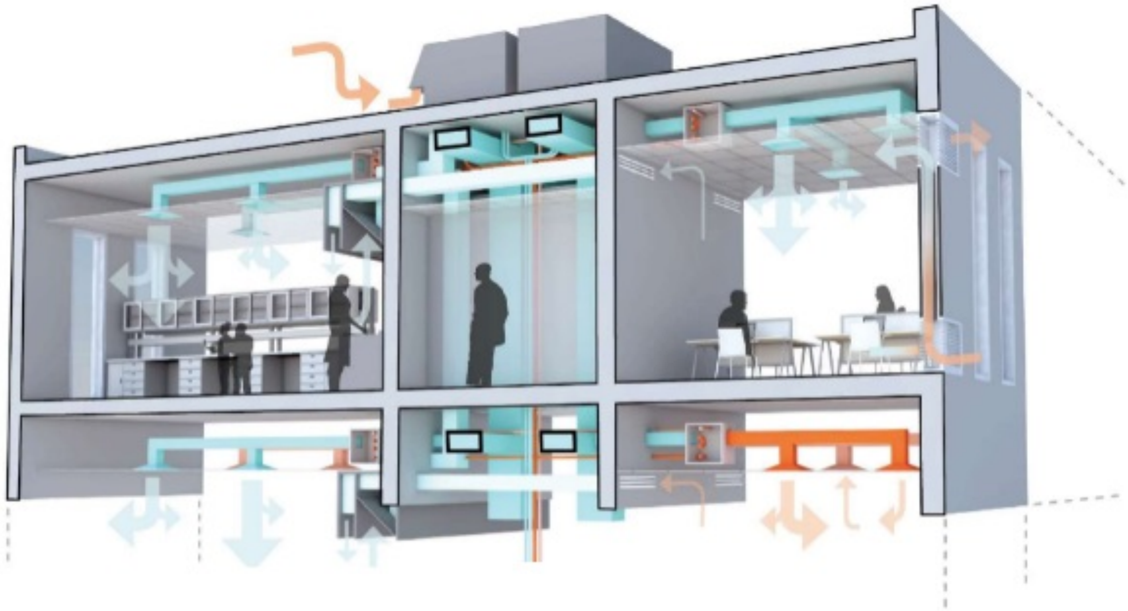
Membrane-based Ionic Liquid Absorption System for Ultra-Efficient Dehumidification and Heating



University of Florida
Saeed Moghaddam, Ph.D.
saeedmog@ufl.edu

Project Summary

Timeline:

Start date: April 1st, 2020

Planned end date: March 31st, 2023

Key Milestones

1. $COP_{cooling} > 1.2$ & $COP_{heating} > 2$; March 31st, 2021
2. $COP_{cooling} > 1.4$ & $COP_{heating} > 2.4$; March 31st, 2022

Key Partners:

University of Florida (Lead)
Gas Technology Institute (GTI)
Modine Manufacturing
Utilization Technology Development
American Gas Association (AGA)

Budget:

Total Project $ to Date:

- DOE: $420,000
- Cost Share: $84,000

Total Project $:

- DOE: $1,707,780
- Cost Share: $427,175

Project Outcome:

- New absorption pairs and compact heat exchangers to reduce the cost of absorption systems
- New techniques for separate sensible and latent control
- Region-specific designs (hot-humid climates)
- Non-vapor compression (improved performance, perceived unreliability, high manufacturing costs)
- Utilizing waste heat for cooling

Team

UF Team


Saeed Moghaddam


Rohit Bhagwat


Sidharth Sanadhya


Sumit Raj


Ashwani Verma


Richard Rode


Raju Bhatia

GTI Team


Paul Glanville


Doug Kosar


Aleksandr Fridlyand


Abbas Ahsan

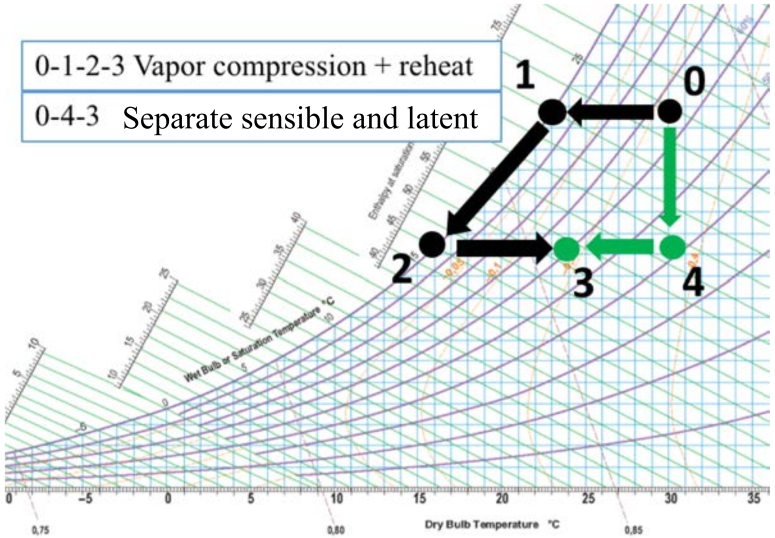

Kaushik Biswas

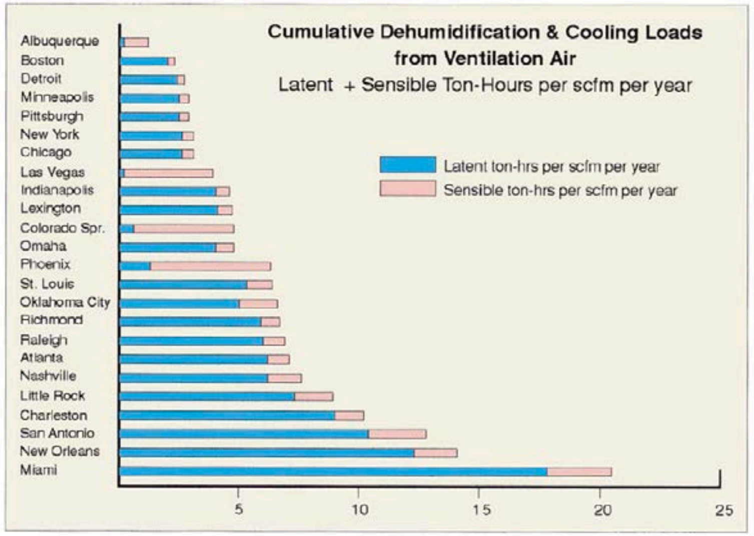
MODINE
APPLIED THERMAL INNOVATION™

UTD.
Utilization Technology Development

AGA
American Gas Association

Challenge – Economical Direct Removal of Moisture from Air





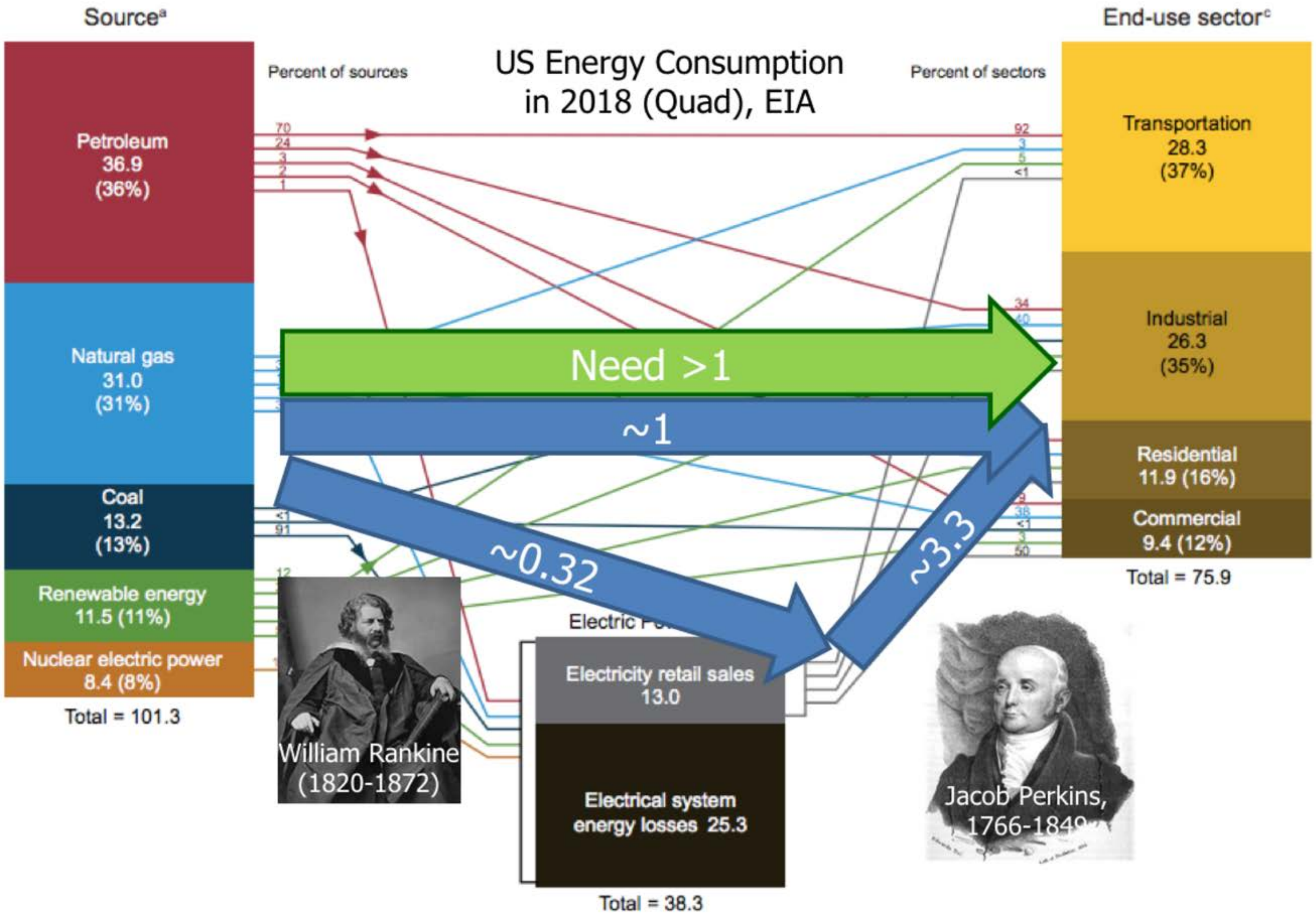
Harriman, III, L G, Plager, D, and Kosar, D. Dehumidification and cooling loads from ventilation air. ASHRAE Journal, 1997.

