ERDC/CERL TR-03-17

US Army Corps of Engineers®
Engineer Research and Development Center

Systems-Level Energy Audit for Main Complex, Construction Engineering Research Laboratory

Mike C.J. Lin, Dale Herron, David M. Schwenk, Chang W. Sohn, Eileen Westervelt, Thomas Hartranft, Thomas D. Miller, Nicholas Josefik, Joseph Bush, and Patricia A. Kemme

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Construction Engineering Research Laboratory

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Construction Engineering Research Laboratory
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Final Report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Abstract: As a follow-up to a sustainability workshop, the Construction Engineering Research Laboratory (CERL) conducted a Phase I energy audit for its main complex (Buildings 1, 2, and 3). The goals of the audit were to review energy and water use in the current main complex building, to review and inventory energy system equipment, and to devise short- and long-term energy improvement and water conservation strategies. Baseline references on utilities consumptions and costs were developed to help future periodic monitoring efforts.

This report documents facility and energy systems information and energy management and water conservation opportunities identified in the study. A 40 percent reduction in building energy use is needed for CERL to meet the Army facility energy goal (by reducing the current Energy Use Index [EUI] of 160 KBtu/sq ft/yr to below 100 KBtu/sq ft/yr). Despite completion of several energy conservation projects at the CERL complex, it was found that the EUI has been increasing since 1998. Likely contributing factors to this increase were summer air dehumidification (starting in FY00) and inadequate building insulation. This report recommends specific short- and long-term energy improvement strategies to address the site's water- and energy-conservation issues.

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Conversion Factors

Non-SI* units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic feet	0.02831685	cubic meters
cubic inches	0.00001638706	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(5/9) x (°F – 32)	degrees Celsius
degrees Fahrenheit	(5/9) x (°F – 32) + 273.15.	kelvins
feet	0.3048	meters
gallons (U.S. liquid)	0.003785412	cubic meters
horsepower (550 ft-lb force per second)	745.6999	watts
inches	0.0254	meters
kips per square foot	47.88026	kilopascals
kips per square inch	6.894757	megapascals
miles (U.S. statute)	1.609347	kilometers
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.006894757	megapascals
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square meters
square miles	2,589,998	square meters
tons (force)	8,896.443	newtons
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

*_Système International d"Unités_ ("International System of Measurement"), commonly known as the "metric system."

Preface

This study was conducted for the Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL), U.S. Army Corps of Engineers under the direction of CERL Sustainability Committee.

The work was performed by the Energy Branch (CF-E) of the Facility Division (CF), U.S. Army Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Dr. Mike C.J. Lin. Special acknowledgement is given to the CERL Public Works Directorate, especially to Dr. Thomas Miller, DPW Chief of Operations, Champaign Site, for their generous support of this project. Dr. Thomas Hartranft is Chief, CEERD-CF-E, and L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Gary W. Schanche. The technical editor was William J. Wolfe, Information Technology Laboratory. The Director of CERL is Dr. Alan W. Moore.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL John Morris III, EN and the Director of ERDC is Dr. James R. Houston.

1 Introduction

Background

In the mid-1960s, the Army Corps of Engineers needed a laboratory focused on construction research to meet its complex construction program requirements. The Corps recognized the potential benefits and savings of a unified construction research effort that would address the entire spectrum of issues within military construction. In 1968, the National Academy of Sciences (NAS) recommended that the Corps establish a laboratory dedicated to this mission. NAS further advised co-locating this facility with a major academic institution with a strong engineering college. After judging proposals from 20 major universities, the Army chose the University of Illinois at Urbana-Champaign (UIUC) as the location for the new Construction Engineering Research Laboratory (CERL). The lab (which then occupied two buildings, each about 120 ft wide and 400 ft long) was dedicated 25 July 1969.

While CERL opened with a charter to do research in construction engineering, it became apparent by the 1970s that installations' facility and environment issues are intertwined and inseparable. In 1972, CERL added an environmental research mission. This program grew so large during the 1980s that, in 1986 an additional building (the "Zackrison Building") was built (about 100 ft wide, 200 ft long) to accommodate increased staff needs. Several additional commercial buildings were rented in the adjacent areas thereafter. Presently, some 100 university personnel supplement the 300 government employees are working at CERL. In 2002, construction of a fourth building was planned.

A CERL sustainability workshop was held in October 2002 to address issues and set goals related to waste, utilities, water, landscaping, telecommuting, transportation, parking, and workspace environmental control. Appendix A includes highlights of the workshop discussions in the areas of utilities, water, and landscaping. Under the "Utilities" category, workshop participants suggested an energy reduction goal of 50 percent—although it would not be possible to know whether this 50 percent reduction goal is realistic and achievable without an actual energy audit. CERL Energy Branch Chief, Dr. Thomas Hartranft, proposed to use CERL in house staff to conduct an energy audit for the CERL main complex.

Objective

The objectives of this work were to:

1. Review energy and water usage in CERL's current main complex building
2. Review and inventory the energy system equipment
3. Devise short- and long-term energy improvement and water conservation strategies. (Baseline references on utilities consumptions and costs would assist in future periodic monitoring efforts.)

Approach

An energy audit proposal was prepared and presented to CERL management on 11 December 2002. A two-phase approach was proposed: the Phase I audit would examine the energy systems (macro-level); the Phase II audit would examine the system components (micro-level). One of the advantages of the phased approach is that it allows mid-course adjustment so that scope of work can be revised before Phase II begins. The Phase I audit was approved immediately after the proposal presentation.

A walkthrough audit was conducted on 10 January 2003, and a follow up meeting held on 16 January 2003. Further data gathering, analysis, and additional meetings, were required to review and finalize short- and long-term recommendations. The results were documented and presented to CERL management on 13 March 2003.

Participants in the Phase I audit (listed alphabetically) were:

- Michael Ashby (DPW)
- Elizabeth Brisson (DPW)
- Joseph Bush (CF-E)
- Thomas Hartranft (CF-E)
- Dale Herron (CF-E)
- Elisabeth Jenicek (CF-E)
- Nicholas Josefik (CF-E)
- Patricia Kemme (CN-E)
- Larry Kimball (DPW)
- Mike C.J. Lin (CF-E)
- Thomas Miller (DPW)
- Paul Nielsen (CF-E)
- David Schwenk (CF-E)
- Gregory Snyder (CF-E)
- Chang Sohn (CF-E)
- John Vavrin (CF-E)
- Eileen Westervelt (CF-E).

Appendix B includes a description of the audit preparation, schedule, and items of focus (energy improvement strategy, exterior walk-around, and interior walk-through). A five-stage energy improvement strategy is followed to complete the audit. Appendix B includes details of the five stages, including lighting, building tune-up, load reduction, heating and cooling distribution system, and the heating and cooling plant. Appendix C shows the FY03 CERL input to ENERGY STAR®, prepared by Eileen Westervelt, which reinstated CERL as an ENERGY STAR® Partner.

Mode of Technology Transfer

Results of this work will be furnished to the CERL Sustainability Committee members and will also be published via the World Wide Web at URL:

http://www.cecer.army.mil/

2 Facility Description

General

CERL was dedicated in July 1969. The lab originally occupied Bldg 1 (originally named the "Materials Laboratory") and Bldg 2 (originally named the "Construction Engineering Laboratory"). Each building has both lab and office space mixed. Building 3 (Zackrison Building) was added in 1986. Table 1 lists the square-footages of the all buildings currently in use by CERL. CERL staff have flexible working hours, generally from 6 a.m. until 6 p.m. during weekdays; few people work on weekends.

Figure 1 shows the main complex layout. Figures 2, 3, 4, and 5 show the AutoCAD drawings for, respectively, Building 1, 2, 3, and the TESS (Triaxial Earthquake and Shock Simulator) Building.

Table 1. Area measurements of CERL buildings.

Building	Footprint Area (sq ft)	Gross Areas All Floors	Total of all Interior Space
Bldg 1	48782	53275	50514
South Hall	932	747	747
UCHI House	582	561	561
Bldg 2	48782	56527	51604
North Hall	1174	1007	1007
Bldg 3	20444	24645	23251
TESS	14018	13497	13285
AT&T	10074	9622	9152
Solar House	886	800	769
Chem Str Bldg	300	264	264
Burn Bldg	201	164	164
Utilities Bldg	4400	4104	4104
Scan Tech	22942	22250	21676
Pole Barn	3086	3067	3034
Foam Panel Bldg	1480	1374	1359
TESS Storage	2517	2368	2368
Green House	297	286	286
Total CERL	180897	194558	184145

HVAC equipment in each building is identified by number. At the walkthrough audit follow-up meeting on 16 January 2003, the DPW staff provided drawings and a list of equipment condition. Appendix D includes HVAC equipment conditions as of 30 December 2002. Appendix D also lists more detailed HVAC equipment specifications that were gathered later. Appendix E provides upgraded drawings that clarify air conditioning/handling units. The drawings focus on air handling units, roof top packaged units, computer room packaged units, room occupancy sensors, and lighting panels.

