Advanced Heat Pump Coalition

2021 Update #2

Sep 22, 2021 – 10:00 AM Pacific

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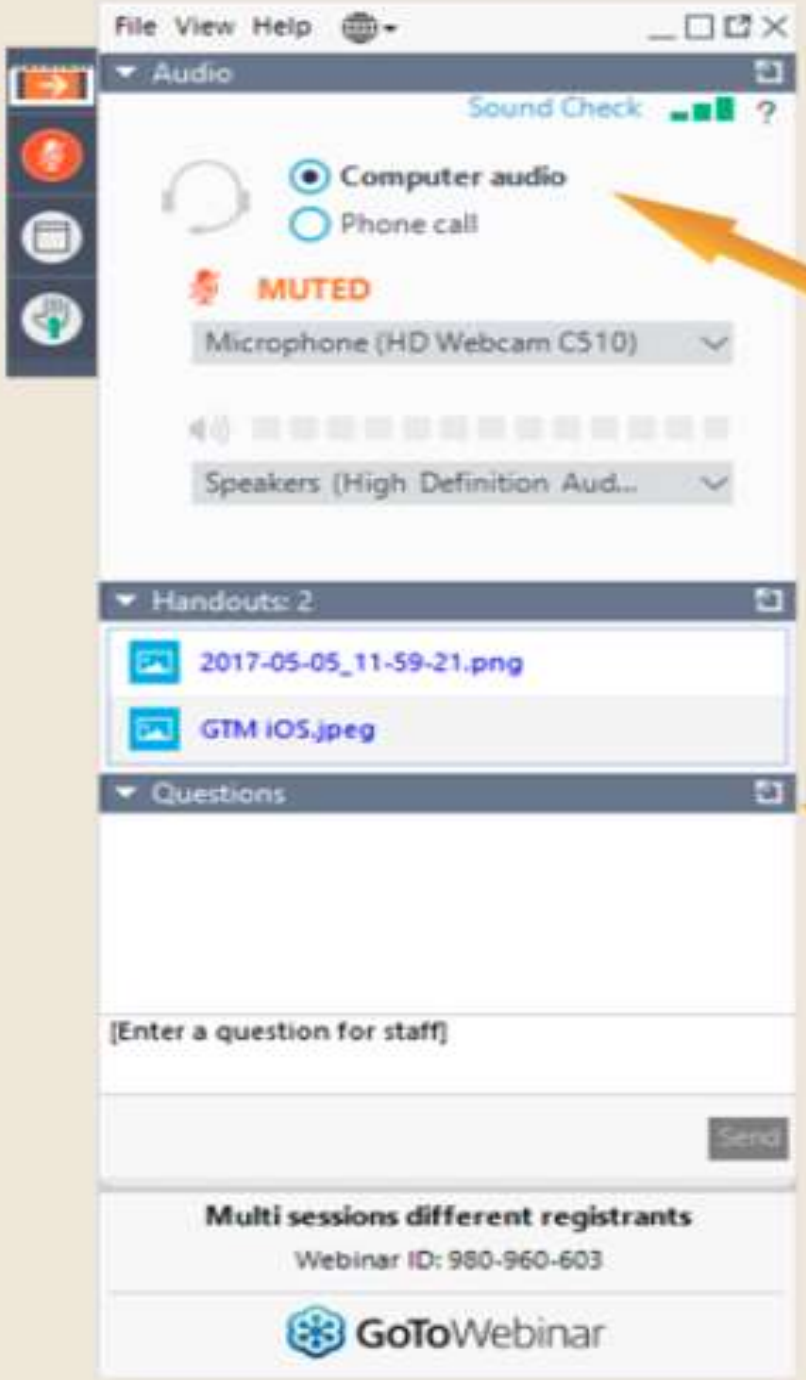
Mute & **un-mute** yourself



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how-to

ASK A QUESTION

during this webinar:

- All phones will be muted.
- We encourage use of the **QUESTIONS feature.**

Type **questions** in this box

GoToWebinar

Agenda

36 slides

General Information **15 minutes**

- Advanced HP Coalition Intro (2 slides)

Workgroup Updates (Christopher Dymond) **15 minutes**

- WG #1 – Improved Test Procedure and QPL
- WG #2 – Roadmap Specification and Manufacturer Engagement
- WG #3 – Design & Install Best Practices

EPA ENERGY STAR (Abi Daken) **15 minutes**

- Overview and updates of ENERGY STAR specs and vision for heat pumps

Department of Energy (Ed Vineyard) **40 minutes**

- Future projects and focus (a work in progress)
- Lab research activities

Intention: Update people on what has been accomplished since June 2020

Objective: Increase collaboration among members

AHPC Workgroup Updates

Christopher Dymond (mostly)

A “Coalition of the Willing”

Goal

To increase research collaboration among energy efficiency organizations that are working to accelerate market adoption of advanced heat pumps

Membership

- ACTIVE = Fund and Guide collaborative activities
- PASSIVE = attend webinars, provide feedback

Workgroups

- Steering Committee
  (NEEA, NEEP, MEEA, CEC, NRCan, EPA, NYSERDA, DOE)
- WG #1 – Improved Test Procedure and QPL
- WG #2 – Roadmap Specification and Mfr Engagement
- WG #3 – Best Practices

Brightest heat pump minds
from organizations such as these:

Challenges We Face

Shifting needs and product technologies

Perfect products do not exist

We don’t know how to identify which are best for what application

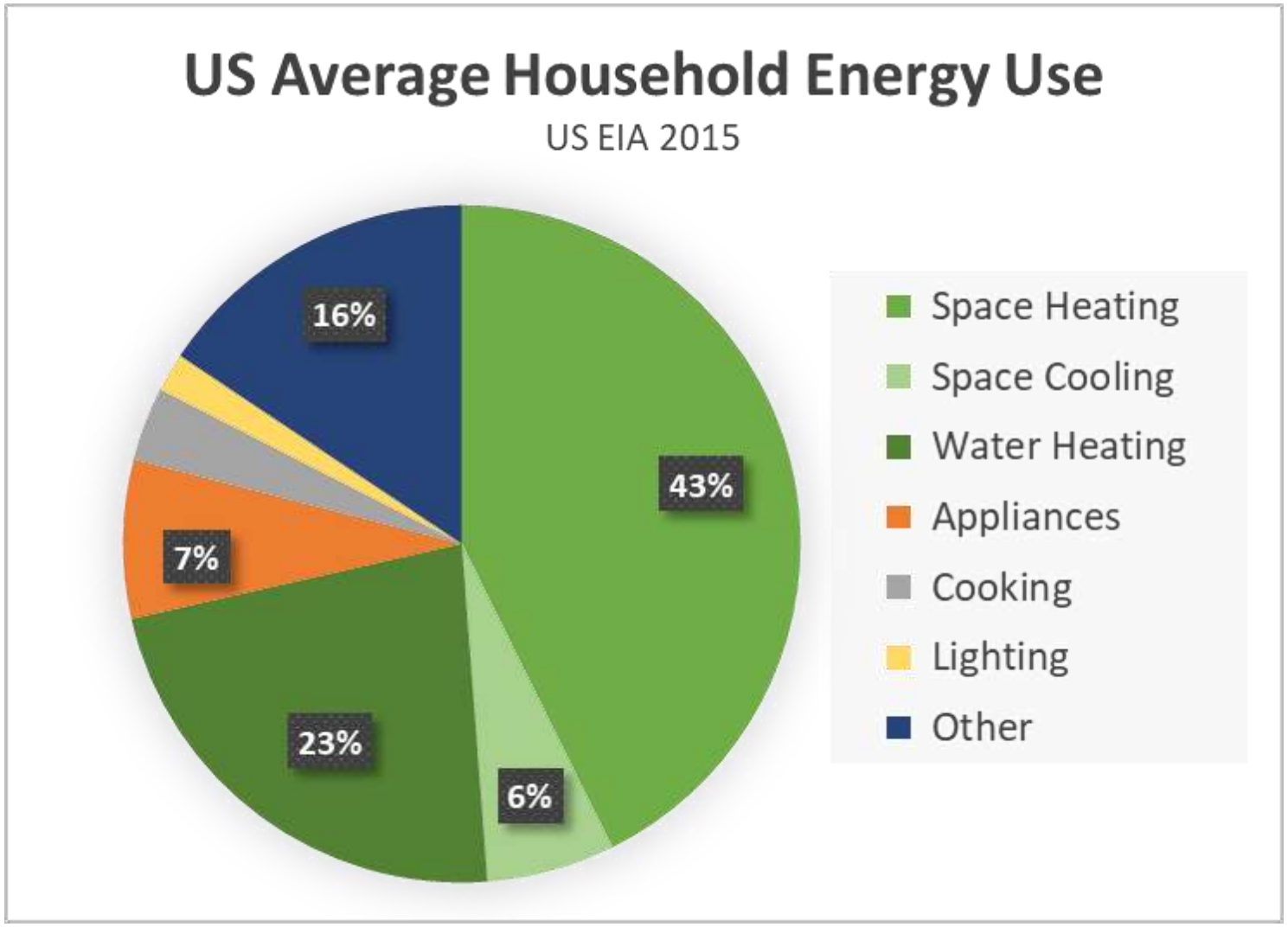
Utility, HVAC industry and decarbonization needs don’t always align

Limited research resources and market leverage

What is possible?

(if these problems were addressed collaboratively)

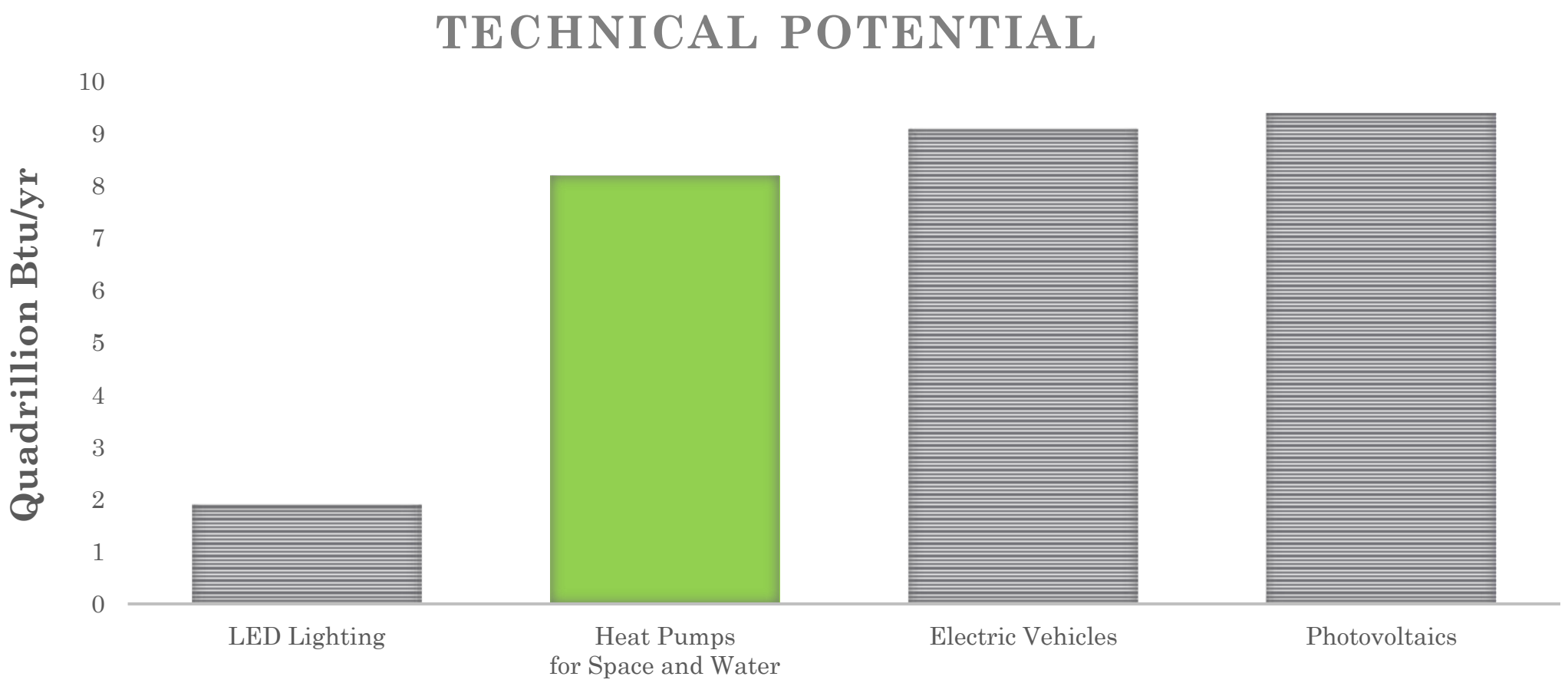
Residential Energy by End Use



green areas
can be served
by a
heat pump

The 3rd Largest Potential

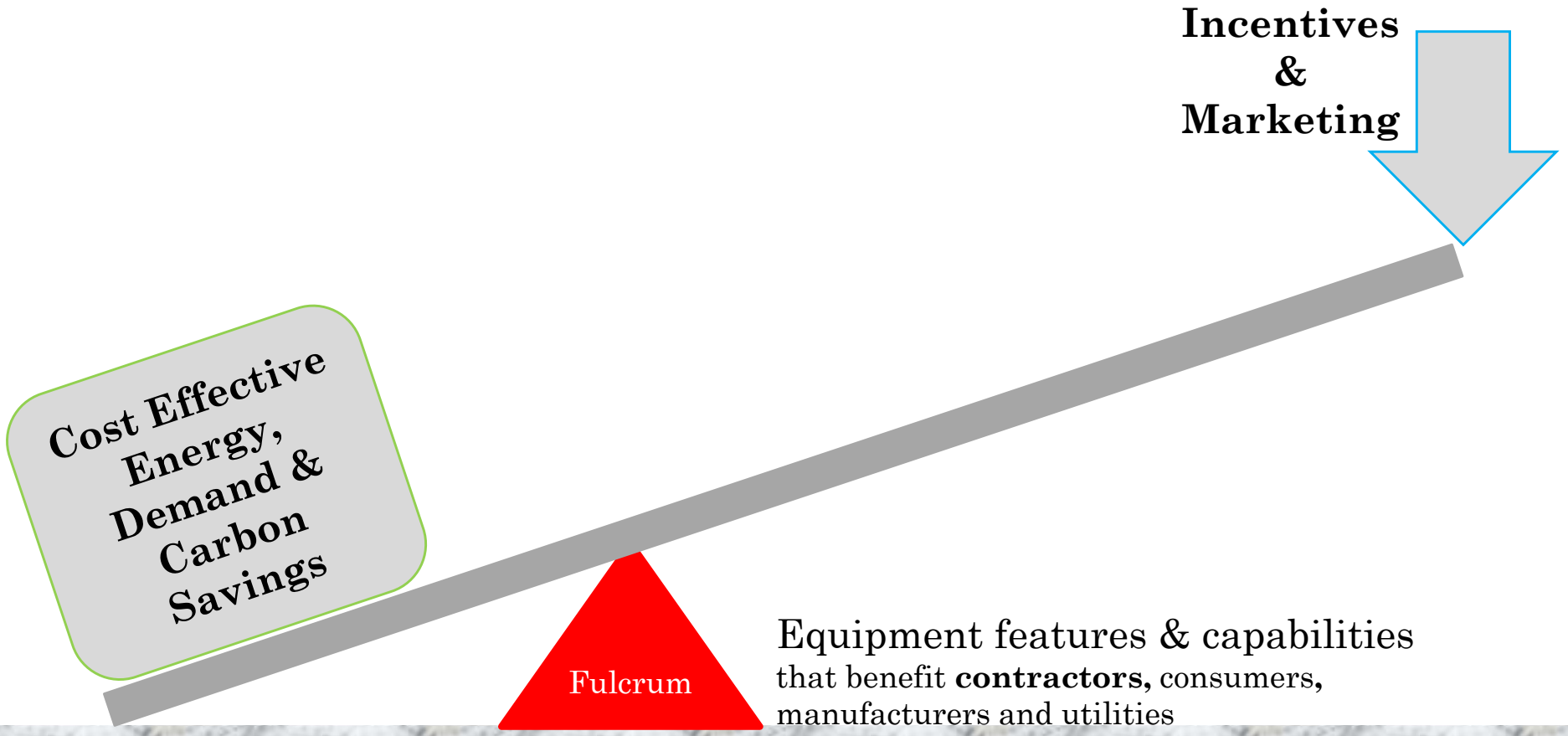
Customer side contribution to meeting our future energy needs



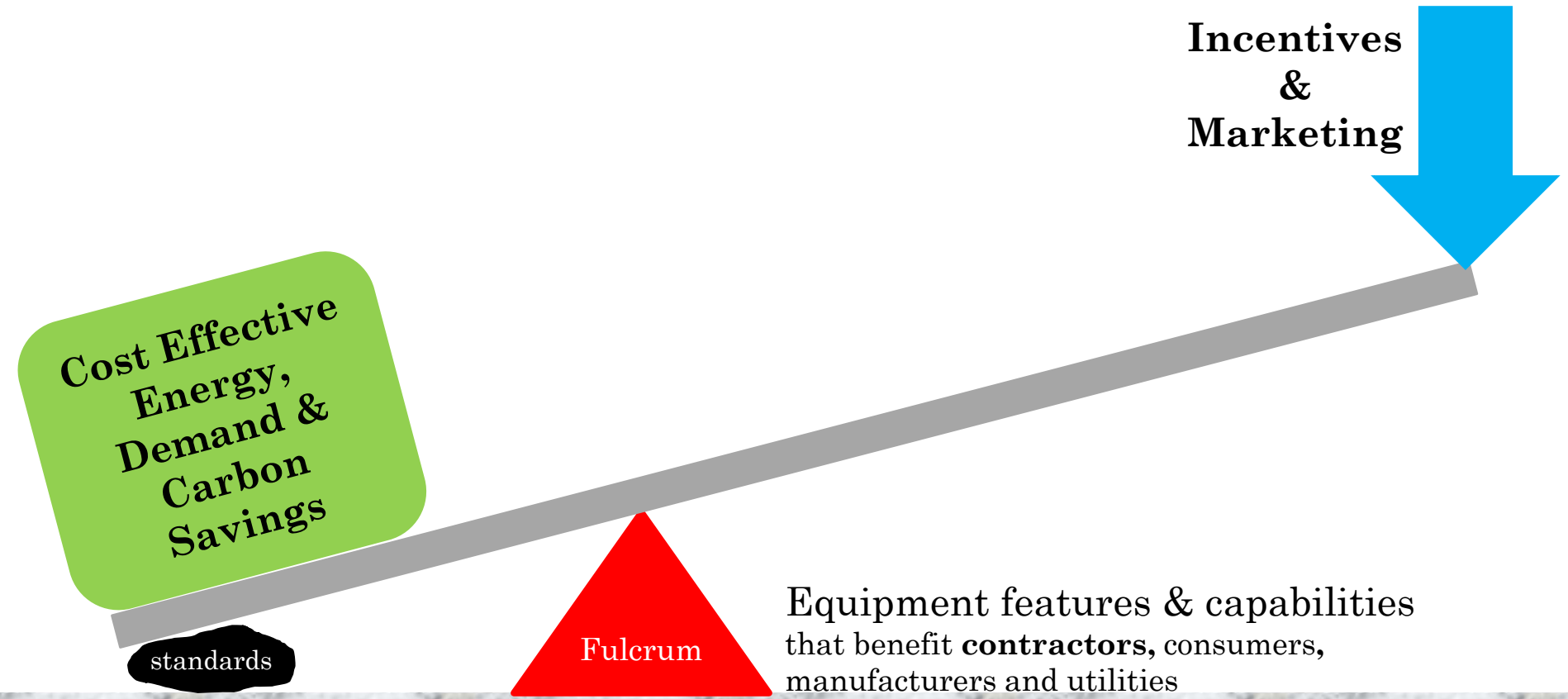
Market Transformation Potential of the ASHP - 2018 ACEEE Paper Excerpt

ASHP systems are based on a seasonal COP of 2.2 for water heating and 3.3 for space heating sourced by a 50% efficient electrical grid (generation, transmission and distribution losses). 50% efficient is high, but chosen as a proxy for a gas turbine + renewable energy dominated utility grid likely by 2050. The iASHP systems could also powered on-site by gas. Such systems would need COP values not much higher than 1.1 for water heating and 1.65 for space heating to provide the equivalent source energy reduction. The lighting baseline estimate is adjusted to pre LED conditions NEEA's building stock assessment (NEEA) values, with end state efficacy estimates of 100 lm/W for residential lighting and 150lm/W for commercial. The photovoltaic "savings" are based on a projected 1000 GWp of installed capacity under a solar resource of 1400 kWh/Wp.

