

High-Efficiency Low-GWP Compressor

2016 Building Technologies Office Peer Review



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

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United Technologies Research Center

Project Summary

Timeline:

Start date: September, 2015

Planned end date: August, 2017

Key Milestones

Phase1: Design complete for Go/No-go review.

Metrics: 5TR capacity; 70% $\eta_{\text{compression, total}}$ (Aug. 2016)

Phase 2: Prototype testing and data analysis complete; 5TR capacity; 73% $\eta_{\text{compression, total}}$; 2.1 primary COP (Aug. 2017)

Budget:

Total Project \$ to Date:

- DOE: \$565,233
- Cost Share: \$242,243

Total Project \$:

- DOE: \$974,054 (\$544,666 Phase I)
- Cost Share: \$417,452 (\$233.428 Phase I)

Key Partners: (none)

Project Outcome:

United Technologies Research Center will demonstrate a high efficiency compressor design that is critical to enabling low direct-GWP high-efficiency small-commercial rooftop systems

Two compressor prototypes designed, fabricated and tested for a 5 TR rooftop advancing the TRL from 2 to 5.

Purpose and Objectives

Problem Statement:

- Current small building HVAC systems use R410A with GWP=2088*.
- Potential regulations and market drivers are pushing the HVAC&R industry to low 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.

Target Market and Audience:

- Mid-term - light commercial rooftop cooling (3 to 20TR)
- Long-term - Residential systems (1.5 to 5 TR)

Impact of Project:

- 30% primary energy savings and with low GWP enabled through:
 - 2 prototype compressors advancing TRL from 2 to 5 ($\eta_{\text{compression,total}} \geq 73\%^{**}$)
 - 5 TR rooftop design (< 25\$/kbtu; SEER > 2.1)
 - Plan for system demonstration (2019)

* IPCC AR4 (2007)

** Drive and compression.

Approach

Approach:

- Leverage proprietary UTC HVAC and aerospace compressor design experience & tools.
- Carrier proprietary software to design rooftop system
- Maximize optimal seasonal efficiency (SEER) through design
- Use Carrier supply chain to determine cost impact of new components.
- Demonstrate compressor performance on calorimeter over required operating envelope. Two prototype iterations.

Key Issues:

- Maximizing compressor efficiency and reliable operation over a wide range of operating conditions and minimize system cost impact

Distinctive Characteristics:

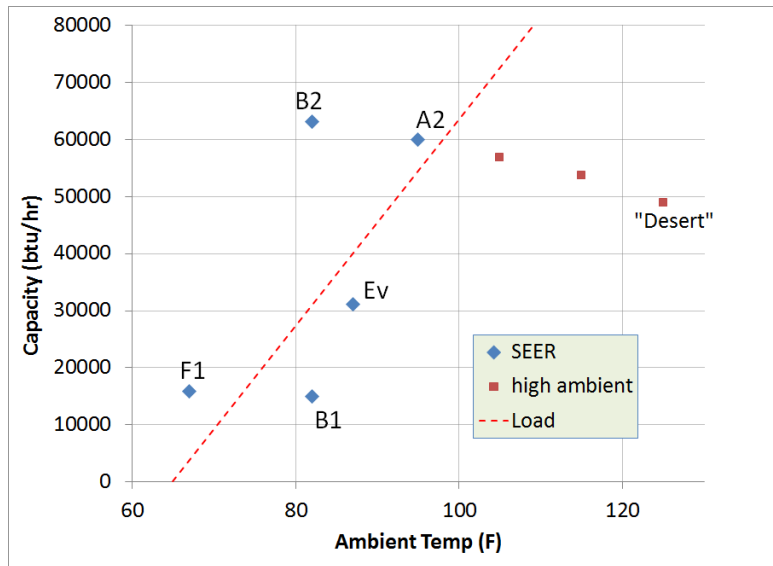
Combination of novel compression with low GWP refrigerant, high efficiency and system-level design optimization that is scalable for residential and light commercial HVAC systems

