University of Nebraska Lincoln

Central Utilities at UNL:
NU Corp & Development of Thermal Energy Storage (TES) at UNL East Campus

Big Ten and Friends
Mechanical & Energy Conference
U of Nebraska-Lincoln – October 15, 2012

NU CORP

Before NU Corp

- No funds for deferred maintenance
- System condition was deteriorating
- Safety and reliability
- Capacity was inadequate

In the Beginning…

- Initial Actions
  - Bonds
  - Gas / Elec Purchases
  - Capital and operating funds

UNL Benefits

- Reduces Capital Budget Requests by providing Financing Mechanism
- Eliminates Deferred Maintenance
- Provides Specialized Expertise
- Improves System Reliability, Efficiency, and Safety
- Implements New Technologies

LES Benefits

- Builds a stronger Relationship with Largest Customer
- Lowers Energy Cost through Joint Purchasing and operating
- Retains Mutual Benefits of joint WAPA Scheduling
- Provides Capacity via Energy Conservation
- Provides Joint Planning and Coordination of Operations

LES's Role

- Fuel purchases
- Rate Analysis
- Accounting /auditing
- Engineering support
- Assist in feasibility studies

UNL's Role

- Operations
- Maintenance
- Construction
- Energy conservation
- Capital Planning

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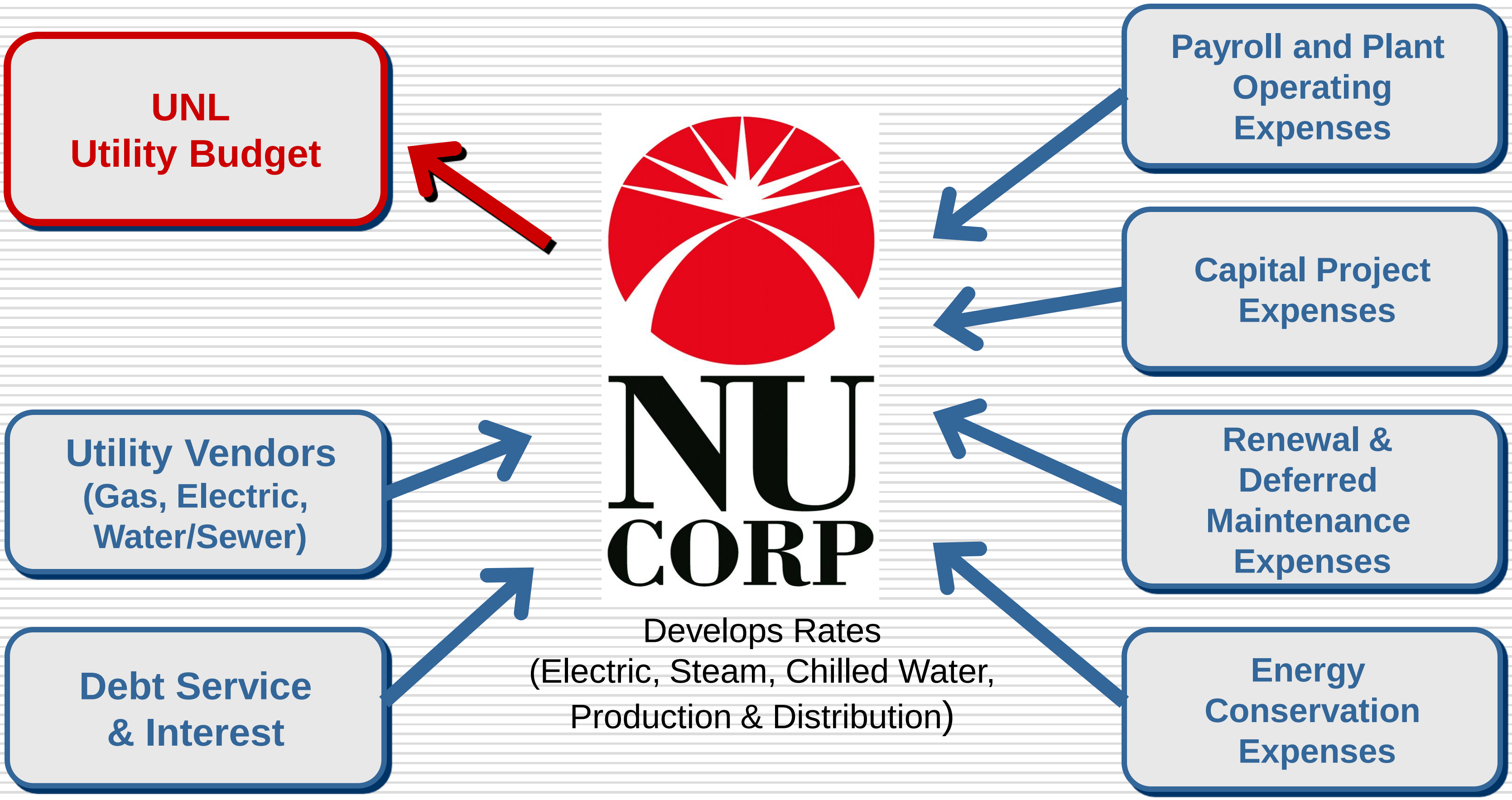
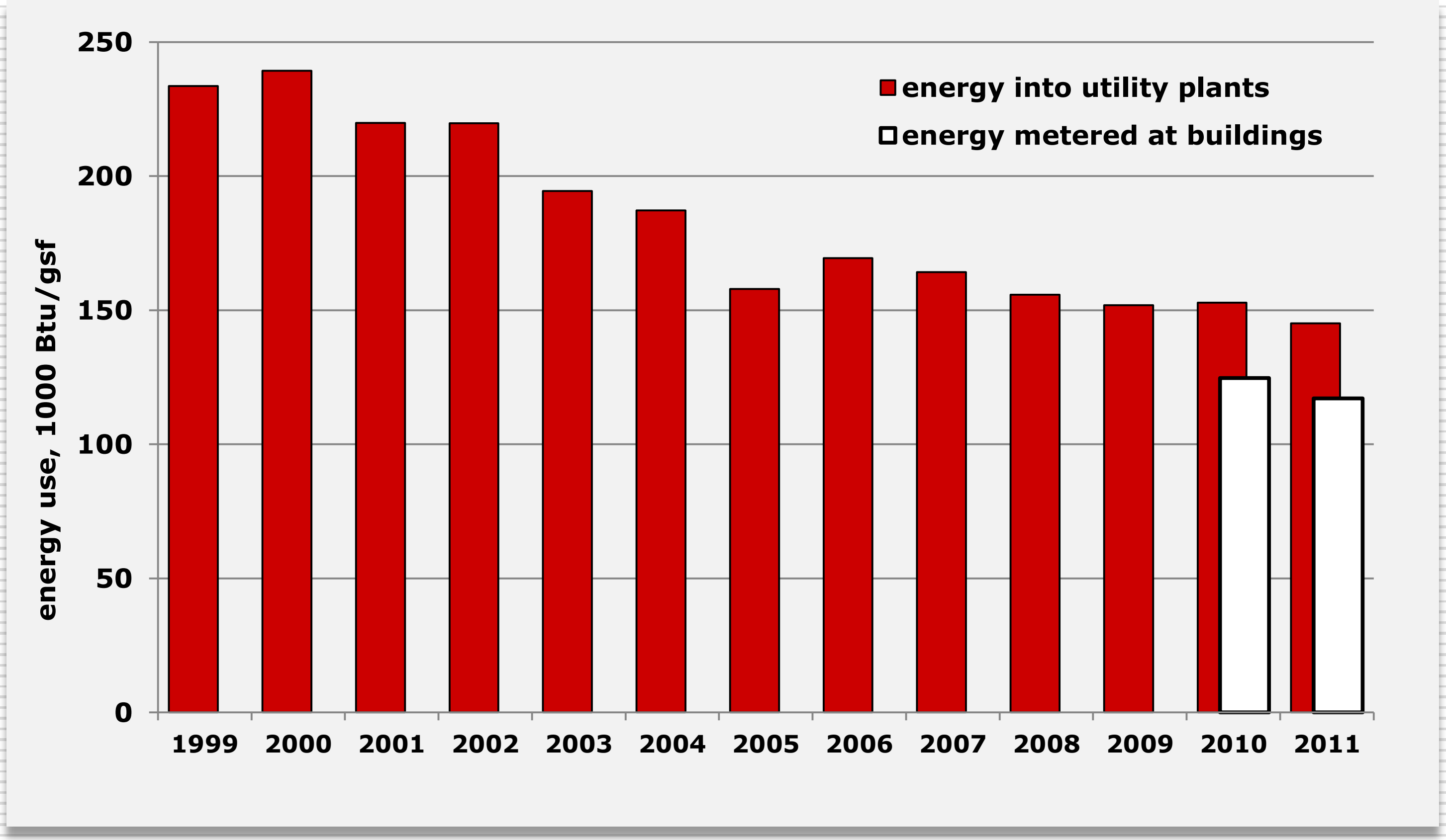