- **Ventilation latent load**
- **Zones re-heating load**

- **Ventilation latent load**
- **Other heating loads (zones + water)**
- **Low dew point (for operating suites)**

- **Internal latent load**
- **Water heating load**

Challenge – Energy Efficiency Perspective



Challenge – It Is More Than Energy Saving!

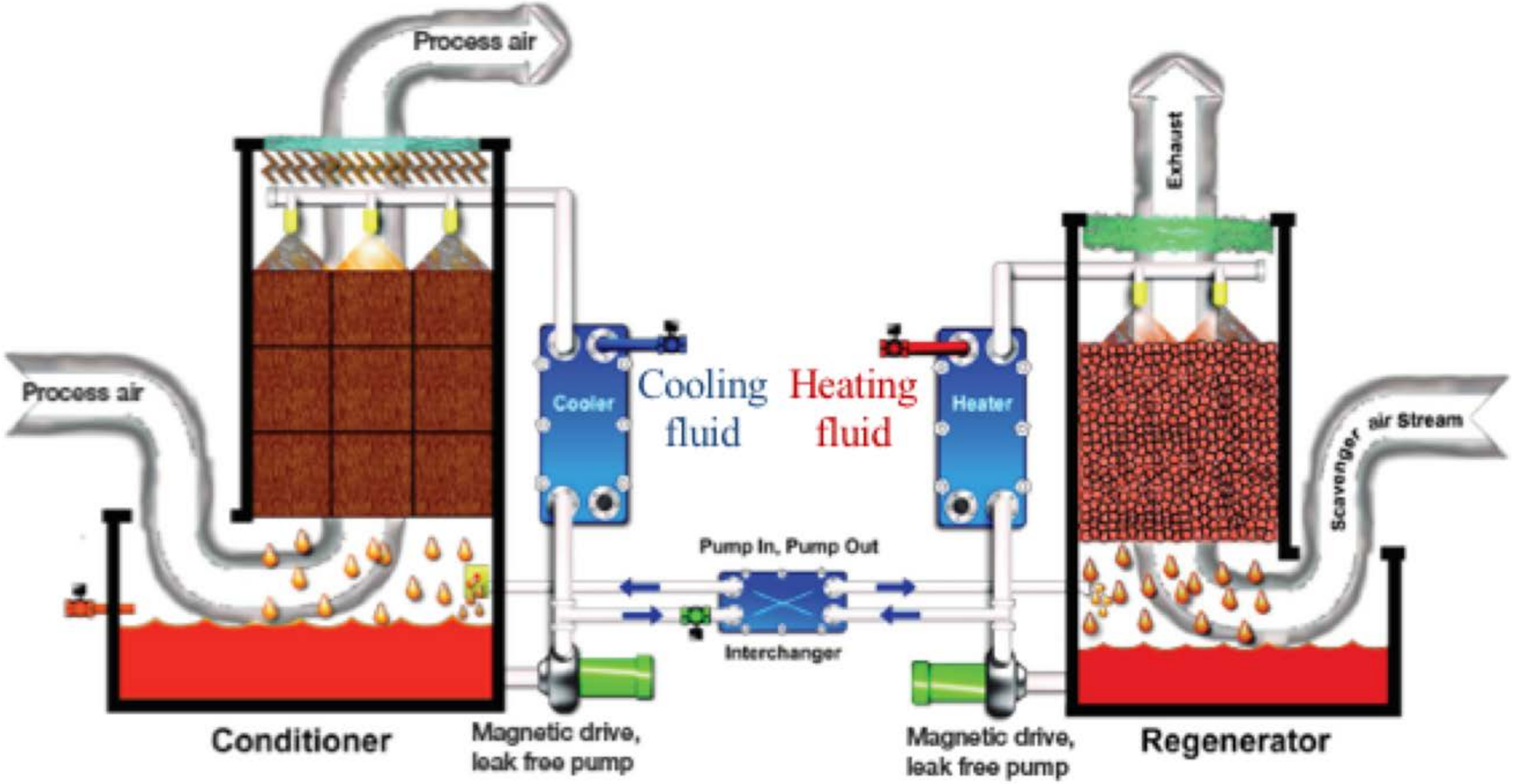
- Value proposition
  - Does it save energy?
  - Does it reduce cost?
  - Does it perform a unique task that can't be accomplished by V/C systems?

- Maintainable
  - Acceptable breakdown frequency
  - Workforce training

- Acceptable size/weight
- Codes & standards

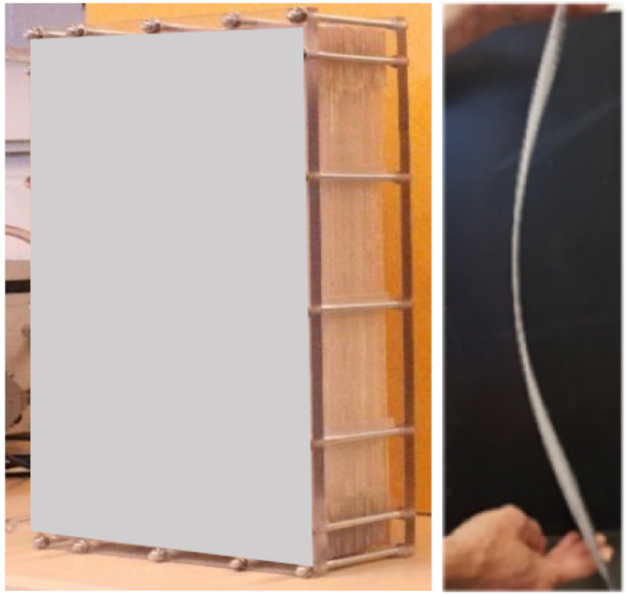
Challenge – Limitations of Current Liquid Desiccant Systems

