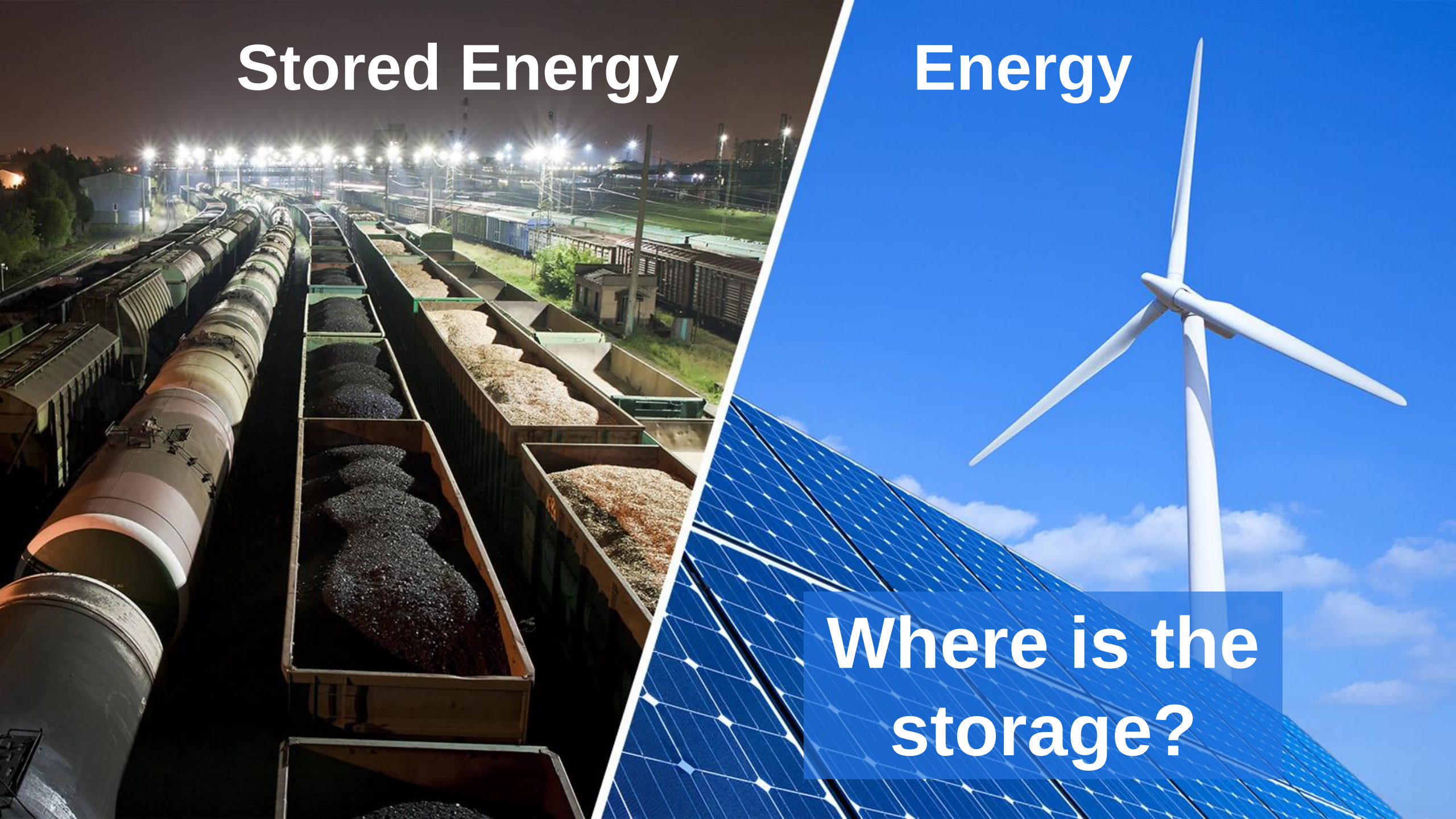
The Trane Thermal Battery System

What it is, why you'd want it

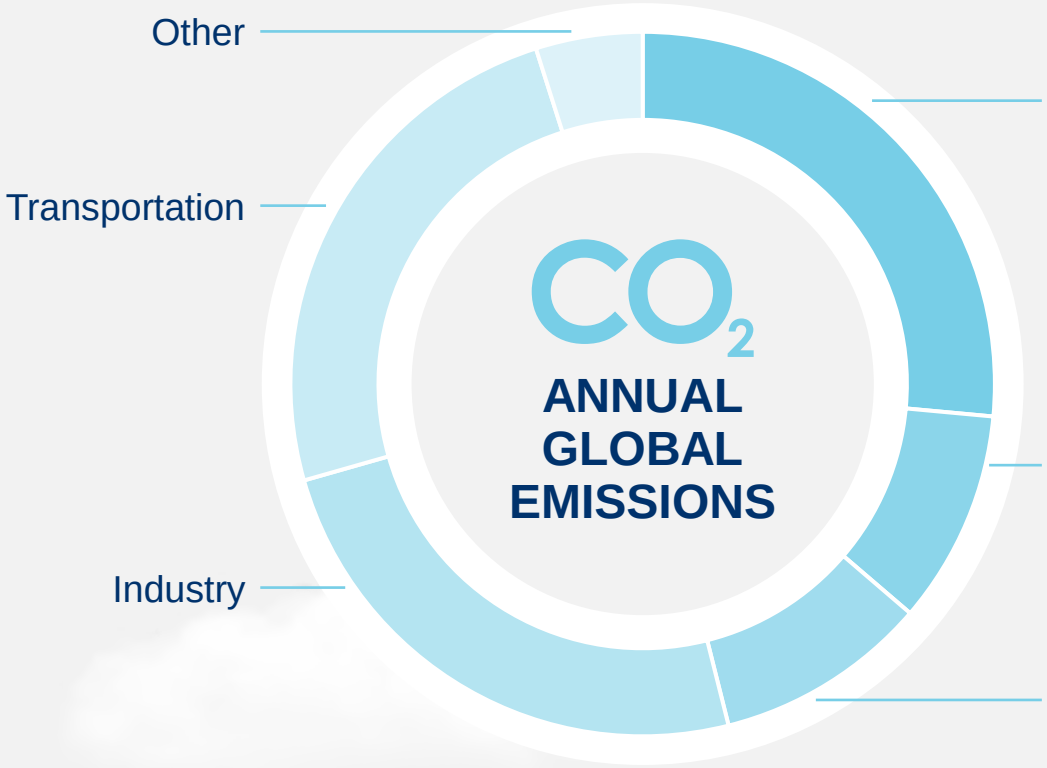
BOMA Manitoba
February 6, 2025
Stephen Scott, P.Eng, LEED AP
Trane


Stored Energy
Energy
Where is the storage?

More than 70 countries have committed to achieving net zero carbon emissions by 2050.

Source: United Nations. Climate change net zero coalition.

The Built Environment



27%
Building Operations

10%
Building Materials & Construction

10%
Other Construction Industry

Source: https://architecture2030.org/why-the-building-sector/

Storage is Key to Sustainability

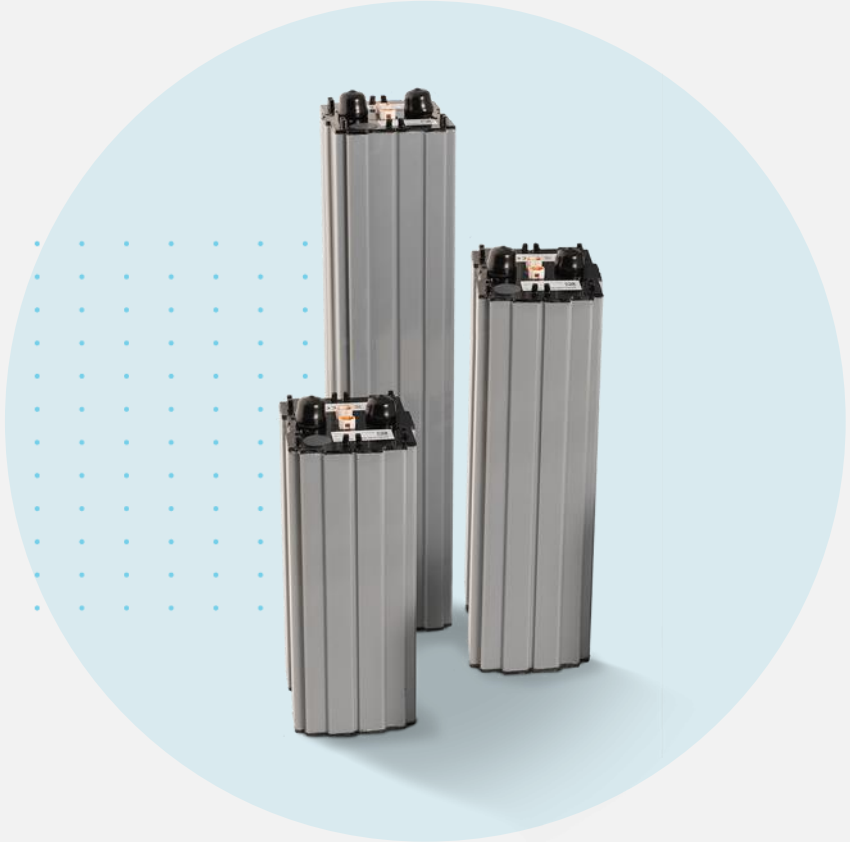
What's missing?

