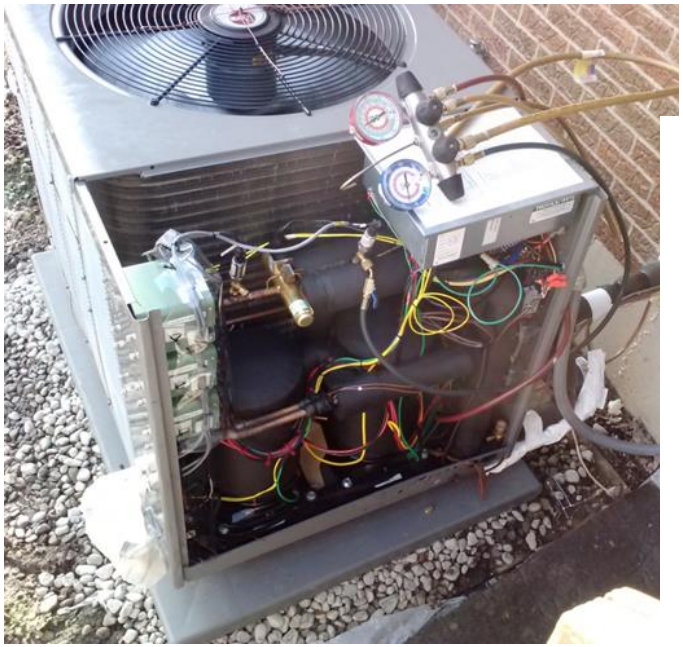
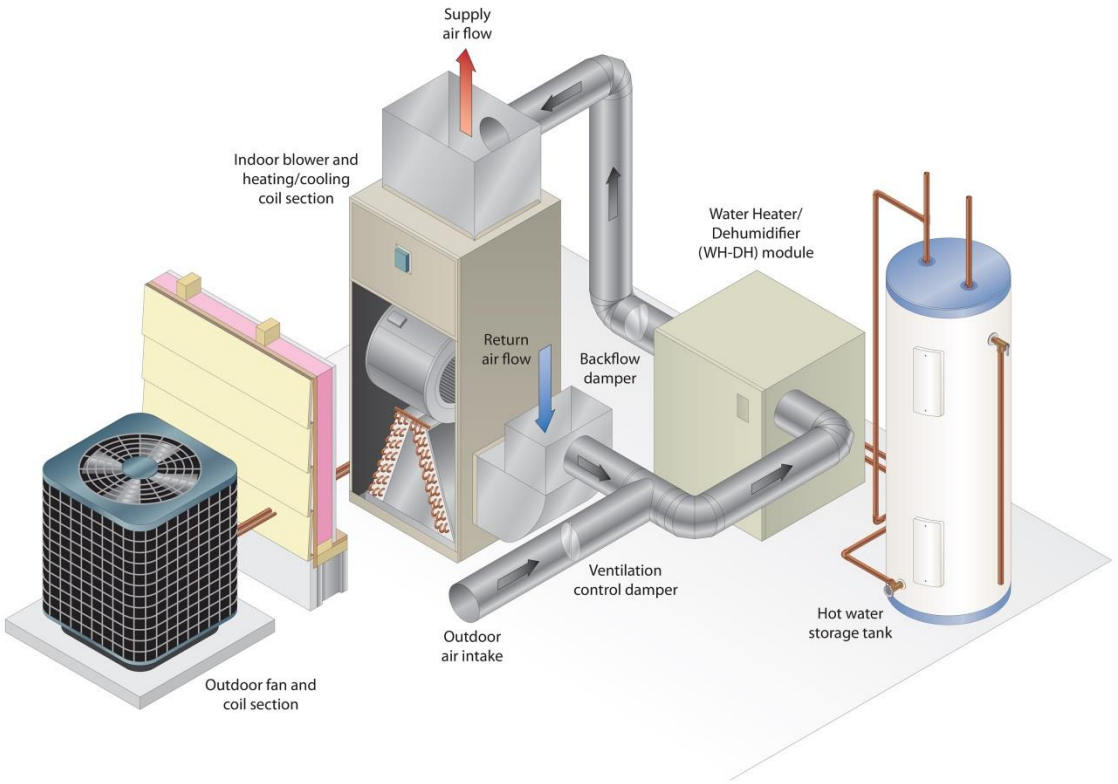
Advanced HVAC Development and Deployment

2016 Building Technologies Office Peer Review





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

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Project Summary

Timeline:

Start date: 10/1/2015

Planned end date: 9/30/2016

Key Milestones

1. Cold Climate Heat Pump Case Study; 6/30/2016
2. Air-Source Integrated Heat Pump Case Study; 9/30/2016

Budget:

Total Project $ to Date:

- AS-IHP: $100k
- CCHP: $50k
- Co-Funded with Emerging Technologies

Total Project $:

- AS-IHP: $100k
- CCHP: $50k

Key Partners:

Emerson Climate Technologies	Lennox International Inc.