Market Transformation



Market Transformation



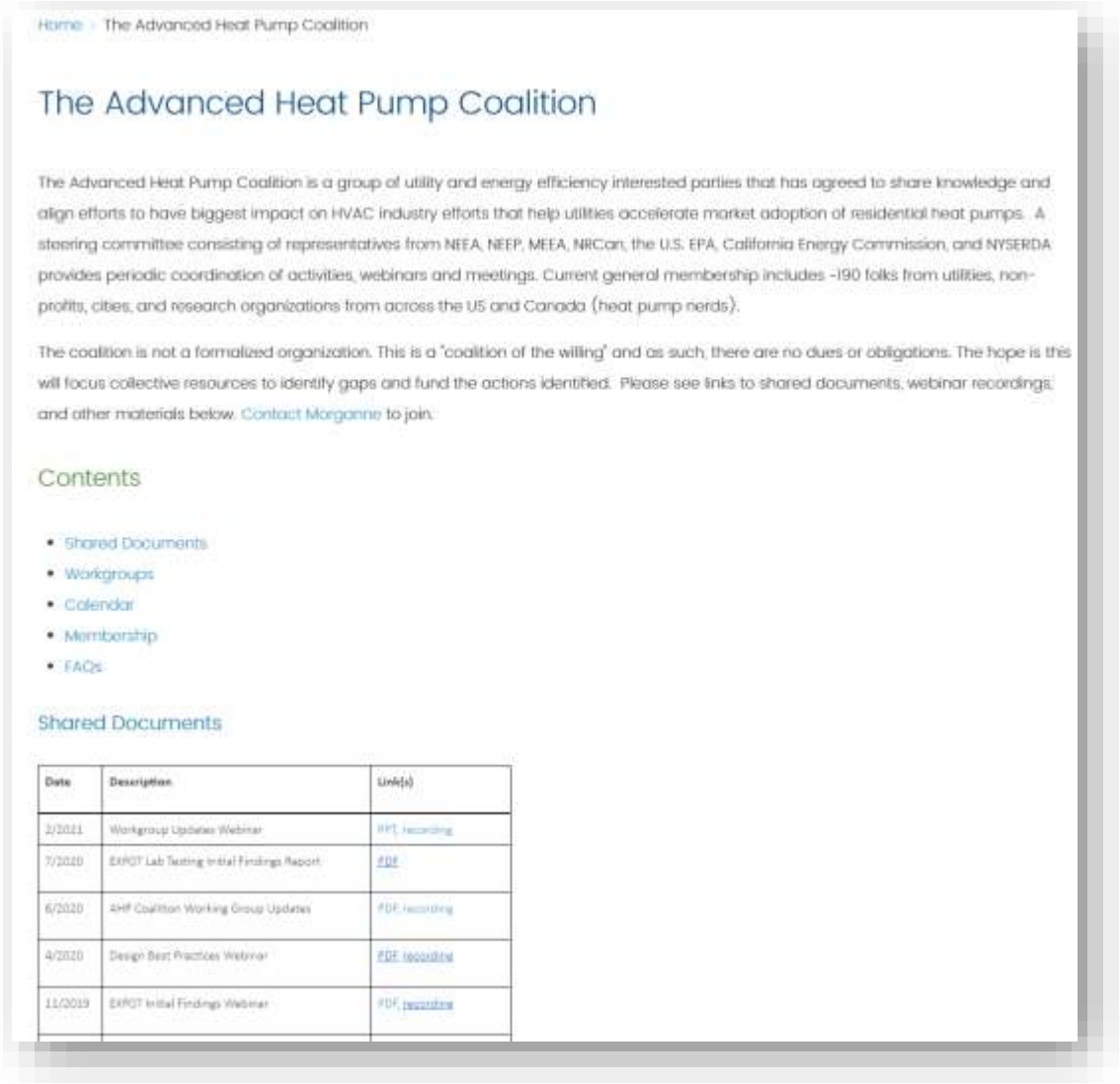
AHPC Website

www.mwalliance.org/advanced-heat-pump-coalition

Contents

- Shared Documents
- Workgroups
- Calendar
- Membership
- FAQs

Website infrequently updated



Home › The Advanced Heat Pump Coalition

The Advanced Heat Pump Coalition

The Advanced Heat Pump Coalition is a group of utility and energy efficiency interested parties that has agreed to share knowledge and align efforts to have biggest impact on HVAC industry efforts that help utilities accelerate market adoption of residential heat pumps. A steering committee consisting of representatives from NEEA, NEEP, MEEA, NRCan, the U.S. EPA, California Energy Commission, and NYSERDA provides periodic coordination of activities, webinars and meetings. Current general membership includes ~190 folks from utilities, non-profits, cities, and research organizations from across the US and Canada (heat pump nerds).

The coalition is not a formalized organization. This is a "coalition of the willing" and as such, there are no dues or obligations. The hope is this will focus collective resources to identify gaps and fund the actions identified. Please see links to shared documents, webinar recordings, and other materials below. Contact Morganne to join.

Contents

- Shared Documents
- Workgroups
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- Membership
- FAQs

Shared Documents

Date	Description	Link(s)
2/2021	Workgroup Updates Webinar	PPT, recording
7/2020	EXPOT Lab Testing Initial Findings Report	PDF
6/2020	AHP Coalition Working Group Updates	PDF, recording
4/2020	Design Best Practices Webinar	PDF, recording
11/2019	EXPOT Initial Findings Webinar	PDF, recording

WG#1 – Improved Test Procedure & QPL

Christopher Dymond, NEEA

Vision

- The marketplace (Efficiency Programs/manufacturers/contractors) can identify ASHP products that will deliver actual performance

Desired Outcomes

- An improved test procedure is developed and validated to show enhanced representativeness of ASHPs
- An Advanced ASHP Qualified Product List (QPL), based on the results of an improved test procedure, is built
- Efficiency Programs use QPL to incentivize adoption of advanced ASHPs that deliver real world performance, increasing savings
- Long term- Federal Standards program ultimately more representative test procedure and rating

Mechanism employed

- Improved Test Procedure
- Qualified Products List

WG#1 – Update

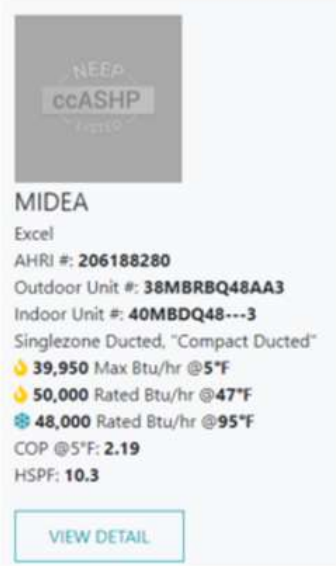
Dave Lis, NEEP

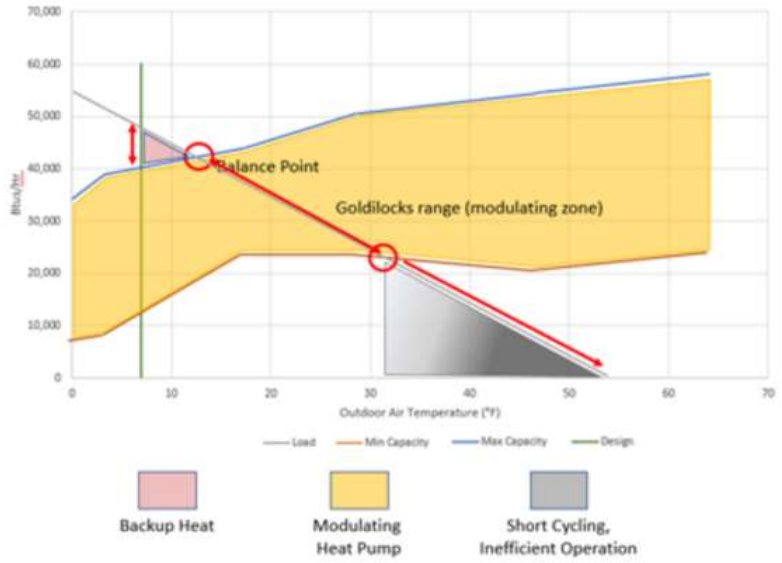
Load Based Test Procedure – CSA EXP07

- Load Based Test Procedure
- 2020 Initial Findings Report and Plain Language Guide Published – EXP07
- 2021 Baseline of Uncertainty Report

NEEP Database Improvements

- More representative seasonal rating
- Verifiable performance mapping
- Tool enhancement



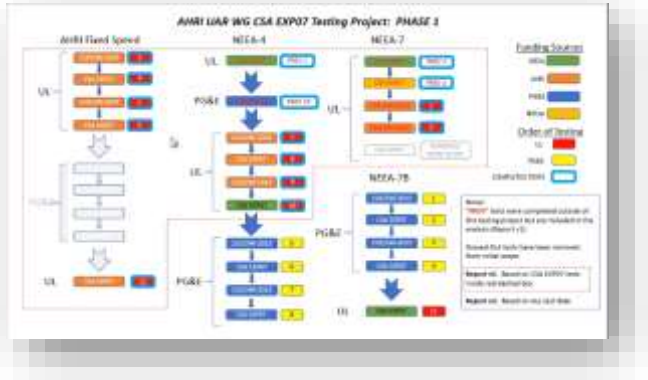


Test Procedure Work

AHRI Repeatability & Reproducibility Research Project

Mark Baines, UL

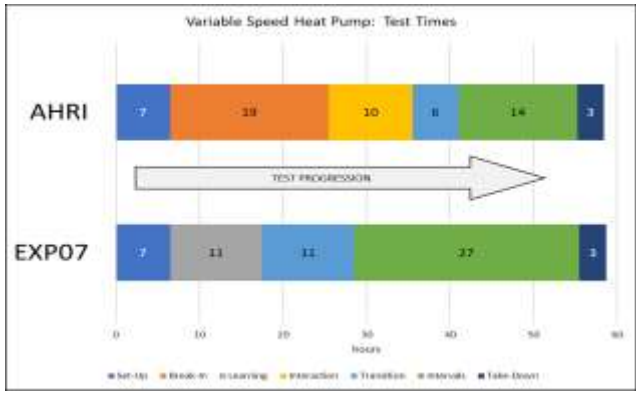
- Considerable Covid delays
- Lab Work Completed
- Purdue starting analysis
- Report expected by EOY



CSA EXP07 Development

Gary Hamer, BC Hydro

- Technical review version published March 2019
- Technical Development Committee is working on
- Updated Version expected Q2 of 2022
- ANSI Accreditation work to be done in 2022



Field Testing and Validation Projects

Best of the Best Testing — Robert Weber, BPA

- 30-40 cold climate central forced air heat pumps in 2 climate zones
- Equipment selection based on NEEP QPL key performance metrics
- Eliminate/reduce ER heat and determine demand reduction value

Xcel - Air Source Heat Pump Technology Demonstration — Dave Podorson, Xcel

- residential central dual-fuel systems
- multifamily systems

NRCan and CanMET Field and Lab Testing — Mvuala Suami, NRCan

- Yukon and Ontario field tests (~16 units)
- CanMET lab homes – 2 units

Representativeness Project – 1A

Christopher D, NEEA

Business Case

- The proposed $650,000 project is intended to help differentiate products with a North American annual market value of over $9.3 billion

Project Partners

- Funders: NEEA, NEEP, AHRI, NYSERDA, ComEd Xcel Energy, Southern California Edison
- SMEs: Carrier, Mitsubishi, Bruce Harley Energy, Underwriters Laboratory, US DOE

Status

- NEEP is contract manager
  - Three capable proposals
  - Negotiation with top candidate
- Seeking additional contributing partners

	Proposed Tests
Construction	Construction Trailers- HLL adjusted using insulation
Location(s)	Mobile Home or RV Park in Region IV
Occupancy	Unoccupied
Length	6 months for each units (heating season)
Number of units	3- ducted 3- ductless
Types of units	Ducted & ductless
Occupancy Load	Simulated
Sizing notes	Units all sized to building load
Comparison type	Field Seasonal COP compared to HSPF, HSPF2, and SCOPh from EXP07
Thermostat	Per OEM recommendation- but not "smart." All located in same location. No setback.

WG#2 – Roadmap Specification

Vision

- Heat pump capabilities that enhance in-field performance are well supported by utility programs and provide additional value to the HVAC industry

What is a "Roadmap Specification"

- It is not program specification
- It includes MT fulcrum items
- It leverages industry direction

Desired Outcomes

- Manufacturers have clear understanding of what Utilities need
- Widespread utility program support exists for the features specified

WG#2 – Final Draft Roadmap

Abi Daken, EPA

Types of Features

- **Performance Rating and Capacity**: What metrics and what level or performance on the metrics.
- **Grid response and Grid Value**: Features that support controlling the time and location of energy use.
- **Automated Integration**: Systems work without complex setup, including legacy equipment.
- **Refrigerants**: Which refrigerants are used.
- **Monitoring and Feedback**: Equipment capability supporting automatic commissioning, utility feedback, and system performance monitoring.
- **User Amenities**: Improved user convenience and safety.

Workgroup #2 - Next Steps

Roadmap Feedback

• Workgroup and Member Input	Q1-2	2021
• Outreach to Manufacturers	October	2021
• AHR Expo Meetings	February	2022
• 2022 Version Published	Q1	2022

Resulting Collaboration Project Ideas

- Connected Diagnostics
- CTA 2045 Capabilities
- NEEP Database Design Tools and Best Practices

"If you do not know where you are going, every road will get you nowhere"

Henry A. Kissinger

Workgroup #3 – Best Practices

Matt Christie, TRC

Vision

- HVAC designers/installers have the knowledge and tools that improve the business case for recommending advanced heat pumps to their customers.

Desired Outcomes

- We understand how to optimize performance
- It is easy and profitable for contractors
- Best practices are accessible, known, and applied in the field

Mechanisms Employed

- Manufacturer training for contractors
- Resources, tools, and trainings from utilities, efficiency organizations, and similar
- Online tools and connected system data

Workgroup #3 – Progress Made

Scope and Resources Defined

- Reviewed, discussed, and collected initial resources and sources
- Narrowed target technologies and topics
- Wrote draft RFP's Scope of Work
- Collaborated with partners to pull together related projects

Gap Analysis

• Upstream Partners Gap Analysis	NYSERDA/TRC
• Best Practices Technical Gaps Analysis	NEEA/TRC/Ecotope/Clearesult

Best Practice Guidelines:

• Education and Awareness Building Strategies (This is a 2022-2023 special project)	Consortium for Energy Efficiency

Next Step - Workgroup Calls

WG #1 – Improved Test Procedure and QPL

- October 6th @ 3:00-4:00 PM EST

WG #2 – Roadmap Specification and Manufacturer Engagement

- October 12th @ 12:00-1:00 PM EST

WG #3 – Design & Install Best Practices

- Not yet scheduled

To join a workgroup – email Morganne

Morganne.Blaylock@icf.com

EPA - Heat Pumps

Abi Daken

ENERGY STAR® CAC/ASHP Updates

The ENERGY STAR Brand

SAVE TODAY. SAVE TOMORROW.
SAVE FOR GOOD.

