2024 PROJECT PEER REVIEW
U.S. DEPARTMENT OF ENERGY
BUILDING TECHNOLOGIES OFFICE

BTO Peer Review: Manufacturing and Deployment of Liquid Desiccant Dehumidifier with Multiple Regeneration Technologies

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Manufacturing and Deployment of Liquid Desiccant Dehumidifier with Multiple Regeneration Technologies

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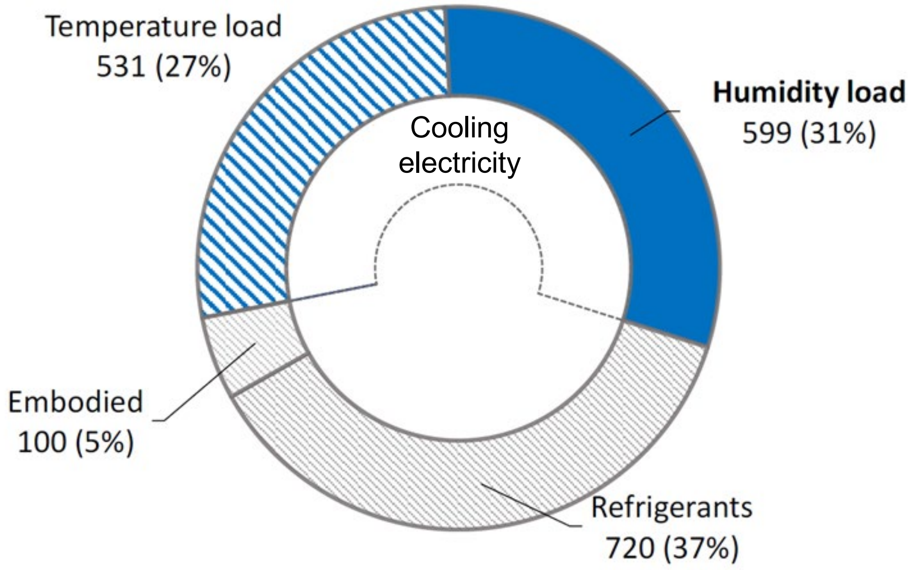
Project Summary

OBJECTIVE, OUTCOME, & IMPACT This project aims to reduce air conditioning energy use by building and field testing 5 liquid desiccant air conditioners NREL's role is to perform laboratory testing of the Mojave system, report on its performance over a range of inlet conditions, and validate numerical models. This will help potential customers understand this technology and its performance, and enable building simulations to provide realistic annual energy performance.	
TEAM & PARTNERS National Renewable Energy Laboratory Mojave	**STATS** Performance Period: 06/01/2024-09/30/2025 DOE Budget: $2.23M (NREL's budget is $384.4k) Cost Share: $702k Milestone 1: Equipment instrumented in the laboratory Milestone 2: Laboratory testing complete Milestone 3: Model validation

Air conditioning accounts for 4% of global greenhouse gas emissions, which come from:

- Cooling electricity
- Refrigerant leaks
- Embodied emissions

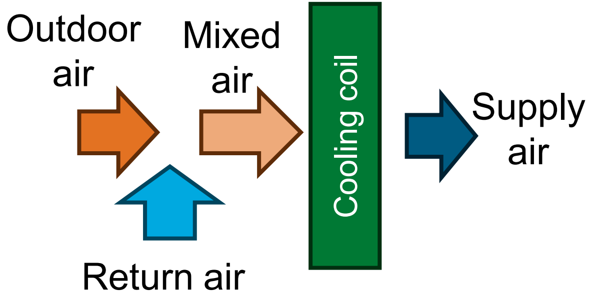


Managing humidity accounts for 31% of the total, **more than the emissions due to reducing the temperature.**

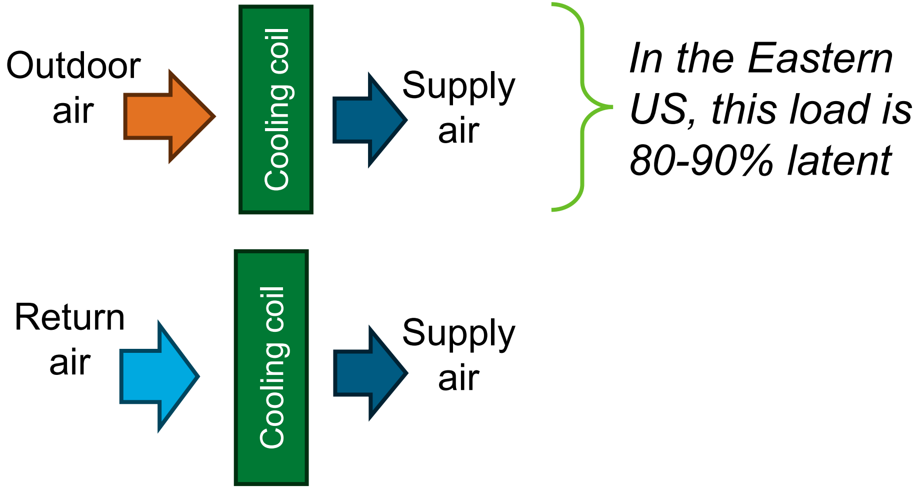
Woods et al., Humidity's impact on greenhouse gas emissions from air conditioning, Joule (2022), https://doi.org/10.1016/j.joule.2022.02.013.

HVAC systems cool both return air and ventilation air, with the ventilation cooling accounting for ~1/2 the load

Traditional Approach:
RTU with outdoor air damper



Improved Approach:
Separate dedicated outdoor air system (DOAS) for ventilation air



Alignment and Impact

In this project, NREL's role is to:

- Evaluate the performance of Mojave's DOAS unit, which efficiently controls humidity.

- Validate prior system models, suitable for use in EnergyPlus, which enables prediction of energy performance in different climates.