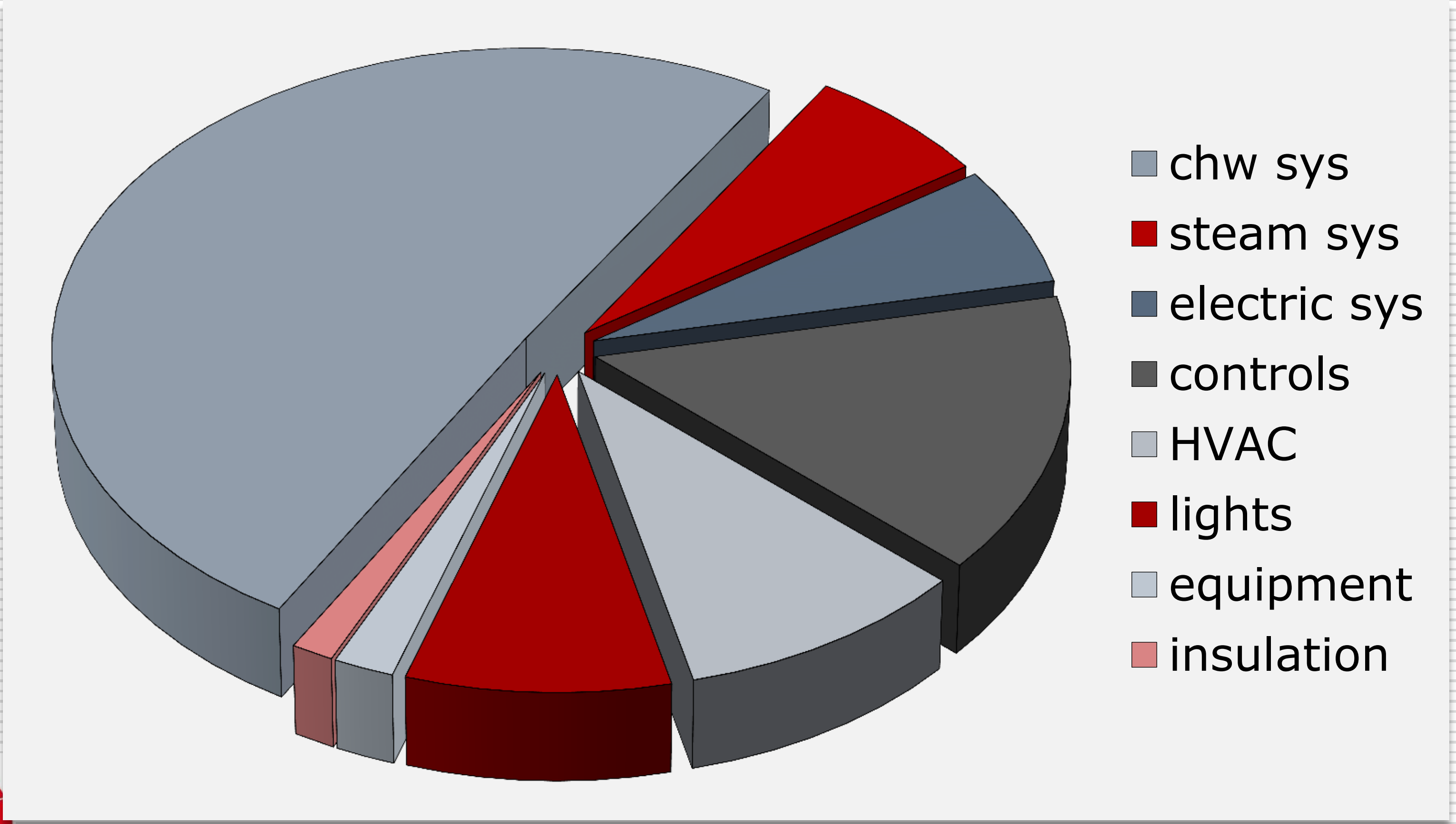
Energy Use under NUCorp



Project Costs & Savings

Project Type	No.	Installed Cost	Annual Savings	SP
chw sys	11	$8,618,303	$238,967	36.1
steam sys	12	$1,118,786	$160,097	7.0
electric sys	4	$1,082,819	$16,039	67.5
controls	16	$2,535,331	$2,071,239	1.2
HVAC	11	$1,641,901	$555,957	3.0
lights	10	$1,477,224	$591,106	2.5
equipment	5	$339,137	$145,793	2.3
insulation	3	$237,595	$186,590	1.3
NUCorp Era	**72**	**$17,051,097**	**$3,965,787**	**4.3**