ENERGY STAR Household Awareness

MORE THAN **90%** RECOGNIZE THE ENERGY STAR® LABEL

MORE THAN **80%** UNDERSTAND WHAT IT MEANS

IN THE PAST YEAR, **56%** PURCHASED ENERGY STAR-LABELED PRODUCTS

OF THESE PURCHASERS

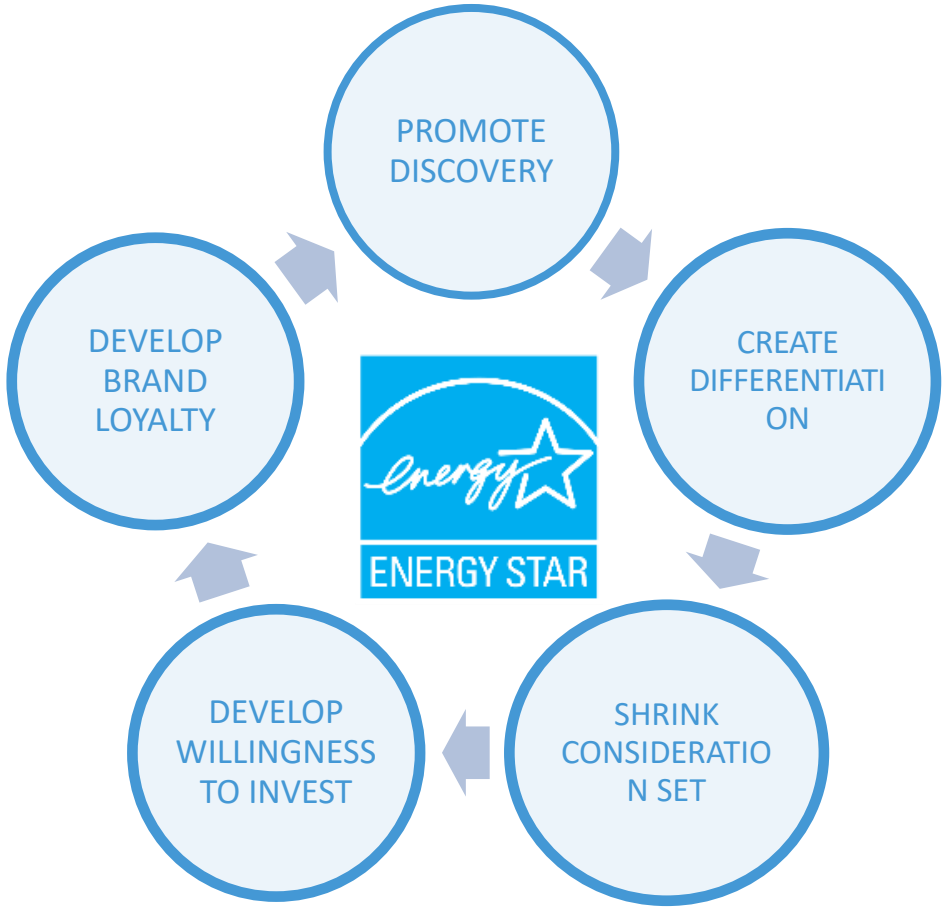
68% were influenced by the label in their decision

71% are likely to recommend ENERGY STAR to a friend

Source: EPA Office of Air and Radiation, Climate Protection Partnerships Division. National Awareness of ENERGY STAR® for 2019: Analysis of 2019 CEE Household Survey. U.S. EPA, 2020.

ENERGY STAR: The Quintessential Ingredient Brand

- Proven impact on partner marketing efforts
- Serves as implicit seal of approval
  - Enhances Partner brand through association
- Provides shortcut to understanding your brand's full value proposition
  - Differentiates product
  - Builds consumer willingness to invest in premium product
- Forges deeper connection with customers
  - Functional: quality, performance
  - Emotional: confidence, trust, loyalty



ENERGY STAR CAC/ASHP Version 6

Status and Timeline

[ENERGY STAR V6 Specification Web Page]

March 30, 2021

Spec finalized, products certify at any time

January 1, 2022

All new certifications must use M1 and CVP

Jan. 1, 2023

Version 5 products drop off list

- Products may certify to Version 6.0 now
- Specification allows for path using current test method
- Expect bulk of V6.0 certification in 2022-23

New Initiatives Reflected in V6.0 Specification

1. **Climate differentiated AHSP criteria and marks** help consumers and contractors easily identify units optimized for cold climates
2. **Installation capabilities** help ensure that excellent equipment will be installed well
3. **Optional connected criteria** focus on harnessing the potential of staged and variable capacity units to balance grid needs and consumer comfort – based on AHRI 1380

Air Source Heat Pumps Different Climates, Different Needs

Cold Climate

- Excellent seasonal heating performance
- Maintains performance at low ambient temperatures
- No geographic limit – programs, contractors, purchasers decide what each home needs

Base ENERGY STAR

- Levels raised to account for 2023 standards, set in new metrics

New ENERGY STAR Heat Pump Criteria (V6)– Cold Climate

- Reduced EER requirements, but higher HSPF
- Split systems: 16 SEER, 11.5 EER, 10 HSPF
- Low ambient performance must be demonstrated
  - Currently, that means tested at 5F: 1.75 COP and max capacity 70% of 47F nominal, plus confirmation that's achieved under native control
  - Additional ways to demonstrate low ambient performance could be added

Installation Capabilities and Connected

- Installation Capabilities:
  - Recent NREL research estimated that AFDD could save US 12 TWh/yr
  - Measures in the CAC/HP Version 6.0 specification advance this work
    - Products that have three of more capacities, or are continuously variable, must meet 3 of 6 specific installation capabilities to certify
    - Coordinated with recent ACCA/RESNET Standard 310: HVAC Installation Grading
- Connected criteria standardize for a future of flexible loads
  - Cooling (and increasingly heating) drive peak electricity demand
  - Standardizing messages and responses make setting up grid responsiveness easier, deliver more value
  - Criteria for CAC/HP based on AHRI 1380

How this specification relates to others

- Very similar to NEEP ccHP specification
  - Adds testing for low ambient performance, including under units' native or recommended control
  - Adds requirements of max heating capacity at 5F at least 70% of nominal 47F heating capacity
- CEE Tier 3 North uses 17F performance
  - Was available when their initiative went into effect
  - In active discussion of alignment

How many certified products will there be, and when?

- Comparing SEER, EER, and HSPF to currently available products that will meet 2023 minimum efficiency standards, expect almost 10% of heat pumps to meet our criteria
- About 4% meet cold climate criteria
- Note that this doesn't take installation criteria or low ambient performance into effect
- Had expected redesigns for 2023, now pushed out to 2025 to coordinate with refrigerant regs
- Limited feedback from manufacturers during revision, now more robust – may revise EER levels (particularly for cold climate heat pumps) and/or installation criteria

ENERGY STAR Most Efficient for Heat Pumps

Proposed ESME 2022 (finalize next week, probably)

- Update in light of V6 and 2023 standards – expect to carry through 2023
- Minor updates to levels, added cold climate recognition for early V6 certification
- Small updates to the system status and messaging criteria to align with V 6.0
  - Unit Setup Information: All products certified to Version 6.0 must meet the Installation Criteria. No change for products certified to Version 5.0
  - Fault History: Must be capable of storing and reporting the last 10 faults
  - Resident Alerts in Plain Text
  - Product must be capable of contacting a service professional when there is a fault that requires professional correction, at the discretion of the owner
- No change to requirement for 3 or more capacity levels
- Added criteria in terms of 2023 performance metrics

Webinar Coming Soon:

New ENERGY STAR Savings Opportunities with High Performance Cold Climate Heat Pumps

- Chandra Gollapudi, Samsung
- David Lis, NEEP
- Ashley Armstrong, DOE
- Abigail Daken, EPA

- **ENERGY STAR Partner Meeting**, planned for early November in person, will not be held
- Much of the content will be in a **webinar series**
- Date of this webinar is TBD, expect it to be November

ENERGY STAR CAC/ASHP Marketing Resources

Marketing Efforts Address Barriers

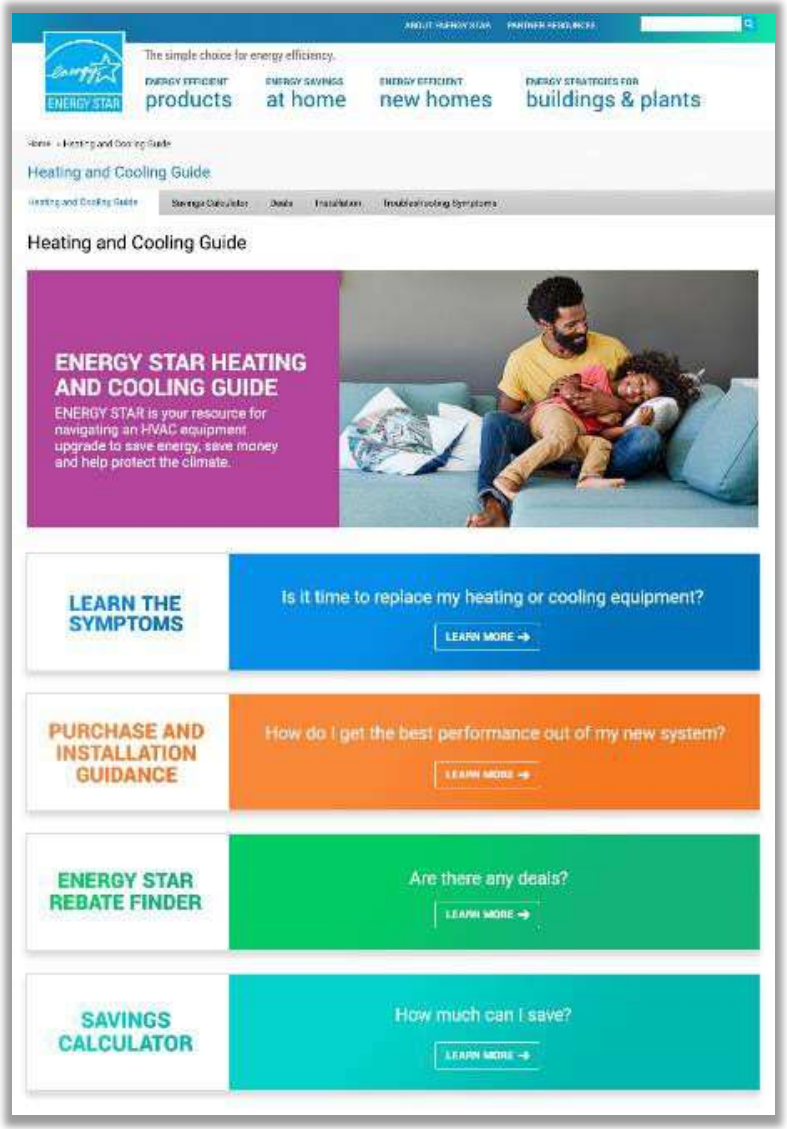
Overcome barriers to generate consumer demand and adoption of ENERGY STAR certified HVAC systems, with a focus on ducted and ductless air source heat pumps

1. Complexity and Cost Barrier

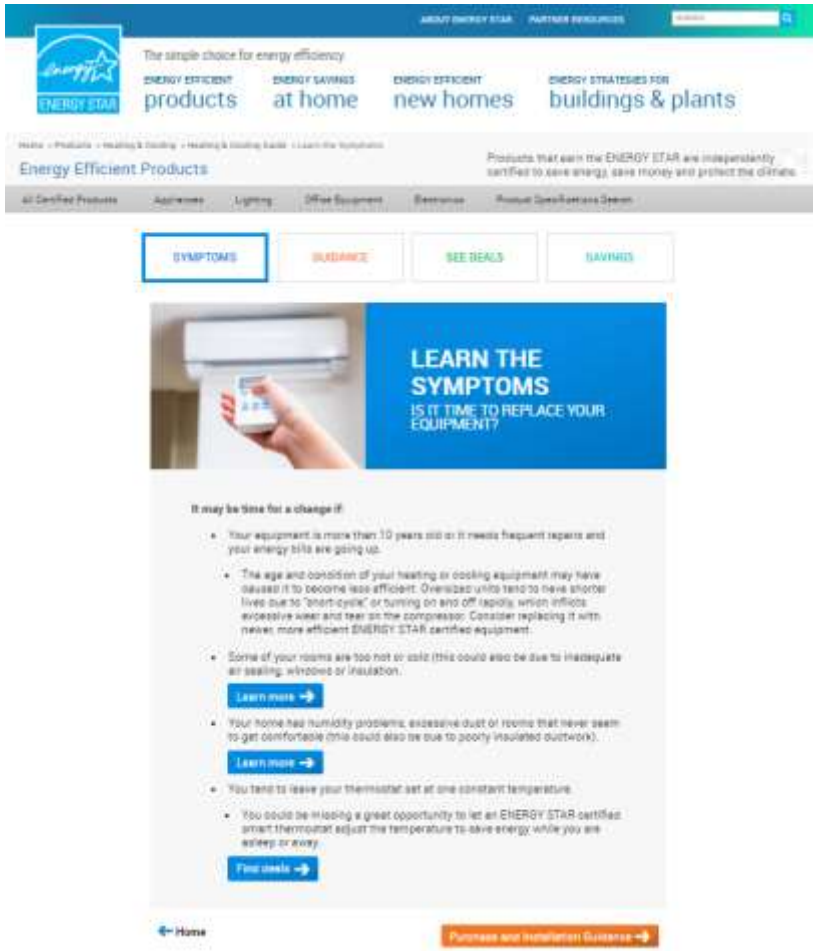
Developed an **ENERGY STAR Heating & Cooling Guide** to give consumers access to the replacement guidance they need:

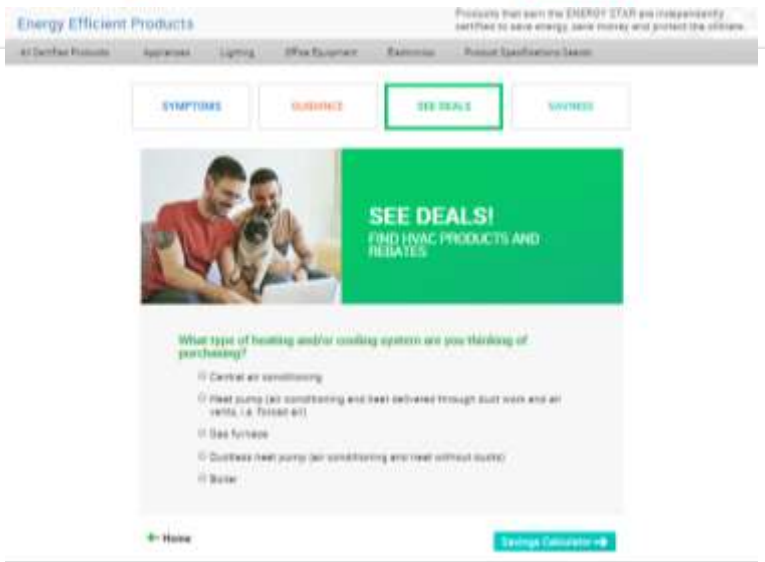
- Information on equipment replacement
- Purchase and installation guidance
- Available Rebates
- Replacement savings calculator

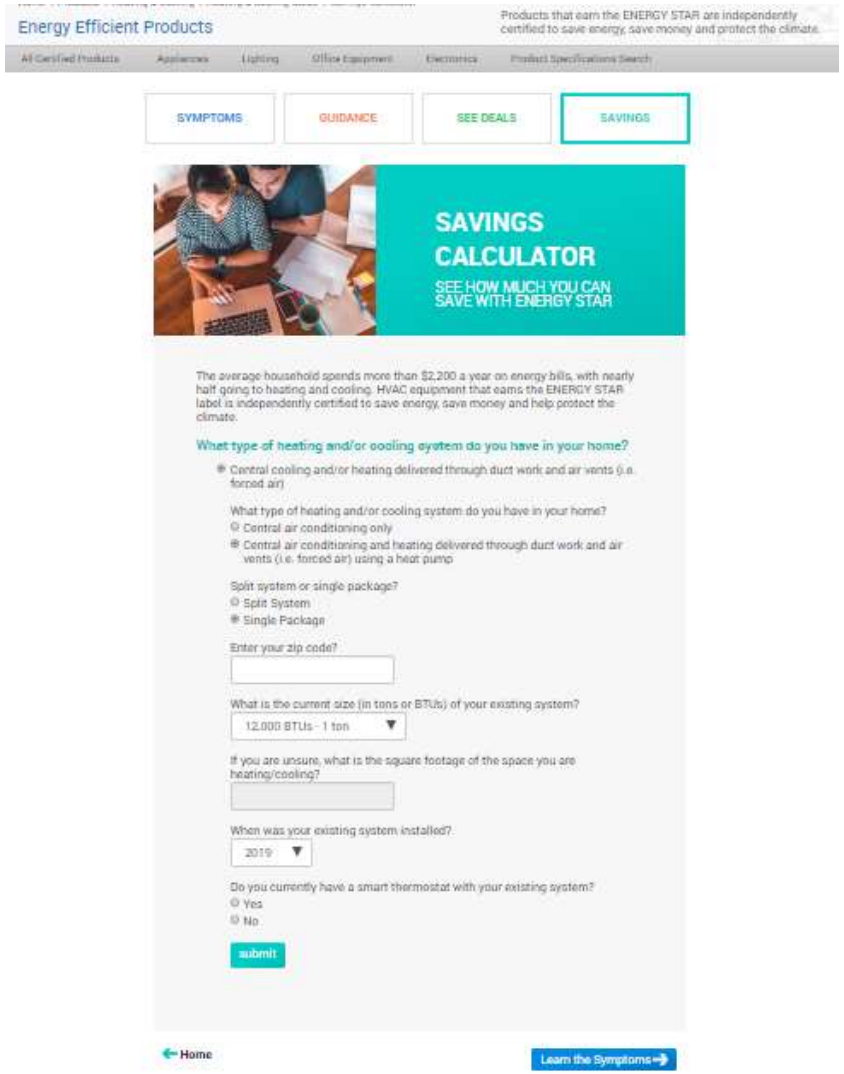
www.energystar.gov/HVACGuide



SAVE TODAY. SAVE TOMORROW.
SAVE FOR GOOD.