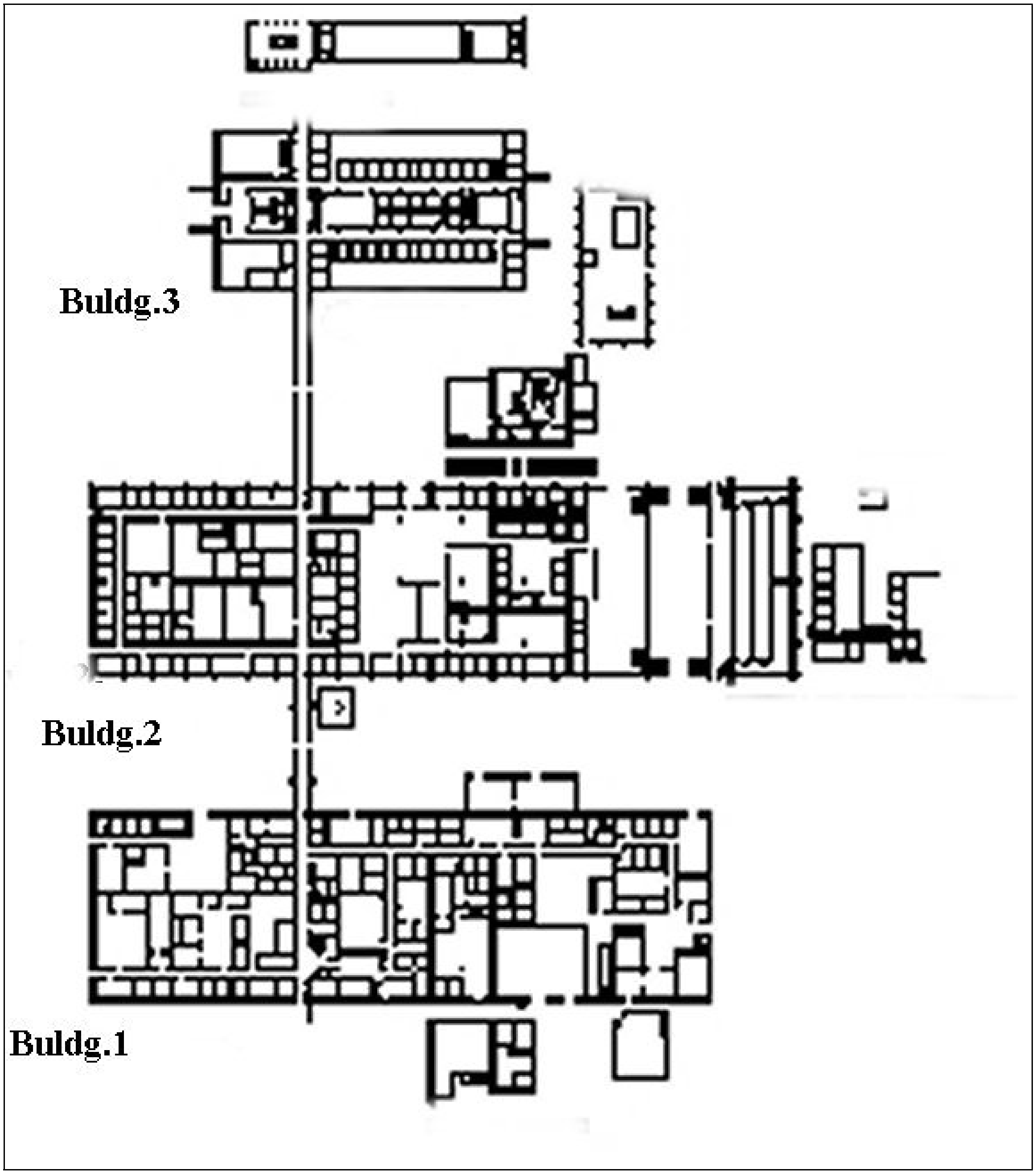


Figure 1. CERL main complex layout.

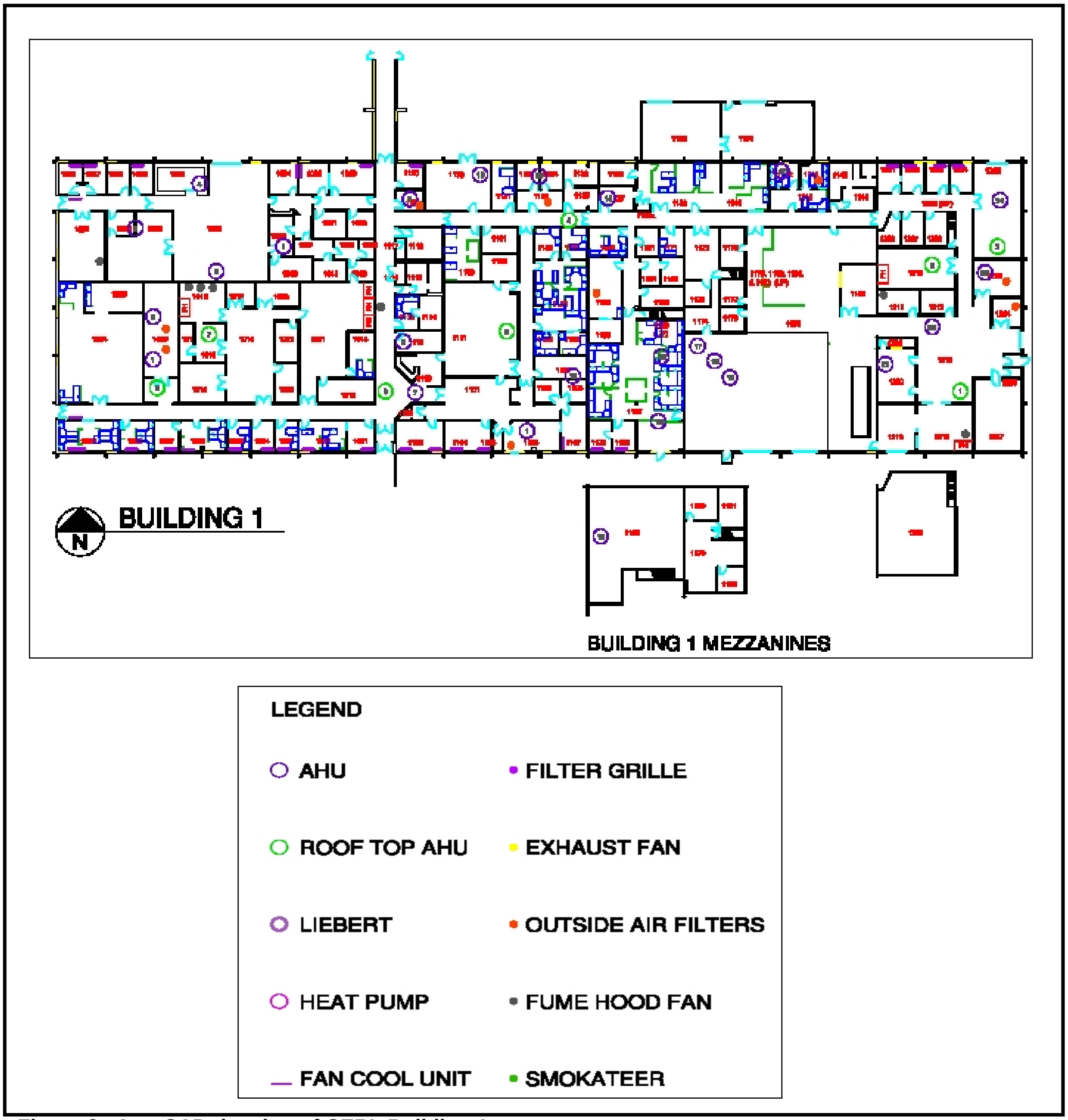


Figure 2. AutoCAD drawing of CERL Building 1.

Figure 3. AutoCAD drawing of CERL Building 2.

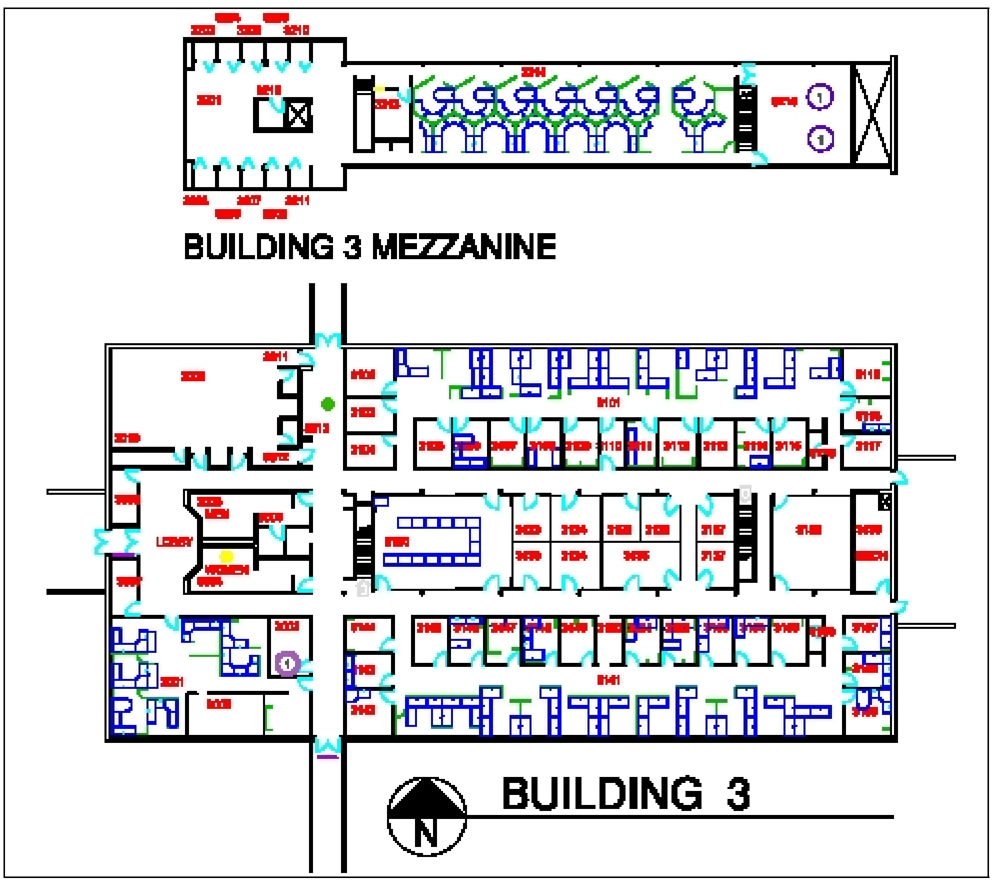


Figure 4. AutoCAD drawing of CERL Building 3.

