



**Capitalize • Optimize • Market Wise**

## **Thermal Storage for Peak Load Shifting at Commercial Sites**

# Topics



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Energy Storage Defined

Energy Loads and Peak Demand

Types of Energy Storage and How They Compare

Market Size

How Ice Systems for Thermal Storage Work

Compatibility of Thermal Storage with Renewables

Benefits

Implementation Criteria

# Energy Storage

Off-grid energy storage is used to shift peak demand

Energy is generated and stored off peak

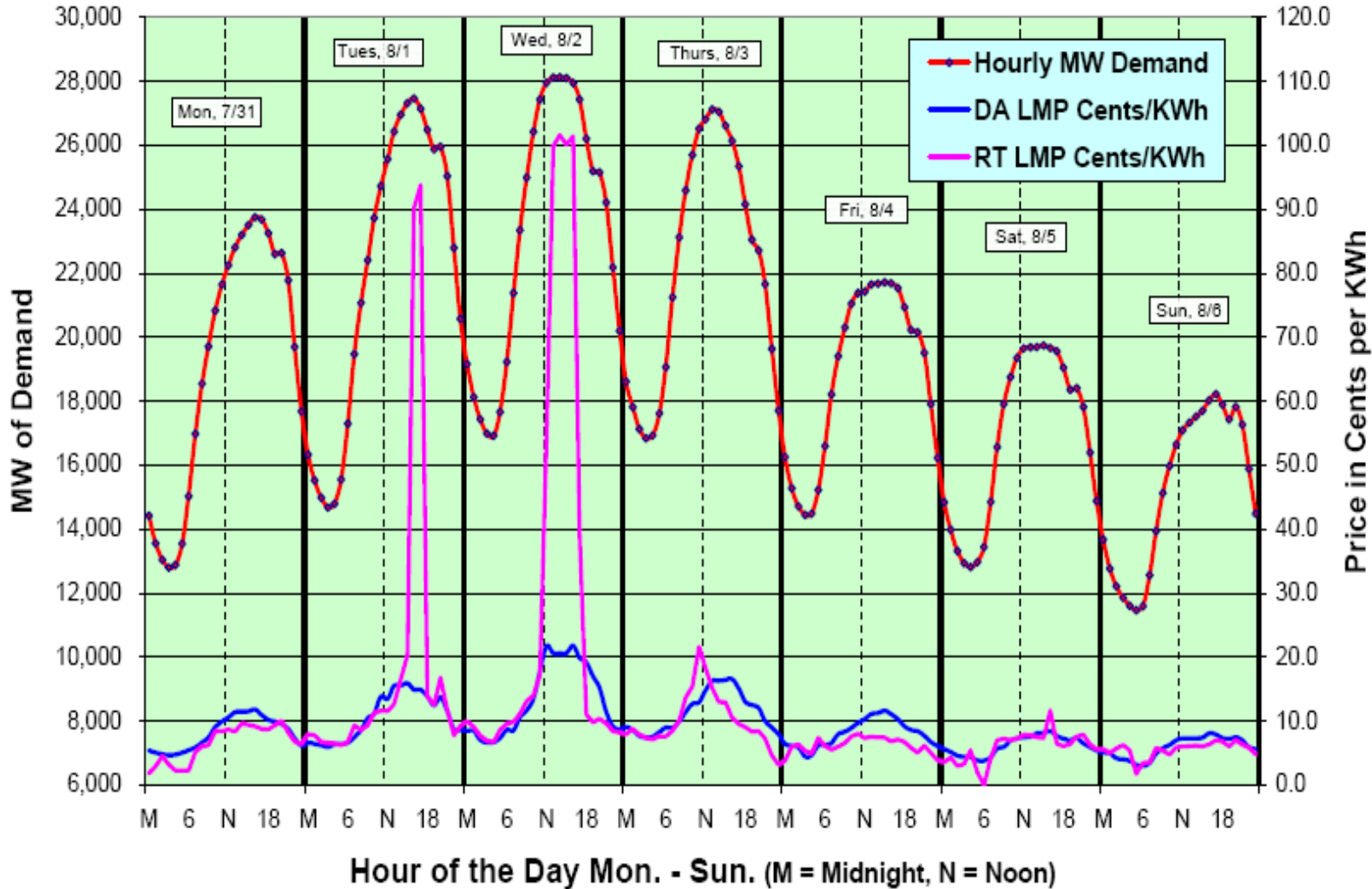
- Off- peak electricity up to 70% less expensive
- The stored energy is used during peak hours

