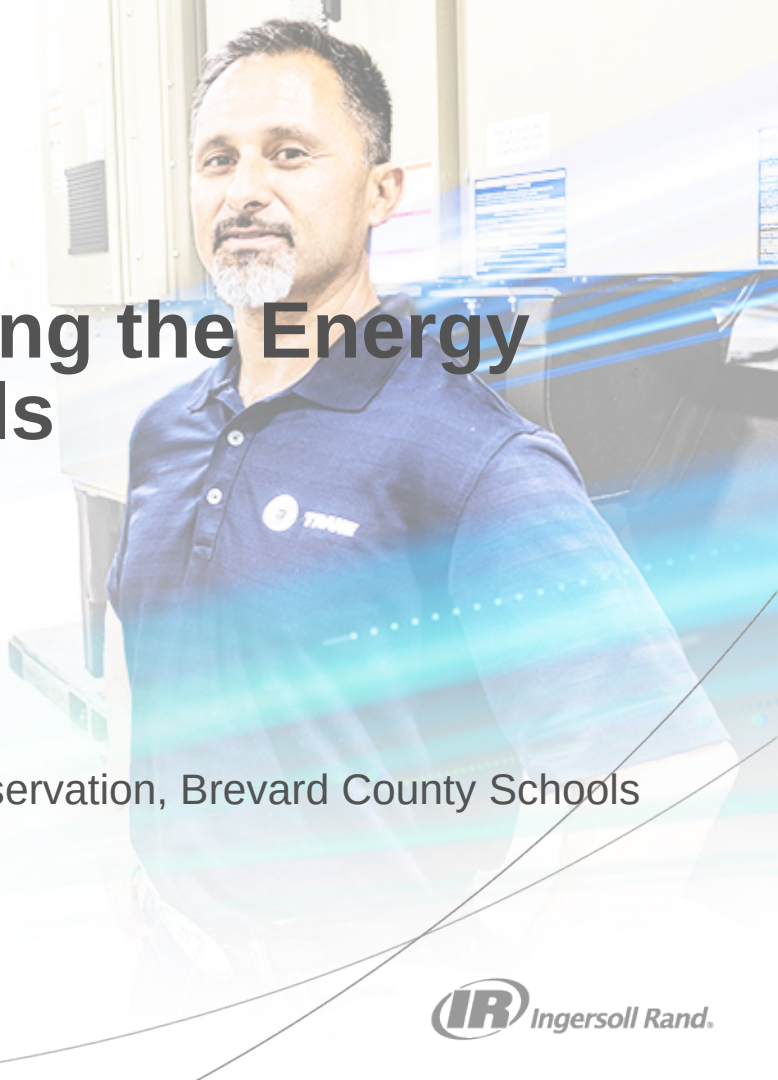
Thermal Batteries: Reducing the Energy Intensity of Florida Schools



- Mark Johnson, CALMAC Portfolio of Trane

- Joe Neri, Systems Sales Engineer, Trane

- Bruce Lindsay, Manager Energy and Resource Conservation, Brevard County Schools

EDUCATION PARTNER

COURSE TITLE

By Provider's Name

GBCI cannot guarantee that course sessions will be delivered to you as submitted to GBCI. However, any course found to be in violation of the standards of the program, or otherwise contrary to the mission of GBCI, shall be removed. Your course evaluations will help us uphold these standards.

Course ID: 0090010881

Approved for:

X

General CE hours

LEED GREEN ASSOCIATE ☐

LEED AP BD+C ☐

LEED AP HOMES ☐

LEED AP ID+C ☐

LEED AP ND ☐

LEED AP O+M ☐

Learning Objectives

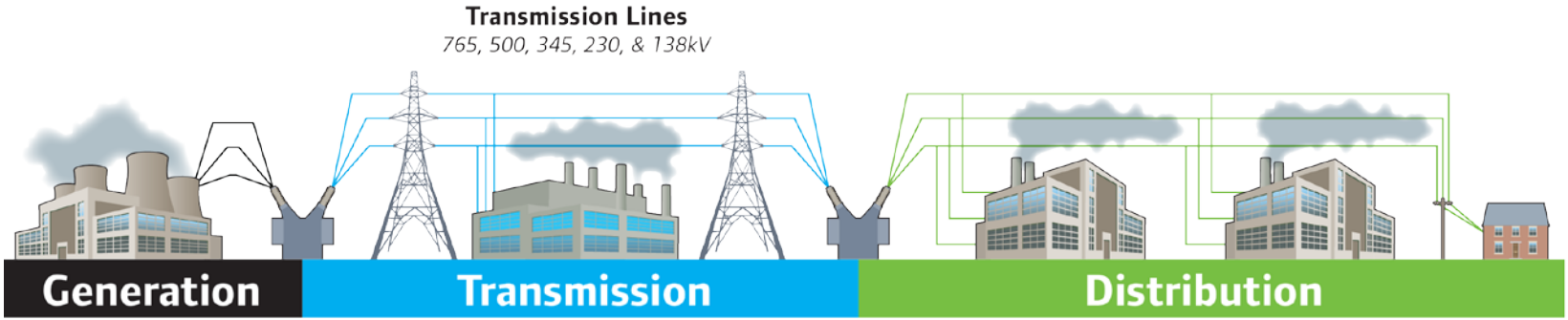
1. Describe why the cost of electricity is much less during off peak hours and how renewable wind and solar energy will reinforce this.
2. Describe why energy storage is a vital component for large scale deployment of renewables
3. Recognize the two major types of storage and how and where they are best applied in commercial buildings
4. Explain how energy storage relates to LEED and Zero Energy Buildings

Big Picture

- Electrical Grid is changing
  - Remote, smaller sources of generation
  - Direction of current
  - Ownership of inputs
  - More microgrids
  - More off the grid customers
  - More ‘Net Zero’ buildings
  - PV & Wind
  - Electric Cars

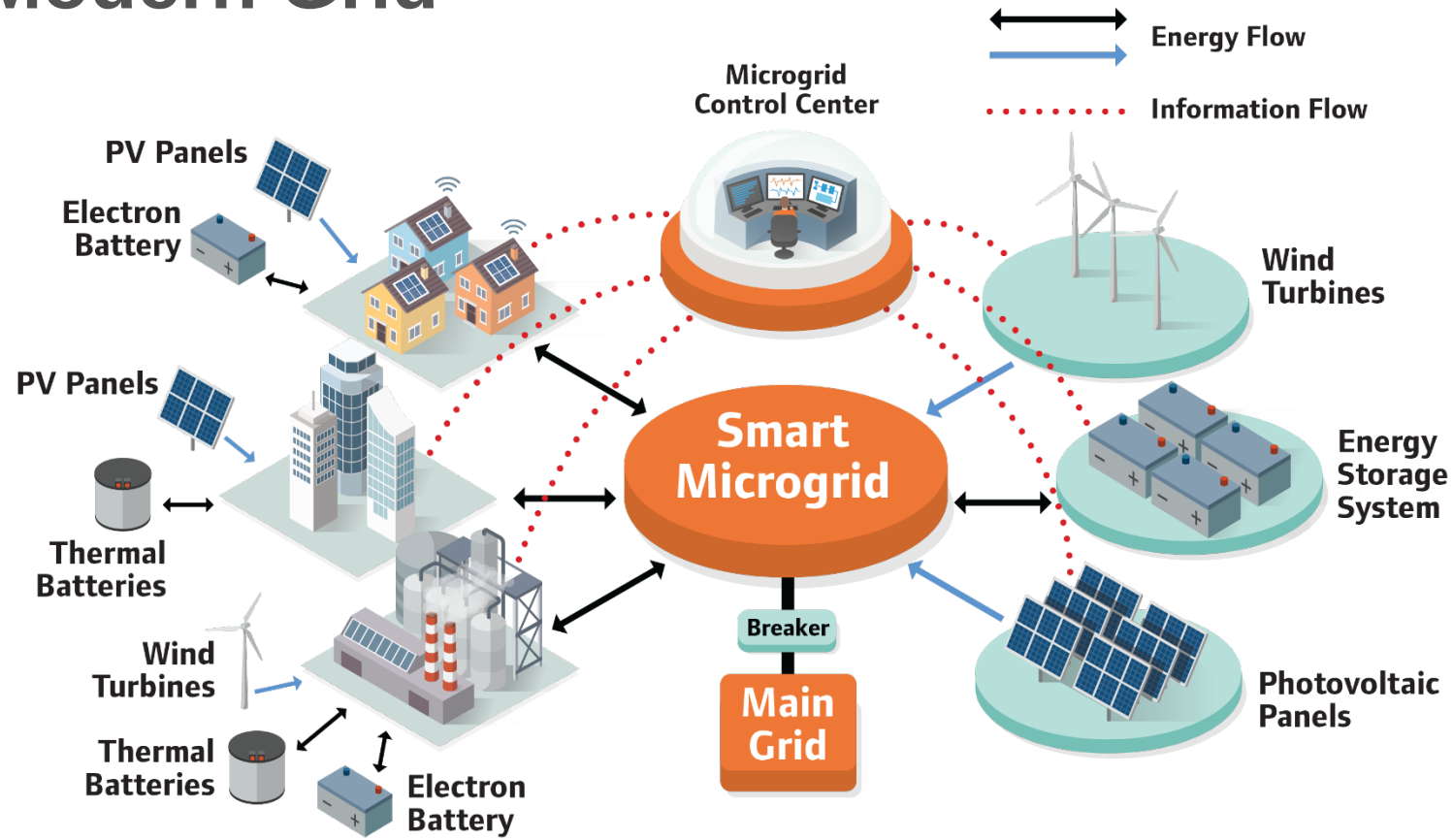
- Electricity is cheaper when?
  - When there is an abundance of supply – off peak
  - Now and in the future

