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

TRANE

CRADA project with Trane

TOP US Commercial HVAC Equipment OEM

Next Generation Rooftop Unit – CRADA

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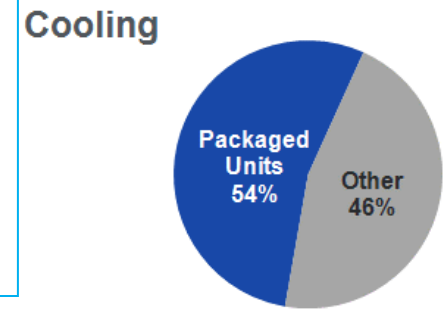
Purpose & Objectives

Problem Statement: half of all US commercial floor space cooled by packaged AC units, consumes more than 1.0 Quad source energy/year; highly efficient systems needed to facilitate DOE/BTO goal for 50% reduction in bldg. energy use by 2030.



Impact of Project:

- An estimated 40,000 10-Ton RTUs sold per year.
- If companies only buy best in class 10-Ton RTUs, they save about $50 million a year in energy costs.
- A typical 100,000 sq. ft. large box retail building contains 20-Ton RTUs.

Project Focus - Support DOE RTU challenge:

1. Development & market implementation of High Efficiency RTUs (10-ton to 20-ton, 20.0 IEER) with up to 50% energy savings vs. min. efficiency systems.
2. Development of advanced RTU model library, analytical tools support of DOE RTU challenge.

Relevance - Support DOE RTU challenge

Equipment Development and Performance Testing

- Our goal is > 20.0 IEER, up to 20-ton cooling capacity, cost-effective (20-ton high efficiency RTU development is a bigger technical challenge).

Analysis Tools Development to Enable Best Practices

- Simulation-driven product development, to shorten development cycle and optimize product performance.
- Enable development of whole product family.
- Performance mapping using fundamental, first-principle, hardware-based equipment model, to reduce testing cost and accelerate market deployment.

Approach

Approach:

1. Extensive modeling and comparison of various system configurations.
2. Laboratory performance testing to validate the tools and verify the energy saving / efficiency (the project metrics).
3. Building energy simulations to reveal energy savings.

Key Issues:

- High part-load operation efficiencies.
- Decreasing air flow by specifying variable air volume rather than constant air volume.
- Increasing fan efficiency from 45% efficiency to premium efficiency.

Distinctive Characteristics:

- Highly modulated system to best utilize HX surface area at part-load conditions.
- Combining a tandem (15-ton) and a variable-speed vapor compression system (5-ton) as a cost-effective option for capacity modulation.

Approach (DOE/ORNL HPDM)

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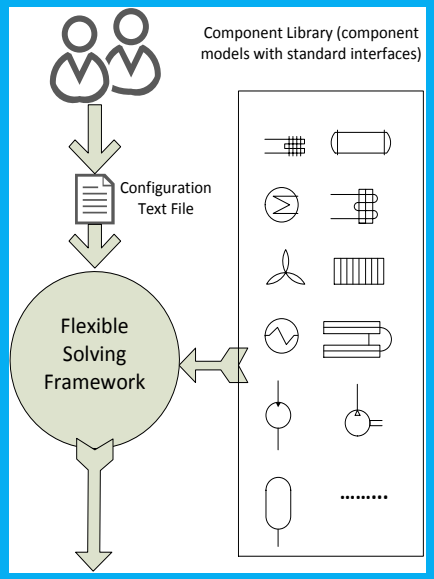
ORNL Building Equipment Model

