Thermal Energy Storage

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The Purpose of TES

- Also called “cool storage” or “off-peak air conditioning”
- Used for air conditioning and process load
- TES:
  - Take advantage of the lower energy costs of non-peak hours
  - Participate in demand response (DR) and/or Non Generator Resource (NGR) “Overgen” markets
  - Reduce the size and costs of the chiller system—maybe
  - Provide a standby water reservoir
## Example Time of Use

### TOU Summer:
- Week days, first Sunday in June through the first Sunday in October (four months)
- **MN**
- 8 a.m. Noon 6 p.m. 11 p.m. **MN**

<table>
<thead>
<tr>
<th></th>
<th>Off Peak</th>
<th>Mid Peak</th>
<th>On Peak</th>
<th>Mid Peak</th>
<th>Off</th>
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### TOU Winter:
- Week days, first Sunday in October through the first Sunday in June (eight months)
- **MN**
- 8 a.m. 9 p.m. **MN**

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<tr>
<th></th>
<th>Off Peak</th>
<th>Mid Peak</th>
<th>Off</th>
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### TOU Weekends and Holidays
- **MN**
- Off Peak

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Utility System Demand Profile

**Summer**

- **Off-Peak**
- **On-Peak**

**Time of Day**

0 6 12 18 24

- **gW**
  - 0
  - 5
  - 10
  - 15
  - 20
  - 25

**Winter**

- **Peak**

**Time of Day**

0 6 12 18 24

- **gW**
  - 0
  - 5
  - 10
  - 15
  - 20
  - 25

Maximum Utility Capacity
Renewable Resources
“What’s the Duck Curve”

Net load - March 31

- Overgeneration risk
- Ramp need ~13,000 MW in three hours

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Building Demand Profile

**Summer**

- Tons on Y-axis
- Time of Day from 0 to 24
- On-Peak period

**Winter**

- Tons on Y-axis
- Time of Day from 0 to 24
- Peak period
Some early TES implementations in the 1980s were criticized for not being as efficient as they could have been. What’s better today?

The early design concepts were based on limited information.

Today’s TES systems are better, lessons were learned.

- Tank design
- Hydraulics pressure equalization
- Controls
- Operations and maintenance
Stratified Tank

TYPICAL STRATA-THERM CHILLED WATER THERMAL ENERGY STORAGE INSTALLATION

- Dome Roof Plate
- Knuckle Plate
- Shell Plate
- Insulation Jacket
- Shell Insulation
- Exterior Primer
- Steel Shell
- Interior Corrosion Protection
- Annular Concrete Ring-Wall Foundation

Optional Ellipsoidal Roof Shown, Alternates Include Dome, Cone, and Spherical Roofs

Typical Shell Nozzles for Chilled/Warm Water (Internals Not Shown) or for NFPA Fire Protection Water Outlet (Optional)
Thermally Stratified Storage
TES Joke

“Nitrates are cheaper than day rates”
Brine Ice Building
Brine Ice Builder
Ice-on-coil External Melt

The diagram illustrates a system where a condensing unit operates at night to create ice. This ice is then used during the day to cool the air. The system is designed to store energy, allowing it to provide cooling at different rates.

- The condensing unit runs at night, creating ice in a 5 Ton condensing unit.
- During the day, it provides 7.5 Tons of cooling.
- The system stores 540,000 BTU of energy.
- It can provide 7.5 Tons of cooling for 6 hours or 5 Tons for 9 hours.

Key temperatures and flow rates are also shown:
- Liquid refrigerant temperature is 48°F.
- Liquid and vapor refrigerant temperature is 46°F.
- Return air temperature is 55°F.

The diagram includes various components and labels that illustrate the flow of refrigerant and the environmental impact of the system.
Ice Harvesting
Glycol and Encapsulated Ice
Phase-Change Materials

- **Internal Weight Bearing Supports**
- **High Density Polyethylene**
- **Stacked Containers with Space for Water Flow**
- **Hermetically Sealed and Adhesively Welded Cap**
Cooling Load Profiles

Building cooling load profile with full-storage TES

Building cooling load profile with partial-storage TES
Economic Example 100 kW Shift: Cost

Givens:

Cost to build:
- $160/ton-hr. OR
- $1,000/ton for 6 hours

Deemed efficiency:
- 0.7 kW/ton water OR
- 1.2 kW/ton air

Size:
143 ton peak TES rendering 100kW peak load reduction (0.7 kW/ton)
Economic Example 100 kW Shift: Savings

Electric rate savings:
- @ $17/kW-month peak demand avoidance (4 months)
- @ 3.5 cents/kWh on-off peak differential

Annual savings for 100 kW shift
- $6,800 kW demand
- $1,670 kWh energy
- $8,473 total
Economic Example 100 kW Shift: Payback

Installed Cost = 143 tons @ $1,000 = $143,000

Incentive = 100kW x $875/kW = $87,000

Net cost = $56,000

Payback = $56,000 cost/$8,473 annual savings = 6.6 yrs.
CAISO Real Time Price Bins by Month of Year (2015)
Overgen scenario additional $10,000/yr

Over 200 hours when the price difference is greater than 50 ¢/kWh
Building Demand Profile

Summer

Tons

Y

0

0

6

12

18

24

Time of Day

On-Peak

Winter

Tons

Y

0

0

6

12

18

24

Time of Day

Peak
Utility Incentives

Select one of the two incentive options

1. Receive incentive in two installments
   - 25% of feasibility study up to $10,000
   - 75% of feasibility and other TES project costs
     ($875 per kW shift, not to exceed 50% of total project cost)

2. Receive incentive in one installment
   - 100% of feasibility and project cost.
     ($875 per kW shift, not to exceed 50% of the total project cost)

Refurbished equipment with the exception of tanks, fuel switching and controls adjusting are not eligible for incentives SCE
SCE PLS Process

Customer submits application (AMIS, sce.com) to PLS HelpDesk

PLS reviews, accepts/rejects application and notifies customer

Customer submits Feasibility Study (See Appendix A)

PVE\(^1\) reviews Feasibility Study

PVE\(^1\) conducts Pre-install Inspection

PLS sends Agreement to the Customer

Customer returns signed Agreement (project approved\(^2\))

Eligible Customer may submit a PLS Payment 1 Letter of Interest to receive 25% of the Feasibility Study cost

Customer installs TES system notifies and submits to PLS HelpDesk the Commissioning Report (See Appendix B)

PVE\(^1\) reviews Commissioning Report and conducts Post-install Inspection

Customer receives rebate incentive (based on Post-installation verification KW shift)

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\(^1\) PVE: Program Verification Engineer

\(^2\) Up to 4 months wait

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Up to 18 months from project approval

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How is it going?

Lately 9 feasibility studies:

- 4 have gone to installation
- 1 is complete
Thank You!