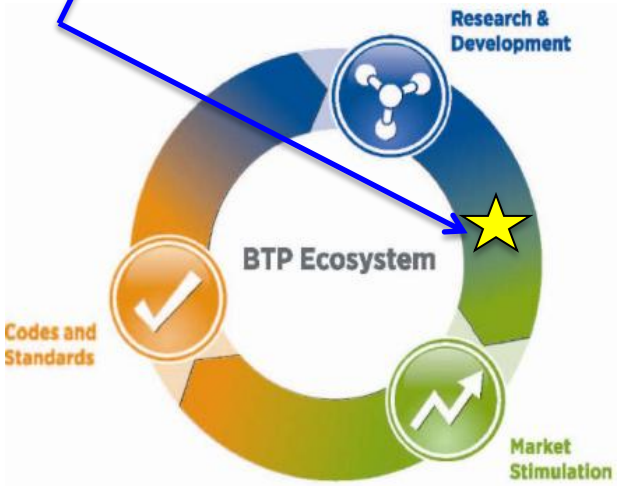
Development of advanced HVAC/WH system options for efficient residential or small commercial buildings, new const. or retrofit

* ET R&D project in support of DOE/BTO Goal of 50% Reduction in Building Energy Use by 2030



IHP concept – all HVAC & WH services integrated into one highly efficient system

NORDYNE
COMPLETE COMFORT. GENUINE VALUE.

CRADA project with Nordyne US HVAC system OEM

Product brands include Maytag & Westinghouse in addition to flagship Nordyne brand

Advanced variable speed air-source integrated heat pump (AS-IHP) - CRADA

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Oak Ridge National Laboratory

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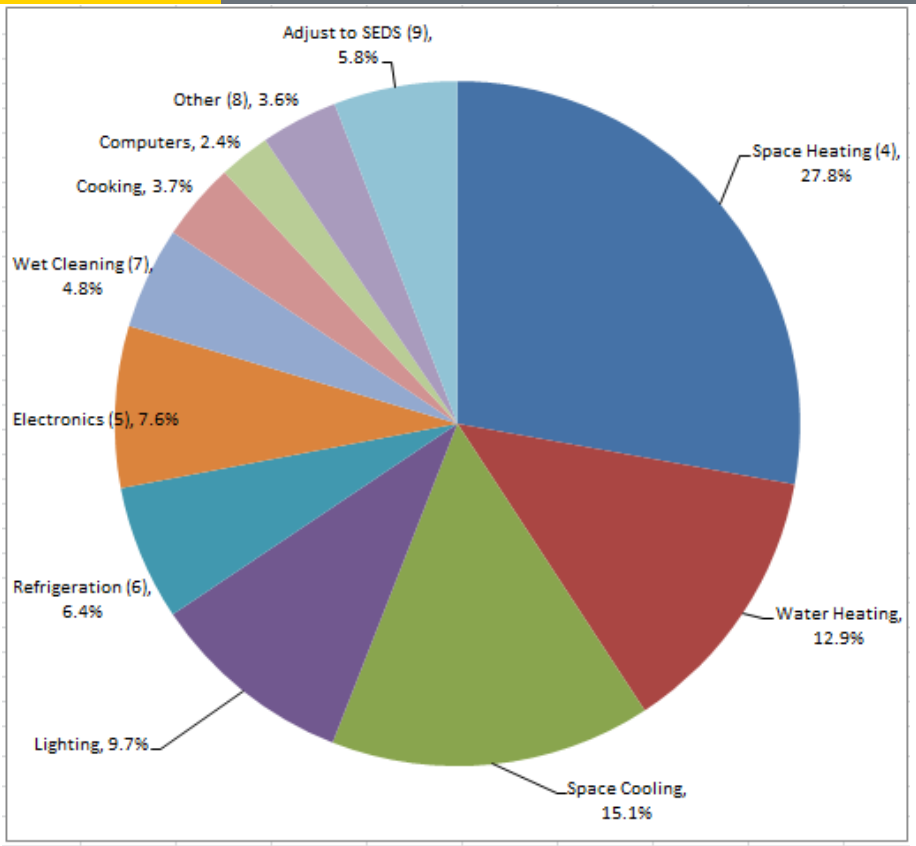
April 3, 2013

Purpose & Objectives

Problem Statement:

Space conditioning & water heating services are responsible for >55% of residential building energy consumption

Highly efficient HVAC & WH systems needed to enable achievement of DOE/BTO goal for 50% reduction in bldg. energy use by 2030



