

R&D Opportunity Assessment: Joining Technologies in HVAC&R

Stakeholder Discussion Forum



June 4, 2015



Navigant,
on behalf of the United States Department of Energy,
welcomes you to this forum on
Joining Technologies in HVAC&R

Introductions and Logistics

- Timing
- Phone use
- Lunch
- Restrooms

Breakout Discussion Groups

Breakout Session 1:

- *Brazing and Joining Technologies and Processes*
- *Advanced Component Design and Materials*

Breakout Session 2:

- *Brazing and Joining Technologies and Processes*
- *Installation, Operation, and Maintenance*

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	2 » Plenary Background	20 min
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The DOE aims to:

Facilitate R&D on next-generation HVAC&R joining technologies by supporting the federal government's HFC phasedown goal, as articulated by the EPA.



What is DOE's Interest?

Develop and promote efficient, affordable, and environmentally friendly technologies, systems, and practices for our nation's residential and commercial buildings that will foster economic prosperity, lower greenhouse gas emissions, and increase national energy security, while providing the energy-related services and performance expected from our buildings.

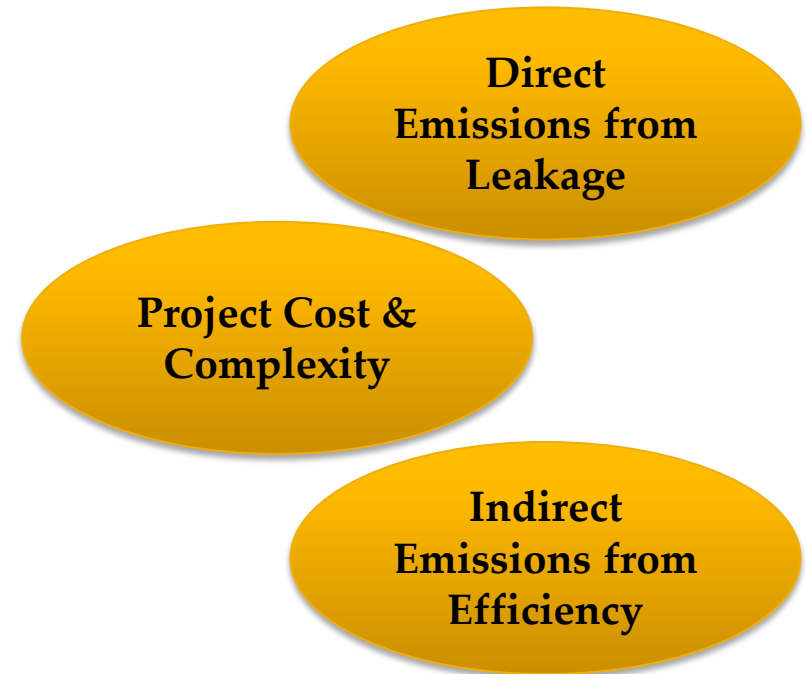
Articulating challenges and R&D opportunities helps DOE determine the appropriate initiatives to undertake to help achieve their goals.

What could R&D initiatives accomplish?

- » Lower refrigerant leakage,
- » Decrease product/project cost and complexity
- » Improve system efficiency
- » Improve system reliability
- » Others...

How?

- » Support R&D activities, including:
 - Traditional lab-based research
 - Analysis tool development
 - Pilot testing and equipment evaluation
 - Others...



DOE BTO has supported the next generation of HVAC&R systems through numerous R&D initiatives, technology roadmaps, and other projects.

- » Last year, DOE BTO published 3 documents on R&D for HVAC&R technologies:
 - *Research & Development Roadmap for Next-Generation Low Global Warming Potential Refrigerants*
 - *Research & Development Roadmap for Emerging HVAC Technologies*
 - *Energy Savings Potential and RD&D Opportunities for Non-Vapor-Compression HVAC Technologies*



DOE BTO has several initiatives underway focusing on next generation refrigerant development and system efficiency.

» **Transcritical CO₂ Supermarket Refrigeration System**

- Oak Ridge National Laboratory's (ORNL's) cooperative research and development agreement (CRADA) with HillPhoenix
- Low GWP refrigerant (CO₂), with 25 percent lower energy consumption than existing systems, and 78% lower GHG emissions



» **New Low-GWP Refrigerant for Supermarkets**

- ORNL's CRADA with Honeywell to developed Solstice N40, a non-toxic hydrofluoroolefin (HFO) -based refrigerant alternative for R-404A
- Offers a lower-global-warming potential and energy-saving replacement for R-404A



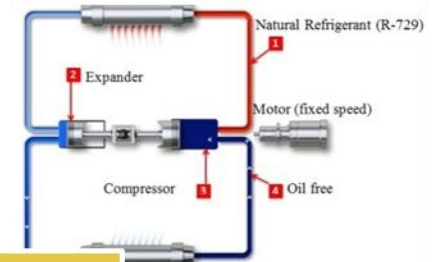
DOE is also funding several R&D efforts for HVAC technologies.



