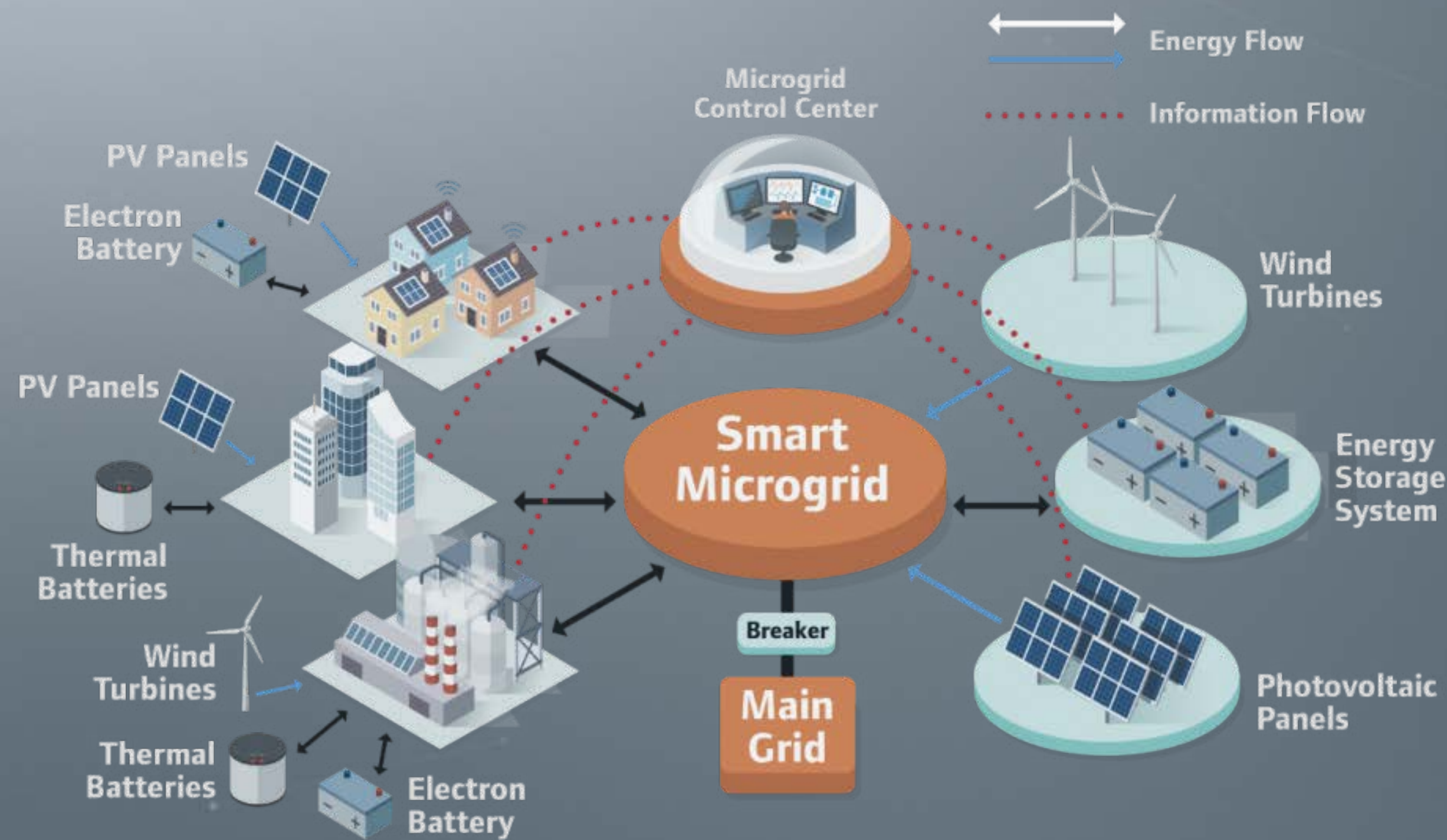


Thermal Battery™ Cooling System

Why is it critical to be aware of Thermal Battery Systems?

- Overview
- Different Energy Storage System Types
- Why Store Cooling?
- Cost Comparison
- Complete Energy Solution
- What Is the Trane Thermal Battery™ System?
- System Components
- CALMAC® Ice Bank®
- Knowledge Becomes Power
- What Are the Benefits?
- Benefits for Building Owners
- Benefits for Utilities
- Benefits for Meeting Environmental Goals
- Holistic Approach
- Why Partner with Trane®?
- Are Thermal Battery Systems Right for Your Building?
- Resources

Overview



The grid is changing due to climate change and growth of intermittent renewable resources. Soon electricity will be priced by time of energy use. When energy is plentiful, energy prices will be cheap but when the sun doesn't shine or wind doesn't blow, or there is a heat wave, energy prices will soar! Can your building react? Storing energy will be vital to overcome peak pricing and intermittency. Partnering with utilities will help the grid make wind and solar more dispatchable—energy more affordable, buildings and grids more agile and resilient.

Different Energy Storage System Types

-   THERMAL
-  LITHIUM ION
-  PUMPED HYDRO
-  COMPRESSED AIR
-  FLYWHEEL

Energy storage can help overcome the intermittency of renewable generation; Can provide resiliency and enable energy agility for the grid and buildings; Plus manage energy costs. All types of energy storage will be important, but one solution stands out—Thermal energy storage.

Why Store Cooling?