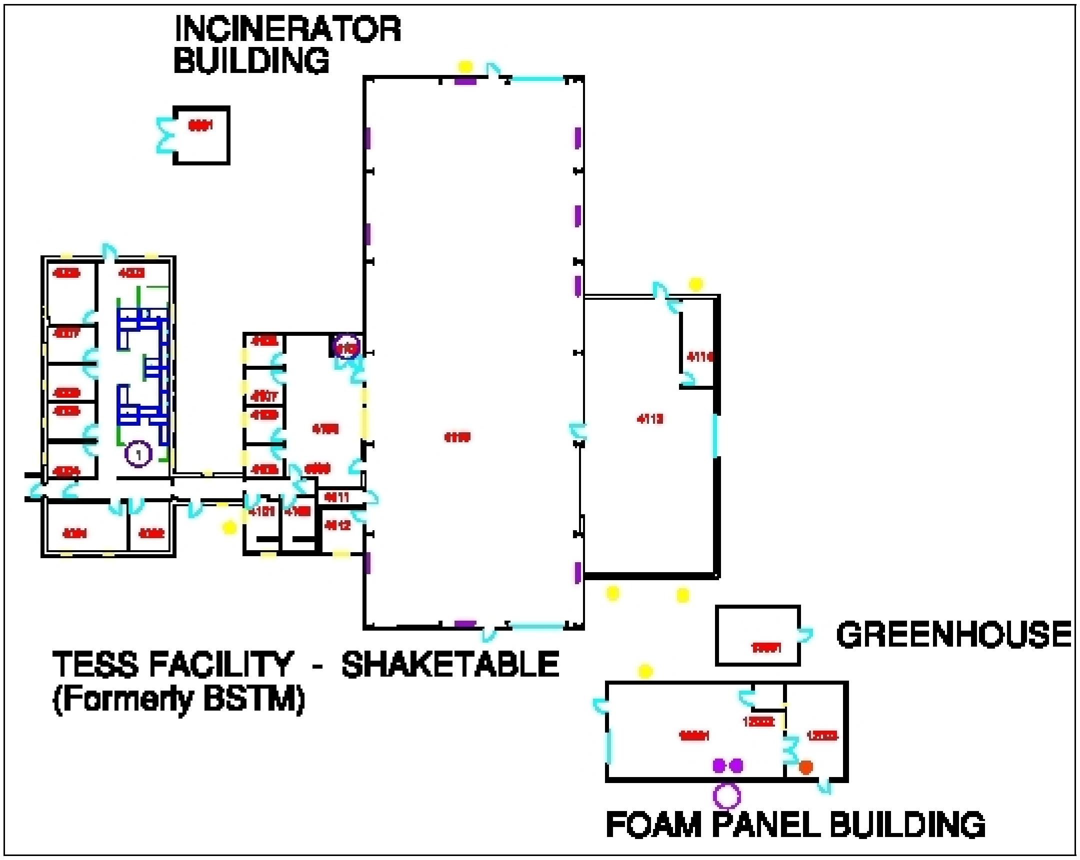


Figure 5. AutoCAD drawing of CERL TESS Building.

Heating

Heating of the main complex (Buildings 1, 2 and 3) is done primarily through a low temperature hot water heating system with two gas-fired boilers. Cooling is provided by two York electric chillers housed in the Utilities Building. Electricity and gas are metered by utility company furnished meters. Electricity for Buildings 1, 2, and 3 are measured by electric meter #82618536; gas for Buildings 1, 2, and 3, and for the TESS Building is metered through gas meter #1TC53644.

Hot Water

The low temperature hot water system consists of two Cleaver Brooks Model CB-760-200 natural gas-fired boilers built in 1969. Each boiler has maximum capacity (250 boiler hp) of a 8,375,000 Btu/hr with pressure rated at 150 psig. Boiler serial numbers are L-47159 (boiler on the north side) and L-47160 (boiler on the south side). The boilers were converted from 4-pass to 2-pass in 1982. The north boiler was overhauled in 2001 and the south boiler in 2002. A Honeywell boiler control system was installed in 1988. University of Illinois, UIUC Operations and Maintenance staff performs regularly scheduled maintenance work. Water quality is checked monthly by UIUC staff. Each Fall when heating season starts, a stack test is conducted to fine tune the boiler, but CERL does not have test records. The hot water temperature setting varies between 180 and 200 °F with 40 psig pressure. There is makeup water for the boiler, but there is no economizer and thus no combustion air preheat.

Each of the three main buildings has a domestic hot water heater. Hot water heaters are all set to 120 °F. Building 1 has an 80-gal heater tank; Building 2 has a 76-gal heater tank. Both are natural gas-fired units. Building 3 has a small “instant recovery” electric water heater with a 20-gal size tank.

Cooling

In the spring of 1993, two R-22 (HCFC) York chiller units (rated at 180 tons each, but which can be peaked at 230 tons under favorable conditions) were installed to replace the old chiller in the Utilities Building with an upgraded unit that included a future ice storage option. The chiller compressor is of rotary screw type. The maximum KW drawn by the chillers has never been recorded. The UIUC Operations and Maintenance staff maintains them on a regular schedule. A diurnal ice storage (DIS) system was installed adjacent to the Utilities Building in 1996 to reduce electric consumption during peak hours (10 a.m. to 9 p.m., Monday–Friday, excluding holidays). A 30,000-gal storage tank with 125,000 dimpled plastic balls with water inside to be frozen during off-peak hours (9 p.m.–10 a.m. M-F). The DIS system was commissioned in October 1996. Ice storage tank operated satisfactorily last summer. The condition of balls will be checked during spring 2003. About 200 KW electric demand was shifted during the cooling season with estimated savings of $15,000 in electric utility bills (summer demand charge $14/KW, 4 months – June through September. Winter demand charge $7/KW, October through May). Total construction cost was $162,500 (tank, ice balls, controls). Thus, simple payback for the DIS system is about 10.8 years. Total storage capacity is 1700 ton-hours. Illinois Power (IP) contributed $50,000 for the study of DIS cooling system (IP POC Tony Wilkins, 217-425-6107).

The chiller is normally operated in one of three “modes,” each mode associated with a time period (10 a.m.–6 p.m., 6 p.m.–9 p.m., and 9 p.m.–10 a.m.). After 15 April of each year, DIS cooling runs between 10 a.m. and 9 p.m. with the two chillers turn off. During 6 p.m. to 9 p.m., only one chiller is on to keep cool. After 9 p.m., one chiller is set at 44 °F for comfort cooling, the other at 22 °F making ice. Details of the chiller operating cycle are as follows:

1. *Weekdays (Normal Routine)*. Chillers shut down at 9:50 a.m. The system discharges ice from the storage tank until 6 p.m.. From 6 p.m. to 9 p.m., both ice discharge and comfort cooling takes place. The second chiller comes on line at 9 p.m. and makes ice in the storage tank from 9 p.m. until 9:50 a.m.
2. *Weekends*. From Friday 6 p.m. until 3 p.m. Sunday, only one chiller runs—for comfort cooling only. At 3 p.m. Sunday, the second chiller comes up to make ice till 9:50 Monday morning when the weekly cycle starts. Normally the water/glycol mix to the buildings is held to 45 °F. It was occasionally set at 47 °F on the weekends, but at that setting, the dew point tends to rise and the humidity in the buildings increases. The chillers can consequently only operate within a narrow range for the operator to be able to both maintain comfort and avoid discharging ice so quickly that the chillers must run during the peak daytime hours.

The temperature of the approximate 30 percent water/glycol mixture going to the thermal ice storage tank is normally held at around 18 to 22 °F. The chilled water supply to the buildings is kept at 45 °F. New software is currently being installed to maintain a more precise control.

In the building layout provided by DPW staff, the air conditioning/handling units (AHU) and the roof top packaged units (RTU) are numbered. The layout shows:

- 45 AHUs (B1-24, B2-17, B3-3, Uchi House-1)
- 9 RTUs (B1-8, B2-1)
- 100 fan coil units (B1-35, B2-63, B3-2, located primarily along the building perimeter)
- 7 exhaust fans (B1-0, B2-4, B3-1, Uchi House-2)
- 20 outside air filters (B1-9, B2-10, B3-0, Uchi-1)
- 7 fume hood fans (in B1)
- 6 Fume Hoods (in B1)
- 1 Smokeater (in B3).

Roofing

David Bailey (CEERD-CF-M) provided the main complex roofing information.

The roofing for Building 1 and 2 consists of:

- metal deck
- 1-in. Perlite board (R=2.8/in.)
- felt asphalt vapor retarder
- 2 layers of 1.25-in. polyisocyanurate insulation (R=6.2/in.)

