CampusEnergy2021

BRIDGE TO THE FUTURE

Feb. 16-18 | CONNECTING VIRTUALLY

WORKSHOPS | Thermal Distribution: March 2 | Microgrid: March 16

Optimizing Capital Investments in the Pandemic and the New Normal

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Q&A Will Not Be Answered Live

Please submit questions in the Q&A box.
The presenters will respond to questions off-line.

Outline

- Introduction: The Pandemic and the New Normal
- Impact on Capital Projects – delays, cancellations, uncertainty
- Situations Still Requiring CHW Capacity Investments
- Comparing Conventional Chiller Plants vs. CHW TES
  - Various Case Studies
- Comparing CHW TES vs. Battery Storage
- Conclusions and Recommendations

Introduction

- The COVID-19 Pandemic changed our lives in 2020, and will continue to do so in many ways throughout 2021, and probably well beyond.
- The "New Normal"
  - Virtual learning may continue at the expense of on-site learning, reducing or delaying load growth on campus.
  - Working from home may minimize city center activities, reducing or delaying urban District Energy loads.

These trends can impact capital investments.

Impact on Capital Projects

- Impacts can include:
  - Uncertainty about future load growth and timing
  - Uncertainty about future revenues
  - Indefinite delays
  - Outright cancellations

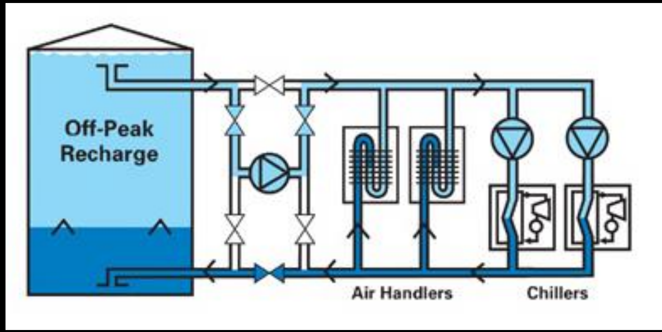
Nevertheless, some capital projects may need to proceed.

Situations Still Requiring CHW Investments

- Capital projects may be required to address:
  - Loads associated with new construction
  - Growth of existing loads on a network
  - Retirement of aging, inefficient, or unreliable equipment
  - Investments to support Mission Critical loads
  - Investments for increased resiliency

If so, consider not only conventional capacity, but ***CHW TES****.*

Chilled Water (CHW) Thermal Energy Storage (TES)



- An insulated tank, full of water at all times.
- Cool, dense CHW Supply in lower zone, at ~40 °F;
- Warm, less dense CHW Return in upper zone, typically at 50 to 60 °F;
- Narrow "thermocline" (temperature gradient) in between the zones.
- TES is charged, off-peak (nighttime): CHWR pumped from top of tank, cooled in chillers; CHWR flows to bottom of tank; thermocline rises in tank, until tank is 100% cool water.
- TES is discharged, on-peak (daytime): CHWS pumped from bottom of tank, meets cooling loads; CHWS flows to top of tank; thermocline falls in tank, until tank is 100% warm water.

No moving parts or heat exchange in tank; just pumps & valves outside.

U of Illinois – Urbana-Champaign

- Faced 7,000 T of load growth, incl’g a 5,400 T “peta-scale” super computer.
- In lieu of a 7,000 T chiller plant add’n, they chose 50,000 T-hrs of **CHW TES** (6.46 million gals at 40/53 °F CHWS/R).
- Reduces peak by ~10,000 T (~7.7 MW), saving ~$715K/yr, for an NPV of ~$5M.

Even though the 5,400 T super computer was somewhat delayed, the TES operating savings were achieved immediately.

U of Nebraska-Lincoln, East & City Campuses

Each campus needed a CHW addition.

Some nights, wholesale electric at -$0.20/kWh.

	UNL East Campus	UNL City Campus
- Thermal (elec) storage:	16,326 Ton-hrs (12 MWh)	52,000 T-hrs (39 MWh)
- Volume at S/R temps:	2.94 Mgals at 42/52 °F	8.46 Mgals at 40/50 °F
- Peak Shift up to:	4,000 Tons (3 MW)	8,333 Tons (6.25 MW)
- Simple Payback / NPV:	immediate / $4.8M	3.6 yrs / $9.7M

Immediate (or rapid) payback justify TES, even if load growth timing in doubt.

