# Thermal Energy Storage: Current Technologies and Innovations

*...AND THE INFLATION REDUCTION ACT*

During this session, the panel will discuss the latest innovations in thermal energy storage, incentives included in the Inflation Reduction Act of 2022, the economic and carbon-reduction benefits to end-users, as well as the benefits to the grid.

Moderator:
Samantha Slater, Air-Conditioning, Heating, and Refrigeration Institute

Speakers:
Guy Frankenfield PE, Energy Market Manager, DN Tanks
Mike Filler PE, Solutions Leader, Trane
Doug Poffinbarger, AEE Fellow, Director Commercial Ops, Nostromo Energy
Wei-Tai Kwok, Managing Director, Thule Energy Storage

# *Welcome and Introductions*

# Program

Introduction

What is thermal energy storage and why is it important?

- Economic benefits
- Grid benefits
- Carbon reduction benefits

What types of thermal energy storage products are commercialized?

- Latent ice storage systems (ice on coil, encapsulated ice)
- Sensible chilled water or hot water storage systems

# Inflation Reduction Act (IRA) of 2022

## Thanks to the IRA -- Now 30-40% Off!

Section 48 Investment Tax Credit

- The provision extends the section 48 energy investment tax credit (ITC), which allows taxpayers to claim a tax credit for the cost of energy property.
- Thermal Storage: For thermal energy storage property, the provision provides a base credit rate of 6 percent and a bonus credit rate of up to 30 (plus 10% if domestic content) percent of the basis of energy property.
    - Projects qualify for the bonus rate if they meet prevailing wage and apprenticeship requirements.
    - The credit is available for thermal energy storage projects that are placed in service after December 31, 2022, and that begin construction before January 1, 2025.
    - Applicable to both public and private entities.

# Definitions: We are familiar with Energy Storage


Electric

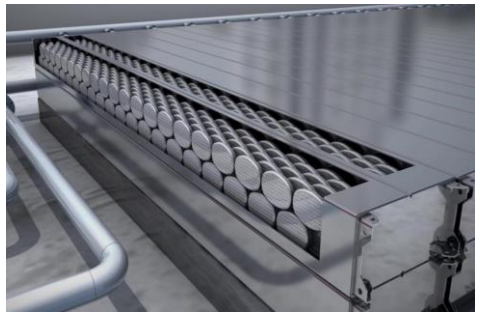
Thermal

# Definitions: Thermal Energy Storage (TES)

- Thermal storage systems remove heat from or add heat to a storage medium for use at another time
- Energy may be charged, stored, and discharged daily, weekly, annually, or in seasonal or rapid batch process cycles
- Fast-acting and/or grid-interactive energy storage systems can provide balancing services and other critical needs of the electric grid
- These grid-interactive systems dynamically couple consumer energy usage to the grid's real-time needs
- Thermal energy storage for HVAC and/or domestic water-heating applications can involve various temperatures associated with heating and cooling

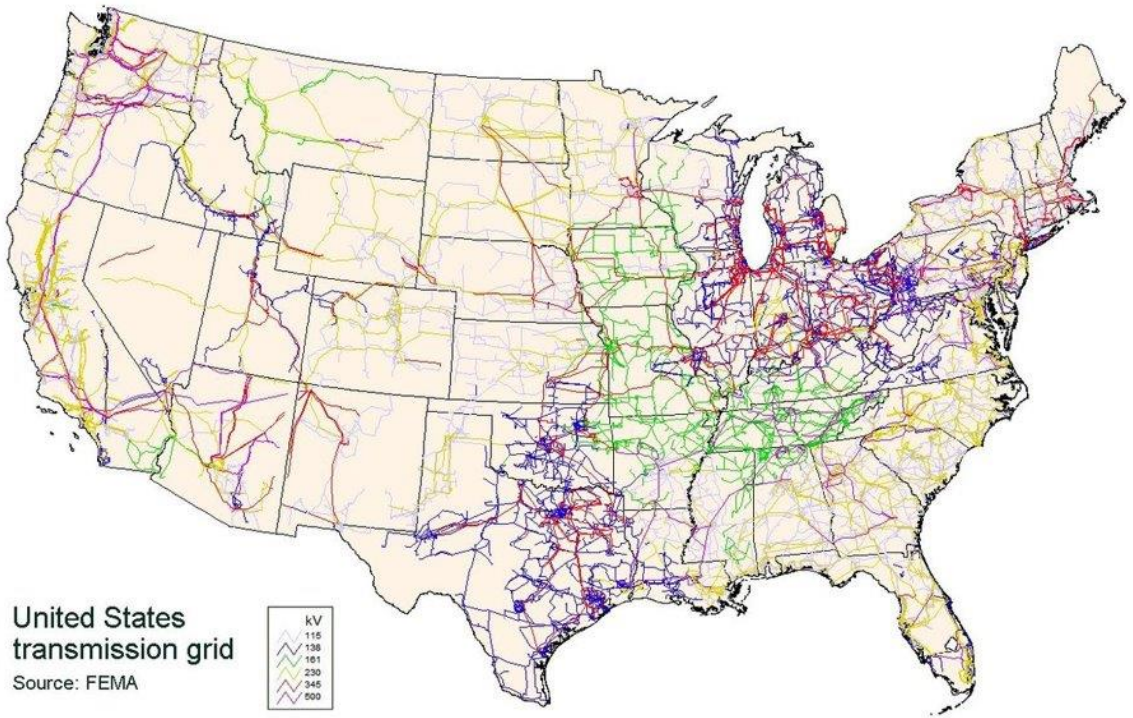
# Commercialized Energy Storage Products

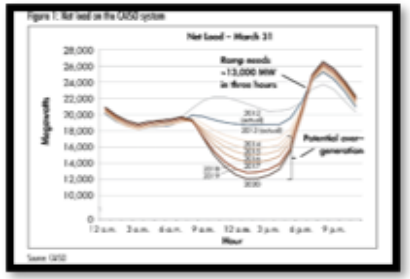

Chilled Thermal Storage



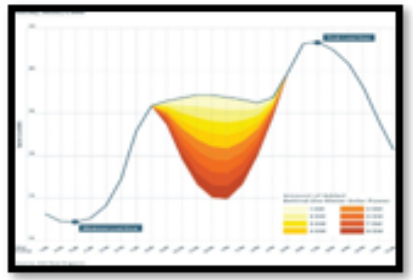
Ice Thermal Storage

# Grid Benefits

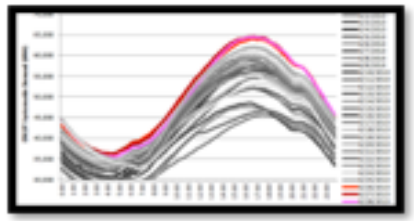


California – “Duck Curve”

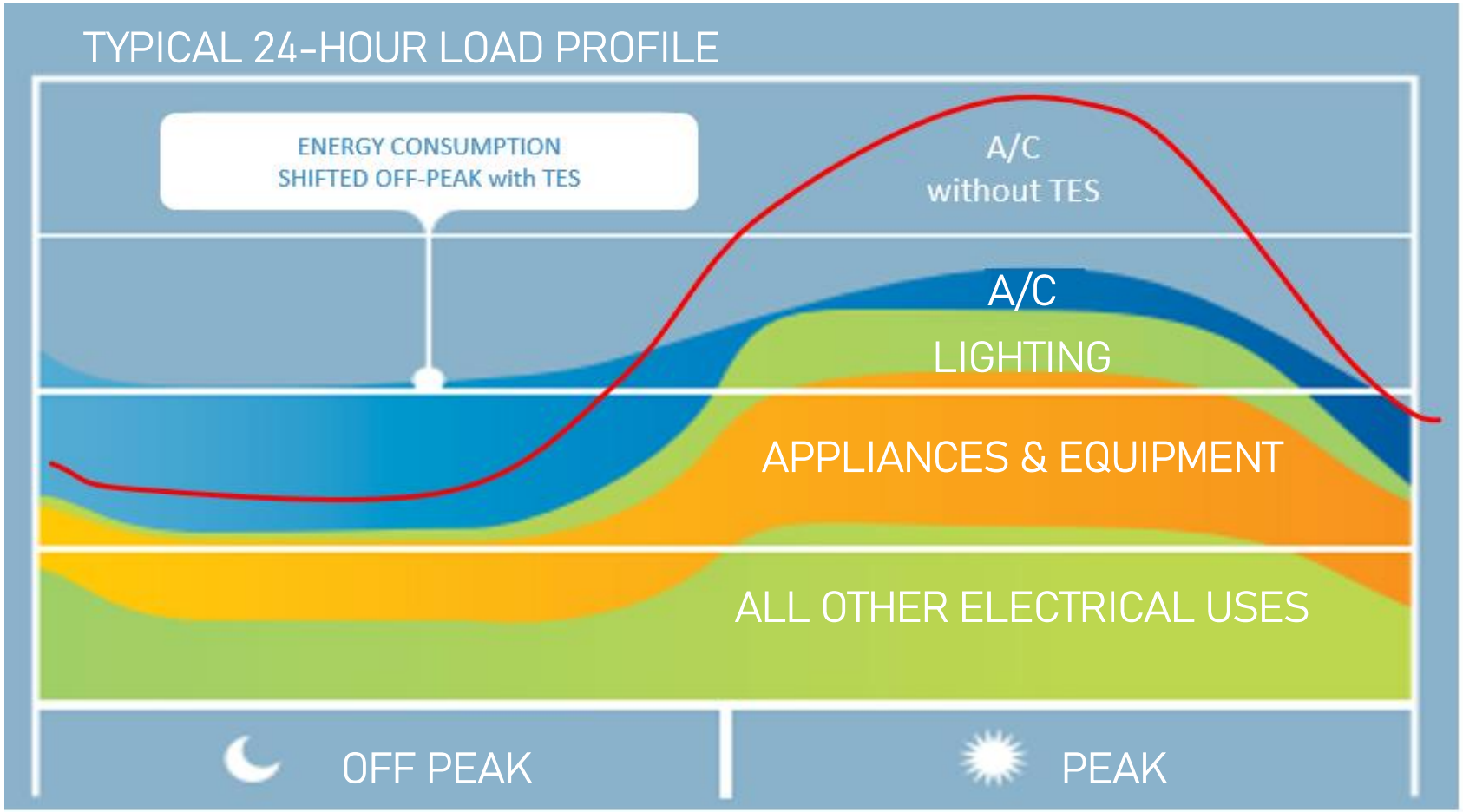


Texas – Summer



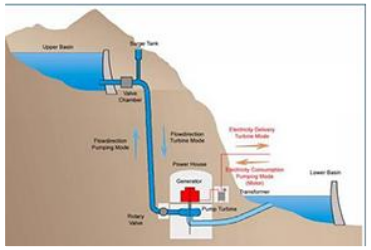
Massachusetts – Winter

# Grid Benefits



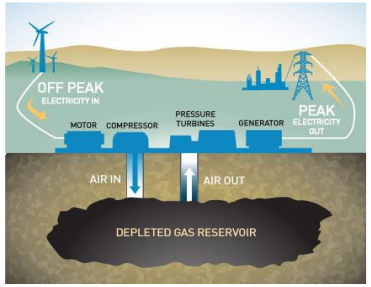
# Grid Scale Energy Storage

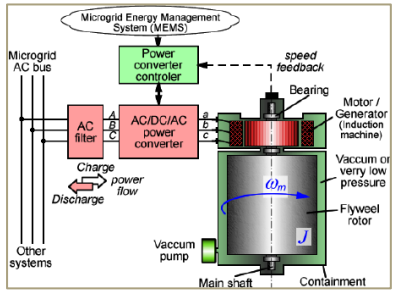
Pumped Hydro



Battery

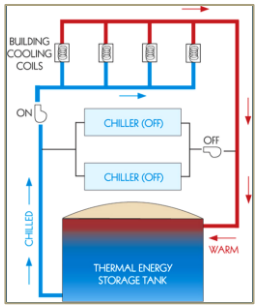
Compressed Air



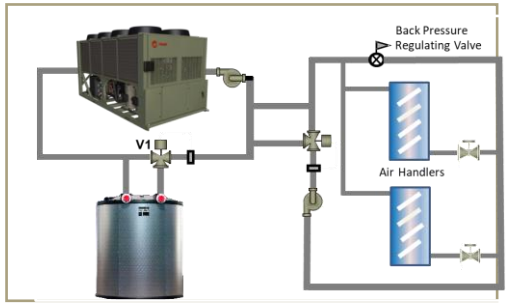




Flywheel

Thermal Energy Storage (TES)




Chilled Water




Ice

# Comparison of Grid Scale Energy Storage

Per DOE Report July 2019

| Energy Storage Technology | Eff (%) | Useful Life (Yrs) | Capital Costs ($/kWh) |
|---|---|---|---|
| Pumped Hydro | 80 | >25 | 165 |
| Na-S Batteries | 75 | 14 | 907 |
| Lead-acid Batteries | 72 | 3 | 549 |
| Li-Ion Batteries | 86 | 10 | 469 |
| Flywheels | 86 | >20 | 11,520 |
| Compressed Air | 52 | 25 | 105 |
| Thermal Storage (TES) | 93 - 100+ | >50 | 30 - 500 |

# As more intermittent renewable power (wind and solar) is added to the electric grid…

…more energy storage will be required to manage the imbalances between the supply and demand of electricity.