EPA

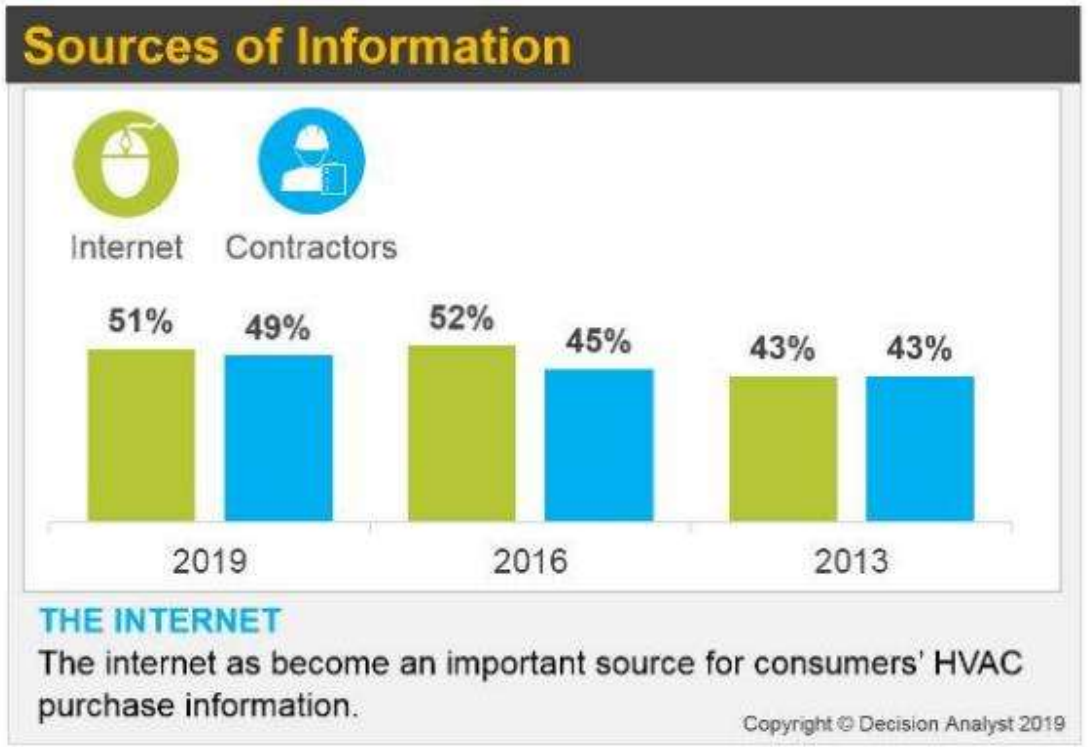
SAVE TODAY. SAVE TOMORROW.
SAVE FOR GOOD.

2. Product/Contractor Information Barrier

- Developed a **Product Finder** that connects customers to brands and ENERGY STAR certified product lines that facilitate contractor support.
- **Updated CEE/AHRI links** on existing product finder with an ENERGY STAR-focused experience that caters more to the end-use consumer.

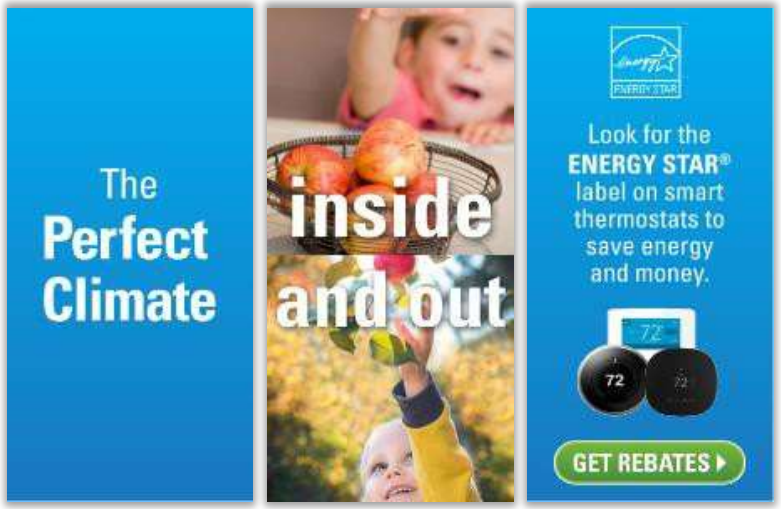
3. Consumer Awareness Barrier

– Implement **awareness campaign** that drives traffic to the HVAC Guide and Product Finder.
  - Campaign highlights benefits of ENERGY STAR certified HVAC:
    - Energy bill savings
    - Comfort
    - Rebates & Tax Credits
    - Environmental benefits



Heating Promotion for HVAC

- Goal: Raise awareness of the benefits of ENERGY STAR certified HVAC.
  - Encourage homeowners to upgrade their entire systems to save
- Media Mix: Google display ads – "The Better Way to Heat"
  - Focused on HVAC with a plug for smart thermostats to get the most out of your system.
- Targets: Markets with active utility programs for smart thermostats and $350+ rebates for HVAC
- Utility Partner Engagement Opportunity
  - Feature ENERGY STAR certification and mark at point-of-sale (online marketplaces, retail).
  - Drive traffic to HVAC Guide utilizing web button.

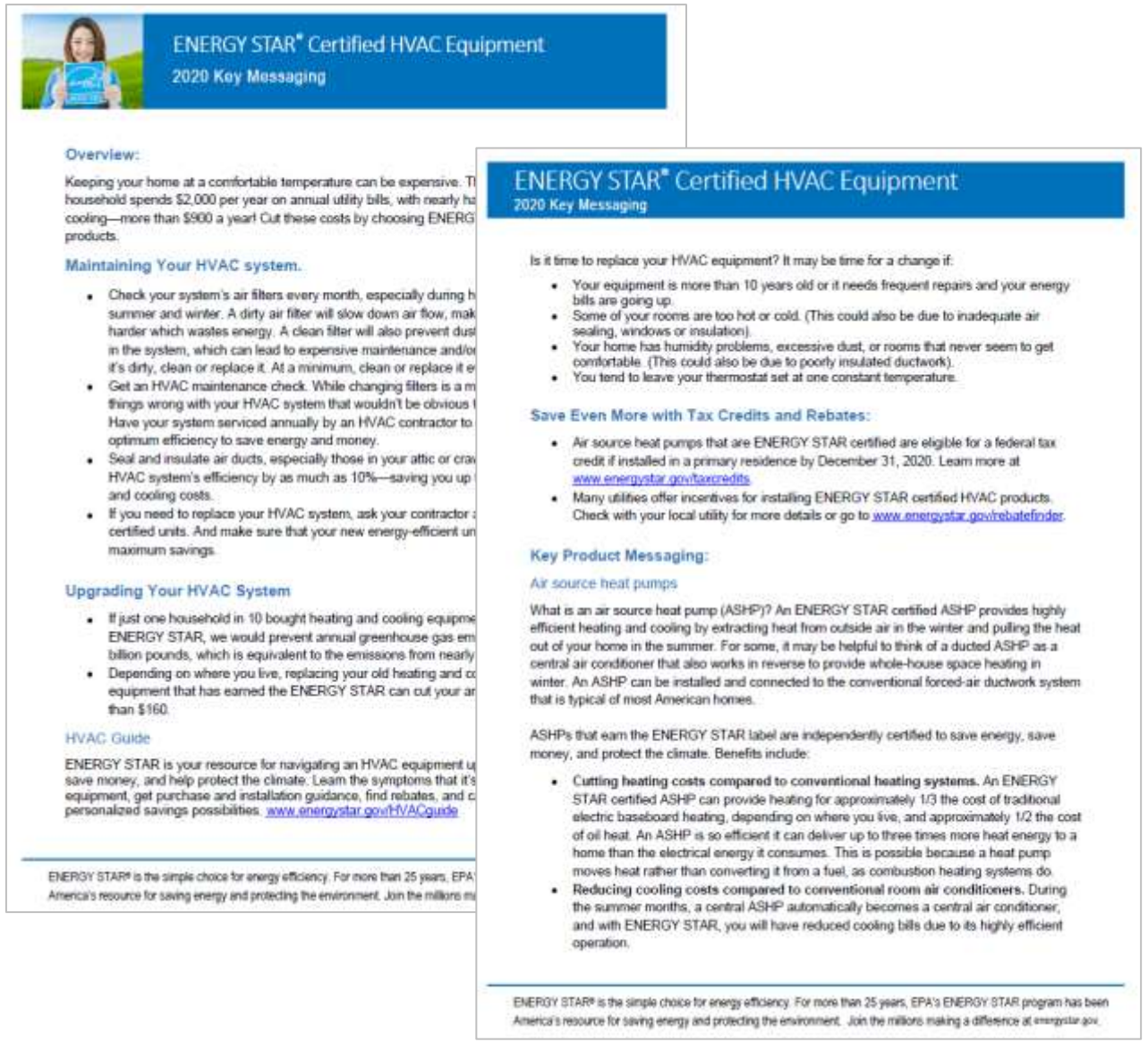


HVAC Promotion Messaging

- The HVAC promotion key messaging document includes educational content and the latest savings facts for you to integrate into your materials, as needed, to help promote the benefits of:
  - ENERGY STAR certified HVAC equipment
  - HVAC maintenance

Link to HVAC Key Messaging

https://www.energystar.gov/sites/default/files/tools/HVAC_Messaging_2020FINAL.docx



ENERGY STAR® Certified HVAC Equipment
2020 Key Messaging

Overview:

Keeping your home at a comfortable temperature can be expensive. T
household spends $2,000 per year on annual utility bills, with nearly ha
cooling—more than $900 a year! Cut these costs by choosing ENERG
products.

Maintaining Your HVAC system.

- Check your system's air filters every month, especially during h
summer and winter. A dirty air filter will slow down air flow, mak
harder which wastes energy. A clean filter will also prevent dust
in the system, which can lead to expensive maintenance and/o
it's dirty, clean or replace it. At a minimum, clean or replace it e
- Get an HVAC maintenance check. While changing filters is a m
things wrong with your HVAC system that wouldn't be obvious t
Have your system serviced annually by an HVAC contractor to
optimum efficiency to save energy and money.
- Seal and insulate air ducts, especially those in your attic or cra
HVAC system's efficiency by as much as 10%—saving you up
and cooling costs.
- If you need to replace your HVAC system, ask your contractor
certified units. And make sure that your new energy-efficient un
maximum savings.

Upgrading Your HVAC System

- If just one household in 10 bought heating and cooling equipme
ENERGY STAR, we would prevent annual greenhouse gas em
billion pounds, which is equivalent to the emissions from nearly
- Depending on where you live, replacing your old heating and c
equipment that has earned the ENERGY STAR can cut your ar
than $160.

HVAC Guide

ENERGY STAR is your resource for navigating an HVAC equipment u
save money, and help protect the climate. Learn the symptoms that it's
equipment, get purchase and installation guidance, find rebates, and c
personalized savings possibilities. www.energystar.gov/HVACguide

ENERGY STAR® is the simple choice for energy efficiency. For more than 25 years, EPA
America's resource for saving energy and protecting the environment. Join the millions m

ENERGY STAR® Certified HVAC Equipment
2020 Key Messaging

Is it time to replace your HVAC equipment? It may be time for a change if:

- Your equipment is more than 10 years old or it needs frequent repairs and your energy bills are going up.
- Some of your rooms are too hot or cold. (This could also be due to inadequate air sealing, windows or insulation).
- Your home has humidity problems, excessive dust, or rooms that never seem to get comfortable. (This could also be due to poorly insulated ductwork).
- You tend to leave your thermostat set at one constant temperature.

Save Even More with Tax Credits and Rebates:

- Air source heat pumps that are ENERGY STAR certified are eligible for a federal tax credit if installed in a primary residence by December 31, 2020. Learn more at www.energystar.gov/taxcredits.
- Many utilities offer incentives for installing ENERGY STAR certified HVAC products. Check with your local utility for more details or go to www.energystar.gov/rebatefinder.

Key Product Messaging:

Air source heat pumps

What is an air source heat pump (ASHP)? An ENERGY STAR certified ASHP provides highly efficient heating and cooling by extracting heat from outside air in the winter and pulling the heat out of your home in the summer. For some, it may be helpful to think of a ducted ASHP as a central air conditioner that also works in reverse to provide whole-house space heating in winter. An ASHP can be installed and connected to the conventional forced-air ductwork system that is typical of most American homes.

ASHPs that earn the ENERGY STAR label are independently certified to save energy, save money, and protect the climate. Benefits include:

- **Cutting heating costs compared to conventional heating systems.** An ENERGY STAR certified ASHP can provide heating for approximately 1/3 the cost of traditional electric baseboard heating, depending on where you live, and approximately 1/2 the cost of oil heat. An ASHP is so efficient it can deliver up to three times more heat energy to a home than the electrical energy it consumes. This is possible because a heat pump moves heat rather than converting it from a fuel, as combustion heating systems do.
- **Reducing cooling costs compared to conventional room air conditioners.** During the summer months, a central ASHP automatically becomes a central air conditioner, and with ENERGY STAR, you will have reduced cooling bills due to its highly efficient operation.

ENERGY STAR® is the simple choice for energy efficiency. For more than 25 years, EPA's ENERGY STAR program has been America's resource for saving energy and protecting the environment. Join the millions making a difference at energystar.gov.

HVAC Sample Social Media

- Sample social media posts include messaging and imagery that you can use as-is or customize as needed.

Link to Social Media Posts

https://www.energystar.gov/sites/default/files/tools/HVAC_Partner_Social-Posts.docx

Link to Social Media HVAC Graphics

https://www.energystar.gov/sites/default/files/tools/HVAC_Partner_SocialGraphics.zip

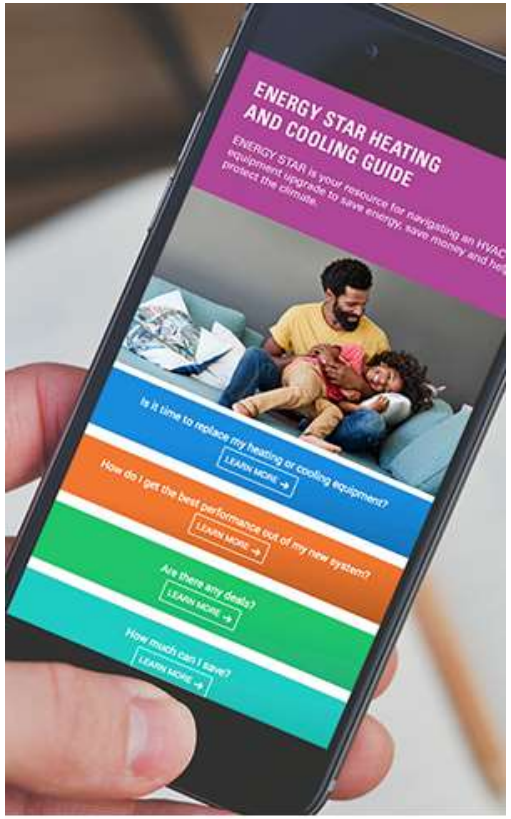
Additional Resources

- Air Source Heat Pump [Factsheet](https://www.energystar.gov/sites/default/files/tools/Central ASHP_Fact Sheet_2020.pdf)

  https://www.energystar.gov/sites/default/files/tools/Central ASHP_Fact Sheet_2020.pdf

- Heating & Cooling Guide [Web Button](https://www.energystar.gov/products/tools_resources/heating-%26-cooling-guide-web-buttons)

  https://www.energystar.gov/products/tools_resources/heating-%26-cooling-guide-web-buttons



Example of web button that can be embedded on your website

DOE - Heat Pumps

Ed Vineyard

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

DOE-BTO Research

Ed Vineyard
Senior Advisor BTO
September 22, 2021

DOE Research: What and Why?

DOE Focus areas:

- Reduce emissions
  - promote electrification by increasing heat pump deployment
    - cold climate heat pump
    - reduce heat pump cost
  - reduce refrigerant GWP
- Reduce peak demand

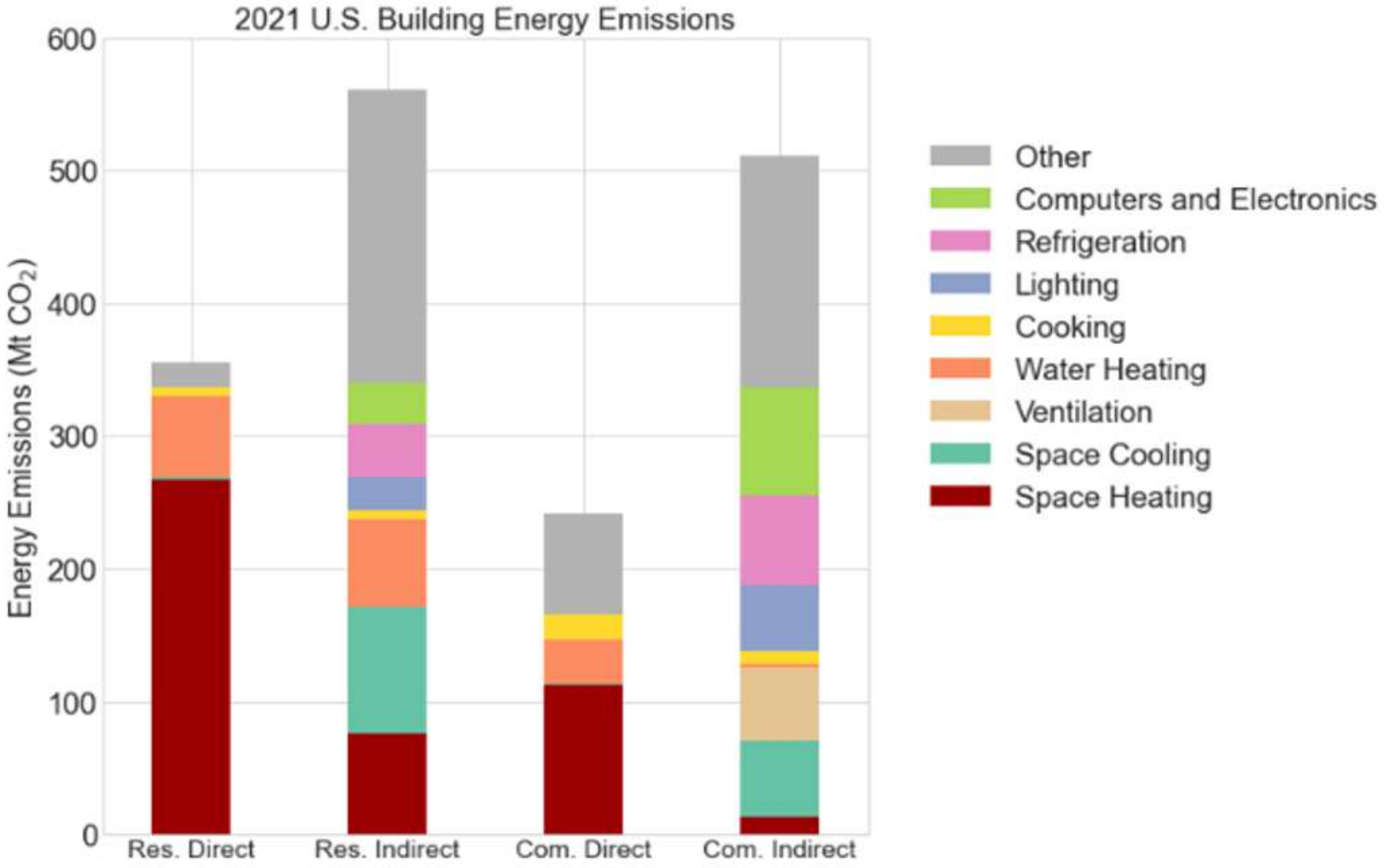
DOE Research: What and Why?

