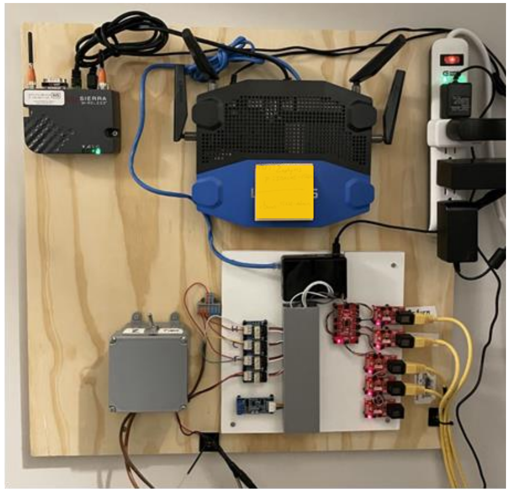
A Grid-Interactive Modulating Air Distribution Manifold






IBACOS
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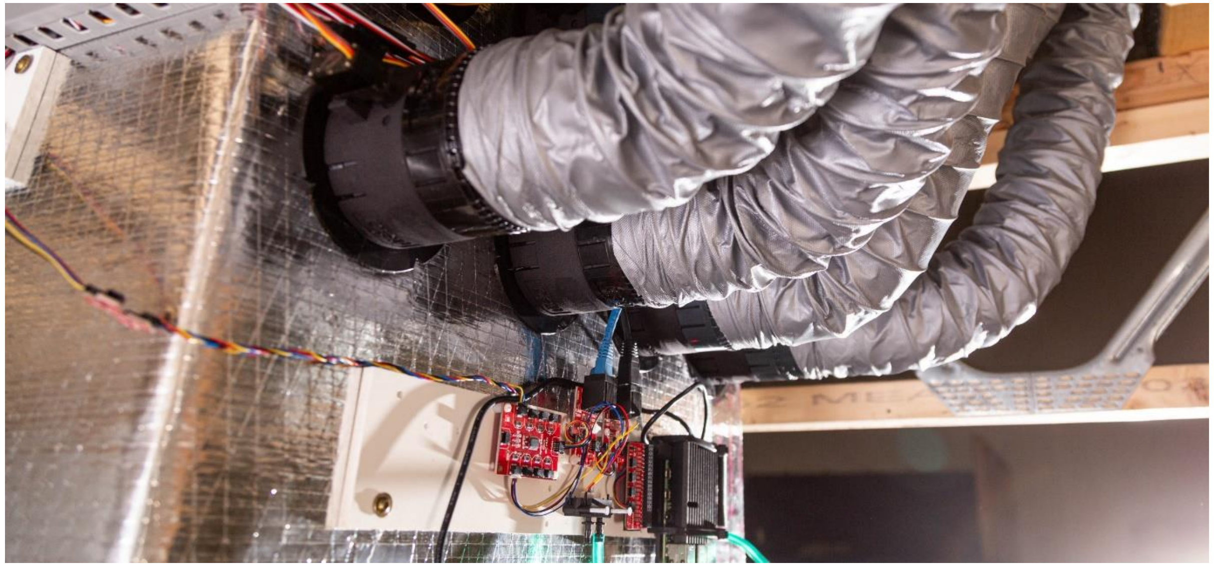
Project Summary

Objective and outcome

Develop and demonstrate an affordable zoned airflow distribution manifold. The product will improve the comfort and energy efficiency of homes, while offering greater satisfaction for occupants during demand response events.