Impact:

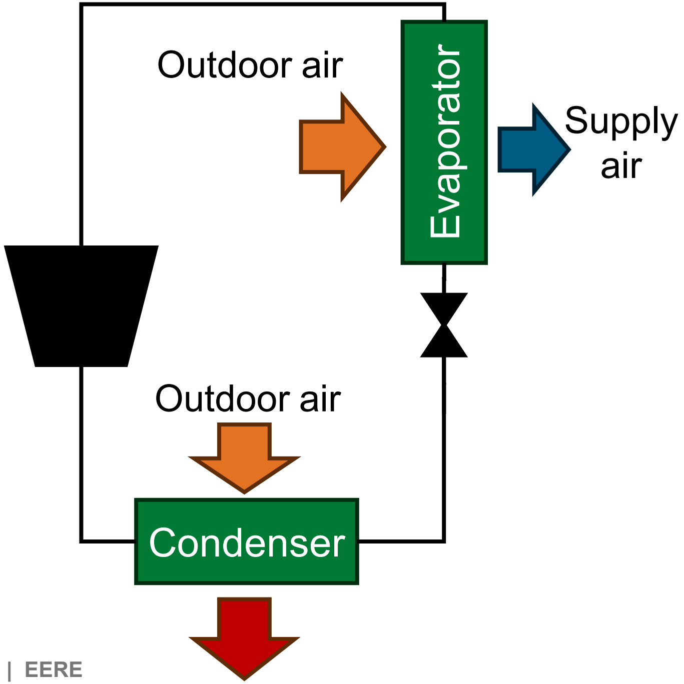
A successful demonstration paves the way for commercialization and deployment of a system with over 20% lower electricity use and emissions for conditioning ventilation air.

- US electricity use due to ventilation air conditioning[1]: 85,000 GWh (7% of electricity used in buildings)

[1] CBECS data: https://www.eia.gov/consumption/commercial/data/2018/ce/pdf/e5.pdf
(assuming 1/2 of air conditioning electricity use is due to ventilation)

Today's DOAS units are not designed for high-latent conditions

DOAS unit with conventional vapor-compression cycle



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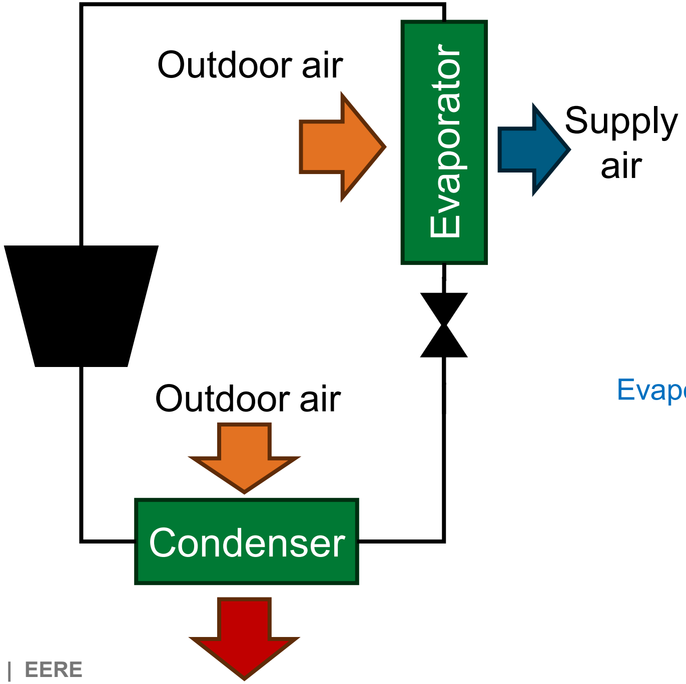
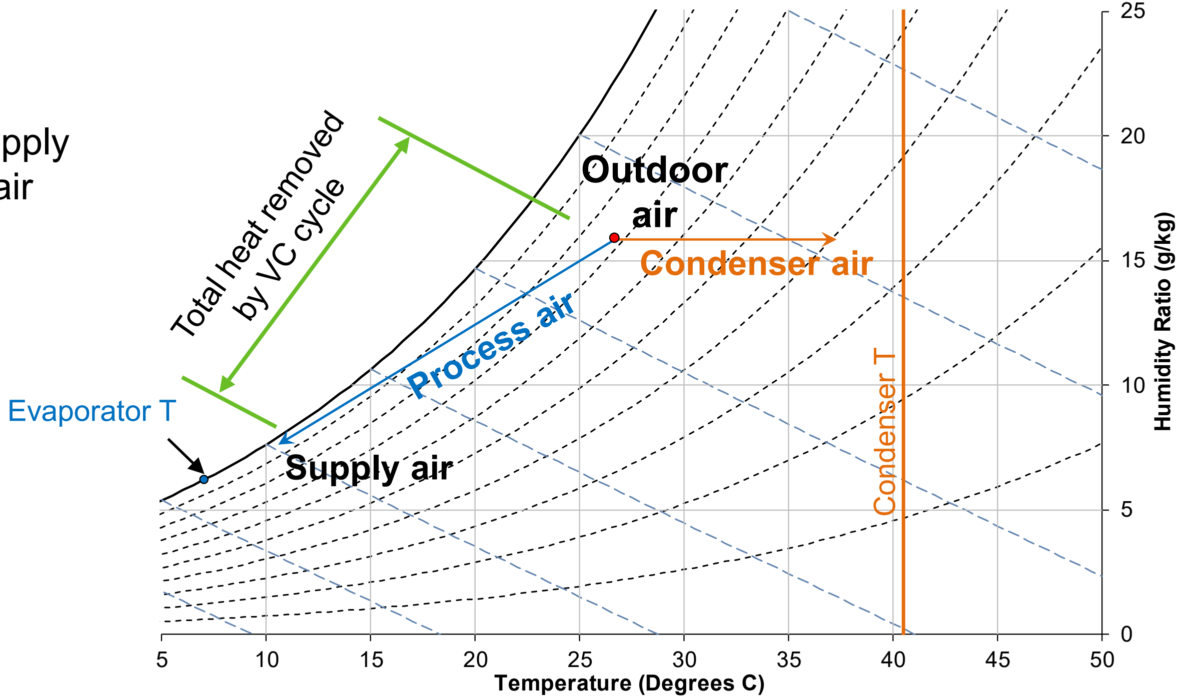
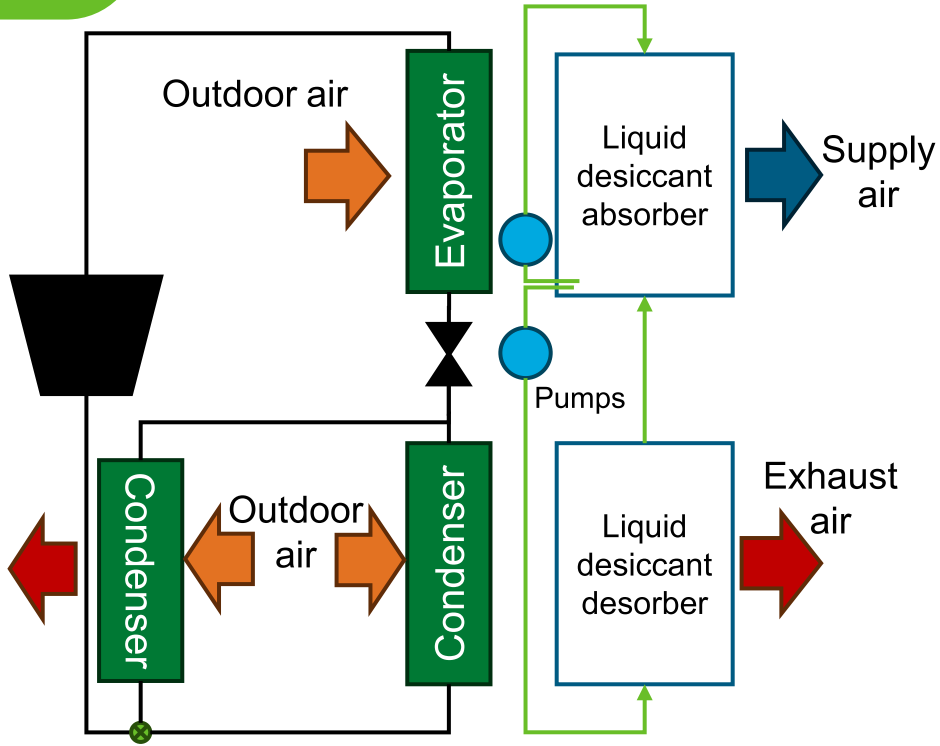
DOAS unit with conventional vapor-compression cycle