Reduce emissions

Estimated 2021 Building Emissions Breakdown

These areas account for half of the US building emissions:

- residential/commercial fossil fuel/electric
- residential/commercial electric cooling
- residential fossil fuel/electric water heating
- commercial electric refrigeration



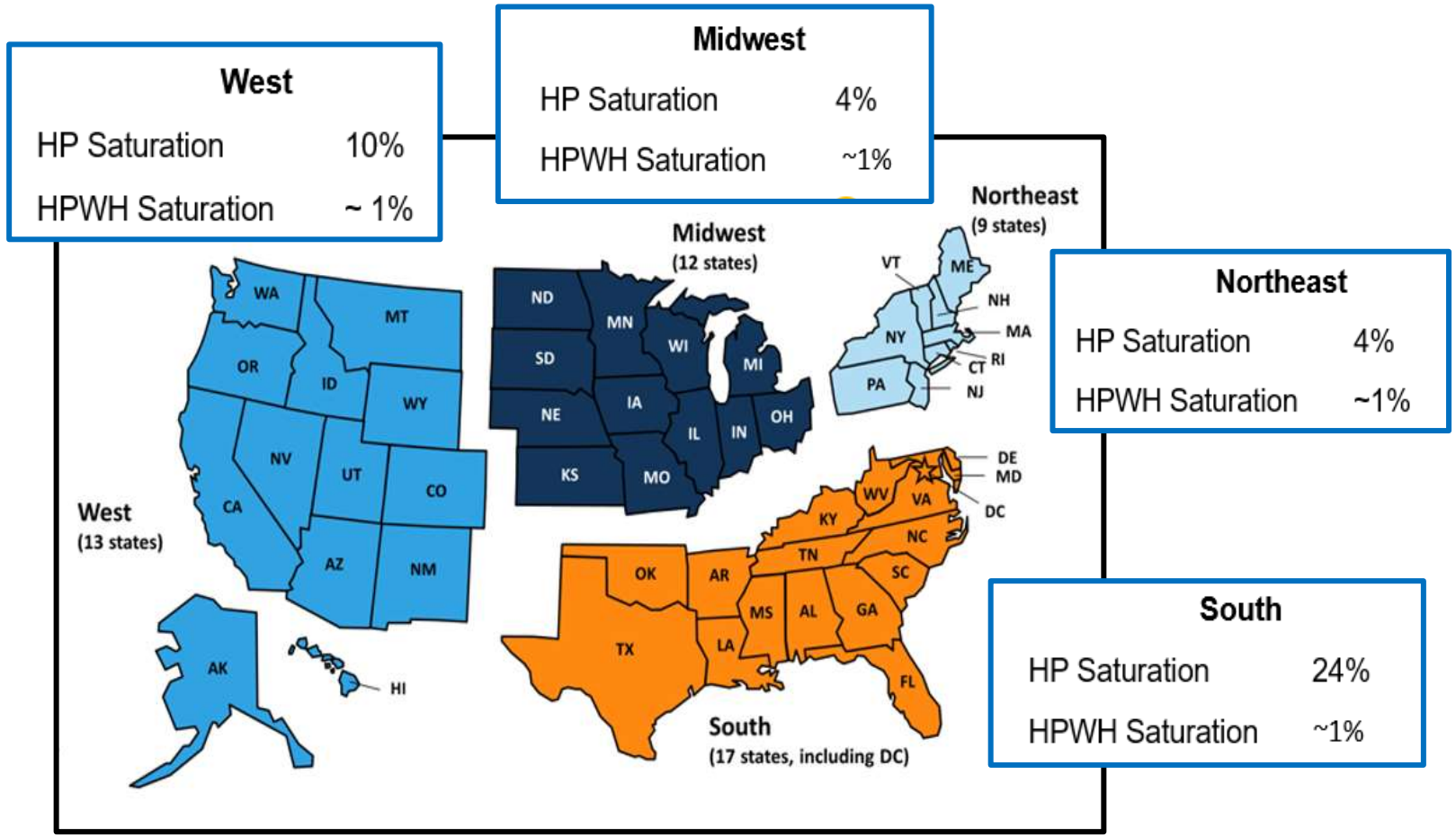
DOE Research: What and Why?

Promote electrification by increasing heat pump deployment

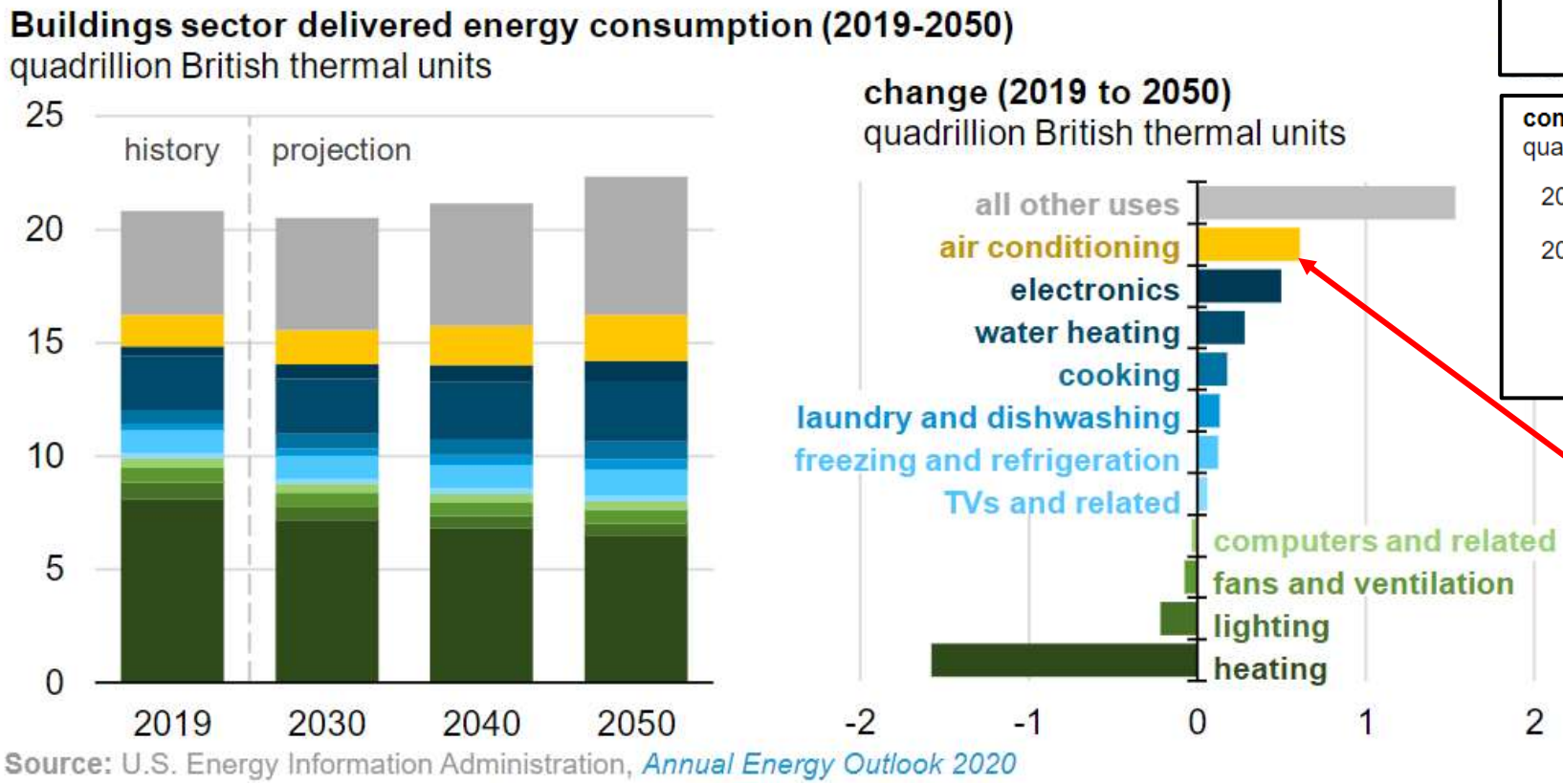
- –cold climate heat pump
- –reduce heat pump cost

Residential HVAC/WH Systems by Climate Region

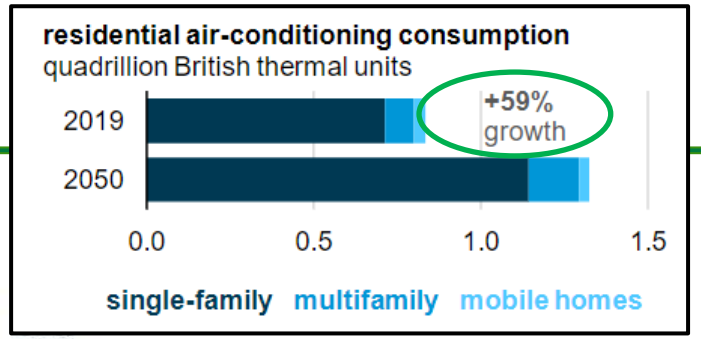
- **Natural gas furnaces dominate, especially in northern regions**
  - costs for heat pumps are significantly higher
    - larger size
    - higher product cost (VS compressor, larger heat exchangers)
    - higher installation cost (labor)
- **Electric/natural gas WHs are 99% of market share**

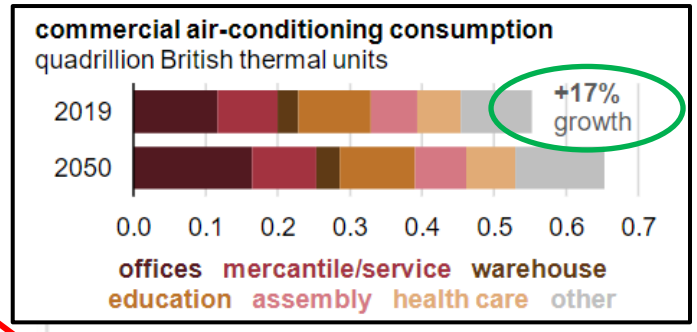


Air Conditioning is Growing



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

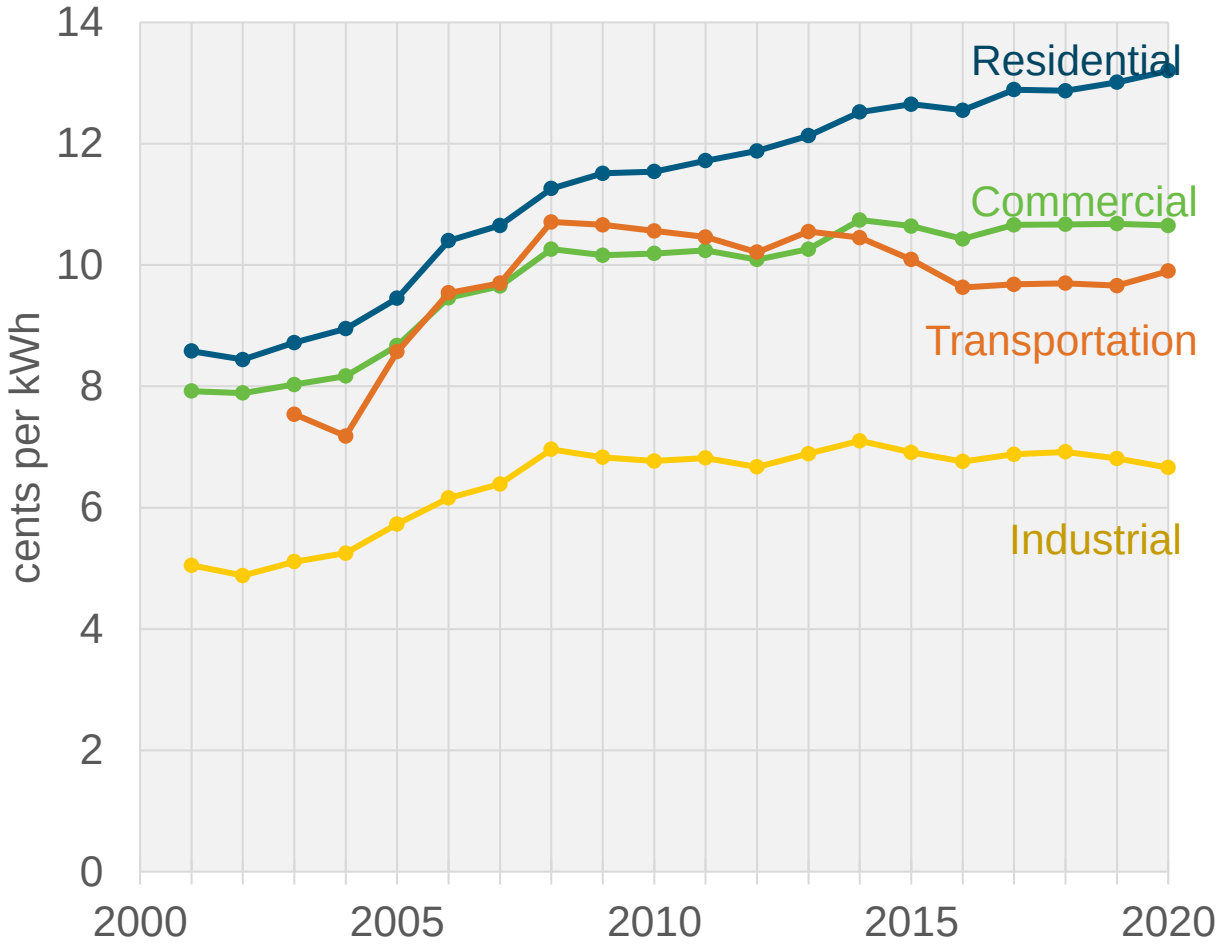




Increase due to projected population shifts from colder to warmer parts of the United States and assumptions of warmer weather

Electricity Prices

- **Rising electricity prices for residential building customers compared to other sectors**
  - a barrier for the penetration of HP in residential sector
  - drives R&D to improve the performance and efficiency

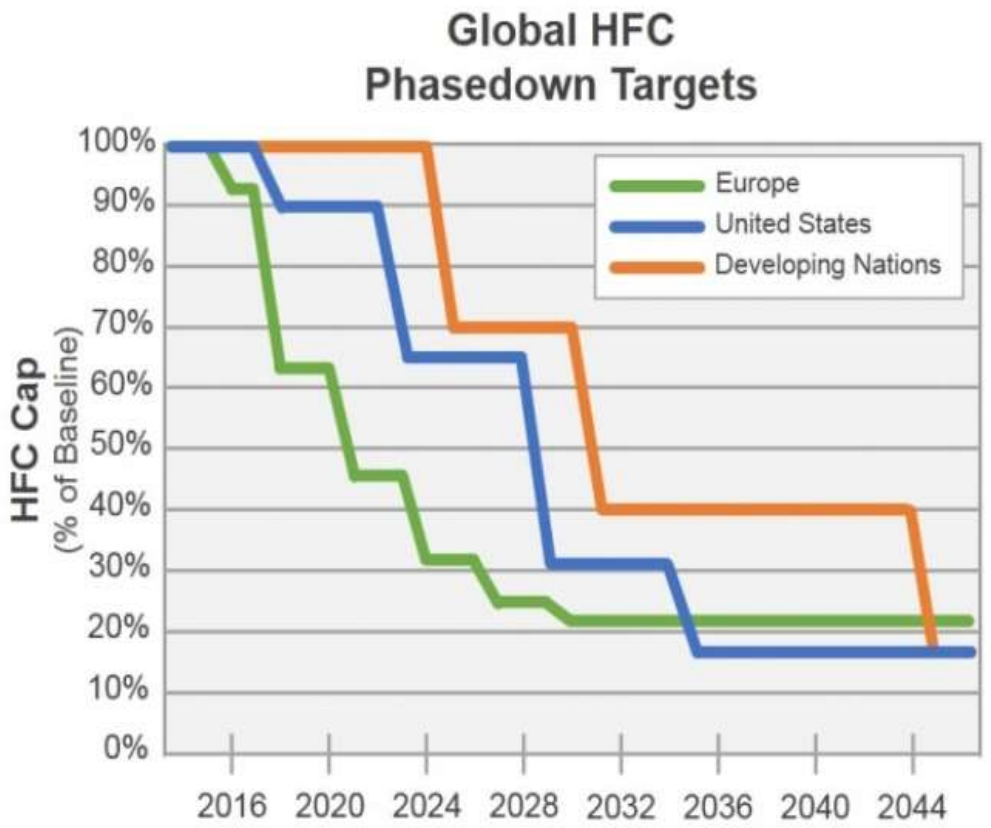


Source: eia.gov

DOE Research: What and Why?