BUILDINGS ARE RESPONSIBLE FOR

40%

of the U.S. energy consumption¹



ALMOST HALF

due to HVAC (Heating, Ventilating and Air Conditioning)¹

70%

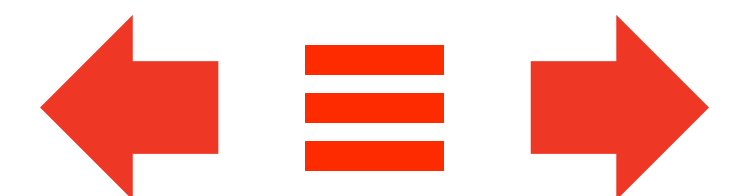
of the US grid's transmission lines and power transformers are **over 25 years old.**²

72GW+

of electrical generating capacity have already, or are **now set to retire.**³

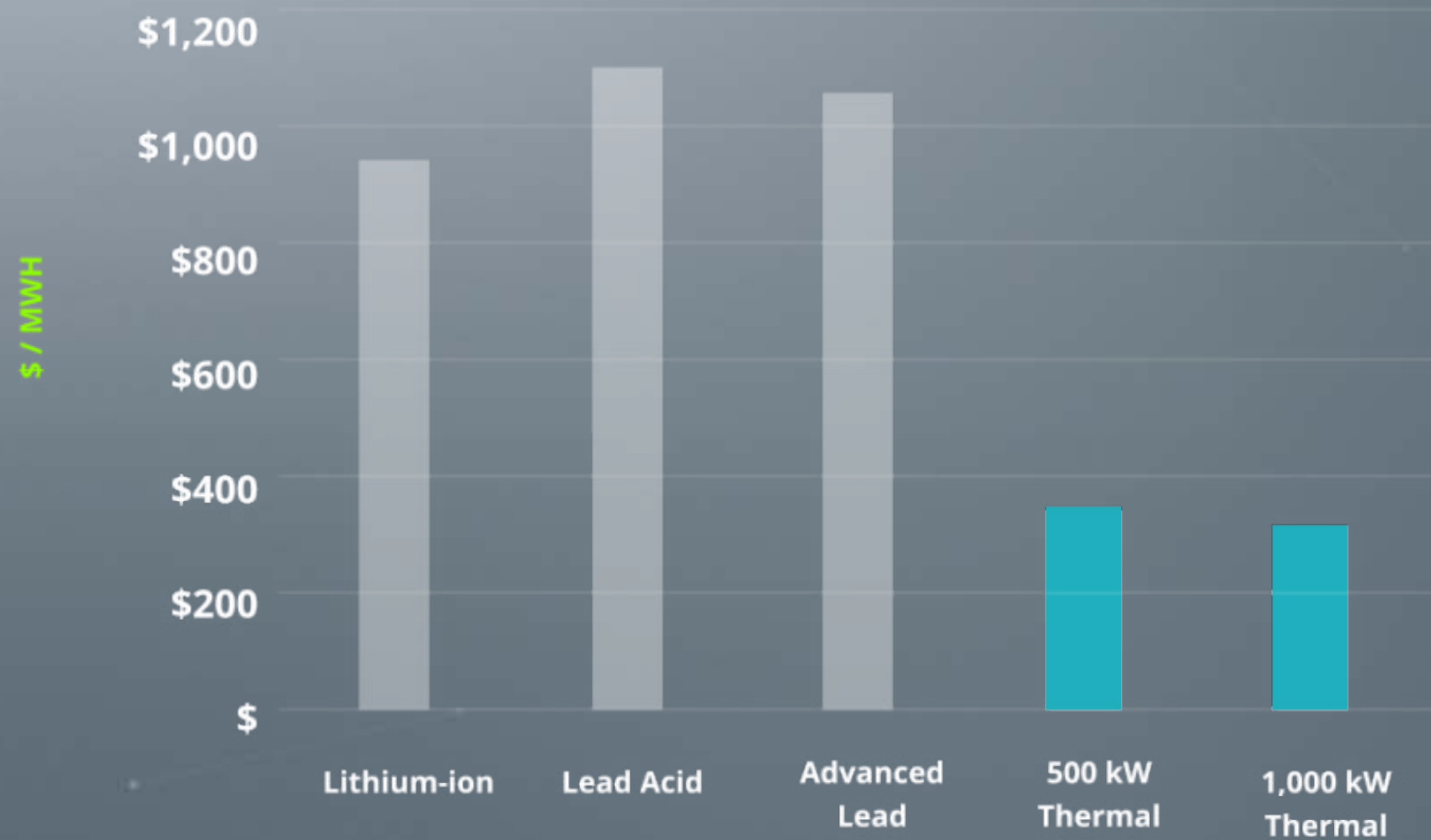
HVAC is responsible for 40% of energy consumption; half of which is due to HVAC. The HVAC industry knows that air-conditioning is the largest, easiest electric load to shift and store. Storing the cooling helps building be a resource for the grid. Plus air-conditioning is the largest easiest load to shift and store.

Sources: 1. Berkeley Lab, June 2009; 2. Energy Department, November 2014; 3. Institute for Energy Research, January 2008