Team and Partners

IBACOS

Rheia

Art and Logic

Essential Design

Stats

Performance Period: 6/28/2021 – 8/21/2023

DOE budget: $1,356,250.00 Cost Share: $0

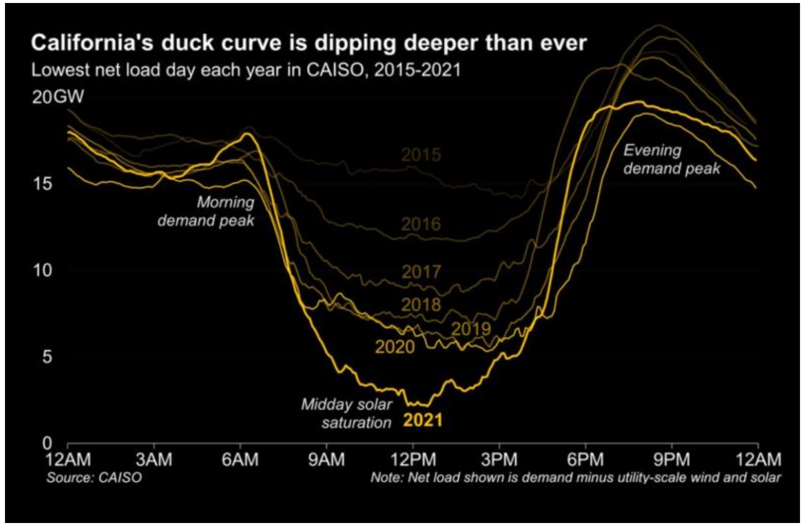
Milestone 1: Design and engineering process documented. Updates to engineering calculation engine completed.

Milestone 2: Control algorithm software developed, tested and ready to be embedded in firmware of controller hardware.

Milestone 3: Demonstrate Product Performance in Test Houses, Months

Problem

- Electric utilities are facing GW+ of resource gaps, especially for winter net peaking utilities*.
- DSM is a critical piece to economically addressing this gap.
- Current thermostat setback programs reduce occupant comfort, and are of limited duration.
- New homes can have comfort challenges with 10°F temperature stratification, but conventional zoning is restrictive and expensive.
- An affordable automatically modulating airflow distribution manifold can address all these challenges.



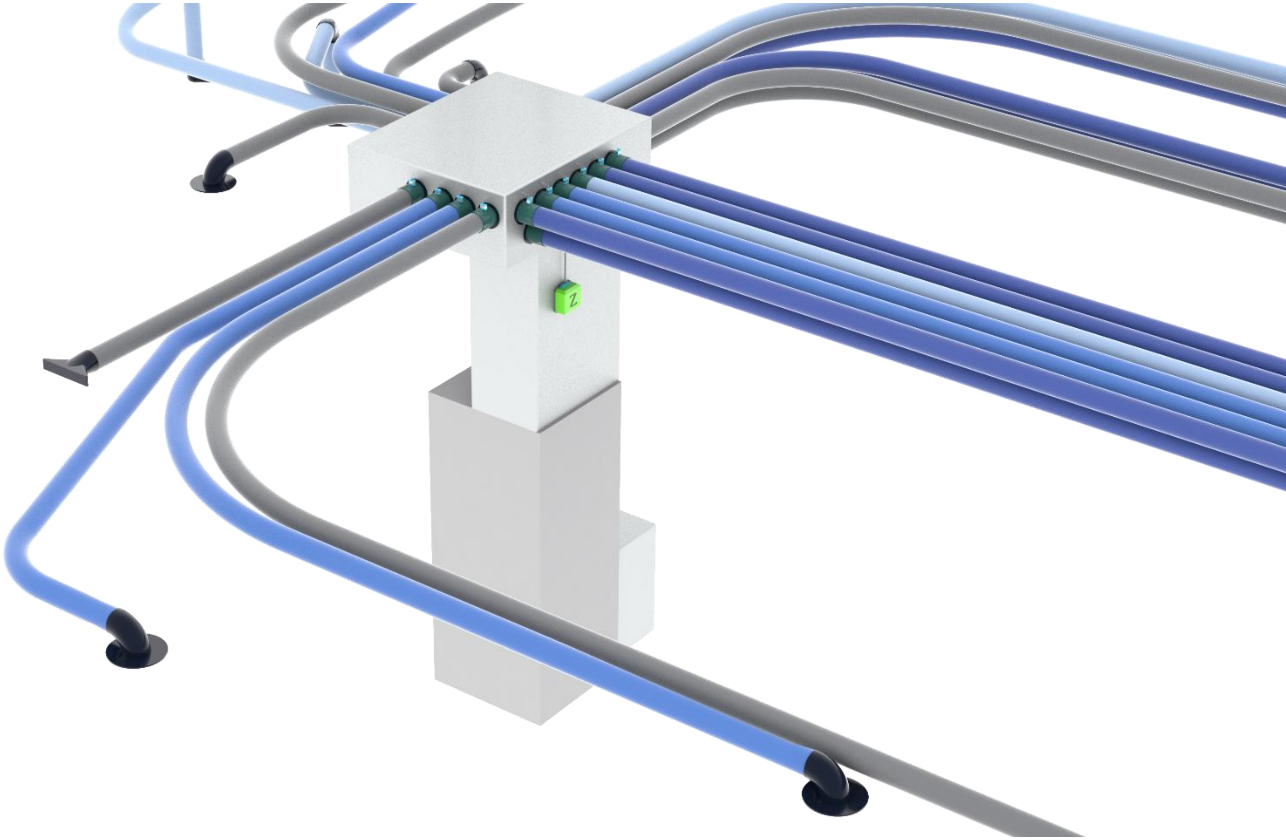
* Duke Energy Progress 2020 Integrated Resource Plan