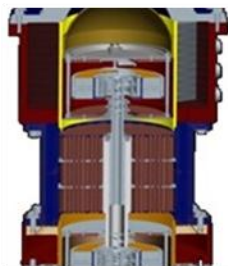
**Multi-Function
Gas-Fired Heat
Pump**



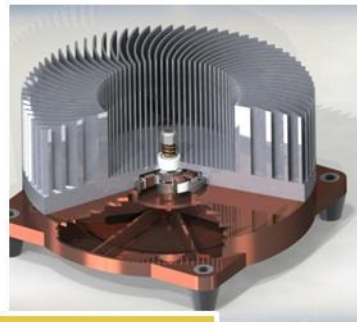
**Supercharger for
Heat Pumps in
Cold Climates**



**Natural Refrigerant
High-Performance
Heat Pump**



**Natural Gas Air
Conditioner and
Heat Pump**



**Rotating Heat
Exchangers**



**Residential Cold-
Climate Heat
Pump**

Today's forum is a critical first step towards defining R&D opportunities and guiding DOE's R&D investments.

Primary focus for discussion:

- » Air conditioning
- » Refrigeration
- » Appliances

While no less important, today we exclude:

- » Policy issues
- » Regulatory actions
- » Market transformation activities

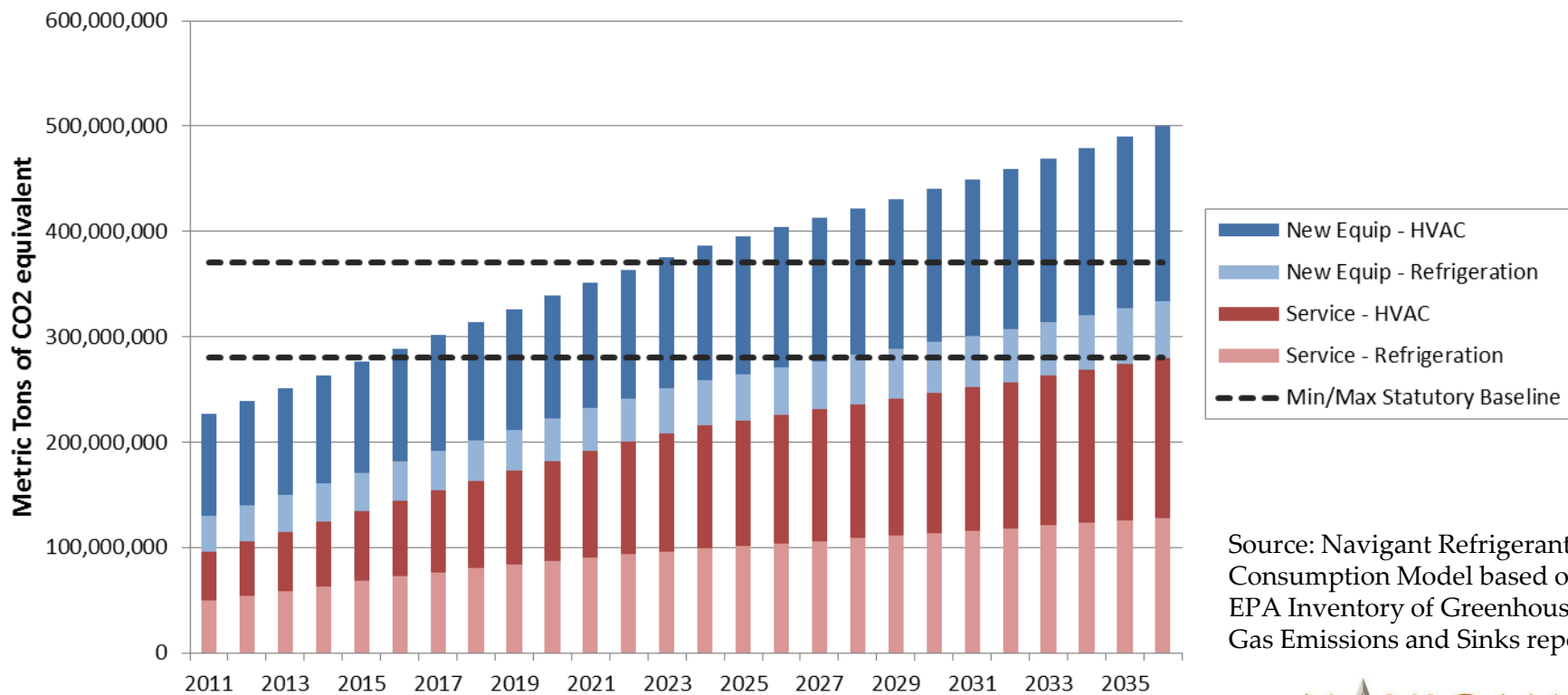
- » Discussion at this workshop does not guarantee funding for specific initiatives, but does support proactive planning for future funding opportunities.