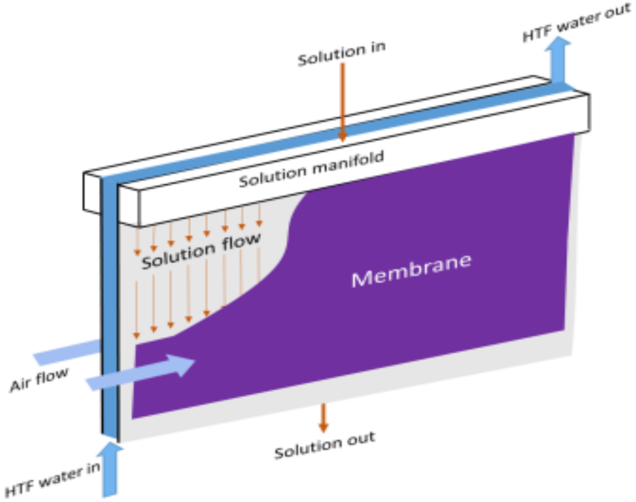
COP ~ 0.5

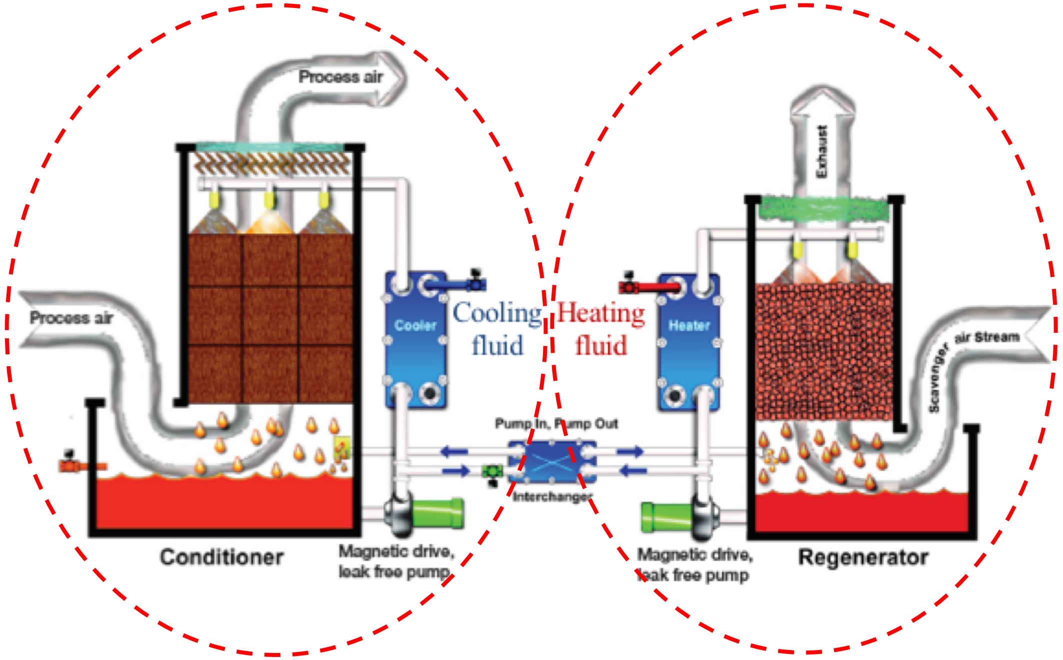


Kathabar liquid desiccant dehumidification system

Approach – Compact Robust Low-cost Heat & Mass Exchangers

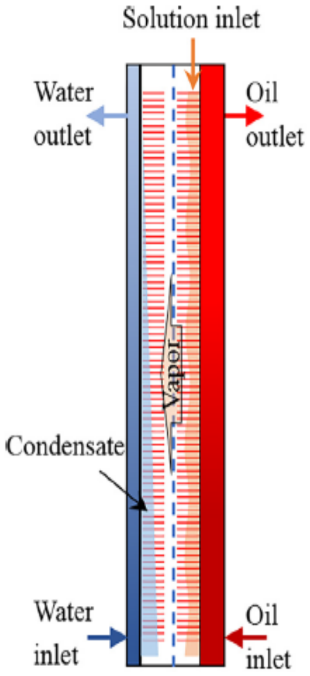




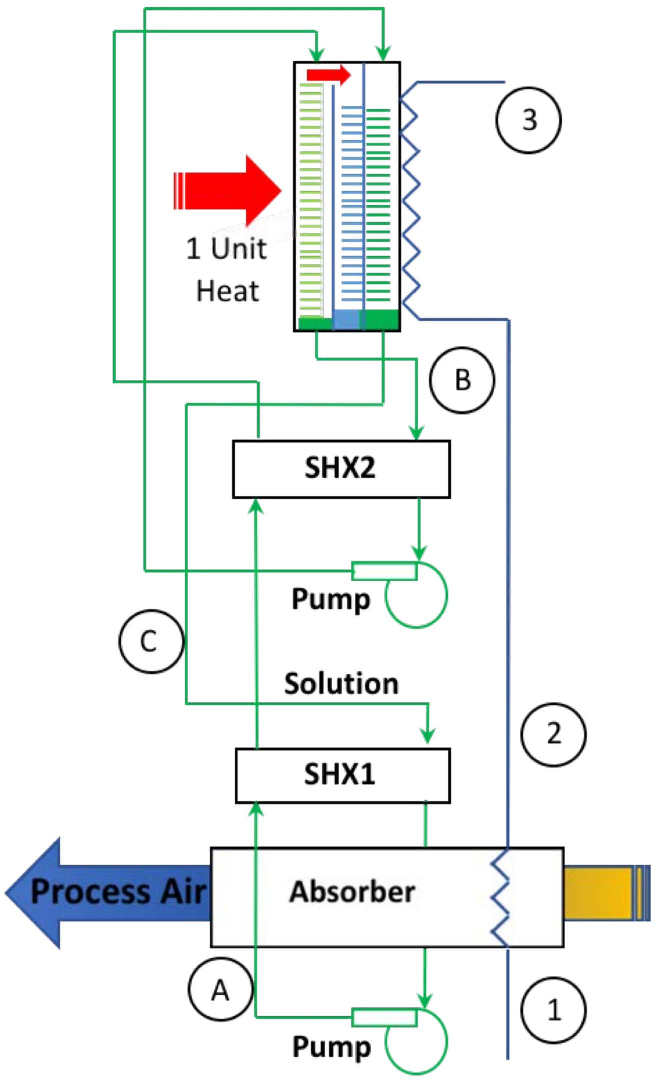


Current liquid desiccant dehumidification system

COP ~ 0.5



Approach – New Cycle and Desiccant



- Non-crystallizing ionic liquids
  - ➢ Enable high temperature operation
    - More efficient cycles
    - Eliminate need for control equipment and associated costs
- Environmentally friendly
- Low corrosion

Impact – Economical Dehumidification & Heating

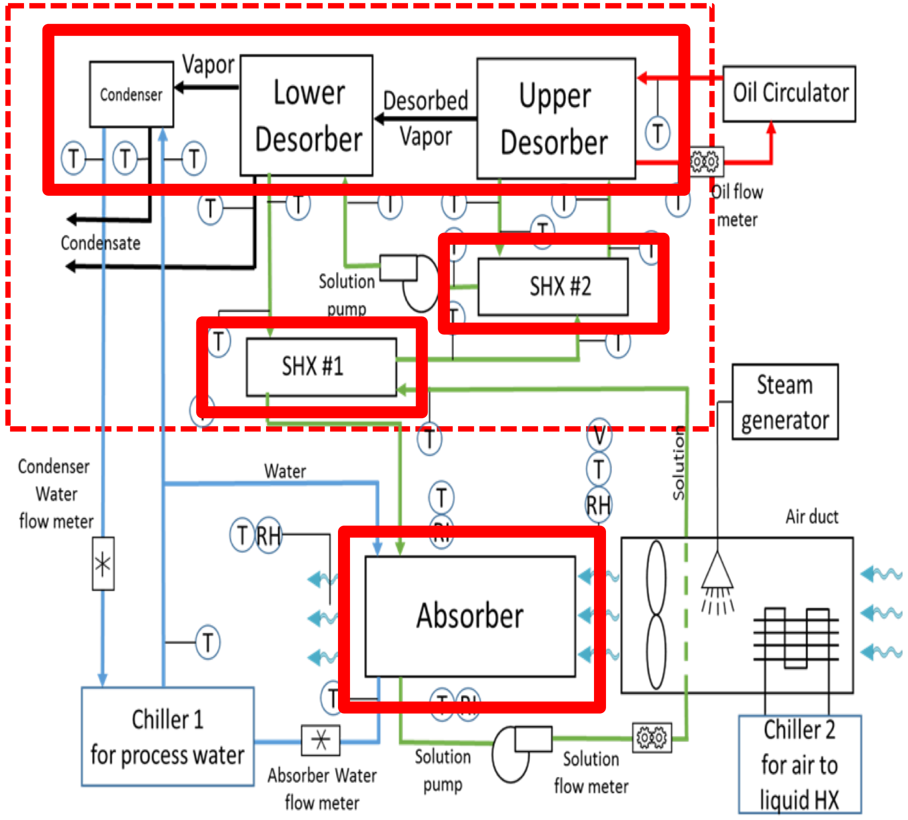
2030 Natural Gas-fired commercial equipment average efficiency (Table F2 in DOE BENEFIT 2019 DE-FOA-0002090, page 113)

