U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Low Temperature Workshop

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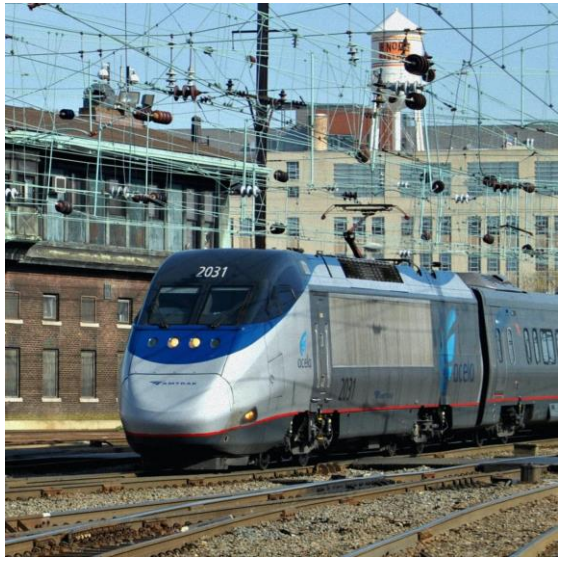
Heat Pumps, getting to our goals…



Trains are more efficient, but cars are more flexible (less planning, GPS to guide you towards your destination).

Heat Pumps are more energy efficient but require some work (planning, engineering and innovation).

Introduction

- Pursue useful, energy efficient and affordable solutions; perfect is the enemy of the useful
- Heat Pumps: About moving heat, not creating heat
- Real world is a complex place
  - Requires knowledge of both the capabilities of heat pumps and industrial process, limited people with combined knowledge set
  - Waste heat is not constant, *waste heat recovery* is key
  - Identifying heat pump integration opportunities is hard (IEA HPP Annex 35), due to lack of awareness of thermal load requirements
  - Limited number of manufacturers, particularly for higher temperatures

Critical research priorities in low-temperature systems

Priority is to decarbonize heat; Industrial Heat Pumps for industrial decarbonization

- Focus on heat and mass transfer processes
  - Better thermal management
  - Better equipment: heat exchangers and compressors
  - Refrigerant R&D for heat pumps supplying heat in the range of 150°C to 250°C; super-critical carbon dioxide (sCO2) and other options

Critical research priorities in low-temperature systems

Priority is to decarbonize heat; Industrial Heat Pumps

- Non-vapor compression R&D with energy efficiency
  - Past limited to just cooling technologies
  - Hybrid solutions should be explored (low lift)
- One size does not fit all, ***build flexibility***
  - Machine learning (ML) and artificial intelligence (AI), builds upon case studies
  - Additive manufacturing (AM) technologies

Major technology opportunities, NOT researched

- Establishment of uniform methods of test for industrial heat pump units; including the development of alternative rating method (ARM), in lieu of actual testing; to simulate the energy consumption of industrial heat pumps
- Non-traditional cycles (low TRL) and working fluids, e.g. super-critical carbon dioxide (sCO_2), hydrogen: electrochemical compressor driven metal hydride heat pump systems
- Circular Economy (material & system efficiency)