CFD



Optimize Equipment Design

- DLL
- Mapping
- Curve-Fitting

MODELICA

TRNSYS 17

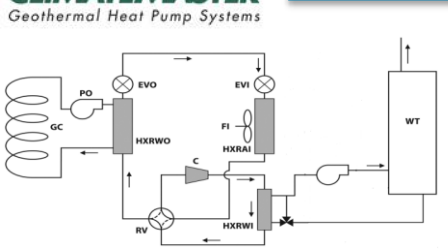
EnergyPlus

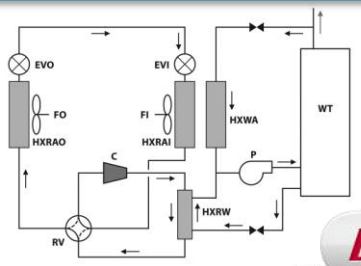
Next Generation Rooftop

Multi-Split VRF

Integrated Heat Pumps

ClimateMaster Geothermal Heat Pump Systems



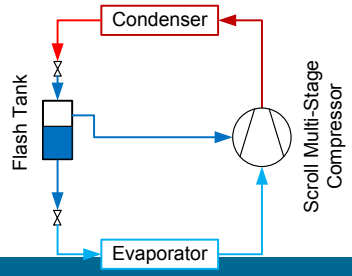


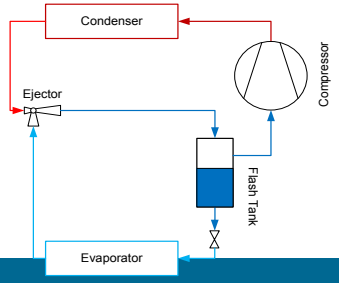
MAYTAG

LENNOX

Cold Climate Heat Pump

EMERSON Climate Technologies





Approach (ORNL Advanced RTU Component Model Library)

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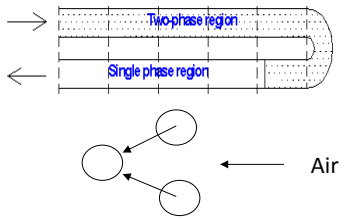
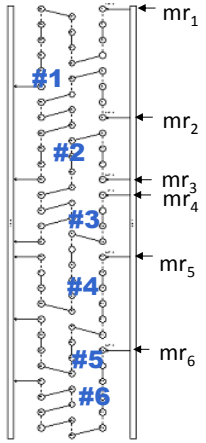
Arbitrary HX Circuitry -- Segmented Fin-&-Tube Coil Modeling

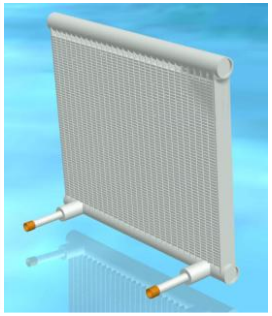


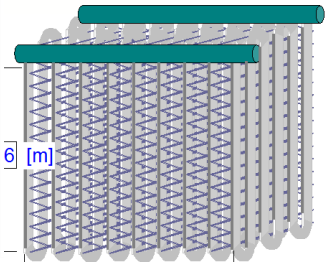
Fin-&-Tube Coil

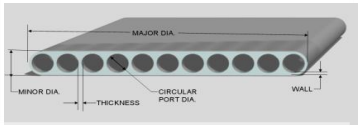


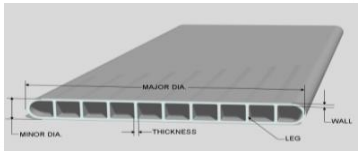
Air flow distribution

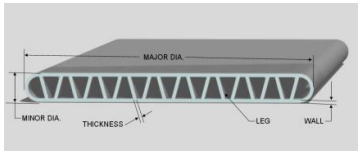
2-D air side distribution; Independent circuit refrigerant entering conditions; Arbitrary circuitry, provides more accurate real-world heat exchanger performance predictions





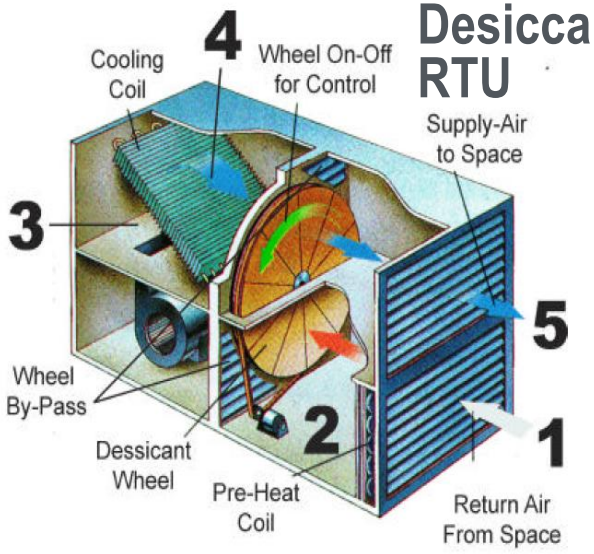






Segmented MHX Modeling

Desiccant-coupled RTU



Variable-speed compressor modeling - High-efficiency permanent magnet motors (integrate OEM's proprietary DLL to our system modeling)

