Icephobic Heat Exchange for Efficient, Resilient, Building Cooling

Shift Thermal
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SBIR Phase II DE-SC0020715

Project Summary

Objective and outcome

Experimentally demonstrate a high-efficiency and operationally versatile ice thermal storage system that is projected to have less than 3-year payback while providing added resiliency for building cooling.

Team and Partners

Shift Thermal, *technology developer*

NREL, *third-party testing*

Optimized Thermal Systems, *heat transfer modeling*

OTS-Energy, *HVAC equipment modeling*

Heat Transfer Technologies, *heat exchanger mfg*

Stats

Performance Period: 08/23/21 - 03/22/24

DOE budget: $1,100k, Cost Share: $0

Milestone 1: High-performance manifold development
Milestone 2: IHEX plate and chiller modeling
Milestone 3: Large area water distributor development
Milestone 4: High, constant discharge hardware development
Milestone 5: Third-party testing by NREL
Milestone 6: Predictive controls development

Problem

Chiller owner-operators are faced with

- carbon reduction mandates
- expensive cooling bills
- cooling resiliency challenges

Cold thermal storage as a solution

- Challenge: expensive and complex, struggling with building space constraints
- Low market adoption
  - Market potential: $10B scale
  - Existing market size: $100M scale

Alignment and Impact

Air conditioning (AC)

- 5% of all US electricity
- Up to 20% of electric energy & 50% power use in buildings

Shift is helping transform AC into a resilient & affordable resource for demand flexibility

Our **plug-and-play thermal energy storage** solution helps decarbonize commercial building cooling efficiently and affordably

- ✓ Fast payback, with enhanced resiliency
- ✓ Simple to design - constant charge & discharge
- ✓ Simple to install - modular, separate power & energy blocks

Current Cold Thermal Storage Solutions

Chilled Water Storage

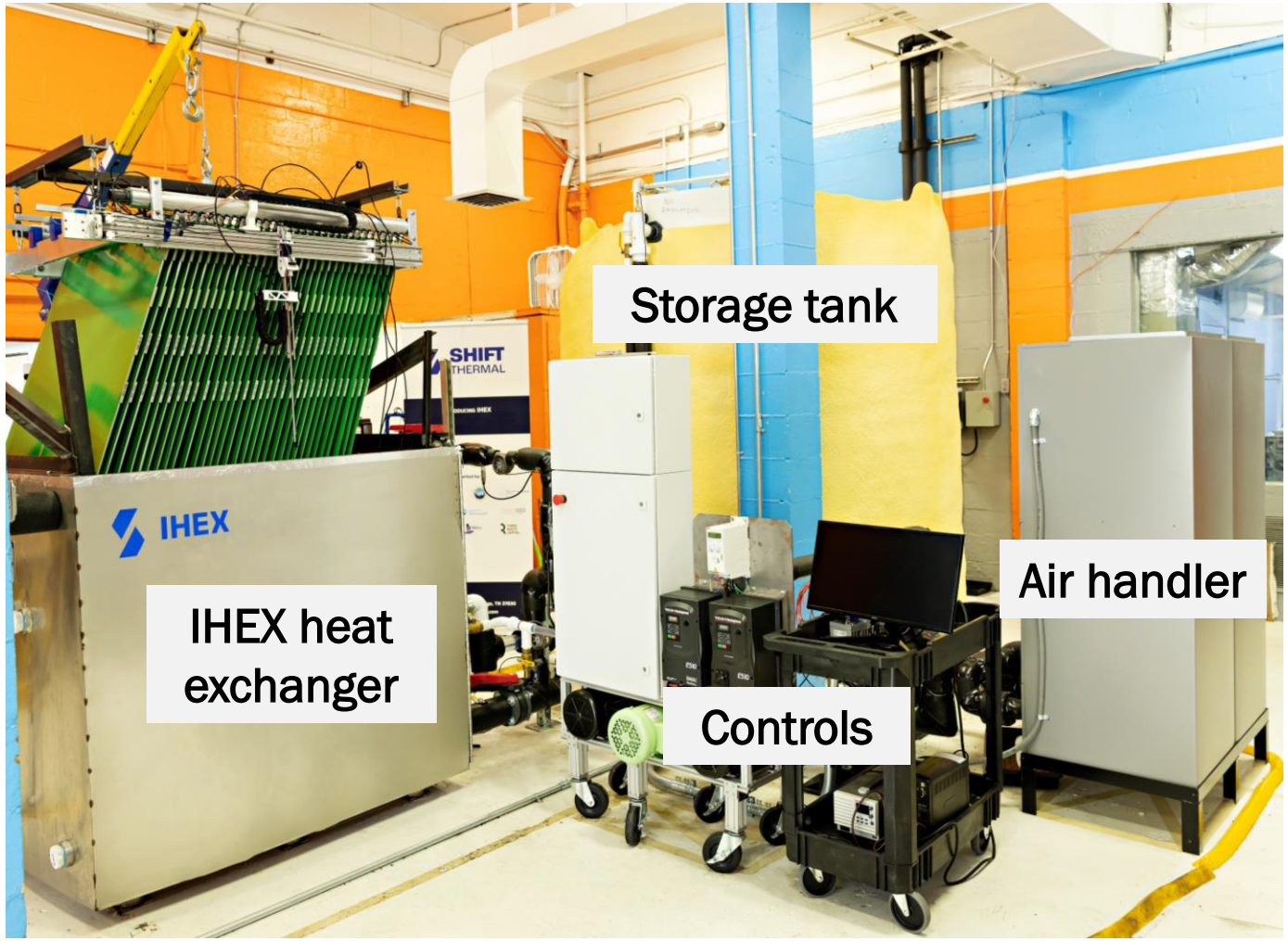
- ✓ Efficient
- ✓ Financially attractive
- ✗ Requires large volume, preventing urban deployments