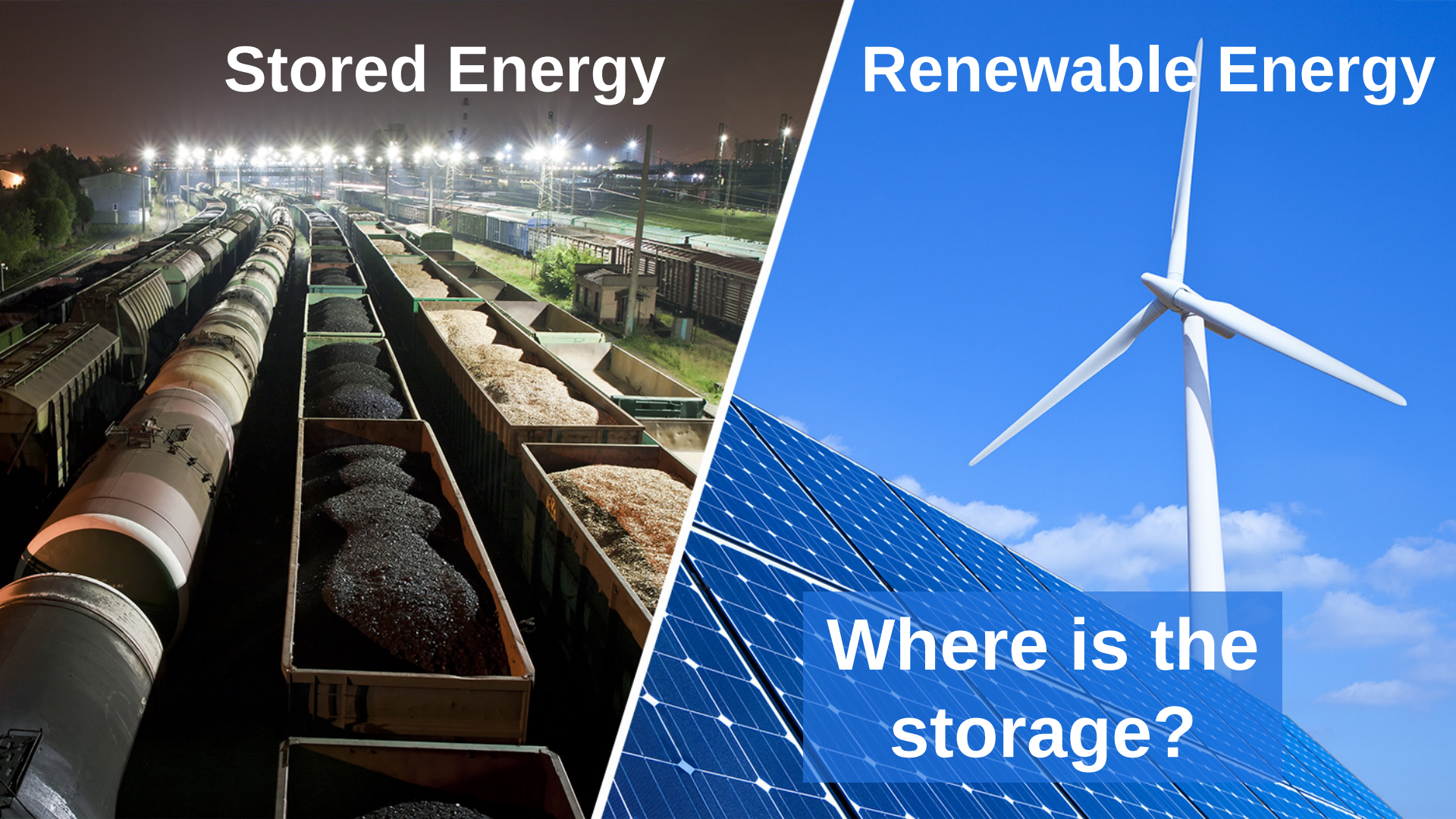
Old Grid



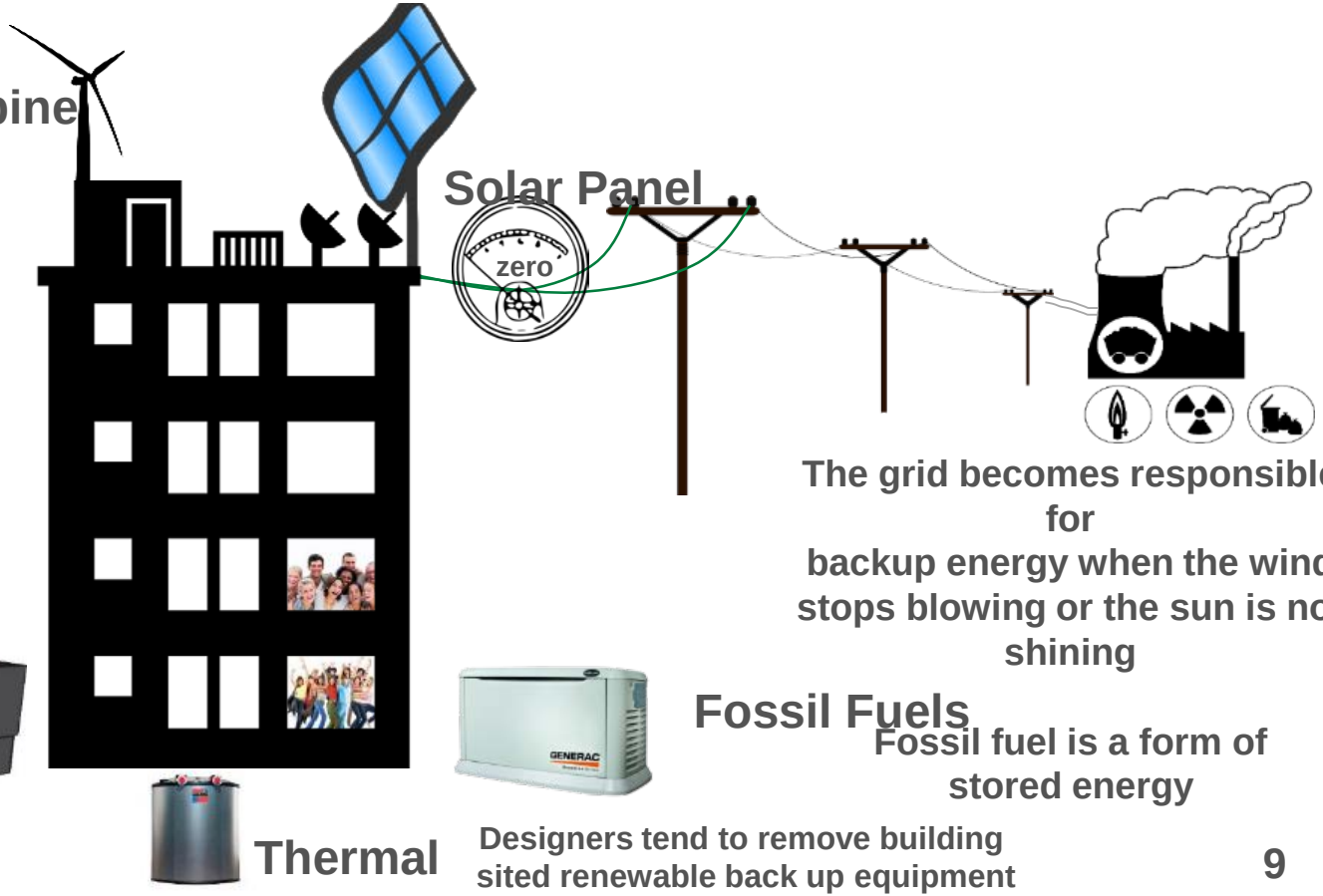
Energy flows mostly one way

Modern Grid


Energy Flow
Information Flow
Microgrid Control Center
PV Panels
Electron Battery
PV Panels
Thermal Batteries
Wind Turbines
Thermal Batteries
Electron Battery
Smart Microgrid
Breaker
Main Grid
Wind Turbines
Energy Storage System
Photovoltaic Panels


Stored Energy
Renewable Energy
Where is the storage?