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Absent improved refrigerant management, Navigant modeling predicts that servicing new and existing HVAC&R equipment will account for over 55% of HFC consumption in the U.S by 2035.

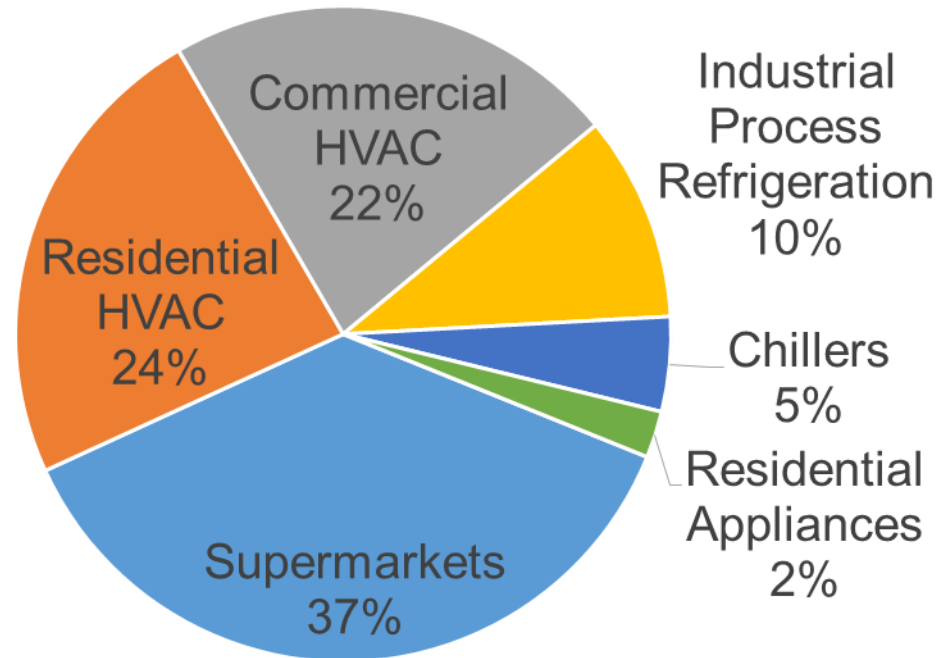
Projected GWP-Weighted HFC Consumption HVAC & Refrigeration Applications Business as Usual Scenario



Source: Navigant Refrigerant Consumption Model based on EPA Inventory of Greenhouse Gas Emissions and Sinks reports

Supermarket refrigeration, residential AC, and commercial unitary AC account for over 80% of annual HVAC&R refrigerant consumption for service purposes.

Percentage of Annual Refrigerant Consumption for HVAC&R Equipment Service (GWP Equivalent)



Source: Navigant Refrigerant Consumption Model based on EPA Inventory of Greenhouse Gas Emissions and Sinks reports

Many HVAC&R equipment types have leakage rates of 10% per year or more due to limitations in joining techniques, system designs, O&M practices, etc.