Storage for dispatchability

TES can increase use of renewables by up to 50%*

Source: ASHRAE RP-1607. 2018

We Will Need Both Types of Batteries

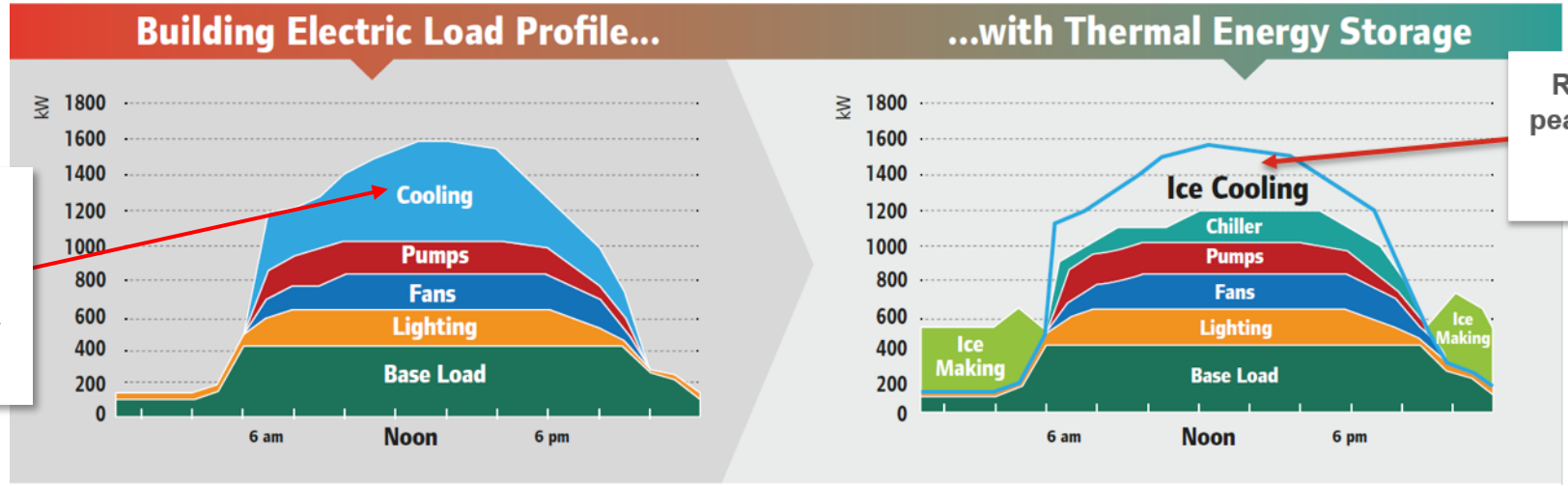


Electric batteries

Thermal batteries

Shift Building Demand by Cooling with Thermal Batteries

Air-conditioning can account for over 40% of the summer peak-day load



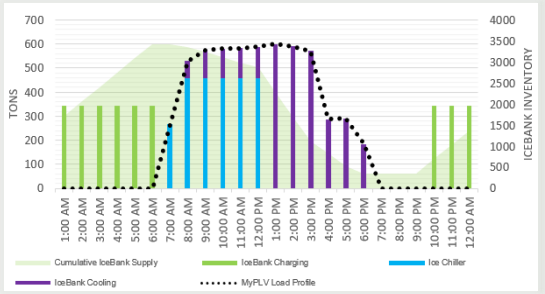
Thermal Batteries meet grid challenges

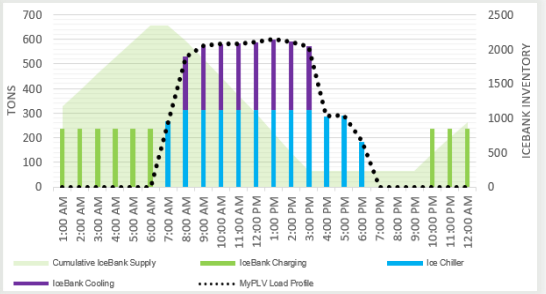
- Addressing **critical** utility/grid peaks
- Avoid **expensive** and **high-emission** peaker plants
- Supporting **advanced grid services** and **demand response**

LET'S TAKE A CLOSER LOOK

New Construction Project: 250,000 sq. ft. building, ON

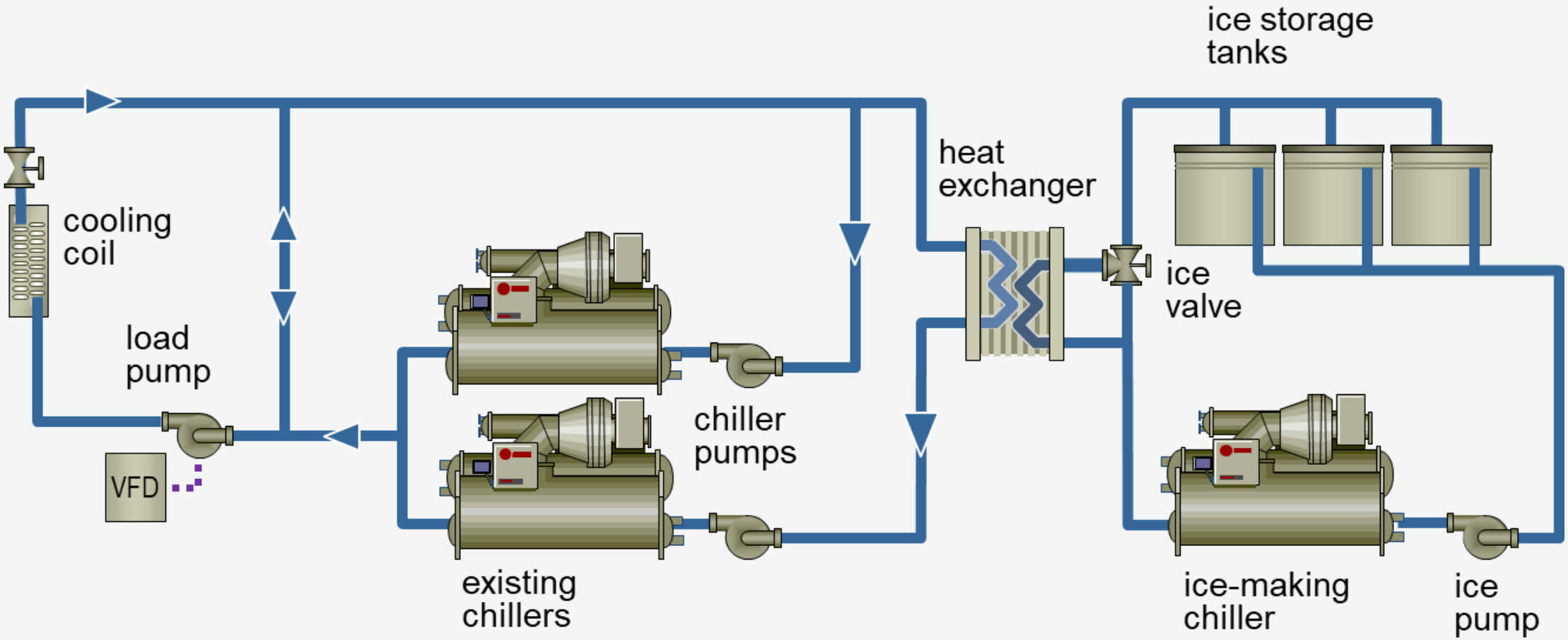
	Conventional	Full Storage	Partial Storage
Chillers	(2) 300-ton AC	(1) 460-ton AC	(1) 320-ton AC
Ice Tanks	N/A	(20) $693k	(14) $485k
Utility Cost*	$131k	$43k	$85k
First Cost	$900k	$1,360k	$995k
Tax Credit (None)	$0	$0	$0
Utility Rebate (IESO)	$0	$(476k)	$(348k)
Revised First Cost	**$900k**	**$884k**	**$647**





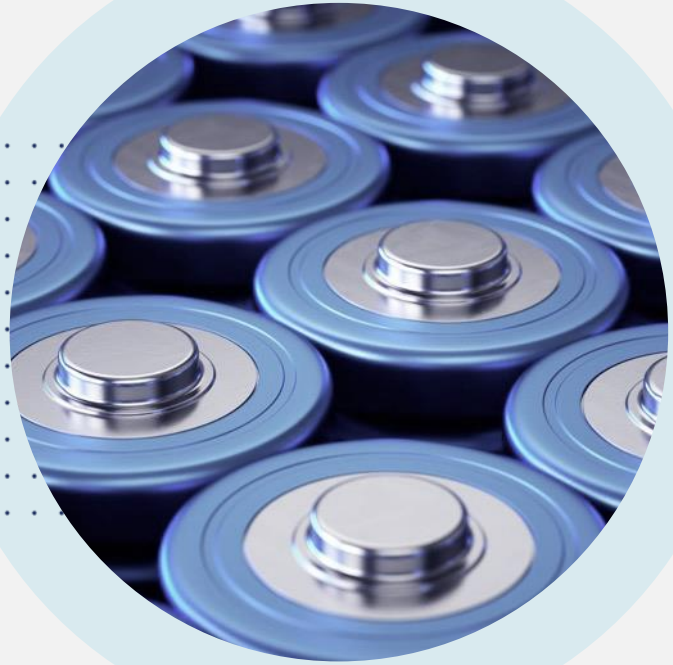
* Annual electric utility costs for the chillers.