Various technologies are mature and viable today

Emerging technologies are attracting attention and investment

# ISO-NE Demand & Price

## Week of 7/31-8/06/06



Graph by Clifton Below, NHPUC, from: 2006\_smd\_hourly.xls, available at: [http://www.iso-ne.com/markets/hstdata/znl\\_info/hourly/index.html](http://www.iso-ne.com/markets/hstdata/znl_info/hourly/index.html)

# Motivation for Reducing Peak Demand



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In 2009, Brattle Group quantified the value of cutting 5 percent of peak load in the United States

- \$66 billion over a 20-year period
- Savings from avoided generation, T&D, energy

The current aim of the DR community is to cut U.S. peak load by 9 percent

Energy storage for load balancing is a potentially vital part of reducing peak demand

# 4 Main Technologies for Energy Storage

## 1. Batteries – convert chemical energy to electricity

- Lithium Ion batteries - generally expensive, high maintenance, limited lifespans
- Flow batteries use tanks of electrolytes, relatively low cost, less likely to overheat
- Liquid metal batteries
- Advanced batteries



## 2. Fly-wheel systems - store kinetic energy

- Accelerate a rotor to very high speed
- When energy is extracted from the system, the rotational speed is reduced
- Conventional systems have short storage capacity



# Reduce Peak Demand Using Energy Storage



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## 3. Pumped Hydro – potential energy stored using elevation

- Water pumped from a lower reservoir to higher reservoir
- Low-cost off-peak electric power is used to run the pumps
- During periods of high demand, the stored water is released through turbines to produce electric power
- Highest capacity grid storage to date



## 4. Thermal Storage – reservoirs store thermal energy for later use.

- Ice
- Molten salt
- Eutectic
- Others



# Thermal Storage with Ice Systems

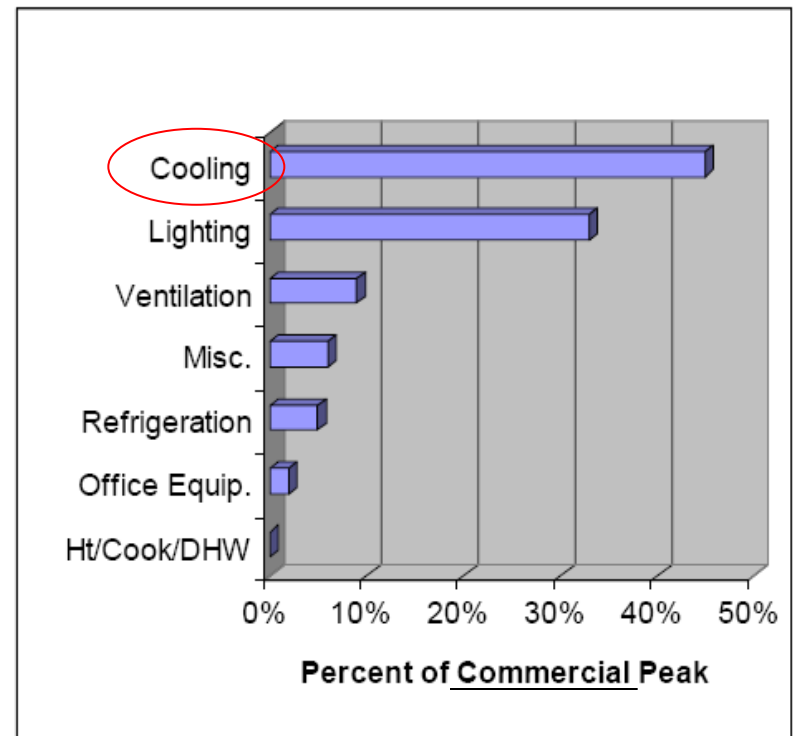
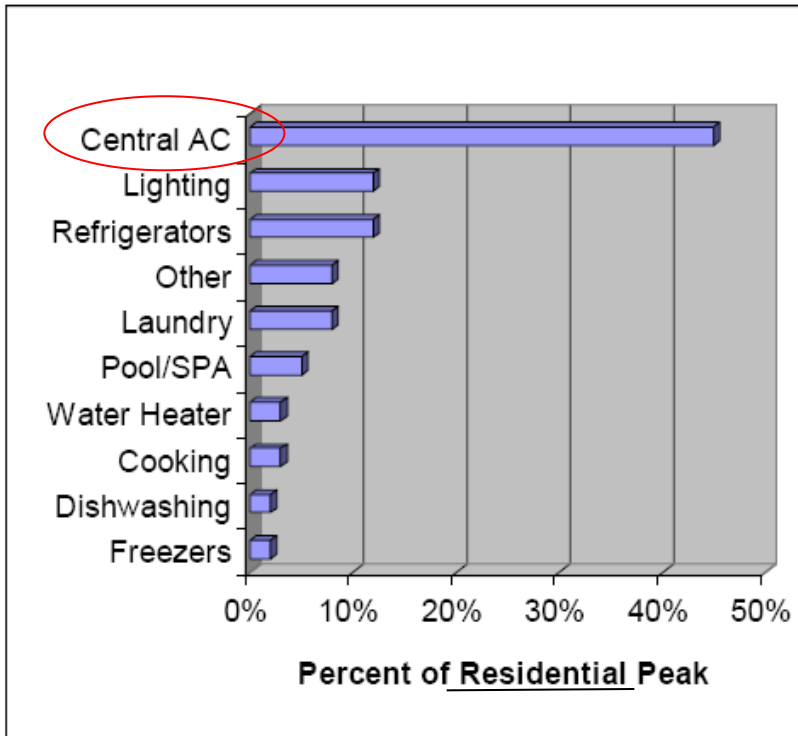
Ice systems use the latent heat of fusion of water to store cooling capacity