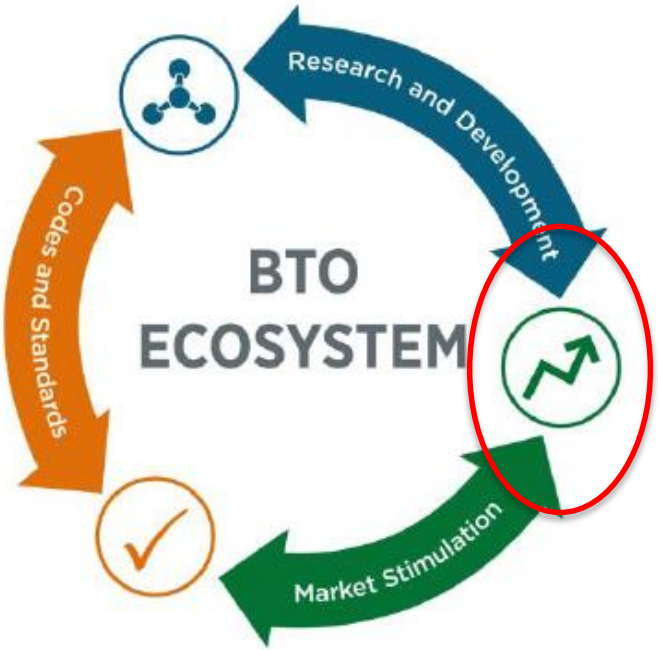
Project Outcome:

- Field tested, market-ready, designs for advanced HVAC systems.
- Increased market awareness of emerging advanced HVAC systems.
- More targeted and well-defined future Building America field studies.

Purpose and Objectives

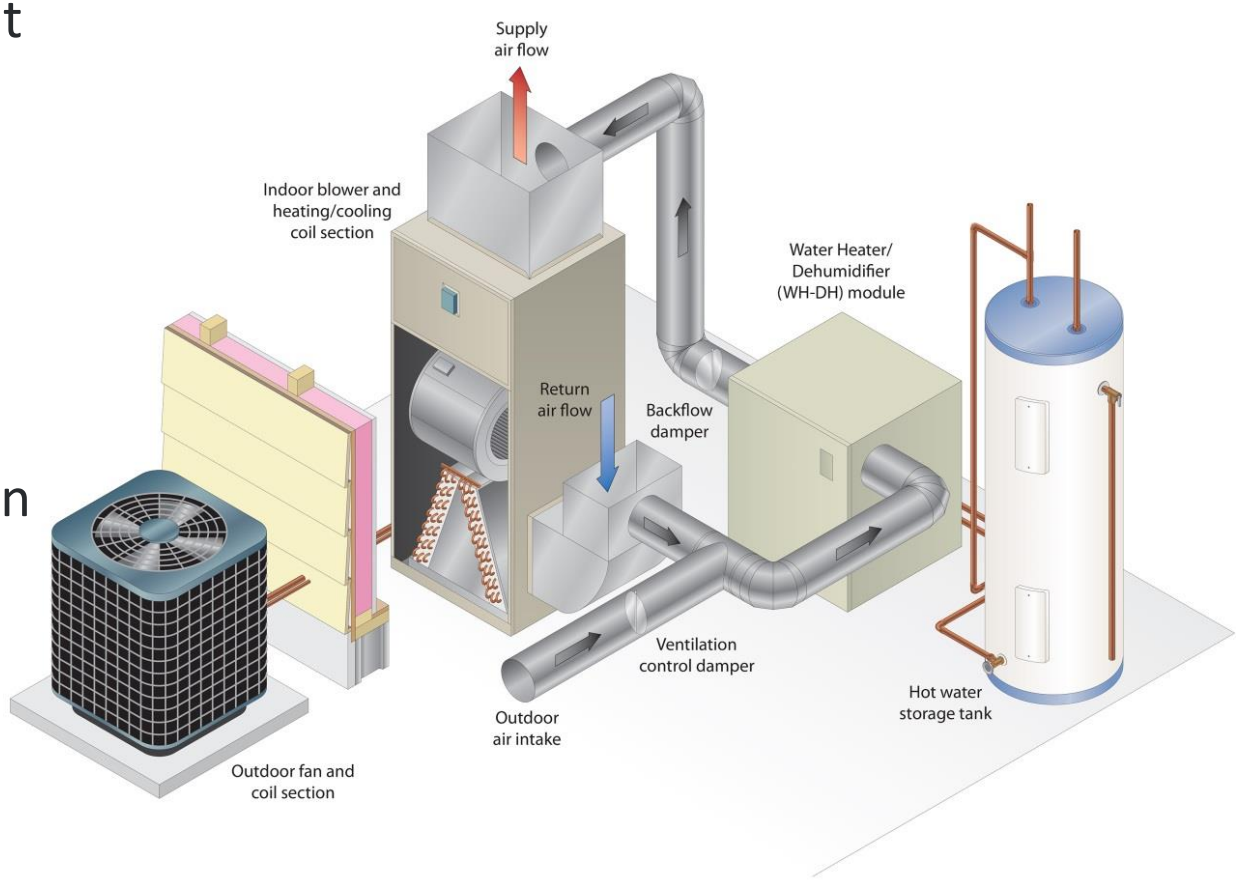
Problem Statement: For new energy saving technologies to be adopted, it is essential to increase market awareness of home builders, contractors, and homeowners and ensure performance when integrated with other building systems.