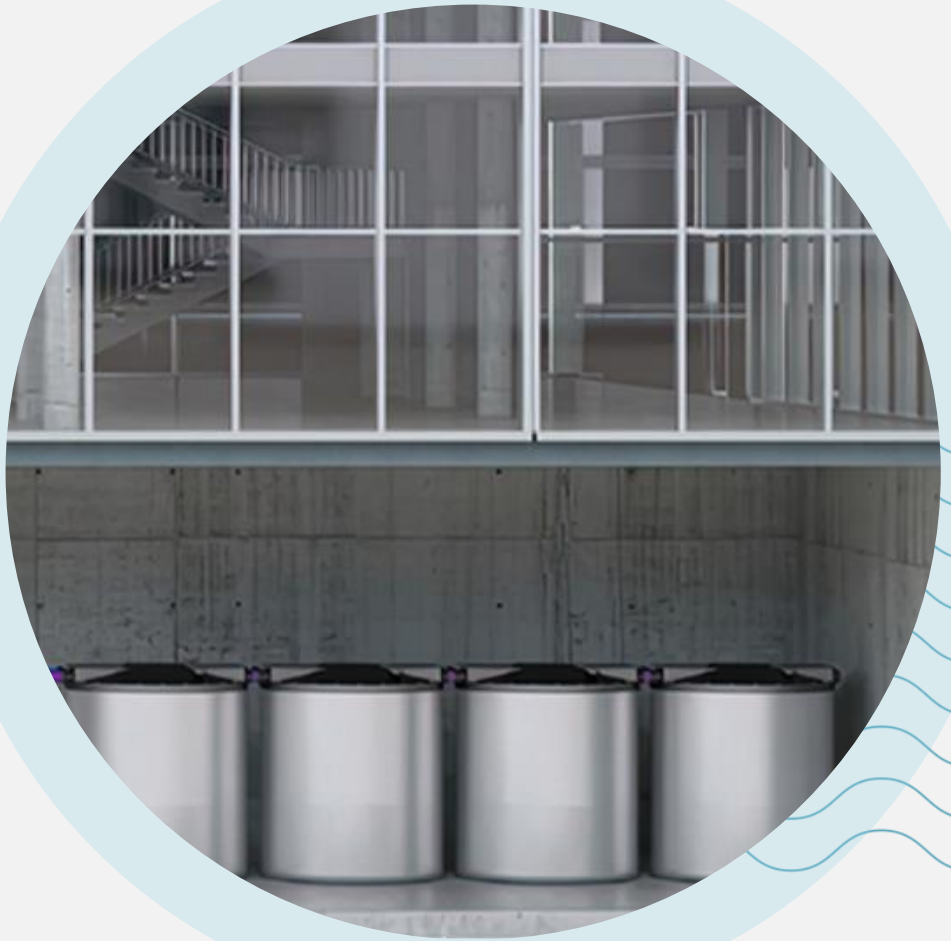
Adding Thermal Storage to a Large Chiller Plant



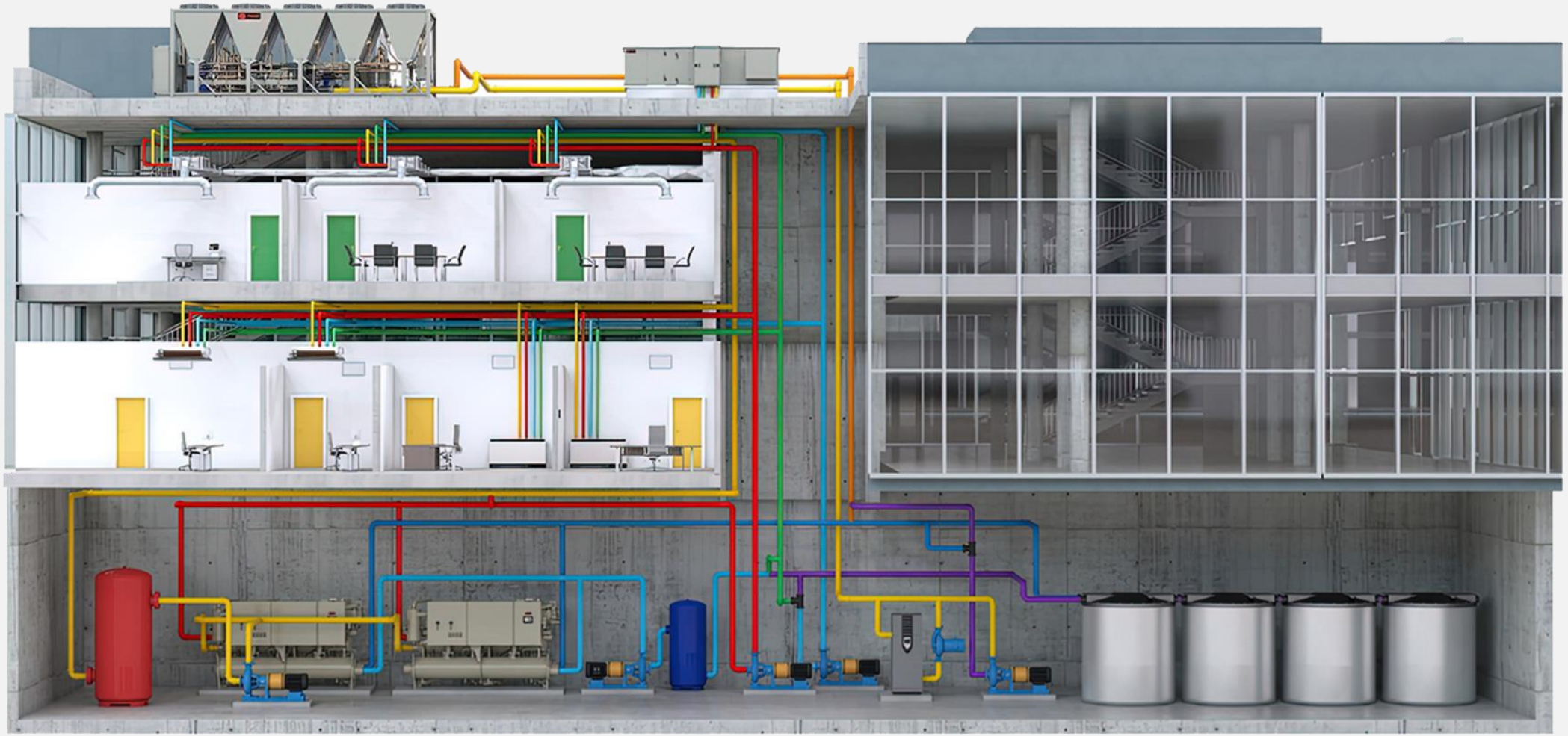
Introducing the Trane Thermal Battery™ System

Imagine a bank of batteries…





…with the ability to cool or heat your whole building



Trane Thermal Battery™ Cooling System

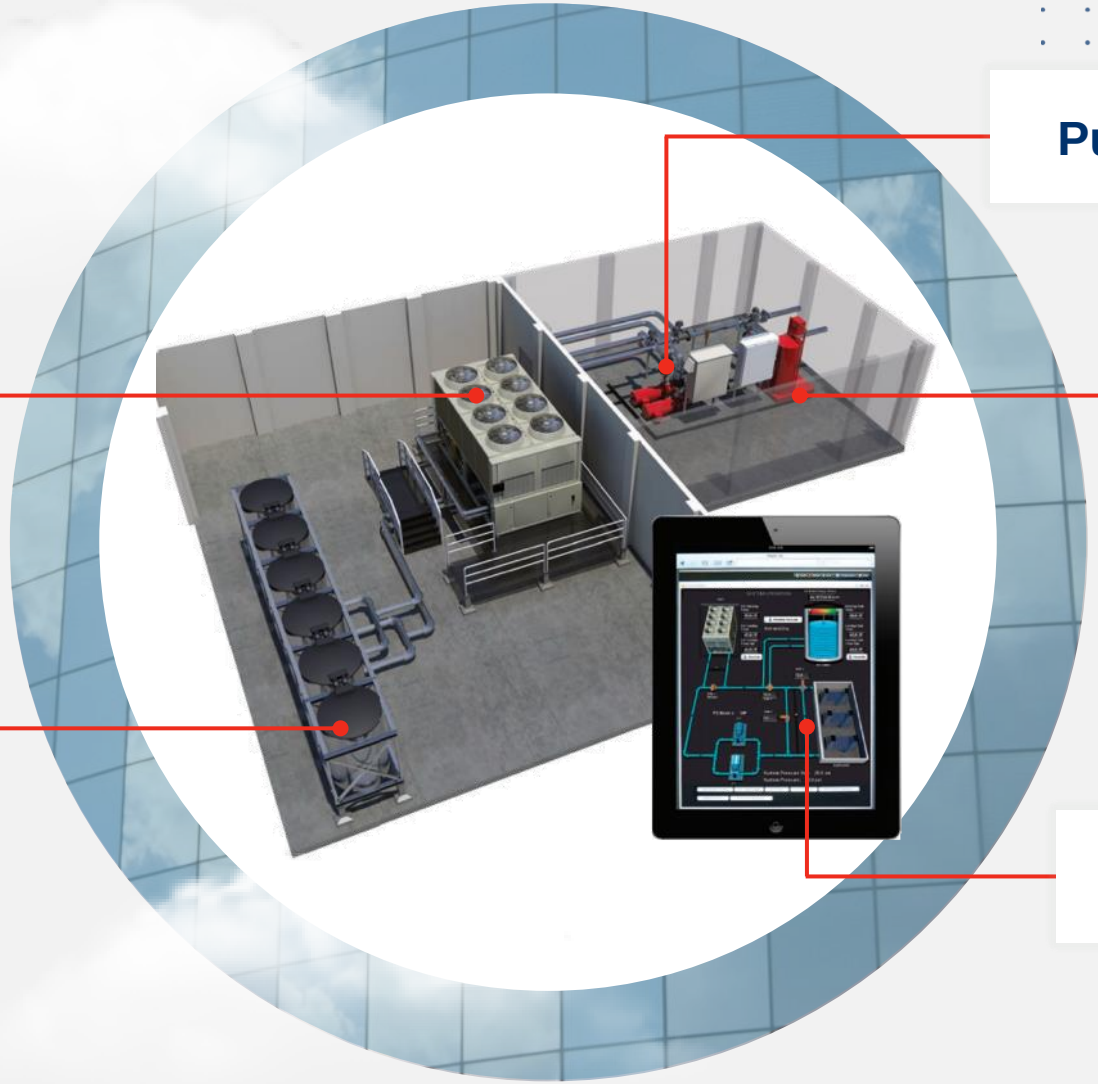
What is it?