Principal application for ice systems: production of ice at night for use in air conditioning systems during the day.

Ice Storage shifts load for thousands of commercial AC cooling units to off-peak hours

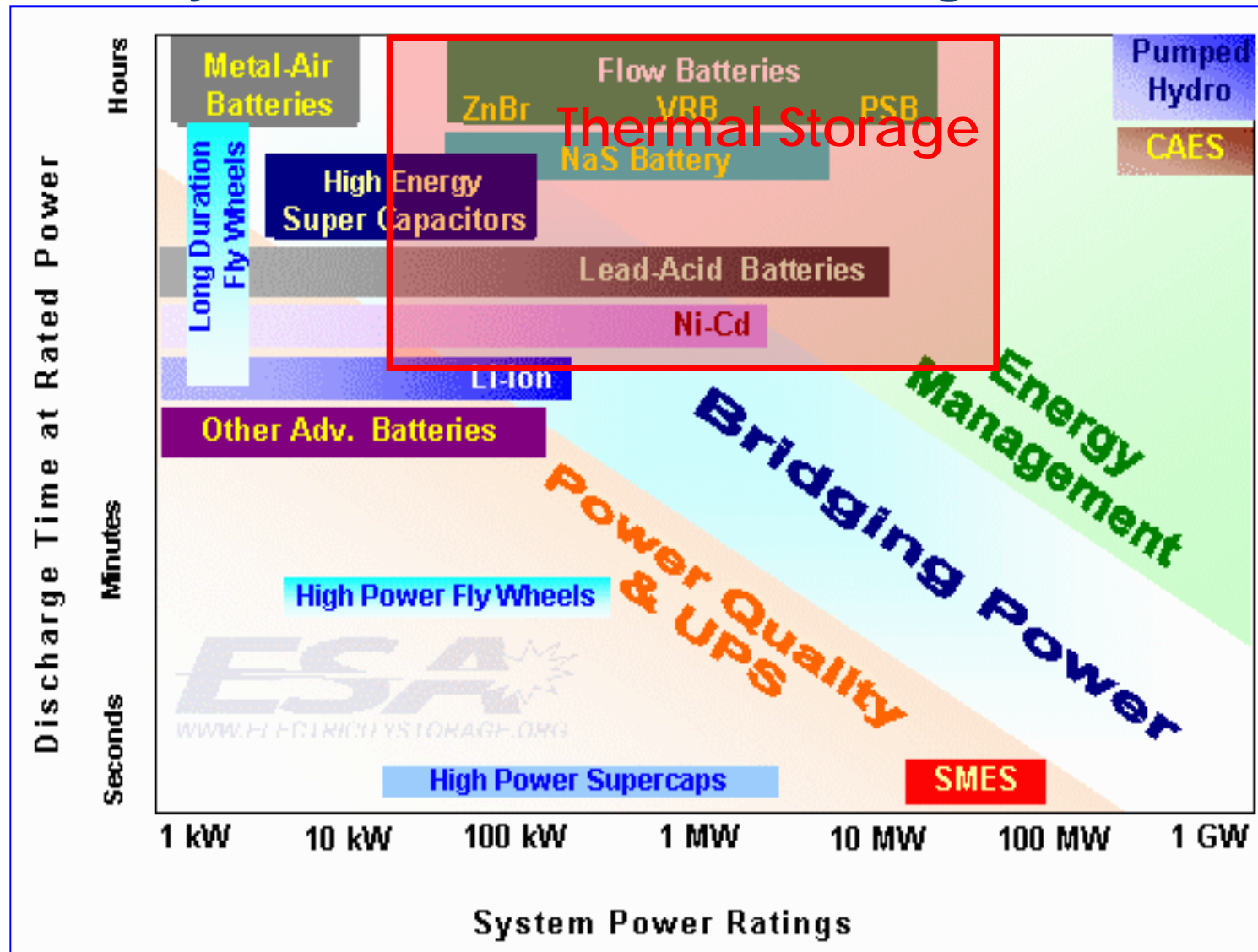
- Reduces peak demand by 40-50%
- Improves system load factor
- Improves overall electric system efficiency and power quality
- Reduces electric system costs
- Among most economical means of storage for commercial sites