Progress and Accomplishments

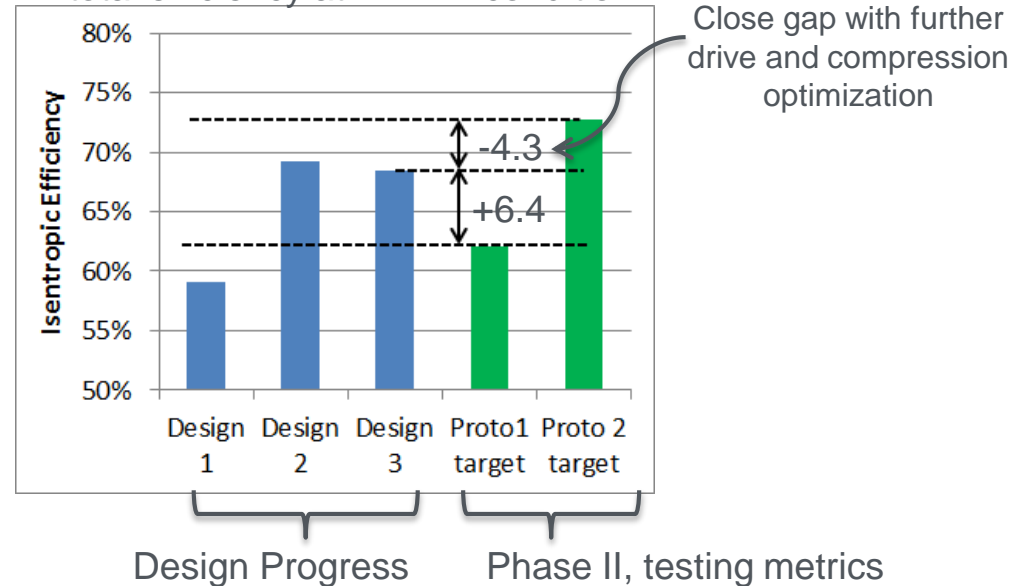
Accomplishments:

- Project is in early stages of development (start Sept 2015)
- SEER and required commercial envelop (Carrier input) defined.
- Preliminary compressor design for prototype I.
 - Detailed design and structural analysis proceeding.
- Prototype drive design completed.

Capacity Requirements
(ARI 210/240 + High-Ambient)



Flange-to-flange compression unit
total efficiency at ARI-A2 condition



Progress and Accomplishments

Market Impact:

The UTRC team is heavily engaged with the Commercial North American HVAC division of Carrier Corporation. This engagement ensures that metrics are met during development to accelerate future transition. Carrier Corporation proprietary tools and other standard work are being used throughout the execution of the project which helps transition the developed system.

Awards/Recognition: Project is in early stages of development.

Lessons Learned:

An additional proof-of-concept compressor test added [Jul. 2016] to accelerate critical risk reduction for better Carrier value proposition



Calorimeter fabricated for compressor testing

Project Integration and Collaboration

Project Integration:

- Carrier Corporation is the commercialization path for HVAC technologies and concepts developed at UTRC.
- Carrier is the world's largest manufacturer and distributor of HVAC&R equipment and has a long history of developing successfully commercialized products.
- UTRC project team is closely engaged with product and engineering teams to ensure metrics are met during conceptualization and testing phases
- Carrier is providing partial cost share for this project and significant in-kind contribution

Partners, Subcontractors, and Collaborators: None.

Communications: Project is in early stages of development.

Next Steps and Future Plans

Next Steps and Future Plans:

- Phase I: (Sept 2015 through Aug. 2016)
 - Compression and drive design complete.
 - Phase I Go/No-go review August, 2016.
- Added Scope:
 - Proof-of-concept compressor testing (Jul. 2016)
 - Better Carrier value proposition and early critical risk reduction
- Phase II: (Sept. 2016 through Aug. 2017)
 - Prototype 1 and 2 calorimeter testing
 - System performance analysis
 - Value proposition evaluation

REFERENCE SLIDES

Project Budget

Project Budget: \$1,391.5K

Variances: none











Cost to Date: \$244,112. (through Feb)

Additional Funding: Cost Share 25% UTRC, 5% Carrier.

Budget History

Sept. 4, 2015 – FY 2015 (past)		FY 2016 (current)		FY 2017 – August 31, 2017 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$10,259	\$4,397	\$554,974	\$237,846	\$408,821	\$175,209

Project Plan and Schedule

Project Schedule									
Project Start: September 2015	Completed Work								
Projected End: August 2017	Active Task (in progress work)								
	 Milestone/Deliverable (Originally Planned)								
	 Milestone/Deliverable (Actual)								
	FY2015	FY2016				FY2017			
Task	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									
Q1 Milestone: Operating conditions defined									
Q2 Milestone: Downselection of Heat Exchangers									
Q3 Milestone: Drive system selected									
Current/Future Work									
Q3 Milestone: Compressor design complete									
Q4 Milestone: Compressor drawings completed									
Q4 Milestone: Calorimeter commissioned/ Added Proof-of-Concept Test									
Go/No-Go Design Review									
Q6 Milestone: Prototype 1 testing complete (phase II)									
Q8 Milestone: Prototype 2 testing complete (phase II)								