Cost Comparison

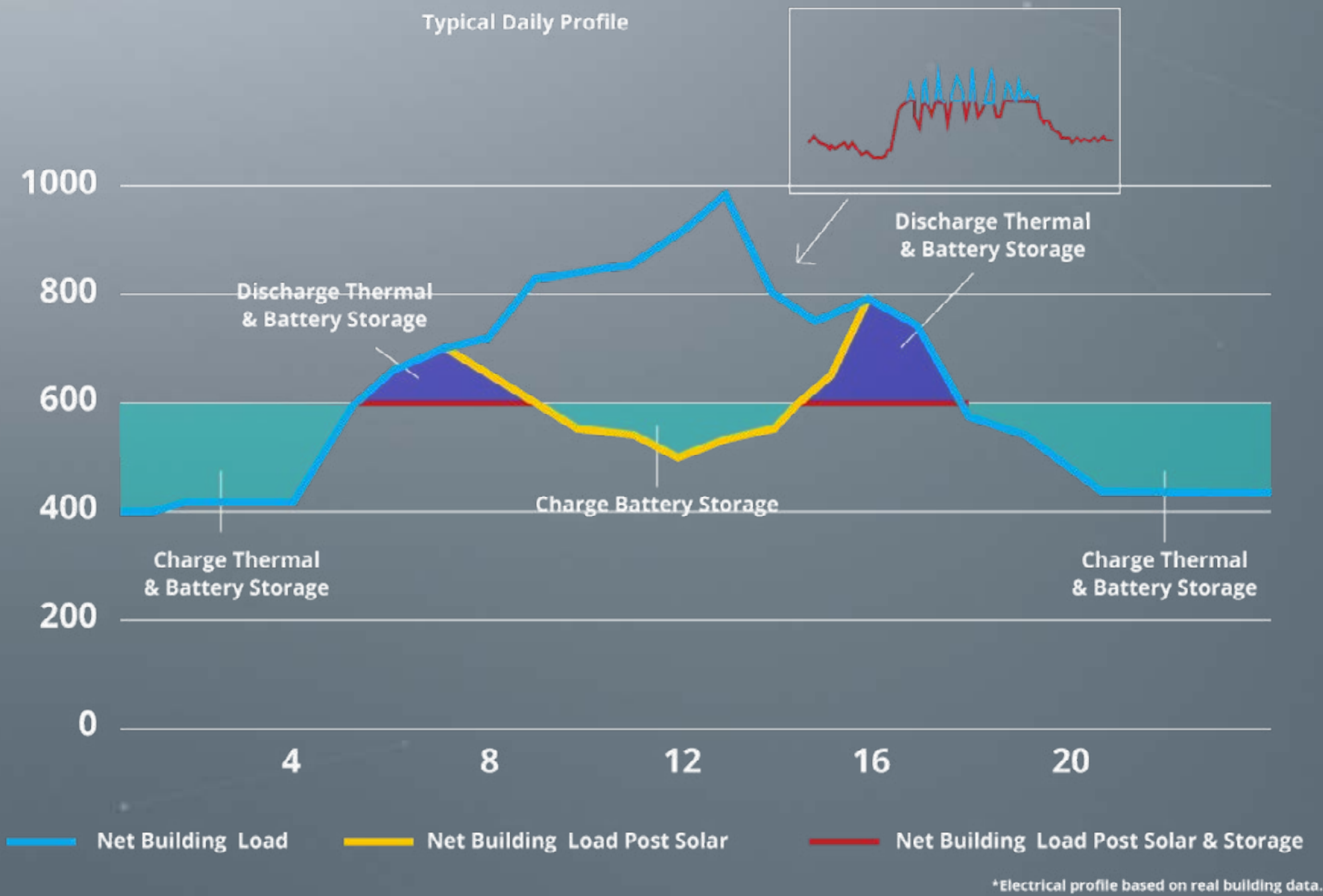
Levelized Technology Cost for BTM Applications^{1,2}



Thermal energy storage stores cooling at 1/3 the cost of battery systems and lasts 2 to 4 times longer. It would make no sense to convert renewable energy to chemical energy only to convert it again with an electric chiller to a btu. That is very expensive and inefficient. Plus with thermal energy storage there is no need for capacity additions due to degradation.

Source: Ingersoll Rand, September 2018

Complete Energy Solution



By combining thermal and battery storage you get a complete energy solution. Both systems can provide more energy awareness and energy agility. Thermal Battery™ systems do the heavy lifting storing the bulk of the energy loads due to HVAC. Electrochemical batteries smooth out the jaggedness. Together they reduce equipment costs by as much as 75% compared to a battery alone.

Source: Commercial Building Example is based on CALMAC analysis as published in Distributed Energy Magazine, January 2018

What Is the Trane® Thermal Battery™ System?



The Trane Thermal Battery system is a Trane controlled chiller plant enhanced with **thermal energy storage**. The chiller plant operates like a battery, charging Ice Bank® energy storage tanks when excess or inexpensive energy is available. And discharging when demand is high or price is high or when the utility asks for the discharge to occur.

System Components



The Thermal Battery™ system features a standard chiller with ice making controls as factory option, completion module with pumps, controls, control valves, PFHX, if needed and all piping specialties. The control system dash boards demonstrate savings, modes of operation, schematics and much more. And of course thermal energy storage equipment.