Net Zero Grid Building



Batteries

The grid becomes responsible for
backup energy when the wind stops blowing or the sun is not shining

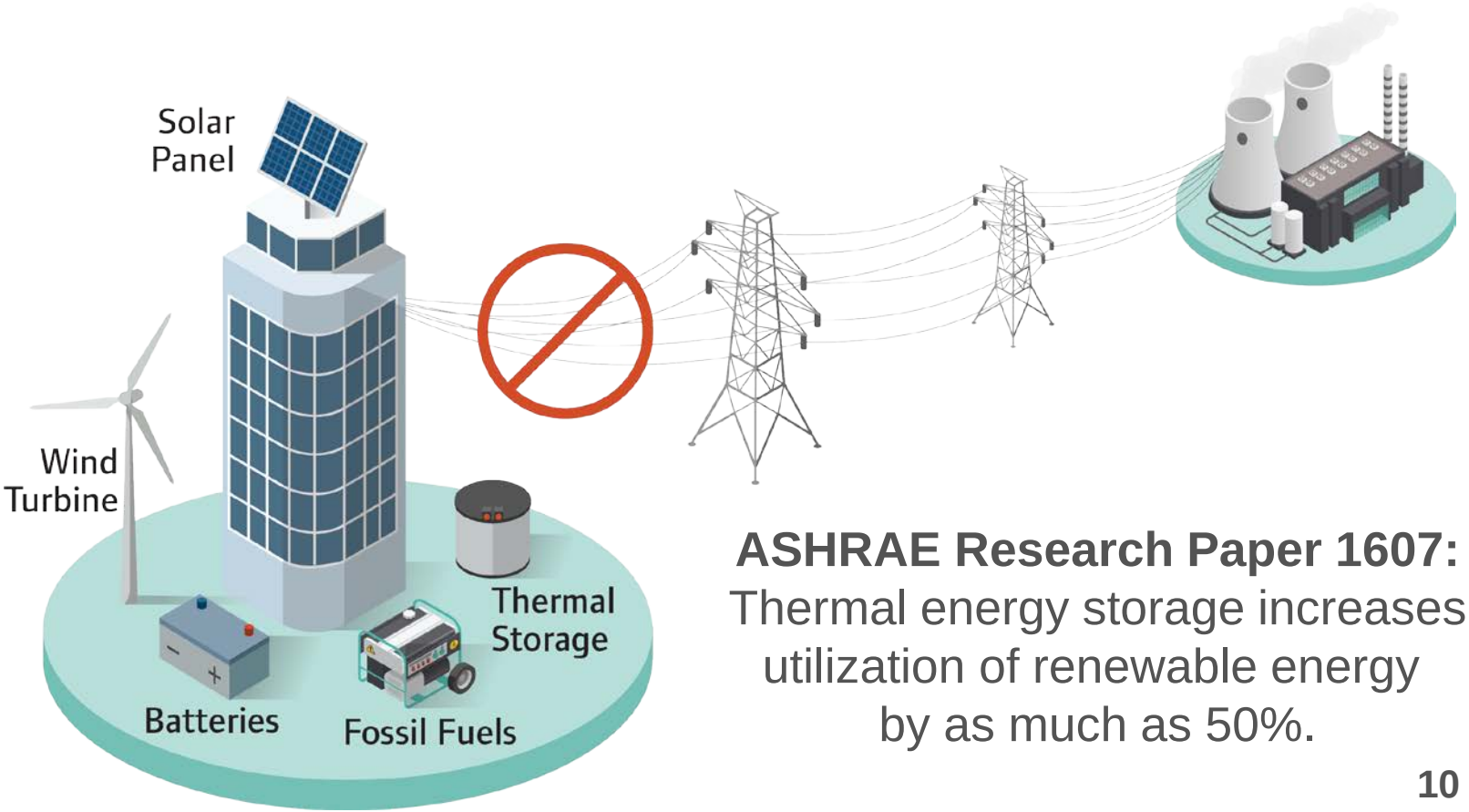
Fossil Fuels

Fossil fuel is a form of stored energy

Thermal

Designers tend to remove building sited renewable back up equipment

Net Zero Building



ASHRAE Research Paper 1607:
Thermal energy storage increases utilization of renewable energy by as much as 50%.

Florida Electricity costs

	FPL[1]	TECO[5]	Duke[4]	GRU[3]
On peak energy charge	$0.055/kwh	$0.067/kwh	$0.07/kwh	$0.13/kwh
Off peak energy charge	$0.0348/kwh	$0.067/kwh	$0.07/kwh	$0.03/kwh
On peak demand charge	$13.48/kW	$11.87/kW	$15.58/kW	$10.15/kW
Off Peak demand charge	$0/kW	$0/kW	$0/kW	$0.0/kW
Blended on peak energy charge[2]	$0.167/kwh	$0.165/kwh	$.20/kwh	$0.21/kwh
Off peak energy charge	$0.0348/kwh	$0.067/kwh	$0.07/kwh	$0.03/kwh
Discount for off peak	**79%**	**59%**	**65%**	**87%**

1 – GSLDT rate (TOU)
2 – blend on peak demand charge into energy charge
3 – GSDT rate (TOU)
4 – GSD rate (non TOU)
5 – GSD rate (non TOU)
6 – does not include franchise fees, taxes

Daytime

$ 3.00/gallon

Nighttime

$ 1.20/gallon

When Would you Fill-up?

Utility Rebates to use MORE off peak (less on peak) Energy with Thermal Batteries

- FPL
  - $600/kW (pays for most or all of the cost of the thermal batteries!)
- TECO
  - $200/kW
- Duke
  - $350/kW

Stable Electric Rates

Edison Electric Institute stated that the only form of Energy that has stayed the same cost or gone down in last 30 to 40 years has been

Off-Peak Electricity

Texas – Free energy

- RTP pricing option; pricing can go negative when there’s too much wind power being added to the grid!