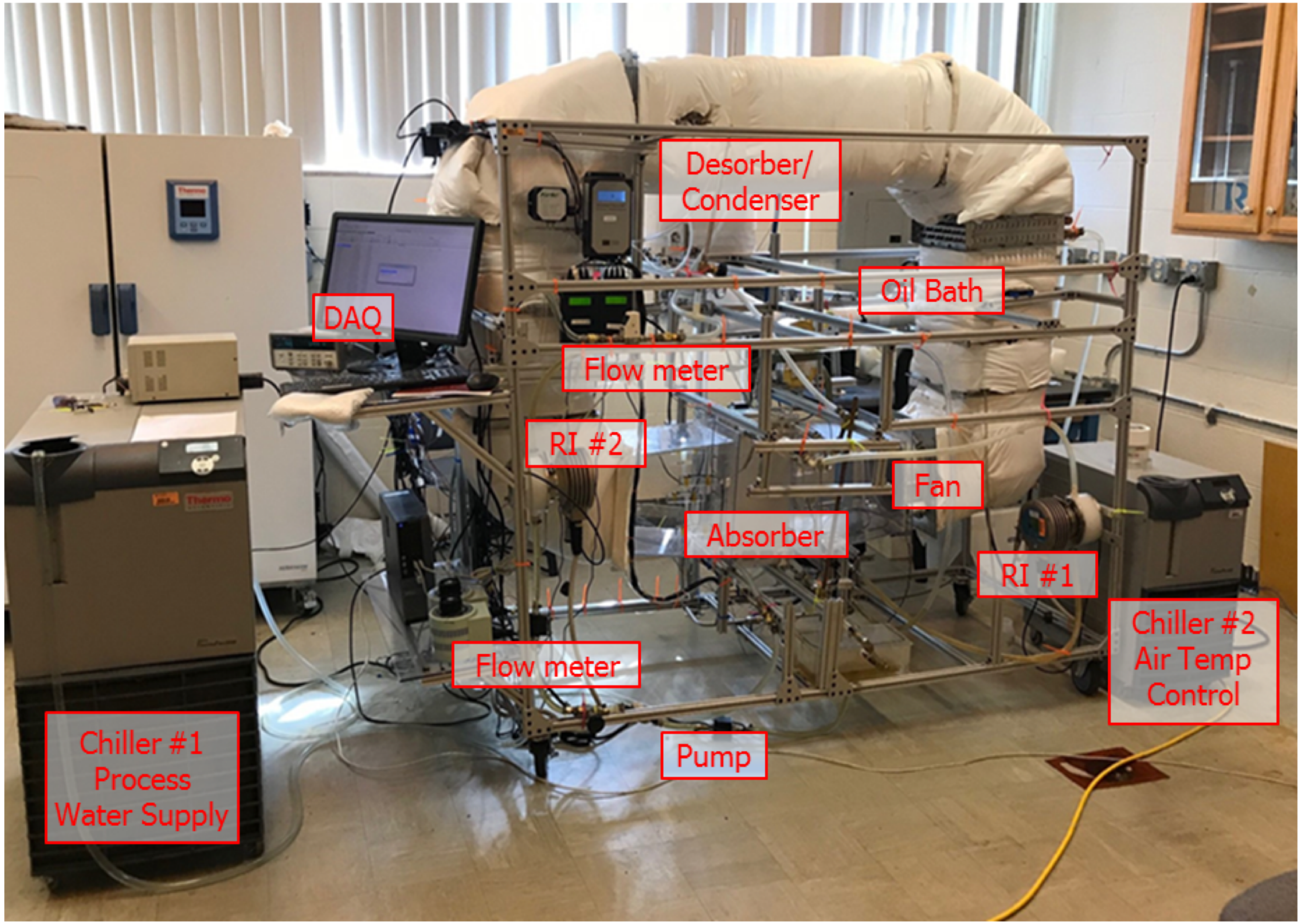
Equipment Class	**Stock Average Efficiency**	**Proposed Cycle Efficiency**
Space Cooling	0.8	~1.5
Water Heating	0.86	~2.5

- Heat-driven dedicated outdoor air system (DOAS)
  - Fuel or waste heat
- DOAS + heat recovering for buildings with high heat load
- Hybrid DX + liquid desiccant system to meet low dew points

Progress – Experimental System (200 CFM)

Regeneration & Heat Recovery

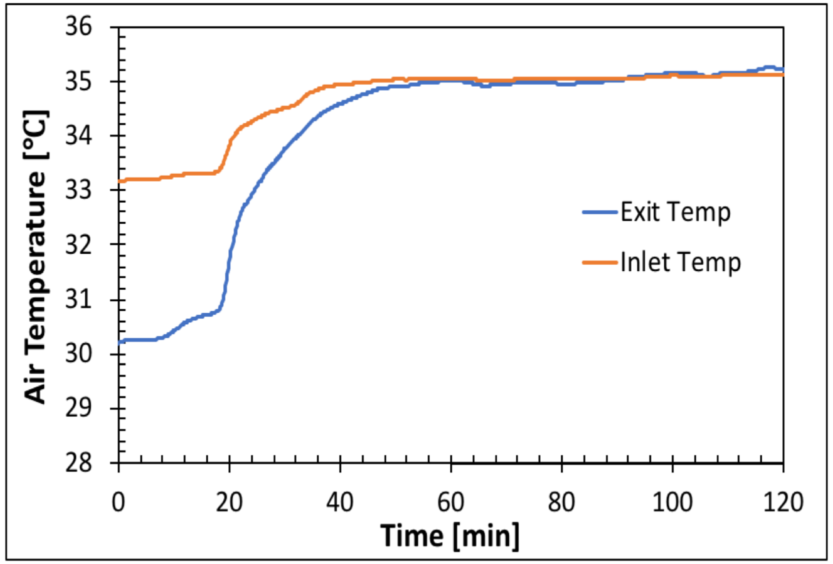


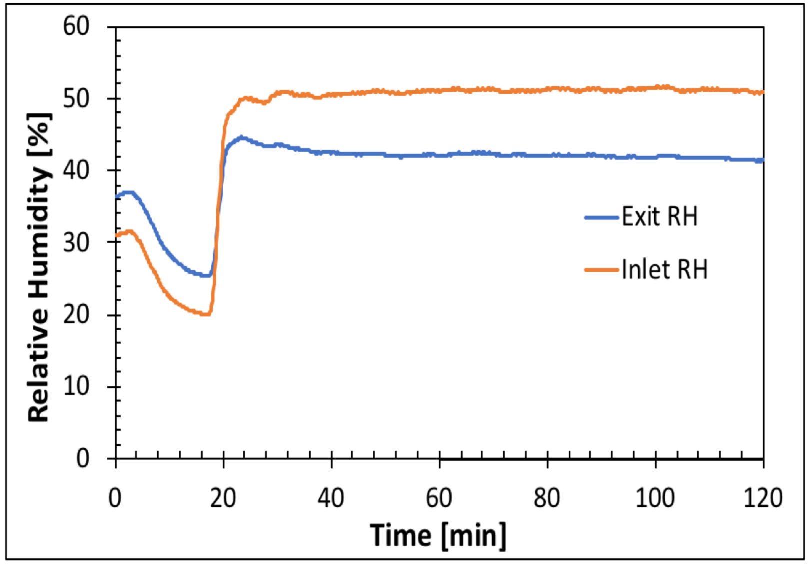


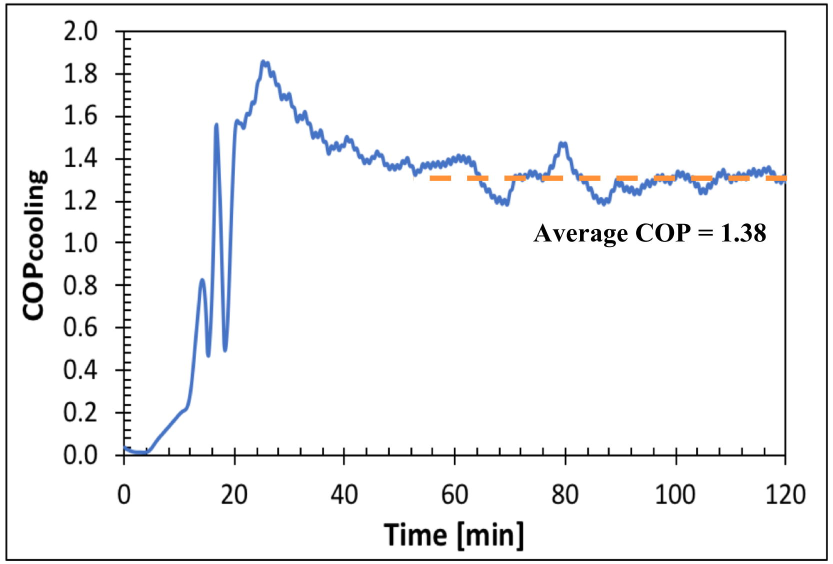
Progress – System Performance (Internally Cooled Abs.)