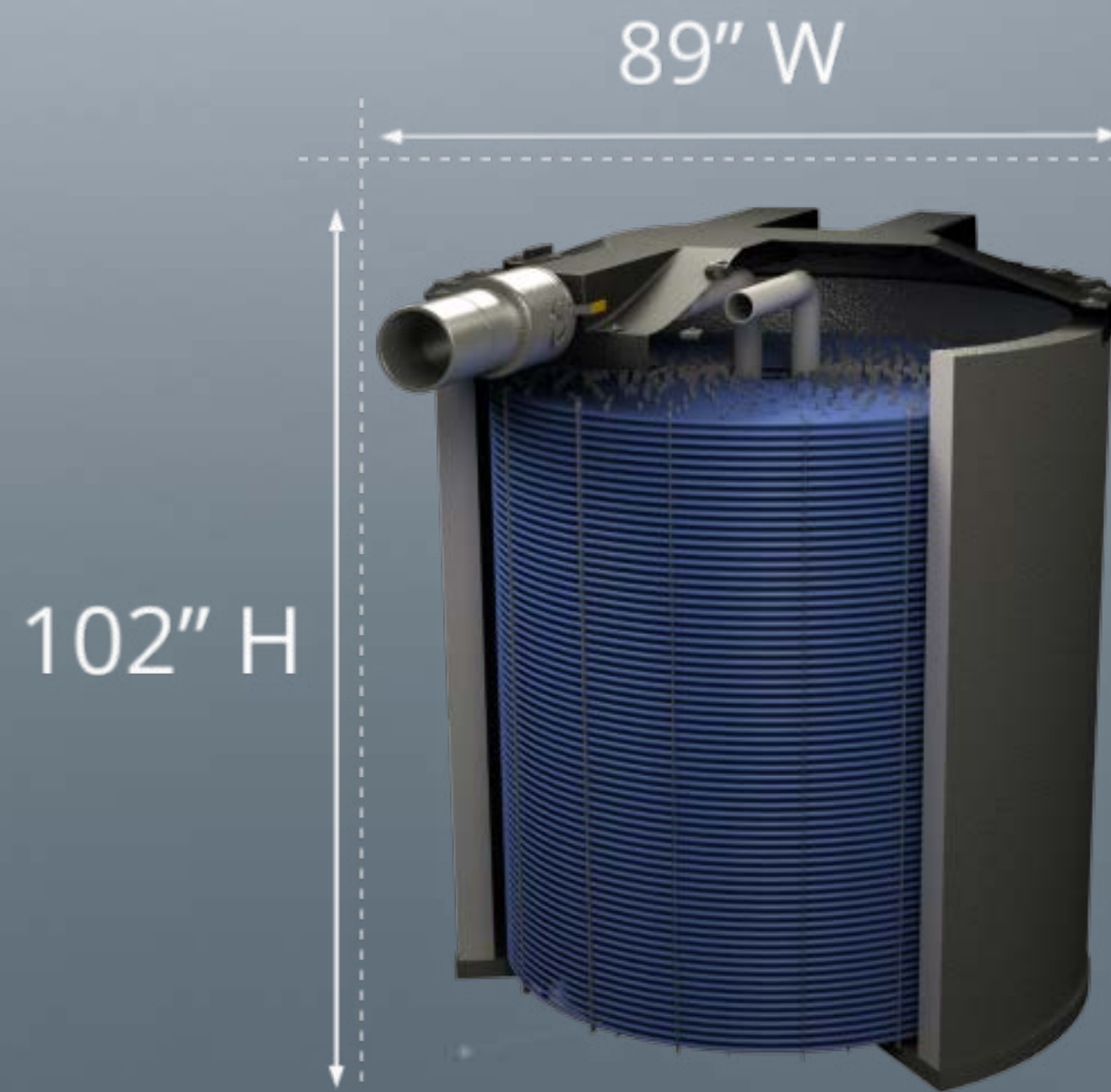
CALMAC[®] Ice Bank[®]



At the heart of the system is a CALMAC Ice Bank thermal energy storage tank, which stores clean, inexpensive energy when available in the form of ice. Unlike other thermal storage systems, the system can come pre-packaged and engineered into a simple turnkey design for easy application—taking the complexity out of the design process.

