U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

High Efficiency Low GWP Compressor

United Technologies Research Center
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Project Summary

Timeline:

Start date: September, 2015

End date: November, 2017 (3 month extension)

Key Milestones

- Prototype testing and data analysis complete; 5TR capacity; 73% $\eta_{flange\text{-}to\text{-}flange}$; 2.1 primary COP (Aug. 2017)
- System design and cost analysis complete: <$25/1000btuh, > 20 SEER (Aug. 2017).

Budget:

Total Project $ to End:

- DOE: $974,054
- Cost Share: $421,630

Total Project Budget $:

- DOE: $974,054
- Cost Share: $417,452

Key Partners: (none)

Project Outcome:

✓ United Technologies Research Center successfully demonstrated 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.

Challenge

Problem Statement:

- 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 lower-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 annual energy savings** and with low direct-GWP enabled through:
  - 2 prototype compressors advancing TRL from 2 to 5 ($\eta_{compression,total} \geq 73\%$**)
  - 5 TR rooftop design (< 25$/kbtu; SEER > 20)
  - Follow-on project for system demonstration (2018); potential field trial (2021)

* IPCC AR4 (2007)

** Drive and compression.

Approach

Approach

- Leverage proprietary UTC HVAC & aerospace compressor design experience/tools
- Maximize optimal seasonal efficiency (SEER) through modeling
- 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 over a wide range of operating conditions including low-capacity for SEER rating

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

Compressor Calorimeter Test Rig

Impact

The UTRC team is actively engaged with multiple Carrier divisions including the Commercial North America HVAC; Innovation and Research; and Technology and Components.

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.

Successful transition to new low GWP refrigerants will significantly reduce direct-GWP impact

And successful implementation of the new high-efficiency technologies will reduce US energy consumption and indirect-GWP

Progress

Project Status:

- **Project completed on Nov. 30th 2017**

Primary SOPO targets:

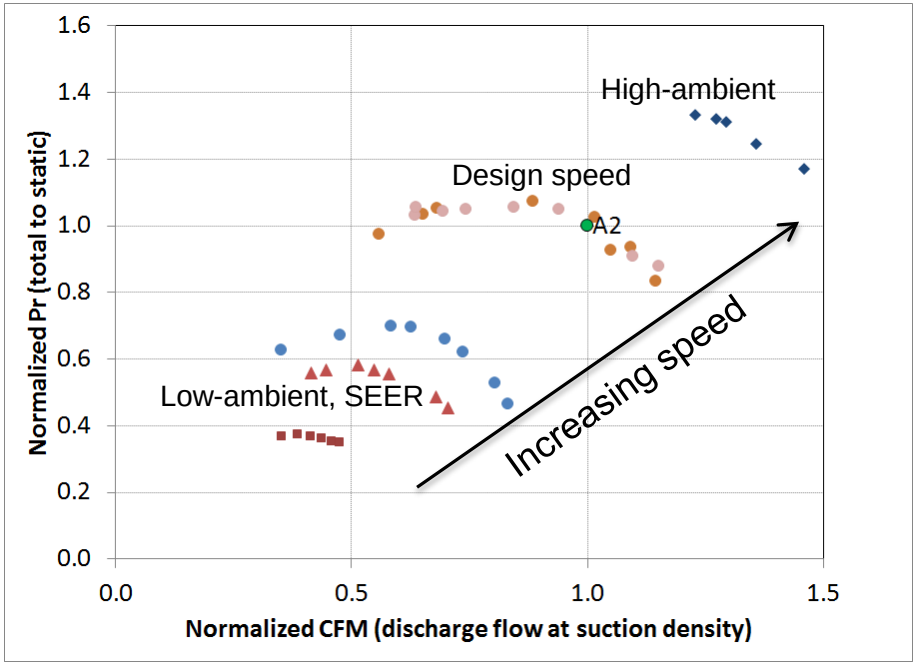
- **Measured Prototype-B Compressor performance:**
  - ARI-A flange-to-flange (including motor) efficiency: 73.8% (Target 73%) ✓
  - ARI-B f flange-to-flange (including motor) efficiency: 67.2%* (Target 73%)
- **Estimated System Cost impact of new technology:** <25$/1000btuh ✓
- **System level SEER analysis**: >20 (with improved fan to offset higher HX pressure drop) ✓

*Compression efficiency goals were exceeded for all SEER conditions, but poorer motor efficiency, especially at one part load, resulted in lower ARI-B flange-to-flange efficiency.

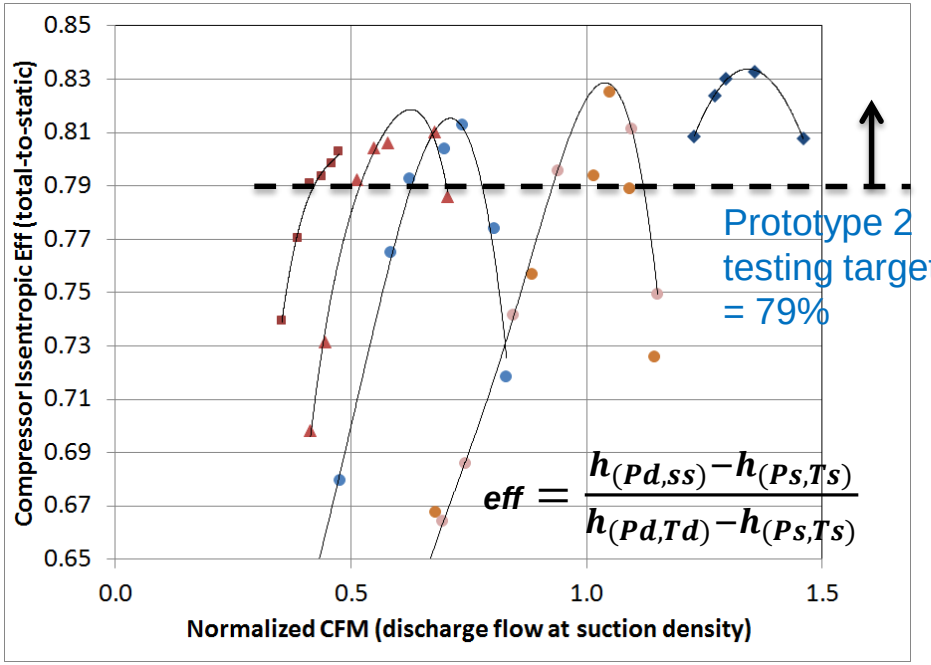
An integrated inverter/motor design is necessary to achieve the target motor/drive efficiency. It was not a target of this project to develop motor/drive.

Progress: Compressor Test Results

Successfully demonstrated compressor performance over wide range of operating conditions



Pressure-Flow Curves



Efficiency Curves
(exceeds targets at “knee”)

Stakeholder Engagement

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

Presented at several UTC CTO, Carrier President and CEO reviews

Remaining Project Work

- Project was completed in 2017
- Compressor technology developed is currently being used in follow-on projects.

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: $1,391.5K
Variances: none
Cost to Date: $1,395.7k (+0.3%)
Additional Funding: Cost Share: 25% UTRC, 5% Carrier.

Budget History					
Sept 2015– FY 2017 (past)		Project completed 2017		Project completed 2017	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$974,054	$421,630				

Project Plan and Schedule

Project Extened 1 quarter.
Compressor testing completed end of September, Technical work completed November 2017.