CHW TES *provides peak chiller plant capacity, and Cap$/kWh < half batteries.*

Univ Med Ctr of Princeton – Plainsboro, NJ

- An ESCO built a new central energy plant, including CHP.
- In lieu of a conventional chiller plant, they included 9,850 T-hrs of **CHW TES** (991,000 gals at 40/58 °F CHWS/R temps).
- Reduces peak by 2,792 T (~2.1 MW), saving ~$152,800/yr.
- Achieves ~2.6 yr simple payback.

In addition, TES flattens daily electric load profiles, which improves the economics for CHP, by allowing use of a larger generator (with a lower capital $/kW) and fully loaded operation for more hrs/yr.

Honeywell – Mexicali, Baja Calif Norte, Mexico

- A new engine manufacturing and engine test facility involved facility air-conditioning plus a low temperature test cell.
- In lieu of a conventional chiller plant for HVAC and Low Temp chillers for the test cell, they chose 3,292 T-hrs of **Low Temp Fluid (LTF) TES** for all loads (250,000 gals at 33/58 °F S/R temps).
- Reduces peak ~561 T (~0.5 MW), saving ~$74,200/yr.
- Achieves ~1.6 yr simple payback and an NPV of ~$574,000.

Even in this small application, TES achieved a rapid payback, justifying the investment regardless of future variations in loads.

Capital and Operating Savings from CHW TES

TES Project Type	Owner	CHW TES Capacity (ton-hrs)	Savings vs. Non-TES Chiller Plants: Initial Capital Savings	Annual Oper'g Savings
retro	Washington St U	17,750	$1 to 2 million	$ 260,000 / yr
new	Lisbon Distr Energy	39,800	$2.5 million	$1,160,000 / yr
retro	U of Alberta	60,000	$4 million	$ 600,000 / yr
new	Chrysler R&D	68,000	$3.6 million	>$1,000,000 / yr
retro	DFW Int'l Airport	90,000	$6 million	~$2,000,000 / yr
retro	OUCooling district	160,000	>$5 million	>$ 500,000 / yr

*Adding **CHW TES** vs. chiller plant capacity = Net Capital Savings;*

while Operating Savings accrues, w/ or w/o load growth.

Consider a Need or Desire for Energy Storage

Beyond the conventional reasons for adding **CHW TES** :

- Reducing on-peak power demand and energy costs
- Adding peaking capacity at a low capital $/Ton
- Flattening load profiles, for better economics of CHP
- Providing emergency back-up for Mission Critical loads

There are other reasons or needs for Energy Storage:

- Supporting intermittent renewables (wind or solar), on- or off-site

*If adding storage, why choose **CHW TES** vs. Battery Storage?*

Comparing TES to Battery Storage

	CHW TES	Li-Ion Batteries
	7 MW / 42 MWh	7 MW / 42 MWh
TES Capacity (0.7 kW/Ton)	60,000 T-hrs	n.a.
TES Volume (14°F CHWS-to-R Delta T)	7.5 million gals	n.a.
Storage Element CapEx	\$125-150 / kWh	\$200-250 / kWh
Fully Installed Storage System CapEx	\$160-270 / kWh	\$400-500 / kWh
Life Expectancy	40+ years	~10 years
Annual Round-trip Energy Efficiency	near-100%	~85%
Fire Safety / Fire Risks	Fire Protection	Fires / Explosions
Added Peak CHW Capacity	10,000 Tons	None
Unit CapEx	\$672-1,134 / Ton	n.a.

Conclusions and Recommendations

- There may well be uncertainties in size & timing of future loads.
- But some investments in CHW capacity may still be needed.
- In those situations, consider large **CHW TES** , as it has:
    1. Lower unit CapEx ($/ton) than conventional chiller plants and
    2. Lower unit CapEx ($/kWh) than battery storage.

And perhaps most importantly,

chiller plant capacity is an idle investment until load catches-up,

while TES provides savings on day-one, even without load growth.

Questions / Discussion ?

Or for a copy of this presentation, contact:

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Until we can all be together again in person, stay safe!



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