# Sources of Peak Demand



- Building A/C is the big demand hog
- 12 GW On-Peak Demand for Building A/C in the U.S.
- 10% of building annual kW-hours, 45% of building peak demand

# Comparison of Energy Storage Technologies: System Power vs. Discharge Time



# Cost Comparison of Energy Storage Technologies



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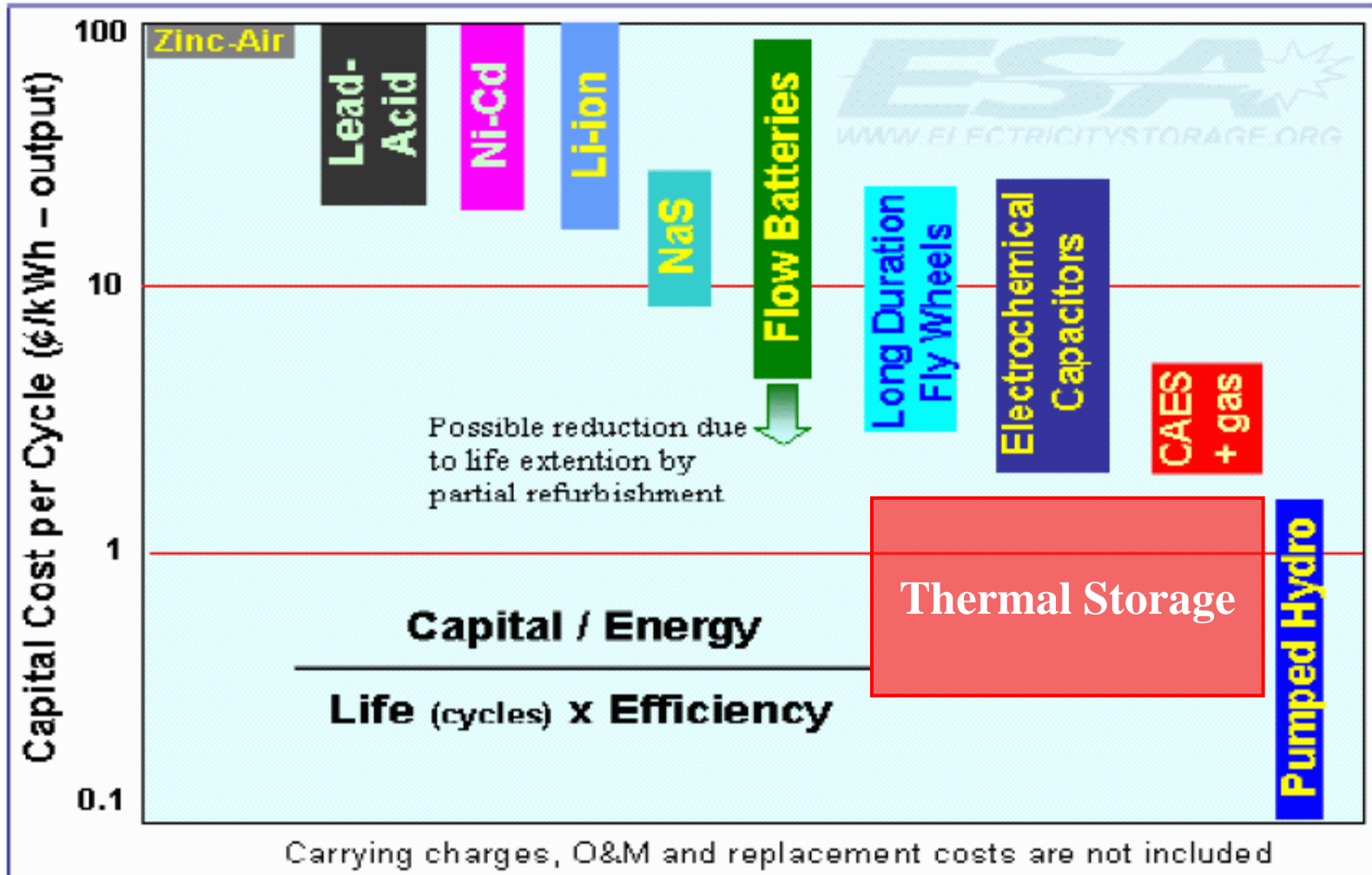


