Annex 53

Advanced Cooling/Refrigeration Technologies Development

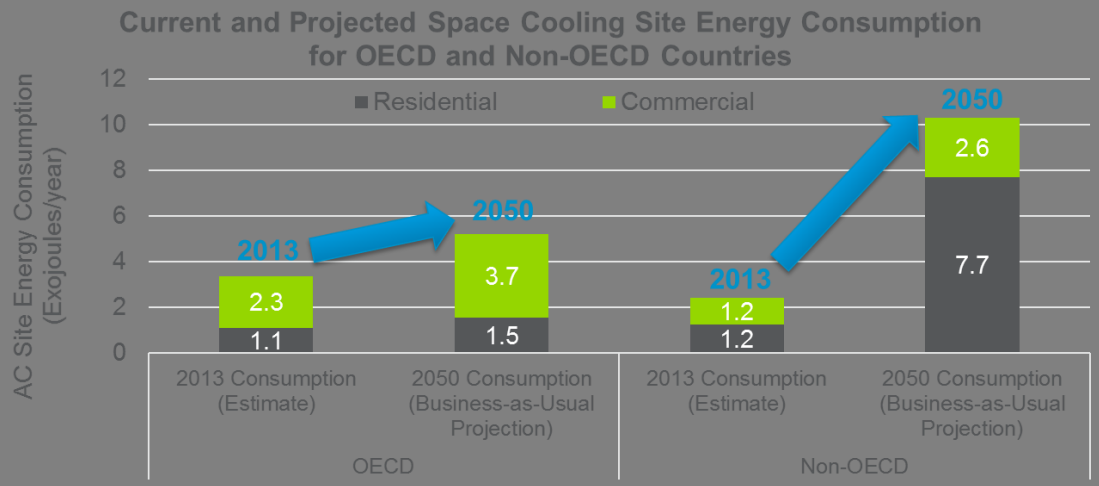
Initial organizing meeting
Atlanta, GA, USA

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

DOING
COLD
SMARTER

FOOD REFRIGERATION

BIRMINGHAM
ENERGY
INSTITUTE

- ~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.

@BHAMENERGY
WWW.BIRMINGHAM.AC.UK/ENERGY
#DOINGCOLDSNMARTER

IEA HPT

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?

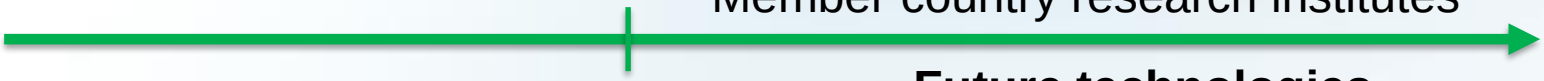
So what should we do: near term and future?