From March 2012 Buildings Energy Data Book

Impact of Project:

>100 Tbtus/y savings potential by 2030 with only 10% penetration of IHP systems to residential electric homes → ~$8B cost savings 2015-2030

Purpose & Objectives

Project Focus:

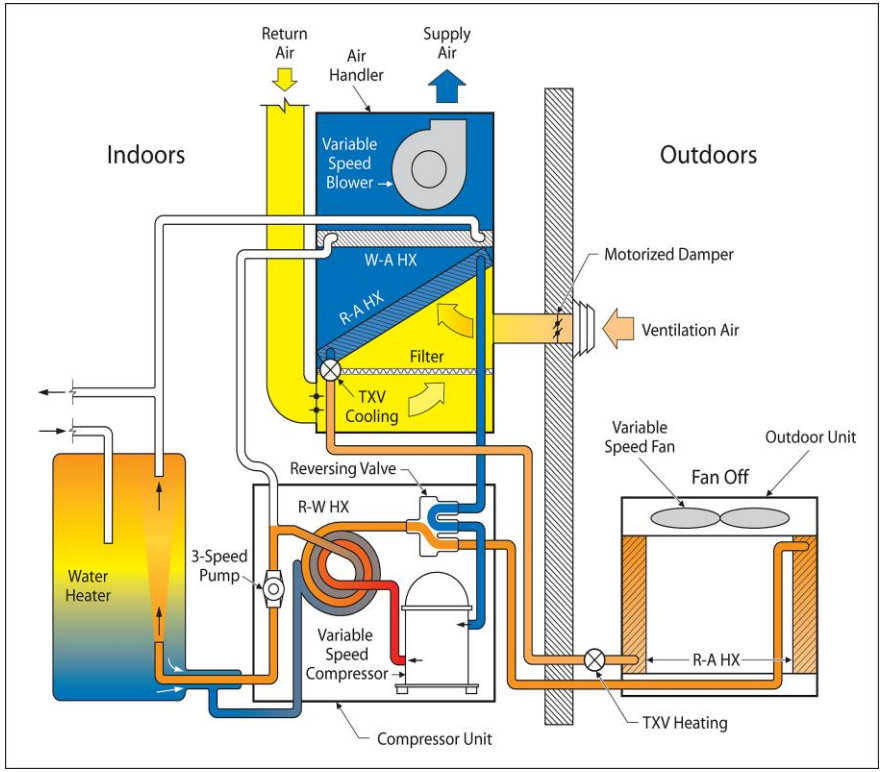
Goal - develop air-source HVAC/WH system based on IHP concept with ≥50% energy savings vs. min. efficiency systems.

Nordyne brings history of successful efficient HP&AC system development (including the highest SEER variable-speed AC/HP units on the market), market savvy, distribution/service infrastructure – key to AS-IHP market penetration.

Past successes in similar CRADAs show that such close collaboration with manufacturers is best path to success – e.g. GeoSpring HPWH, Trilogy GS-IHP, NextAire GEHP, Trane CDQ hybrid desiccant AC system, etc.

Approach

- Approach:
  - Collaborative/iterative prototype system design development with Nordyne
  - Experimental/modeling characterization of prototype systems and feedback to next generation prototype
  - Through field test demonstration system
- Key Issues:
  - Balance of charge and flow control among operational modes (SC, SH, WH and combined SC+WH and SH+WH)
  - Determination of optimal component speed ranges for different modes
- Distinctive Characteristics:
  - Efficient high-capacity water heating
  - Variable capacity control for maximum part load efficiency
  - Multiple patents and patent applications covering proprietary design aspects



AS-IHP system concept

Possible AS-IHP packaging approach

Approach

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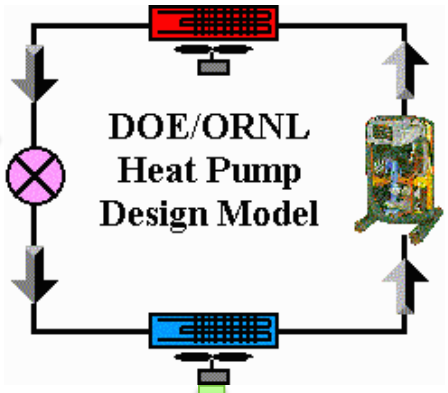
- Starting from basic IHP concept – lab prototype system dev. by Nordyne and ORNL; tested at Nordyne and ORNL in FY12; estimated annual energy savings based on lab proto design ~54% for Atlanta location (vs. 50% target)
- 1st gen packaged prototype based on lab proto tests/analyses completed & under test