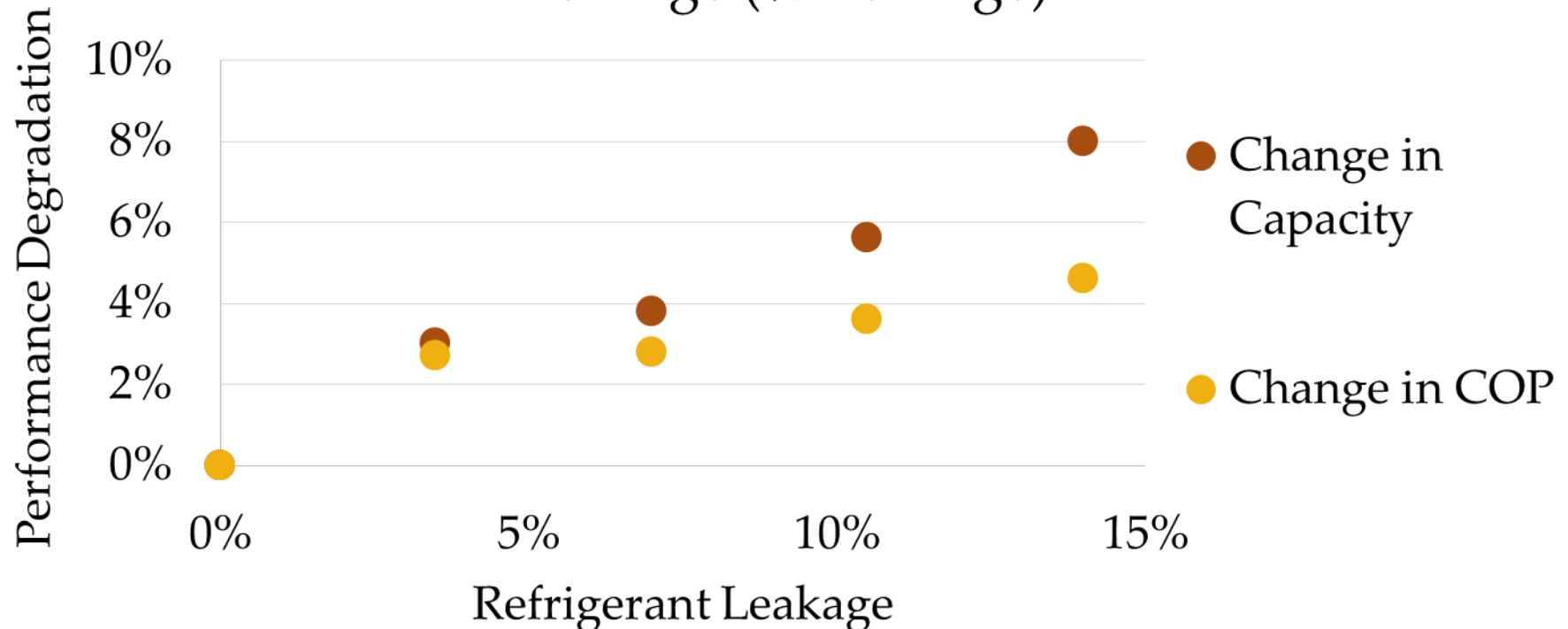
Equipment Type	Estimated Annual HFC Emissions Rates
Supermarkets and Other Retail	1-25%
Mobile Air Conditioners	2-18%
Cold Storage	15%
Residential Unitary AC	12%
Industrial Process Refrigeration	4-12%
Centrifugal Chillers	2-11%
Commercial Unitary AC	8-9%
PTAC/PTHP	4%
Refrigerated Appliances	1%

Source: EPA Inventory of Greenhouse Gas Emissions and Sinks 1990-2013 (April 15, 2015)

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Beyond HFC emissions, refrigerant leakage adversely affects cooling capacity, efficiency, reliability, and lifetime for HVAC&R systems.

Changes in Rooftop Operation due to Refrigerant Leakage (% Leakage)



Modeled effect of degradation faults on a 3-ton (10.6 kW) rooftop unit with a fixed-orifice expansion device
Source: Breuker et al. 2000. "Smart Maintenance for Rooftop Units." ASHRAE Journal. November 2000.

We need to improve joining technologies for HVAC&R equipment to reduce refrigerant leakage, decrease project cost, and improve equipment operating efficiency.

- » HVAC&R refrigerant leakage represents a substantial opportunity to reduce overall HFC consumption to meet HFC phasedown goals.
- » There are many potential pathways to reduce HFC refrigerant leakage, including:
 - Improved brazing techniques and technologies
 - Development of advanced heat exchanger and component designs with fewer brazing points
 - Ensuring optimal operation of installed equipment through leak detection, location, and repair methods
 - Others...