Project Types Funded



Electrical Distribution

Steam Infrastructure

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Chilled Water Infrastructure

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Plant Additions

Chillers

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Cooling Towers

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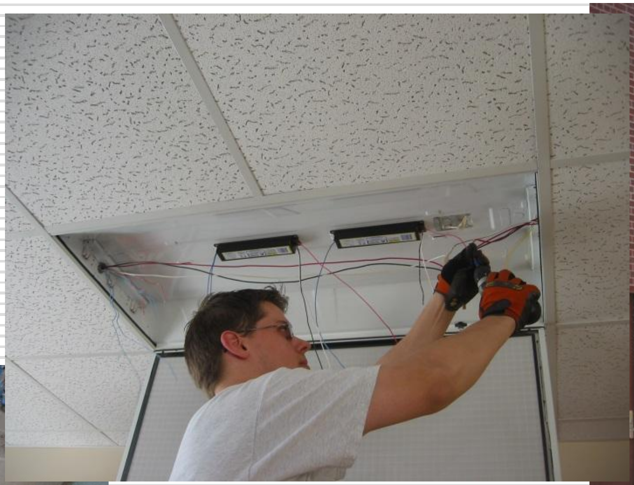
Energy Conservation



Deferred Maintenance

Heat Pump Loop

Thermal Energy Storage

Central Utilities at UNL:
Thermal Energy Storage (TES) at UNL East Campus

John S. Andrepont, President

The Cool Solutions Company

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Outline

- Intro to Thermal Energy Storage (TES)
  - Concept, Drivers, Types, and Characteristics
- The Extensive Use of TES on Campuses
- TES at the UNL East Campus
  - Analysis and Justification
  - Selection, Sizing, and Design Specifications
  - Initial Operating Results and Benefits
- Summary and Conclusions

Terminology

- CHP - Combined Heat & Power
- CHW - Chilled Water
- CHWS / R - CHW Supply / Return
- LTF - Low Temperature Fluid
- NPV - Net Present Value
- PSV - Pressure Sustaining Valve
- TES - Thermal Energy Storage

TES Concept

- Store thermal energy for cooling or heating
- De-couple generation from usage
- Reduce installed equipment capacity (just as in your home water heater)
- Reduce peak power demand
- Shift energy use from peak to off-peak
- TES can be charged-discharged seasonally, weekly, or (most often) daily

Drivers for Using TES

- “Flatten” thermal and electric load profiles
- Reduce electric “demand” costs
- Reduce on-peak energy costs
- Can often reduce net capital costs (through avoided conventional equip investment, e.g. new constr, retro expansion, or equip rehab)
- Reduces life cycle costs of ownership
- Improve operational flexibility and stability
- Can often add redundancy and reliability

Types of TES

- “Full shift” or “partial shift” TES configuration
- Latent Heat TES Systems
  - Energy is stored as a *change in phase*
  - Typically, *Ice* TES
- Sensible Heat TES Systems
  - Energy is stored as a *change in temp*
  - Stratified *Chilled Water (CHW)* TES, or
  - Stratified *Low Temp Fluid (LTF)* TES

Inherent Characteristics of TES

(typical generalizations only)	Ice	CHW	LTF
Volume	good	poor	fair
Footprint	good	fair	good
Modularity	excell	poor	good
Economy-of-Scale	poor	excell	good
Energy Efficiency	fair	excell	good
Low Temp Capability	good	poor	excell
Ease of Retrofit	fair	excell	good
Rapid Charge/Dischrg Capability	fair	good	good
Simplicity and Reliability	fair	excell	good
Can Site Remotely from Chillers	poor	excell	excell
Dual-use as Fire Protection	poor	excell	poor

The Extensive Use of TES in Campus District Cooling Applications

TES Survey (IDEA *District Energy* mag, 2005):

- 159 TES installations on 124 campuses
- Over 1.8 million ton-hrs
- Peak load shift over 258,000 tons (194 MW)
- Avg 14,584 ton-hr, 2,083 ton (1.6 MW) / campus
- 78% sensible heat TES (CHW or LTF)
- 22% latent heat TES (Ice)
- Many repeat users, e.g. Cal State U system has 16 CHW TES on 14 campuses (278,000 ton-hrs)