- A Trane-controlled chiller plant enhanced with thermal energy storage.

What does it do?

- Chiller plant operates like a battery, charging Ice Bank® energy storage tanks (filled with water) when excess or inexpensive energy is available.
- And discharging when demand or cost is high, or when the utility asks for the discharge to occur.

Trane Thermal Battery™ Cooling System



Pumps

Glycol management system

Ice-making chiller

CALMAC® Ice Bank® storage tanks

Controls

Trane Thermal Battery™ System

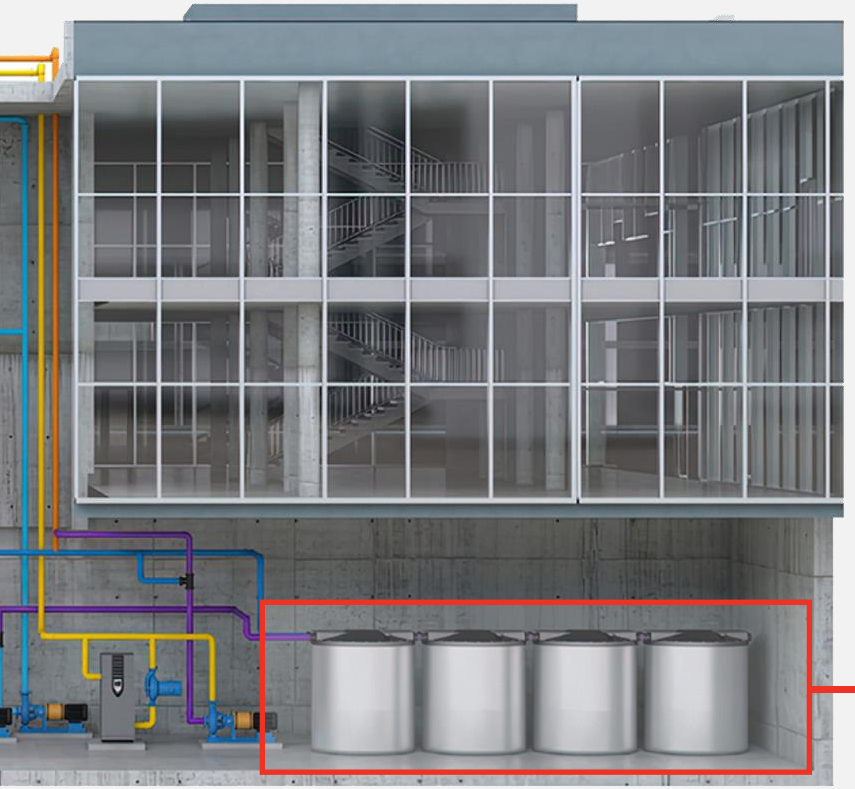
How does it work?

At the heart of the system is the CALMAC Ice Bank®

- Contains water; changes water to ice or ice to water depending on application
- Just one tank has the capacity to cool six homes
- 40-year lifespan

Trane Thermal Battery™ Heating & Cooling Systems

Enables electrified heating in cold climates



Each battery can store 2 million BTUs – the equivalent of:

14 gallons
of fuel

2000 lbs
of steam

20 therms
of natural gas

Trane Thermal Battery™ System can be **designed to heat buildings** using thermal energy storage, chiller-heaters and air-to-water heat pumps

How can ice be used for heating?

5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-

Available energy to collect and store for tomorrow's heating requirements

Tomorrow's heating requirements

1 6 12 18 24 6 12 18 24

Heating Load Btus
Cooling Load Btus

What can it do for you?

- Increases operational flexibility
- Reduces operating expenses
- Increases reliability
- Lowers carbon emissions
- Boosts resiliency
- Makes indoor spaces comfortable
- Reduces capital expenditures
- Eligible for new tax incentives

Heating in Cold Urban Cities

- Replace gas boilers with electric
  - Resistance heat will exacerbate winter peaking
- GSHP restricted by underground infrastructure
- ASHP limited by ambient
  - Electric reheat supplemental
  - Defrost derating
  - Limited roof space

• Thermal Energy Storage Tank Capacity

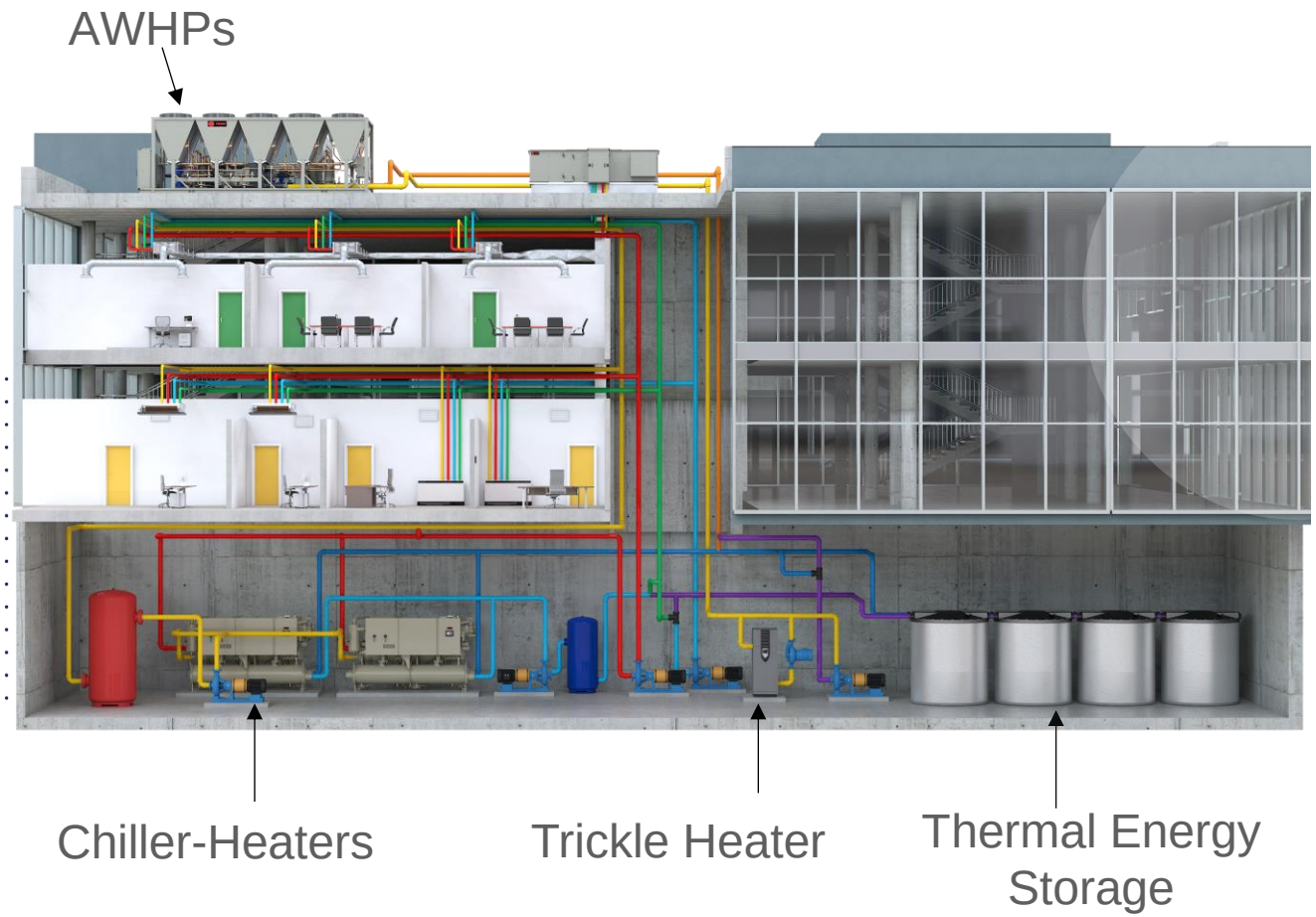
- 1 Tank is 8’-6” Tall x 7’6” Dia.
  - 1655 Gal of Water = 13,786 lbs.
  - 13,786 lbs. x 144 Btu’s/lb. ~2,000,000 Btu’s
  - 2,000,000 Btu’s =
  - ~14 Gallons of Fuel Oil
  - ~20 Therms of Natural Gas
  - ~160 Ton-hrs.