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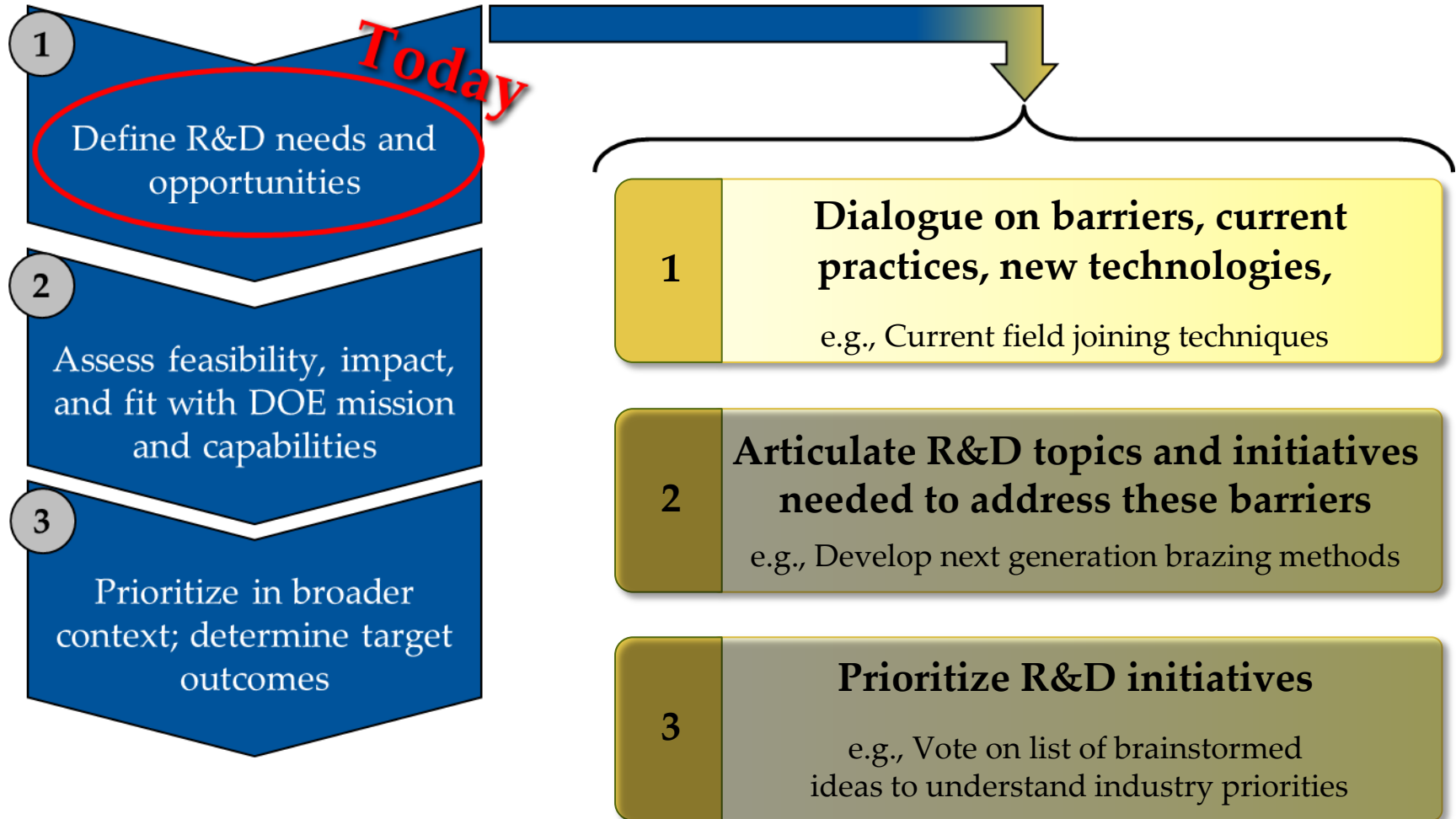
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5 » Lunch 45 min

6 » Breakout Session 2 45 min

7 » Initiative Review and Prioritization 40 min

Today's discussion will cover innovative and emerging ways to join HVAC&R systems, components, etc. to distribute refrigerants.



We have identified the following list of key challenges.

- » Creating reliable, consistent, and cost effective brazing connections in factory or field settings
- » Validating the effectiveness of compression-based, torque-based, and other advanced joining techniques and fittings
- » Overcoming limitations with current leak detection, location, and repair methods
- » Reducing the high number of potential leakage points in current heat exchangers and HVAC&R systems layouts
- » Ensuring safe and reliable operation for HVAC&R systems using alternative refrigerants with pressure, flammability, or toxicity issues.

What are other key challenges?

Group Brainstorming

What are the R&D topics, technologies, or initiatives that you think will have the biggest impact on reducing refrigerant leakage and increasing system efficiency?