- What is the real-world performance of advanced HVAC systems?
  - "Retrofit-ready" air-source integrated heat pump (AS-IHP) with on-demand dehumidification
  - Advanced cold-climate heat pump (CCHP) with tandem compressors and vapor injection



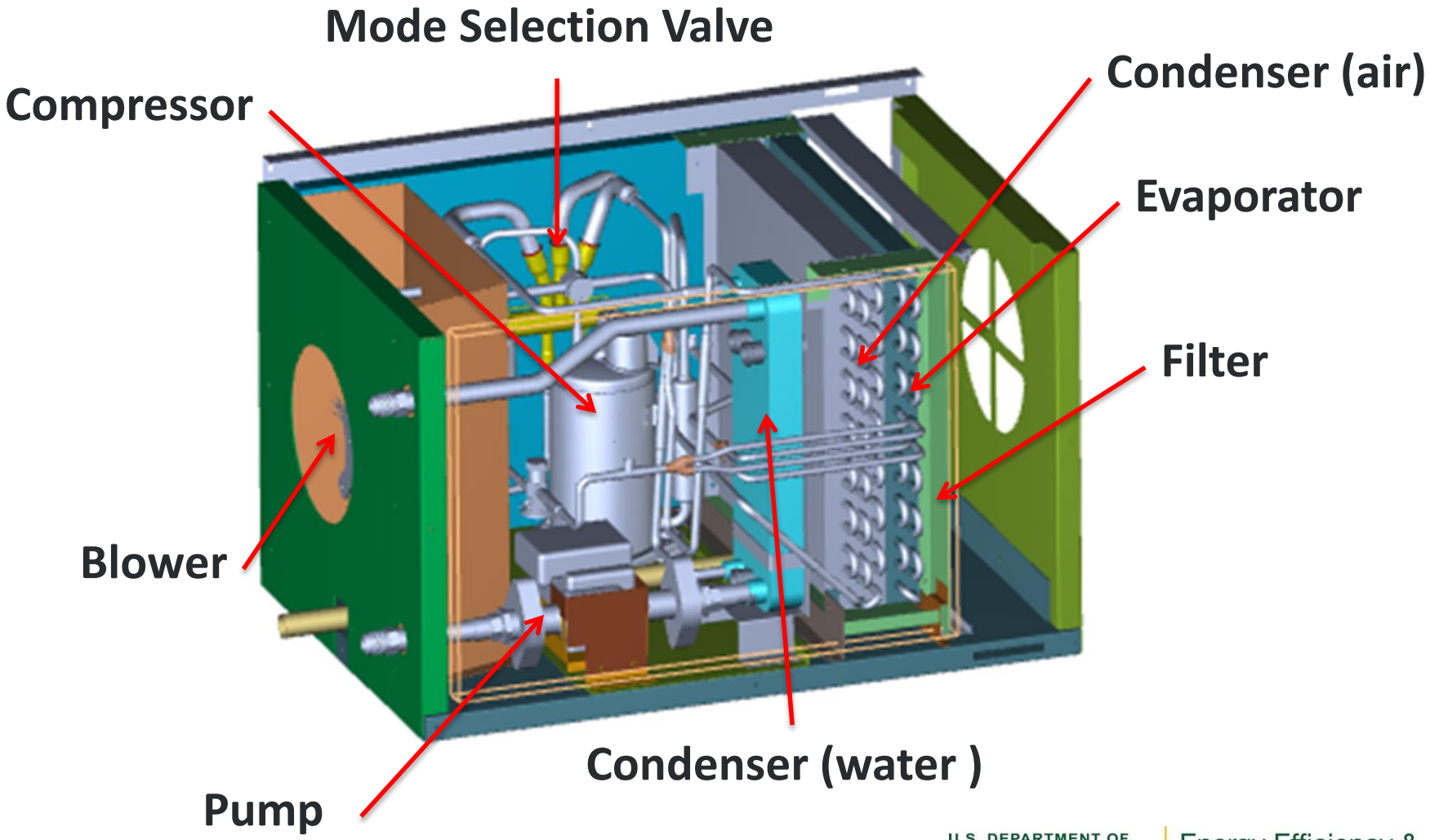
Air-Source Integrated Heat Pump

- "Retro-fit" ready design
- Variable-Speed Heat Pump
  - Space Cooling
  - Space Heating
- Water Heater/ Dehumidifier
  - Dehumidification
  - Water Heating
  - Ventilation



Air-Source Integrated Heat Pump

- Water Heater/Dehumidifier Module



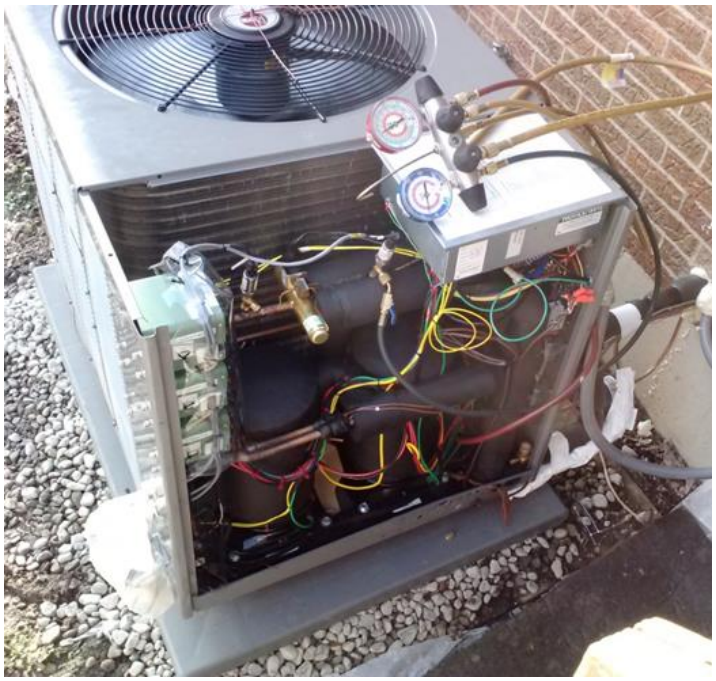
Cold Climate Heat Pump

- Design Targets
  - COP @ 47°F > 4.0
  - Capacity @ -13°F > 75% of capacity @ 47°F
- Unique Features
  - New heating focused compressor design allows for higher discharge temperatures, up to 280°F. Critical for low temperature operation
  - Tandem, equal capacity compressors. Unit sized for cooling load using one compressor. 2nd compressor provides higher heating capacity at low outdoor temperatures
  - Insulated compressors separated from airflow of outdoor coil.
  - Discharge temperature controlled by electronic expansion valve allows for optimized charge over a wide range of conditions