- A New York City project has 44 tanks
  - 88,000,000 Btu’s
  - 616 gal of Fuel Oil
  - 880 Therms
  - 88 Mlbs of Steam
  - ~7,000 Ton-hrs.

There’s a lot of stored energy in the cold water contained in these tanks!

Storage-Source Heat Pump System (SSHP)

An innovative way to make all-electric heat pump heating possible even in cold climates and dense urban environments where there is limited roof space.



FEATURES

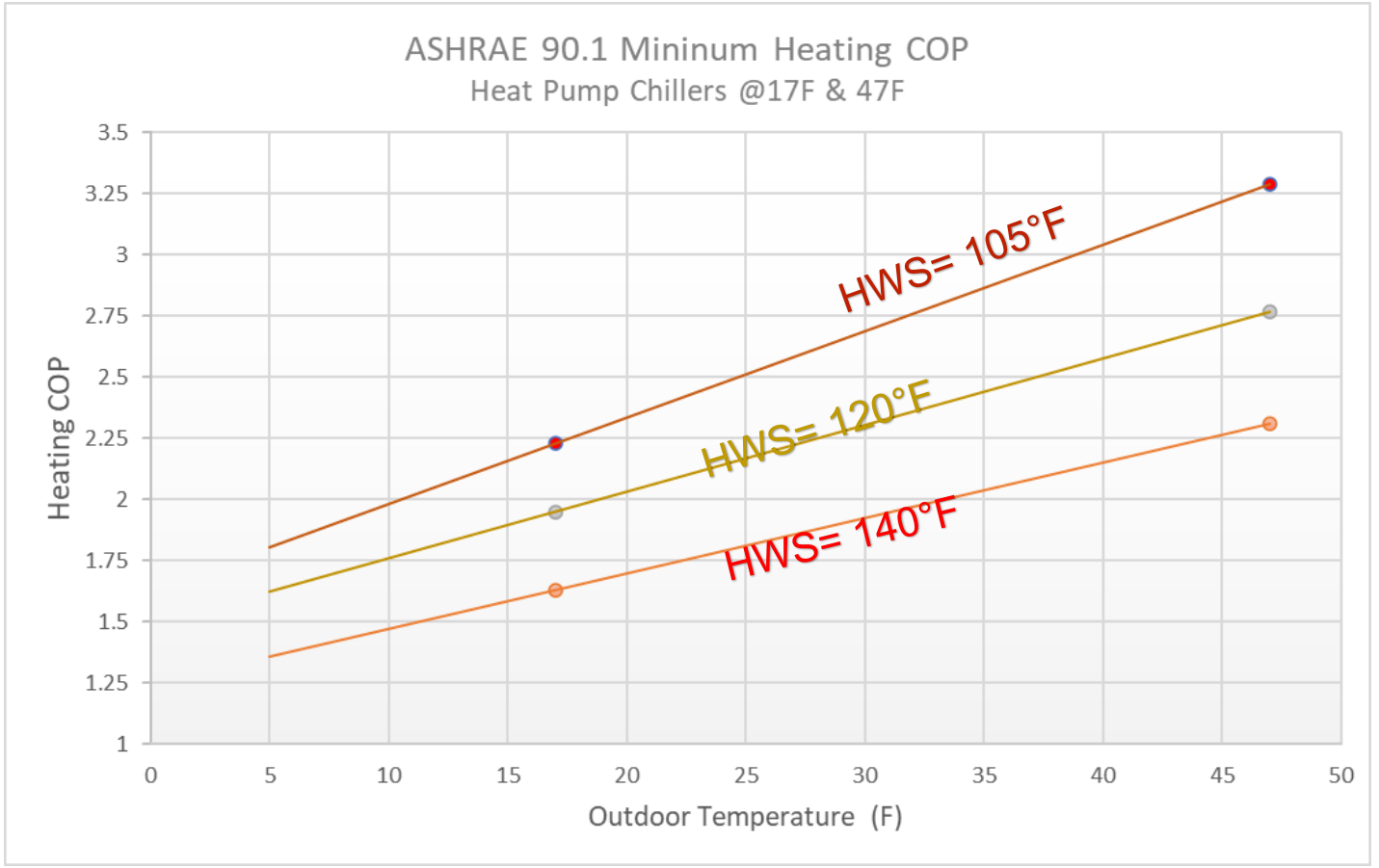
- **Energy efficient:** Reclaims excess heat from the building using it to heat when needed.
- **Reliable operation:** Collects and stores heat from air-to-water heat pump operation during favorable conditions enabling heating at **all** outdoor conditions including extreme cold.
- **Save roof space:** Collecting and storing heat over 24-hour period for later use, can reduce required air-to-water heat pump capacity and cost.
- **Higher supply water temperatures:** Sourcing energy from a stable thermal energy storage source enables up to 130F.
- **Lowers costs:** Storing thermal energy for later use provides flexibility to use lower-cost electricity. Thermal energy storage can frequently qualify for up to tax credits (if available) reducing overall system costs.

Hot Water Supply Temperature, Outdoor Air and COP

ASHRAE 90.1-2019 specifies minimum efficiency for 105°F or 120°F or 140°F, each at 17°F and 47°F

140°F hot water requires 35% more peak power and annual heating energy than 105°F

Rule of Thumb → +1% penalty per 1°F above 105°F



• Extending the Low Ambient Capabilities

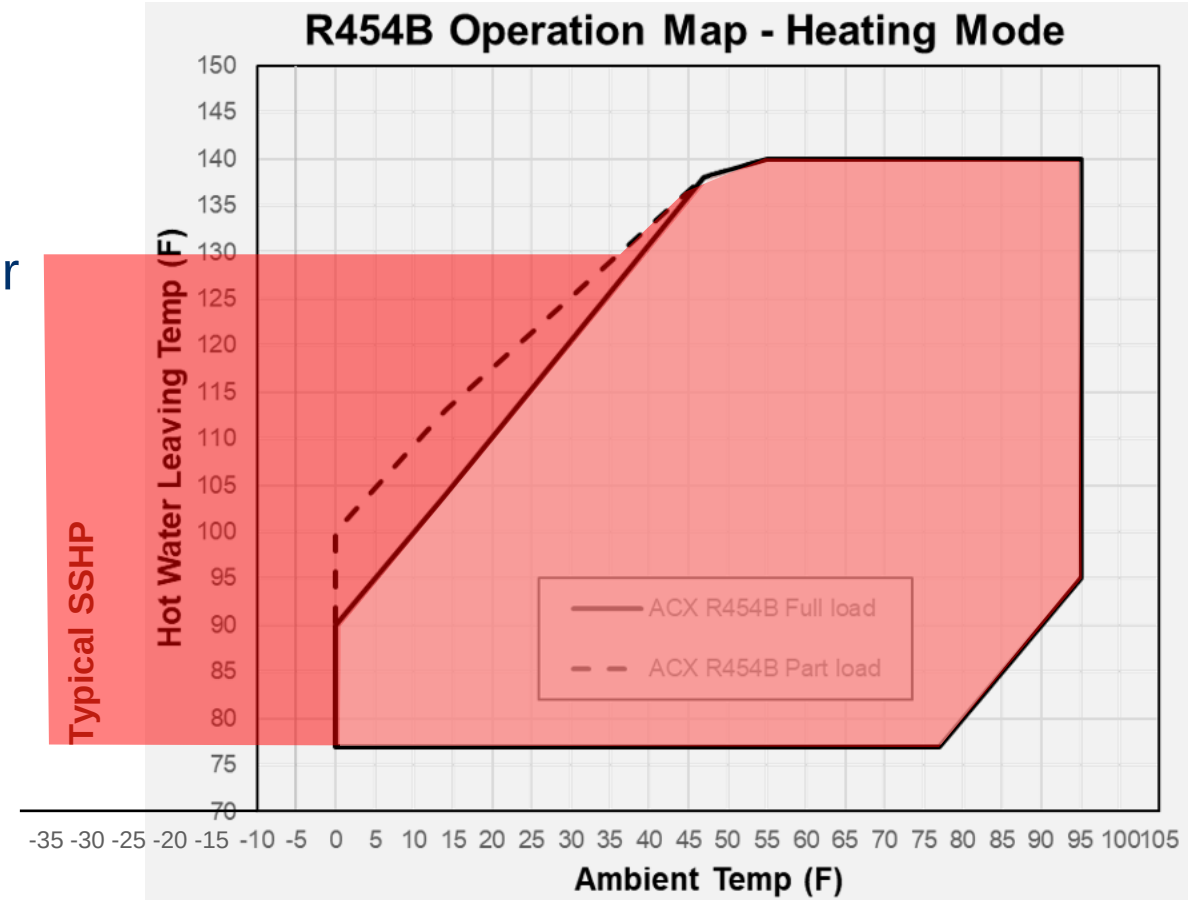
AWHPs have operational limits at low ambient temperature