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



Now, near-term

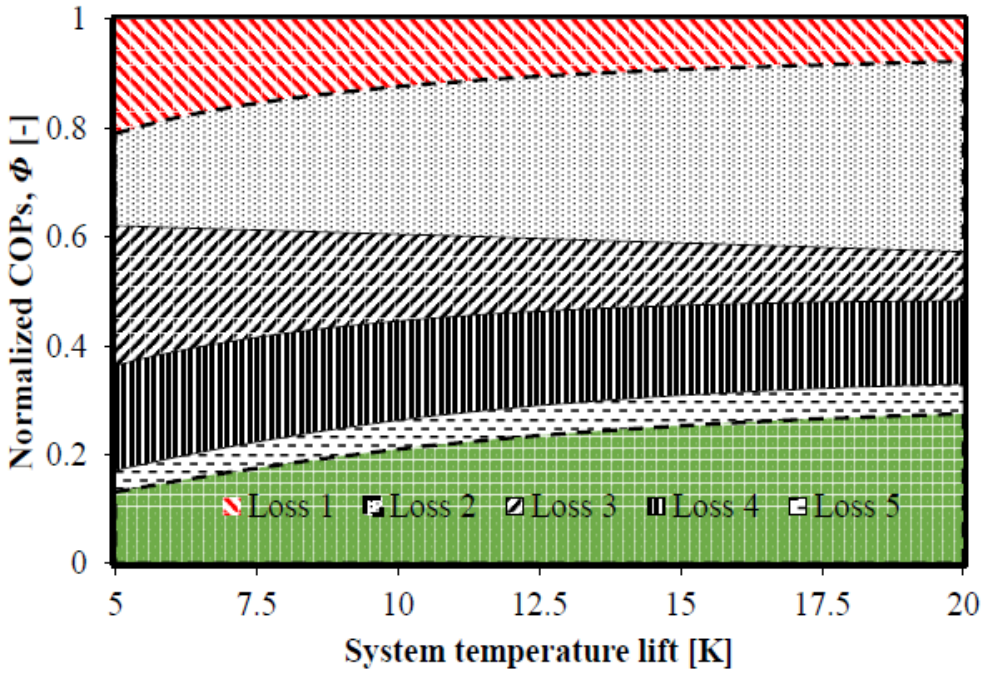
Future technologies 2025 and beyond

Advanced AC/R technologies

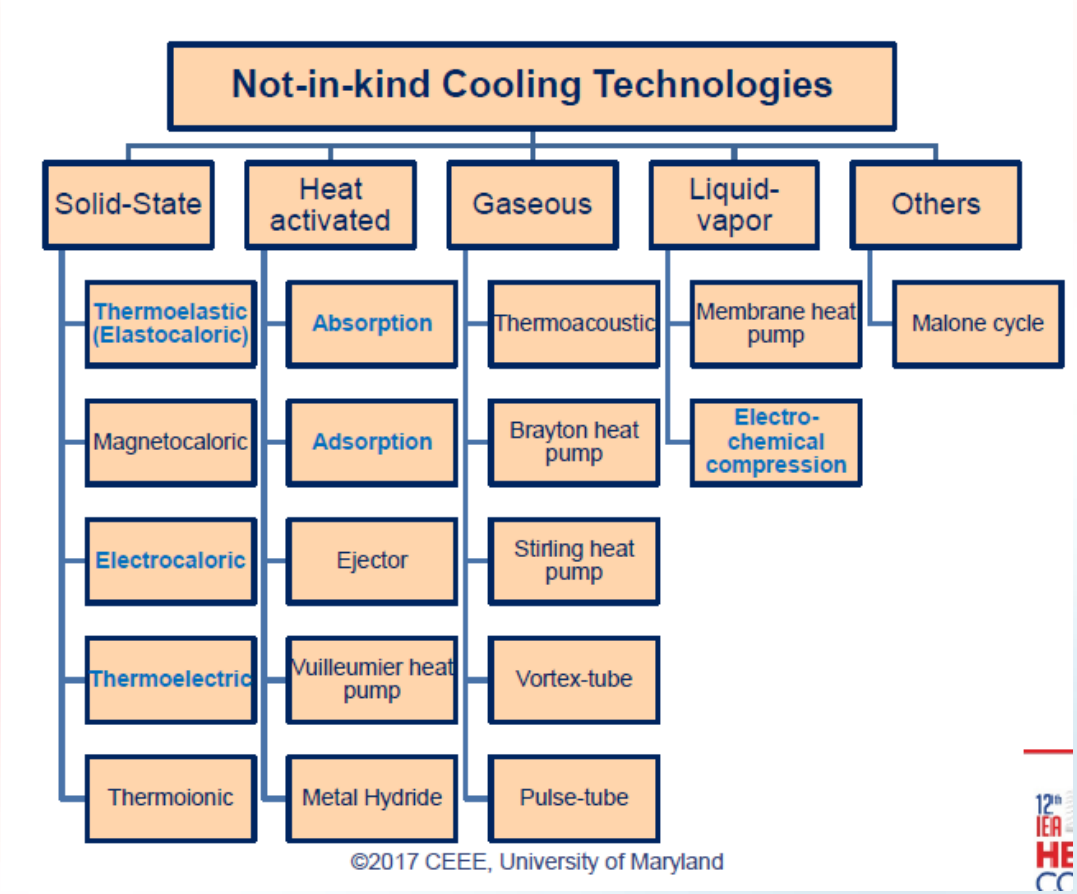
Two possible paths

(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**

Annex 53

- **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 (CO_2) 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)