U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

High-efficiency Low Global-Warming Potential (GWP) Packaged Rooftop System

United Technologies Research Center

Dr. Ahmad M. Mahmoud, Associate Director, Research Engineering

Tel: 860-610-7149 E-mail: mahmouam@utrc.utc.com

Project Summary

Timeline:

Start date: 1/1/2018

Planned end date: 2/28/2020

Key Milestones

1. Design Review (Go/No-Go) 9/1/2018
2. First prototype system tested at key SEER conditions (5/1/2019)
3. Second prototype system meets value proposition (1/1/2020)

Budget:

Total Project to Date: $82k (as of 3/31/18)

- DOE: $57.4k
- Cost Share: $24.6k

Total Project : $1,885k

- DOE: $1,320k
- Cost Share: $565k

Key Partners:

Carrier Central Engineering
Carrier Commercial HVAC (North America)
Carrier Innovation and Research

Project Outcome:

United Technologies Research Center (UTRC) proposes to demonstrate (TRL6) a high-efficiency 5TR packaged cooling Rooftop Unit (RTU) that:

- Uses a non-flammable, low GWP and high efficiency refrigerant as a disruptive, high efficiency sustainable and safe space cooling solution.
- Has the potential to provide >30% annual energy savings with a primary seasonal COP > 2.1 (DOE goal 2.0)

High-efficiency Low GWP Packaged RTU System

Team

DOE

Industrial Advisory Board
M. Lombardo
(Carrier VP Eng. I&R)
L. Burns
(Carrier I&R Advanced Systems)
C. Walker
(UTRC Senior Director)
J. Deltoro
(Carrier, Associate Director, Unitary Rooftop)

Dr. Ahmad M. Mahmoud
Principal Investigator

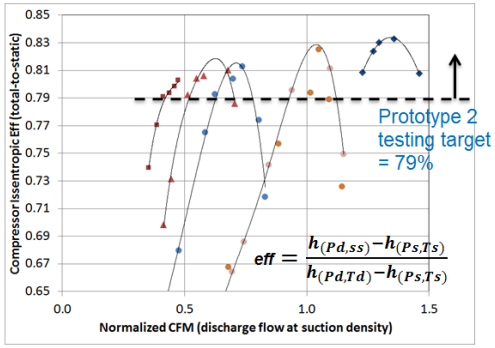
Parmesh Verma, M.B.A.
Project Leader

Dr. Abbas Alahyari
Heat Transfer

Dr. Fred Cogswell
Testing & Verification

Dr. William Cousins/
Dr. Chaitanya Halbe
Aerodynamics

Compressor Development



Efficiency Curves
(exceeds targets at "knee")

System Test Facilities

Unique Qualifications

- Completed compressor development project
- Market analysis & cost (Carrier BU)
- High-fidelity modeling & experimental facilities

High-efficiency Low GWP Packaged RTU System

Problem Definition:

- Current small commercial building HVAC systems use R410A with GWP=2088*.
- Potential regulations and market drivers are pushing the HVAC&R industry to lower direct GWP and higher efficiency systems (indirect GWP).
- New low-GWP refrigerants require new approaches for compressor and system design in order to achieve high efficiency and safe/reliable operation.

Solution must be cost-effective and have favorable value proposition (e.g. <2 year payback in new and retrofit construction)

Target Market and Audience:

Packaged Systems:

- Primary: Commercial rooftop cooling systems
- Secondary: Residential cooling systems

High-efficiency Low GWP Packaged RTU System

The Solution

State-of-the-Art

- Radical departure in compressor, heat exchanger and system balance of plant and integration requires significant R&D
- Current technology solutions pose challenges with future GWP or flammability mandates

Develop and demonstrate (TRL6) a high-efficiency 5TR packaged roof-top system:

- Cost-effective
- Sustainable, non-flammable, non-toxic and high-efficiency refrigerant
- High cycle efficiency (>+10% vs. R410A).
- Technology shall be matured from Technology Readiness Level (TRL) 4 to 6* in 26 months (a fully functional prototype tested at relevant conditions in a relevant environment)

Metric	State of the Art	Proposed
Use of Low GWP A1 refrigerants	R410A; Not possible to meet capacity and efficiency targets	Integrated system with low GWP refrigerant: • High-efficiency compressor • Highly effective and low pressure drop evaporator • High-effectiveness compact condenser
Primary COP	15.6 SEER Rooftop systems (5– 20 Ton)	>20SEER (i.e. >2.1 primary seasonal COP) leading to 30% primary energy reduction
Payback	<5 years	< 2 years (new construction & retrofits)

*https://www.nasa.gov/directorates/heo/scan/engineering/technology/txt_accordion1.html

High-efficiency Low GWP Packaged RTU System

Approach

Phase 1: Component and system design and optimization and supplier engagement.

Phase 2: Two prototypes will be built, and commissioned and tested at UTRC Psychrometric Facility to demonstrate:

1) targeted system performance i.e. Seasonal Energy Efficiency Ratio (SEER)
2) system operability over a wide range of conditions dictated by market needs
3) validate value proposition.

Advantage, Differentiation, and Impact

UTRC's detailed system analysis shows that the proposed high-efficiency low GWP system has the potential to provide **primary seasonal COP > 2.1 (vs. 2.0 BTO goal)** at a cost premium that meets market needs.

Other "desirable characteristics" include:

- Demonstration of long-term safe low-GWP refrigerant solution
- High part-load performance
- Significant energy consumption potential upon full (new and retrofit) commercialization

Progress

Accomplishments

- Early stage project (project start: 1/1/18)
  - Developed key system operating and performance requirements with Carrier stakeholders
  - Identified state-of-the-art Carrier system for benchmarking and value proposition
  - Identified system operational envelope for compressor and heat exchanger design and selection
  - Evaluated alternative condenser and evaporator designs to enable high-efficiency system testing
  - Began discussions with suppliers to procure condenser and evaporator
  - Initiated evaluation of previously developed compressor at envelope conditions

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: Project started 1/1/18
Variances: No variances, no changes
Cost to Date: Identify what portion of the project budget has been expended to date.
Additional Funding: None.

Budget History					
1/1/18– FY 201 (current)		FY 2019 (planned)		FY 2020 – 2/28/ (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$607k	$260k	$587k	$252k	$125k	$53k