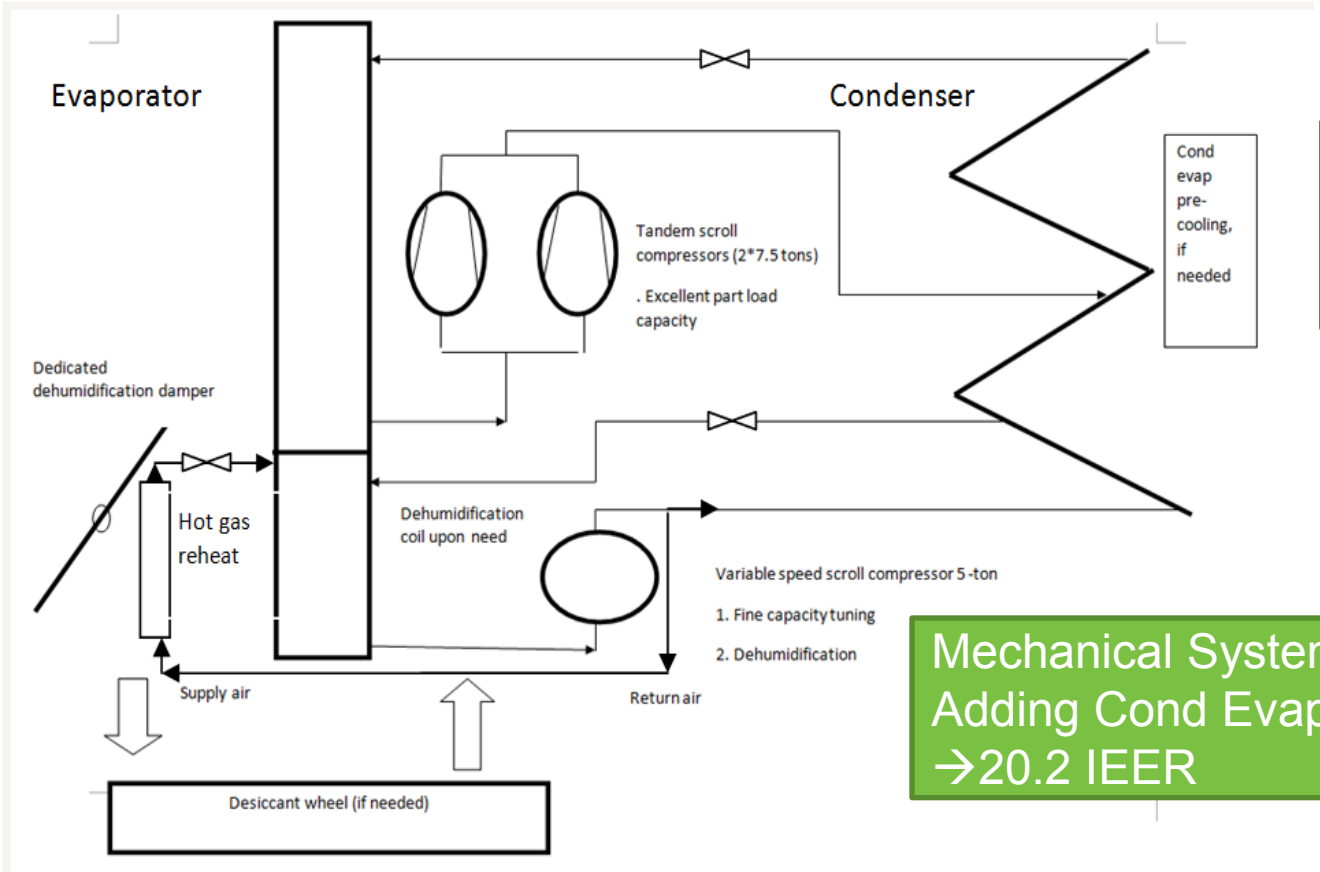
Approach (Laboratory Performance Testing)

- ORNL is the only DOE lab, having a facility capable of testing RTUs up to 20-ton.
- Performance testing work to be done in summer, 2013 (pictures from other project work).