Figure 2: Capital Costs of Different Energy Storage Technologies<sup>4</sup>

# Off-Grid Energy Storage Market

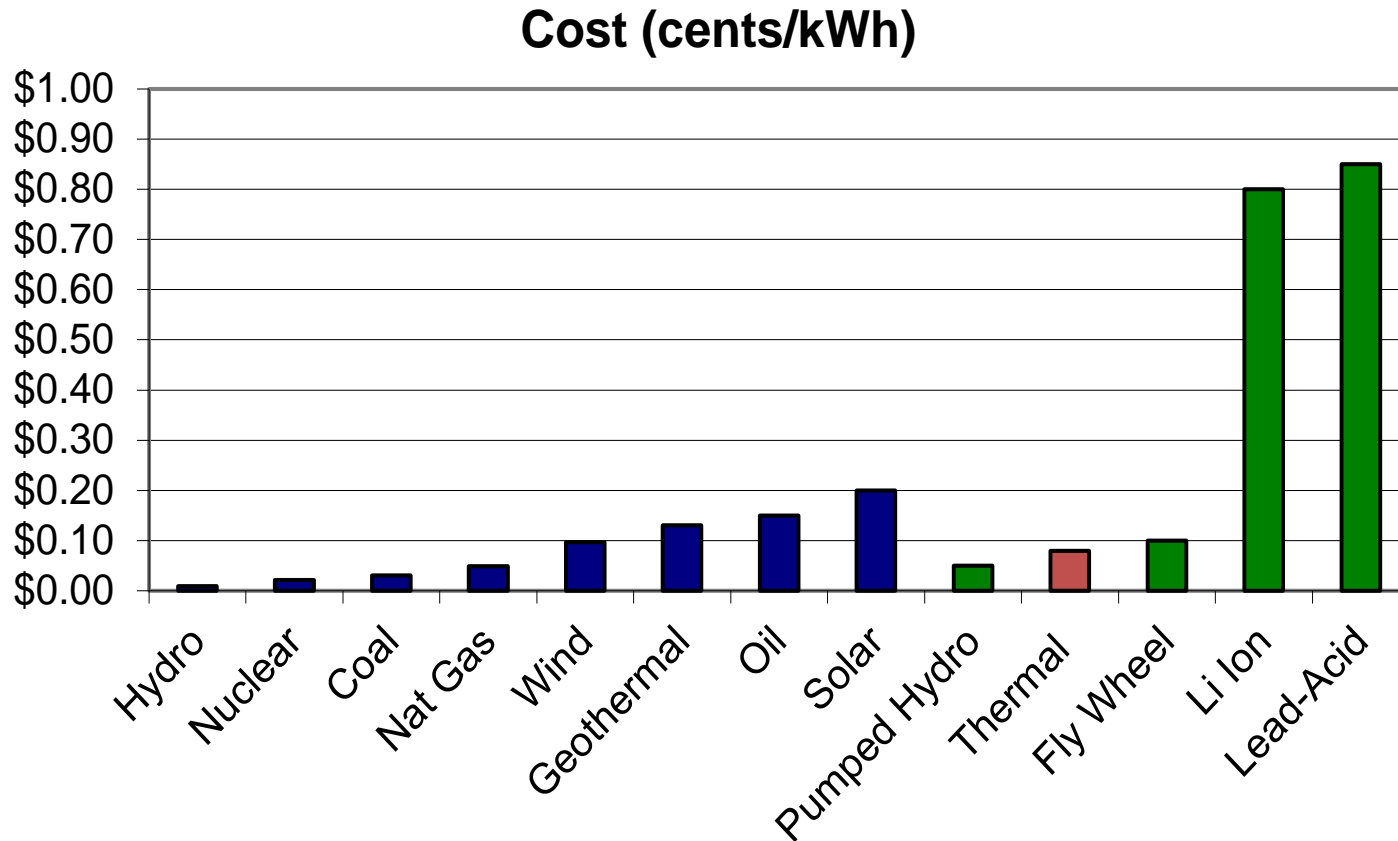
## Current Market

- 2,500 MW installed
  - advanced batteries
  - flywheels
  - thermal energy storage
  - etc.
- Total size of U.S. market: \$9.9B
- Emerging technologies \$1.3B (of total)

## Market Projections (Lux Research)

- By 2016, market will grow to \$13.5B
- Emerging technologies could triple in next 5 years to \$4B