- various membranes:
    - Bldg 2 High Bay – modified bitumen (1999)
    - Bldg 2 Low Bay – PVC (1984)
    - Bldg 2 west – APP modified Bitumen (1987)
    - Bldg 1 far west half – PIB (1989)
    - Bldg 1 east & west half – Hylon (1990).

The total R Value was calculated to be about 20 and the expected life is estimated at 20 Years.

Building 3 has a 6-in. thick batt insulation in roofing with an estimated R of 24, assuming the batt has a R value of 4 per in. The recommended R value for buildings in Champaign/Urbana area is about 38.

3 Utilities Bill Analysis

Utility Rate Structure

Table 2 lists the account and rate schedule information for CERL electric and gas utility meters. Appendix F details the Illinois Power Company's electric rate schedule 19, which is applicable to the CERL main complex. During the implementation of a microturbine (30KW) and other backup electric generation, a CERL researcher (William Taylor) discovered that CERL may switch to an unbundled rate schedule 110 to save about \$12k – \$13k per year. Under this schedule, no standby tariff will be required when the microturbine is connected to the electric grid. Further investigation of the advantages implicit in converting to the new rate schedule is recommended.

Utilities Consumptions and Costs

Tables 3 and 4 list CERL utilities costs and consumptions (including the main complex and outer satellite buildings) for the past 7 fiscal years (1996–2002). Over that time, total utilities cost varied between about \$357k and \$457k.

Table 2. CERL electric and gas meter information.

Utility	Building	Acct. #	Meter #	Rate Schedule
Electricity	Main	3672521259	82618536	Rate 19
Electricity	Shake Table	8118125874	91449092	Rate 11/19
Electricity	AT&T	9625532442	95942149	Rate 11
Electricity	AT&T	9625532442	62244514	Rate 10
Electricity	AT&T	5426792846	19356949	Rate 11
Electricity	AT&T	5426792846	20499350	Rate 11
Electricity	Scan Tech	4422013076	81489830	Rate 11
Electricity	1175 County Rd.	2047536454	97133213	Rate 10
Electricity	1175 County Rd.	2047536454	2SA41868	Rate 10
Gas	Main	4481815225	1TC53644	Rate 64
Gas	AT&T	5426792846	6TC08275	Rate 63
Gas	AT&T	5426792846	5TC54864	Rate 63
Gas	Scan Tech	4422013076	TC92940	Rate 63

Table 3. CERL utility costs summary.

Utility	Building	FY96	FY97	FY98	FY99	FY00	FY01	FY02
Electricity	Main/2902 Newmark Dr.	$195,854.97	$191,966.77	$171,705.66	$194,188.77	$193,862.81	$198,223.99	$190,609.00
	Shaketable/2906 Newmark Dr. '95	$116,050.00	$77,980.67	$75,720.90	$77,543.51	$66,285.02	$57,453.65	$54,230.69
	AT&T/3001 Newmark Dr.	$8,320.42	$9,059.51	$9,039.26	$11,916.64	$8,816.93	$8,237.02	$6,841.56
	Deli/3000 Research Rd.	$6,977.96	$1,716.18	$0.00	$0.00	$0.00	$0.00	$0.00
	Harris/3001 Research Rd.	$27,171.11	$30,853.93	$28,126.34	$8,506.87	$0.00	$0.00	$0.00
	Henneman 1/1702 Research Dr.	$1,784.15	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Henneman 2/2803-5 Research Rd.	$12,755.90	$9,098.45	$0.00	$0.00	$0.00	$0.00	$0.00
	Scantech/2902 Farber Dr.	$18,167.50	$18,087.04	$16,456.14	$16,547.53	$16,699.39	$17,730.78	$15,630.90
	Bondville–3 Meters, 2 Meters after '98	$1,456.42	$1,299.82	$1,195.25	$708.00	$730.48	$1,604.49	$969.56
	Totals	*$388,538.43*	*$340,062.37*	*$302,243.55*	*$309,411.32*	*$286,394.63*	*$283,249.93*	*$268,281.71*
Gas	Main/2902 Newmark Dr.	$38,210.51	$51,686.32	$43,715.46	$38,208.91	$53,567.56	$100,487.48	$72,779.00
	Shaketable/2906 Newmark Dr.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	AT&T/3001 Newmark Dr.	$2,327.13	$2,804.37	$2,316.74	$2,402.38	$2,520.95	$5,727.84	$3,607.91
	Deli/3000 Research Rd.	$3,012.11	$1,359.30	$0.00	$0.00	$0.00	$0.00	$0.00
	Harris/3001 Research Rd.	$4,229.63	$5,489.19	$3,618.16	$3,290.20	$0.00	$0.00	$0.00
	Henneman 1/1702 Research Dr.	$1,220.56	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Henneman 2/2803-5 Research Rd.	$2,504.77	$3,168.41	$0.00	$0.00	$0.00	$0.00	$0.00
	Scantech/2902 Farber Dr.	$4,213.33	$5,455.78	$4,415.37	$3,964.29	$3,335.03	$6,148.69	$4,702.12
	Totals	*$55,718.04*	*$69,963.37*	*$54,065.73*	*$47,865.78*	*$59,423.54*	*$112,364.01*	*$81,089.03*

Utility	Building	FY96	FY97	FY98	FY99	FY00	FY01	FY02
Water	Main/1502 Interstate Dr.	$7,419.62	$5,381.10	$5,159.14	$5,147.40	$7,085.42	$6,521.18	$4,534.77
	Shaketable/2906 Newmark Dr.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	AT&T/3001 Newmark Dr.	$212.78	$301.00	$305.49	$126.91	$397.44	$247.66	$319.61
	Deli/3000 Research Rd.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Harris/3001 Research Rd.	$260.27	$304.80	$273.53	$326.68	$0.00	$0.00	$0.00
	Henneman 1/1702 Research Dr.	$145.53	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Henneman 2/2803-5 Research Rd.	$391.92	$404.12	$0.00	$0.00	$0.00	$0.00	$0.00
	Scantech/2902 Farber Dr.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Totals	*$8,430.12*	*$6,391.02*	*$5,738.16*	*$5,600.99*	*$7,482.86*	*$6,768.84*	*$4,854.38*
Sanitary	Main/1502 Interstate Dr.	$4,063.03	$3,197.00	$1,989.75	$2,022.93	$3,789.84	$4,478.98	$4,130.42
	Shaketable/2906 Newmark Dr.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	AT&T/3001 Newmark Dr.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Deli/3000 Research Rd.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Harris/3001 Research Rd.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Henneman 1/1702 Research Dr.	$90.41	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Henneman 2/2803-5 Research Rd.	$303.62	$137.02	$0.00	$0.00	$0.00	$0.00	$0.00
	Scantech/2902 Farber Dr.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Totals	*$4,457.06*	*$3,334.02*	*$1,989.75*	*$2,022.93*	*$3,789.84*	*$4,478.98*	*$4,130.42*
	Grand Total	***$457,143.65***	***$419,750.78***	***$364,037.19***	***$364,901.02***	***$357,090.87***	***$406,861.76***	***$358,355.54***

Table 4. CERL utilities consumption summary.

Utility	Building	FY96	FY97	FY98	FY99	FY00	FY01	FY02
Electricity (MBtu)	Main/2902 Newmark Dr.	9,605	9,248	8,789	9,141	10,010	10,219	9,956
	Shaketable/2906 Newmark Dr. '95	1,509	1,376	1,442	1,436	1,673	1,642	1,388
	AT&T/3001 Newmark Dr.	221	247	244	219	230	201	169
	Deli/3000 Research Rd.	216	40	0	0	0	0	0
	Harris/3001 Research Rd.	1,039	1,178	1,212	538	0	0	0
	Henneman 1/1702 Research Dr.	59	0	0	0	0	0	0
	Henneman 2/2803-5 Research Rd.	488	334	0	0	0	0	0
	Scantech/2902 Farber Dr.	757	713	756	738	698	713	706
	Bondville–3 Meters, 2 Meters after '98	19	8	6	0	0	32	3
	Totals	*13,914*	*13,145*	*12,448*	*12,072*	*12,611*	*12,806*	*12,222*
Gas (MBtu)	Main/2902 Newmark Dr.	11,825	10,956	10,221	10,014	11,609	13,554	14,175
	Shaketable/2906 Newmark Dr.	0	0	0	0	0	0	0
	AT&T/3001 Newmark Dr.	526	438	379	440	428	608	561
	Deli/3000 Research Rd.	468	161	0	0	0	0	0
	Harris/3001 Research Rd.	991	915	593	682	0	0	0
	Henneman 1/1702 Research Dr.	313	0	0	0	0	0	0
	Henneman 2/2803-5 Research Rd.	582	542	0	0	0	0	0
	Scantech/2902 Farber Dr.	1,224	1,155	979	975	735	860	846
	Totals	*15,929*	*14,167*	*12,173*	*12,111*	*12,772*	*15,022*	*15,582*