Approach

Analytical evaluation of 10 technical solutions (HPDM)

- **Innovative component technologies: variable-speed compressors, micro-channel HXs, condenser evaporative pre-cooling, desiccant wheel, etc.**
- **Cost-effective modulation strategy: tandem system (15-ton) provides major modulation; small VS system (5-ton) provides fine tuning.**

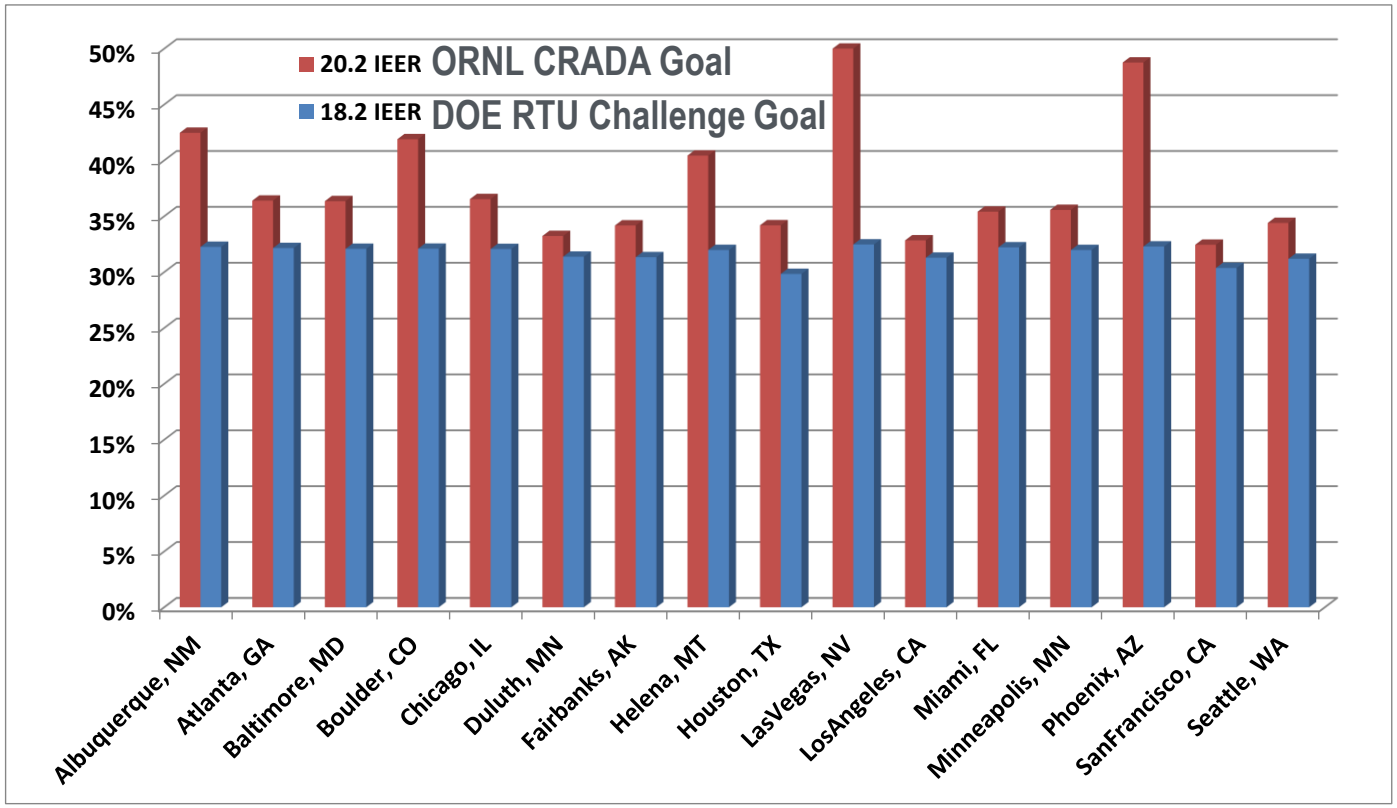


ORNL concept design

Mechanical Systems→18.2 IEER
Adding Cond Evaporative Precooling →20.2 IEER

Approach

Energy analyses completed to establish pathway to performance targets (EPlus Simulations)



ORNL concept design

- Baseline Single-speed RTU, IEER of 11.2, in commercial, small office buildings
- Only list the savings in vapor compression systems, not including savings by fans, economizer, etc.

Accomplishments and Progress

Accomplishments:

1. RTU component & equipment model library ready to support public use.
2. ORNL's concept design finished.
3. Building energy simulations done to reveal saving potentials, based on the concept design.
4. CRADA agreement signed with Trane (Sept/2012).