Knowledge Becomes Power

STORAGE CAPACITY



6 houses



40,000 AA batteries

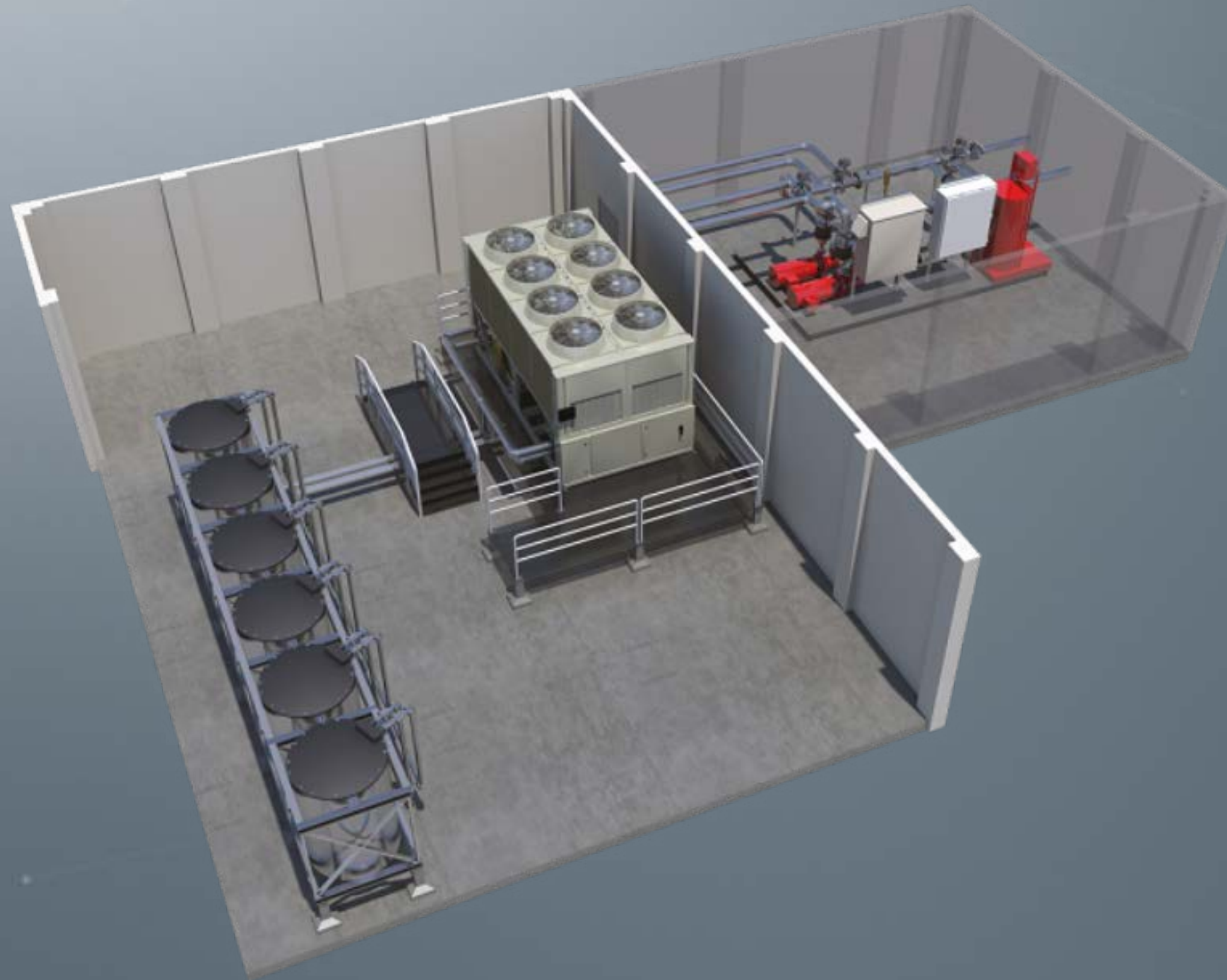


6 electric vehicles

Electrochemical batteries are leading the conversation around renewables however thermal based batteries represent enormous benefits including low cost operations. Just one thermal based battery has the capacity to cool 6 homes. Energy in the form of ice is stored inside the Ice Bank[®] tank. One Ice Bank tank* can store 18kW over 6 hours to cool over 7,400 sqft. That is 108kWh/day per system.

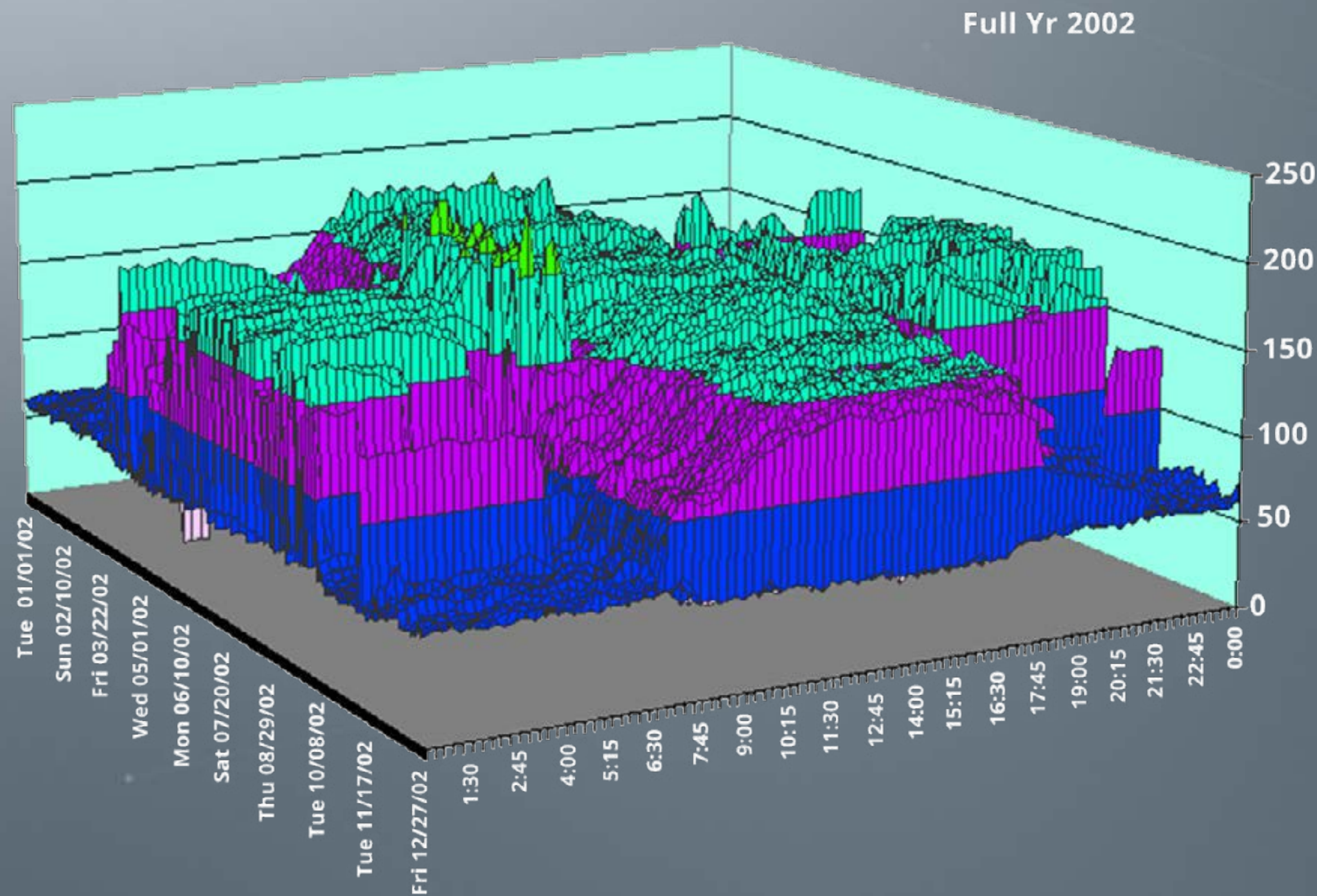
*One Thermal Battery system with one thermal energy storage tank based on COP of 1.0/kW/ton.

What Are the Benefits?