Utility	Building	FY96	FY97	FY98	FY99	FY00	FY01	FY02
Water (100 cu ft)	Main/1502 Interstate Dr.	5840	3,930	5,729	3,712	5,438	4,916	5,041
	Shaketable/2906 Newmark Dr.	0	0	0	0	0	0	0
	AT&T/3001 Newmark Dr.	53	97	120	128	153	76	118
	Deli/3000 Research Rd.	0	0	0	0	0	0	0
	Harris/3001 Research Rd.	35	38	38	13	0	0	0
	Henneman 1/1702 Research Dr.	61	0	0	0	0	0	0
	Henneman 2/2803-5 Research Rd.	205	89	0	0	0	0	0
	Scantech/2902 Farber Dr.	0	0	0	0	0	0	0
	Totals	*6194*	*4,154*	*5,887*	*3,853*	*5,591*	*4,992*	*5,159*
Sanitary (100 cu ft)	Main/1502 Interstate Dr.	3417	3,270	2,248	2,243	3,282	3,074	2,818
	Shaketable/2906 Newmark Dr.	0	0	0	0	0	0	0
	AT&T/3001 Newmark Dr.	0	0	0	0	0	0	0
	Deli/3000 Research Rd.	0	0	0	0	0	0	0
	Harris/3001 Research Rd.	0	0	0	0	0	0	0
	Henneman 1/1702 Research Dr.	62	0	0	0	0	0	0
	Henneman 2/2803-5 Research Rd.	199	87	0	0	0	0	0
	Scantech/2902 Farber Dr.	0	0	0	0	0	0	0
	Totals	*3678*	*3,357*	*2,248*	*2,243*	*3,282*	*3,074*	*2,818*
	Total Electricity & Gas (MBtu)	***29,843***	***27,312***	***24,621***	***24,183***	***25,383***	***27,828***	***27,805***

Figures 6 and 7 show, respectively, plots of the CERL main complex electric, gas, and water consumption; costs for the fiscal years 1998 through 2002; and Heating degree days (HDD) and cooling degree days (CDD) for the corresponding years. Annual electricity cost was about 3 to 4 times of gas cost and about 30 to 40 times of water cost. It is interesting to note that FY01 had the highest number of HDD, but not the largest amount of gas consumption.

Figure 8 shows the number of occupants in the main complex for the past 6 years (1997 through 2002). Despite gradual reduction of occupants from 366 to 299, the energy consumption increased since 1998. Figure 9 shows water usage and costs for the past 8 years (1995 through 2002). Average water cost is $6256/yr, and average usage is 3977 kgal/yr. On an average, water cost is $1.6/kGal. Similarly, Figure 10 shows sanitary usage and costs. Average sewage cost is $3527/yr, and average sanitary usage is 2310 kgal/yr. On an average, sanitary cost is $1.52/kGal. Total water and sanitary cost constitutes only a small portion of the total utilities bill paid (about 2 to 3 percent). Efforts on water conservation thus will not yield significant economic impacts.

Energy Utilization Index (EUI) in kBtu/sq ft /Yr and Energy Cost Index (ECI) in $/sq ft/Yr

Monthly gas and electric consumptions and costs were obtained from the invoices sent by Illinois Power Company. Tables 5–11 list monthly and annual Energy Use Index (EUI), in KBtu/sq ft/yr, total facility electric and gas energy used (in MBtu) divided by the building gross areas of all floors (in square feet), and the associated cost index (ECI, in $/sq ft/yr) for FY96 through FY02. Since this study covered only the main complex, gas used by the TESS Building must be excluded. This exclusion is based on the ratio of the footprint area of the TESS building (14,018 sq ft) to that of the main complex (125,096 sq ft), or about 10 percent of the gas metered.

The gross areas for all floors of the main complex are about 141,162 sq ft, which includes 4400 sq ft of the Utilities Building since this building uses the same sources of electric and gas energy for heating and cooling. Figure 11 shows a plot of annual EUI and ECI for FY96 through FY02. The EUI decreased from 143.1 (FY96) to 126.62 (FY98), then increased in the following years to 160.5 (FY02).

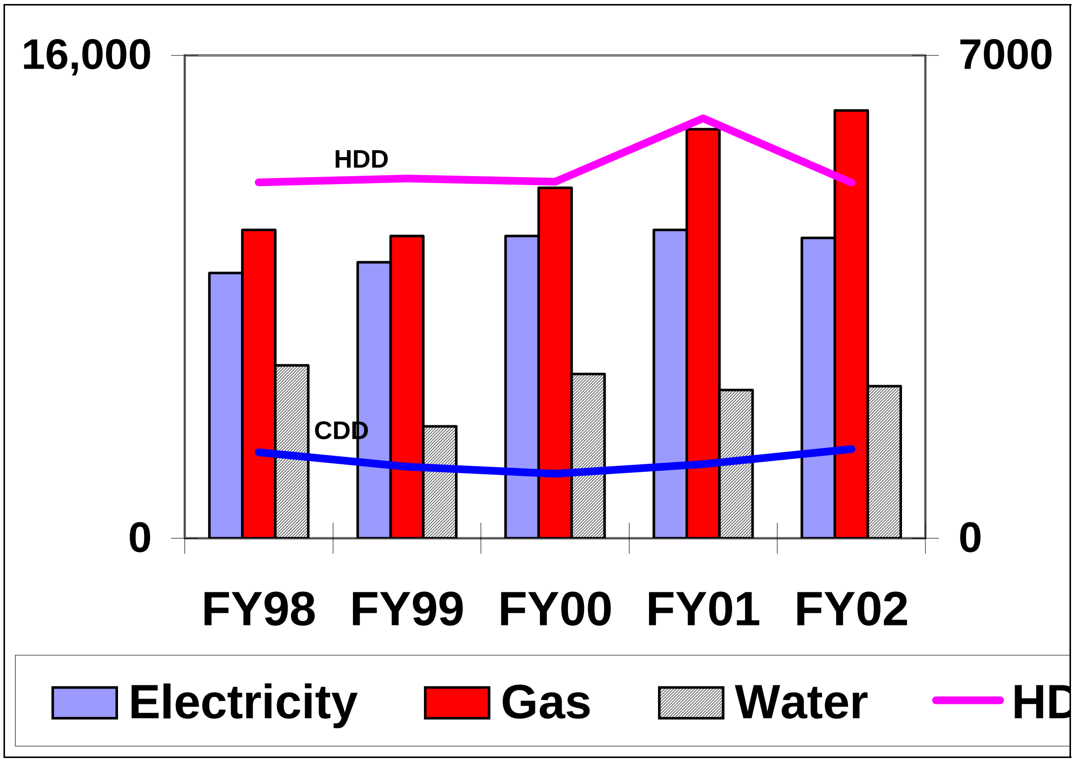


Figure 6. CERL main complex utilities consumption.

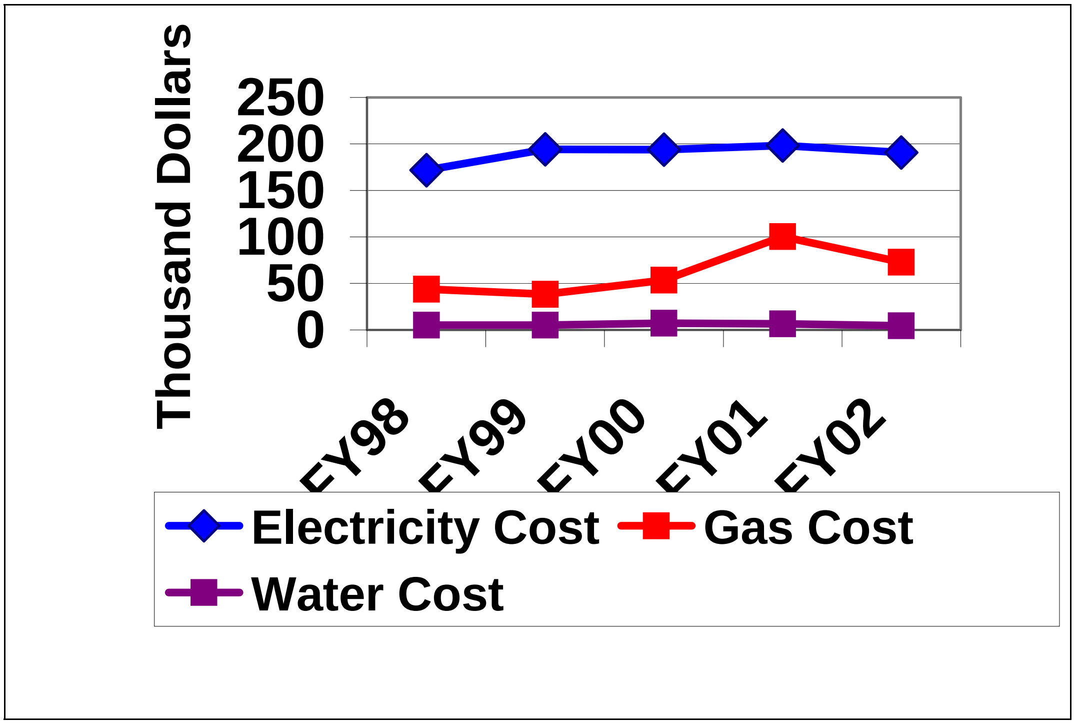


Figure 7. CERL main complex utilities cost.

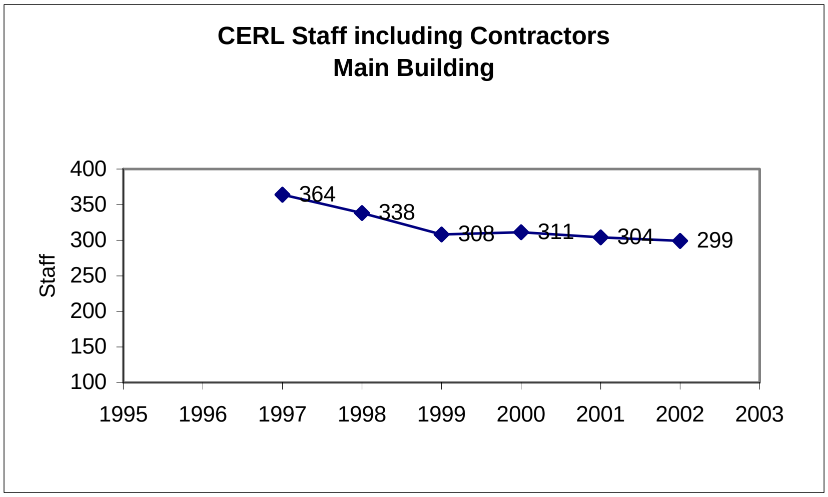


Figure 8. Number of occupants of the CERL main complex.