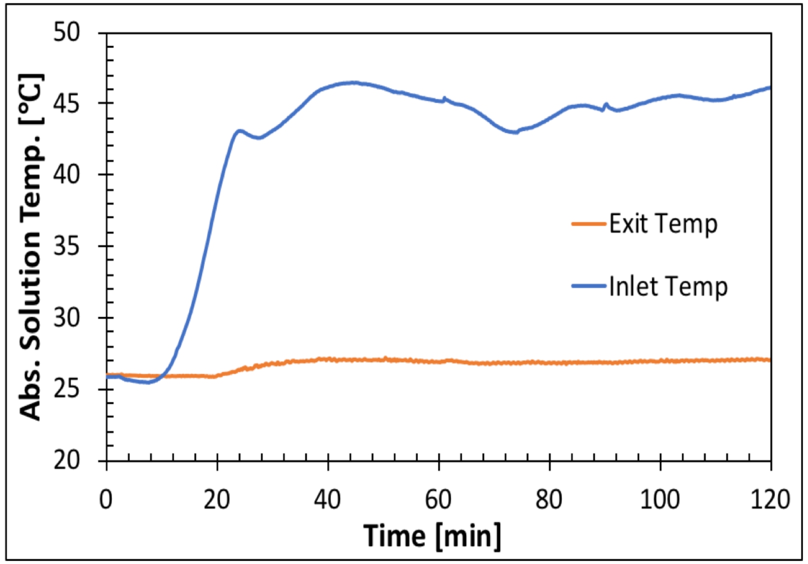
ISMRE:

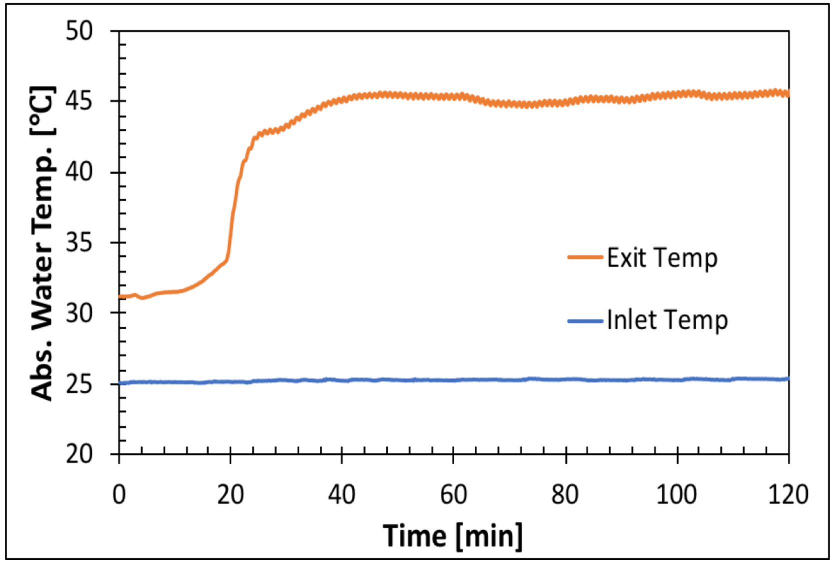
Condition A







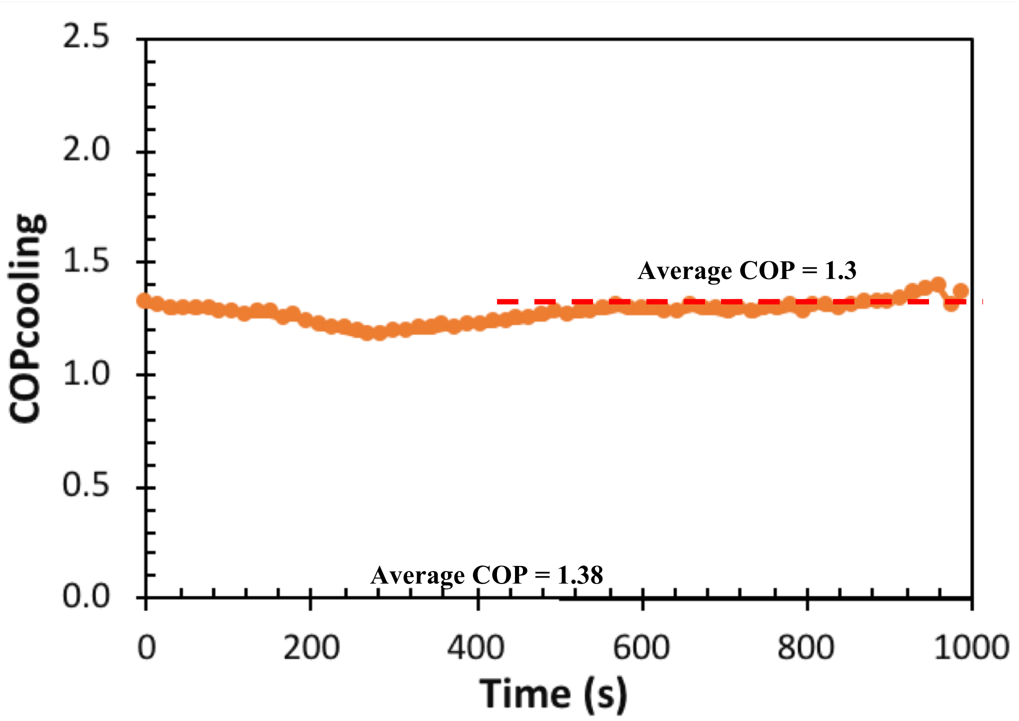


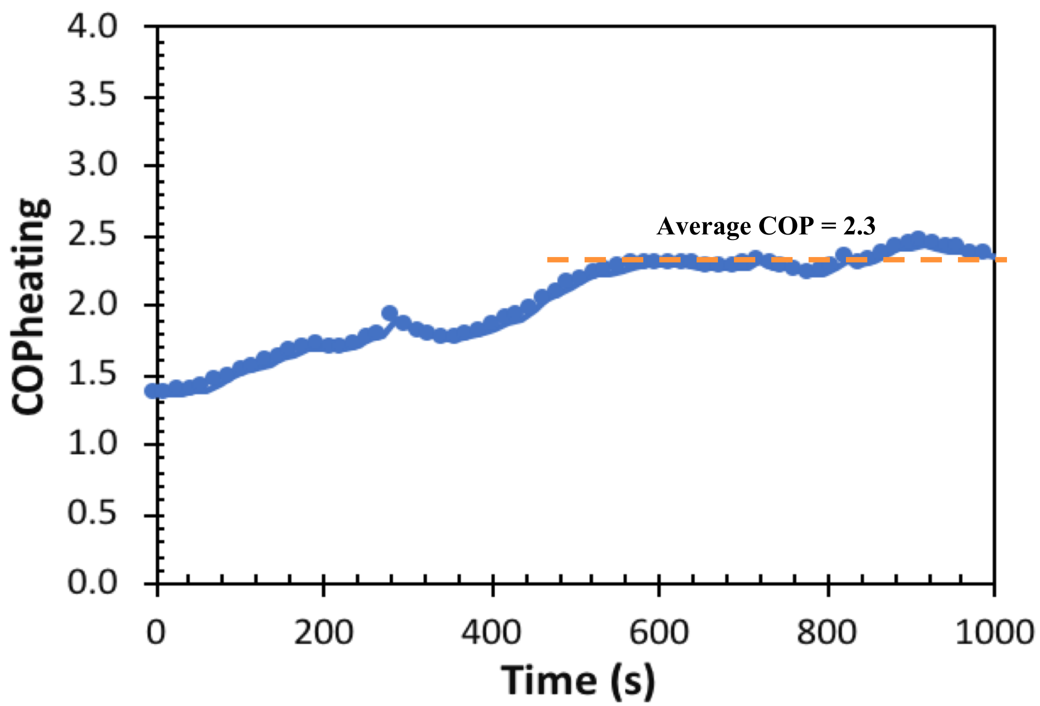


Progress – System Performance (Internally Cooled Abs.)