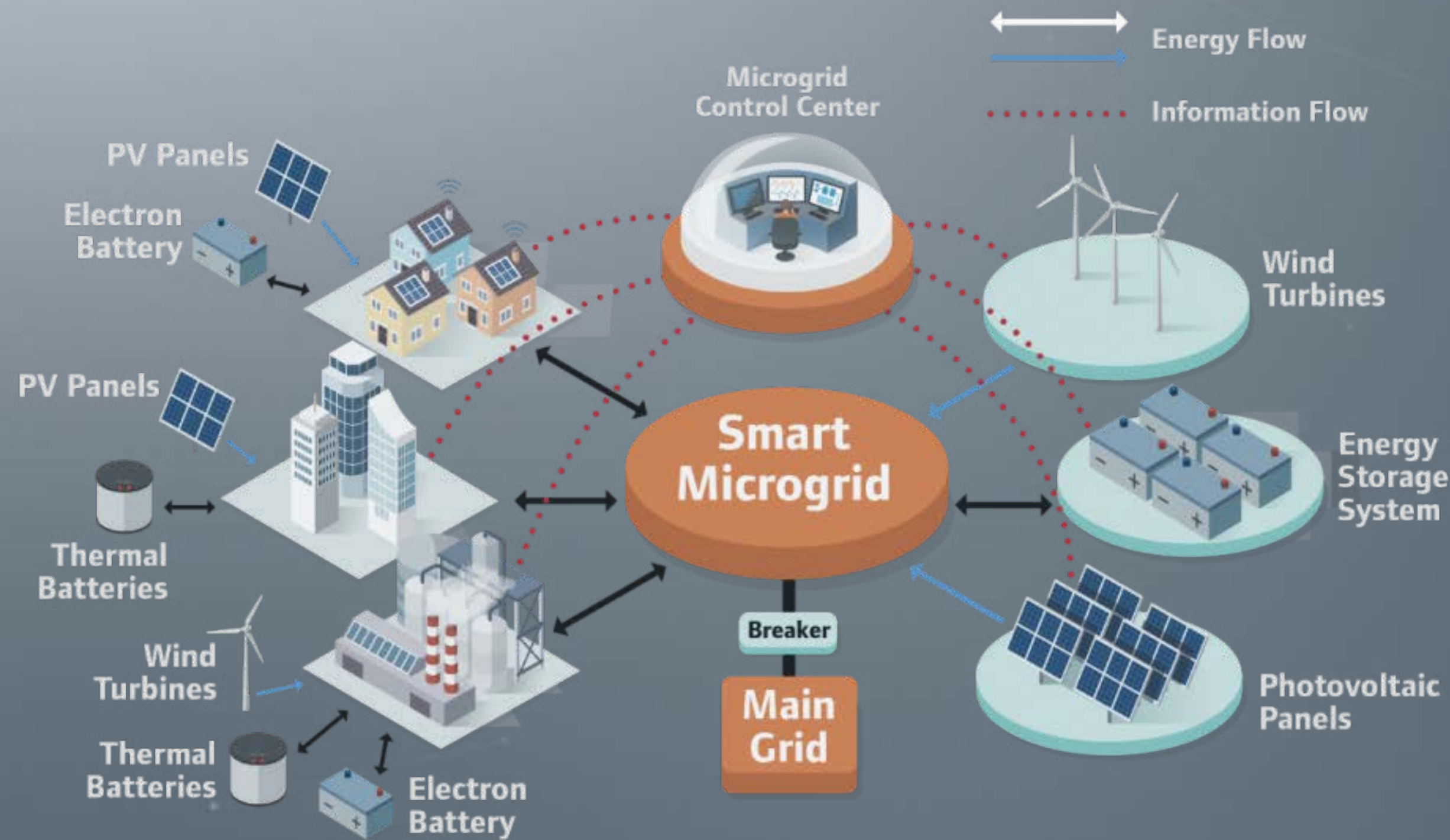
There are benefits for all—
Building owners, utilities,
the environment.

Benefits for Building Owners



Building owners have an energy agile building resource that provides low cost of operation. The Thermal Battery™ system can reduce demand charges, allow participation in demand response without sacrificing occupant comfort, open the facility to off-peak rates or electricity markets, where deregulated, improve resiliency, lower carbon footprint, foster good grid citizenship.

Benefits for Utilities



The utility gets improved asset utilization and the environment utilizes more renewable energy to keep air clean. Thermal energy storage lowers peak grid demand to help balance and lower impact of cooling on the grid. Thermal energy storage can also lower peak connected load and is critical for energy preparedness and heat events. In fact, according to the Western Cooling Efficiency Center at University of California Davis, thermal energy storage is 77% more valuable for the grid than previously thought.

Source: Western Cooling Efficiency Center at University of California-Davis, December 2017 <https://wcec.ucdavis.edu/thermal-energy-storage-valuation/>