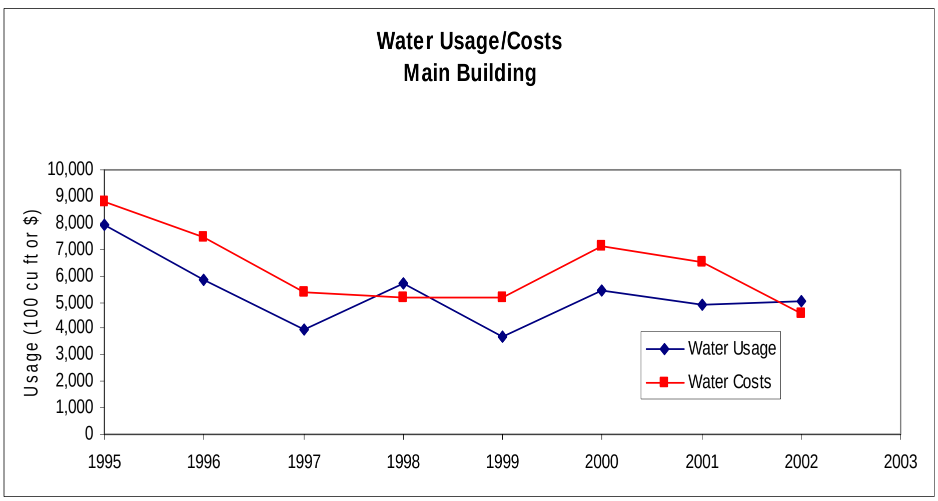


Figure 9. Water usage and costs for the past 8 years.

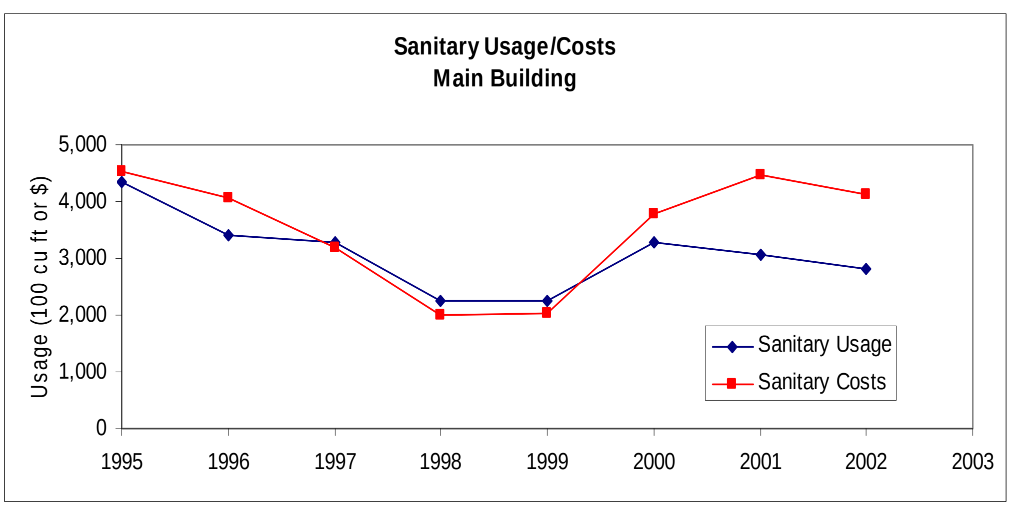


Figure 10. Sanitary usage and costs for the past 8 years.

Table 5. FY02 monthly energy consumptions, costs, use indices and electric load factors.

Month	Gas (MBtu)	Gas ($)	Elec. (dmdk)w	Elec. (KWh)	Elec. (MBtu)	Elec. ($)	E+G (main) (MBtu)	EUI (KBtu/sq ft)	ECI ($/sq ft)	Load factor (kwh/Dkwh)
Oct	1013	4264.09	609.6	231200	789.09	15149.19	1696.73	12.02	0.13	0.51
Nov	1102	5818.01	414.4	194400	663.49	12419.33	1650.88	11.69	0.12	0.65
Dec	1716	8533.48	387.2	199200	679.87	12345.55	2217.41	15.71	0.14	0.69
Jan	1616	8334.6	442.4	200000	682.60	12852.72	2130.54	15.09	0.14	0.61
Feb	1672	9188.73	432	190400	649.84	12442.67	2147.95	15.22	0.15	0.66
Mar	1804	9315.42	548	216800	739.94	14129.51	2356.32	16.69	0.16	0.53
Apr	988	5219.36	619.2	204800	698.98	14272.8	1584.23	11.22	0.13	0.46
May	1097	5712.24	644.8	308000	1051.2	17796.39	2034.12	14.41	0.16	0.64
Jun	751	3979.98	603.2	296000	1010.2	21144.16	1683.14	11.92	0.18	0.68
Jul	645	3313.31	511.2	315200	1075.8	20586.54	1653.70	11.71	0.17	0.83
Aug	838	4088.29	482.4	302400	1032.1	19629.4	1782.94	12.63	0.17	0.84
Sep	933	5011.54	452.8	258597	882.59	17841.07	1718.56	12.17	0.16	0.79
Sum	*14175*	*72779.05*	*6147.2*	*2916997*	*9955.7*	*190609.3*	*22656.51*	*160.50*	*1.81*	*0.66*
Ave	***$/MBtu***	***5.134325***			***$/KWh***	***0.065344***				

Table 6. FY01 monthly energy consumptions, costs, use indices and electric load factors.

Month	Gas (MBtu)	Gas ($)	Elec. (dmdkw)	Elec. (KWh)	Elec. (MBtu)	Elec. ($)	E+G(main) (MBtu)	EUI (KBtu/sq ft)	ECI ($/sq ft)	Load factor (kwh/Dkwh)
Oct	738.6	5380.45	487.2	175008	597.30	12261	1259.09	8.92	0.12	0.48
Nov	1828	12347.49	600.8	220000	750.86	14681	2388.30	16.92	0.18	0.51
Dec	2406	20668.15	394.4	232000	791.82	13512	2947.23	20.88	0.23	0.79
Jan	1896	18416.37	461.6	219200	748.13	13634	2446.95	17.33	0.21	0.64
Feb	1607	12116.95	444	194400	663.49	12625	2103.36	14.90	0.17	0.65
Mar	1210	9088.8	520	203200	693.52	13431	1777.68	12.59	0.15	0.53
Apr	801	5781.48	586.4	296000	1010.2	17193	1727.94	12.24	0.16	0.70
May	634.4	4690.65	657.6	286400	977.48	17170	1545.91	10.95	0.15	0.59
Jun	622	3367.73	516	330400	1127.7	21127	1684.97	11.94	0.17	0.89
Jul	481	2465.25	600.8	313600	1070.3	21708	1501.29	10.64	0.17	0.70
Aug	666	3284.51	477.6	316000	1078.5	20034	1675.24	11.87	0.16	0.89
Sep	664	2884.58	621.6	235200	802.74	19454	1397.68	9.90	0.16	0.53
Sum	13553	100492.4	6368	3021408	10312.	196830	22455.64	159.08	2.03	0.66
Ave	$/MBtu	7.414718			$/KWh	0.065145				

Table 7. FY00 monthly energy consumptions, costs, use indices and electric load factors.

Month	Gas (MBtu)	Gas ($)	Gas (Dmdkw)	Elec. (KWh)	Elec. (MBtu)	Elec. ($)	E+G(main) (MBtu)	EUI (KBtu/sq ft)	ECI ($/sq ft)	Load factor (kwh/Dkwh)
Oct	765.9	3452.52	476	180800	617.07	12450.4	1303.32	9.23	0.11	0.51
Nov	1055	4821.18	439.2	207200	707.17	13002.29	1652.81	11.71	0.12	0.66
Dec	1681	6556.32	425.6	191200	652.57	12321.12	2158.74	15.29	0.13	0.60
Jan	1961	7528.66	440	208800	712.63	13007.89	2470.05	17.50	0.14	0.64
Feb	1264	5054.59	521.6	190400	649.84	13037.43	1782.56	12.63	0.12	0.54
Mar	1080	4319.86	518.4	190400	649.84	12963.88	1617.96	11.46	0.12	0.49
Apr	969.7	4106.56	526.4	256800	876.46	15234.59	1745.31	12.36	0.13	0.68
May	505.5	2690.33	605.6	265600	906.49	16002.73	1359.42	9.63	0.13	0.59
Jun	459.9	2976.02	715.2	296800	1013	22771.62	1425.05	10.10	0.18	0.58
Jul	519.3	3242.17	477.6	337600	1152.2	20679	1617.52	11.46	0.17	0.95
Aug	468.4	2804.34	536	299200	1021.2	20217	1440.86	10.21	0.16	0.75
Sep	881.3	6015.01	640.8	308000	1051.2	22158	1840.85	13.04	0.20	0.67
Sum	11613	53567.56	6322.4	2932800	10010	193846	20414.45	144.62	1.71	0.64
Ave	$/MBtu	4.612922			$/KWh	0.066096				

Table 8. FY99 monthly energy consumptions, costs, and use indices.