Ice-on-coil Ice Storage

- ✓ Sufficient energy density for urban deployment
- ✗ Reduced efficiency
- ✗ Limited operational capabilities
- ✗ Rigidity in storage tank design

Our solution: Icephobic Heat Exchange (IHEX)

Our technology: **Icephobic Heat Exchange**



Leads to an efficient ice slurry chiller and thermal storage system with

- ✓ Low cost & efficient system
- ✓ Constant rates of charge & discharge throughout state-of-charge
- ✓ High rate of discharge

Project plan, challenges, risks, and mitigation strategies

Project Plan	Challenges	Status
Optimized performance hardware	High-performing heat exchanger manifold	Complete
	Uniform large area water drop distributor	In progress
Advanced modeling	IHEX HVAC system with performance maps	Complete
	Predictive controls optimizing cost/benefit while providing added resiliency	In progress
Third-party testing	IHEX system testing by NREL	In progress

Project plan, challenges, risks, and mitigation strategies

Project Plan	Challenges	Status	Risks	Mitigation strategy
Optimized performance hardware	High-performing heat exchanger manifold	Complete		
	Uniform large area water drop distributor	In progress	Insufficiently high flow rate	Use CFD & experimental tools to tailor design
Advanced modeling	IHEX HVAC system with performance maps	Complete		
	Predictive controls optimizing cost/benefit while providing added resiliency	In progress	Model projecting overly high payback	Improve performance and minimize cost
Third-party testing	IHEX system testing by NREL	In progress	Not capturing full performance potential	Preliminary in-house commissioning

NREL Demonstration

Current ice storage limitation	IHEX solution
Low efficiency	Demonstrate ice-making at -3 to -5C refrigerant temperatures, a 15% efficiency gain

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Limited operational capabilities	Demonstrate • Constant ice making and melting rates • 3X greater max discharge vs charge rate