# Economic Benefits for Owners

- Reduce Energy Costs
  Permanently reduce peak electric demand (kW)
  Reduce time-of-use consumption costs (kWh)
  Reduce peak electric consumption (by operating during cooler ambient conditions)
  Utilize a more beneficial electric rate structure

- Avoid Capital Costs
  Instead of adding more refrigeration equipment – add a TES system instead
  Instead of replacing an existing chiller – add a TES system instead

- Manage Thermal Imbalances – store cold or hot water from a geothermal system, or capture waste heat from a combined heat and power system for later use

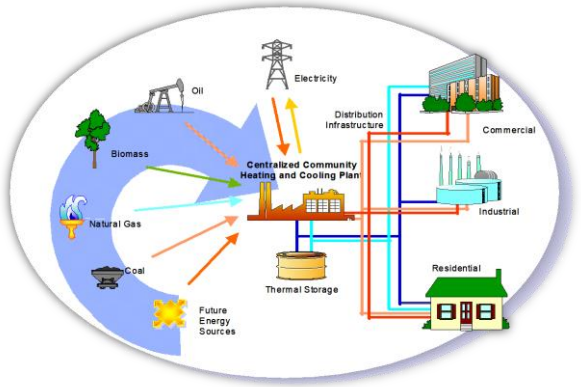
- Provide Resiliency – utilize the TES system as a backup for mission critical operations

Guy Frankenfield, PE
Energy Market Manager
DN Tanks

A Thermal Energy Storage tank can be applied to any large district cooling or heating system

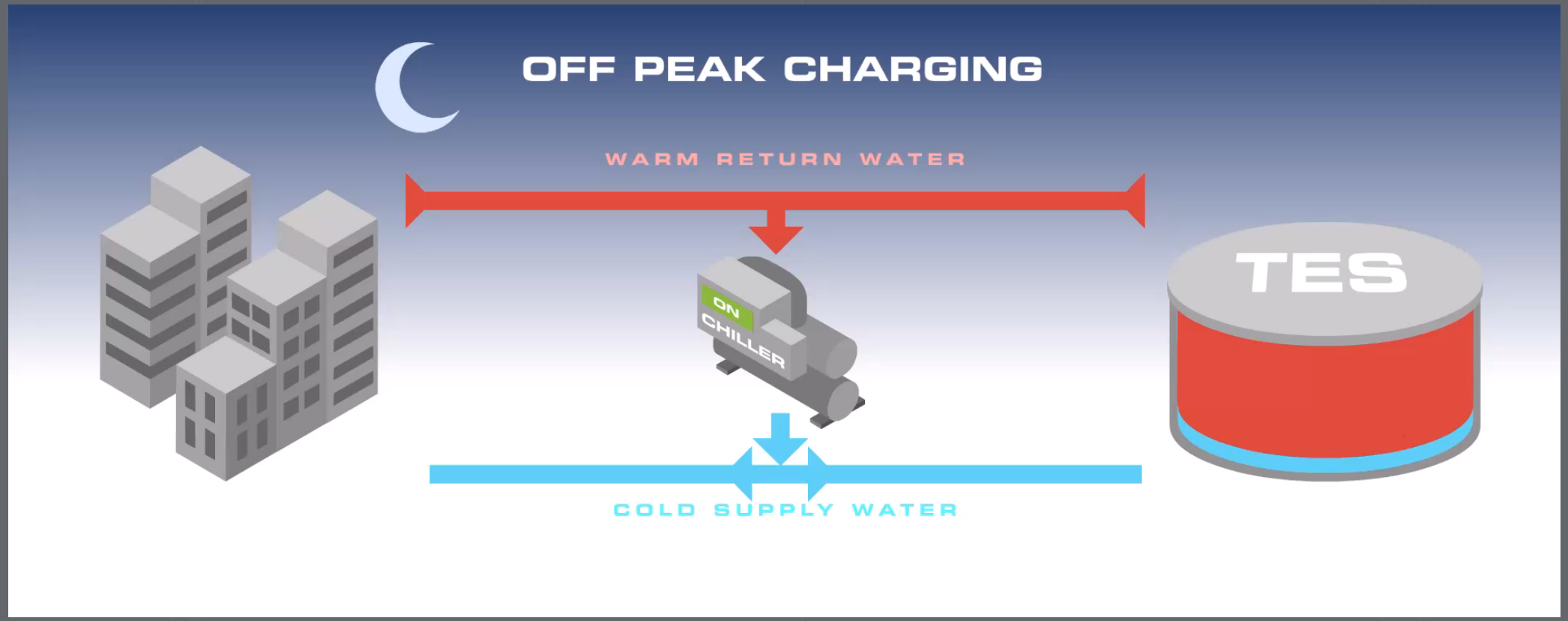
- Education
- Industrial
- Commercial
- Aviation
- Healthcare
- Government
- Data Centers
- Power Plants

# Large Chilled Water or Hot Water TES Tanks




- Proven Technology – 40+ years with TES tanks throughout the world
- Typical Applications – medium- to large district cooling or heating HVAC systems
- Things to consider – must be connected to an HVAC system, it is like a virtual battery, but does not store electricity

# How does it work?



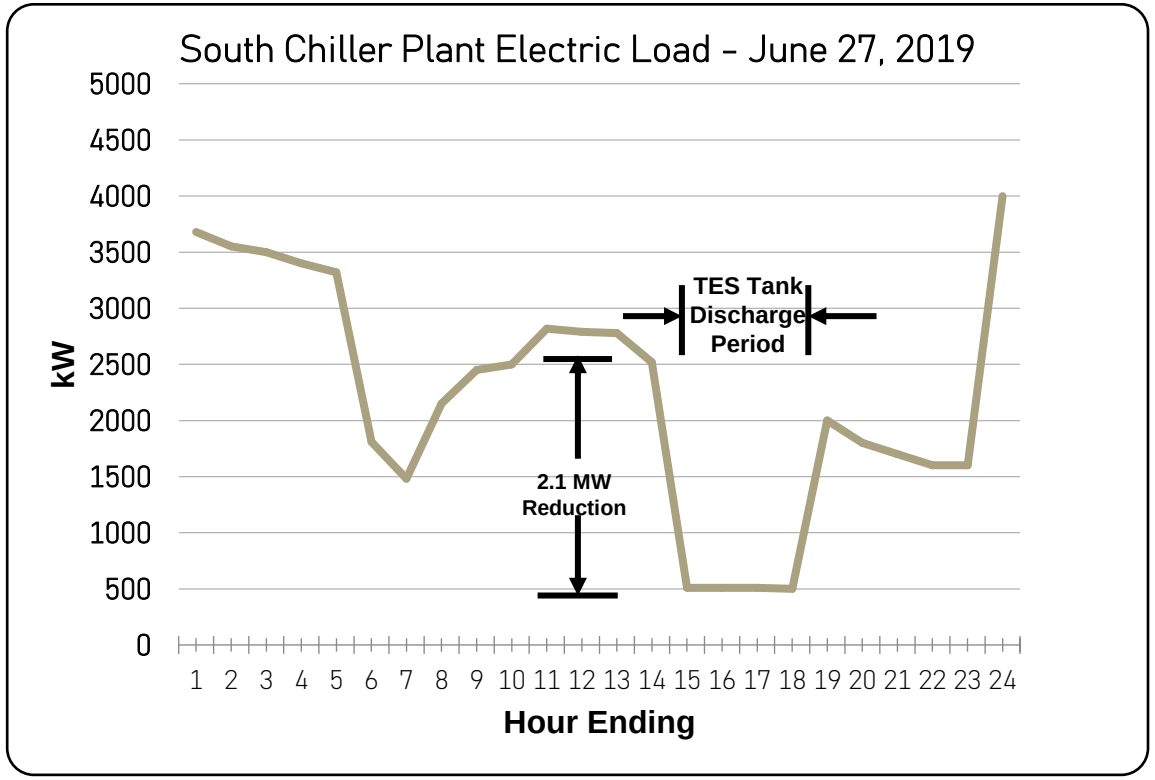
MIAMI UNIVERSITY
OXFORD, OH • EST. 1809

- Public university in OH
- 2018 – a campus expansion
- University has an electric rate with a high peak-period demand (kW) electric rate

- Instead of adding more chiller equipment for the campus expansion cooling requirements, the owner added a 1.7-million-gallon chilled water TES tank

# Cost Savings and Increased Cooling Capacity

- Chillers with 3,500 tons of cooling capacity can be de-energized for 4.5 hours during peak periods
- With a chiller plant efficiency of 0.60 kW/ton on a peak load day, de-energizing the chiller equipment reduces the electric load by 2.1 MW
- Over $200,000 in annual energy cost savings




Information on this slide is courtesy of Tim LaGrange, Associate Director of Physical Plant, Miami University

# Concrete TES Tanks Can Be Partially Buried...

Differentially buried into a sloping hillside

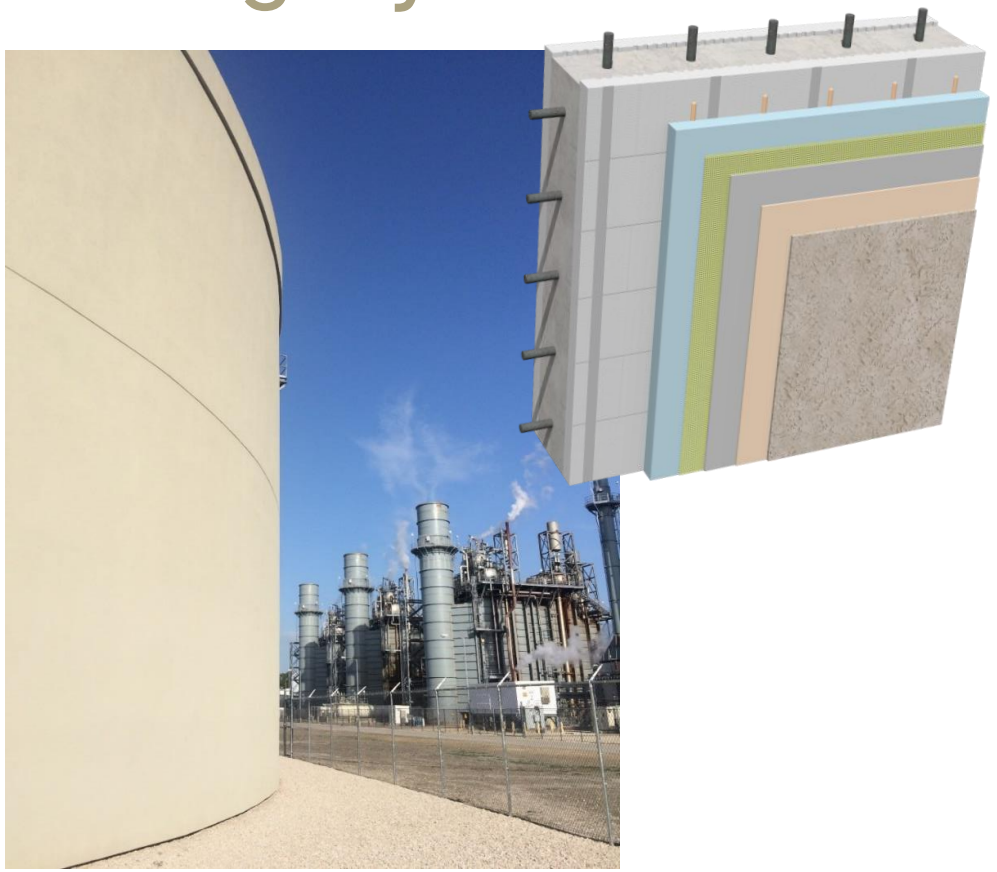
Mostly buried, reducing wall insulation and lowering the overall profile