How to use more energy off peak - Basic Thermal Storage

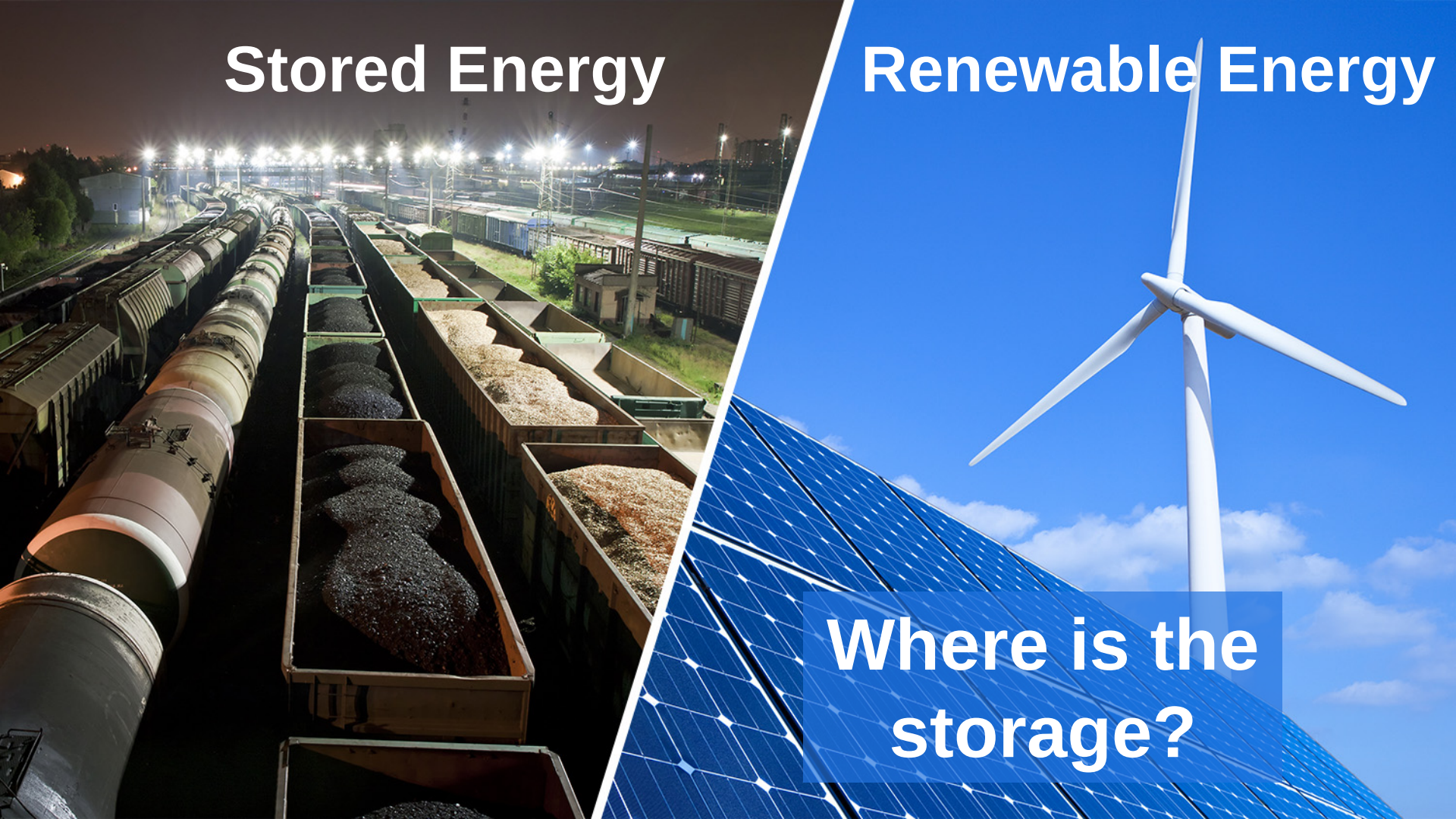
Thermal Storage Basics

How many lbs. of ice do you need for each person for a party? **~1 lbs.**

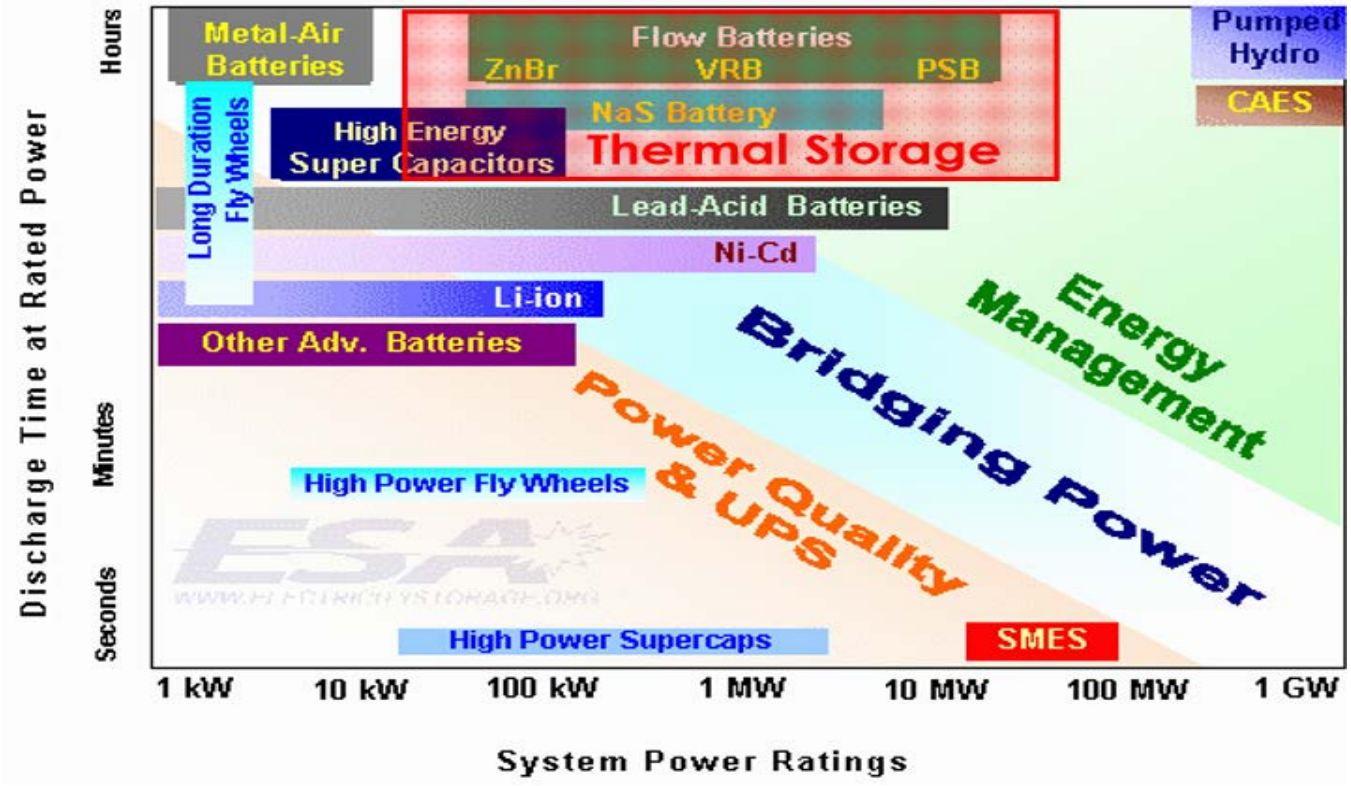
How many lbs. of ice do you need each day to cool each person in a typical office building?

Architect	**100 ft²/per person**	**200 ft²/per person**	
Engineer	**300 ft²/ton**	**400 ft²/ton**	**500 ft²/ton**

100 ft²/pp / 400 x 8hr = 2 ton-hrs = 160 lbs of Ice/Person/Day
200 ft²/pp / 400 x 10hr. = 5 ton-hrs = 400 lbs of Ice/Person/Day

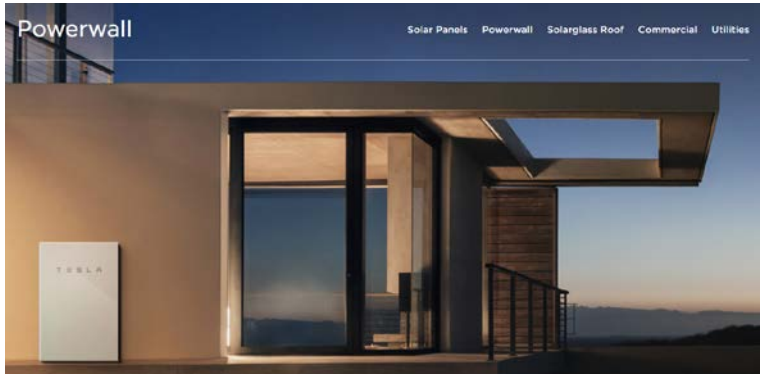

Stored Energy
Renewable Energy
Where is the storage?

Energy Storage Types



*Energy Storage Association

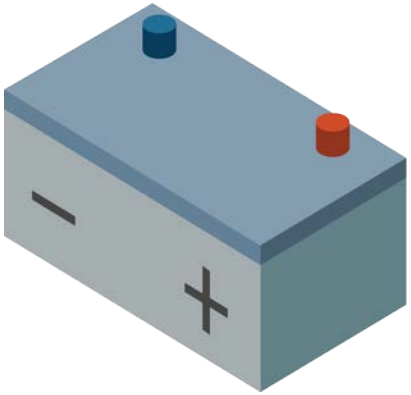
TESLA


Powerwall
Solar Panels
Powerwall
Solarglass Roof
Commercial
Utilities
TESLA


TESLA
TESLA

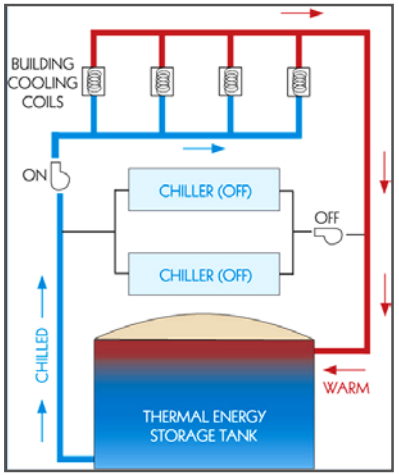
Customer Side (of meter) Energy Storage Technologies