Alignment and Impact

- More affordable zoning solution. Installed for <$1,000 vs >$2,000 for current two zone solutions.
- Product target is to have wide applicability as opposed to being a niche high end offering (as zoning often is today).
- Creates greater HVAC load flexibility to enable more adoption of renewables on grid. Provides 4-6 hours of load flexibility per device as opposed to 2 for current thermostats.
- Give consumers an easy way to manage HVAC energy use in their homes, and a choice in how significantly to prioritize efficiency.
- Project will be successful if comfort, energy efficiency, and load flexibility is demonstrated in real world test homes, and technical hurdles identified or overcome.
- Product will be successful if it is scaled up and commercialized, and installed in a significant number of new homes following the Rheia sales channel.

Approach

- Current approaches to zoned comfort control are typically expensive and difficult to install. Once installed they are not reconfigurable as occupant needs change.
- Conventional smart thermostats control the whole house with one switch and offer limited duration demand response with reduced occupant comfort.
- ‘Zephyrus’ is a modulating air distribution manifold that affordably integrates with the Rheia snap fit air distribution fittings and provides automated whole house airflow balancing on single stage and multi-stage equipment.



Comfort | Energy Efficiency | Load Flexibility

Approach

SBIR · STTR
America's Seed Fund

Phase I

Phase II

2021	2022	2023	2024	2025

Zephyrus
Intelligent air

Prototype Development

In Field Demonstration & Validation

rheia™

Commercialization & Growth

Phase I: Prototype → Mockup and measure → Simulate → Predict and analyze

Phase II: Prototype → Demonstrate → Engineer → Commercialize

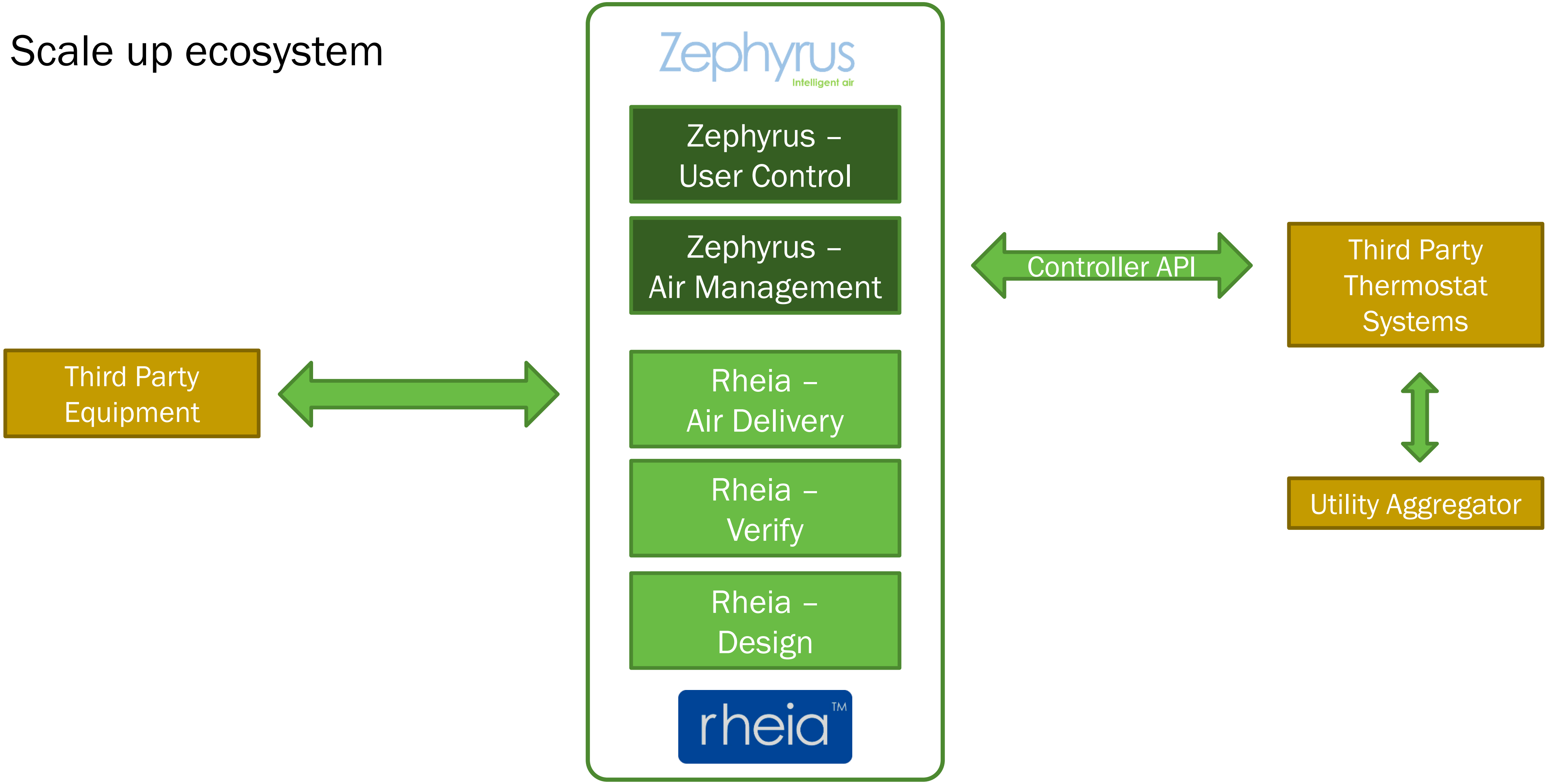
Approach

Barriers, challenges, risks:

- **Integration into existing smart home ecosystem**
  - Working closely with software consultant to evaluate current ecosystem.
  - Discussions with OEMs on integrations with their platforms.
- **Code approvals**
  - Will work closely with UL and others to identify relevant code compliance and testing for UL 181 and UL 2043 approvals.
- **Growing commercial sales**
  - Follow Rheia’s established beachhead market with national builders and contractors
- **Integration with utility programs**
  - Ongoing discussions with electric utilities on the development of the technology and how to best deliver grid value