Flat roof tank can be used as a patio or observation deck

# …or Fully Buried

# Exterior Insulation & Finishing System

Polystyrene board epoxy bonded to the exterior wall



Cementitious coating over an armor mesh

Mike Filler, PE
Solutions Leader
Trane

# Ice Storage vs. Chilled Water Storage

144 Btu/lb (334 kJ/kG)

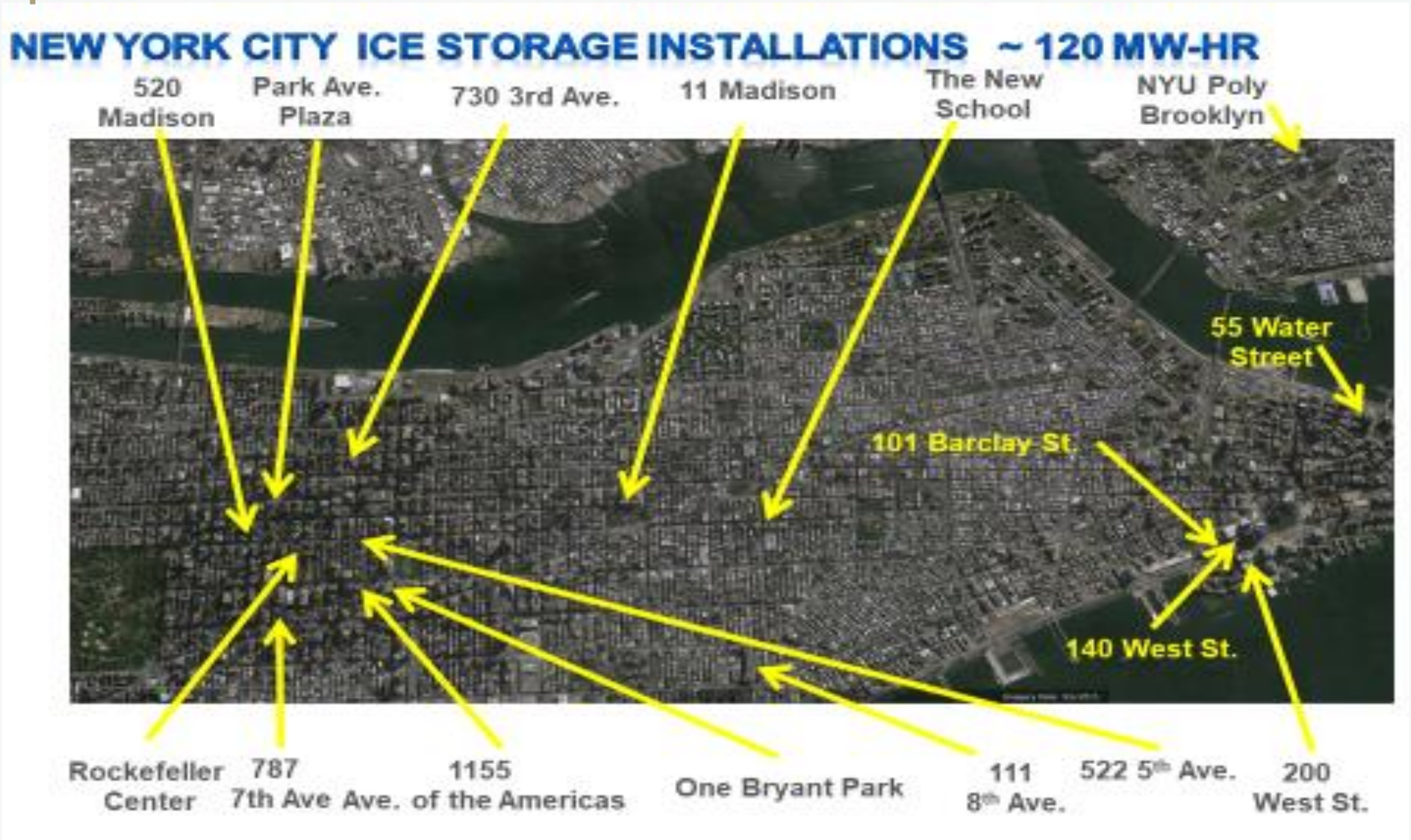
40F supply/60F return or 20 Btu/lb (46 kJ/kG)

# Where to Put the Tanks?

## Tank Location Ideas

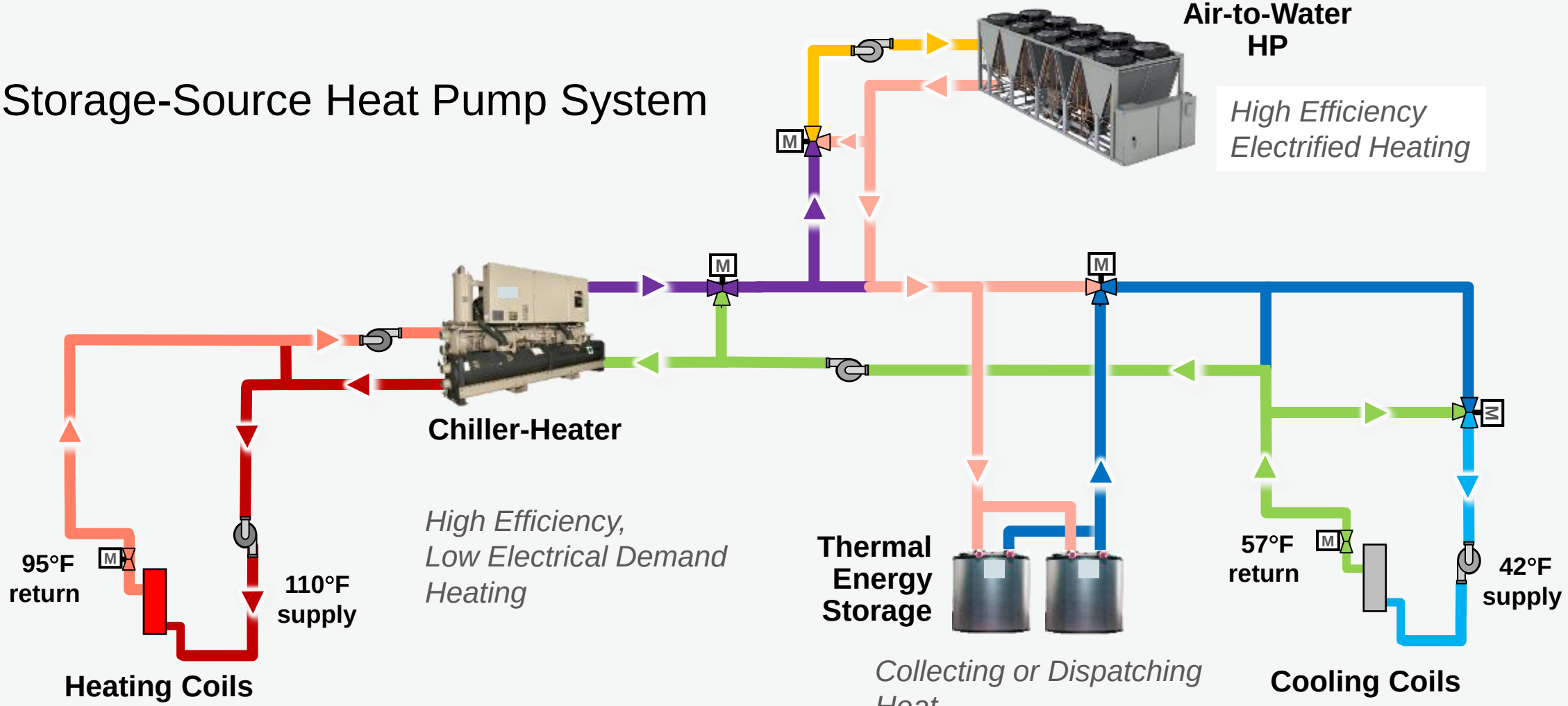
- ✓ Indoors or outdoors
- ✓ Partially or fully buried
- ✓ Basements, equipment rooms, roofs


# Expensive Real Estate



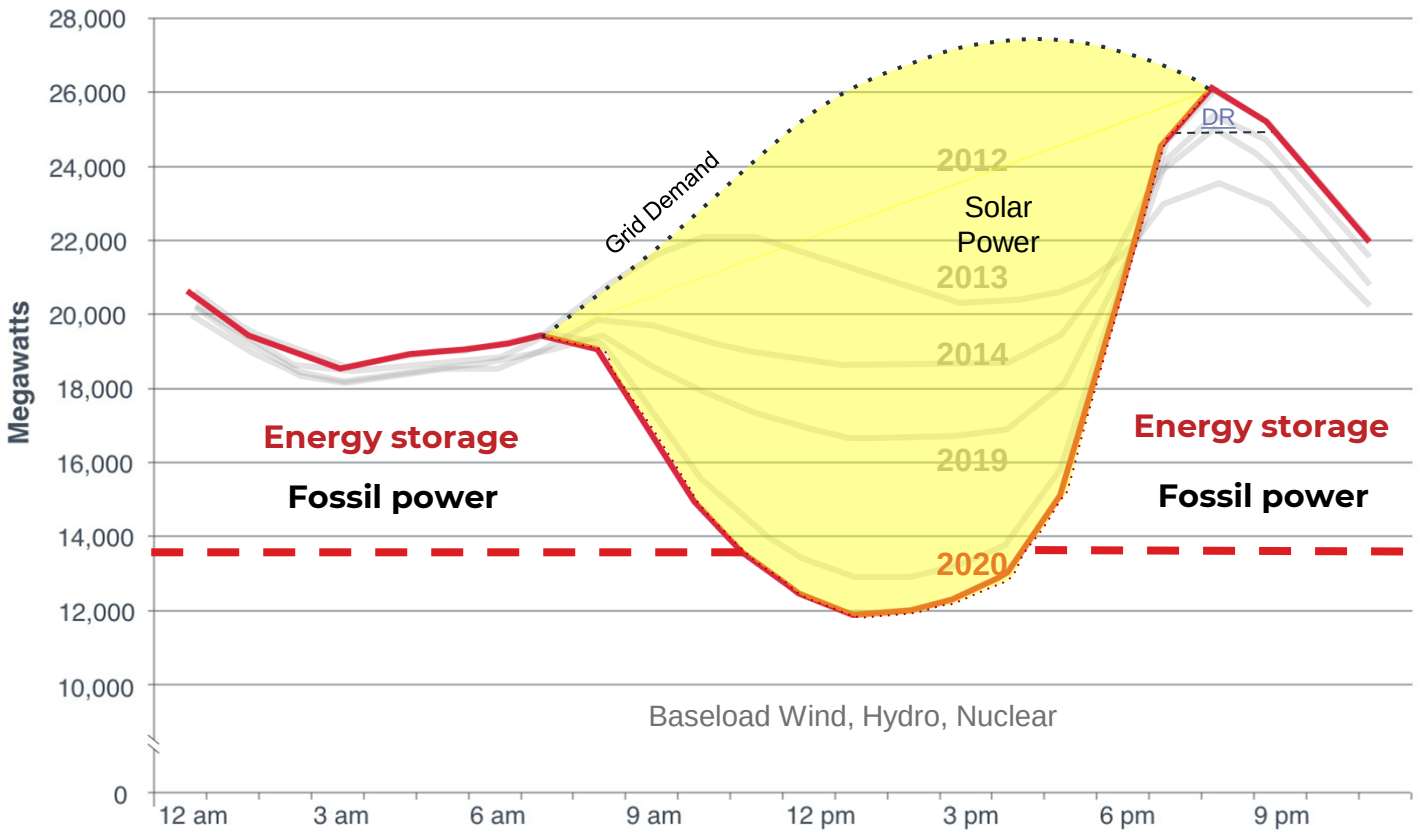
# Solving Decarbonization Challenges with TES

## Storage-Source Heat Pump System



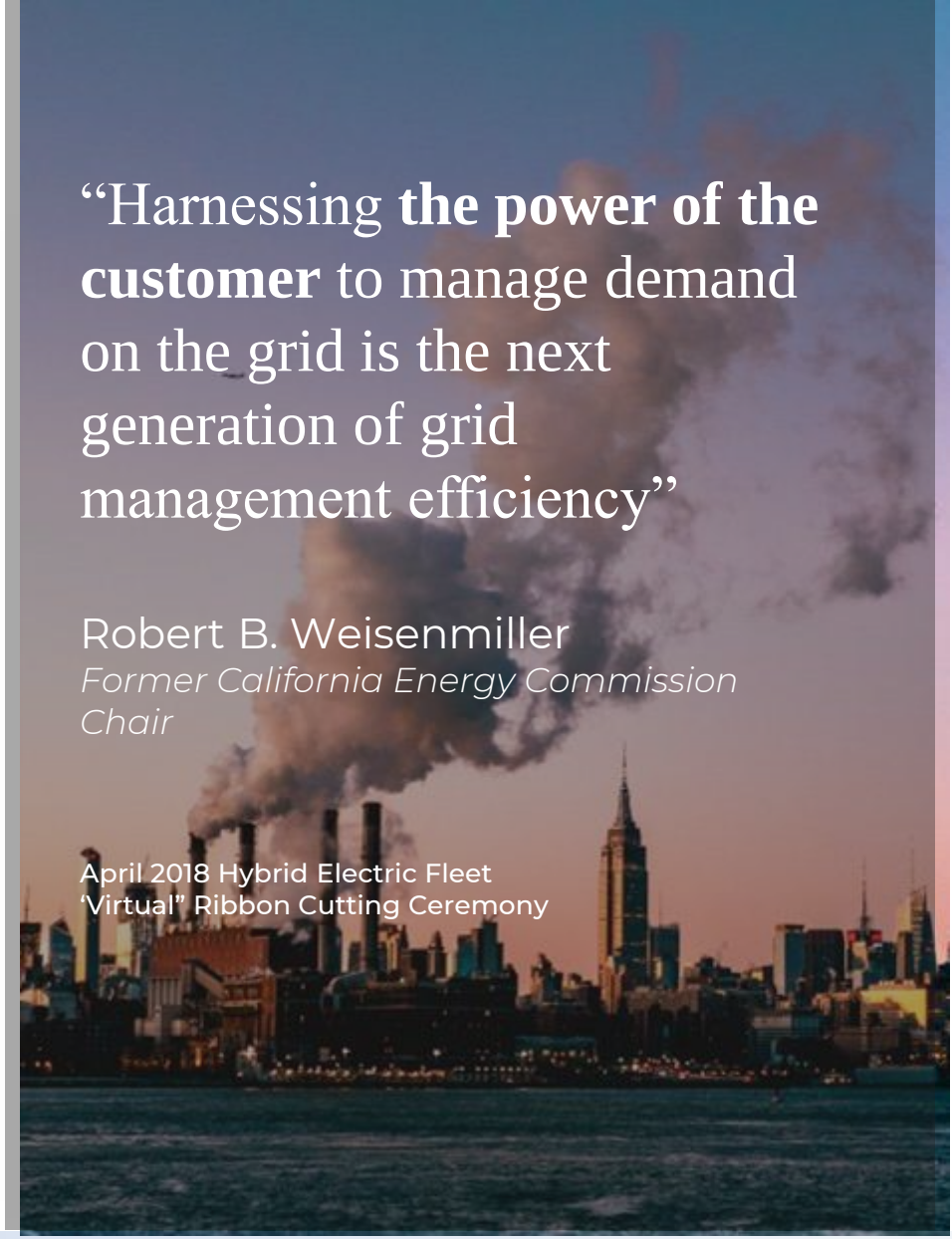
Doug Poffinbarger
AEE Fellow
Director Commercial Ops
Nostromo Energy