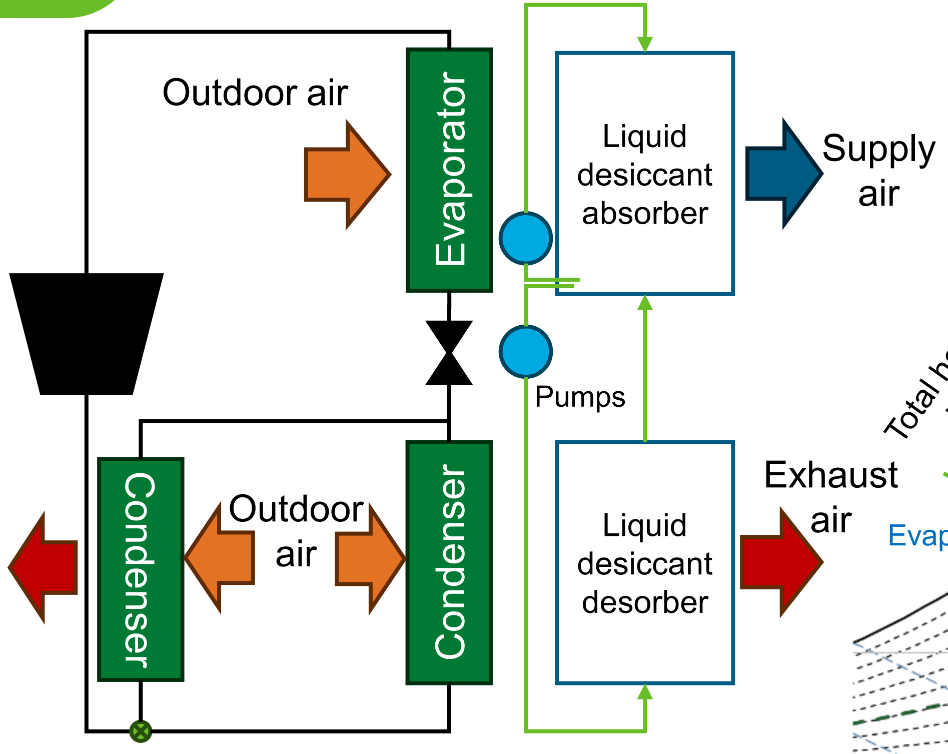


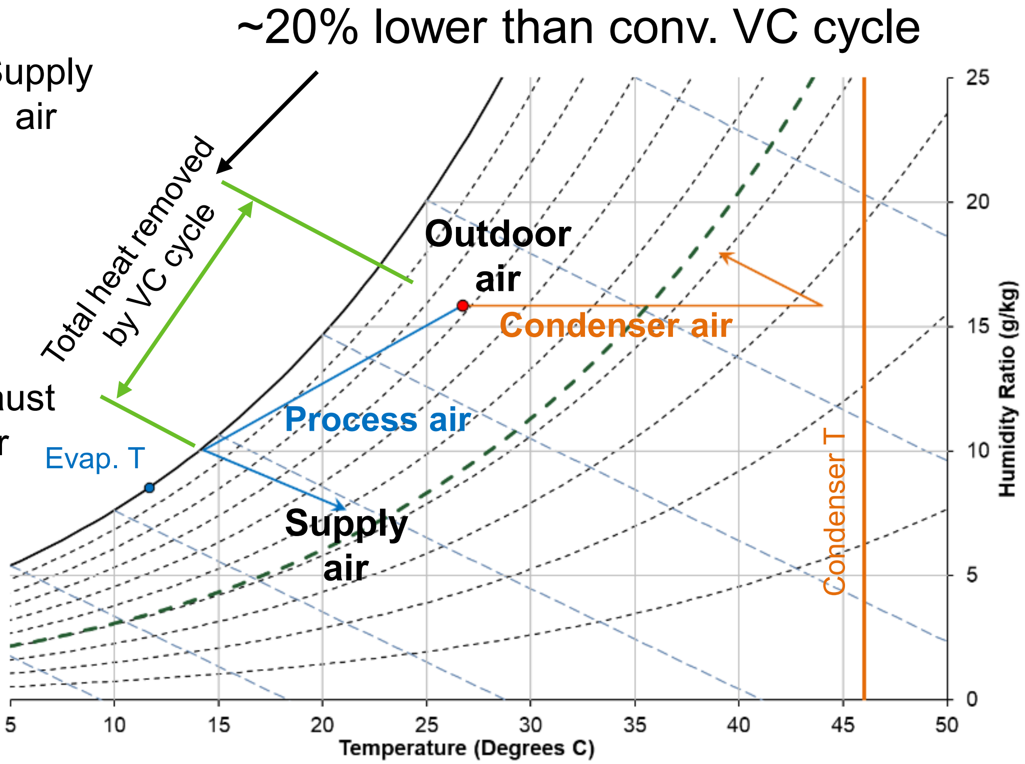


Mojave's technology: efficient high-latent cooling



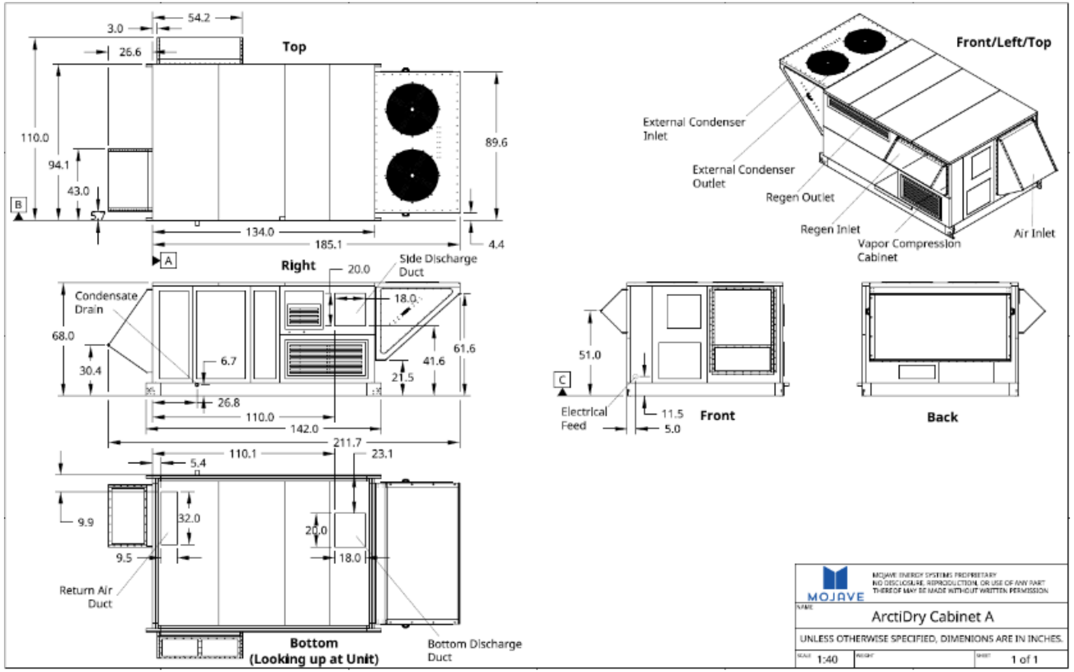
Mojave's technology: efficient high-latent cooling