How can we build on or expand these ideas to address industry challenges?

Discussion Guidance:

- » Consider technologies beyond your daily focus
- » Think about big picture
- » Build on others' ideas
- » Every idea has equal worth

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During each of the two breakout sessions, the group will split to different rooms to discuss one of two topics for that session.

- » Each group will discuss ideas to reduce refrigerant leakage, improve reliability, and lower system cost around a specific area of the HVAC&R supply chain.

Breakout Session 1

Choose one:

1. Brazing and Joining Technologies and Processes
2. Advanced Component Design and Materials

Breakout Session 2

Choose one:

1. Brazing and Joining Technologies and Processes
2. Installation, Operation, and Maintenance

- » After today's workshop, we can hold one-on-one interviews to capture any additional ideas and feedback.

Breakout Session 1

--30 minutes of discussion--

Brazing and Joining Technologies and Processes

Scope:

- Advanced brazing techniques
- Brazing materials
- Factory vs. field brazing
- Compression fittings
- Torque or threaded fittings
- Quick-connect fittings

ROOM: TBD

Advanced Component Design and Materials

Scope:

- New heat exchanger designs
- Soft vs. hard copper, aluminum alloys
- Leakage rates of specific valves or other components
- Polymer-based components

ROOM: TBD

Assign one person to report back to the larger group after the breakout; you will have 3 minutes to share the major points.

Report Out: *3 minutes per group* - *briefly* share the key talking points.

Purpose:

- Disseminate ideas to all attendees
- Encourage combination of initiatives and synthesis of new ideas

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Breakout Session 2

--30 minutes of discussion--

Brazing and Joining Technologies and Processes

Scope:

- Advanced brazing techniques
- Brazing materials
- Factory vs. field brazing
- Compression fittings
- Torque or threaded fittings
- Quick-connect fittings

ROOM: TBD

Installation, Operation, and Maintenance

Scope:

- Field installation techniques
- Leak detection and location techniques
- Field repair for inaccessible leakage points
- Loss of equipment efficiency and/or capacity

ROOM: TBD

Assign one person to report back to the larger group after the breakout; you will have 3 minutes to share the major points.

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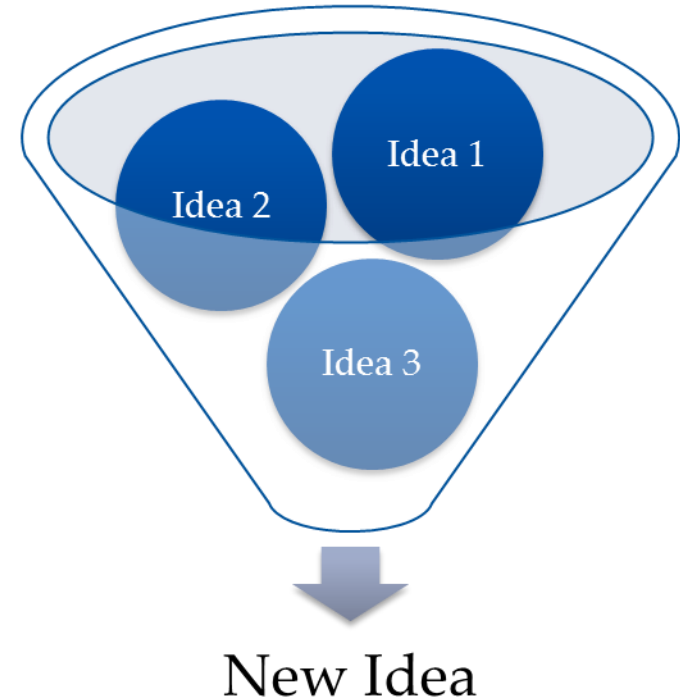
6 » Breakout Session 2 45 min



7 » Initiative Review and Prioritization 40 min

Final Discussion – Any additional thoughts or ideas from our dialogue?

- Combinations of existing ideas?
- New ideas?
- New twists?
- Important but missing details?
- New perspectives?



Let's review the ideas we have generated today to confirm that we have a clear understanding of each one.

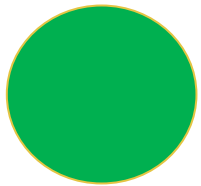
Additional questions for discussion:

Are there any other relevant issues that we did not discuss today?

How should we solicit further feedback for this project?

Who else should we talk to?

Prioritization Voting



5 dots per person to indicate high priorities

Please do not vote for any initiative more than once.

Key CONTACTS



Thank you for your inputs

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