Reduce refrigerant GWP

HFC Refrigerant Phasedown Schedule: 85% Reduction by 2035



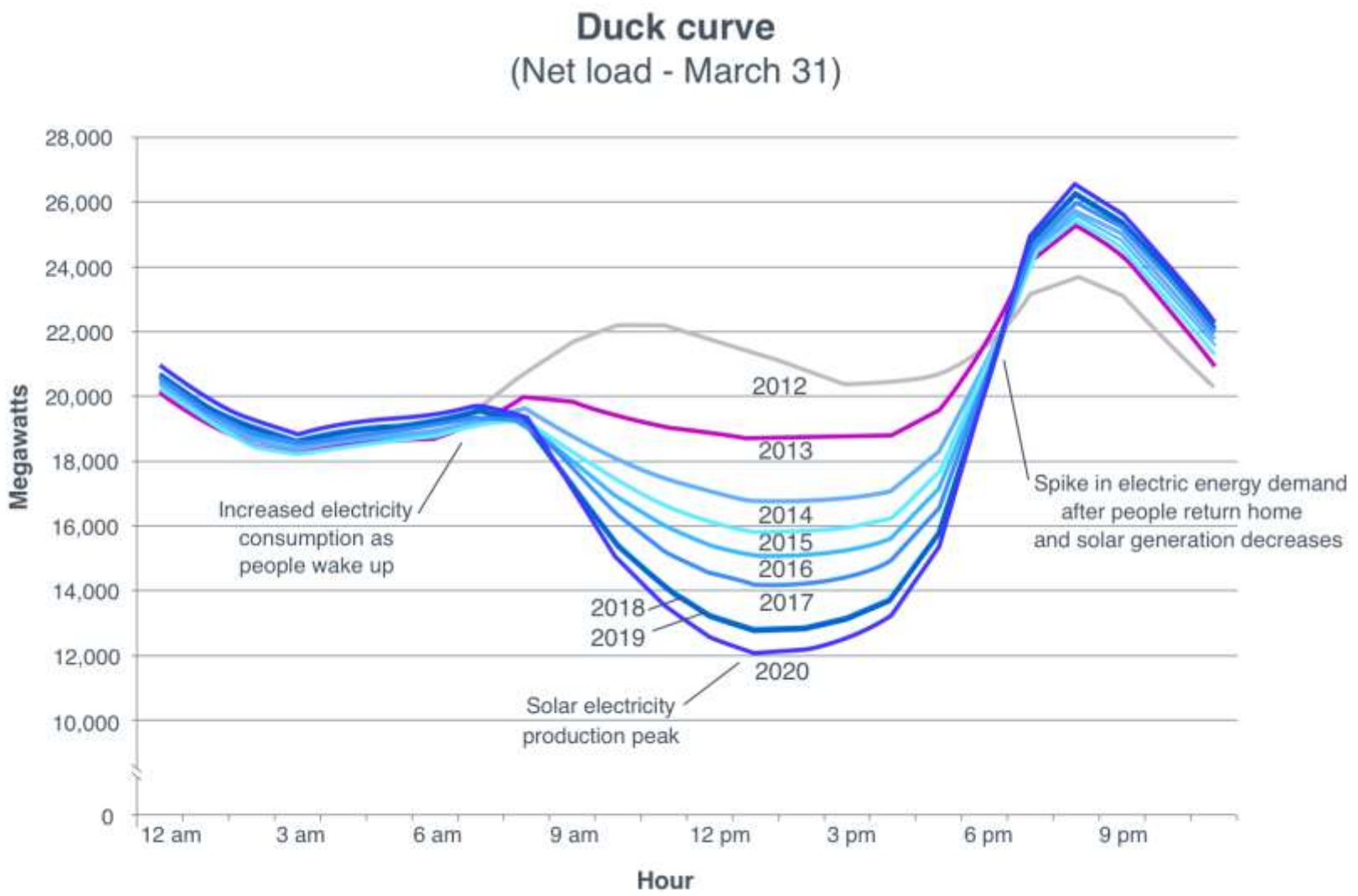
reduction by 2035, through R&D and testing of low-to zero-GWP technologies.

DOE Research: What and Why?

Reduce peak demand

California Duck Curve

- **The duck is getting more prominent**
  - electrification may further exacerbate
  - load shifting is a priority
  - research needs
    - connected equipment
    - thermal storage



Source: CAISO

DOE Research: Focus for FY22 and Beyond

All things heat pump

Potential Research Areas (Based on FY22 Funding):

Reduce HP Cost

- Heat exchangers, compressors

Support Cold Climate Solutions

- CCHP, RTU

Heat Pump Water Heaters

- 120V/240V
- Commercial

Device Level Control

- AFDD
- Grid-Flexibility
- Dual-fuel

Thermal Storage

- HP/TES Integration

Refrigerants

- HP, RTU, HPWH

Field Validations

- Establish national data base
- Address barriers, benefits, and performance issues

Project Areas

Project List

- **Heat Exchanger/Compressor Cost Reduction**
- Cast Heat Exchanger using the Novel Ce-Al Alloy
- Low-Cost, High-Performance Polymer Composite Heat Exchanger using Additive Manufacturing Techniques
- Liquid Piston with Spray Cooling Near-Isothermal Compressor
- Stirling Compressor

- **GWP<150 Component Research**
- Compressor Technology Development for Compressors with GWP<150
- Heat Exchanger Solutions for High-Glide Refrigerants<150
- Direct Expansion Heat Pump for GWP<150
- A3 Refrigerant Sensor
- Reconfigure System Architecture for Low GWP Refrigerants

- **Heat Pump Water Heater**
- Flexible HPWH with Embedded Energy Storage
- Thermoelectric HPWH
- Propane HPWH
- Max-Tech HPWH

- **Cold Climate Heat Pump**
- Cold Climate Heat Pump
- Seamlessly Fuel-Flexible Heat Pump

- **Thermal Storage**
- Thermal Energy Storage Consortium - Heat Pump Integration

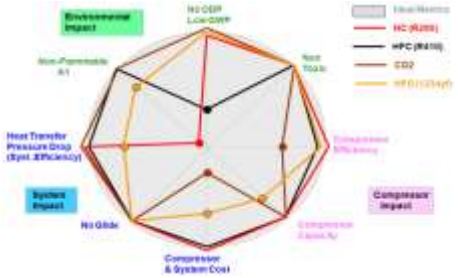
- **HVAC**
- Integration of Piezo-Electric Sensor-Actuators into Heat Exchangers to Alleviate Flow Maldistribution
- Separate Sensible and Latent Air-Conditioning System
- Drop-In Retrofit Furnace with Maximum Efficiency
- Flexibility Measures for HVAC Equipment in EnergyPlus

- **Commercial Refrigeration**
- Novel Compact Flooded Evaporator
- High Efficiency Flammable Refrigerant Leak Event Risk Mitigation
- Low GWP Vending Machines
- Next Generation Transcritical CO2
- Impact of Leak in Commercial Refrigeration using Zeotropic Refrigerants
- Frost Sensor

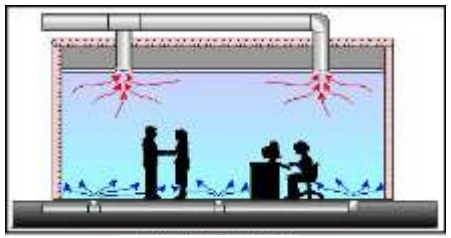
Majority of technologies, if successful, are expected to be market-ready in 3 to 5 years

Big Picture

Environmentally-Friendly Refrigerants



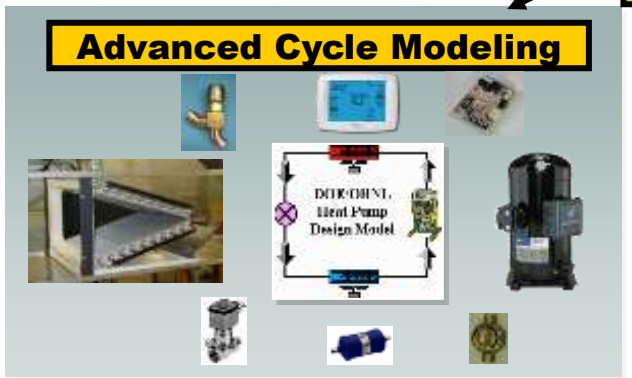
Goal: Same Amenities, Less Energy



Field Research

Component & System Characterization

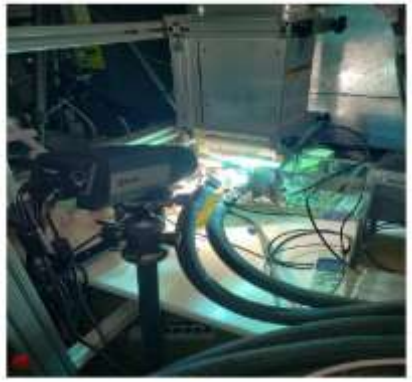
Advanced Cycle Modeling

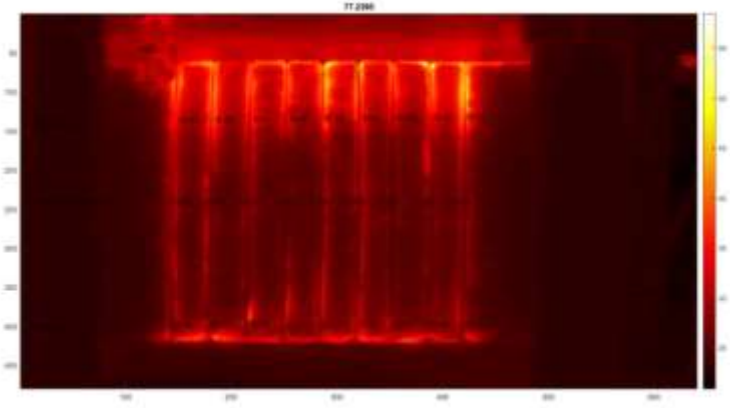


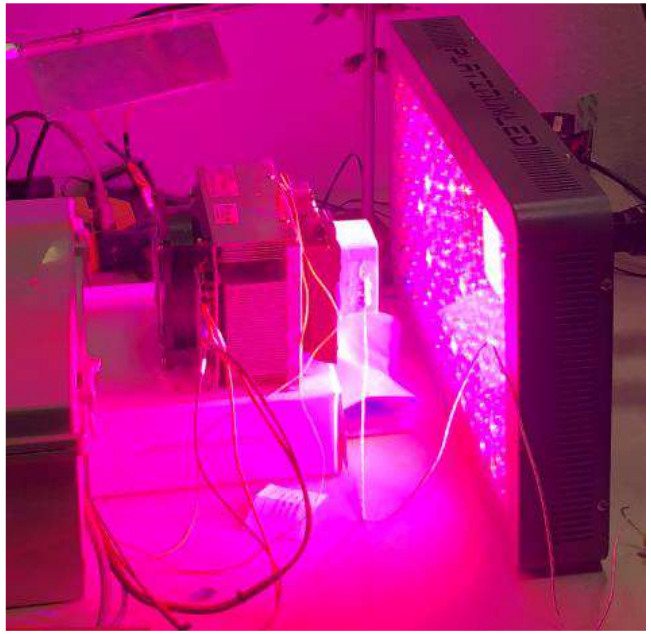
Prototyping Labs, Environmental Chambers

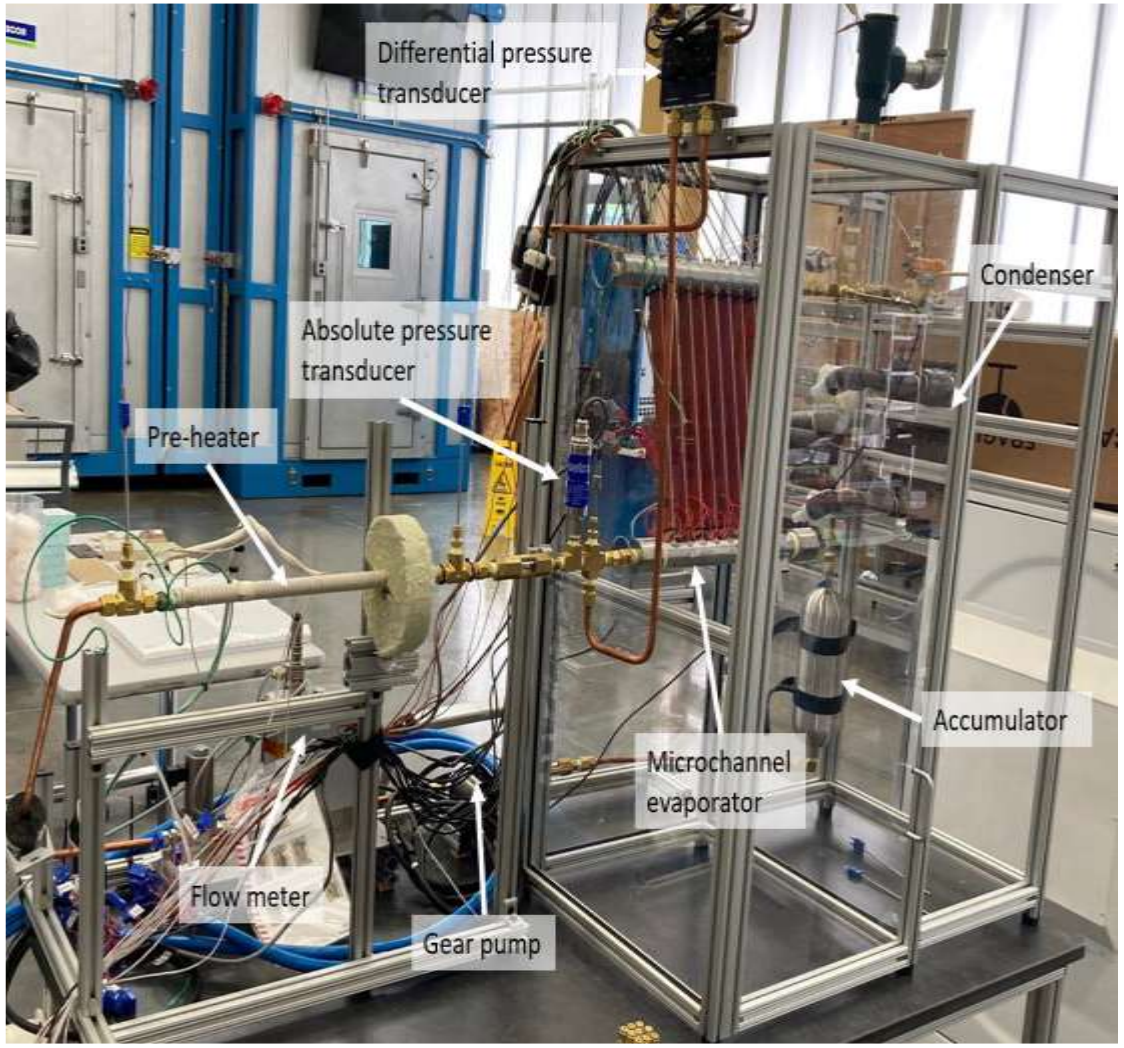
Sustainable, Healthy, Comfortable, Durable, Maximum Energy Efficient Buildings

Heat Exchanger Testing



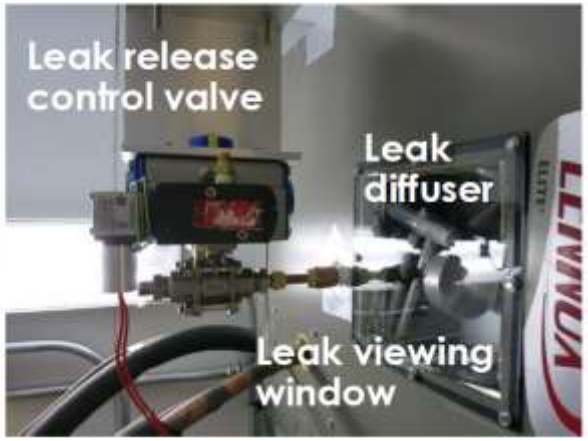






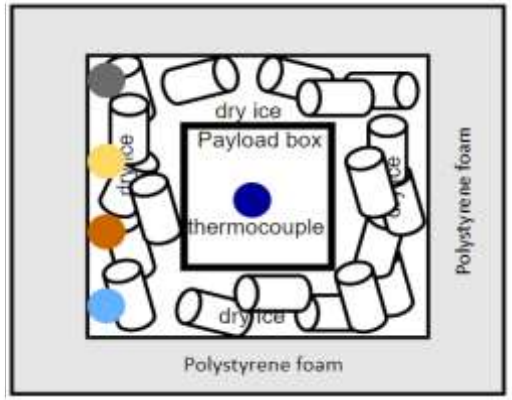
Compressor Research

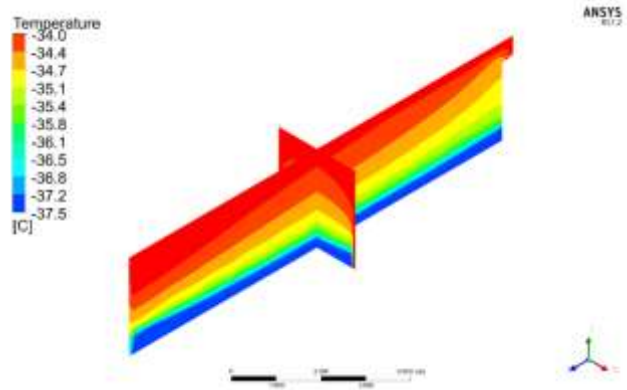
Low GWP Refrigerant Testing

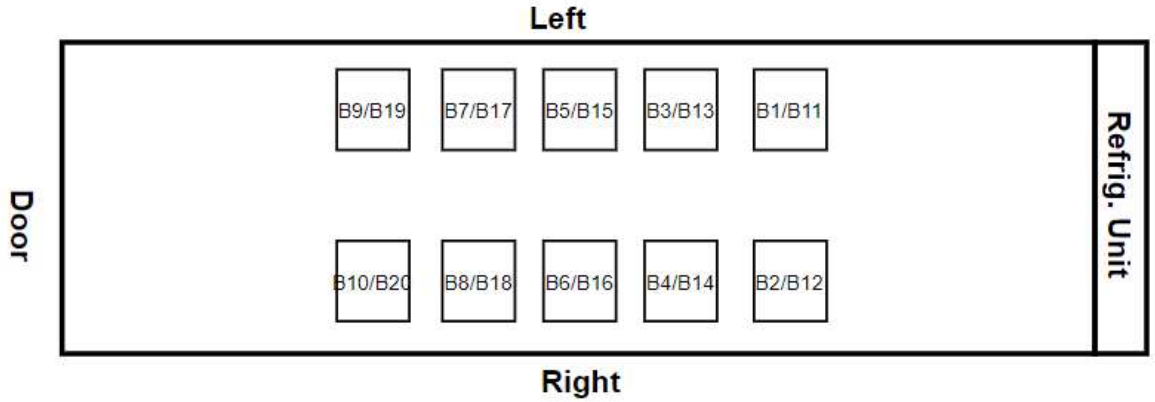


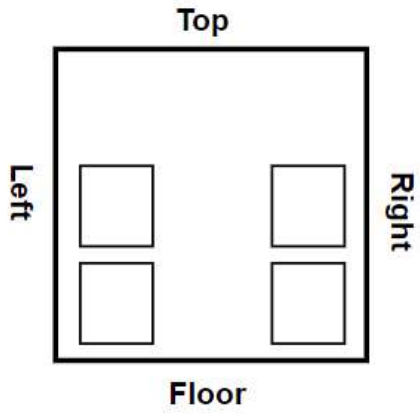
HPWH Research

COVID Vaccine Transportation Testing









Selected Projects for Discussion

- **Cold Climate Heat Pump**
- Cold Climate Heat Pump
- Seamlessly Fuel-Flexible Heat Pump