TES Analysis for UNL EC

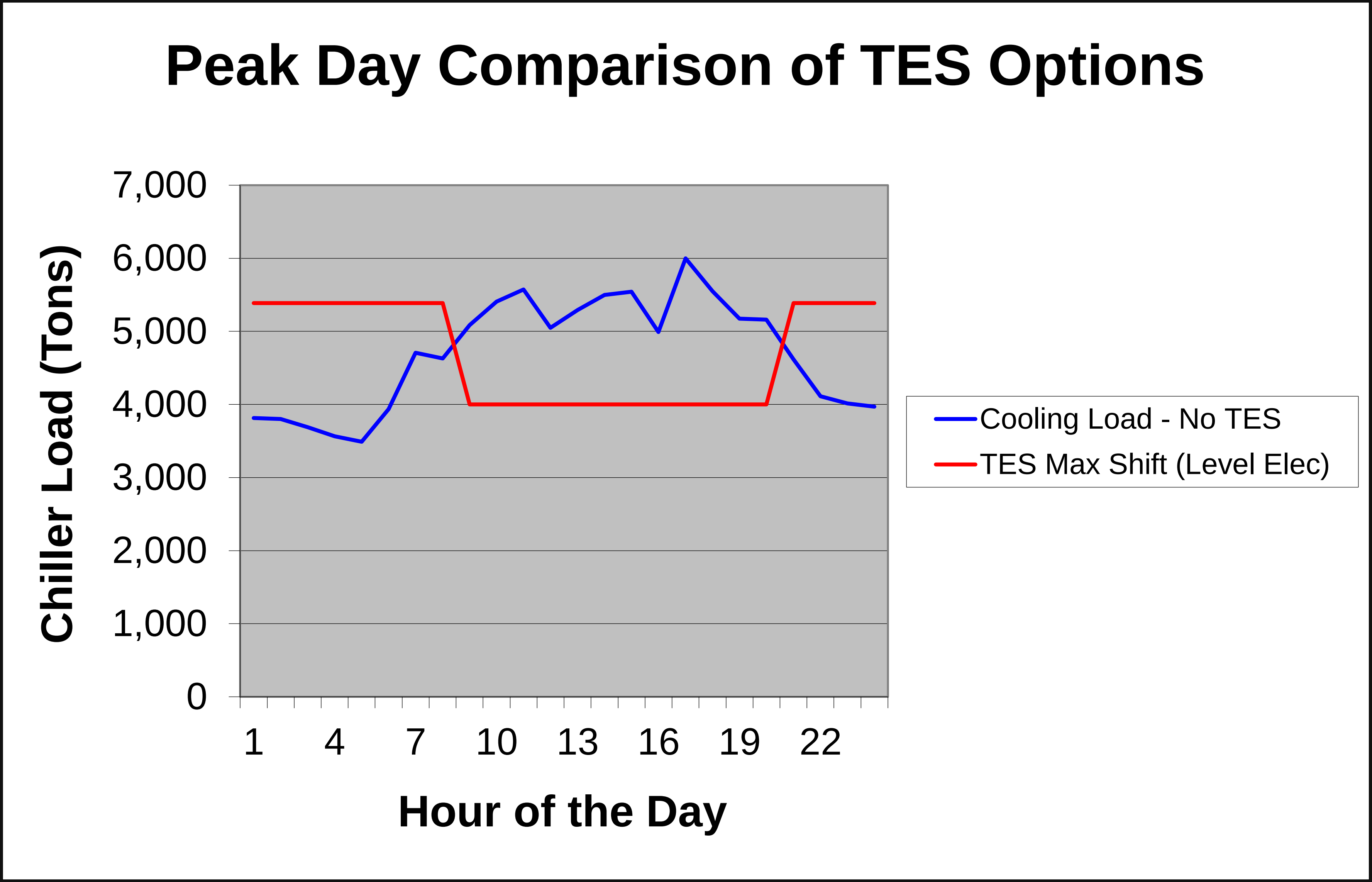
- Inputs: existing & future projected peak cooling loads & 24-hr load profiles; existing CHW plant equip; CHWS/R temps; electric utility rates; CHW distribution issues; siting
- Options: TES type & configuration; temps; location; tank-to-system pumping & valving; all vs. a No-TES base case
- Spreadsheet Outputs: equipment capacities; capital cost; electric & other operating costs; payback & NPV; all vs. a No-TES base case

TES Justification for UNL EC

- 2009 chillers: 7000T total; 4000T “firm” (N-1)
- Peak load: 5020T in 2012; 6000T in 2015
- Postpone new chiller, but add TES by 2012
- Add 2000T chiller in ‘15; can add 1700T load
- Achieve cooling “load level” w/ N-1 chillers; and deeper “load shift” (beyond cooling load level) with N chillers, for electric load level.
- Reduce demand by 2,000 T (1.6 MW)

Near 0-yr payback + over $4M in 20-yr NPV

UNL EC - 24-hr design day (2015)