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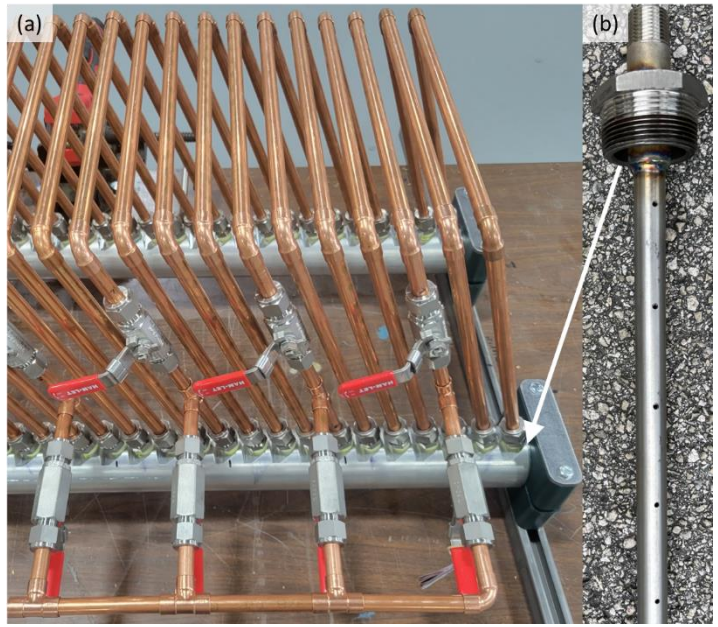
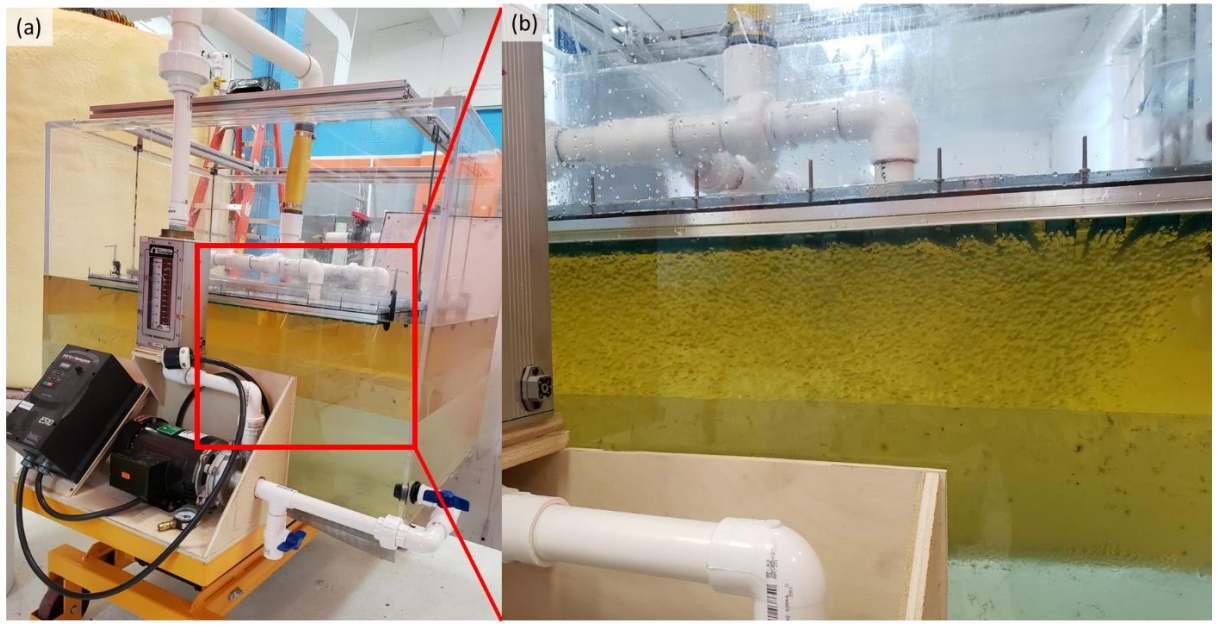
Current ice storage limitation	IHEX solution
Low efficiency	Demonstrate ice making at -3 to -5C refrigerant temperatures, a 15% efficiency gain
Limited operational capabilities	Demonstrate • Constant ice making and melting rates • 3X greater max discharge vs charge rate
Rigidity in storage tank design	Demonstrate ice making in one tank, transfer + storage in another