Benefits for Meeting Environmental Goals

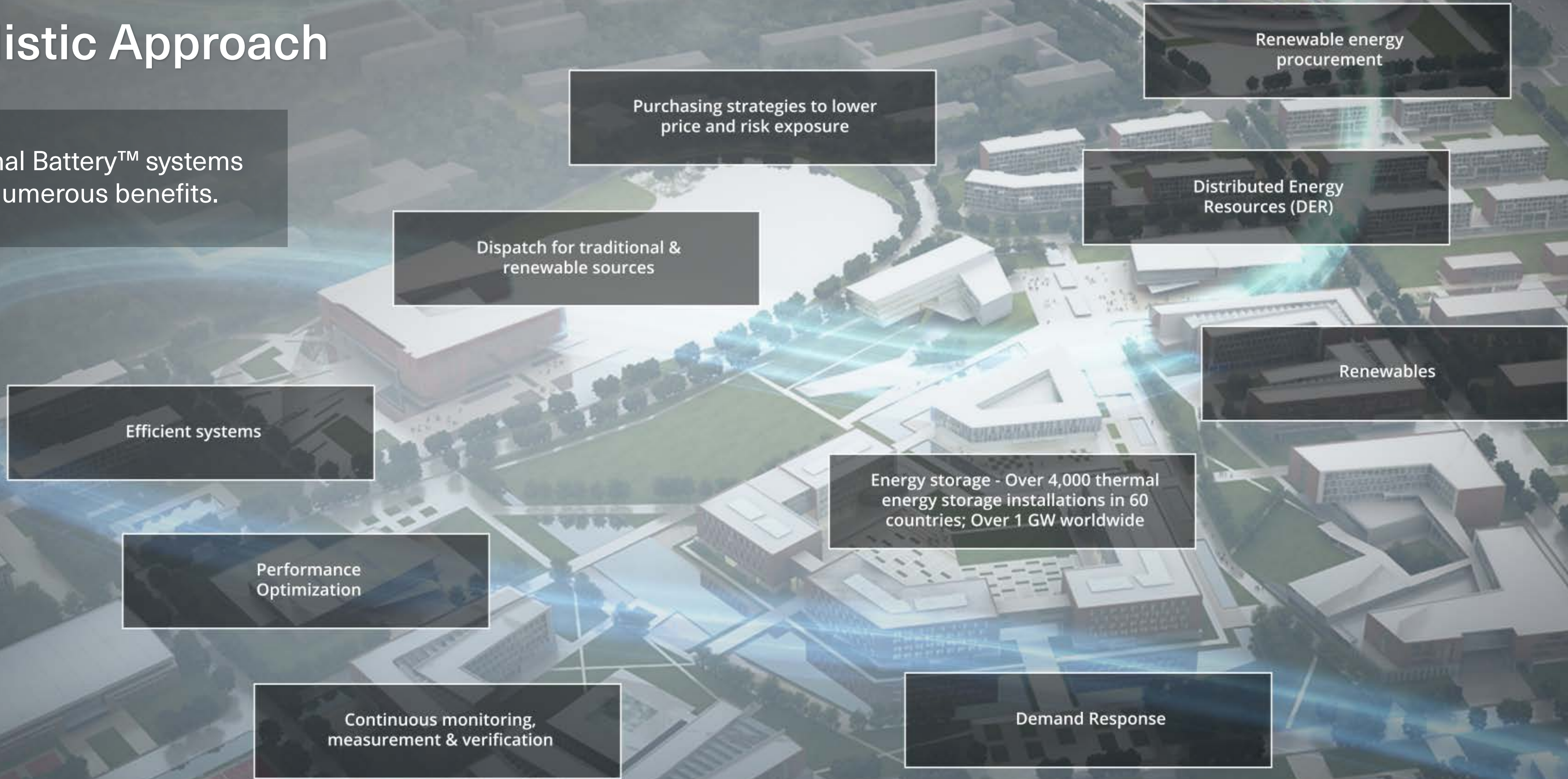


Thermal energy storage promotes higher sustainability. In fact, thermal energy storage is part of the solution for renewable intermittency. Thermal energy storage can create off-peak loads for renewable wind generation and may increase utilization of renewable energy by as much as 50%.* Thermal energy storage discharges stored energy when renewable resources are not available or prices are high. The Ice Bank® energy storage equipment is extremely durable and recyclable and can last up to 40 years. In addition, Ice Bank energy storage optimizes electrochemical battery cycles, life cycle and first costs.