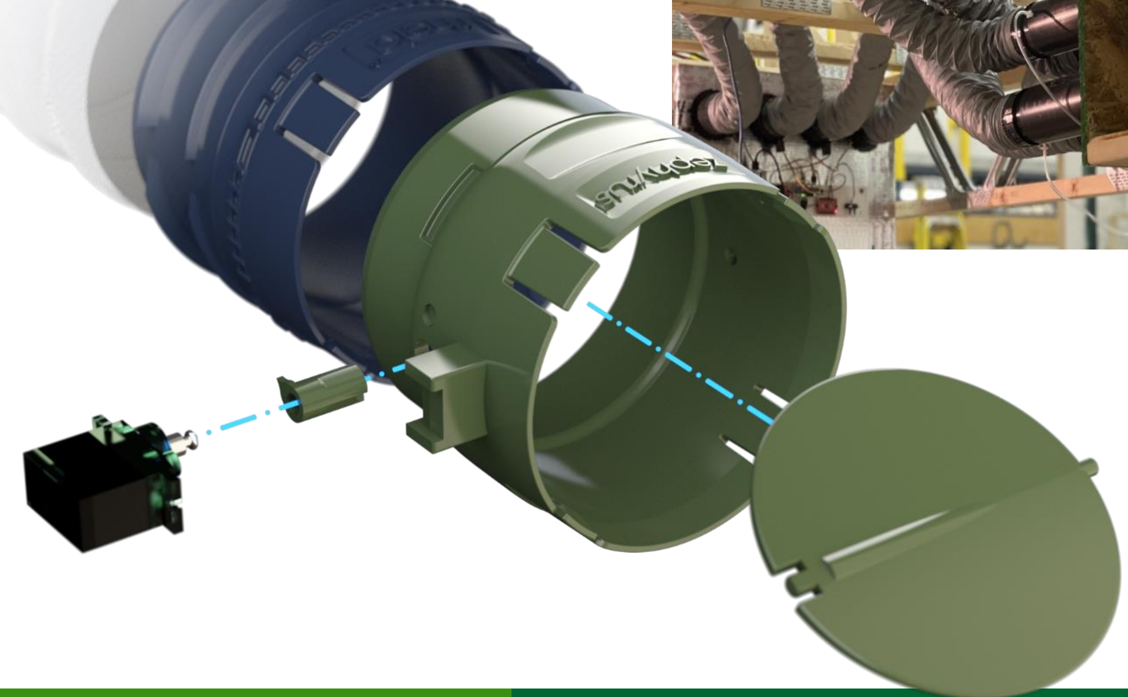
Approach

Scale up ecosystem



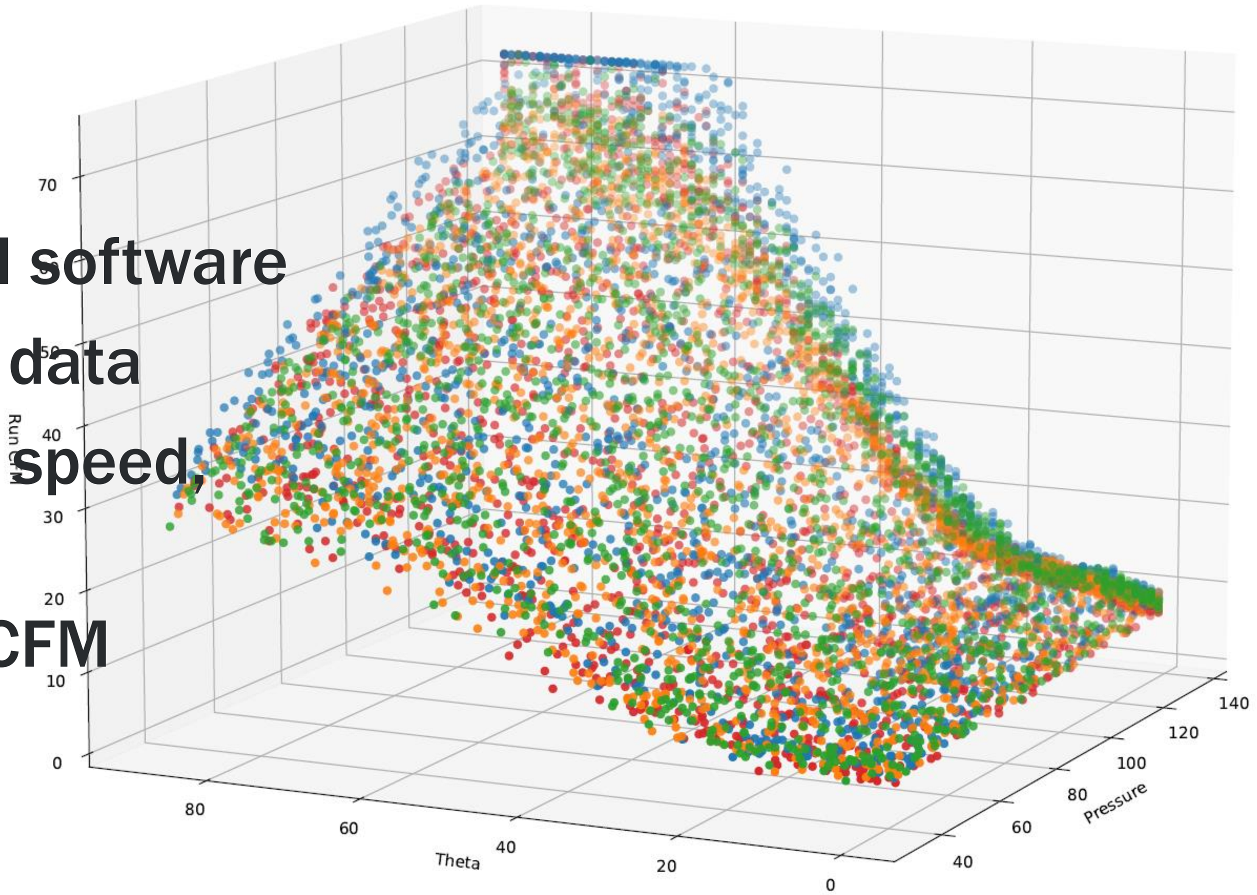
Progress and Future Work

Phase I Prototype

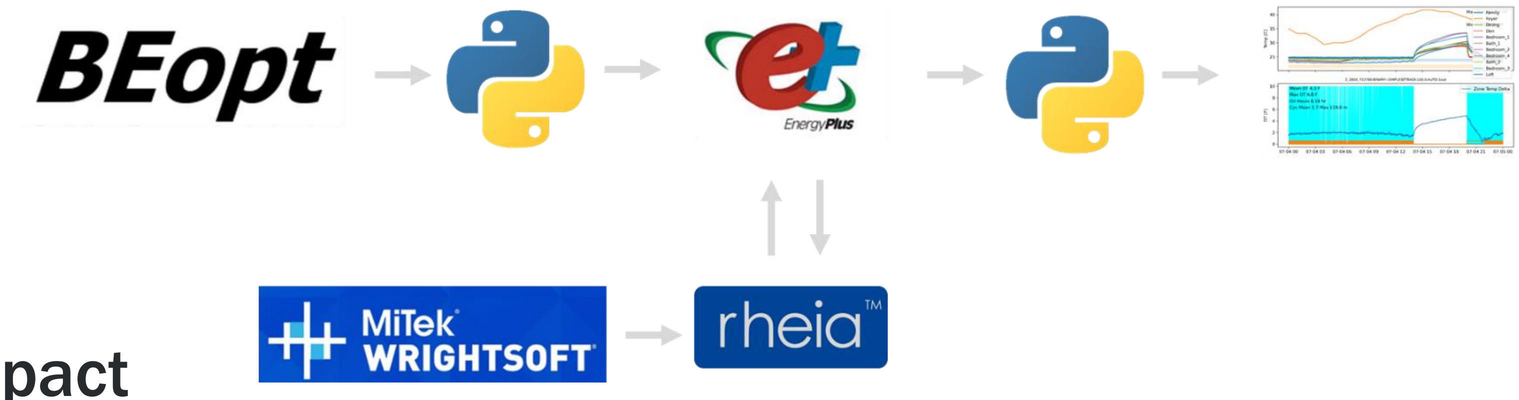


Progress and Future Work

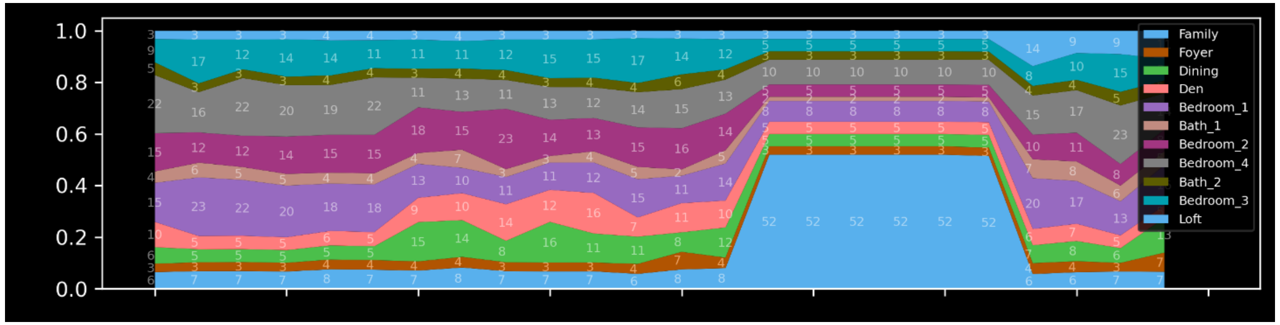
- Flowmeter in every duct run
- Whole system airflow
- Manifold static pressure
- Continuous damper control
- Integrated measurement and control software
- Duct system calibrated to measured data
- 1000 Randomized samples vary fan speed, damper angle
- Model airflow prediction: RMSE 1-2 CFM