Achievements to date

1. High-performing manifold



2. Uniform drop distribution at 0.5 - 1 GPM/plate

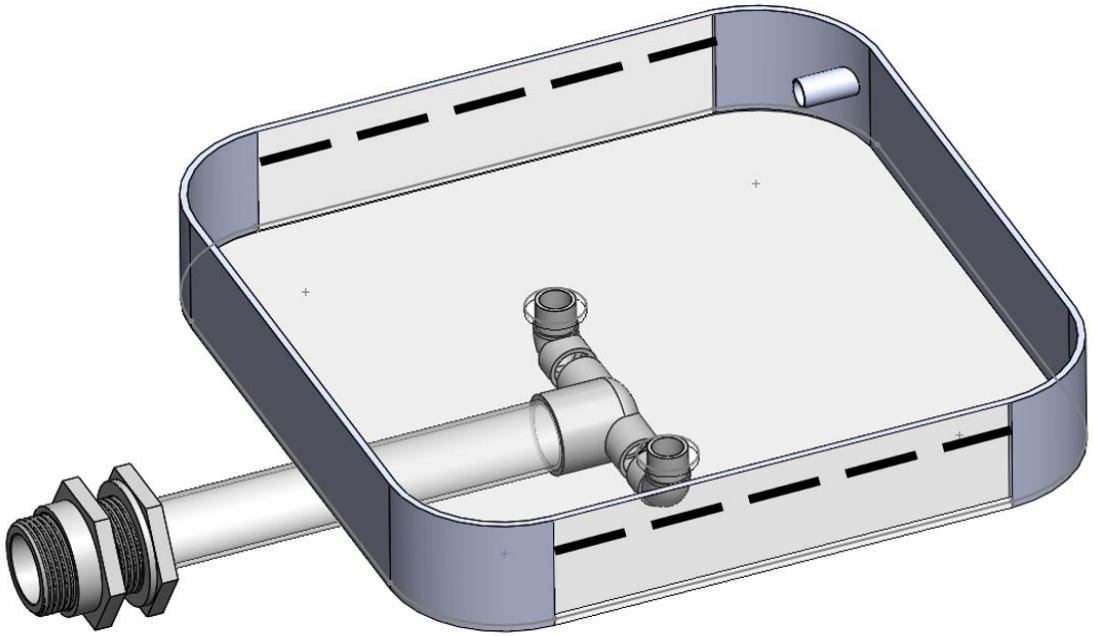


3. System Modeling

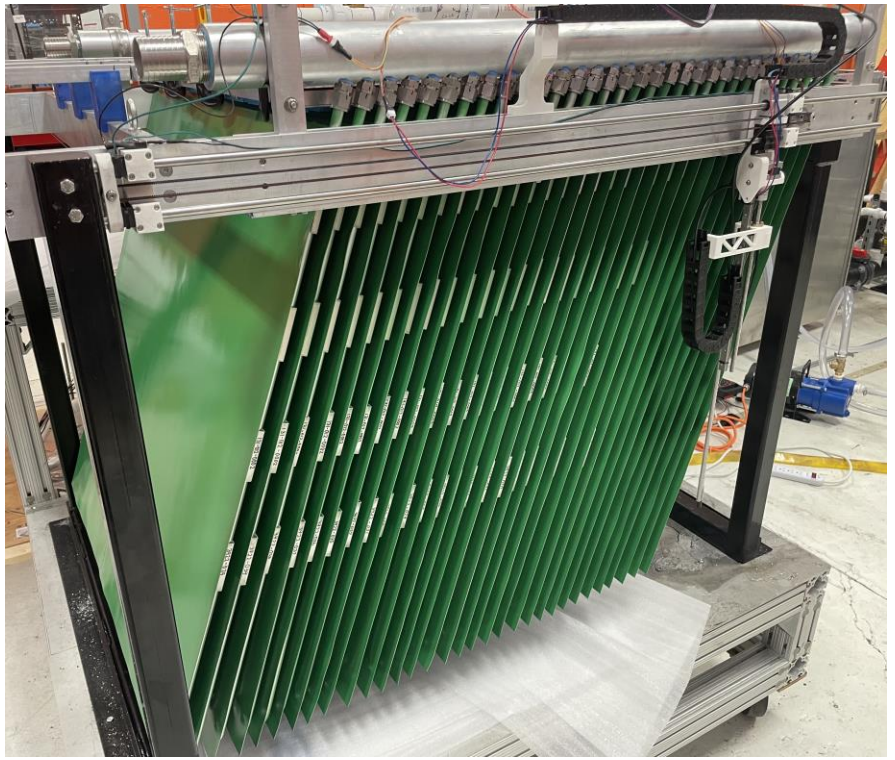
4. NREL System designed & under construction