# The clean transition needs...
## a lot of **Energy Storage**



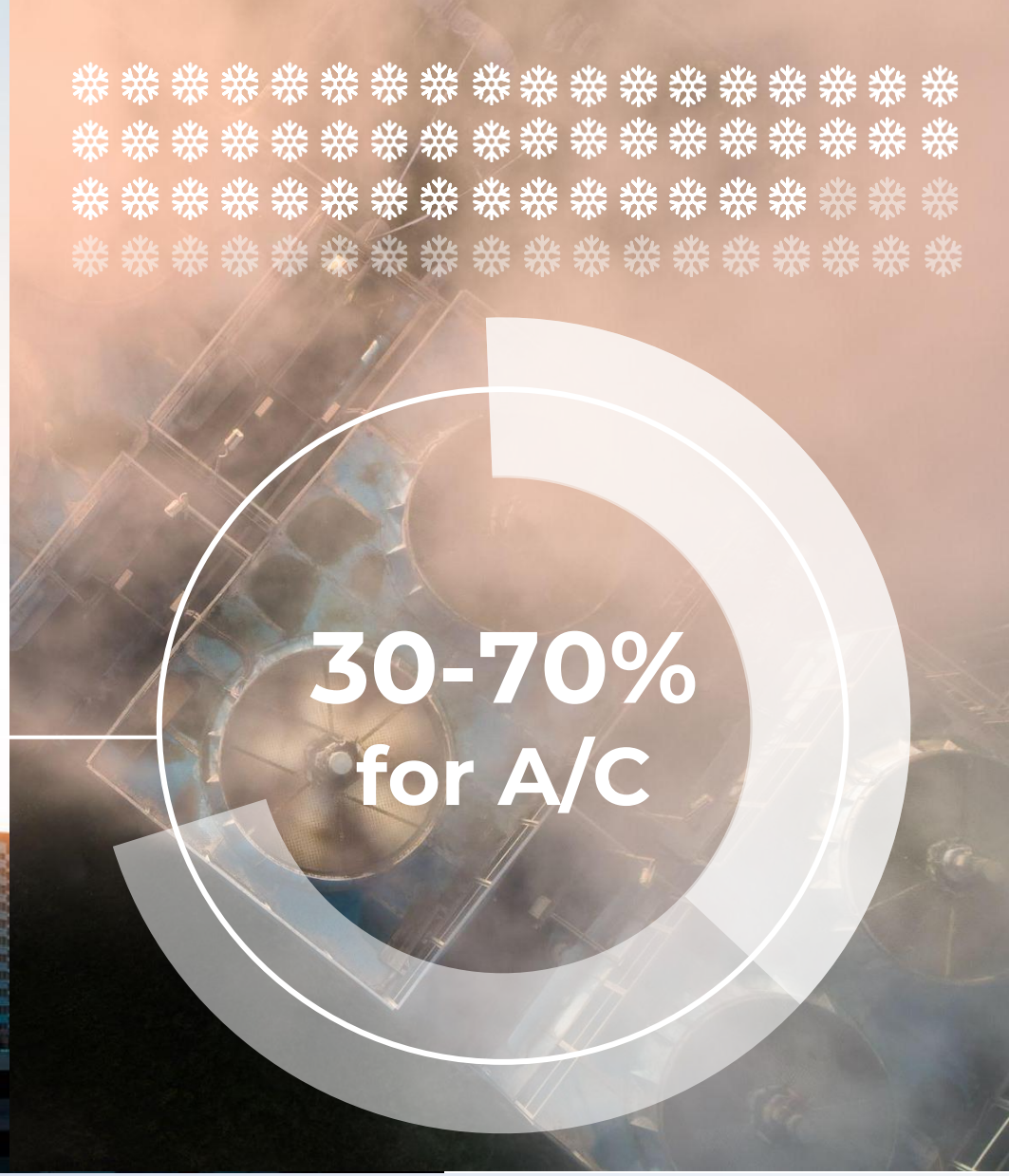

Source: CAISO

Typical spring day in California



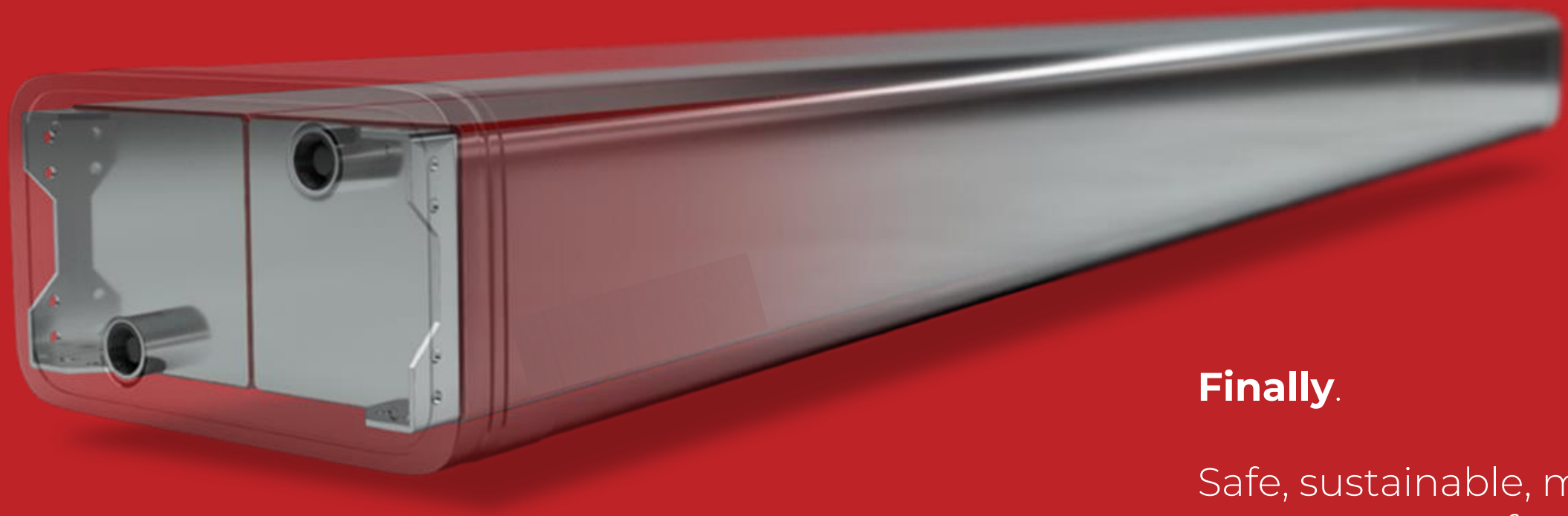
# Buildings consume 74% of electricity

## Most of that is for cooling



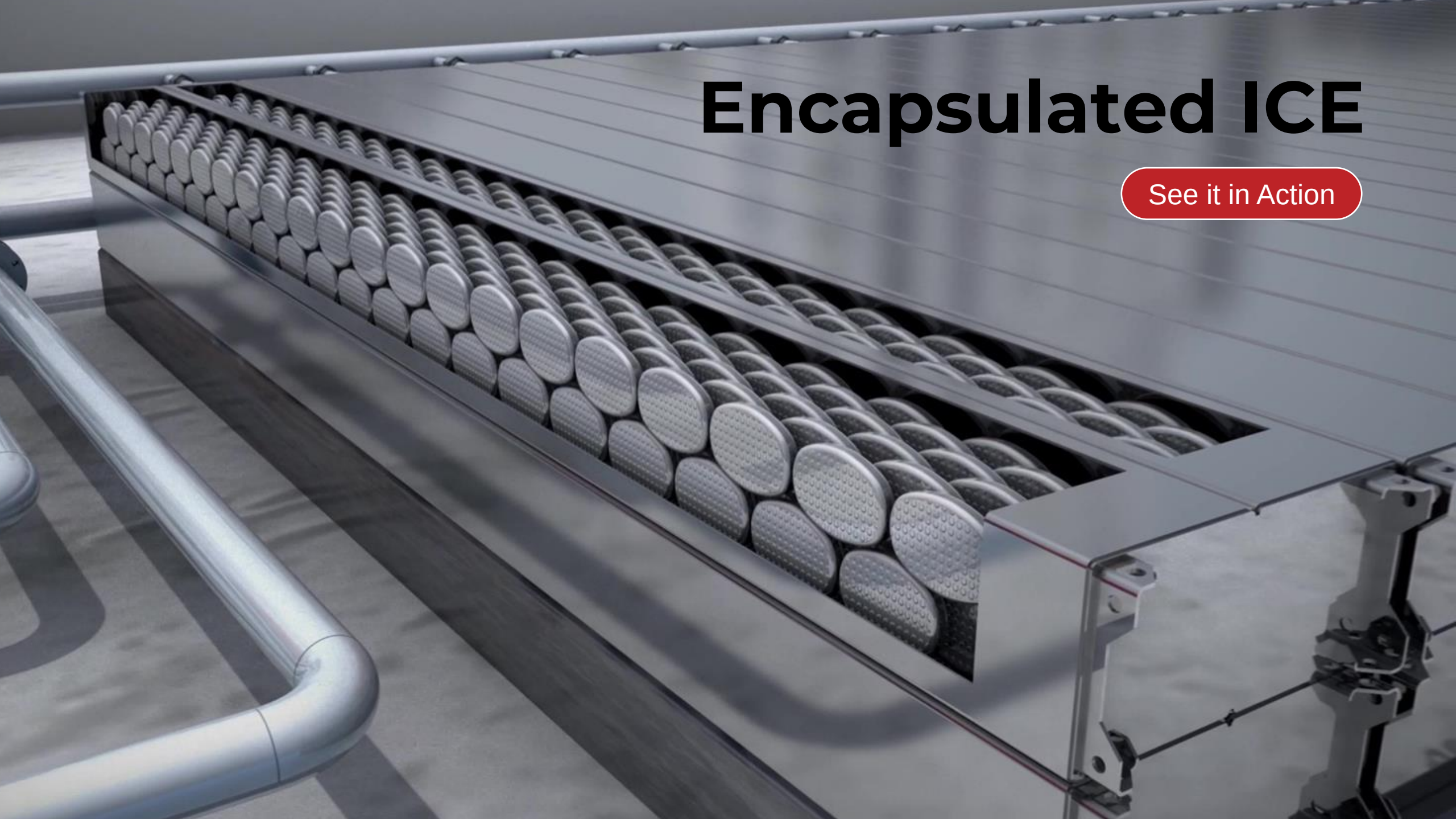

US EIA.gov 2022

# MODULAR ICE BATTERIES

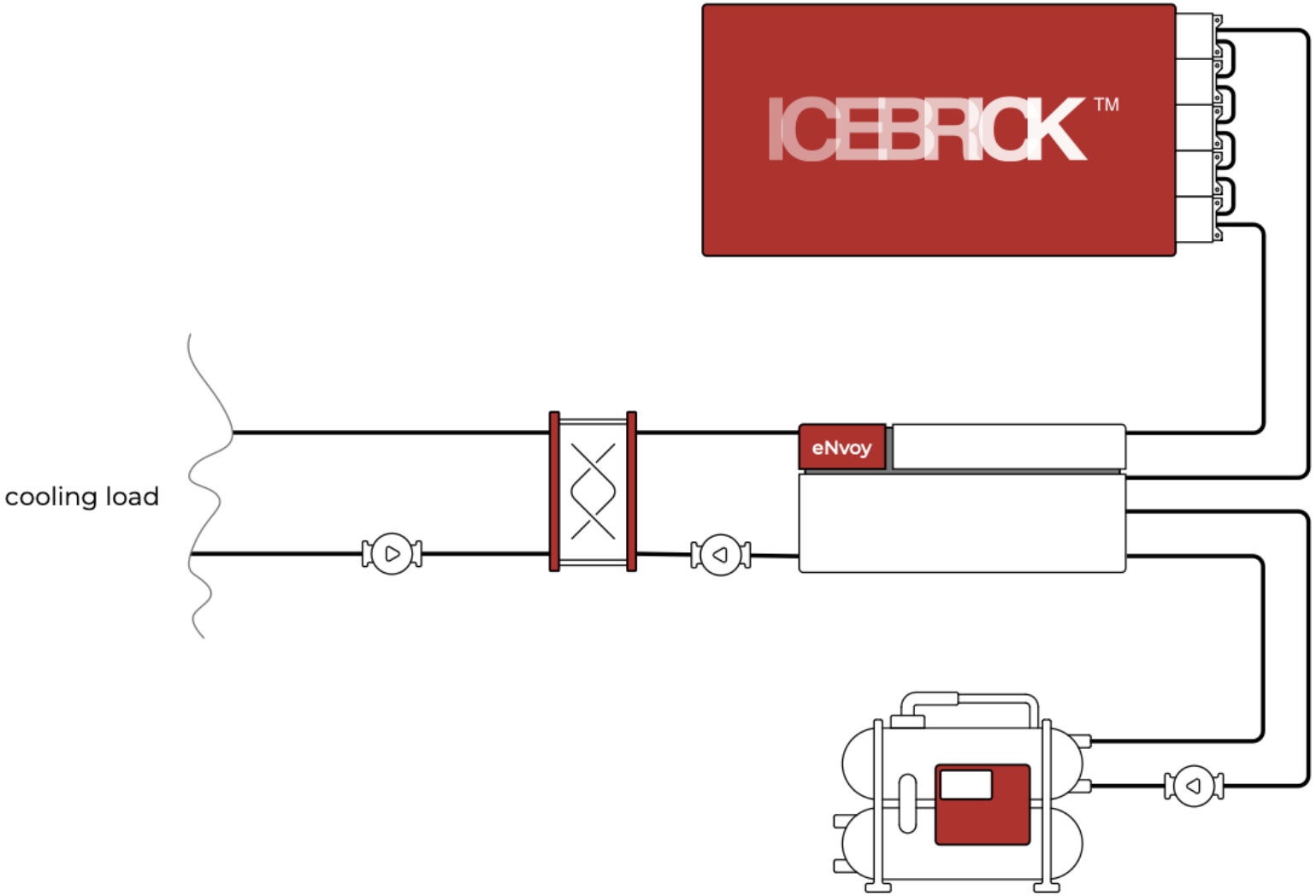


**Finally**.

Safe, sustainable, modular energy storage for pairing with chilled water systems.


Encapsulated ICE
See it in Action

# Schematic




The IceBricks use encapsulated ice to efficiently store and discharge energy to precool the chilled water system. Each IceBrick stores 10 ton-h.

The eNvoy is a pre-fabricated skid that manages system operation and Cirrus cloud communications. It includes circulating pumps, valves and metering and standalone heat exchanger.

The glycol charging chiller is used to efficiently cool the ice bricks to 28F for phase change or directly to the heat exchanger if extra support is needed.

# Versatile Applications

Offices

Hotels

Industry

Government

Hospitals


Large Scale Retail