- Capacity and hot water temperature drop dramatically
- Storage extends the map

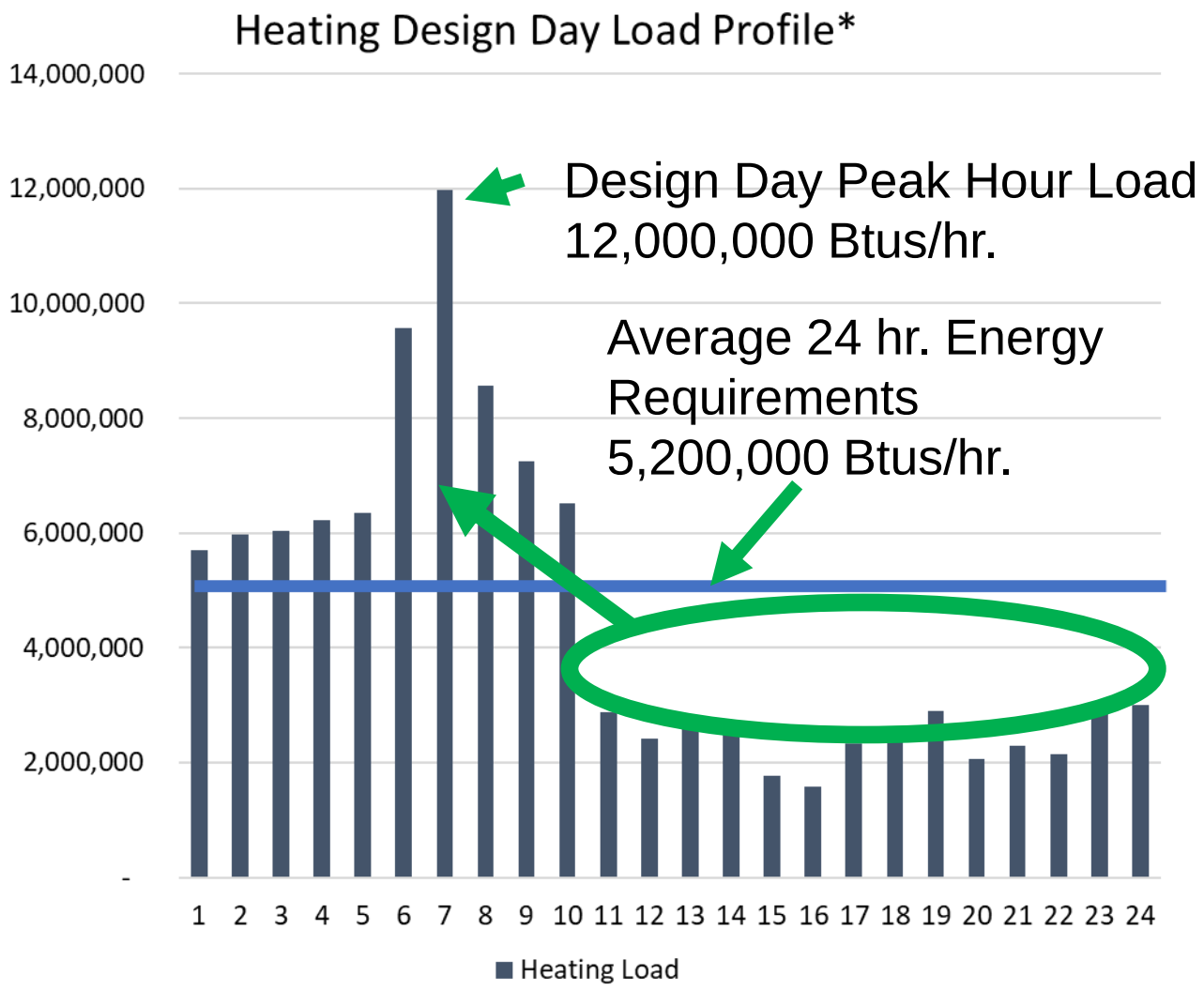
Higher hot water temperatures

at

Lower ambient



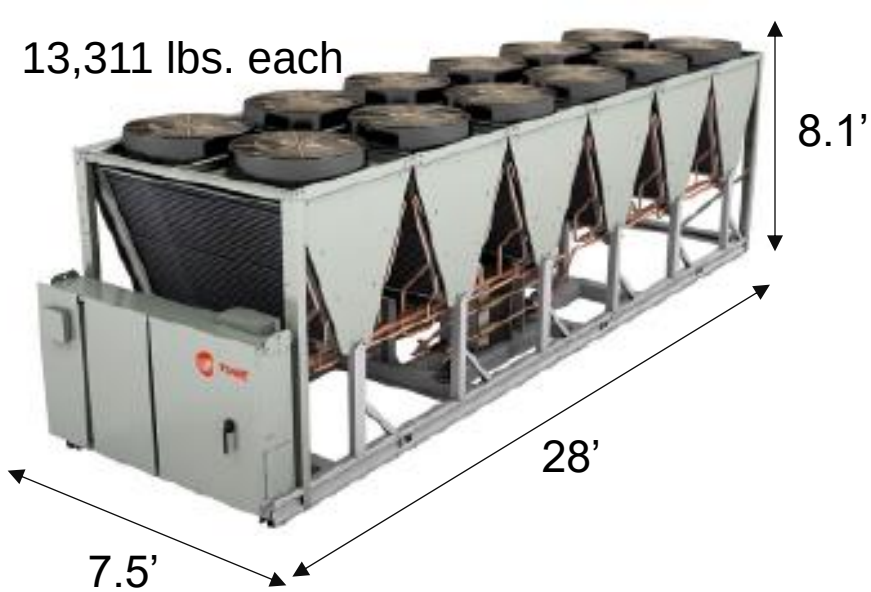
Storage enables downsizing of AWHP



~~10~~ 5

AWHP – 1,295,000 btuh's

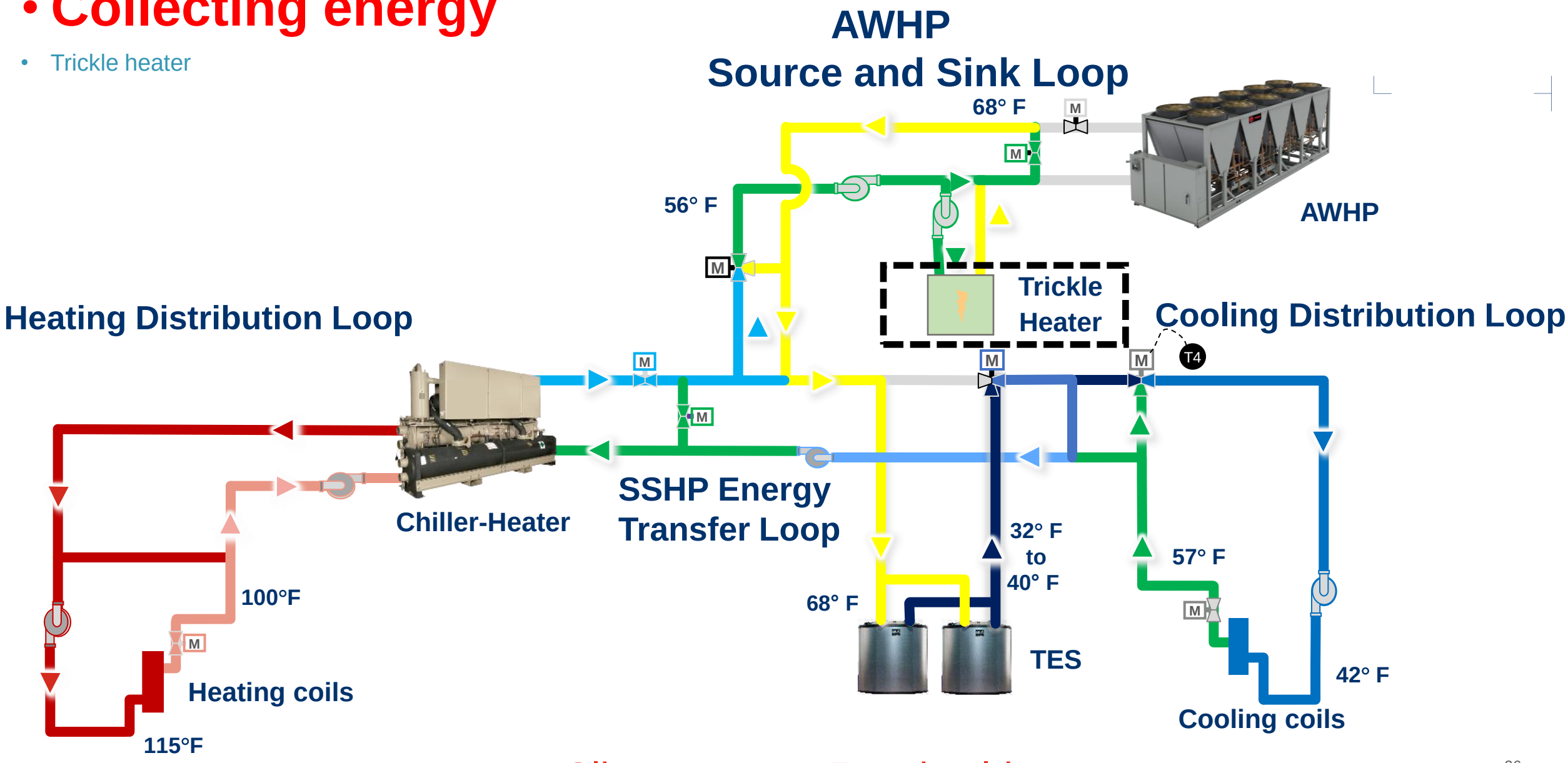
Require ~~10~~ units – maybe more to accommodate defrost cycle



* Depending on building type and climate.