Cold Climate Heat Pump

- Laboratory Test Results

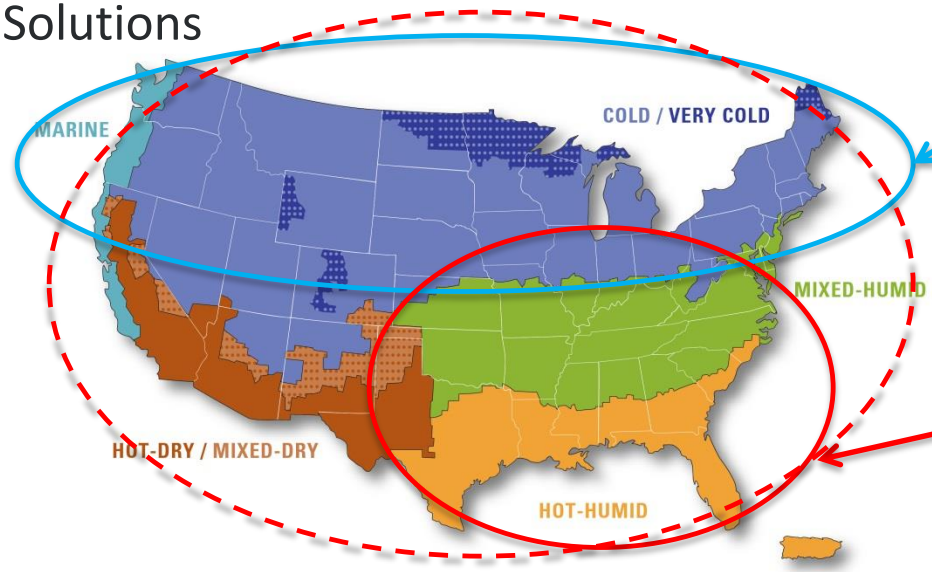
	Lower Cost		Premium w/Vapor Injection	
Outdoor Ambient	COP	Capacity (kBtu/h)	COP	Capacity (kBtu/h)
47°F (1 compressor)	4.24	39.7	4.40	40.0
17°F (2 compressors)	2.80	50.9	2.88	59.5
-13°F (2 compressors)	1.94	30.3	2.00	35.2



Purpose and Objectives

Target Market and Audience:

- Regional Solutions



Cold Climate Heat Pump

Air-Source Integrated Heat Pump

  - AS-IHP: Residential electric HVAC and WH market of ~3.1 quads with maximum adoption potential savings of ~1.3 quads/year in 2030
  - CCHP: Residential electric heating in cold/very cold climates estimated at ~151 TBtu with maximum adoption potential savings of ~92 TBtu/year in 2030
- Field test results will be used to inform stakeholders
  - Equipment manufacturer: feedback on potential improvements
  - Home builders, contractors, and homeowners: system benefits and performance potential

Purpose and Objectives

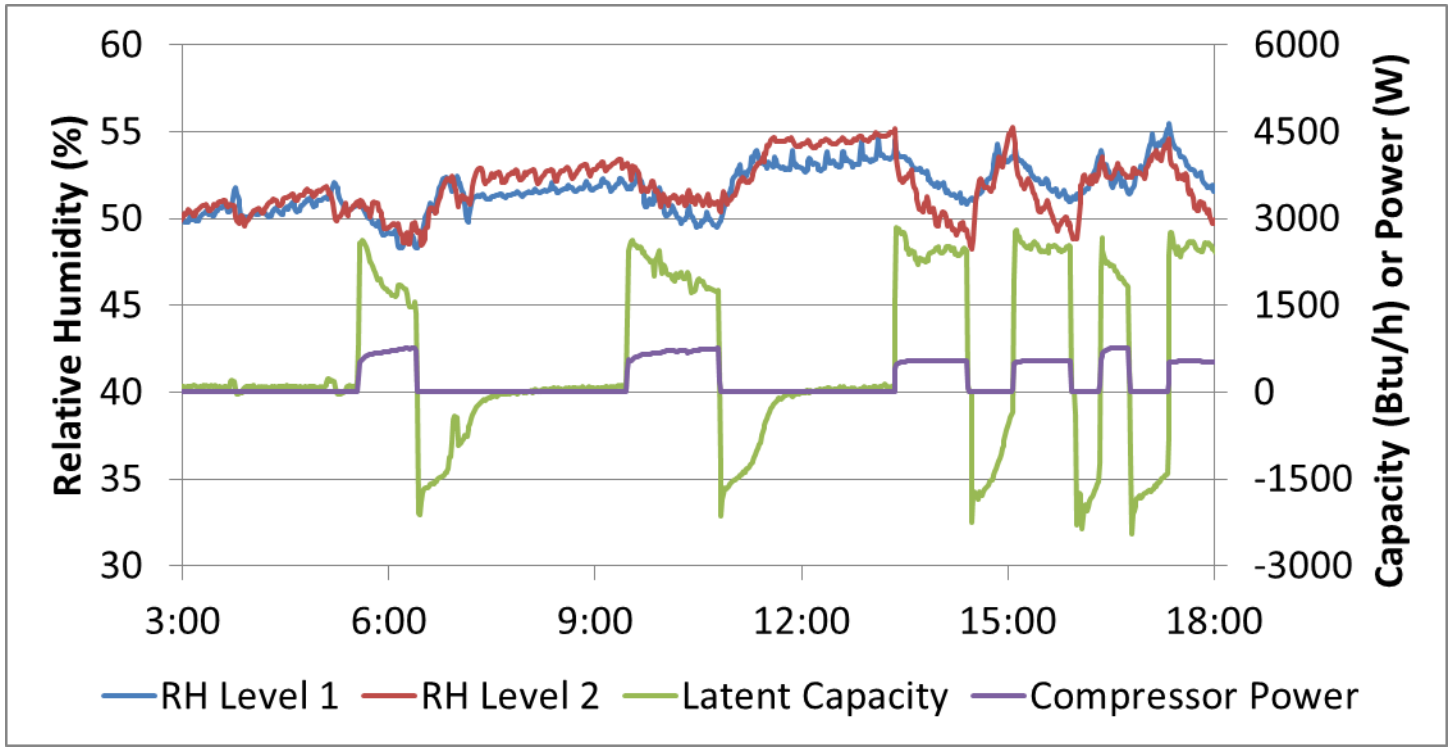
Impact of Project:

- Help manufacturer bring a viable product to the market. Address potential system-level and building integration issues before a product is brought to market.
  - Intermediate: Product released to market 1-2 years after project completion
  - Long-term: Building America teams perform larger scale field demonstrations of the commercially available product → Better success rate with fully vetted product
- Case study documenting the field test, performance of the equipment, and lessons learned.
  - Near-term: Increase home builder, contractor, and homeowner awareness of the product concept and its benefits through deployment on the Building America Solution Center

Approach

Approach: Field testing emerging technologies in real-world, but controlled, environments to ensure the equipment performs as intended and identify any issues that occur when integrating the equipment with other building systems.

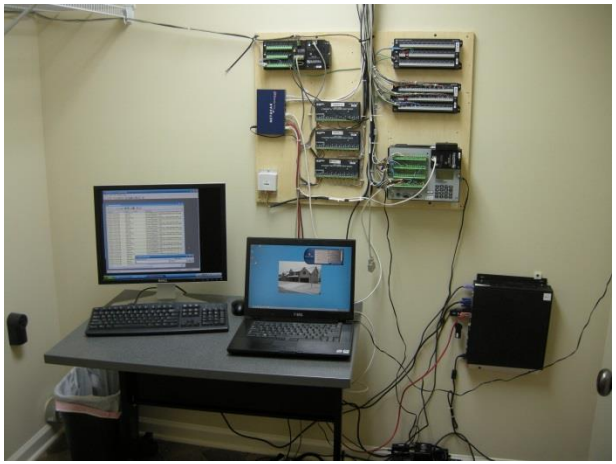
Key Issues: AS-IHP: Re-evaporation of condensation during ventilation



Approach

Distinctive Characteristics:

AS-IHP: Using unoccupied research house for field test. Controlled but realistic loads through the use of Building America Analysis Spreadsheet loads and Domestic Hot Water Event Generator.



CCHP: Field testing in Fairbanks, Alaska, to ensure extreme cold conditions are achieved.