Progress and Future Work

15-ton unit ready for testing



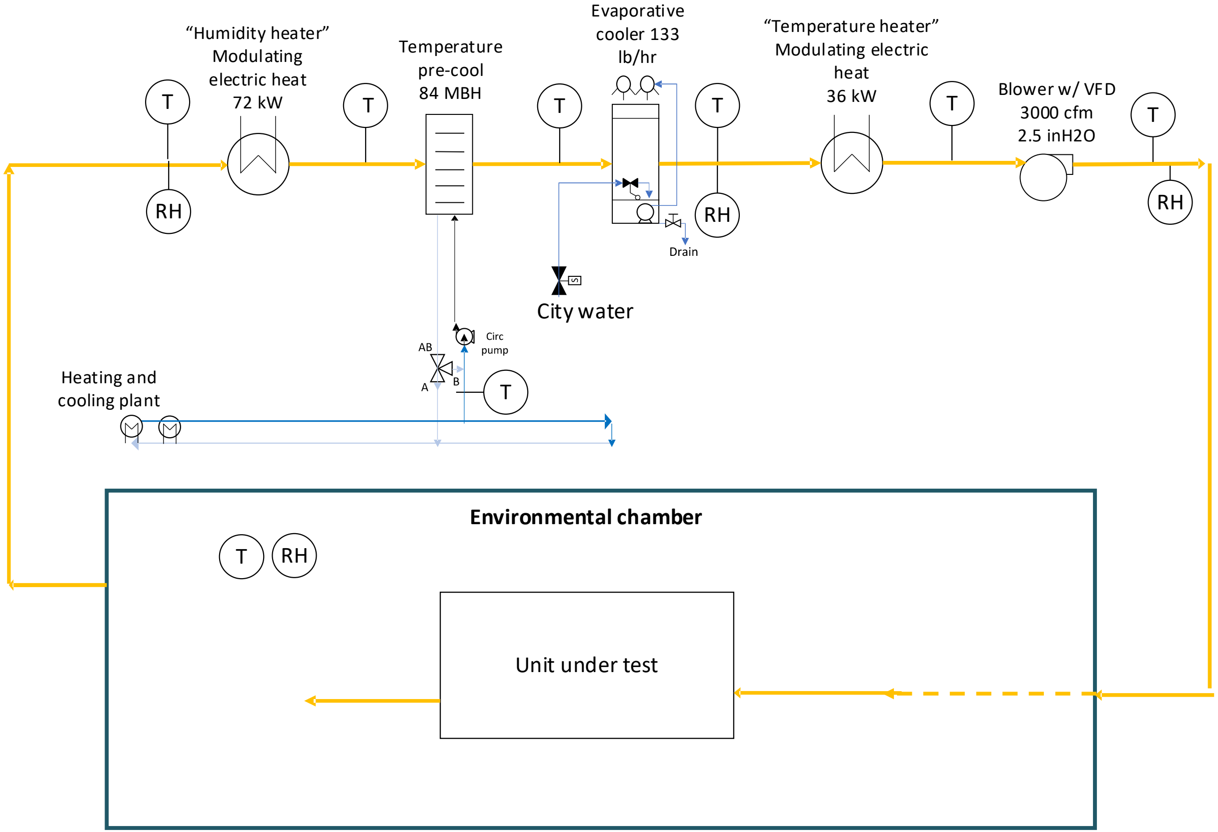
Capacity:	15 tons
Airflow:	3,000 cfm
Supply air drybulb:	60-75 F
Supply air dewpoint:	40-55 F
Refrigerant:	R454B
ISMRE (claimed):	9 lb/kWh