Battery



Thermal Energy Storage

(TES) Hot, Cold or Ice, Active or Passive



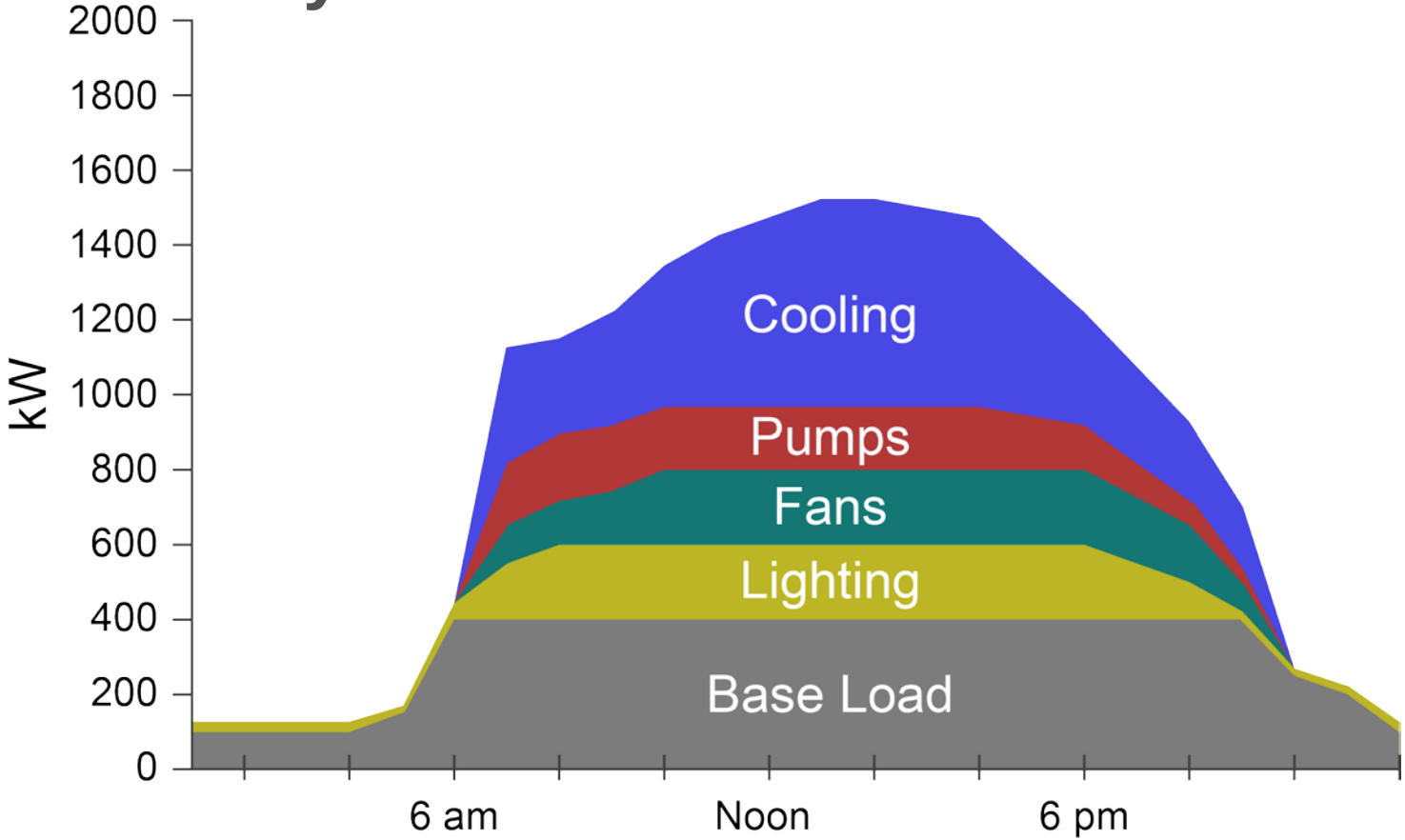
100 kW
700 kwh storage

Comparison: Energy Storage Options

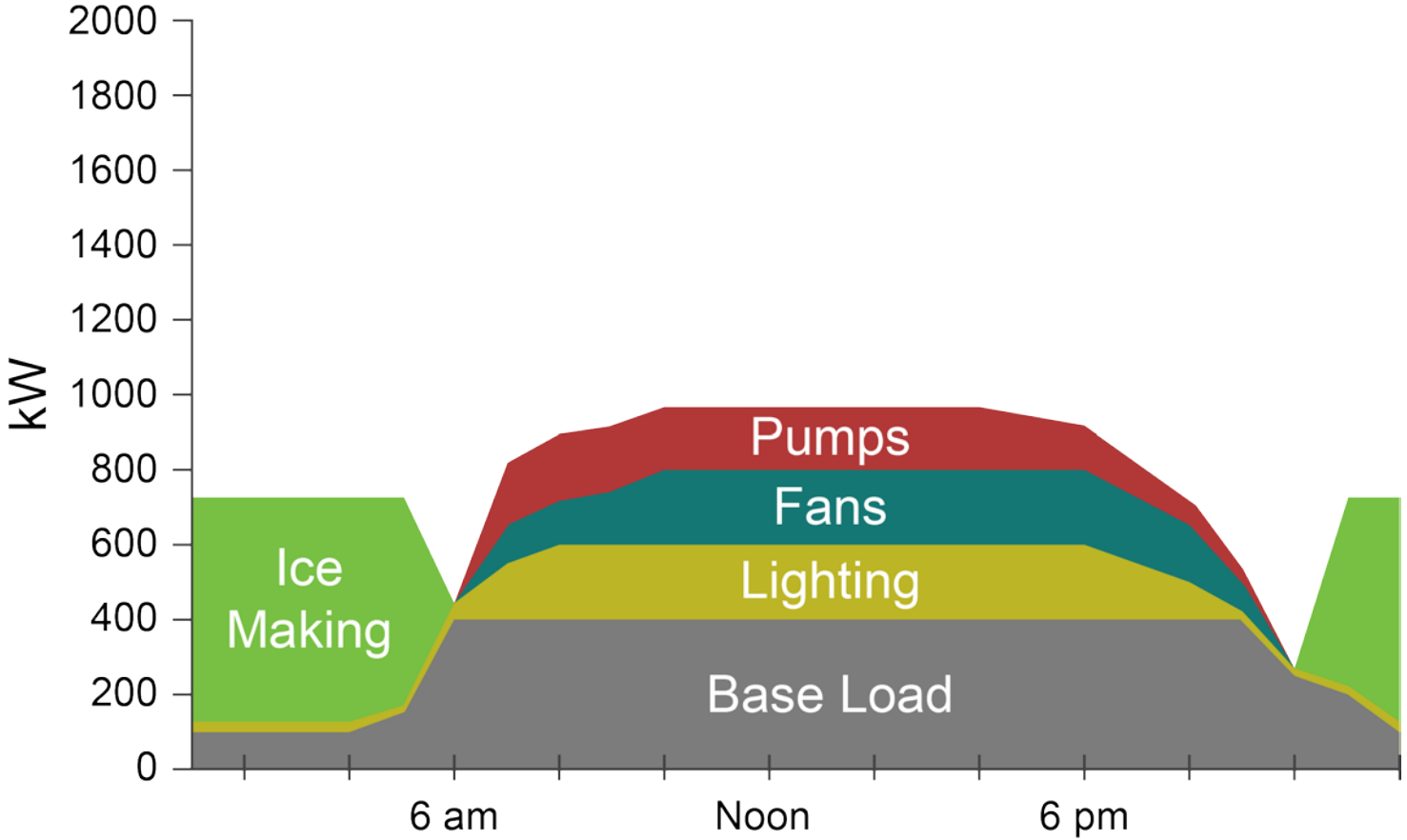
Energy Storage Technology	Tech Maturity	Useful Eff (%)	Life (Yrs.)	Capital Costs ($/kWh)
~~Pumped Hydro~~	~~mature~~	~~70-80~~	~~40+~~	~~310-380~~
Na-S Batteries	mature	80	5	650-700
Lead-acid Batteries	mature	85-90	7-15	500-750
Li-Ion Batteries	new	80-90	7-10	450-1125
~~Flywheels~~	~~new~~	~~90~~	~~20~~	~~7800-9000~~
~~Compressed Air~~	~~demo~~	~~70-80~~	~~40+~~	~~80-150~~
Thermal Storage	**mature**	**90-100+/-**	**50+**	**30-500**

Thermal Energy Storage (TES) has low initial cost, high efficiency, and longer useful life

Electric Load Profile – Energy Intensity



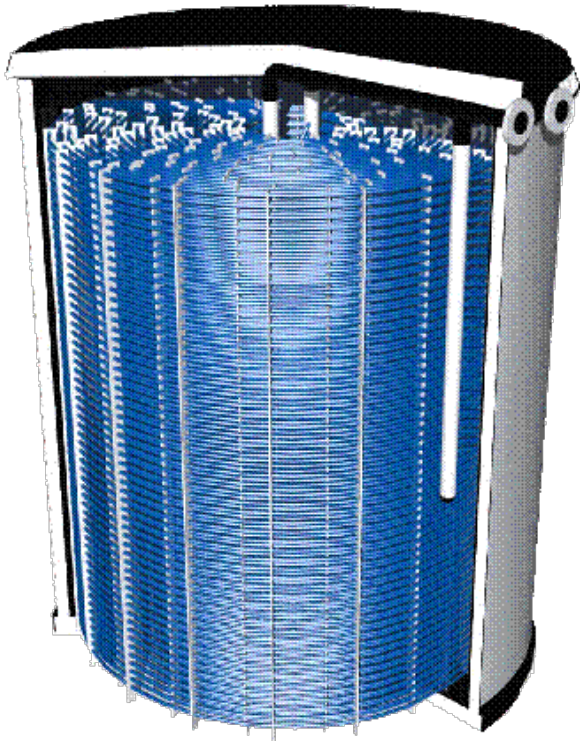
Electric Load Profile



Cool Storage Systems

Two Basic Systems:

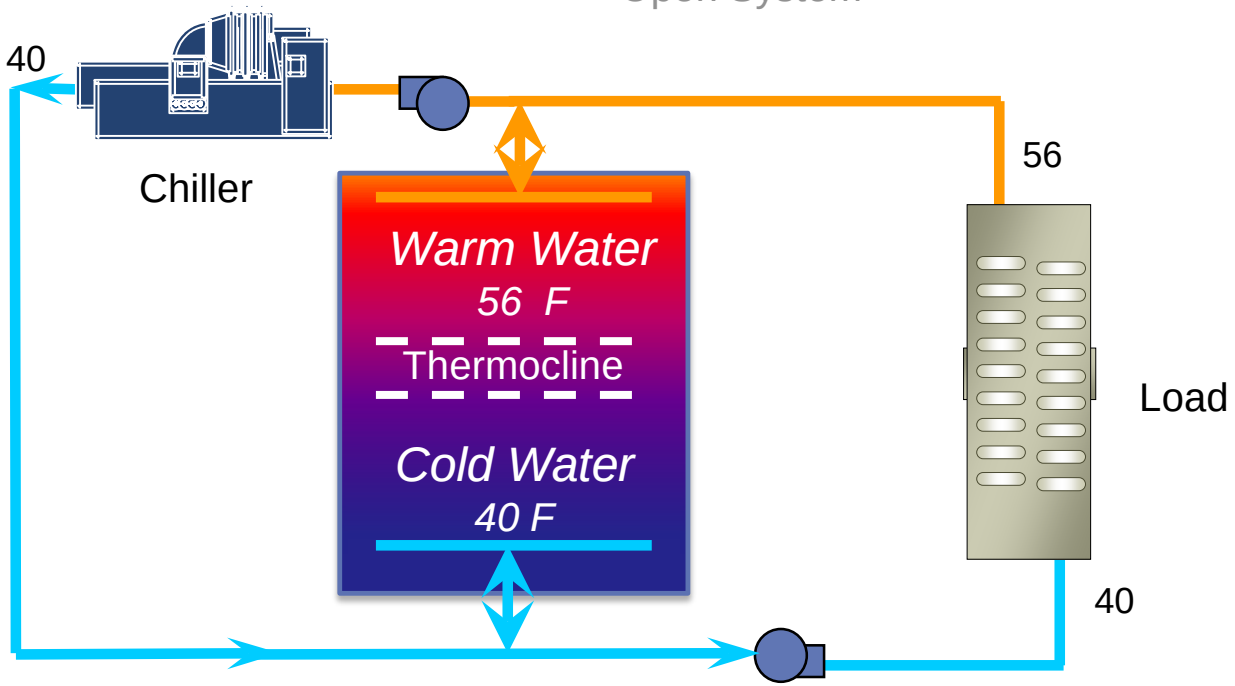
- Water
- Ice



Water Storage

So what is “Different”?

Storage Tank
Keeping System delta T is a must
Open System

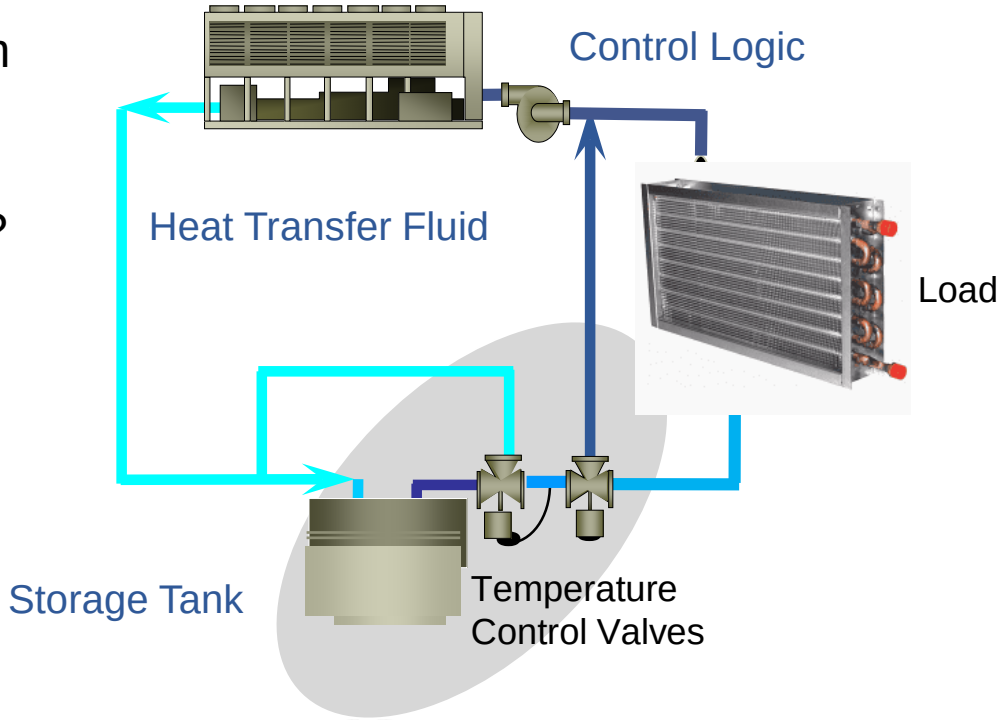


Ice Storage Systems

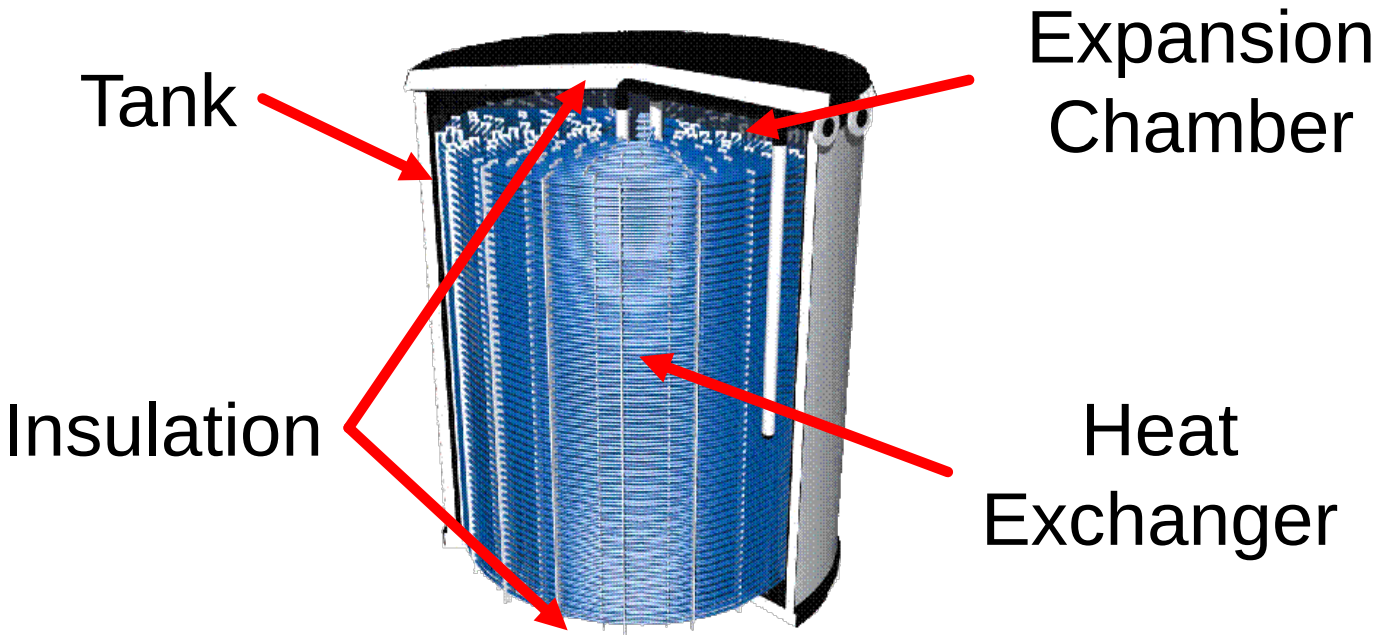
Chiller Based System

Closed System

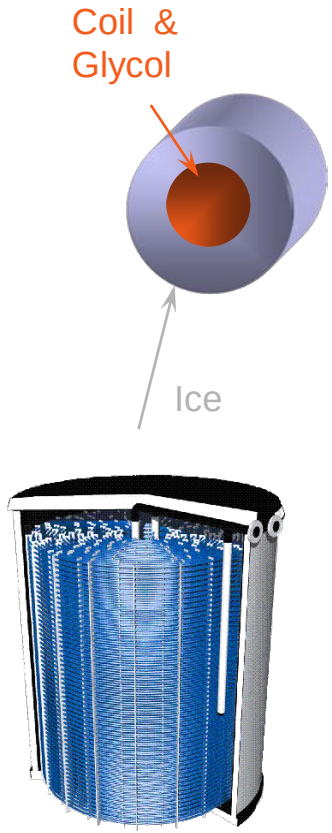
So What is Different?