Progress on Goals:

1. ORNL's concept design is being evaluated by the CRADA partner during their product development.
2. ORNL has applied the ORNL concept to the Trane equipment by setting up the ORNL model and calibrating to their baseline equipment.

Project Plan & Schedule

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- Original initiation date (analytical support for RTU challenge) – 01-Oct-2010; Planned completion date – 30-Sept-2013
- Extension to 30-March-2014, to complete laboratory testing on a breadboard unit, final model calibrations, building energy simulations and economics assessments, and finalization of draft report.
- Reason for slipped milestones and slips in schedule - delayed completion of CRADA agreement - signed in September 2012

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				FY2013				FY2014			
	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)
Project Name: Next Generation Rooftop Unit												
Complete overall rooftop unit model development	◆											
Rooftop unit concept design (IEER = 20)	■	◆										
Building energy simulations based on concept design		■	◆									
CRADA agreement with Trane signed	■	■	■	■	◆							
Current work and future research												
Finish 20-ton RTU product design					■	◇	■					
Complete lab tests of prototype RTU							■	◆				
Building energy simulations and economics assessments									■	■	◆	
Go/no-go decision to proceed to field test											◇	

Project Budget

Project Budget: $1072k FY11-FY13 total

Variances: none so far

Cost to Date: ~$532k through February 2013

Additional Funding: none so far

Budget History							
FY2011		FY2012		FY2013		FY2014	
DOE	Cost-share*	DOE	Cost-share*	DOE	Cost-share*	DOE	Cost-share*
$122k	$0k	$500k	*	$450k	*	$0k	*

* In-kind contribution from CRADA partner – confidential information

Project Integration, Collaboration & Market Impact

Partners, Subcontractors, and Collaborators: CRADA partner is the Trane Company, Ingersoll Rand.

Technology Transfer, Deployment, Market Impact: Ultimate target is to enable development and market entry of high efficiency (IEER > 20.0) RTU system option aimed at commercial bldgs. by 2015.

Communications: Regular monthly progress reporting to DOE and Trane; and two publications:

- B. Shen, K. Rice, E. Vineyard, "Development of 20 IEER Rooftop Units – A Simulation Study", International Refrigeration Conference at Purdue, 2012.
- B. Shen, K. Rice, E. Vineyard, "Development of 20 IEER Rooftop Units – System Modeling and Building Energy Simulations", submitted to International Journal of HVAC&R.

Next Steps and Future Plans:

-Complete testing of the prototype unit– September 2013

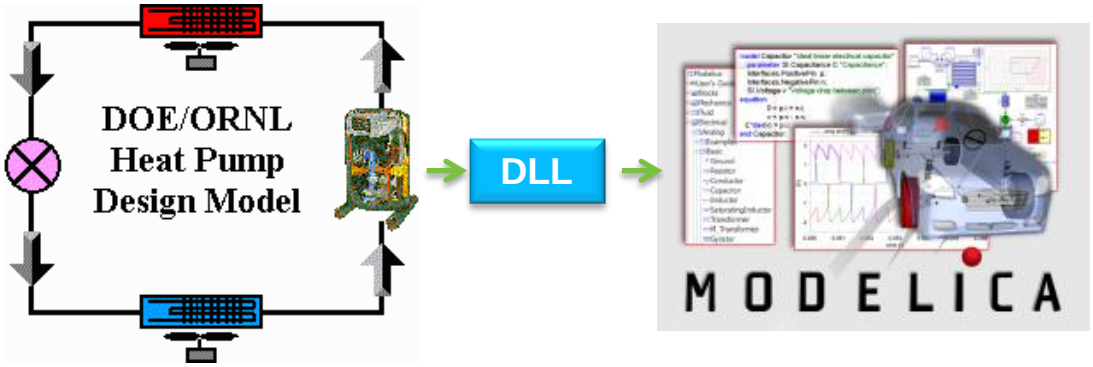
-Calibrate RTU equipment model to test results – November 2013

- Control strategy development
- Equipment performance mapping

-Assess building energy savings and economics– March 2014

- EnergyPlus building energy simulations in sixteen US cities
- Payback periods estimates

-Go/no-go decision to proceed to field test using ORNL's Commercial Flexible Research Platform – March 2014



Hardware-based HPDM/Modelica model library to support RTU design, building control strategy development, fault diagnosis, etc.