Progress and Future Work

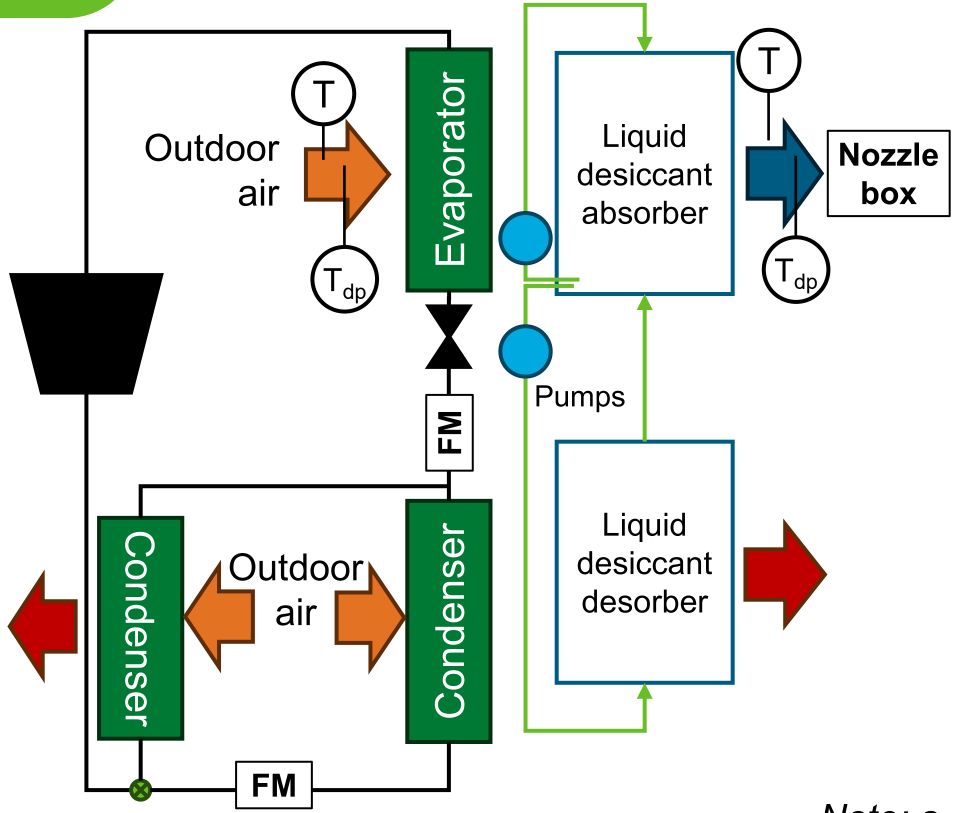
For Mojave’s portion of the project, they have installed two of the five field units (Orlando, FL and Houston, TX).

Test plan

For the lab testing, we will leverage Mojave's large environmental chamber.