# Production & Storage Cost



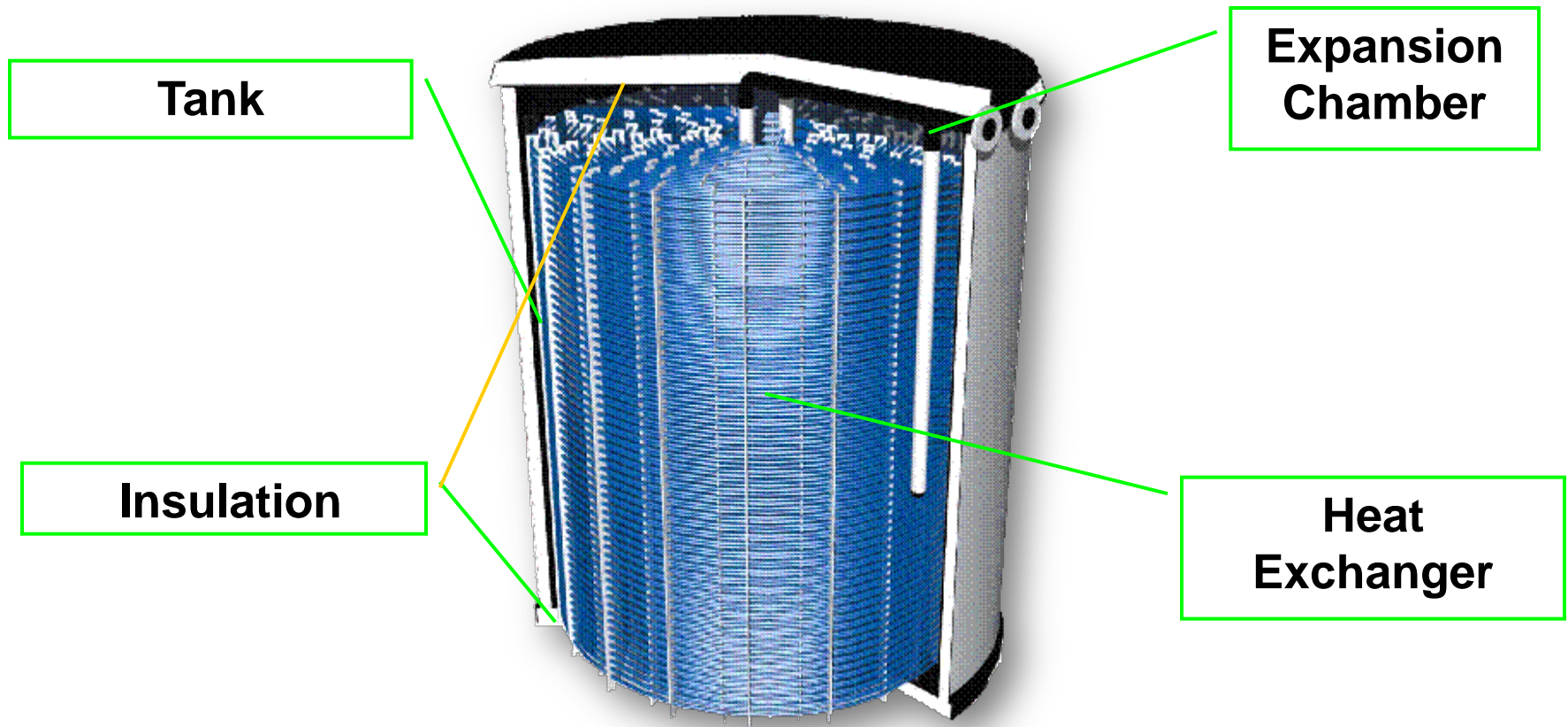
Sources: Nuclear Energy Institute  
Energy Information Administration

# Thermal Storage Tank

## Ice on Coil, Internal Melt



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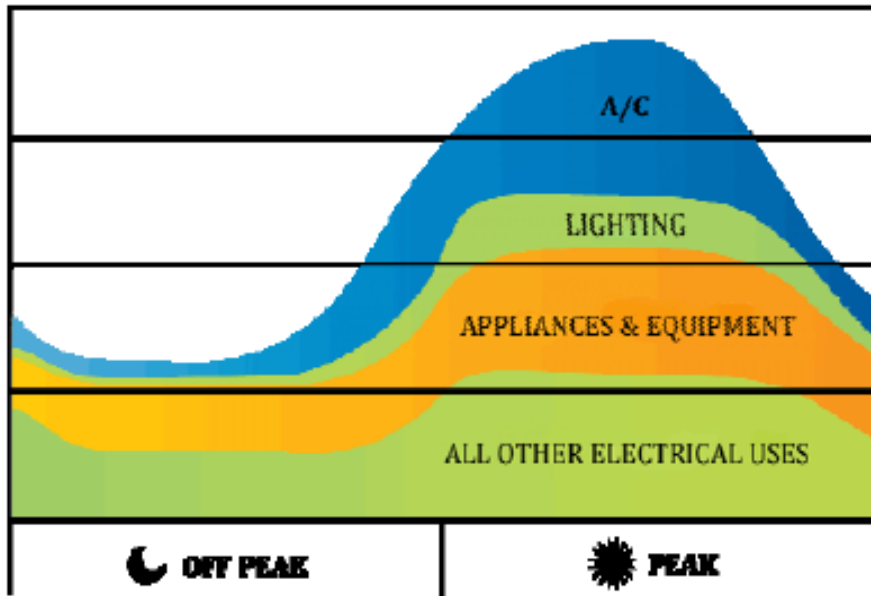


