Energy Storage Technologies: Building Strategies for More Optimal Grid Operation

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CALMAC is a portfolio of Trane
Where is the storage?

Old Grid:

Energy flows mostly one way
Modern Grid

Net Zero Grid Building:

Designers tend to remove building sited renewable back up equipment
Buildings becoming part of the storage and distribution system

BNEF projections of storage deployment over the next decade

Grid Side (of meter) Energy Storage Technologies

Pumped Hydro

Battery

Compressed Air

Flywheels
Building side (of meter)
Energy Storage Technologies

Battery

Thermal Energy Storage (TES) Hot, Cold or Ice, Active or Passive
Thermal Storage

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 ft^2/ per person, 200 ft^2/ per person
Engineer: 300 ft^2/ton, 400 ft^2/ton, 500 ft^2/ton

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

Utility Load Factors* in the USA

Utility Load Factors* in the USA

*Load Factor = \frac{Avg. Load}{Peak Load}
AC

40% of $S

ISO-New England 2005 & 2006 Hourly MW Load Duration Curve

In 2006, top 6,000 MW of Demand (21% of total peak demand) was for only 165 hours (1.9% of the year).

2006 Winter peak = 29,559 MW (73% of summer peak)

2006 Median Hourly Demand = 15,298 MW (Avg. = 15,100)

ISO-NE Hourly Demand & Price Week of 7/31-8/6/06

Graph by Clifton Belsito, INPUC, from 2006_week_hourly.xls available at: http://www.iso-ne.com/markets/toolsdata_long/hourly/week.html
ASHRAE 90.1 Building Electrical Profile
Non-Storage

Total kWh = 19,200/day
(Load Factor = 53%)

ASHRAE 90.1 Building Electrical Profile
with Cool Storage

Total kWh = 19,200/day
(Load Factor = 88%)
Building Load Flexibility

When Would you Fill-up?

Daytime

$ 2.49/gallon

Nighttime

$ 0.99/gallon
The Demand Charge Effect Simplified

Tucson Energy LSG -13 Rate

Energy (usage):
Day: $0.054/kWh
Night: $0.054/kWh

Demand: $15.25/kW/Month

How big an effect is the Demand Charge??

Energy is 63% less expensive at night
For a daytime peaking building

Utilities with Demand above $14 / kW

- ConEd
- SCE
- PG&E
- SDG&E
- LIPA
- Eversource
- HECO
- O&R (NY)
- Santee Cooper (SC)
- Austin Energy
- United Illuminating (CT)
- PSEG (NJ)
- Dominion (VA)
- Appalachian Power
- Forked Deer (TN)
- Delmarva
- City of Batavia (IL)
- Mon Power (WV)
- Potomac Edison
- Duke Carolinas
- Tucson Electric Power
- Lincoln Electric Service (NE)

- LG&E (KY)
- Hydro One (Qu.)
- Rocky Mountain Power (UT)
- Toledo Edison
- Duke Indiana
- Consumers Energy (Mich.)
- NV Energy
- Arizona Public Service
- El Paso Electric
- Public Service of NM

Representative List - a small fraction
Many types of Energy Storage will be needed on both sides of the electric meter for Renewable Energy, Net Zero Buildings and the Grid to Function Reliably

**Grid Side**
- Pumped Hydro
- Compressed Air
- Fly Wheels
- Super Capacitors

**Building Side**
- Chemical Batteries
- Thermal Mass (passive)
- Thermal Batteries (active)

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**Energy Storage Options**

<table>
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<tr>
<th>Energy Storage Technology</th>
<th>Tech Maturity</th>
<th>Useful Eff (%)</th>
<th>Life (Yrs.)</th>
<th>Capital Costs ($/kWh)</th>
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<td>Na-S Batteries</td>
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<tr>
<td><strong>Thermal Storage</strong></td>
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<td>90-100+/-</td>
<td>50+</td>
<td>30-500</td>
</tr>
</tbody>
</table>

*Thermal Energy Storage (TES) has low initial cost, high efficiency, and longer useful life.*
Thermal Batteries are 1/3 the cost of electric battery systems for C&I

Levelized Technology Cost for BTM Applications

- Cost advantages
  - No inverter expense
  - Lower component costs, including balance of system; lower O&M
  - No need for capacity addition due to degradation

- Lower capital costs mean lower financing costs

1. Costs represent average of range pulled from LCOS 3.0 for battery technologies.
2. Conservative case that includes full cost of chiller.

Source: Ingersoll Rand
Economic, Social and Environmental Benefits of Energy Storage are real

Conclusion

The best sustainable storage solution for the customer is to have Thermal Batteries meet Thermal Loads and Electric Batteries meet Electric Loads