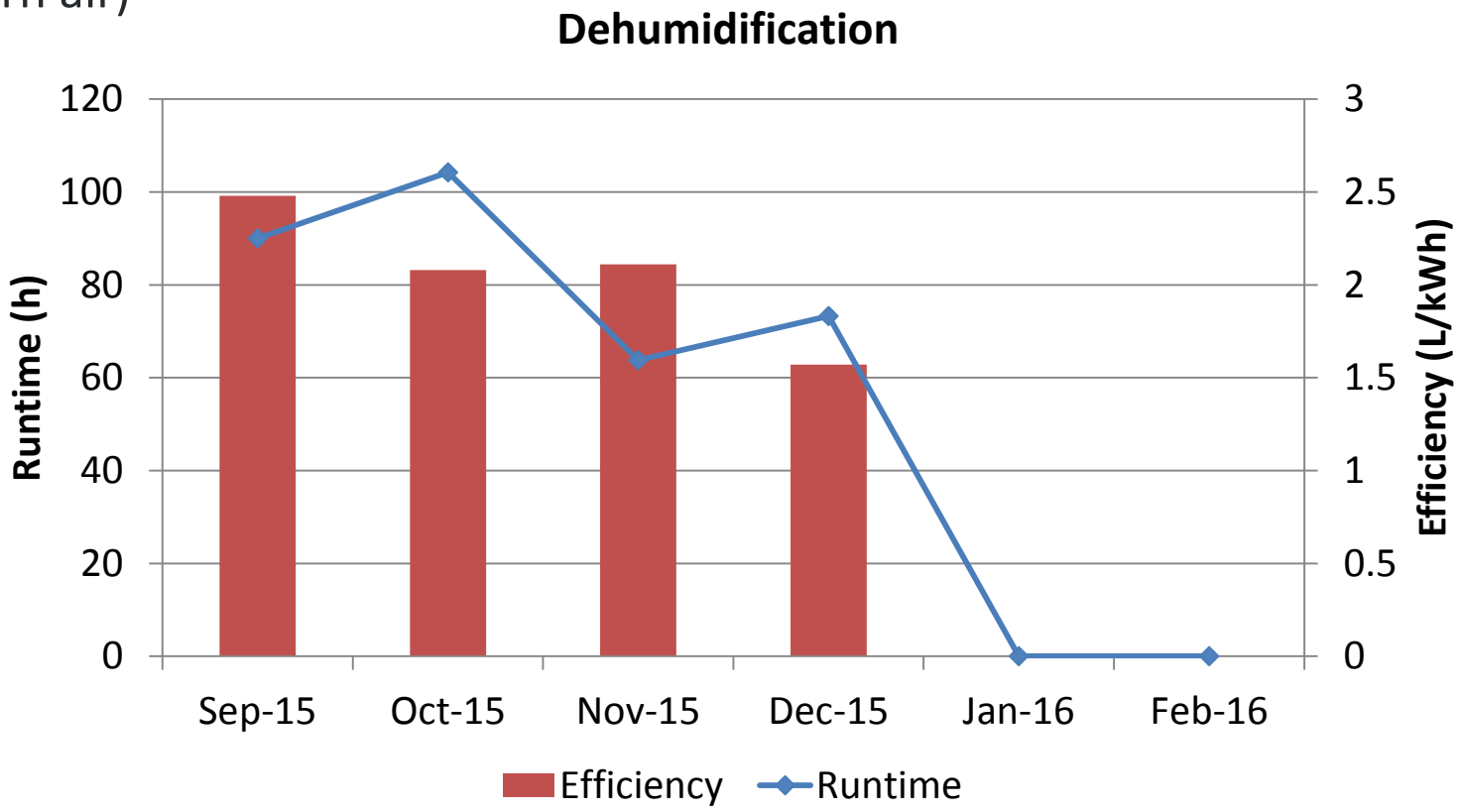
Progress and Accomplishments

Accomplishments:

AS-IHP:

Fall/Winter Dehumidification

- Efficiency of 1.6-2.5 L/kWh (variation due to ventilation air mixed in with return air)