- **Heat Exchanger/Compressor Cost Reduction**
- Low-Cost, High-Performance Polymer Composite Heat Exchanger using Additive Manufacturing Techniques

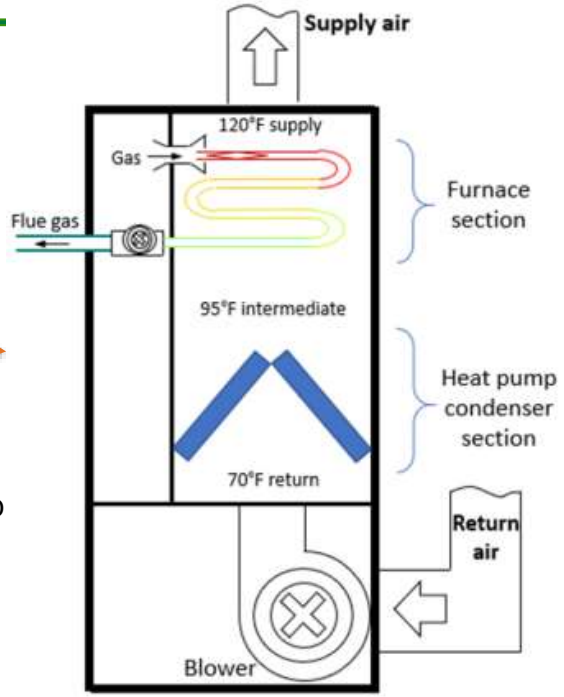
- **GWP<150 Component Research**
- Direct Expansion Heat Pump for GWP<150

- **Heat Pump Water Heater**
- Flexible HPWH with Embedded Energy Storage

- **HVAC**
- Multi-Functional Equipment for Direct Decarbonization with Improved Indoor Air Quality (IAQ)
- Flexibility Measures for HVAC Equipment in EnergyPlus

Sample of Current DOE HP Projects

- **Cold Climate Heat Pump**
- Cold Climate Integrated Heat Pump
- Seamlessly Fuel-Flexible Heat Pump

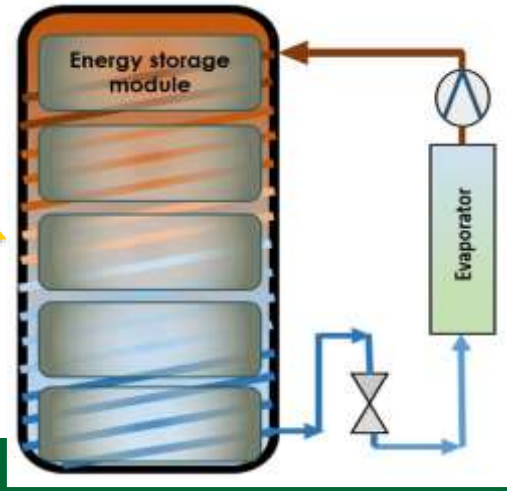


- **Heat Exchanger/Compressor Cost Reduction**
- Low-Cost, High-Performance Polymer Composite Heat Exchanger using Additive Manufacturing Techniques

45% less size
28% lower pressure drop
20% less cost

- **GWP<150 Component Research**
- Direct Expansion Heat Pump for GWP<150

- **Heat Pump Water Heater**
- Flexible HPWH with Embedded Energy Storage



- **HVAC**
- Multi-Functional Equipment for Direct Decarbonization with Improved Indoor Air Quality (IAQ)
- Flexibility Measures for HVAC Equipment in EnergyPlus

Cold Climate Heat Pump Challenges

- High discharge pressure at low ambient
- COP (heating) is low due to large delta T (indoor to outdoor)
- Heating capacity insufficient if sized for cooling load
  - Capacity deficit met using resistance heating
    - increased power demand during peak (for winter peaking)
- Increased cycling losses if sized for heating load
  - During cooling
  - At moderately low ambient temperatures
- High Cost

Results

- **Field demonstration in Fairbanks Alaska**

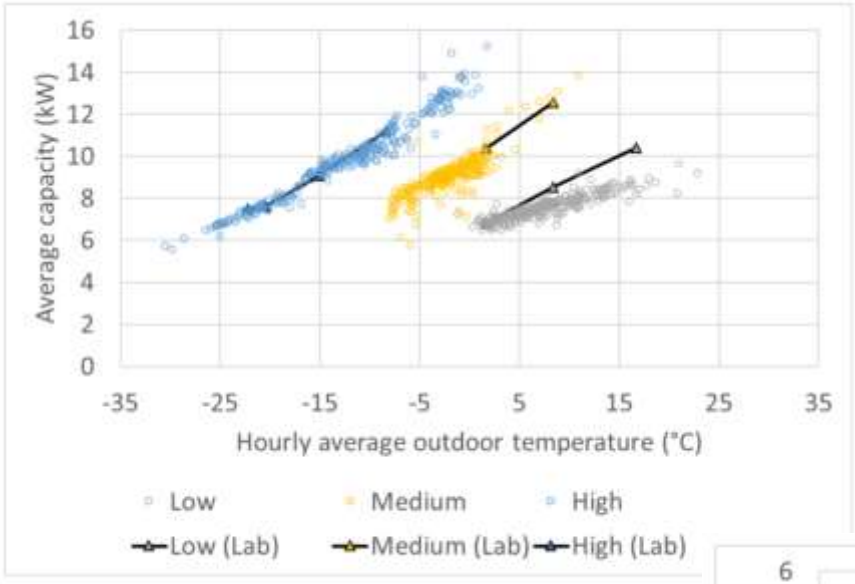


Figure 10. Average measured capacity of the field-test unit for hours with more than 5 min of runtime in the indicated stage compared with the measured laboratory data.

Capacity ~ 23000 Btu/hr @ 25° C

COP>2 @ 25° C

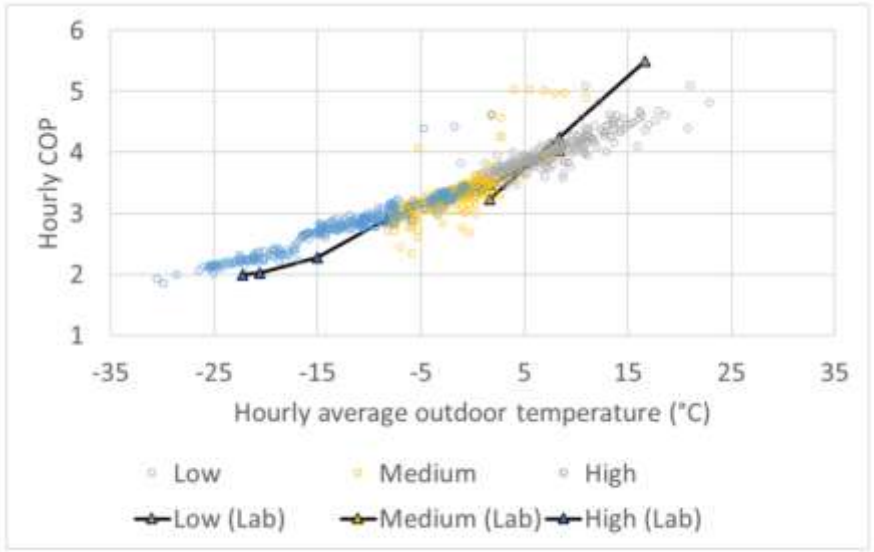


Figure 11. Average measured COP of the field-test unit for hours with more than 5 min of runtime in the indicated stage compared with the measured laboratory data.

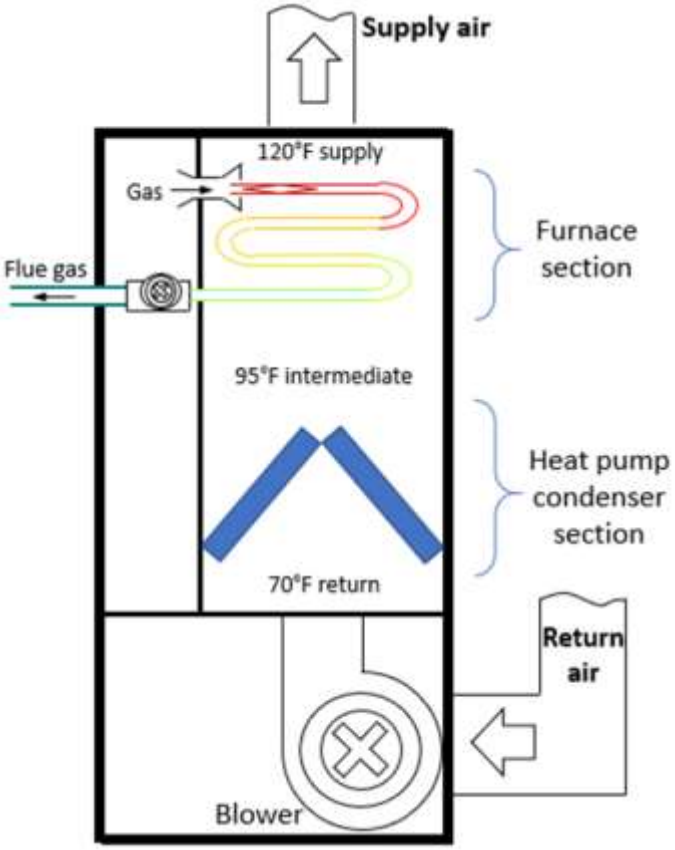
Seamlessly Fuel-Flexible Heat Pump

Existing space heating challenges:

- **Conventional heat pumps**
  - Rely on inefficient (high CO_2) electric resistance and exacerbate the peak at low ambient temperatures
  - Higher electricity costs (versus gas) in colder climates
- **Conventional furnaces**
  - No improvement in CO_2 footprint as grid incorporates renewables
  - Don't address grid flexibility

Expected Outcome:

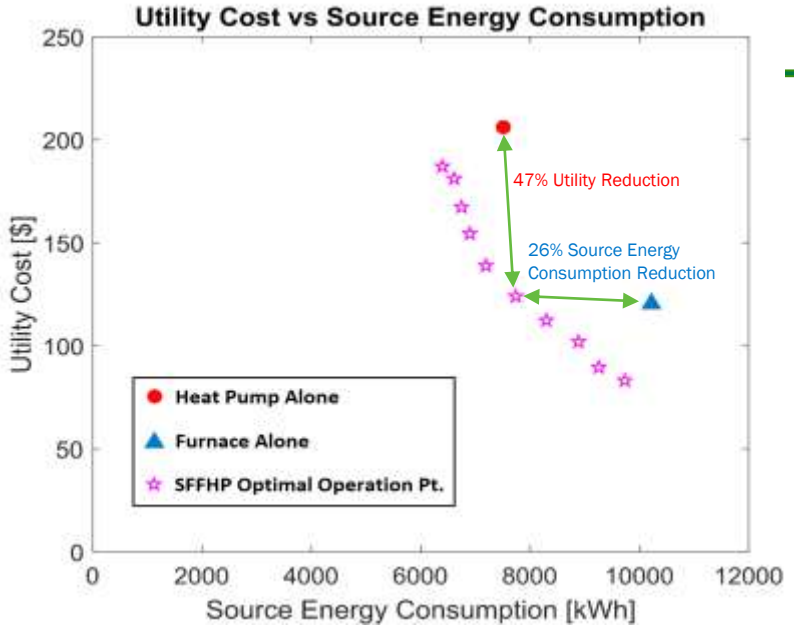
- **Fuel-flexible heat pump pairing an electric HP with a gas furnace**
  - Operation adjusted based on real time utility price signals or other factors
  - Transitional heat pump product for market currently dominated by natural gas
  - Prototype with 25% primary energy and CO_2 savings, 30% utility cost savings, and 90% peak demand reduction

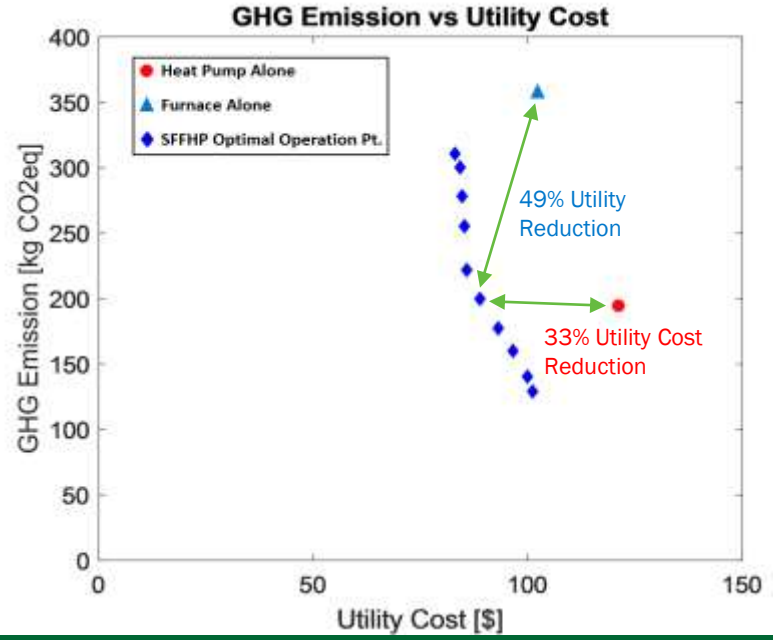


Additional details in ORNL Invention Disclosure 81921483

Approach

- Potential optimization strategies
  - Minimize primary energy use
  - Minimize utility cost
  - Minimize CO_2 emissions
  - Sizing (unit cost)
  - Combination of the above





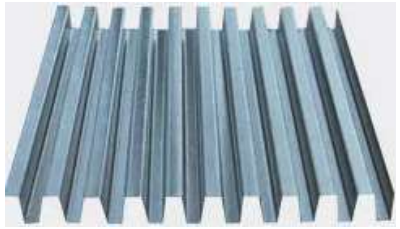
Low-Cost, High-Performance Polymer Composite Heat Exchangers

- **Air-to-refrigerant heat exchangers**
  - account for more than 50% of the energy consumption
  - 60-80% of thermal resistance to heat transfer is on the air-side
  - enhancements add to cost

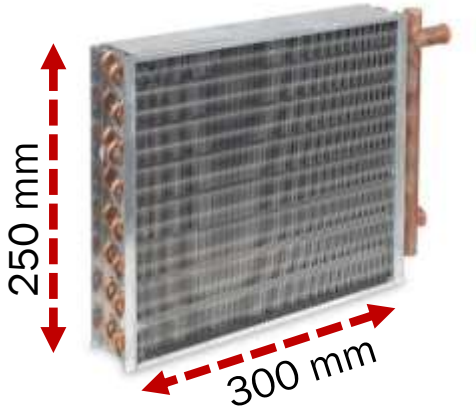

Louver fin


Wavy fin

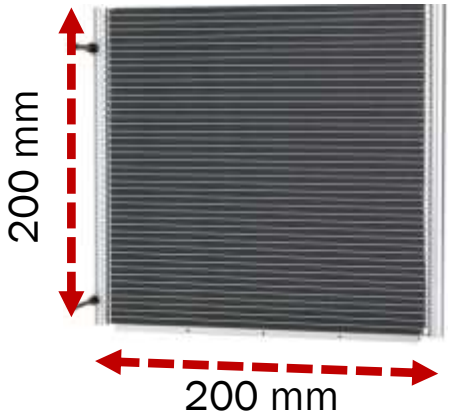

Staggered fin


Plain fin

Capacity= 5 kW



Coil weight= 6 kg
Pressure drop= 3.5 bars
Thickness= 36 mm
Manf Cost=>$55



Coil weight= 1.2 kg
Pressure drop= 2.5 bars
Thickness= 18 mm
Manf Cost=~$40

Project Impact

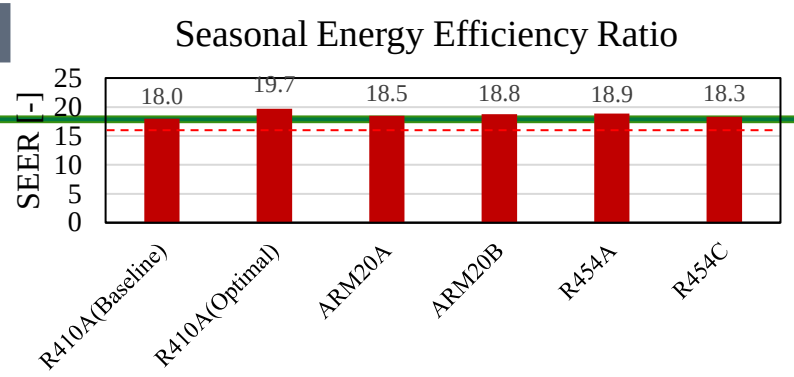
- **Develop next generation heat exchanger**
  - Improved thermal-hydraulic performance (indirect GHG emission reduction)
  - 50% reduction in manufacturing cost
  - Increased operational life
  - 3-4 times more compact compared to SOA
- **Enables deployment of A2L and A3 refrigerants**
  - Reduction in refrigerant charge (direct GHG emission reduction)