Education

Data Centers

Source: Woods Mackenzie, McKinsey.

244,500 chiller cooled buildings in USA (excl industry and data centers).

- Central cooling (chillers)
- Versatile Benefits
  - TOU saver
  - Demand response
  - Backup cooling
  - Resilience
  - Carbon cutting
  - Extend life

# GROWING GLOBALLY

## Cool Projects

**ELECTRA M&E**
HVAC Integrator, Israel
Completed

200 kWh

**MEDINOL**
Medical Device, Israel
Completed

600 kWh

**SOROKA***
1,100-bed hospital, Israel
Expected Q1/2023

1,000 kWh


**HOSPITAL****
TBA (Government)
Expected H1/2023

1,200 kWh

**DATA CENTER****
Partner TBA
Expected H1/2023

1,100 kWh


**BEVERLY HILTON***
Visitor Center, CA
Complete Q1/2023

1,500 kWh


**SANDSTONE***
Office Building, LA
All permits received

900 kWh

**AB Inbev***
Baldwinsville, NY
Expected Q3/2023

1,000 kWh

**UNIVERSITY****
TBA, CA
Expected H1/2023

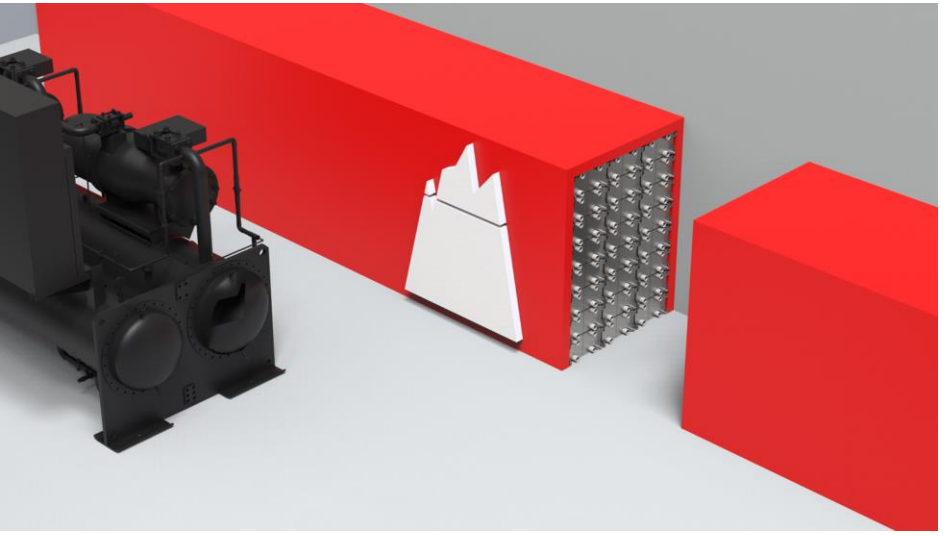
3,000 kWh

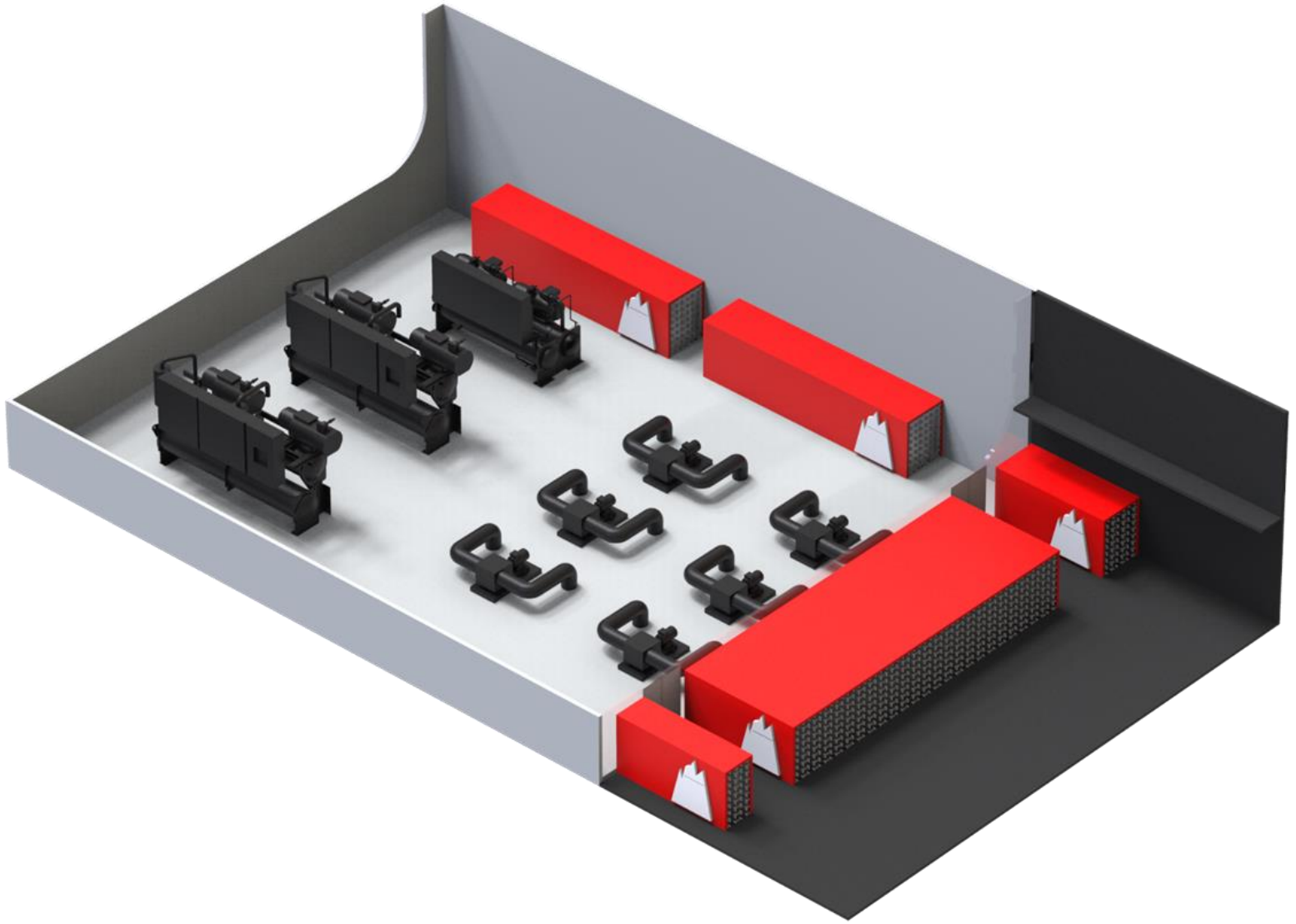
**FILM STUDIOS****
TBA, CA
Expected H1/2023

2,000 kWh

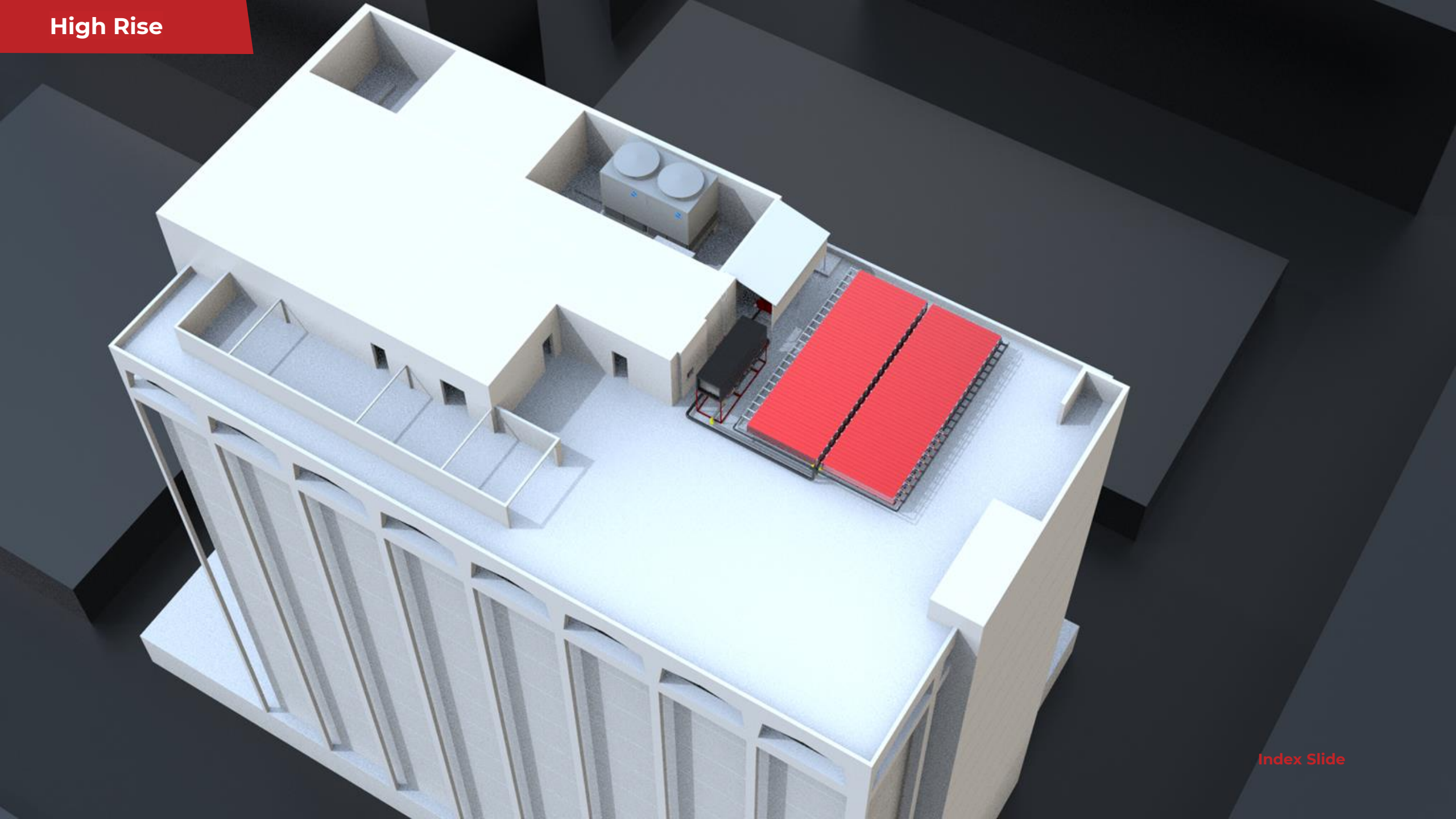
* In design/construction
** In contract/negotiations