Measurement plan



We will use NREL-installed sensors and data acquisition system

<u>Key measurements:</u>

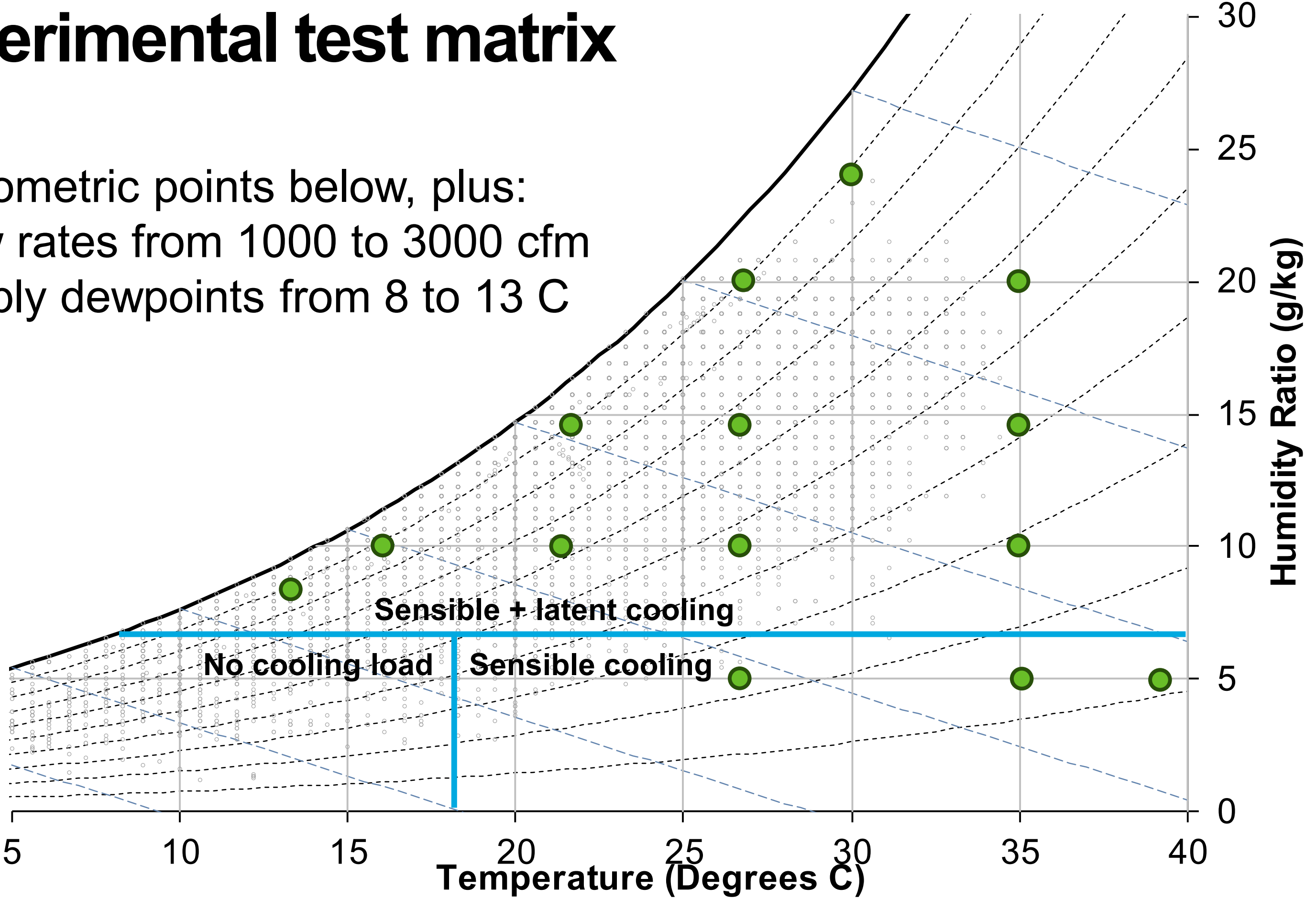
- Refrigerant flow rate (2)
- Supply air flow rate
- Inlet T and humidity
- Supply T and humidity
- Electric power draw

Note: a complete list of sensors is shown in the extra slides

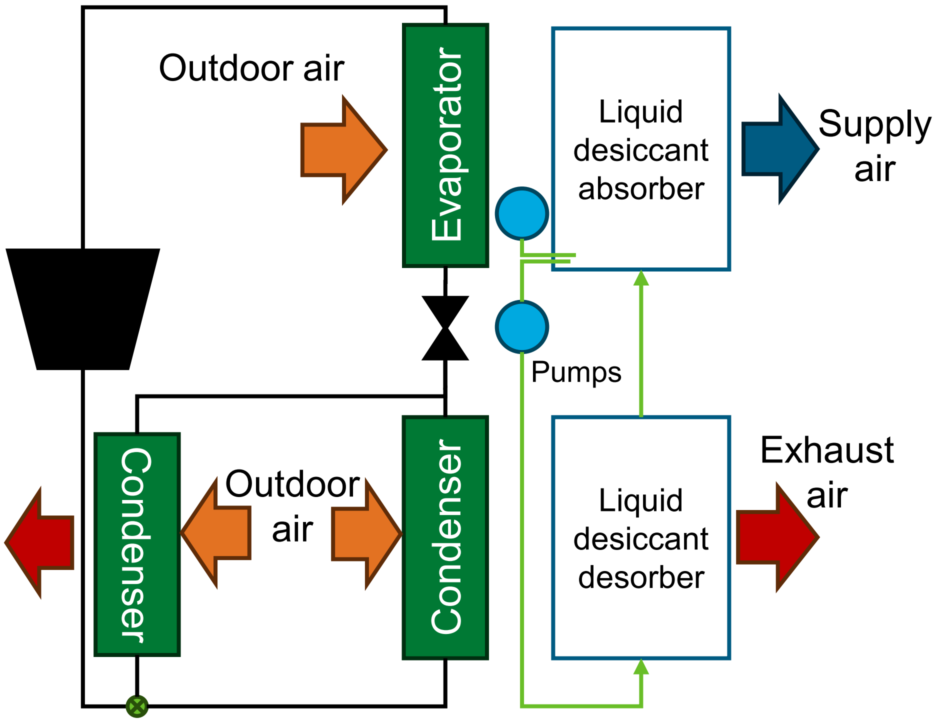
Experimental test matrix

Psychrometric points below, plus:

- Flow rates from 1000 to 3000 cfm
- Supply dewpoints from 8 to 13 C



Model validation



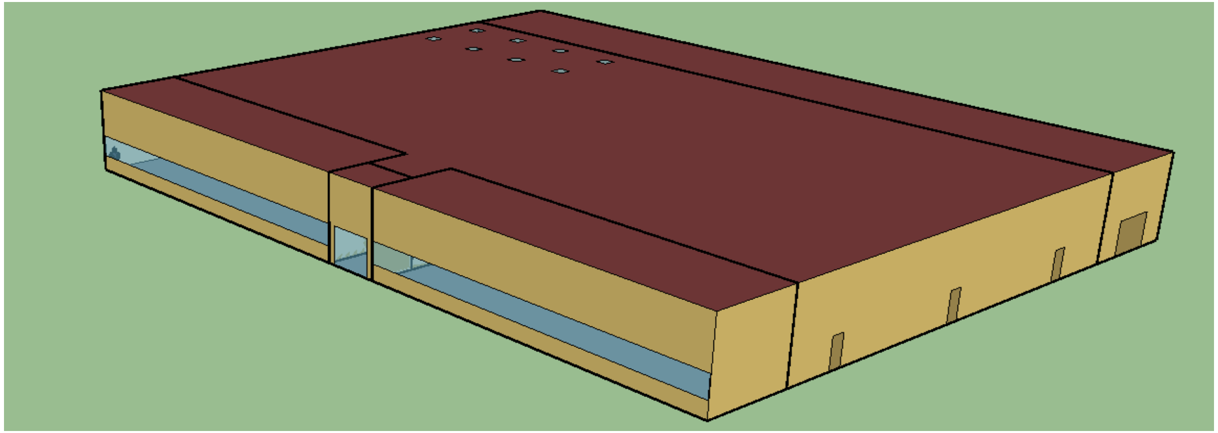
This data will be used to validate:

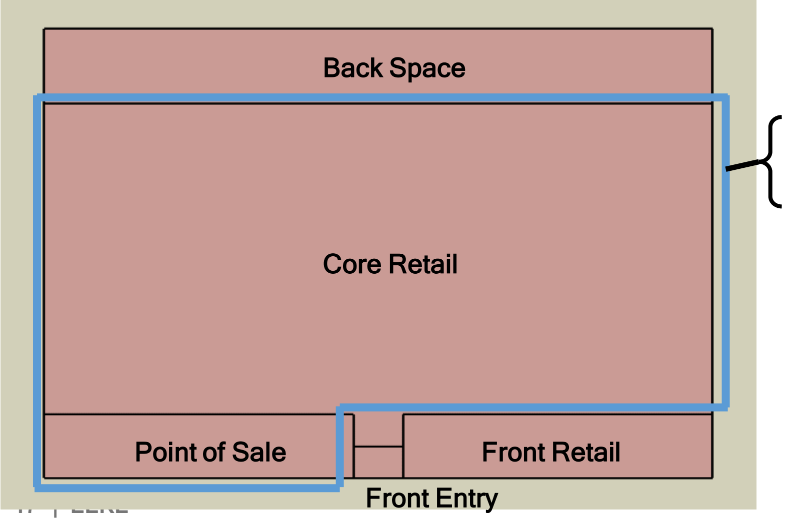
- System model (outlet conditions and power use)
- Finite-difference models of absorber and desorber

Building simulations

Stand-alone Retail DOE Prototype Model (24,700 ft²)

Preliminary Mojave DOAS model added to two zones below. Will update with validated system model.





Unit No.	Zone	Floor Area (ft²)	Total capacity (tons)
1	Back Space*	4,089 ft²	10.5 tons
2	Core Retail**	17,228 ft²	50 tons
3	Point of Sale**	1,623 ft²	6.5 tons
4	Front Retail*	1,623 ft²	5 tons
5	Front Entry	129 ft²	No cooling
		24,693 ft²	72 tons

*Served with separate, typical RTUs (no Mojave unit)

**Recirculating RTU for sensible loads and separate 12.5-ton Mojave DOAS

Future work

- January 2025: Ship data acquisition and instrumentation to Mojave
- February 2025: Commission DOAS unit and data acquisition system
- March-May 2025: Perform experiments
- June-July 2025: Data analysis, model validation, and updated building simulations

Thank you

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Reference Slides

Project Execution

	FY2024				FY2025			
Planned budget	$70k				$314.4k			
Spent budget	$70k				$314.4k			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Past Work								
Q2: Determine location for testing 15-ton DOAS unit								
Q3: Develop experimental test plan								
Q4: Order long-lead components and instrumentation								
Current/Future Work								
Q1: Receive instrumentation and NREL DAQ system components								
Q2: Commissioning of 15-ton DOAS unit at Mojave facility								
Q3: Complete experiments on 15-ton DOAS unit								
Q4: Final CRADA report and other reporting								