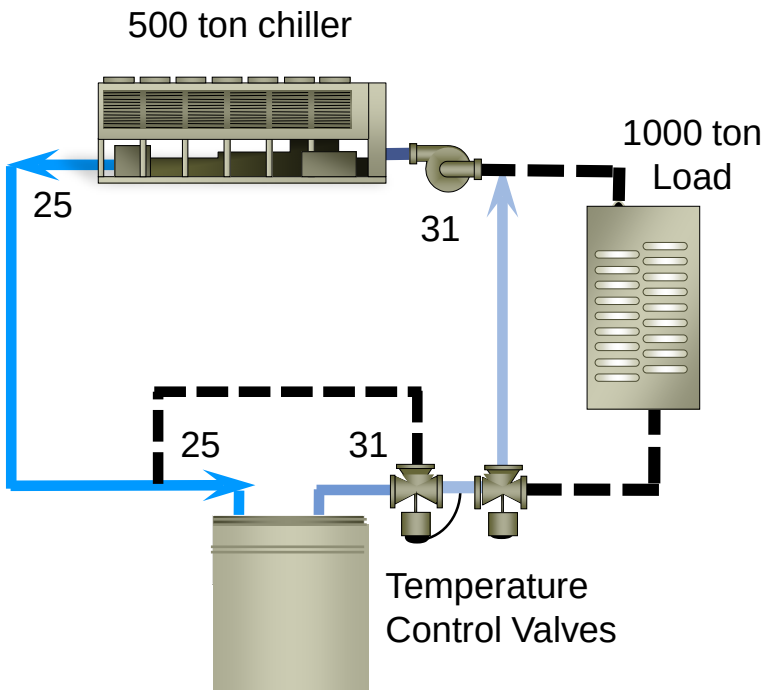


Thermal Battery: Ice-on-Coil Internal Melt

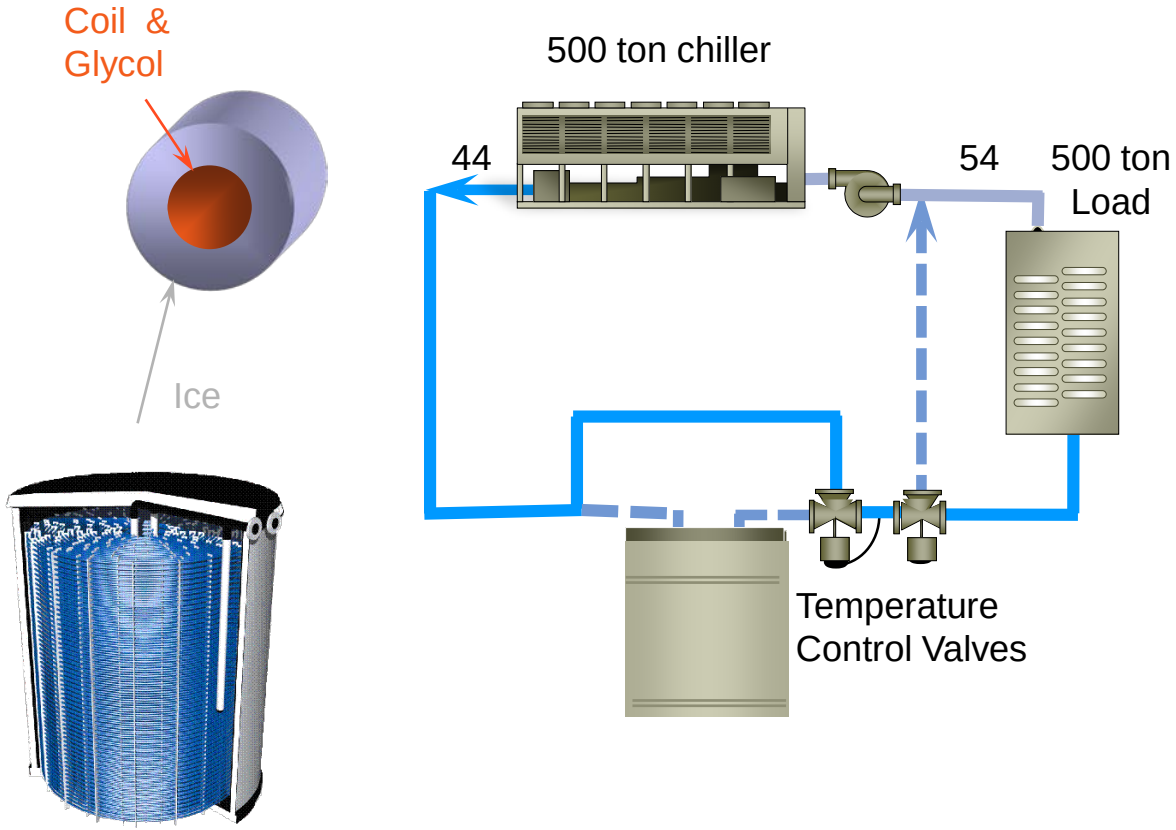


Ice Making

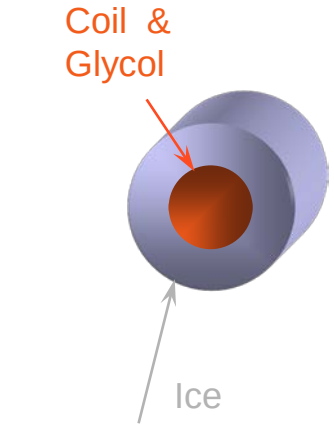

Coil &
Glycol
Ice

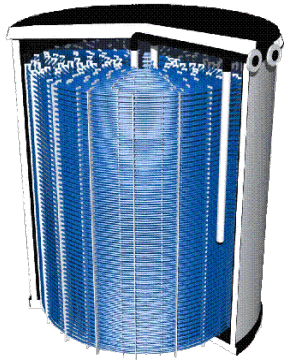

500 ton chiller
1000 ton
Load
25
31
25
31
Temperature
Control Valves

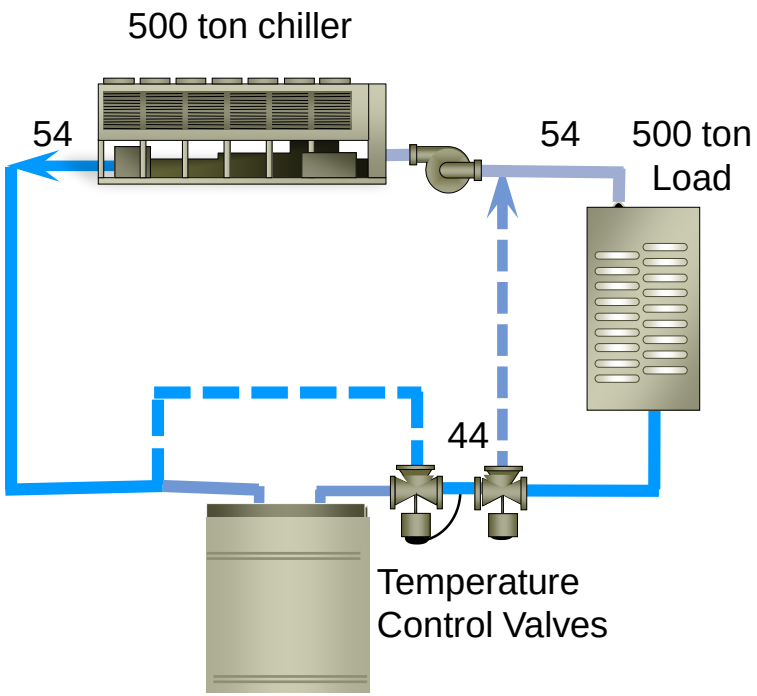
Direct Cooling – Chiller



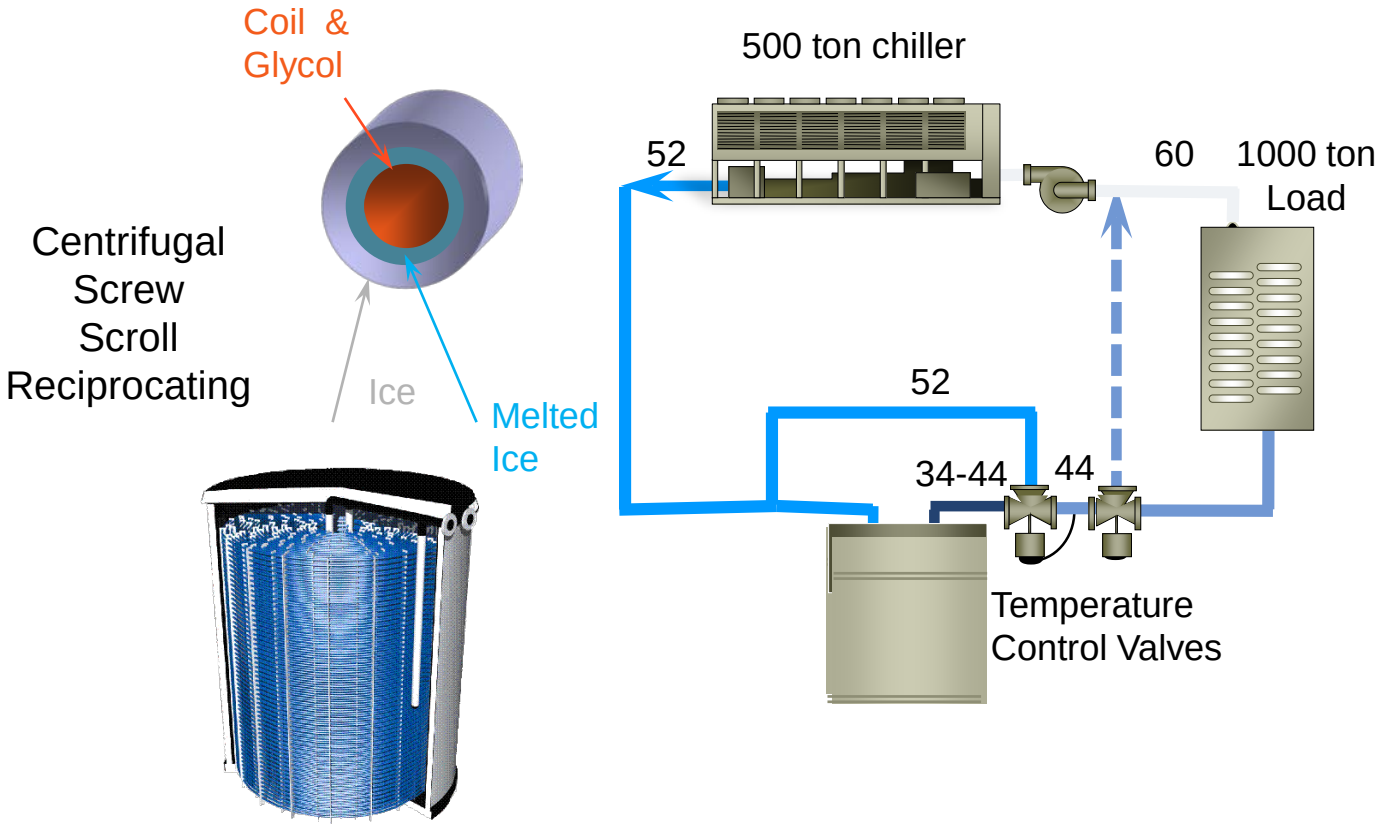
Direct Cooling – Ice







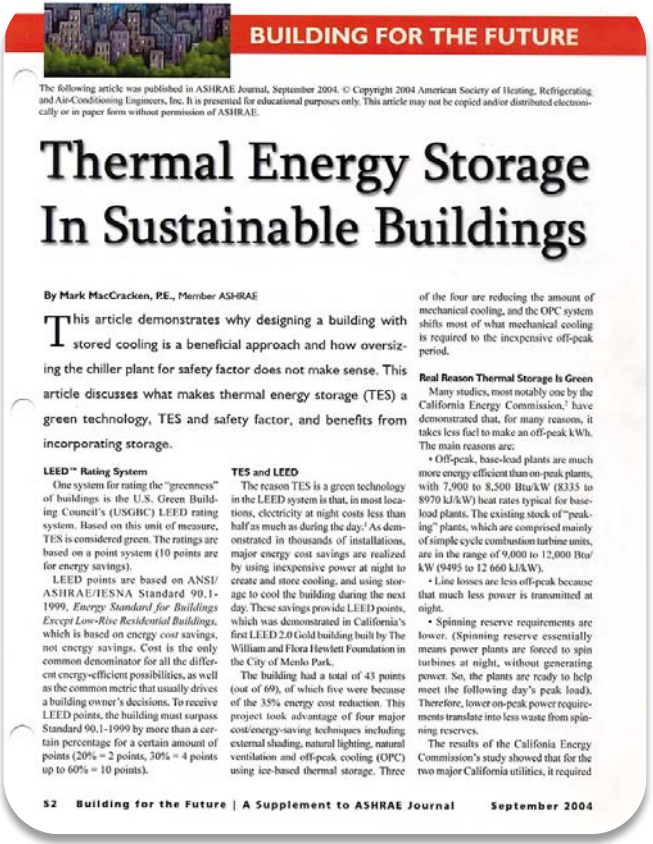
Chiller & Ice Cooling



School Installations in Florida – over 150 by CALMAC

- Sarasota County
- St Lucie County
- Lee County
- Collier County
- Hillsborough County
- St. Lucie County
- Martin County
- Palm Beach County
- Broward County
- Flagler County
- St. John's County
- Charlotte County
- Brevard County

For more on Renewables and Thermal Batteries & LEED



BUILDING FOR THE FUTURE

Thermal Energy Storage In Sustainable Buildings

By Mark MacCracken, P.E., Member ASHRAE

This article demonstrates why designing a building with stored cooling is a beneficial approach and how oversizing the chiller plant for safety factor does not make sense. This article discusses what makes thermal energy storage (TES) a green technology, TES and safety factor, and benefits from incorporating storage.

LEED™ Rating System

One system for rating the "greenness" of buildings is the U.S. Green Building Council's (USGBC) LEED rating system. Based on this unit of measure, TES is considered green. The ratings are based on a point system (10 points are for energy savings).

LEED points are based on ANSI/ASHRAE/IESNA Standard 90.1-1999, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, which is based on energy *cost* savings, not energy savings. Cost is the only common denominator for all the different energy-efficient possibilities, as well as the common metric that usually drives a building owner's decisions. To receive LEED points, the building must surpass Standard 90.1-1999 by more than a certain percentage for a certain amount of points (20% = 2 points, 30% = 4 points up to 60% = 10 points).

TES and LEED