• Collecting energy

- Trickle heater



Climate zones 5 and colder

Same Profile – Dirty Grid

Compare the exact same load on 2 different grids to show the impact in CO2e

- SSHP is 68% CO2e reduction on “clean” grid vs Gas Heat, 26% CO2e reduction vs ASHP!

SSHP - Heating Carbon Estimates — Chicago

SSHP System Total Output Emission Rate: *1,159,482 lbs CO2e*

	Gas Heat	Electric Heat	Heat Pump
Conventional Systems (lbs CO2e)	*2,168,399*	*3,745,128*	*1,461,513*
Additional Carbon vs. SSHP	*87.0%*	*223.0%*	*26.0%*

SSHP - Heating Carbon Estimates — Buffalo

SSHP System Total Output Emission Rate: *604,183 lbs CO2e*

	Gas Heat	Electric Heat	Heat Pump
Conventional Systems (lbs CO2e)	*2,168,399*	*1,951,512*	*761,566*
Additional Carbon vs. SSHP	*258.9%*	*223.0%*	*26.0%*

More Flexibility, Less Money

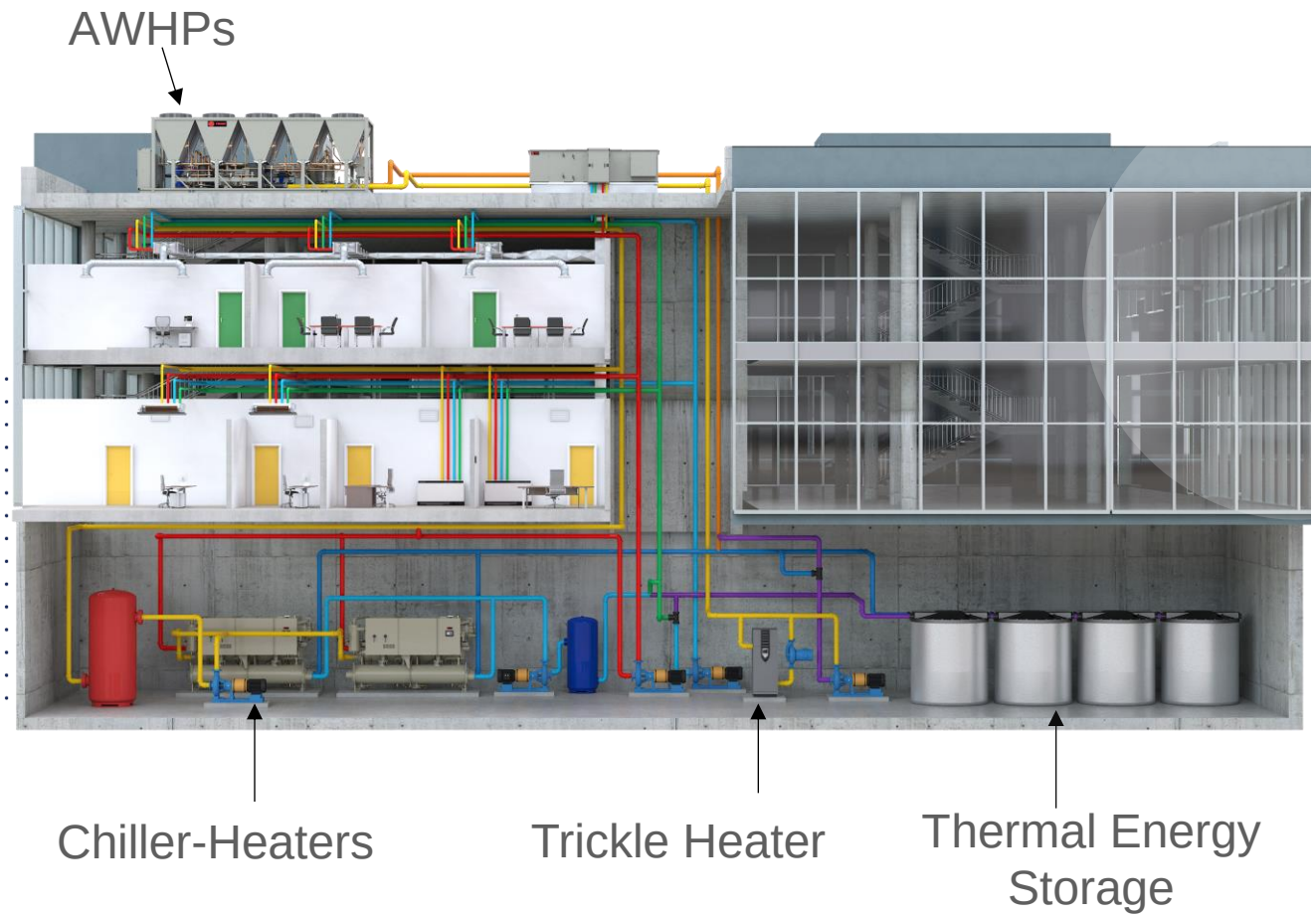
- Provides demand flexibility and can reduce reliance on grid (thus reducing costs)
- Enables renewable energy and decarbonization
- Assure reliable heating & cooling with redundancy
- Incentivized by utility programs, federal tax incentives and local funding programs

TES can increase use of renewables by **up to 50%***

* Source: ASHRAE RP-1607.2018

First SSHP Installation in LaCrosse, WI

Trane Training Center



FEATURES

- **80,000 SF Building**.
- **180-Ton Air to Water Heat Pump**
- **Two 110-Ton Heat Recovery Chillers**
- **Seven Ice Storage Tanks-160 ton-hour**
- **Research Project--**optimize controls, address heat recovery options
- Installed November 2023. Mild winter. Offering tours. Consortium of utilities monitoring performance.
- **Recruiting partners to demonstrate technology at other cold locations and accelerate decarbonization**

MB Hydro Electricity Rates

General service medium

Charge	Cost
Basic monthly charge	$34.43
First 19,500 kWh	8.769¢/kWh
Balance of kWh	4.546¢/kWh
First 50 kVA of monthly billing demand	No charge
Balance of billing demand	$11.91/kVA

Monthly bill demand is the greatest of the following (expressed in kVA): measured demand; OR 25% of contract demand; OR 25% of the highest measured demand in the previous 12 months.

General service large – exceeding 750 V but not exceeding 30 kV

Charge	Cost
Energy charge	4.219¢/kWh
Demand charge	$10.35/kVA

Monthly bill demand is the greatest of the following (expressed in kVA): measured demand; OR 25% of contract demand; OR 25% of the highest measured demand in the previous 12 months.

Curtailable rate program

Eligible industrial customers are expected to drop a minimum of 5,000 kW of load within a specified time-frame when requested. You will receive a monthly credit on your electricity bill. This credit is dependent on the amount of curtailable load you make available and the curtailment option you selected.

Contact your Energy Service Advisor for alternative rate information, and terms and conditions.

https://www.hydro.mb.ca/account/billing/rates/commercial/

MB Hydr-2023 Integrated Resource Plan

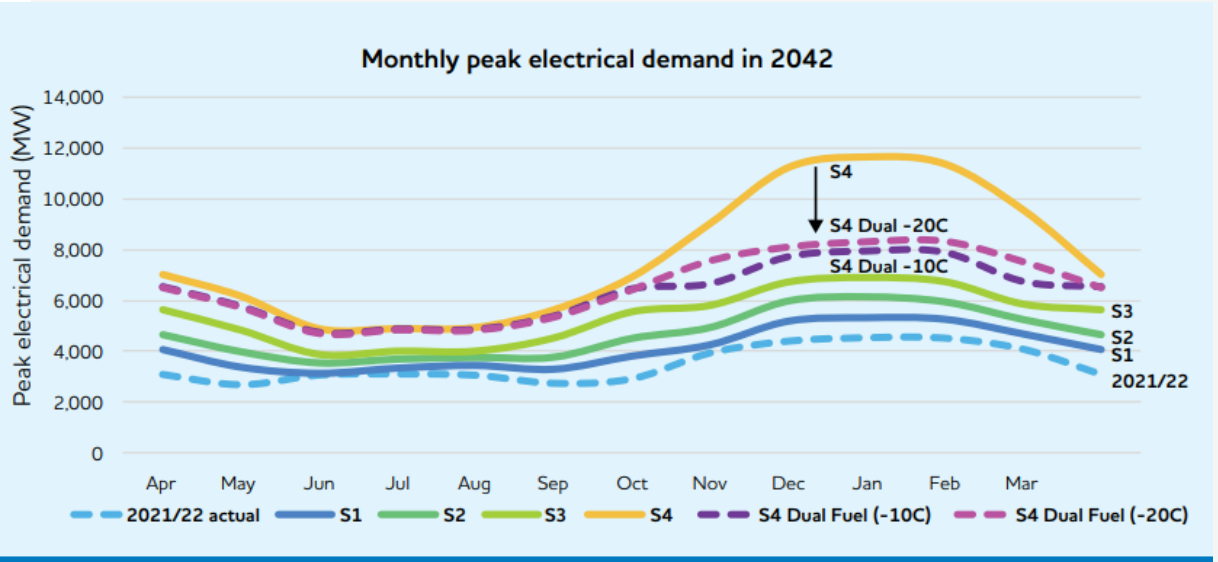


Figure 6.20 – IRP scenario demand projections for monthly peak electrical demand in 2042, including dual fuel sensitivities