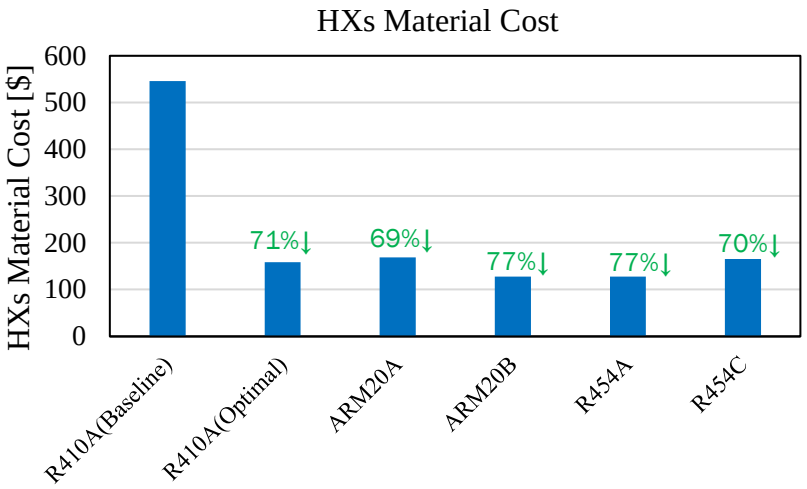
Next Generation Low Cost Direct Expansion Heat Pumps Using Refrigerant Mixtures with GWP <150

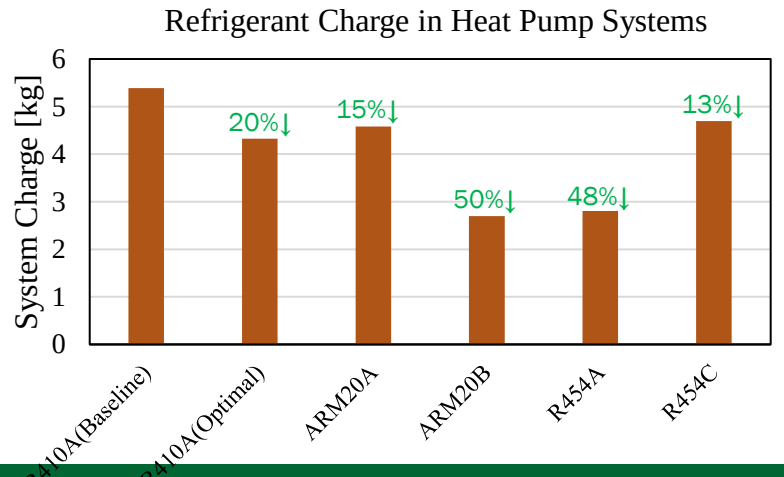
- Refrigerants with GWPs > 750 will be banned after 2023
- Long-term refrigerants with GWP < 150 are the next step
- Issues
  - higher glide
  - flammability and toxicity
    - requires reduced refrigerant charge
  - smaller systems
  - larger compressor displacement
  - unit cost should be comparable

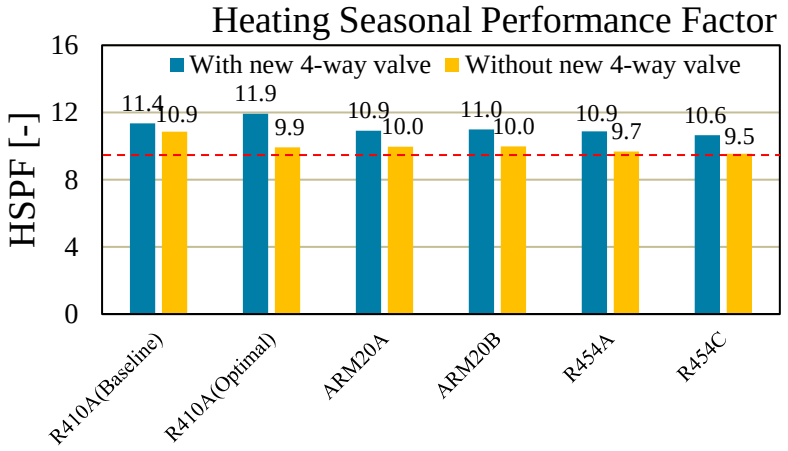
Progress - Modeled

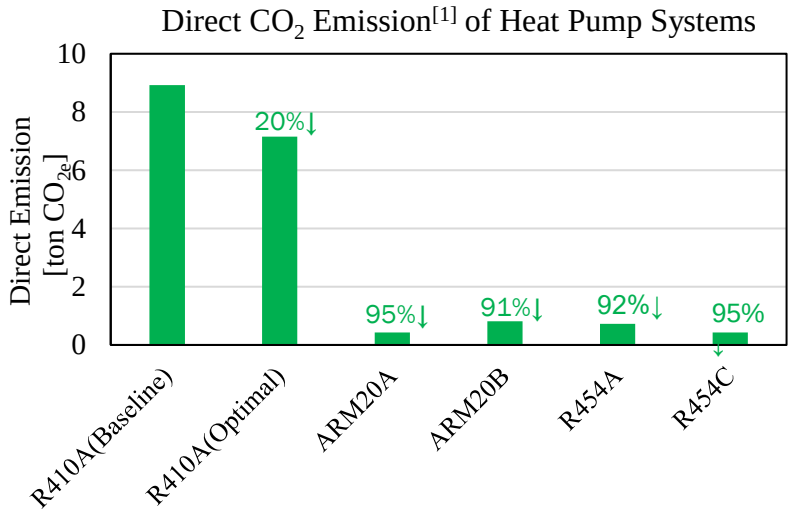
- **Seasonal Energy Efficiency Ratio (SEER) is 18.3-18.9**
  - Goal: SEER > 16)
- **Heating Seasonal Performance Factor (HSPF) is 10.6-11.0**
  - Goal: HSPF > 9.5)
- **Heat exchangers material cost is reduced by 69% -77%**
- **Refrigerant charge reduced by 13%-50%,**
- **Direct CO_2 emission reduced by 91%-95%**





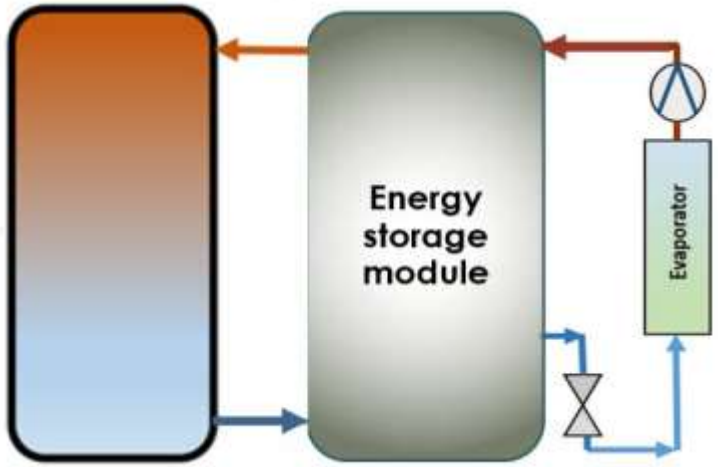


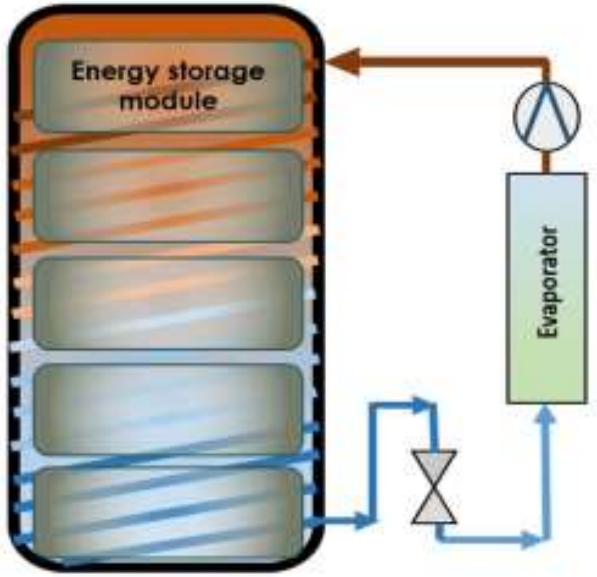




Flexible HPWH with Embedded Energy Storage

- **Next-generation HPWH for distributed energy storage**
- **Demonstrate cost-effective technology**
  - Selection of energy storage medium is key
- **Alpha prototype enables at least 20% higher capacity**
  - 4 hours of load shifting capability
  - Improved first hour rating (FHR)
- **Embedded solution**
  - Addresses logistic constraints due to additional space requirements
  - Lower capital cost
  - Improved consumer acceptance





Multi-functional Equipment for Direct Decarbonization with Improved Indoor Air Quality – New Start

Objective

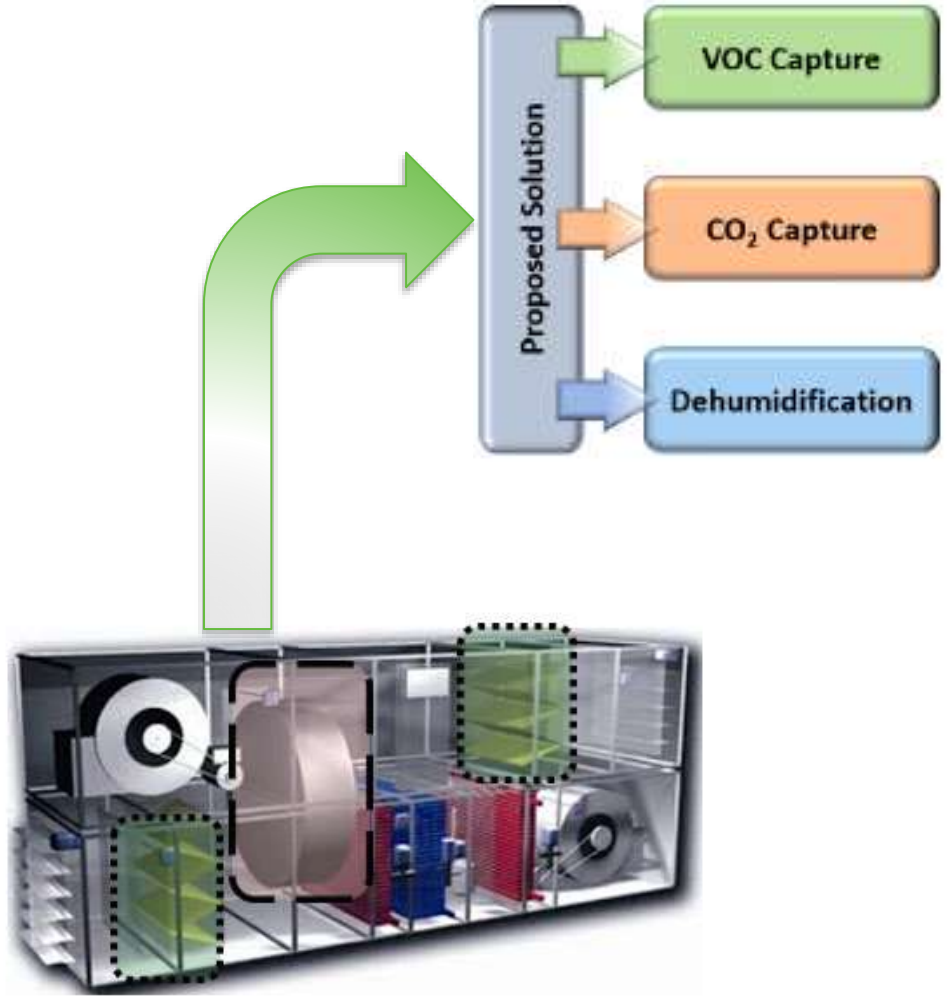
- Integrated HVAC system design
  - separately dehumidifies the air-steam
  - uses waste heat to regenerate liquid desiccant
  - Eliminates hot air carryover
  - incorporates filters and rotating wheels to capture VOCs and CO2
  - mitigation airborne transmission of COVID-19 or other microorganisms

Explanation of Need

- IAQ is becoming a bigger issue as buildings become tighter
- Conventional approaches introduce hot, humid air or cold air to the building which increases HVAC energy consumption

Goal/Target Outcome

- Improved IAQ
- 30% reduction in energy
- On-site sequestration processes for captured CO2 will be evaluated



DOE Team and Structure

Building Technologies Office

BTO is one of 11 program and technology offices within the Office of Energy Efficiency and Renewable Energy (EERE).

Our FY 2019 budget is $226 million, or about 9.5% of EERE's $2.379 billion budget. DOE's total spending is about $35.7 billion.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

ENERGY EFFICIENCY	RENEWABLE POWER	SUSTAINABLE TRANSPORTATION
Advanced Manufacturing	Geothermal Technologies	Bioenergy Technologies
Building Technologies	Solar Energy Technologies	Fuel Cell Technologies
Federal Energy Management	Wind Energy Technologies	Vehicle Technologies
Weatherization & Intergovernmental	Water Power Technologies	

Building Technologies Office Programs & Staff

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David Nemtzow

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COMMERCIAL BUILDINGS INT.

Amy Jiron, Program Manager (Acting)

RESIDENTIAL BUILDINGS INT.

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CODES AND STANDARDS

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Emerging Technologies Team

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Mary Hubbard

Technology-to-Market Manager

P. Marc LaFrance

Windows Technology Manager

Dr. Wyatt Merrill

Technology Manager for Building Electric Appliances, Devices, and Systems (BEADS)

Sven Mumme

Envelope and Thermal Energy Storage Technology Manager

Monica Neukomm

Grid Interactive Efficient Buildings (GEB) Technology Manager

Dr. Amir Roth

Building Energy Modeling Technology Manager

Dr. Brian Walker

Lighting R&D Technology Manager

R&D Partners

Emerging Technologies Program

Technology Sub-Program Areas

- Building Envelope
- Windows
- Building Equipment
- Lighting R&D
- Building Electrical Appliances, Devices and Systems
- Building Controls
- Thermal Energy Storage
- Building Energy Modeling

Appliance and Equipment Standards Program

- Identify equipment/appliances needing further R&D support; set minimum efficiency standards

Building Energy Codes Program

- To facilitate development of appropriate codes and standards

Residential Building Integration Program

Commercial Building Integration Program

- To bridge the gap from technology commercialization to broad market acceptance

National labs, academia, small businesses, manufacturers, and other industry stakeholders

- R&D to advance technology levels and support commercialization

Standards and certifying bodies and technical organizations (e.g., ASHRAE, AHRI)

- To help accelerate market acceptance

Partnering Programs within US Department of Energy Building Technology Office

DOE Building Technologies Office (BTO) Ecosystem

Research & Development (ET)

Develop high impact technologies through collaborations with industry

Standards & Codes

Minimum efficiency levels can be raised once enough products can meet new levels and codes can be updated to promote their adoption

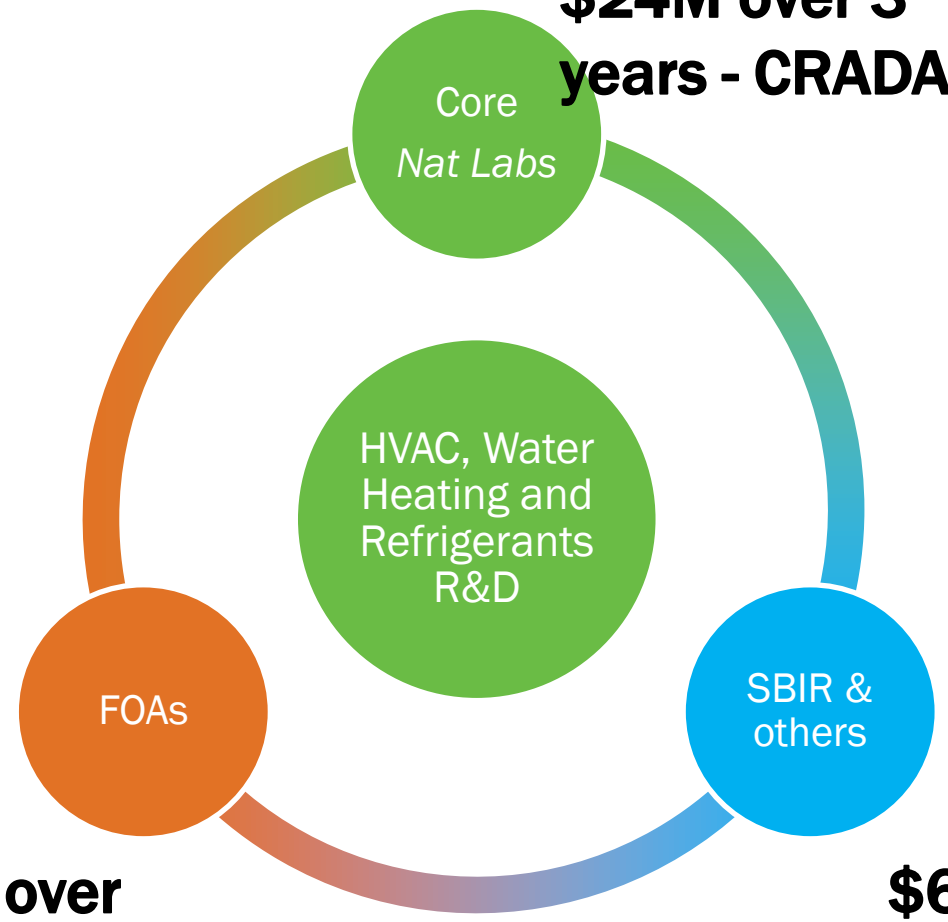
Market Stimulation (RBI, CBI)

Accelerate market uptake to enable raising minimum efficiency standards

HVAC, Water Heating, Refrigerants R&D

- **Three main types of funding:**
  - Core funding to National Labs
    - majority is for Cooperative Research and Development Agreements (CRADAs)
  - Funding Opportunity Announcements
  - Small Business Innovative Research
- **Other**
  - Technology Commercialization Fund

  https://www.energy.gov/technologytransitions/technology-commercialization-fund



Working with industry to accelerate delivery of solutions to market

Questions?

Discussion?

Next Step - Workgroup Calls

WG #1 – Improved Test Procedure and QPL

- October 6th @ 3:00-4:00 PM EST

WG #2 – Roadmap Specification and Manufacturer Engagement

- October 12th @ 12:00-1:00 PM EST

WG #3 – Design & Install Best Practices

- Not yet scheduled

To join a workgroup – email Morganne

Morganne.Blaylock@icf.com

Thank You

Special thanks Midwest Energy Efficiency Alliance for hosting a website