Annex 53

Advanced Cooling/Refrigeration Technologies Development

Initial organizing meeting
Atlanta, GA, USA

January 11, 2019
So what’s the problem?
Future of AC: Energy Consumption

- IEA projects energy consumption for space cooling to grow 4.4 times in Non-OECD countries by 2050 versus 1.5 times for OECD countries.
- Rising incomes and greater access to AC equipment in many developing nations opens the door to building cooling for billions of people.

(Source: IEA, Energy Technology Perspectives 2016)

Note: Exajoule [EJ] = $10^{18}$ Joules or 0.95 Quadrillion [$10^{15}$] Btus
FOOD REFRIGERATION

- ~1/3 of food is wasted between harvest and home – much due to imperfect refrigeration.
- The global CO2 emissions (10%) associated with refrigeration and air con is greater than aviation and shipping combined. Need to focus on refrigerant leaks.
- Supermarket equipment buyers focussed on capital cost and not LCC.
- Best in class equipment usage could improve efficiency by 30%.
- Doubling the UK efficiency could save the UK £1b.
- Need to put doors on refrigeration cabinets as standard.
Future of AC/R: what is the future?

Growing populations and increasing global demand, especially in hot-humid countries, will make reaching global energy and climate goals even more challenging.

What actions can the global HVAC&R community take to reduce the impact of future space cooling, dehumidification, and refrigeration needs?
So what should we do: near term and future?

**Near term**
- Maximize deployment of SOA technologies
- Promote minimum energy performance standards

Organizations: UNEP, World Bank, others

**Advanced technologies**
- Vapor compression based
  (maximize efficiency, minimize GWP)
- Alternative cycle technologies

Organizations: IEP/AHPT (*Annex 53*, *Annex 54*)
IEA/SHC (new Task in development on solar cooling technologies)
IIR: Working groups, THERMAG events, etc.
Member country research institutes

**Future technologies 2025 and beyond**
Advanced AC/R technologies

Two possible paths

Future Path 1:
Advanced Vapor Compression with Low or Ultra-Low GWP Refrigerants

Future Path 2:
Non-Traditional Technologies (Zero-GWP)

(Source: U.S. Department of Energy Building Technologies Office, Emerging Technologies Program)
VCC System Performance Breakdown

Loss 1: material irreversibilities
Loss 2: compressor efficiency and expansion loss
Loss 3: pressure drop in two refrigerant heat exchangers
Loss 4: external heat transfer irreversibility
Loss 5: parasitic power (pump, fan, etc.)
• No one technology is a clear winner for AC or refrigeration
• VC has had decades of RD&D to date (and it is continuing)
  • VC may likely continue to be system of choice
    • Especially for near term, and possibly long term as well
  • But is vulnerable to further refrigerant restrictions
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- **Impetus**
  - Projected major increase in worldwide AC/refrigeration demand (energy use)
    - IEA projects >4-fold increase for AC alone in non-OECD countries vs. 30% growth projection in OECD world

- **Objective**
  - Develop technology solutions for higher efficiency AC/refrigeration systems to minimize/reduce projected energy consumption increase
    - WE DO NOT WANT another simple technology options ranking exercise!

- **Main technology focus areas**
  - Traditional vapor compression (VC), alternative VC approaches, and non-traditional cycle approaches for AC and/or refrigeration applications
  - Scope is broad but general consensus from discussion in October that the challenge is also huge; not likely to be one or even a few “right” solutions

- **Specific topics for investigation could include**
  - Advance technology readiness level (TRL) of non-traditional cooling technologies
  - Better integration with nZEB or other low energy buildings, including better optimized waste heat recovery
  - Independent latent and sensible control; systems tailored for different climate conditions
  - Early stage R&D focus (meets new EERE guidance)
Annex 53 – current approach/tasks

• **Task 1 –**
  • Participants to identify and quantify development status of technologies they plan to emphasize
    • Provide country reports describing current development status of focus technology(ies) and summarizing R&D project plans to OA
    • Should include SOA analyses of how proposed technologies will address/overcome inefficiencies and GHG emission levels of current SOA AC/ref technologies

• **Task 2 (main R&D task) –**
  • Analyses (modeling/simulation case studies, etc.)
  • Lab proof of concept testing/model validation/ revised case studies, etc.
  • Best estimates of cost potential vs. VC technology
  • Submit country report to OA with detailed task results

• **Task 3 –**
  • Based on Task 2 results develop recommendations for further development with focus on both efficiency and cost effectiveness
    • Suggestions for follow-on Annex proposal(s)
    • Identify potential manufacturing partners to extent practical
    • **UK comment – include some assessment about “first entry” market segment possibilities**

• **Task 4 –**
  • Participants submit draft country reports summarizing all Annex activities
  • OA prepares final Annex report for ExCo review/approval
  • OA establishes web site for Annex
Sample US Early-Stage AC R&D Projects

- **Separate sensible & latent (SSLC)**
  - Solid-desiccant based system
  - Membrane-based dehumidification (DH) using ultrasonic enhancement
  - Electrostatic field based DH (carbon nano-rods)
  - Membrane-based heat & mass exchanger (HMX) model development

- **Alternative cycles**
  - Solid-state: Thermoelastic cycle investigation (UoMD)
  - Solid-state: Magnetocaloric refrigerator development
  - Sorption-based: triple-state absorption heat pump

- **Advanced VC-related**
  - Oil-less compressor/high-speed centrifugal compressor rotor
  - R-718 (water) or R-744 (CO2) based commercial refrigeration (recover expansion loss, pressure exchanger concept)
  - Electrochemical compression based cycle development (proton exchange membrane concept; papers O.4.9.3 & 4 at 2017 heat pump conference)