# Mechanical Rooms



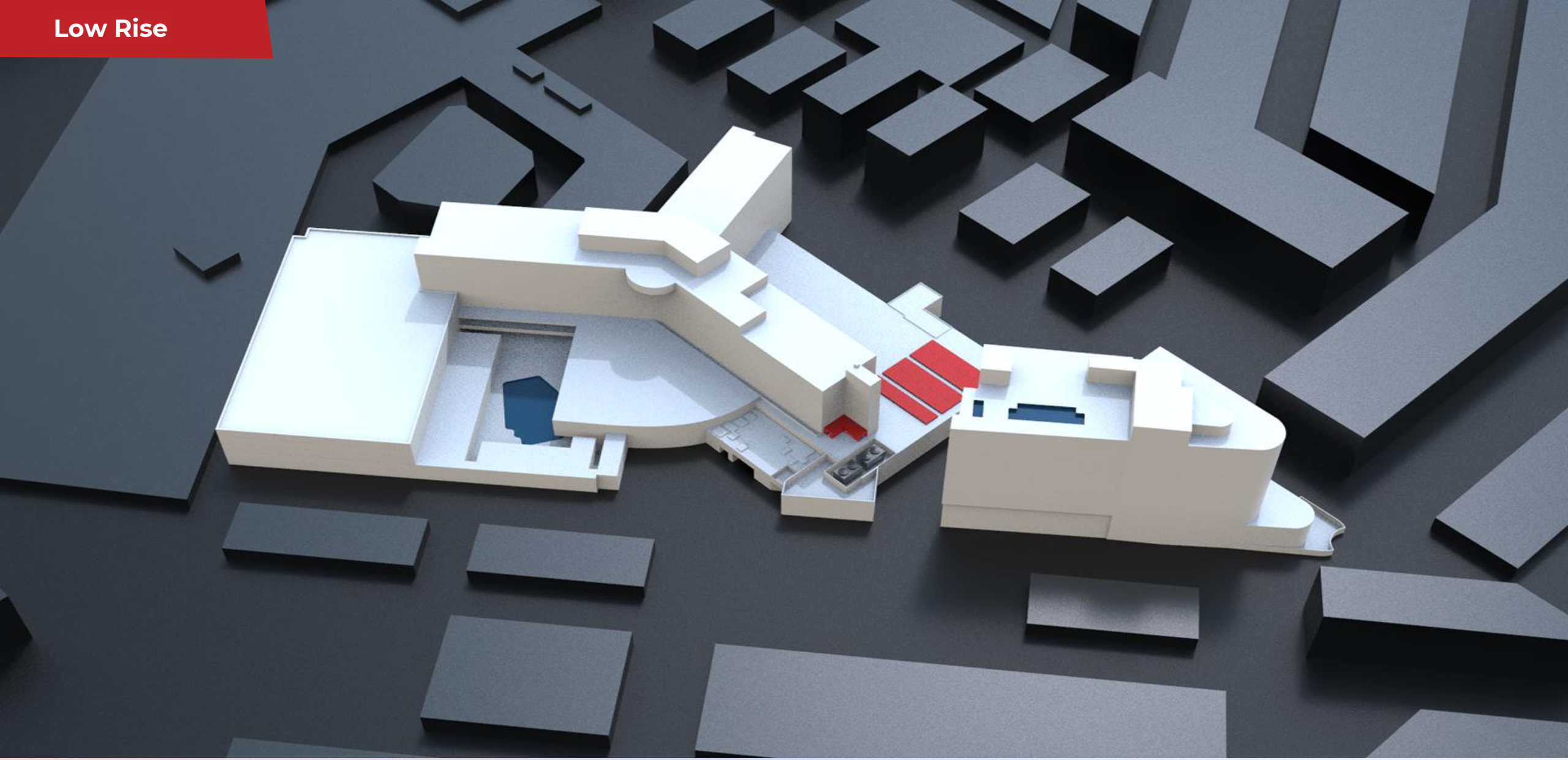


# High Rise

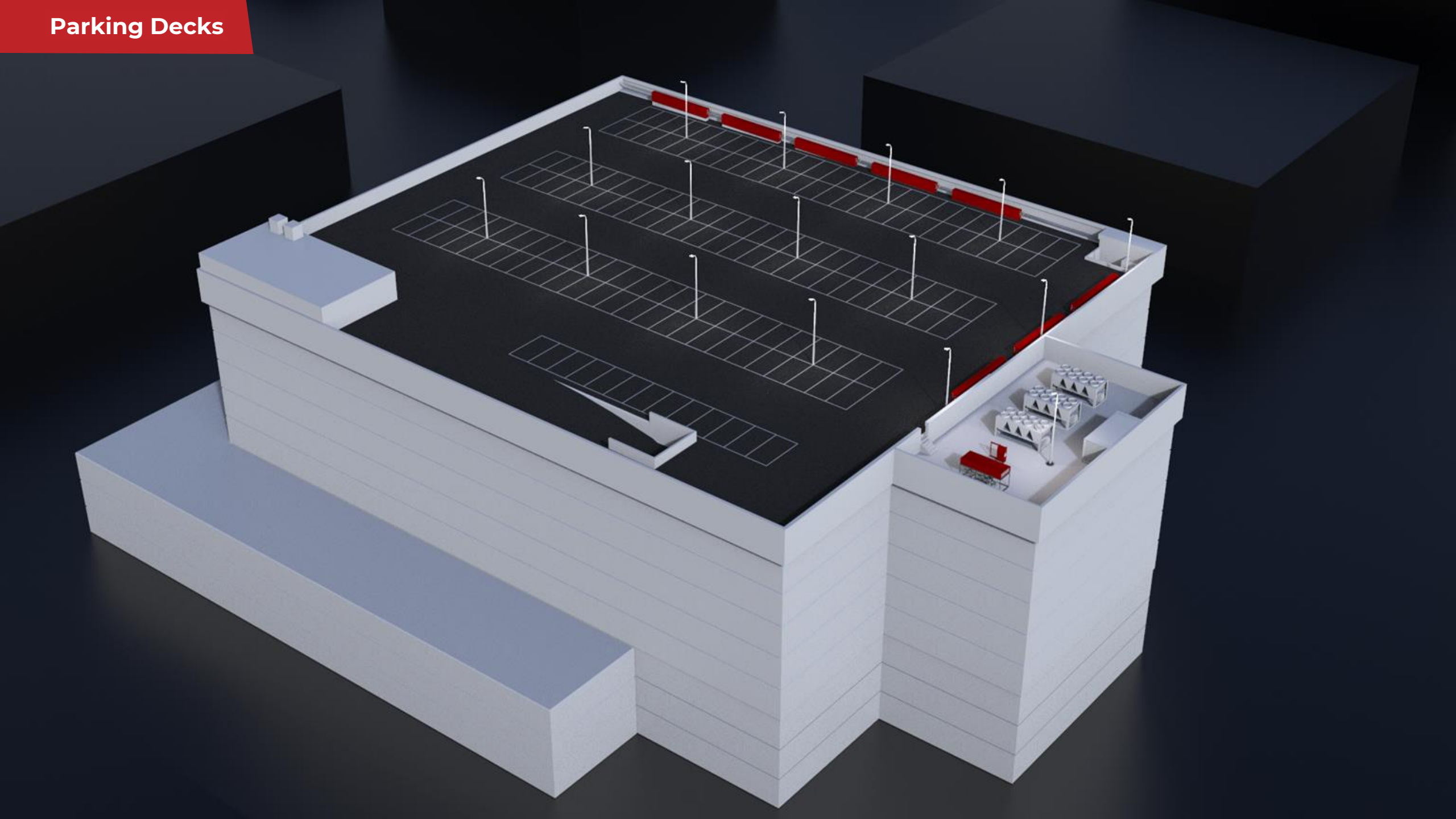


Index Slide

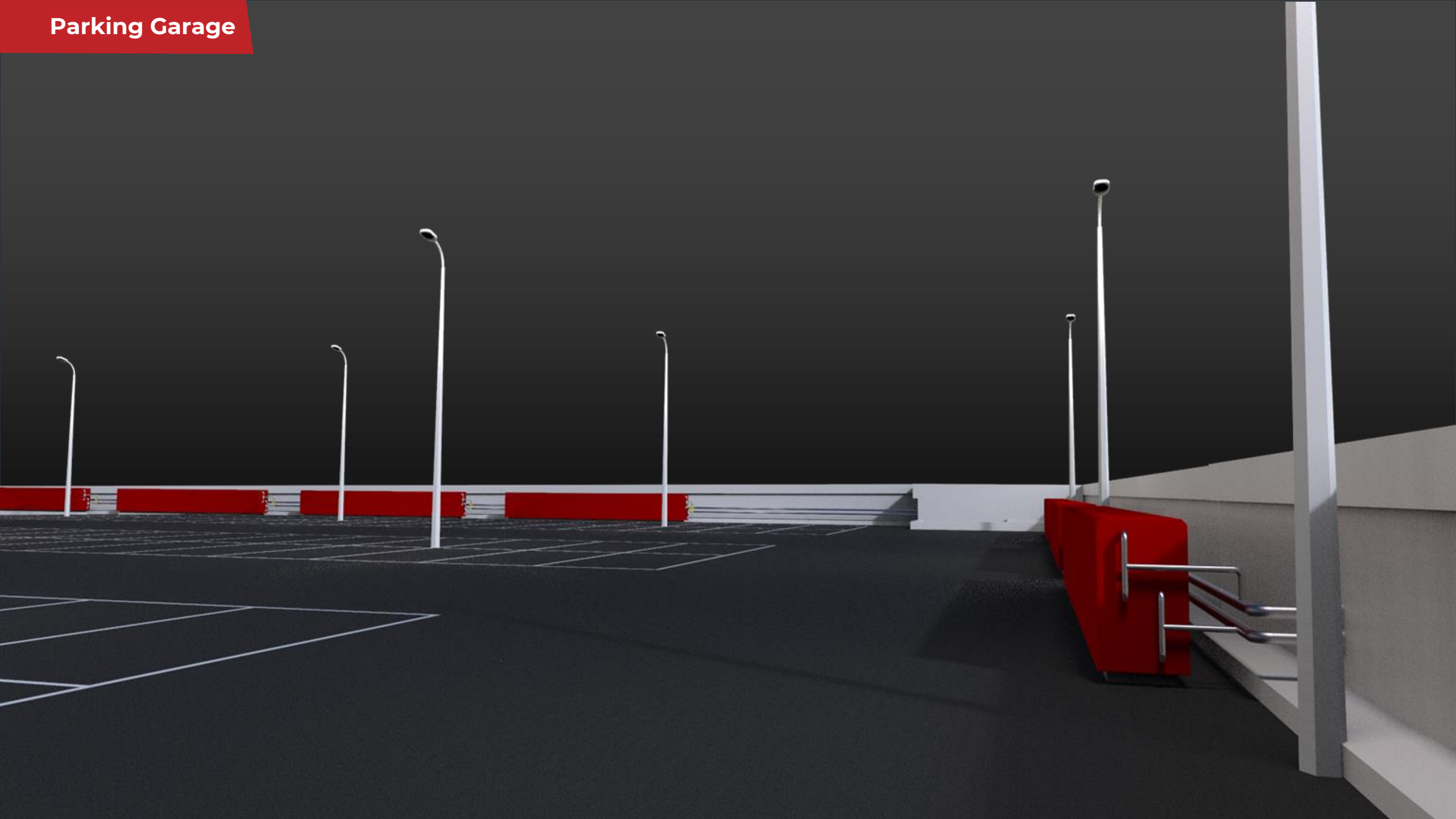
Low Rise



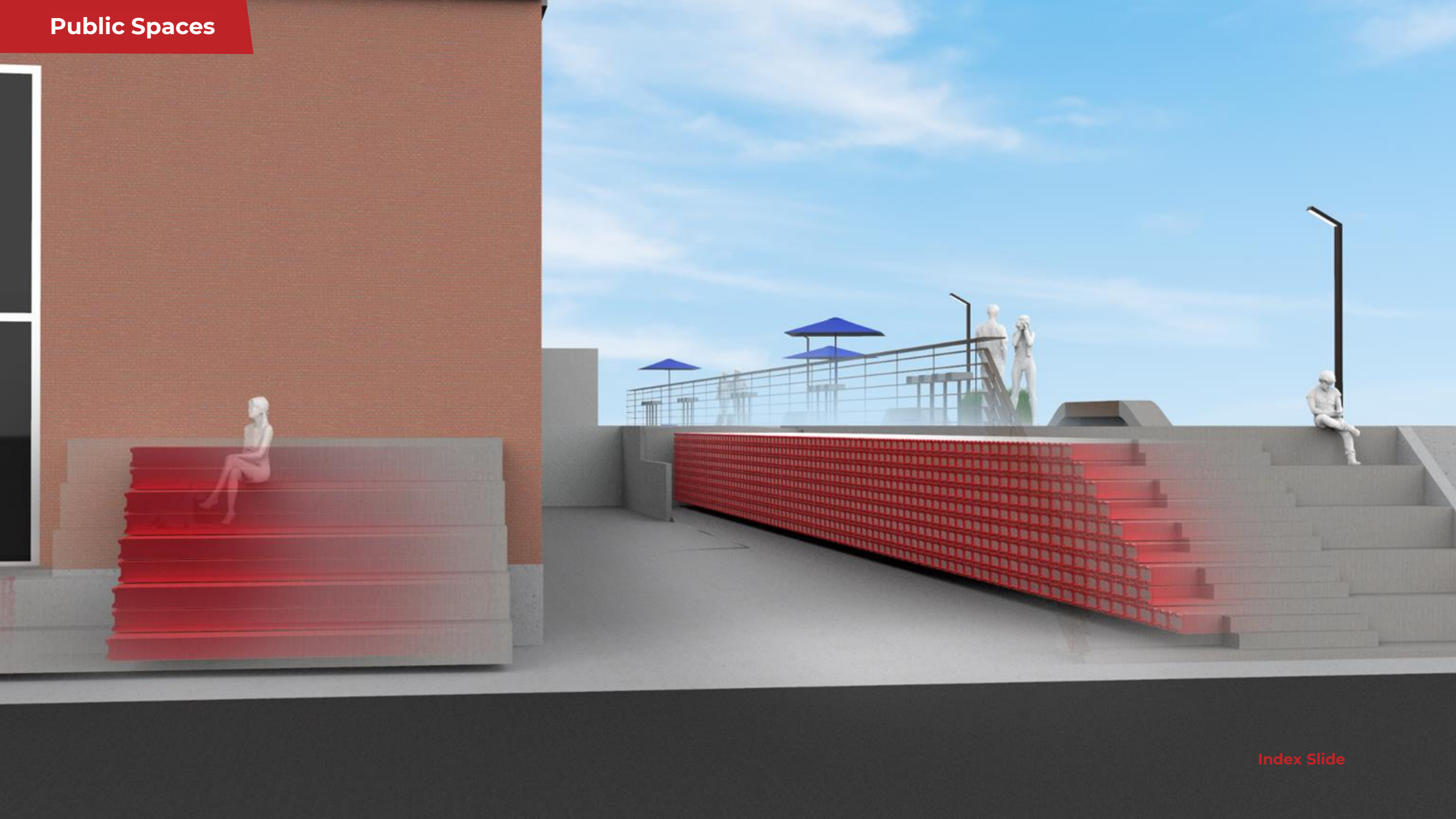
# Parking Decks



# Parking Garage



# Public Spaces

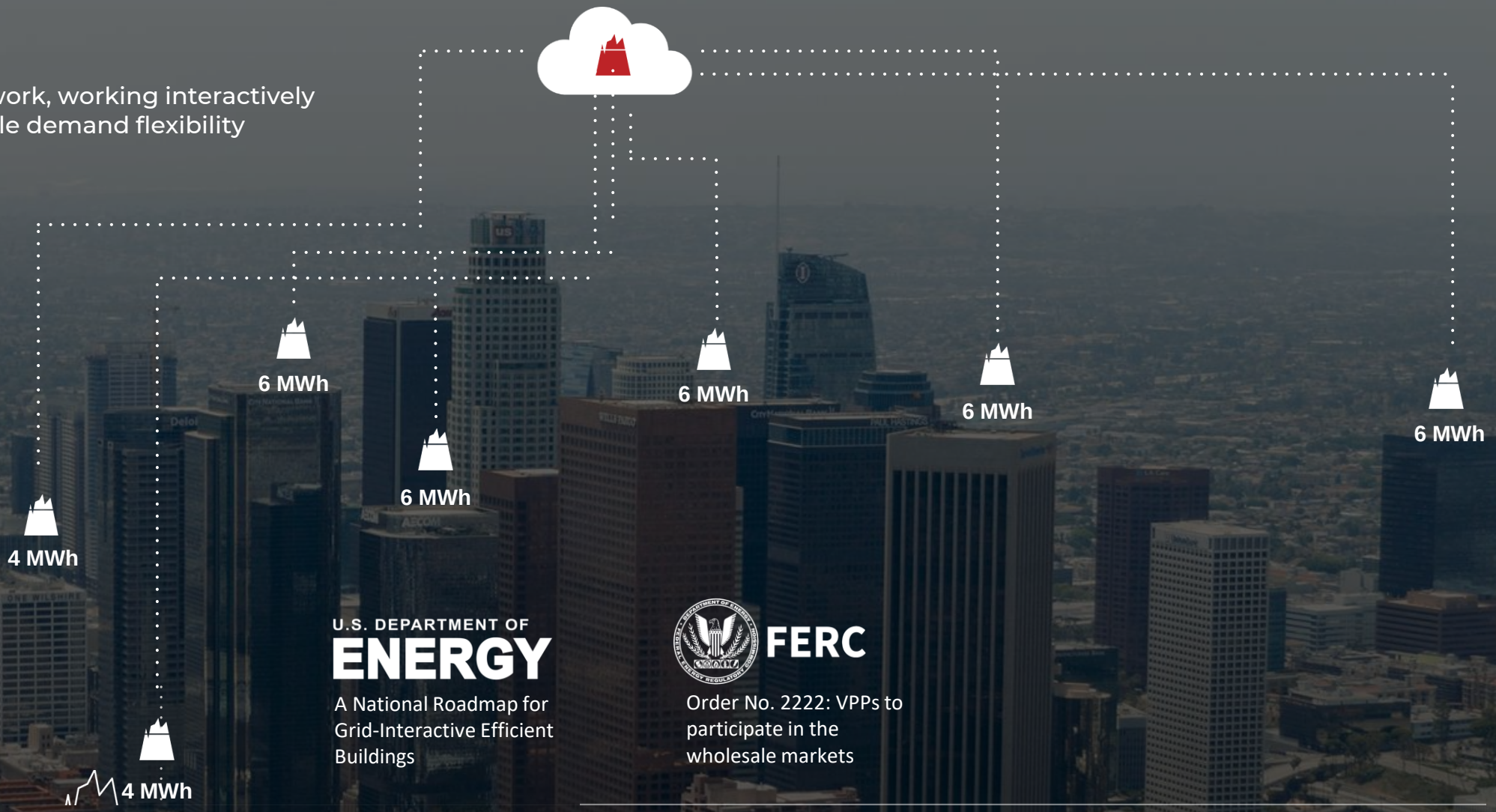


Index Slide

INFINITELY SCALABLE

# Portfolio Ready | VPP Capable

Multi-Megawatt network, working interactively with the grid to enable demand flexibility




U.S. DEPARTMENT OF ENERGY

A National Roadmap for Grid-Interactive Efficient Buildings

FERC

Order No. 2222: VPPs to participate in the wholesale markets

# Cool Projects

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HVAC Integrator, Israel
Completed

200 kWh

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Medical Device, Israel
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TBA, CA
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* In design/construction
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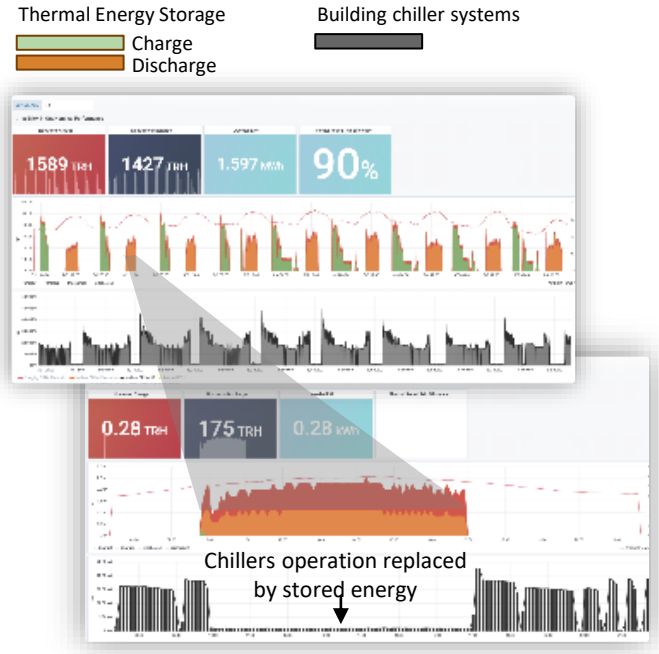