Team

Jason Woods

Sr. Research Engineer

PI

Eric Kozubal

Sr. Mechanical Engineer

Lead experiment design

Greg Shoukas

Research Technologist

Instrumentation and
data collection

Team, continued

Aaron Meles
Vice President – Product
Mojave

Rachel Ellman
Vice President – Engineering
Mojave

Sensor list

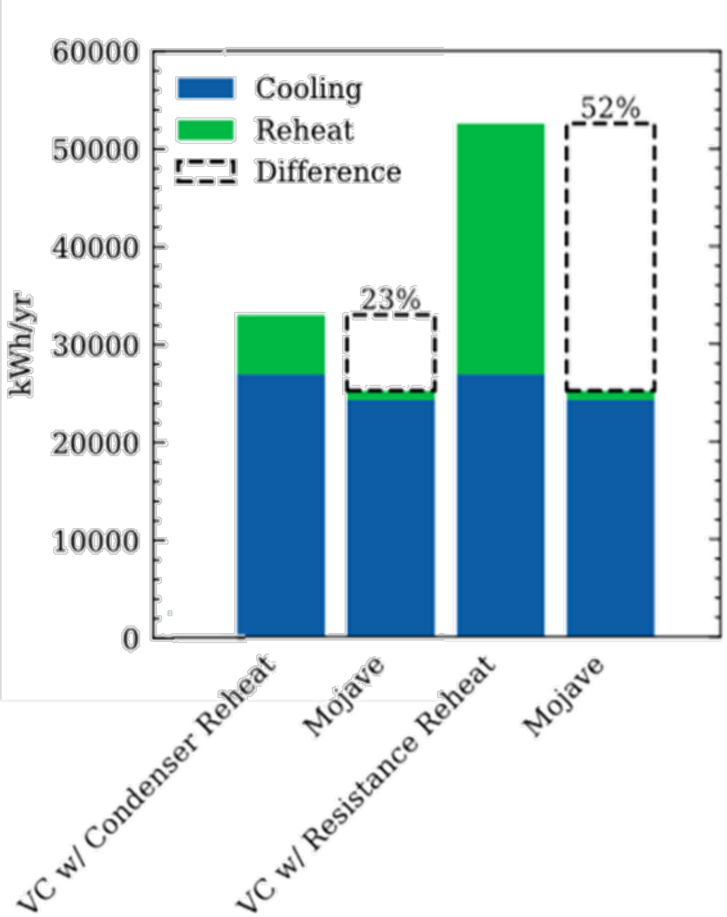
	Parameter	Variable	Units	Measurement instrument
Electric power	System elec power	P_el_sys	kW	Power meter
	LD pump 1 elec power	P_el_pump_LD1	kW	Power meter
	LD pump 2 elec power	P_el_pump_LD2	kW	Power meter
	Condenser air fan elec power	P_el_fan_Cond	kW	Power meter
	Process air fan elec power	P_el_fan_P	kW	Power meter
	Regen air fan elec power	P_el_fan_R	kW	Power meter
Process air	Volumetric process air flow rate	V_dot_air_P	m^3/h	Nozzle box / code tester
	Process air inlet temperature - TC psychrometer	T_air_P_1-psychr-TC	C	type-T TC (pychrometer)
	Process air inlet temperature - RTD psychrometer	T_air_P_1_psychr-RTD	C	RTD (pychrometer)
	Process air inlet temperature - tree	T_air_P_1_tree-TC	C	type-T TC (tree)
	Process air inlet dew point	Tdp_air_P_1	C	DP hygrometer 1, w/ sampling tree
	Evaporator outlet temperature	T_air_P_2	C	type-T TC (avg of ~9)
	Supply air temperature - TC psychrometer	T_air_P_4-psychr-TC	C	type-T TC (psychrometer)
	Supply air temperature - RTD psychrometer	T_air_P_4-psychr-RTD	C	RTD (pychrometer)
	Supply air temperature - tree	T_air_P_4_tree-TC	C	type-T TC (tree)
	Supply air dew point	Tdp_air_P_4	C	DP hygrometer 2, w/ sampling tree
	Process air abs out P	dP_air_P_3-amb	Pa	Setra dP#1
	Process air absorber delta P	dP_air_P_2-3	Pa	Setra dP#2
	Process air total static	dP_air_P_4-amb	Pa	Setra dP#3
	Evaporator condensate	m_dot_cndnst_E	kg/s	Tank on scale
Regen air	Volumetric regen air flow rate	V_dot_air_P	m^3/h	Flow-power correlation using vane anemometer
	Regen air inlet temperature - TC psychrometer	T_air_R_1_psychr-TC	C	type-T TC (pychrometer)
	Regen air inlet temperature - RTD psychrometer	T_air_R_1_psychr-RTD	C	RTD (pychrometer)
	Regen air inlet temperature - tree	T_air_R_1_tree-TC	C	type-T TC (tree)
	Regen air inlet dew point	Tdp_air_R_1	C	DP hygrometer 1, w/ sampling tree
	Regen condenser outlet air T	T_air_R_2	C	type-T TC (avg of ~9)
	Regen desorber outlet air T - TC psychrometer	T_air_R_3_psychr-TC	C	type-T TC (psychrometer)
	Regen desorber outlet air T - RTD psychrometer	T_air_R_3_psychr-RTD	C	RTD (psychrometer)
	Regen air outlet dew point	Tdp_air_R_3	C	DP hygrometer 3, w/ sampling tree
	Regen air inlet pressure	P_air_R_2-amb	Pa	Setra dP #4
	Regen air regenerator delta P	P_air_R_1.5-2	Pa	Setra dP #5
	Regen air total delta P	P_air_R_2-3	Pa	Setra dP #6

Sensor list

	Parameter	Variable	Units	Measurement instrument
Ext. condenser air	Ext. condenser airflow rate	V_dot_air_ExtC	m^3/h	Flow-power correlation using vane anemometer
	Ext. condenser Inlet T	T_air_extC_in_psychr-TC	C	type-T TC (pychrometer)
	Ext. condenser Inlet T	T_air_extC_in_psychr-RTD	C	RTD (pychrometer)
	Ext. condenser Inlet T	T_air_extC_in_tree-TC	C	type-T TCs
	Ext. condenser Outlet T	T_air_extC_out	C	type-T TC (avg of ~6)
Refrigerant	Refrigerant mass flow rate	m_dot_refr	kg/s	Refr Coriolis meter
	Refr evap inlet temperature	T_refr_1	C	type-T TC (surface mount)
	Refr evap outlet temperature	T_refr_2	C	type-T TC (surface mount)
	Refr suction temperature	T_refr_3	C	type-T TC (surface mount)
	Suction pressure	P_refr_3	kPa	pressure transducer
	Suction temperature	T_refr_4	C	type-T TC (surface mount)
	Discharge pressure	P_refr_4	kPa	pressure transducer
	Discharge temperature	T_refr_4	C	type-T TC (surface mount)
	Refr ext condenser outlet T	T_refr_5	C	type-T TC (surface mount)
	Refr regen condenser outlet T	T_refr_6	C	type-T TC (surface mount)
	Refr mixed condenser outlet T	T_refr_7	C	type-T TC (surface mount)
	Refr receiver outlet T	T_refr_8	C	type-T TC (surface mount)
	Refr SLHX liquid-side outlet T	T_refr_9	C	type-T TC (surface mount)
Absorber LD stream	Absorber LD mass flow rate	m_dot_LD_1	kg/s	Paddle meter
	Absorber LD inlet temperature	T_LD_1	C	type-T TC (inserted)
	Absorber LD inlet conc.	C_LD_1	kg/kg	Atago refractive index sensor
Desorber LD stream	Desorber LD mass flow rate in	m_dot_LD_2	kg/s	Paddle meter
	Desorber LD inlet temperature	T_LD_2	C	type-T TC (inserted)
	Desorber LD inlet conc.	C_LD_2	kg/kg	Atago refractive index sensor
	Desorber LD outlet temperature	T_LD_3	C	type-T TC (inserted)
	Ambient pressure	P_ambient	kPa	Pressure transducer

Preliminary building simulation results (uncalibrated model)

Standalone retail building
New York City
12.5 ton DOAS



VC = standard vapor compression system