The reason TES is a green technology in the LEED system is that, in most locations, electricity at night costs less than half as much as during the day.[1] As demonstrated in thousands of installations, major energy cost savings are realized by using inexpensive power at night to create and store cooling, and using storage to cool the building during the next day. These savings provide LEED points, which was demonstrated in California's first LEED 2.0 Gold building built by The William and Flora Hewlett Foundation in the City of Menlo Park.

The building had a total of 43 points (out of 69), of which five were because of the 35% energy cost reduction. This project took advantage of four major cost/energy-saving techniques including external shading, natural lighting, natural ventilation and off-peak cooling (OPC) using ice-based thermal storage. Three of the four are reducing the amount of mechanical cooling, and the OPC system shifts most of what mechanical cooling is required to the inexpensive off-peak period.

Real Reason Thermal Storage Is Green

Many studies, most notably one by the California Energy Commission,[2] have demonstrated that, for many reasons, it takes less fuel to make an off-peak kWh. The main reasons are:

- Off-peak, base-load plants are much more energy efficient than on-peak plants, with 7,900 to 8,500 Btu/kW (8335 to 8970 kJ/kW) heat rates typical for base-load plants. The existing stock of "peaking" plants, which are comprised mainly of simple cycle combustion turbine units, are in the range of 9,000 to 12,000 Btu/kW (9495 to 12 660 kJ/kW).
- Line losses are less off-peak because that much less power is transmitted at night.
- Spinning reserve requirements are lower. (Spinning reserve essentially means power plants are forced to spin turbines at night, without generating power. So, the plants are ready to help meet the following day's peak load). Therefore, lower on-peak power requirements translate into less waste from spinning reserves.

The results of the California Energy Commission's study showed that for the two major California utilities, it required

Go to www.calmac.com for pdf of article

Questions?

Joe Neri: joe.neri@trane.com
Mark Johnson: mjohnson@calmac.com
Bruce Lindsay: Lindsay.Bruce@brevardschools.org