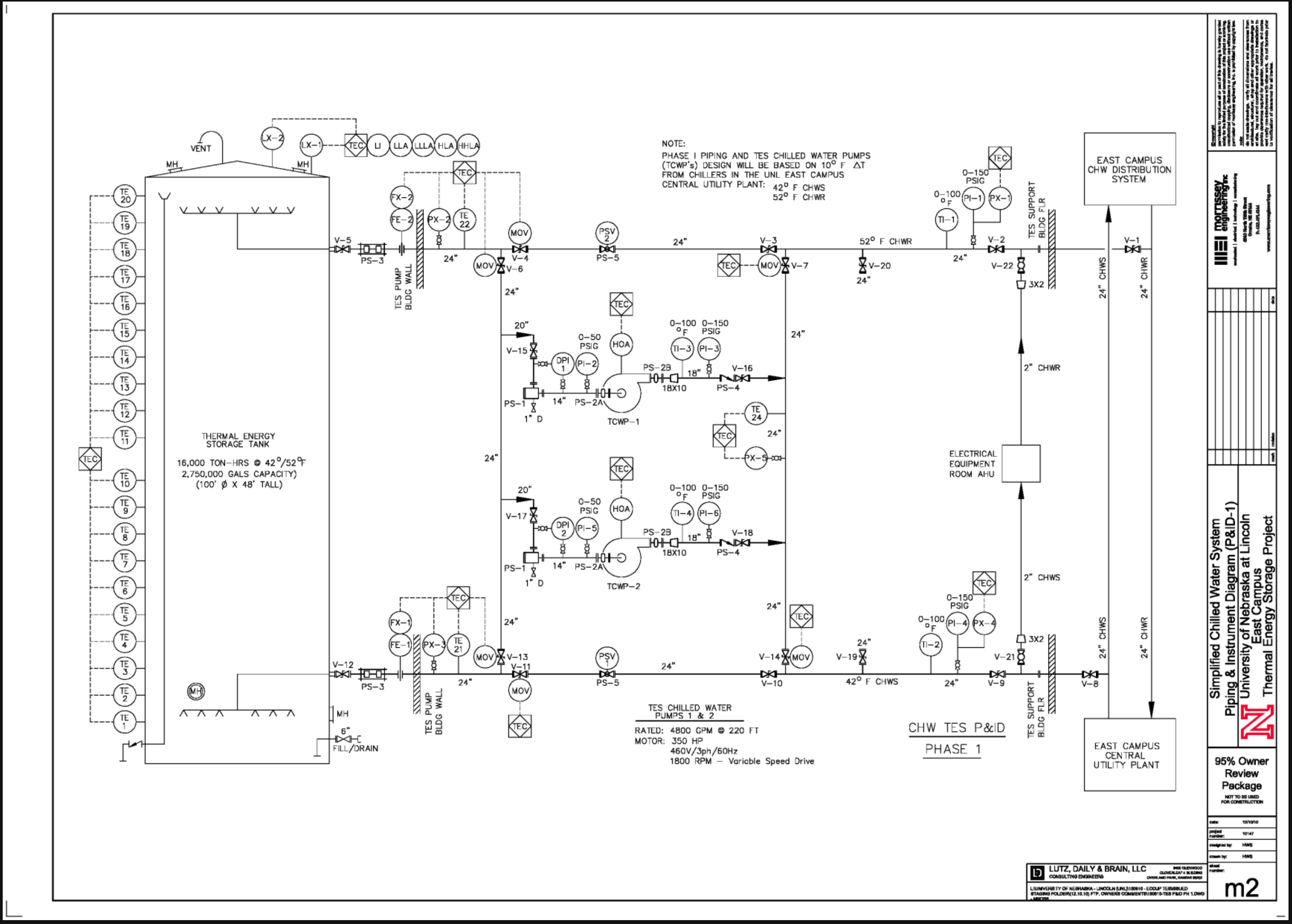


UNL EC - TES Design / Specifications

- Tank sited remotely from CHW plant, with dedicated TES pumps and PSVs
- Above-grade welded-steel CHW TES tank: 2.94 M gals gross tank vol. (100’ D x 50’ H)
- 16,326 T-hrs at 42 / 52 °F CHWS / R temps
- Max load reduction = 4,000 Tons (3.2 MW)
- Turnkey: foundation, tank, diffusers, paint, insulation, thermal performance guarantees

Potential for future conversion to LTF TES at 32 / 52 °F for 32,260 T-hrs and 7,900 Tons