Progress and Future Work



- **HVAC Daily Impact**
  - 1-3.3°F ΔT Improvement
  - 39-77% Peak Load Reduction (6 hrs)
  - 10-26% HVAC kWh Reduction
  - 10-32% CO_2 Reduction
- **Annual Impact (PHX – 4 stage)**
  - 4% kWh Reduction (433 kWh)
  - 4% CO_2 Reduction (0.14 MT)



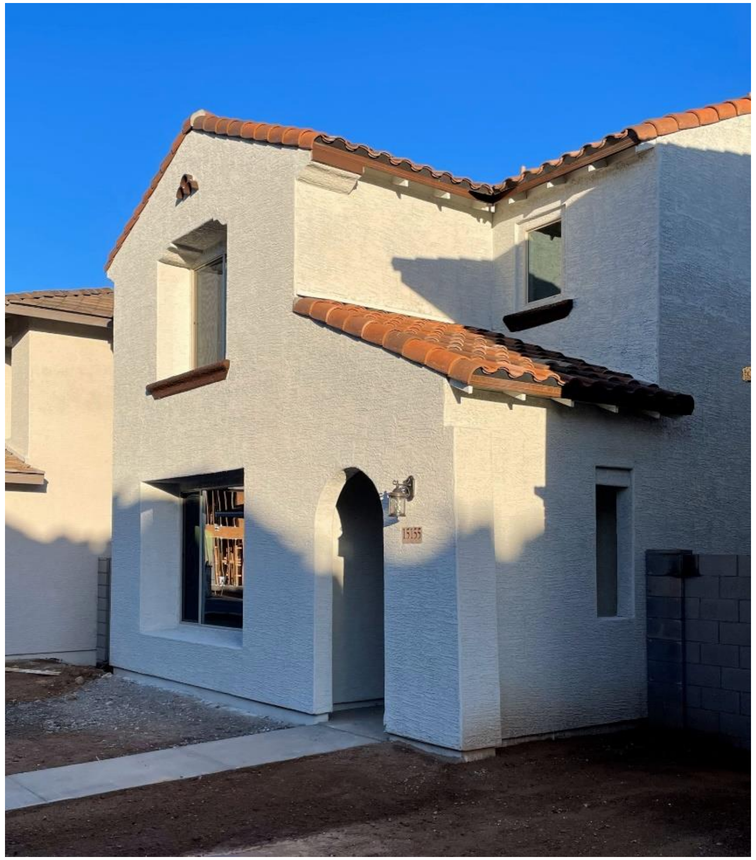
Progress and Future Work

Phase II – Test Homes

Cold Climate

Minneapolis, MN

2-story town home



Hot Climate

Phoenix, AZ

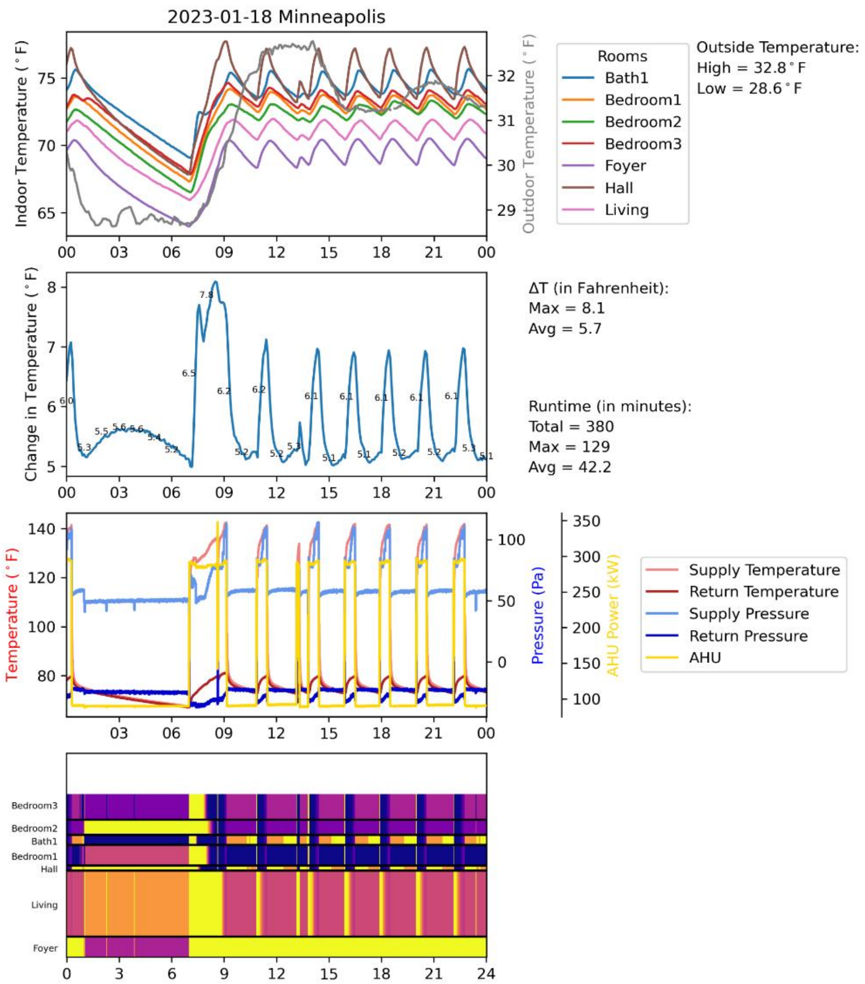
2-story detached

- Prototype dampers and controller
- Sensors in every room

Progress and Future Work

- Baseline stratification due to slab on grade construction.
- ACCA Manual J does not adequately account for infiltration location and heat loss through slab.
- Dialed in control algorithm to best adjust airflow while controlling static pressure.
- Active control and continuous fan operation helped reduce stratification.

Operation Mode	Date	Type	Outdoor Temperature (F)	Runtime (m)	S.B. Runtime [1AM-7AM] (m)	Runtime Reduction	Average Temperature Delta (F)
Static	3/11/2023	Cool	29	454	140		8.8
	3/2/2023	Cold	24	672	221		13.6
Auto	2/27/2023	Cool	33	407	110		5.2
	1/13/2023	Cold	19	514	150		6.8
Setback	3/27/2023	Cool	32	345	1	99%	6.7
	2/26/2023	Cold	21	420	90	40%	7.5



Progress and Future Work

- Wrap up cold climate testing
- Finish commissioning of hot climate test home (once construction is complete).
- Run hot climate test home through test scenarios this summer.
  - Quantify uniform comfort improvement, room by room setpoint control, load flexibility and energy savings.
  - Dial in control algorithms.
- Investigate alternate options for active damper location.
