worldwide are likely to drive rapid growth in demand, particularly for air-conditioning and dehumidification equipment[3]. This in turn will create opportunities for firms able to capture these growing markets with breakthrough technical solutions.

---

[1] Edward Rightor, Andrew Whitlock, and R. Neal Elliott, Beneficial Electrification in Industry, ACEEE, 2020, https://www.aceee.org/sites/default/files/pdfs/ie2002.pdf

[2] DOE, Quadrennial Technology Review, 2015, https://www.energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter5.pdf

[3] IEA, 2018, The Future of Cooling, https://webstore.iea.org/download/direct/1036

Issues for Discussion:

1. What are the most critical research priorities in low-temperature systems to meet US climate targets while creating opportunities to increase the competitiveness of US manufacturers in a global economy focused on climate goals? Research areas would include high-efficiency heat pumps for a range of temperatures, replacements for conventional refrigerants, and new water removal technologies.
    - Are critical research topics or topic areas missing?
    - Are some of the topics suggested clearly dead ends?
    - Who (what communities) should have been included in our discussion but are missing?
2. How can research on innovations in low-temperature industrial processes best be integrated with building technology research?
3. What novel approaches have the greatest potential to increase product quality and/or process yield?
4. Should low-temperature processes be a part of an initiative in zero-carbon fuels (e.g. hydrogen or ammonia made from renewable electricity.)
5. Can we anticipate the energy requirements of new industrial processes that may replace many conventional petrochemical and food-processing industries (e.g. synthetic biology)
6. What are major technology opportunities that are NOT currently being researched?

Invited speakers:
Tony Bouza, DOE Advanced Manufacturing Office
David Claridge, Texas A&M Matthew Gurwin, Heat X
Melissa Lapsa, Oak Ridge National Laboratory
Ayyoub Momen, Ultrasonic Technology Solutions
Kashif Nawaz, Oak Ridge National Laboratory
Paul Scheihing, 50001 Strategies
Lena Schnabel, Fraunhofer ISE
Jamal Yagoobi, Center for Advanced Research in Drying

Agenda:

Session 1: Heat Pumps

- General Introduction: Joe Hagerman, 5 min
- Defining the topic: Kurt Roth, 5 min
- Short talks
    - Tony Bouza (Moderator) 5 min intro
    - Lena Schnabel, 10 min
    - Kashif Nawaz, 10 min
    - Matthew Gurwin, 10 min
    - Paul Scheihing, 10 min
- Facilitated Discussion: 35 min
    - What advancements in heat pump technology are necessary to allow for major implementation in industrial applications?

5 min break

Session 2: Drying

- Defining the topic: Henry Kelly, 5 min
- Short talks
    - Melissa Lapsa (Moderator), 5 min
    - Jamal Yagoobi, 10 min
    - Ayyoub Momen, 10 min
    - David Claridge, 10 min
- Facilitated Discussion 35 min
    - Will there be feasible, electrified drying processes that can replace fossil fuel-based drying in applications such as pulp and paper manufacturing

Closing thoughts: Joe Hagerman, 10 min