Unexpected issues

Ice Slurry Management



Supply Chain Delays



Lessons learned

Diagnostics

Sometimes better to focus on increasing quantity VS quality of diagnostics

Iteration Speed

Sometimes better to improve iteration speed at the expense of near-term experiments

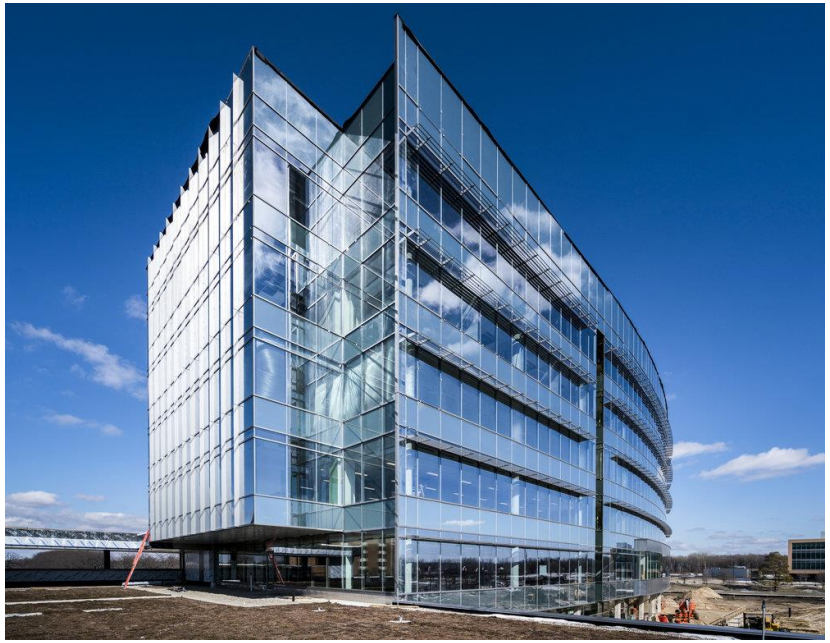
Simulation and Industry Knowledge

Valuable to know but not the most effective at helping solve our major challenges

Plans beyond Project

Commercial Pilots

Innovative building owners



Partners

Chiller and similar HVAC OEMs

Validate performance in field with commercial system

Goals

Demonstrate payback of 3 years or less in

- 4-hr applications with established mfg
- 8-hr applications at high volume mfg

Thank You

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REFERENCE SLIDES

Project Execution

	FY2021	FY2022				FY2023				FY2024
Planned budget	$ 108,687	$ 489,749				$ 501,562				
Spent budget	$ 55,803	$ 458,209				$ 127,320				
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Past Work										
Q1 Milestone: High-performance manifold development										
Q3 Milestone: IHEX plate and chiller modeling										
Current/Future Work										
Q2 Milestone: Large area water distributor development										
Q4 Milestone: High, constant discharge hardware development										
Q5 Milestone: Third-party testing by NREL										
Q6 Milestone: Predictive controls development										

Q1 and Q2 planned completion dates slipped for us to increase performance to high, satisfactory level

Q4 and Q5 planned completion dates slipped primarily due to supply chain challenges

Team

SHIFT THERMAL

Project lead and primary technology developer

Optimized Thermal SYSTEMS

Modeling and testing heat exchanger's heat transfer performance

Heat Transfer Technologies LLC

Supporting heat exchanger design and guiding its manufacturing

OTS•energy

Modeling IHEX system operation within building HVAC

NREL Transforming ENERGY

Third-party testing the IHEX system