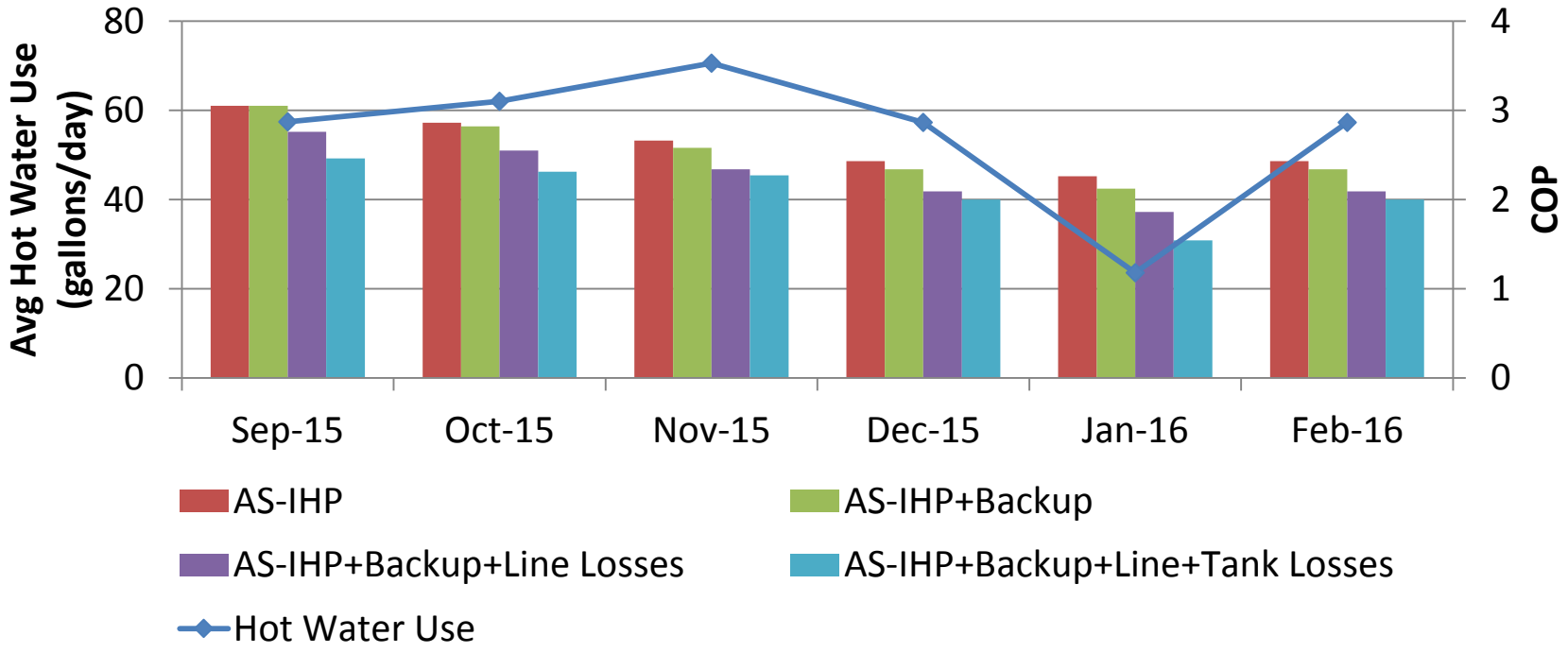
Progress and Accomplishments

Accomplishments:

AS-IHP:

Fall/Winter Water Heating

- COP of equipment 2.4 to 3.0
- Overall COP 2.0 to 2.4
- Should keep water lines short and insulated (research house has ~35’ total)



Project Integration and Collaboration

Project Integration: Advanced HVAC system projects include close work with industry partners. This ensures that feedback from the study is received by the manufacturer and can be incorporated into the production design.

Partners, Subcontractors, and Collaborators:
AS-IHP: Lennox International Inc.
CCHP: Emerson Climate Technologies

Communications: AS-IHP and CCHP designs have been presented at ASHRAE, IEA Heat Pump, and ACEEE conferences. Field test results will be presented at the conclusion of the study.

Next Steps and Future Plans

Next Steps and Future Plans:

- Complete field tests
- Provide feedback to industry partners
- Provide case studies for the Building America Solution Center
- Provide guidance for future Building America FOAs regarding larger scale field tests of commercially available products

REFERENCE SLIDES

Project Budget

Project Budget: AS-IHP: 100k, CCHP: 50k
Variances: none
Cost to Date: ~30k
Additional Funding: Co-funded with emerging technologies

Budget History					
FY 2015 (past)		FY 2016 (current)		FY 2017 – (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
		AS-IHP: 100k CCHP: 50k			

Project Plan and Schedule

- Project initiation date: 10/1/2015
- Project planned end date: 9/30/2016
- Milestone 1: AS-IHP case study
- Milestone 2: CCHP case study
- CCHP field test start date is delayed due to delays with the prototype production and chamber availability. Will delay deliverable.

Project Schedule		
Project Start: 10/1/2015		Completed Work
Projected End: 9/30/2016		Active Task (in progress work)
		Milestone/Deliverable (Originally Planned) use for missed
		Milestone/Deliverable (Actual) use when met on time

	FY2015				FY2016				FY2017			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Past Work												
Current/Future Work												
AS-IHP Field Test/Case Study												
CCHP Field Test/Case Study												