FY 99	Gas (MBtu)	Gas ($)	Elec. (Dmdkw)	Elec. (KWh)	Elec. (MBtu)	Elec. ($)	E+G(main) (MBtu)	EUI (KBtu/sq ft)	ECI ($/sq ft)
Oct	891.7	3371.82		216000	737.21	13280.93	1536.17	10.88	0.12
Nov	1084.4	4089.56		180000	614.34	11595.34	1585.96	11.24	0.11
Dec	2240.4	8606.92		208000	709.90	11752.8	2717.30	19.25	0.14
Jan	1451.6	5602.66		160800	548.81	9708.84	1849.44	13.10	0.10
Feb	1752.3	6326.75		195200	666.22	12324.69	2236.28	15.84	0.13
Mar	1125.9	3878.77		204000	696.25	13438.51	1705.06	12.08	0.12
Apr	781	2751.29		218400	745.40	14217.74	1445.18	10.24	0.12
May	186.7	845.02		244800	835.50	14442.14	1002.79	7.10	0.11
Jun	111	563.05		288800	985.67	21030.26	1085.13	7.69	0.15
Jul	49.4	345.7		255200	871.00	20017.92	915.26	6.48	0.14
Aug	101.9	589.96		268800	917.41	34159.76	1008.72	7.15	0.25
Sep	238.1	1237.39		238400	813.66	18219.84	1027.00	7.28	0.14
Sum	*10014.4*	*38208.89*		*2678400*	*9141.38*	*194188.8*	*18114.28*	*128.32*	*1.62*
Ave	***$/MBtu***	***3.815395***			***$/KWh***	***0.072502***			

Table 9. FY98 monthly energy consumptions, costs, and use indices.

Month	Gas (MBtu)	Gas ($)	Elec. (Dmdkw)	Elec. (KWh)	Elec. (MBtu)	Elec. ($)	E+G(main) (MBtu)	EUI (KBtu/sq ft)	ECI ($/sq ft)
Oct	63.6	438.78		201600	688.06	14723.49	745.05	5.28	0.11
Nov	617.4	3400.35		150400	513.32	11298.56	1066.51	7.56	0.10
Dec	1813.8	9200		224800	767.24	12956.76	2392.41	16.95	0.15
Jan	1858.2	7797.03		216800	739.94	13005.53	2404.89	17.04	0.14
Feb	1597.9	6251.57		170400	581.58	11264.57	2013.29	14.26	0.12
Mar	1592.8	5901.26		202400	690.79	12370.72	2117.94	15.00	0.13
Apr	1195.4	4545.98		200800	685.33	12963.31	1756.41	12.44	0.12
May	671.9	2695.22		214400	731.75	14431.97	1333.77	9.45	0.12
Jun	341	1416.66		260800	890.11	15416.01	1195.65	8.47	0.12
Jul	234	987.33		265600	906.49	19324.46	1116.16	7.91	0.14
Aug	38.3	300.81		210400	718.10	16600.58	752.41	5.33	0.12
Sep	65.6	385.07		269600	920.14	17032.47	978.92	6.93	0.12
Sum	*10090*	*43320.06*		*2588000*	*8832.84*	*171388.4*	*17873.39*	*126.62*	*1.49*
Ave	***$/MBtu***	***4.293408***			***$/KWh***	***0.066224***			

Table 10. FY97 monthly energy consumptions, costs, and use indices.

Month	Gas (MBtu)	Gas ($)	Elec. (Dmdkw)	Elec. (KWh)	Elec. (MBtu)	Elec. ($)	E+G(main) (MBtu)	EUI (KBtu/sq ft)	ECI ($/sq ft)
Oct	67.6	409.2		236000	805.47	19355.84	866.04	6.14	0.14
Nov	723.3	2770.43		176000	600.69	13431.95	1248.76	8.85	0.11
Dec	1799.5	8480.4		212000	723.56	12844.66	2335.91	16.55	0.14
Jan	1885.3	10777.14		184000	627.99	11956.95	2317.22	16.42	0.15
Feb	2214.1	10842.24		204000	696.25	13174.38	2680.09	18.99	0.16
Mar	1419.2	6749.84		179200	611.61	12435.43	1883.21	13.34	0.13
Apr	1141	4517.86		184000	627.99	12636.7	1650.33	11.69	0.12
May	1023	3779.47		196000	668.95	14136.1	1585.56	11.23	0.12
Jun	423.7	1733.12		228000	778.16	15275.61	1157.80	8.20	0.12
Jul	92.8	488.72		235200	802.74	16636.03	885.89	6.28	0.12
Aug	46.4	322.36		229600	783.62	17006.59	825.20	5.85	0.12
Sep	56.5	376.76		244000	832.77	18351.04	883.40	6.26	0.13
Sum	*10892.*	*51247.54*		*2508000*	*8559.80*	*177241.3*	*18319.39*	*129.78*	*1.58*
Ave	***$/MBtu***	***4.70489***			***$/KWh***	***0.07067***			

Table 11. FY96 monthly energy consumptions, costs, and use indices.

Month	Gas (MBtu)	Gas ($)	Elec. Demand (KW)	Elec. (KWh)	Elec. (MBtu)	Elec. ($)	E+G(main) (MBtu)	EUI (KBtu/sq ft)	ECI ($/sq ft)
Oct	202.7	747.15		240800	821.85	19915.11	1003.47	7.11	0.15
Nov	797.7	2389.77		245600	838.23	15762.53	1552.97	11.00	0.13
Dec	1866.6	5309.6		220000	750.86	14746.57	2423.33	17.17	0.14
Jan	2016.9	6148.32		216800	739.94	13649.01	2547.08	18.04	0.14
Feb	2251.8	8093.57		224000	764.51	13886.04	2782.12	19.71	0.15
Mar	1875.6	5681.79		228800	780.89	14293.15	2461.43	17.44	0.14
Apr	1468.4	4561.77		202400	690.79	12444	2006.48	14.21	0.12
May	833.1	2837.98		199200	679.87	13926.29	1426.33	10.10	0.12
Jun	324.8	1196.18		224000	764.51	15035.6	1055.53	7.48	0.11
Jul	63.5	399.42		267200	911.95	20117.05	968.85	6.86	0.15
Aug	58.5	400.38		251200	857.35	20417.56	909.76	6.44	0.15
Sep	65.6	444.13		294214	1004.15	21662.06	1062.93	7.53	0.16
Sum	*11825*	*38210.06*		*2814214*	*9604.91*	*195855*	*20200.29*	*143.10*	*1.63*
Ave	***$/MBtu***	***3.23124***			***$/KWh***	***0.069595***			

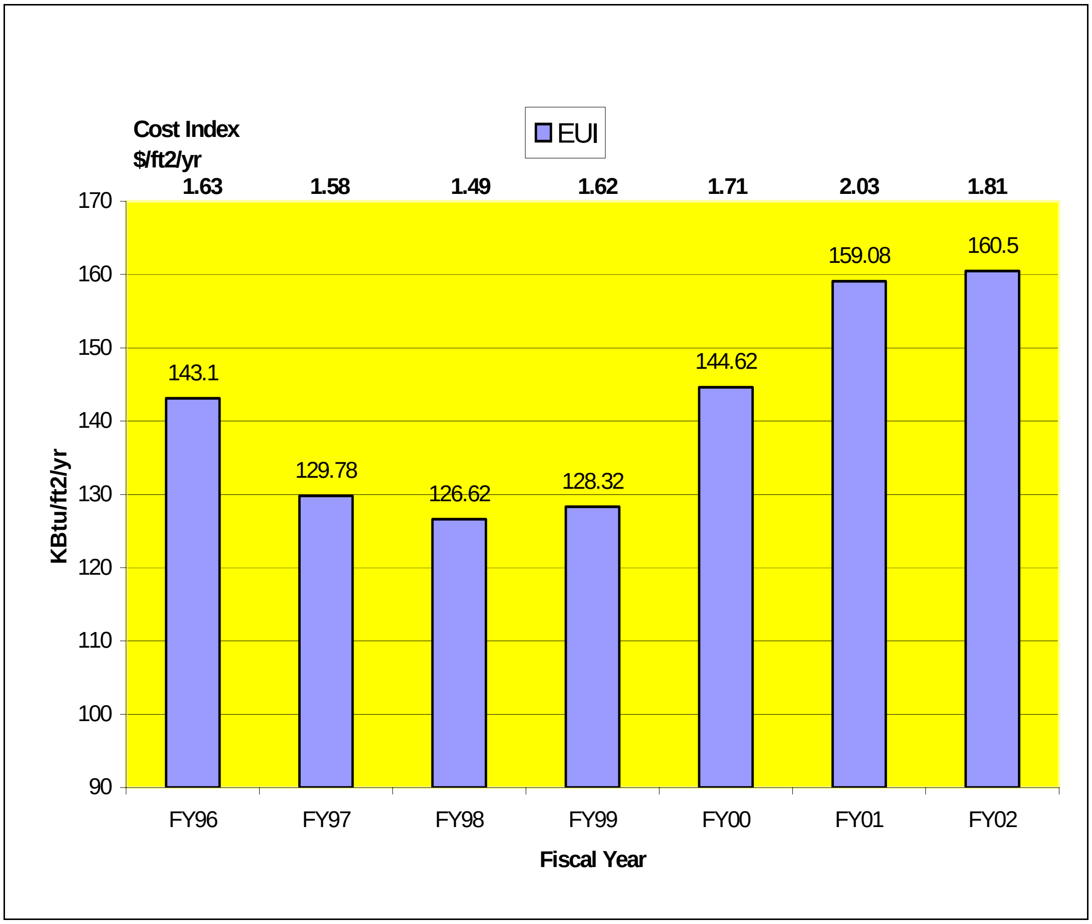


Figure 11. CERL main complex energy use index and cost index.