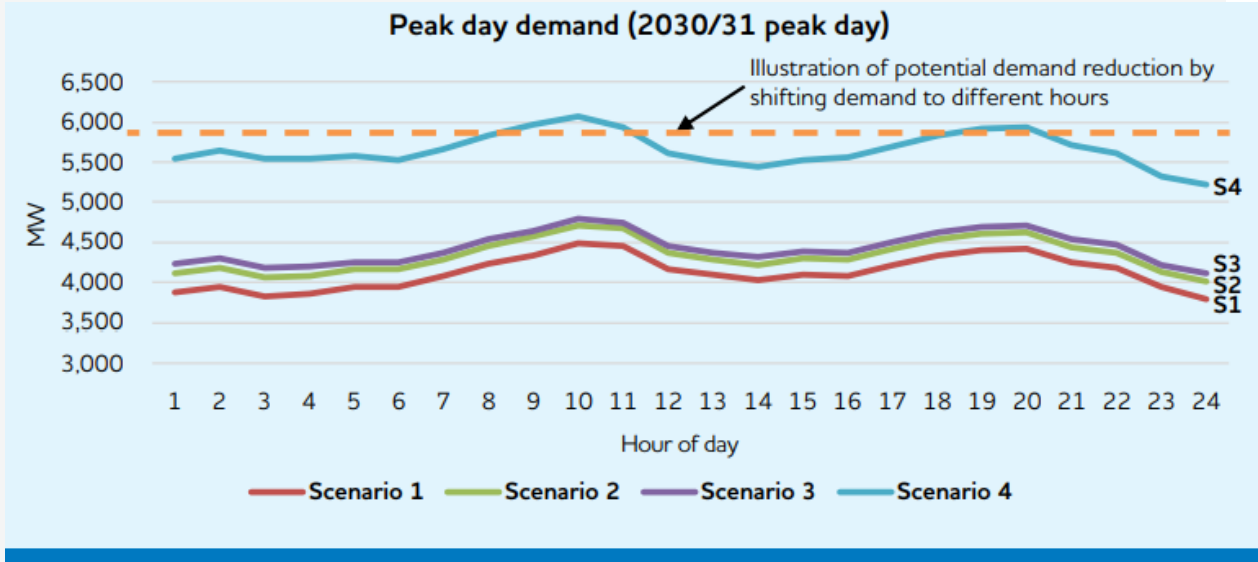


Figure 6.24 – Illustration of potential demand response impact in 2030/31

https://www.hydro.mb.ca/docs/corporate/irp/irp-2023-integrated-resource-plan.pdf

Ontario Commercial Electricity Rates-Small

TOU Price Periods	Summer (May 1 – October 31)	Winter (November 1 – April 30)	TOU Prices (effective until October 31, 2024) (¢/kWh)
ff-Peak	Weekdays 7pm – 7am Weekends and holidays all day	Weekdays 7pm – 7am Weekends and holidays all day	8.7
Mid-Peak	Weekdays 7am – 11am and 5pm – 7pm	Weekdays 11am – 5pm	12.2
On-Peak	Weekdays 11am – 5pm	Weekdays 7am – 11am and 5pm – 7pm	18.2

For more information on Time-of-Use Pricing, visit oeb.ca.

2024 Tiered Pricing and Thresholds (Effective January 1, 2024 – October 31, 2024)

Tier	Price ¢/kWh
Tier 1 (up to 750 kWh)	10.3
Tier 2 (above 750 kWh)	12.5

*A line loss adjustment factor of 1.0353 is applied to these charges.

Winter 2023-2024 Ultra-Low Overnight Rate pricing and periods (Effective November 1, 2023 until April 30, 2024)

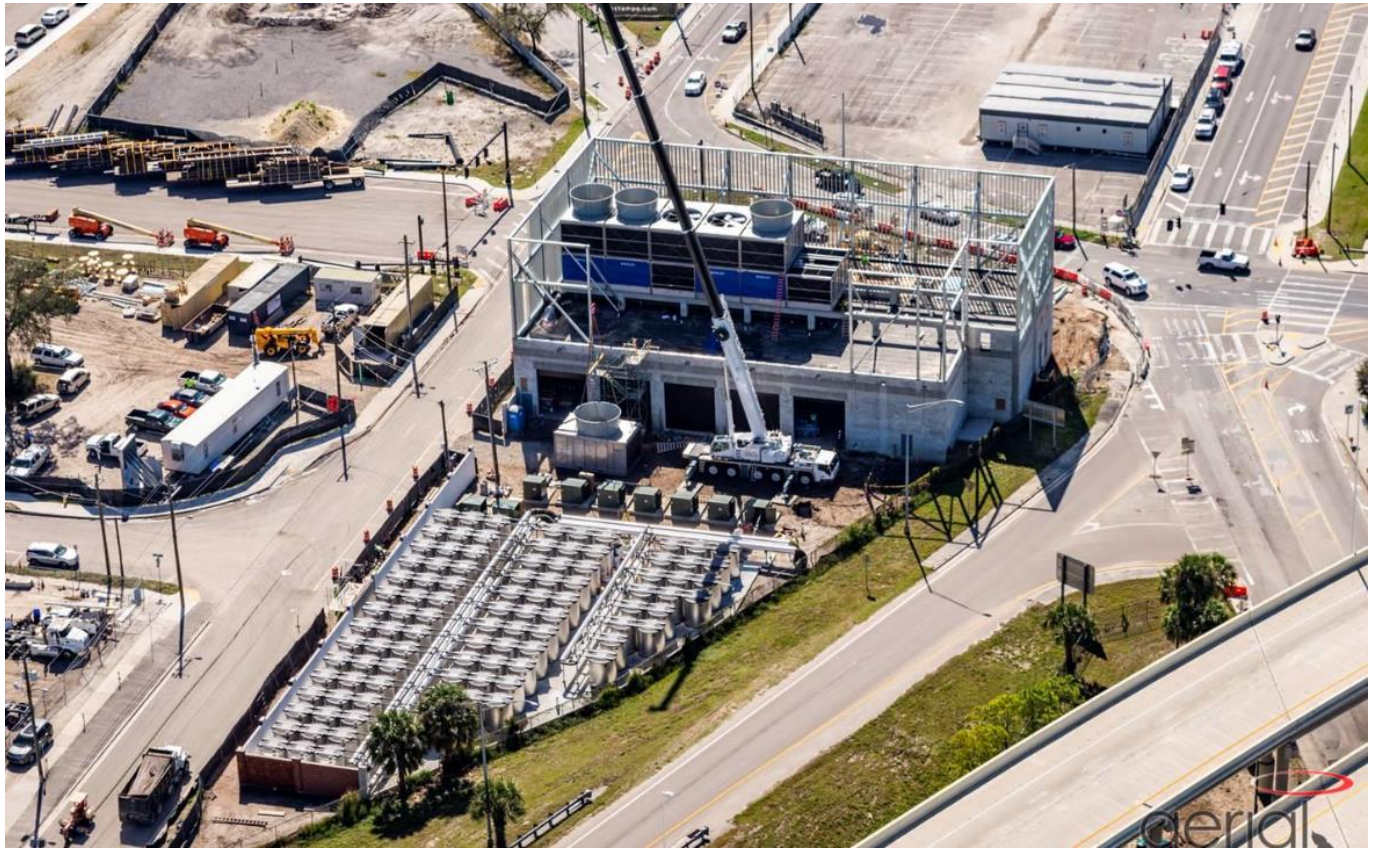
ULO Price Periods	All Year	ULO Prices (¢/kWh)
Ultra-Low Overnight	Every day 11pm – 7am	2.8
Weekend Off-Peak	Weekends and holidays 7am – 11pm	8.7
Mid-Peak	Weekdays 7am – 4pm and 9pm to 11pm	12.2
On-Peak	Weekdays 4pm – 9pm	28.6

https://enovapower.com/my-account/electricity-rates/

University of Arizona

- 25,000 total cooling tons on the loop
- 5,000 tons of load shift with ice; approx. 40,000 total ton-hours at two plants
- Largest University Central Energy Plant in the US
- Two installations
- First Install early 2000’s

Tampa Bay Waterfront District



- Jeffrey Vinik; owner of Tampa Bay Lightning
- Services Amalie Arena, USF Medical Center, other loads
- 16,000 ton-hours of load shift
- CHW ‘Merchant’ Plant
- Chillers on both sides of HX
  - Water side optimized
- Ice used to
  - Help with chiller staging
  - Increase sweet spot operation
  - Reduce on peak demand
  - Reduce on peak energy

Pinellas County, FL CEP

- Serves 5 Pinellas County Buildings and One Residential Tower
- Currently 2,000 tons of chiller and 3,400 ton-hours of ice storage; will grow to 4,500 tons of chiller and 9,720 ton-hours

Hillsborough County CEP

- 4,000 tons of cooling capacity
- 13,700 ton-hours of ice
- Multiple end users
  - County Govt
  - County School District
  - Federal Govt
  - Private office

Shell Point Village – 25,000 ton-hours

Ideal for Commercial Buildings

Larger commercial buildings with hydronic (water-based) systems

Offices, high-rises, campuses with multiple buildings

Buildings that have an air- or water-cooled chiller plant, air-to-water heat pump or water-to-water heat pump

New construction or chiller plant replacements

Buildings with:

- High energy costs
- Space for tanks
- On-site wind turbines or plans to go solar
- Utilities that have renewables on the grid

Thank you!