Temperature: ~31 ºC

Humidity: ~75%



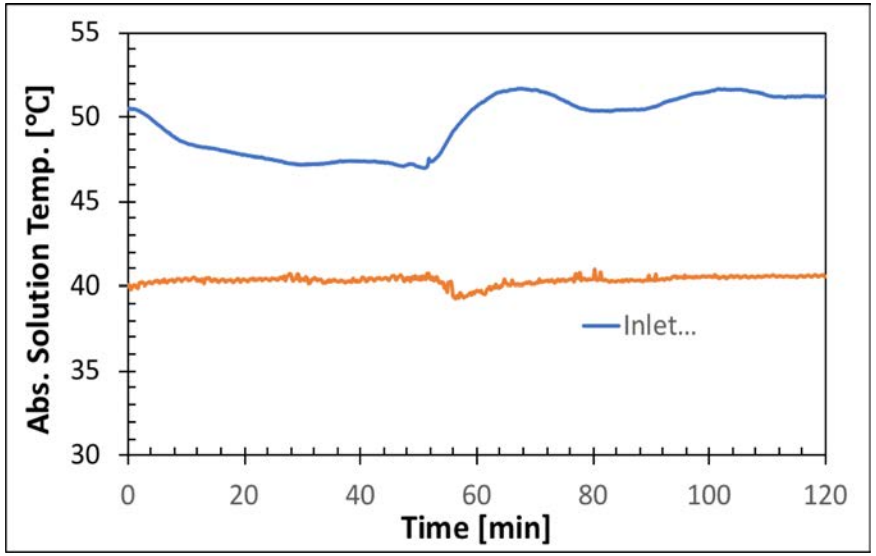


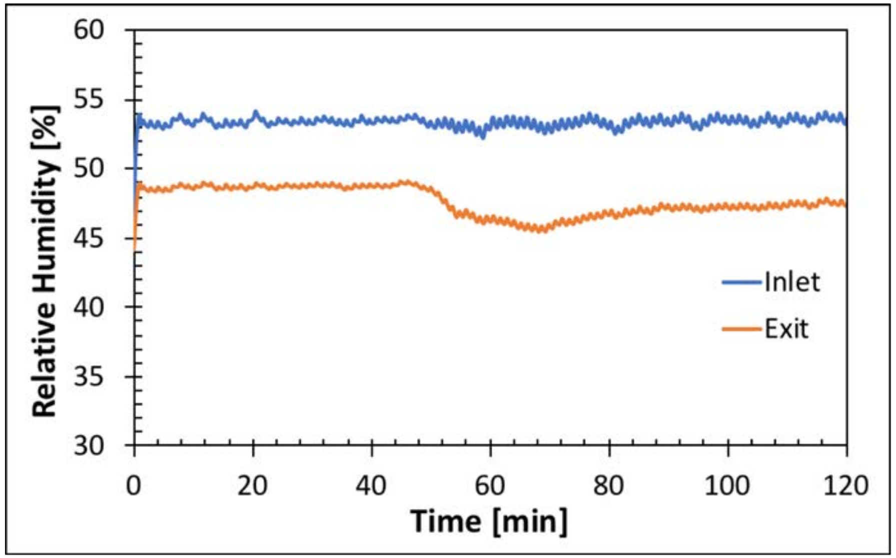
Total COP ~ 3.6

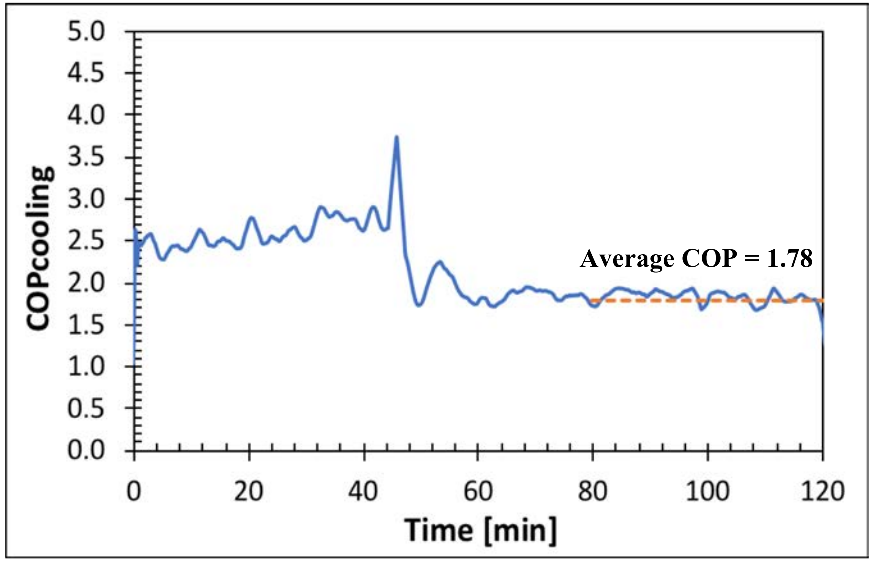
Progress – System Performance (Adiabatic Abs.)

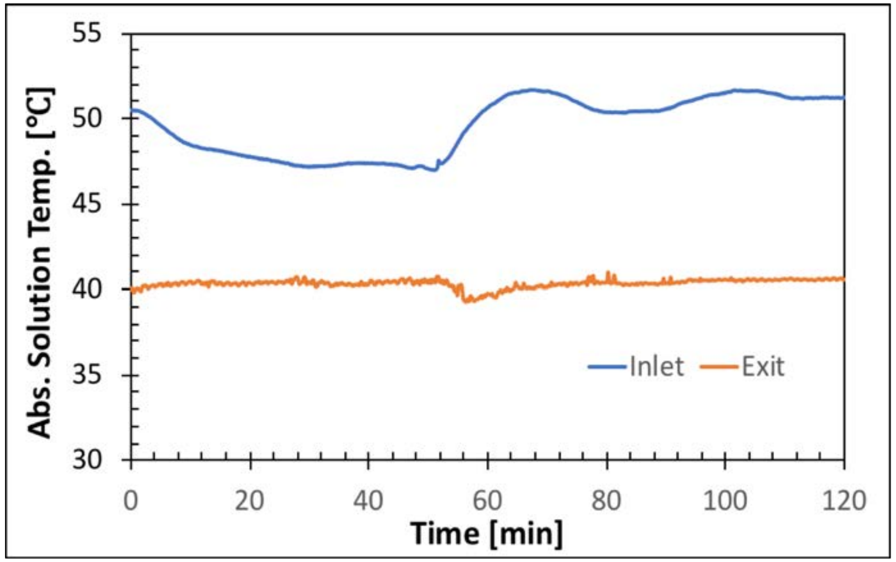
ISMRE:

Condition A





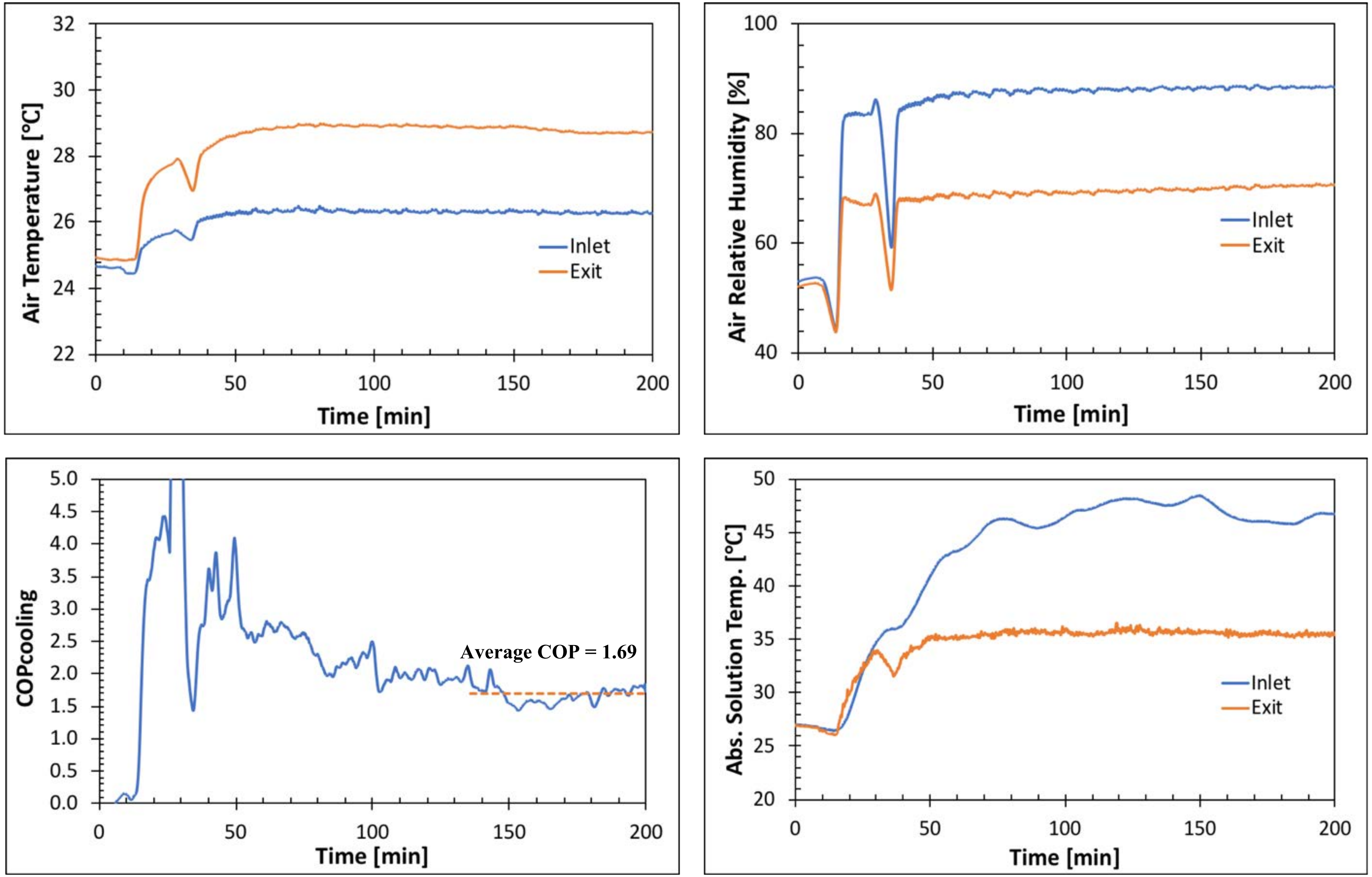




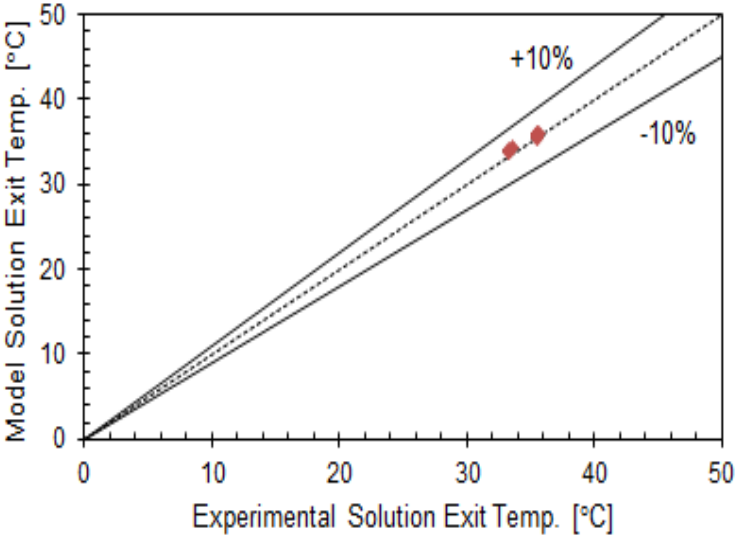
Progress – System Performance (Adiabatic Abs.)

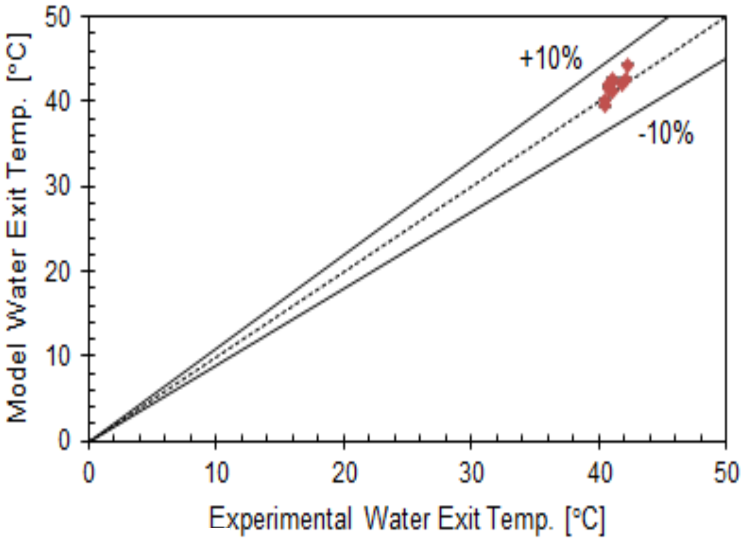
1% Humidity

Gainesville, FL

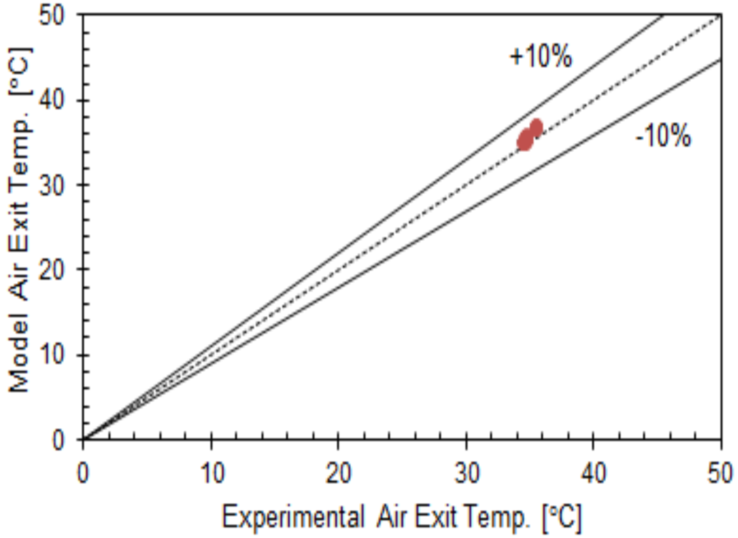


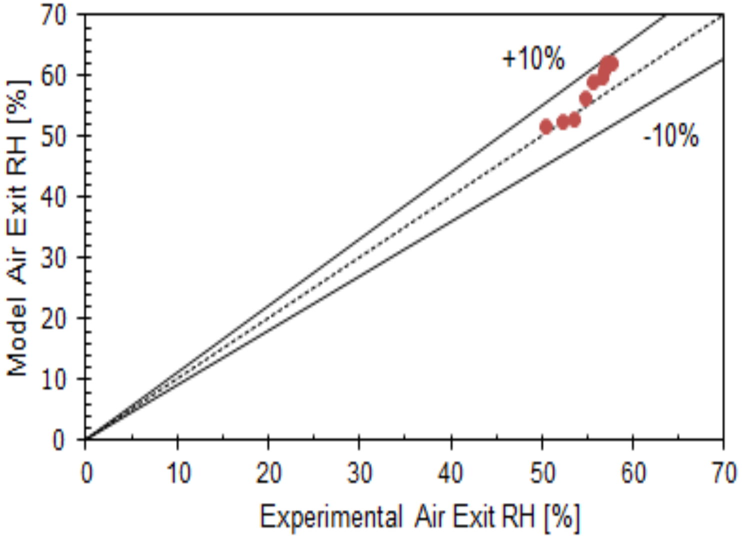
Progress – Absorber Modeling & Upgrading