# Encapsulated Ice Thermal Energy Storage for Commercial & Industrial Buildings

## *Sample Sites*






**Charge/Discharge**
When the thermal energy storage (TES) system *discharges* (orange chart = discharging cycles), typically during peak electricity demand, it replaces the building's chillers (black), so the building A/C operates on stored energy (green chart = charging cycles) instead of electric energy from the grid.

Illustration video

## *Technology*

Each Brick includes capsules filled with plain water and freeze-accelerating agents, designed and arranged for **highly-efficient** heat transfer with circulating chilled water .

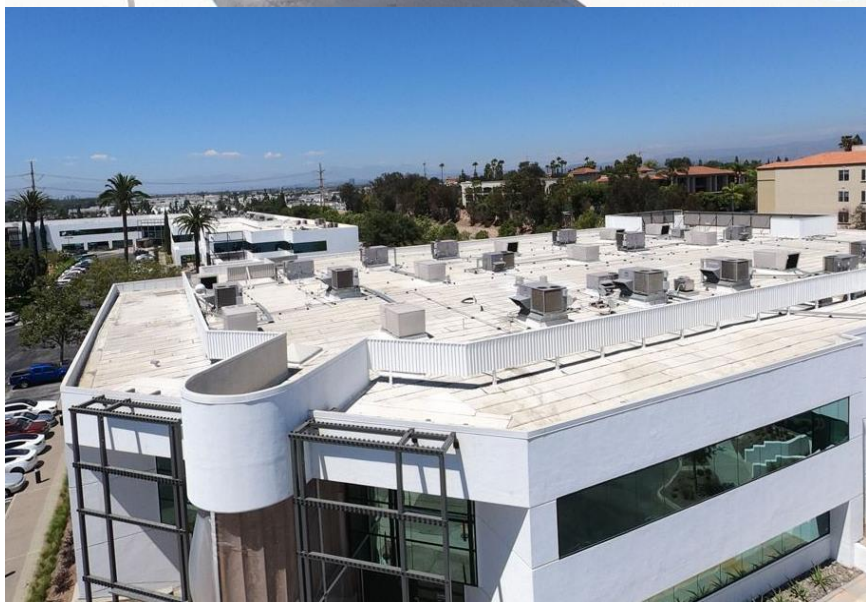

The system *charges* by freezing the capsulates, using electricity during off-peak hours or from renewable energy source.

The system *discharges*, during peak hours or after sunset, by chilling the building's A/C water instead of the using chillers, which account for 30-70% of the building's demand for electricity.


The system is modular and compact and can be retrofitted into any building that uses chilled water for cooling, turning it into a **large-scale energy storage asset**.

Wei-Tai Kwok
Managing Director
Thule Energy Storage

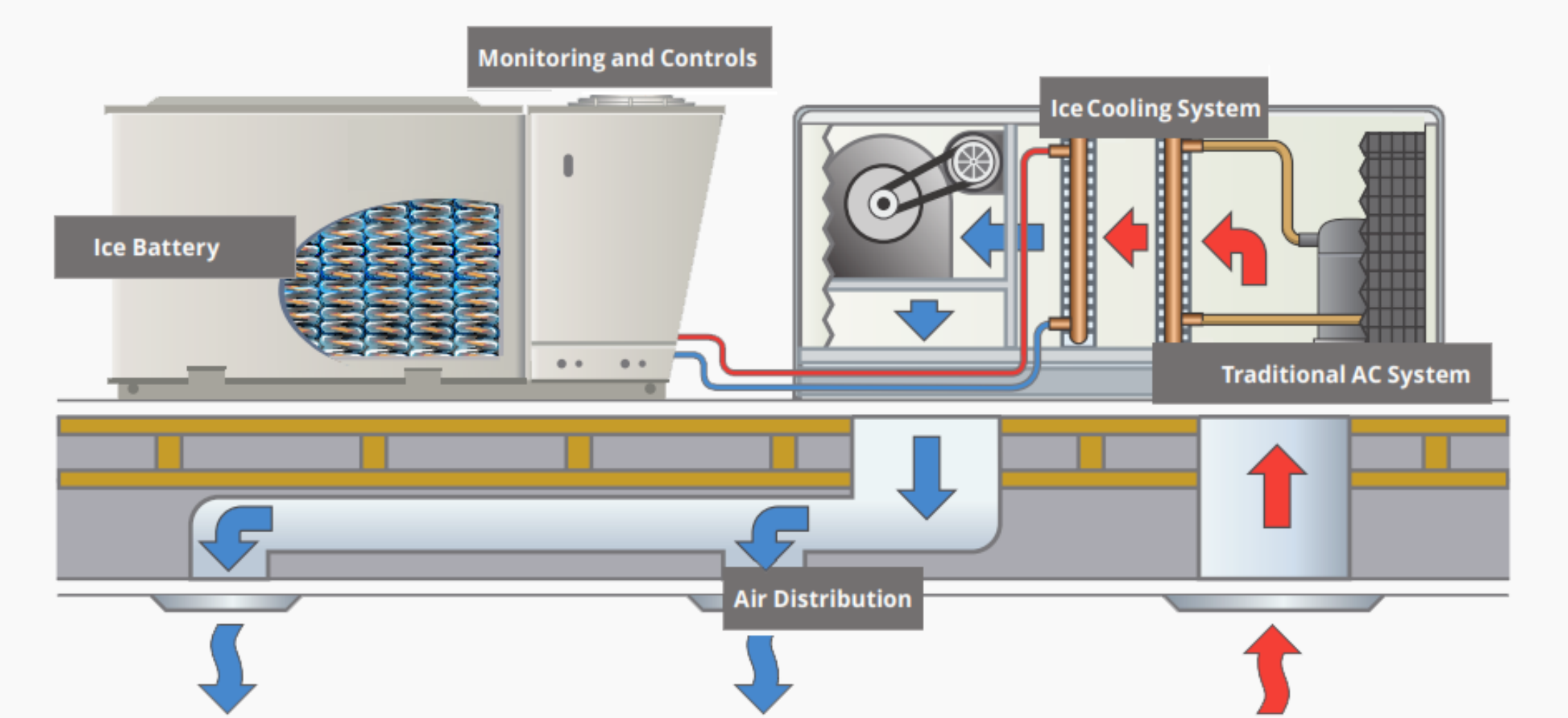
# Ice Storage in Residential and Commercial