# Electrical Load Profiles of Typical Commercial Buildings

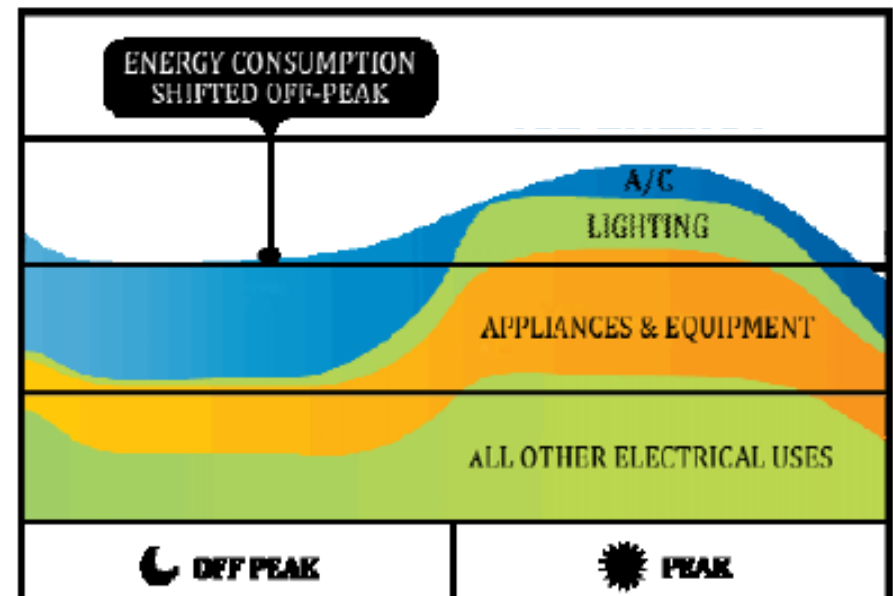


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Normal Load



Using thermal storage for load shifting



# Cost Analysis

Day	Hour Ending	Price	Totals	
6/21/2011	1	32.41	Running Chiller	Ice Storage
6/21/2011	2	27.56	398.31	209.52
6/21/2011	3	24.17		
6/21/2011	4	23.19	Savings 53%	
6/21/2011	5	23		
6/21/2011	6	24.62		
6/21/2011	7	26.06		
6/21/2011	8	28.51		
6/21/2011	9	30.76		
6/21/2011	10	32.34		
6/21/2011	11	34.7		
6/21/2011	12	38.85		
6/21/2011	13	43.05		
6/21/2011	14	48.8		
6/21/2011	15	54.72		
6/21/2011	16	70.51		
6/21/2011	17	75.34		
6/21/2011	18	64.2		
6/21/2011	19	49.58		
6/21/2011	20	39.2		
6/21/2011	21	38.44		
6/21/2011	22	37.27		
6/21/2011	23	36.26		
6/21/2011	24	32		

Running **Chiller** on-peak vs.  
Recharging **Ice Storage** off-peak

ERCOT Day-Ahead Power Prices

# Commercial Opportunities for Thermal (Ice) Energy Storage



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## Currently Installed Capacity

- 3,000 installations
- Mainly commercial and industrial
- Installed capacity will soon double

## Potential

- 80,000 chillers currently installed in U.S.