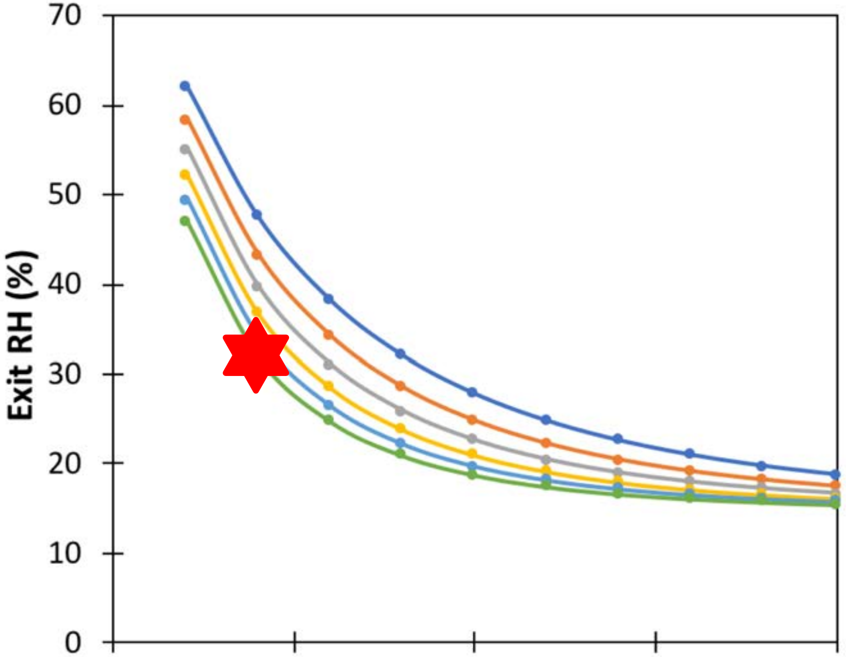


Highly accurate absorber model

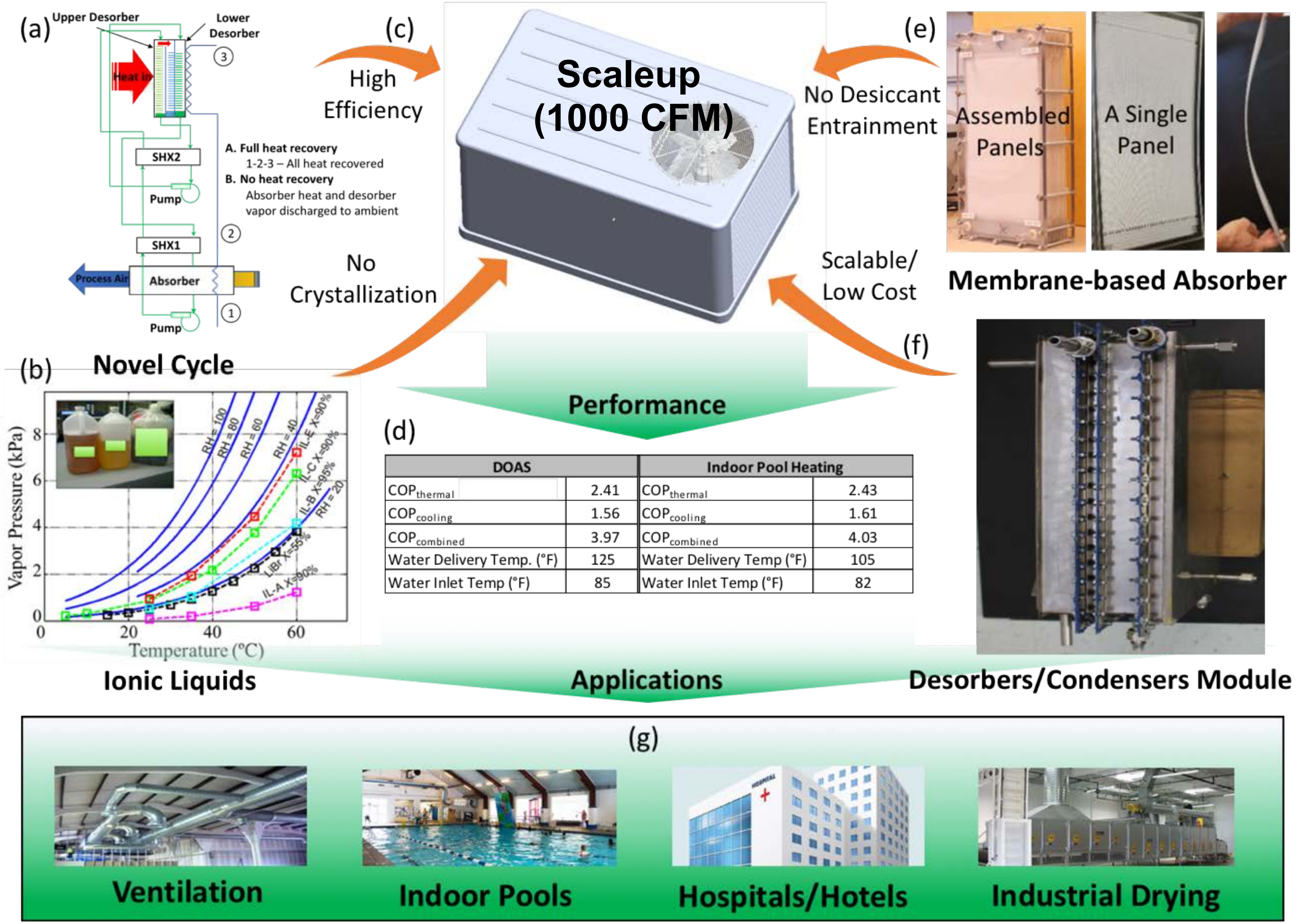




Next generation absorber



Progress – Current Status (Summary)



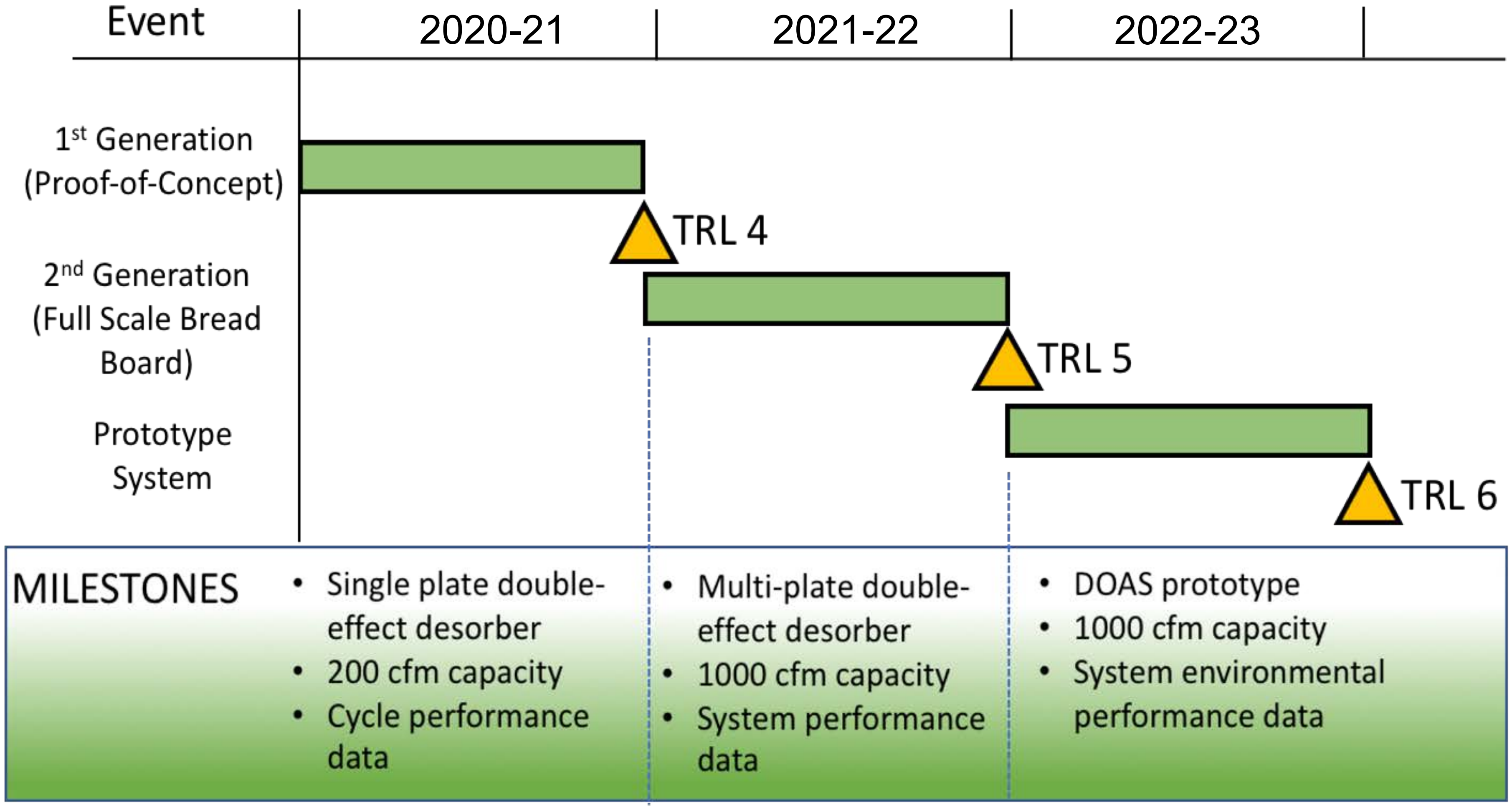
DOAS		Indoor Pool Heating	
$COP_{thermal}$	2.41	$COP_{thermal}$	2.43
$COP_{cooling}$	1.56	$COP_{cooling}$	1.61
$COP_{combined}$	3.97	$COP_{combined}$	4.03
Water Delivery Temp. (°F)	125	Water Delivery Temp (°F)	105
Water Inlet Temp (°F)	85	Water Inlet Temp (°F)	82

Stakeholder Engagement

Project Partners:

- University of Florida (cycle and components development)
- Gas Technology Institute, GTI (combustion system development and environmental testing)
- Modine Manufacturing (manufacturing partner)
- Utility Technology Development (co-sponsor)
- American Gas Association (utilities perspectives)
  - 200 natural gas companies supplying more than 76 million residential, commercial and industrial natural gas customers in the U.S.

Remaining Project Work



Thank You

University of Florida
Saeed Moghaddam, PhD
saeedmog@ufl.edu

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