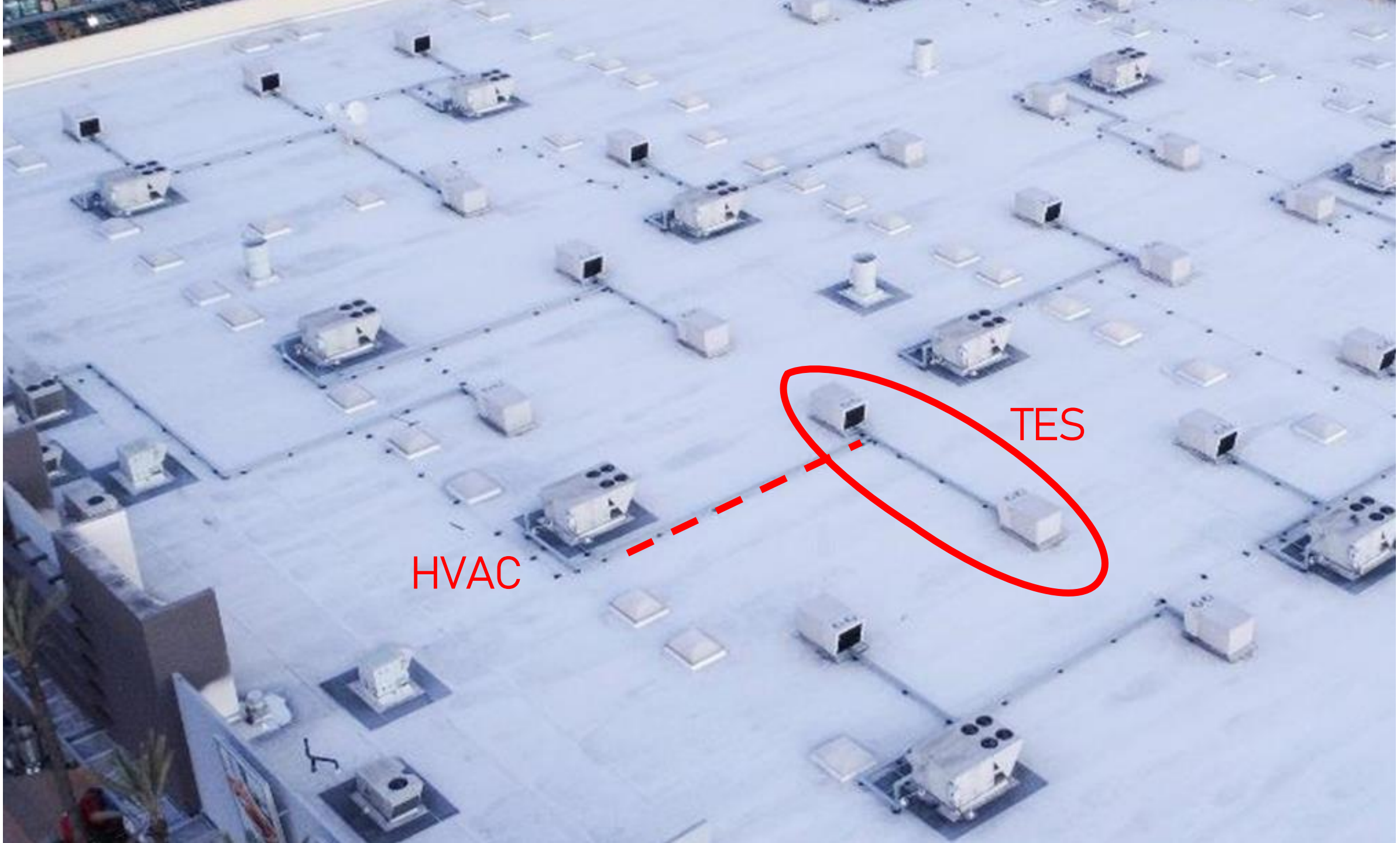


# Ice Cold Inside

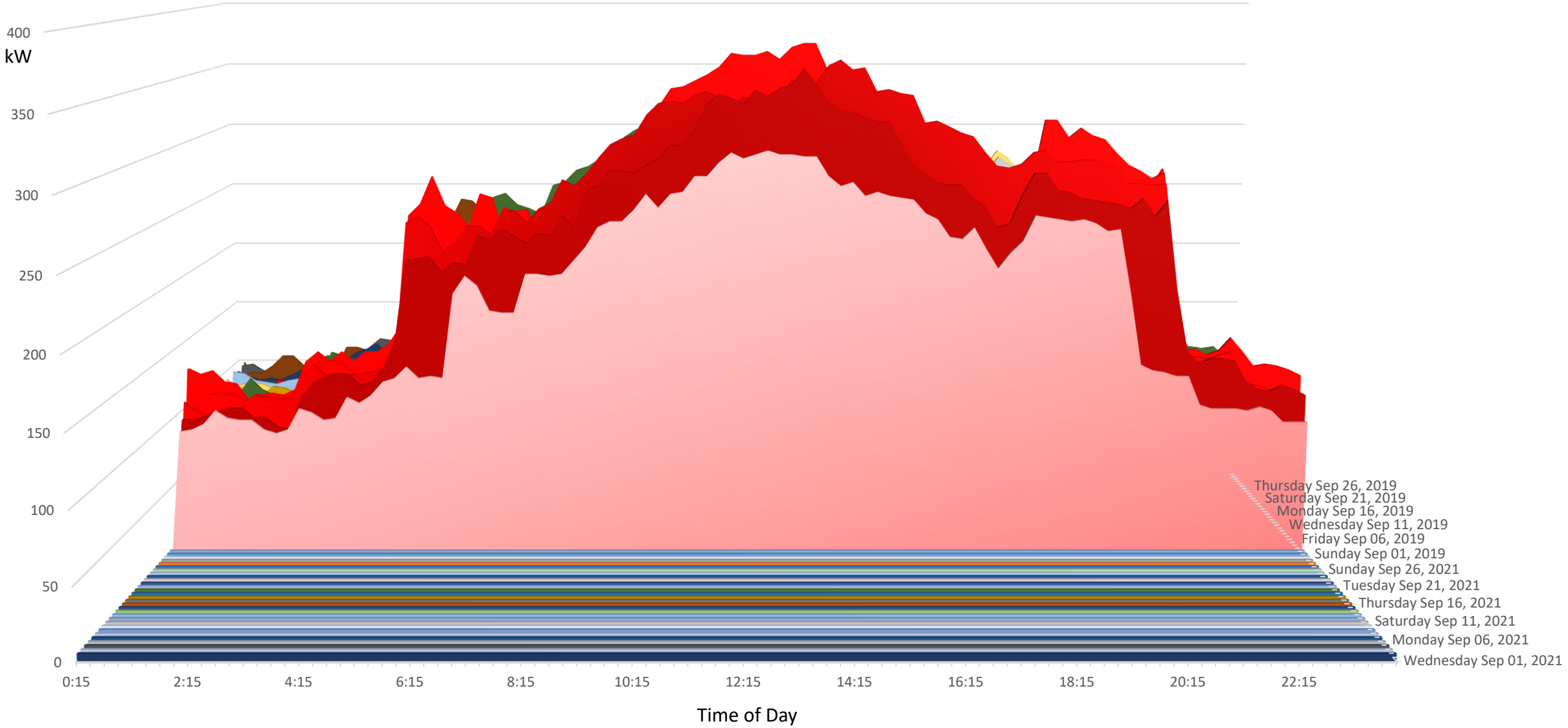
# Ice Cold Inside

# How it works

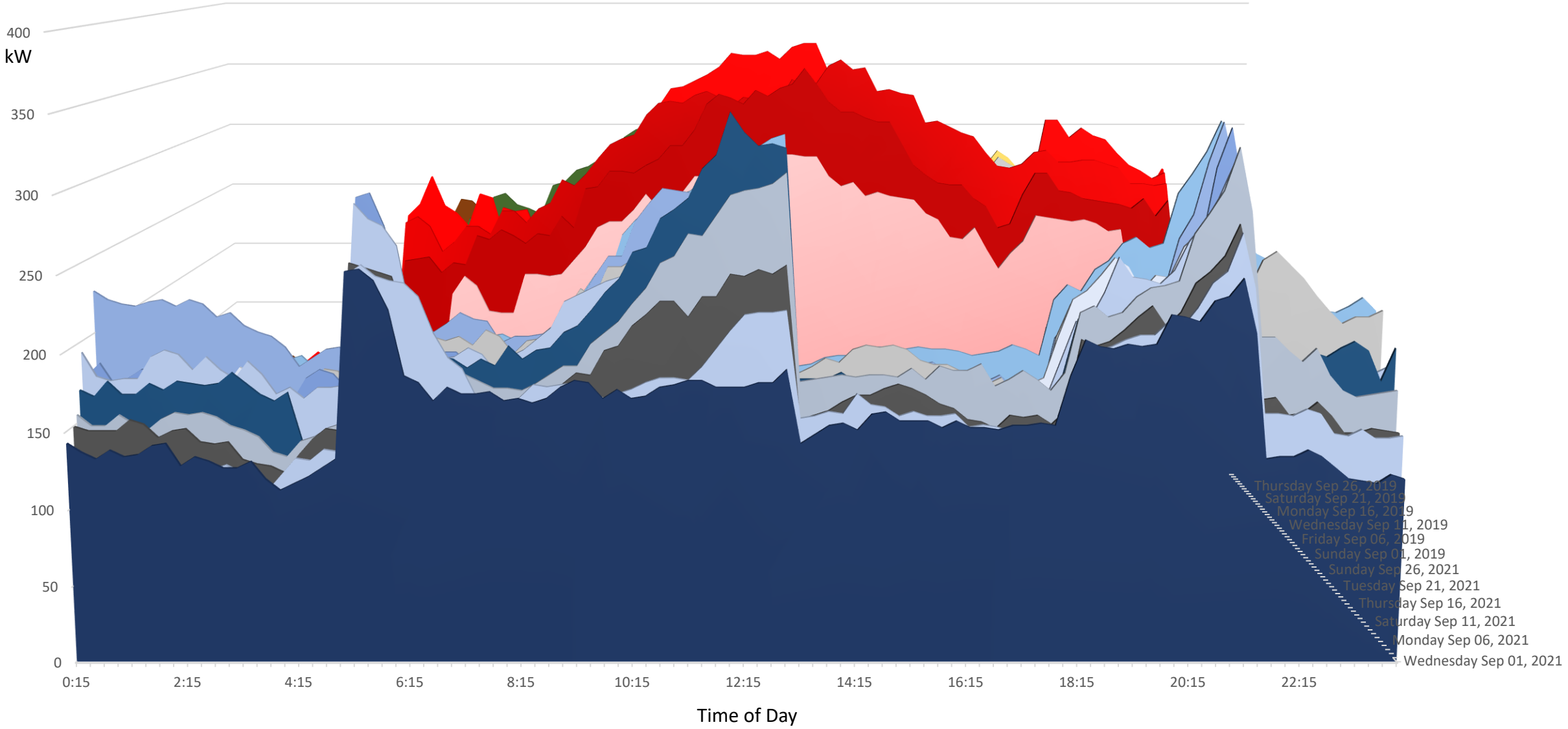

Monitoring and Controls
Ice Cooling System
Ice Battery
Traditional AC System
Air Distribution


TES
HVAC

# Before vs. After TES installation (in kW)



# Before vs. After TES installation (in kW)



# Questions?


Chilled or Hot Water Tanks for Campus-size Applications

Commercial & Industrial: Ice Thermal Storage


Commercial & Industrial: Encapsulated Ice

Commercial & Residential: Ice Energy Storage

# Thank you for joining us!

Please contact Samantha Slater at AHRI
for additional information (sslater@ahrinet.org)