# Benefits for T&D

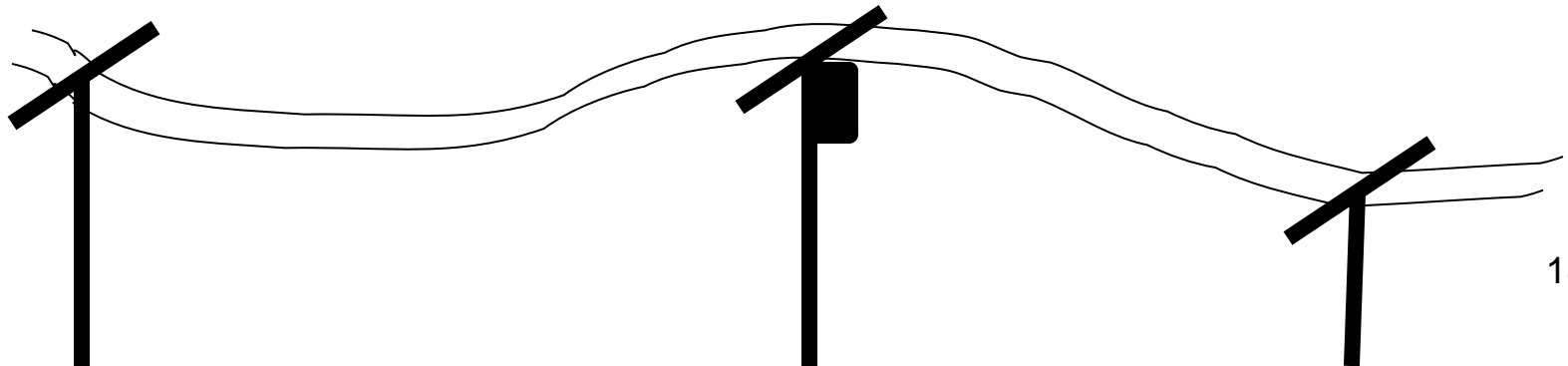
Storage is at the demand point

- Elimination of new investments for T&D upgrades
- Reduced congestion

Reduced line losses

- Substantially higher during peak periods
- Lower T&D losses of between 4-7%

Lowers transmission pricing



# Benefits for Commercial Buildings

Biggest cost benefit when utility has significant on-peak demand charge or offers a special time-of-day rate

## Reduced Peak Energy Consumption

- Typically by 40-50%
- Off-peak electricity is only energy to decrease in cost over last 40 years

Reduced a building's carbon footprint by 10% or more

## Improved Building Energy Performance

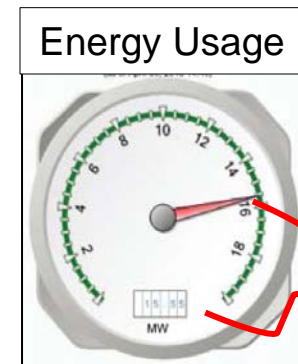
- LEED Points – based on Energy Cost Reduction

Reduced capacity for chiller or HVAC systems base

- A factor for new installations
- Thermal storage provides supplemental peak-period cooling

No Cost Utility-Sponsored Programs

- Utility pays for equipment, installation and maintenance



Reduced

# Benefits for Utilities

Permanently Shifts Peak Demand

- Relieves Congestion on Peak

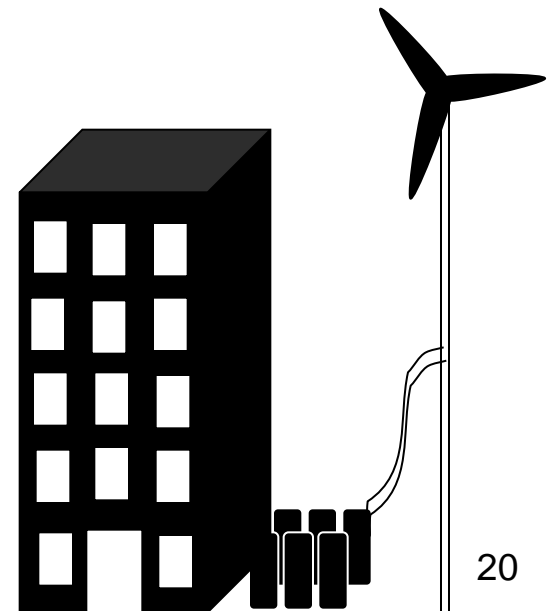
Cost-effective Alternative to New Peaking Generation

Improves System Efficiency & Grid Reliability

Easy, Rapid Deployment at a Multi-Megawatt Scale

Uses Cleaner Off-Peak Power ie: wind

- Enables Reliable Integration of Renewables
- Reduces Greenhouse Gas Emissions



# Renewable Energy and Thermal Storage



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Wind and solar energy availability don't correspond to peak use

- Solar has low availability starting in late afternoon
- Wind tends to be most available at night

Thermal energy is one way to alleviate challenge of integrating renewables

- Stored energy can be used during peak hours on the following day

California has 1,000 MW of wind installed

- Only 20% typically available during peak power usage

Thermal storage allows 100% of wind's output to be used during peak hours

- Less than 33% of installed cost of additional wind turbines
- Peak capacity of the wind resource is increased by a factor of 5
- Cost per delivered peak kW is decreased by 1/3

# Implementation Criteria

## Cost

- Cheaper than fly wheels and batteries
- The size and cost of air handlers, motors, ducts, and pumps can be reduced by 20 to 40 percent

## Large AC energy cost

- Can specify chillers at 50 to 60 percent of the previous size, reducing capital outlays

## Building layout

## T&D limitations

## Ease of siting

- Technically and environmentally

## Long life expectancy

- 30+ years
- Return on investment greater than other technologies

# Thank You



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