TES Tank, Pumps, Valves, I&C



TES Results & Benefits

- New chiller plant addition avoided/postponed
- Peak demand and electric cost reduced
- Oper’l flexibility & redundancy enhanced
- Low maintenance and long life expectancy
- Also serves as a fire protection reservoir
- CHW TES capacity increases with Delta T, potentially by double with conversion to LTF
- Flat electric load enhances econ’s for CHP
- Peak load mgmt aids electric grid (and renewables); thus, utility may offer incentives

Summary and Conclusions

- Cool TES flattens cooling and electric load profiles, and thus aids the economics of campus cooling.
- TES (mostly CHW TES) is widely used on campus.
- For UNL's East Campus, the new CHW TES:
  - – meets load growth at near-zero net capital cost,
  - – reduces peak demand and electric costs,
  - – captures millions of $ in NPV, and
  - – adds oper'l redundancy, reliability, and flexibility.

Best value from TES occurs at times of:

new construction, retro expansion, or chiller rehab.

Thermal Energy Storage

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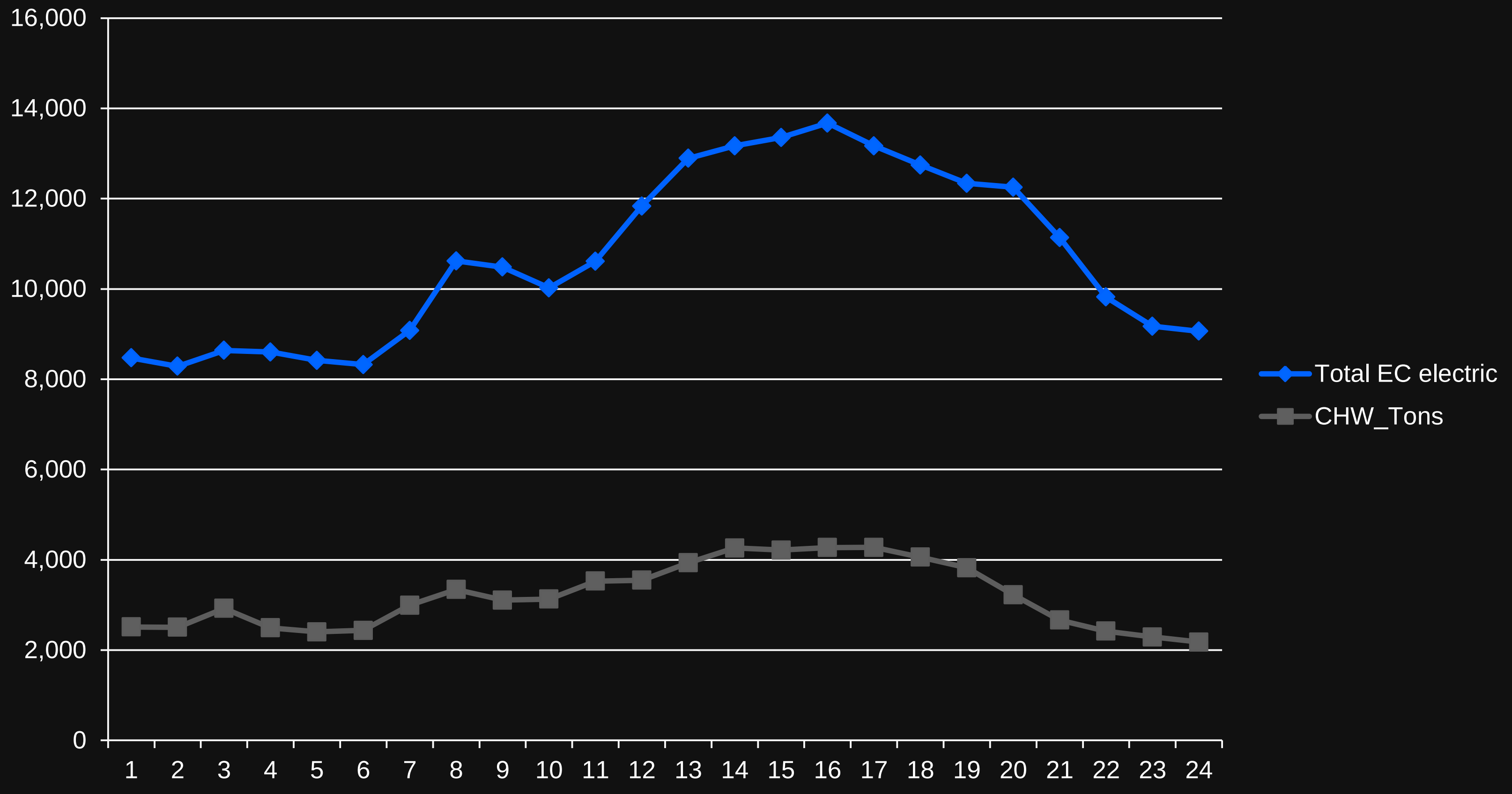
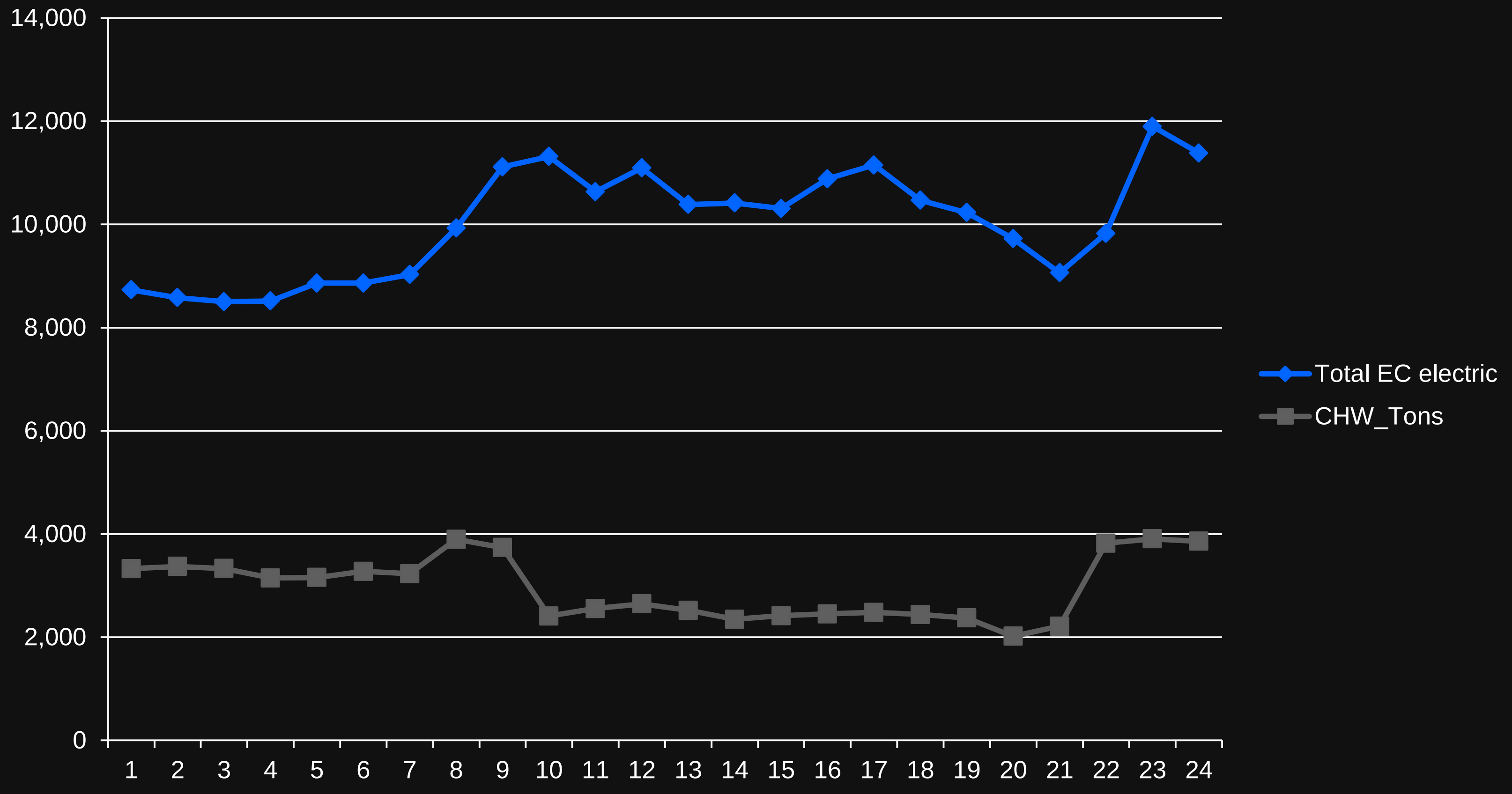
UNL EC - Chiller Load without TES
Aug 8, 93 F day with light student load



UNL EC - Chiller Load with TES
Aug 30, 92 F with full student load



Acknowledgments

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TES Tank: CB&I (Chicago Bridge & Iron)

Questions / Discussion ?

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