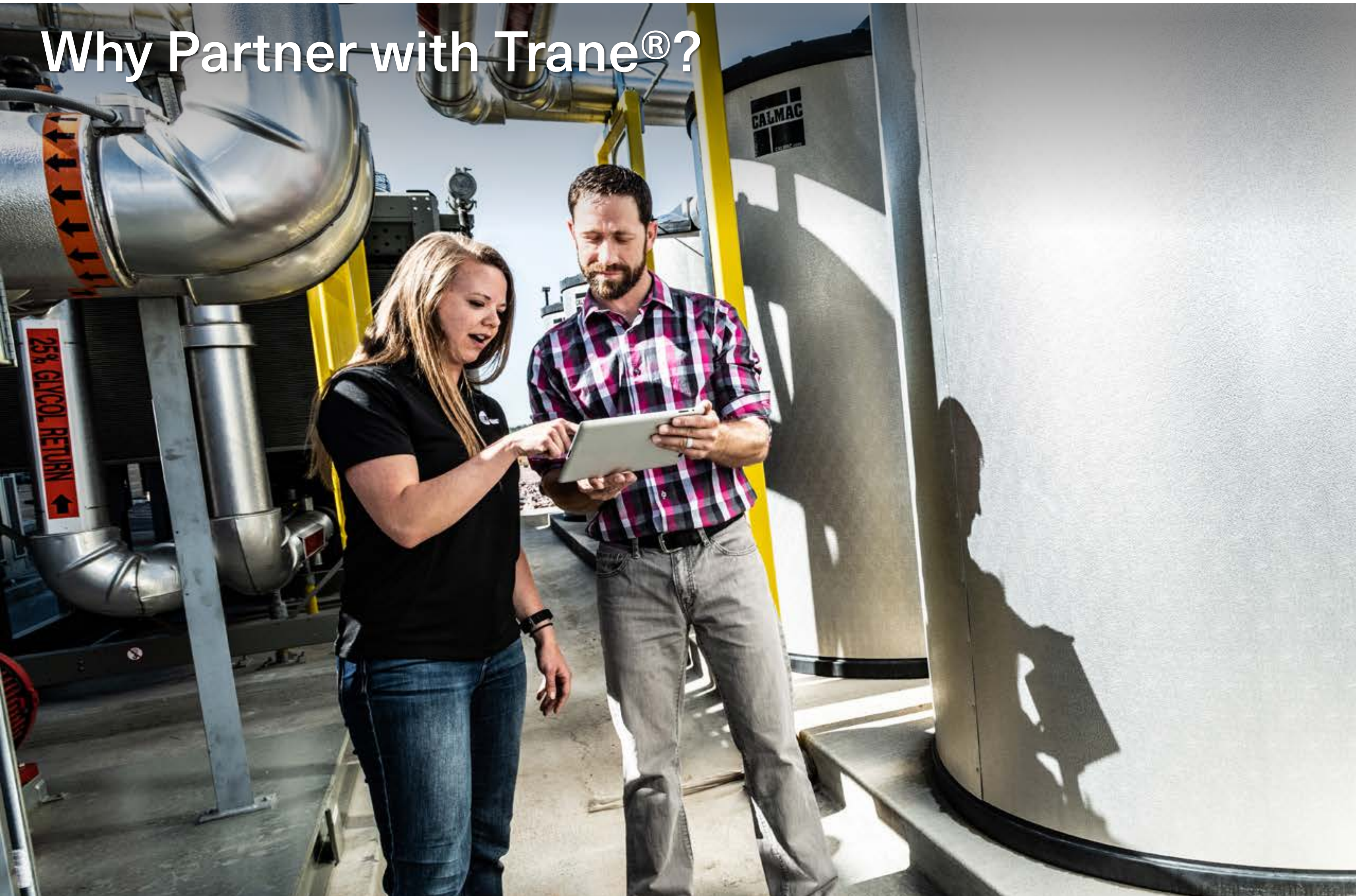
*ASHRAE Research 2018

Holistic Approach

Thermal Battery™ systems offer numerous benefits.



Why Partner with Trane®?



At Trane, we know buildings because we have been involved with them for over 100 years. With knowledge comes power and knowledge is leading us to go beyond efficient HVAC equipment and services to capture a building's hidden potential. The biggest opportunity for buildings comes from the energy market. The energy market and the electric grid is changing rapidly due to climate change and growth of renewable resources.

The power of this knowledge is that with energy storage solutions, energy services and controls, buildings can be an energy resource and can have major financial and environmental impacts for the grid, your business and clients! You can't play if you don't know.

Are Thermal Battery™ Systems Right for Your Building?

FirstPass™

Building Profile

City / Location	Guatemala (2A), Guatemala (GTM)
Building Type	Office
Chiller Type and Peak Load	Air Cooled @ 600 Tons

Energy Savings Summary

Energy Demand Cost Savings	\$24,000
Energy Utility Rate Savings	\$0
Annual Operating Cost Reductions	\$24,000

Conventional System

Chiller Capacity	600 Tons
On-Peak Demand	780 kW

Business Case

First Cost Premium	\$72,370
Net Present Value	\$132,254
Internal Rate of Return	33.1%
Payback Period	3 years 0 months

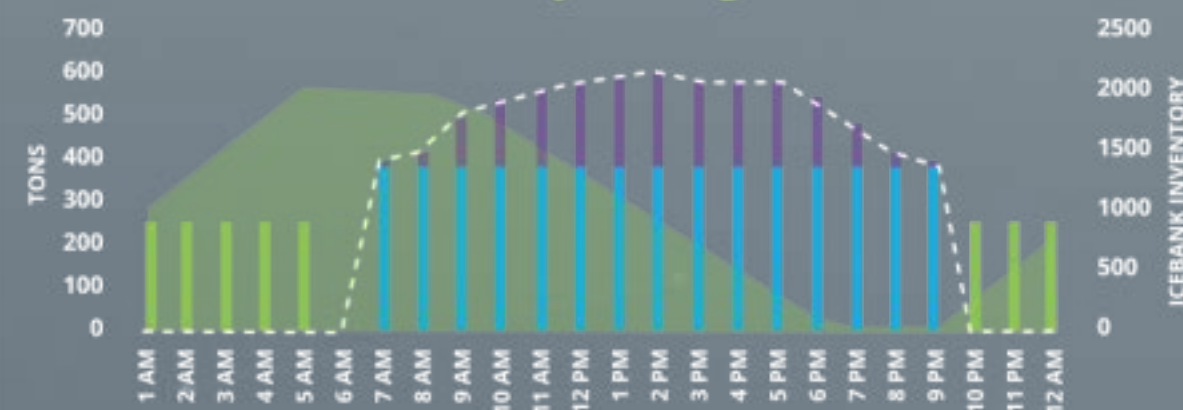
Ice Storage System

Ice Chiller Nominal Capacity	381 Tons
Ice Chiller Ice Making Capacity	248 Tons
IceBank Energy Storage Capacity	1978 Ton-Hrs
On-Peak Cooling Load Reduction	220 Tons
Ice Chiller On-Peak Demand	495 kW
On-Peak Demand Reduction	286 kW

Cumulative Cash Flow



Peak Day Cooling Profile



Ice System Architecture

Storage Farm of 1190C Units	13
Approximate Square Footage	910
Pump Flow (GPM)	957
Pump Power (HP)	20
Pipe Size (in)	8

If interested in seeing if the Thermal Battery cooling system is right for your next project, we have some amazing tools that can be used to quickly compare systems and analyze financial savings.

Resources

trane.com
calmac.com

Trane – by Trane Technologies (NYSE: TT), a global climate innovator – creates comfortable, energy efficient indoor environments through a broad portfolio of heating, ventilating and air conditioning systems and controls, services, parts and supply. For more information, please visit trane.com or tranetechnologies.com.

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