- Develop user app mockups and software requirements.
- Showcase technology to stakeholders.
- Conduct DFM engineering of plastic and electro-mechanical parts.

Thank You

Performing Organization(s)

PI Name and Title

PI Tel and/or Email

WBS #, FOA Project # and/or any other Project #

REFERENCE SLIDES

Project Execution

	FY2022				FY2023				FY2024			
Planned budget					$515,304				$498,773			
Spent budget					$259,142							
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Current/Future Work												
1. Develop Design and Engineering Process and Calculations												
2. Control algorithm software developed												
3. Final damper location hardware topology selected												
4. Test Homes Underway												
5. Software and hardware requirements documented												
6. All component designs finalized and ready to be released to toolmaker												
7. Installation and commissioning methodology documented												

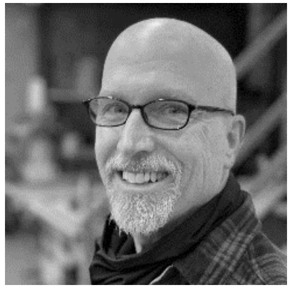
Team


Andrew Poerschke
PI


Ari Rapport
Business Lead


Mark Tilley
CEO


Anthony Grisolia
Senior Project Specialist


Bruce Dickson
Senior Specialist

EERE/BTO goals

(Not a template slide – for informational purposes only)

The nation's ambitious climate mitigation goals

Greenhouse gas emissions reductions

50-52% reduction by 2030 vs. 2005 levels

Net-zero emissions economy by 2050

Power system decarbonization

100% carbon pollution-free electricity by 2035

Energy justice

40% of benefits from federal climate and clean energy investments flow to disadvantaged communities

EERE/BTO's vision for a net-zero U.S. building sector by 2050