Prototype design process



prototype design – fabricated and put through initial tests by Nordyne

TRNSYS 17

Performance maps to TRNSYS for energy savings analysis

Lab prototype test system

Lab performance testing in various modes completed August 2012

HPDM calibrated to test results; TRNSYS/HPDM annual energy savings estimate exceeds target

Decision to proceed; system design reoptimized; Nordyne fabricates 1st gen. packaged prototype & conducts initial tests

1st gen packaged prototype system

1st generation packaged prototype system fabrication and initial testing completed in early October 2012

Compressor & WH section

System delivered to ORNL in mid October – detailed performance mapping tests underway

HPDM to be calibrated to test results then used for optimization of field test prototype design and expanded TRNSYS/HPDM annual energy savings analyses

Accomplishments and Progress

Accomplishments:

- Initial lab prototype design completed and tested
- Annual energy savings estimates based on initial design show 54% savings for Atlanta climate vs. 50% target
- Decision made to proceed to packaged (1st generation) prototype stage
  - Prototype fabricated and undergoing performance mapping tests

Progress on Goals:

- Initial annual performance estimate exceeds project target
  - 54% overall HVAC/WH savings vs. baseline in Atlanta
    - ~30% HVAC savings and >70% WH savings

Project Plan & Schedule

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Original initiation date – 01-Oct-2011; Planned completion date – 30-Sept-2014 (extension to 31-Mar-2015 anticipated to complete field test data analysis, final model calibrations & assessments, and finalization of draft report)

Project on schedule to meet FY13 project milestones

Go/no-go decision points

- Sep '12 proceed to packaged prototype - **Passed**; Sep '13 proceed to field test; late CY '14/early CY '15 proceed to product introduction (Nordyne)

Summary	
WBS Number or Agreement Number	
Project Number -- 18810	
Agreement Number -- 6800	

Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Task / Event	FY2012 Q1 (Oct-Dec)	FY2012 Q2 (Jan-Mar)	FY2012 Q3 (Apr-Jun)	FY2012 Q4 (Jul-Sep)	FY2013 Q1 (Oct-Dec)	FY2013 Q2 (Jan-Mar)	FY2013 Q3 (Apr-Jun)	FY2013 Q4 (Jul-Sep)	FY2014 Q1 (Octt-Dec)	FY2014 Q2 (Jan-Mar)	FY2014 Q3 (Apr-Jun)	FY2014 Q4 (Jul-Sep)
Project Name: Advanced Air-Source Integrated Heat Pump												
Complete design analysis and fabrication of lab prototype and initial testing												
Complete WH tests, calibrate HPDM, and provide design input on next generation unit												
Go/no-go decision to proceed												
Complete fabrication of 1st generation packaged system												
Current work and future research												
Complete next gen system testing and provide design input on field test prototype												
Go/no-go decision to proceed												
Complete fabrication of field test system and install at site												
Complete field test and analyze data												
Go/no-go decision to proceed to market late CY2014 or early CT2015												

Project Budget

Project Budget: DOE total $1750k FY12-14

Variances: none so far

Cost to Date: ~$750k through February 2013

Additional Funding: none expected

Budget History					
FY2012		FY2013		FY2014	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$420k	*	$700k	*	$630k	*

* In-kind contribution from CRADA partner – confidential information

Project Integration, Collaboration & Market Impact

Partners, Subcontractors, and Collaborators: CRADA partner is Nordyne, Inc. Small subcontract to Thermal Energy System Specialists to assist in TRNSYS implementation. TVA cofunded establishment of field test site to be used in FY14.

Technology Transfer, Deployment, Market Impact: Ultimate target is development and market entry of highly efficient HVAC/WH system option aimed at residential & small commercial bldgs. by 2015.

Communications: Regular monthly progress reporting to DOE and Nordyne; Nordyne has patents and patent applications covering innovative aspects of the design.

Next Steps and Future Plans:

- complete testing of the 1st generation prototype – July 2013
- calibrate HPDM to test results – August 2013
  - to identify optimal speed ranges/operational limits for field test prototype design
  - update annual energy savings estimates to latest design for multiple locations
- Pending decision to proceed (September 2013), 2nd generation unit to be fabricated by Partner and field tested at test house near ORNL during FY14
- Complete draft final CRADA report at end of CY 2014 or 1st Q CY 2015

Test house #2 at Campbell Creek Community in Knoxville – intended field test site

- **Well characterized**
- **Design cooling load well matched to prototype system capacity**
- **Install system and begin field test by October/November 2013**