Note that, by the end of 1996, lighting upgrades and an ice storage system were completed. Also, starting in summer 2000, gas boilers were used for air dehumidification, which raised natural gas consumption. As a reference, the EUI for an average U.S. commercial office building is about 90 KBtu/ sq ft /yr, 92 KBtu/sq ft /yr for an average Army building, and 245 KBtu/sq ft/yr for a U.S. restaurant. Rodman Materials Lab in Aberdeen Proving Ground has an EUI of 454 KBtu/sq ft/yr, which represents an extreme case. Energy cost indices vary with electric and gas rates. Due to energy trading problems, the cost of gas increased dramatically in FY01, resulting in a CERL gas bill of over $100,000. CERL's cost index for FY02 was $1.81/sq ft/yr as compared to $0.85/sq ft/yr for an average Army building (Figure 12).

Figure 13 shows plots for natural gas usage and heating degree days (HDD) for the period from January 1997 through September 2002. The figure shows that gas usage correlates very well with HDD. However, the electric usage did not correlate as well as the cooling degree days (CDD) (Figure 14).

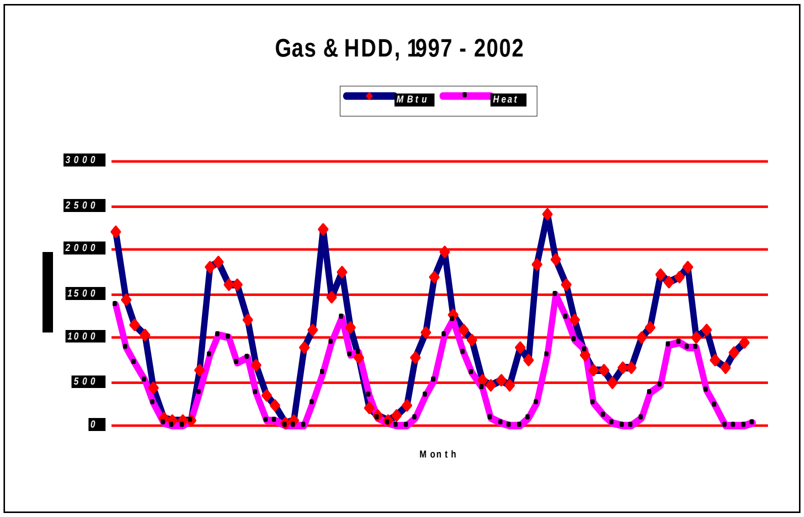


Figure 12. Natural gas usage and HDD.

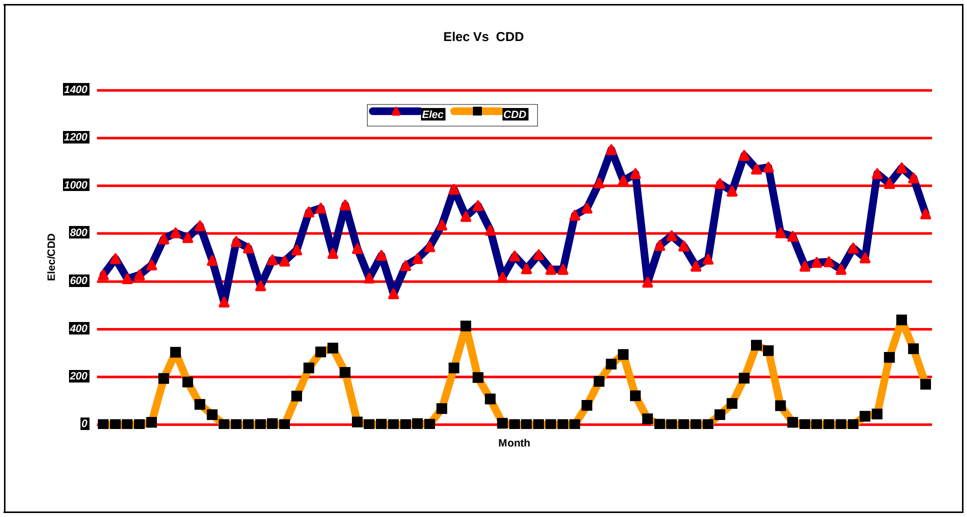


Figure 13. Electric usage and CDD.

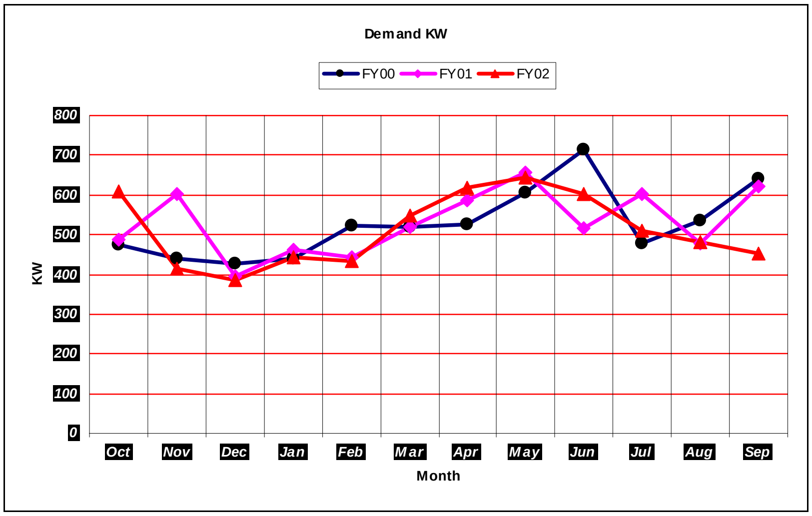


Figure 14. Monthly billing demand for CERL main complex.

Tables 5, 6, and 7 also show the main complex electric load factors. Load Factor (LF) is a ratio of total kWh, divided by the product of Billing Demand, times the operating hours. A low LF may indicate short-pulsed, high-demand processes may be in use such as induction furnaces. If there is no demand charge, then low-LF is tolerable. If there is a demand charge, a low LF may indicate that DSM (Demand Side Management) techniques could be implemented. A high LF, on the other hand may indicate that everything is operating steadily. Steady operation may be acceptable for an office building with a smaller variation coming from the seasonal weather conditions. It could also mean that all power-consuming equipment is turned on all the time. CERL has a LF of about 0.65. This may suggest that CERL has a two-shift operation instead of one. The fact that some computers and office/lab equipment are on all the time will undoubtedly raise the load factor.

An examination of the main complex monthly electric bills for the period from May 2001 to April 2002 (totaling $221,528) shows that demand charge represents 31 percent ($69,207), energy charge represents 54 percent ($119,646), and the rest (various relatively fixed charges) represents 15 percent ($32,675). Therefore, every 5 percent reduction in billing demand can realize about $3500 of savings per year, or, for every 5 percent reduction in demand, the electrical bill will be reduced by about 1.5 percent.

Figure 14 shows plots of the main complex monthly billing demands for the past 3 years (FY00, 01, and 02). The lowest and highest values are 387.2 KW and 715.2 KW. With proper load management, it appears that there is potential to keep the billing demand below 500 KW year round.

Energy Consumption for Domestic Hot Water Production

Domestic hot water is produced through a gas-fired water heater in Buildings 1 and 2, and an electric heater in Building 3. The majority of the gas consumed during summer is probably attributable to domestic hot water production. Therefore, to estimate energy used for domestic hot water production, one shall examine the summer gas consumption. From FY96 to FY02, the lowest monthly gas consumption for each year were

- August 1996 58.5 MBtu
- August 1997 46.4 MBtu
- August 1998 38.3 MBtu
- July 1999 49.4 MBtu
- August 2000 468.4 MBtu
- September 2001 481.0 MBtu
- July 2002 645.0 MBtu.

Note that summer air dehumidification starting from FY00 raises summer gas consumption. The lowest gas usage from 1996 through 2002 was in August 1998, or 38.3 MBtu/month. Thus, nominal energy usage for hot water production is estimated to be about 35 MBtu/m for the two gas-fired hot water heaters. This translates to $231/month (gas @5.1343/MBtu in FY02) or $7.7/day for hot water production. About 80 percent of the main complex occupants reside in Buildings 1 and 2. Thus, CERL is probably paying about $10 per day for its hot water heating bill, or about 1 percent of its total utilities bill ($358k for FY02). It is interesting to note that a typical commercial office building uses 40 percent of its energy for heat (24 percent for ventilation air heating and 16 percent for building envelope heat loss), 30 percent for light (28 percent indoor and 2 percent outdoor), and 30 percent for power (15 percent to power fans, 10 percent to power air conditioning pumps and 5 percent for domestic hot water).

Lighting System Retrofit Project at CERL

A lighting system retrofit project was conducted in 1996 at CERL. Since lighting uses high-cost electrical energy, it provides an attractive opportunity for energy reduction efforts. Lighting systems are also cheaper to retrofit and less complex than many other building systems such as central heating or cooling plants or building automated control systems.

Appendix G provides retrofit details documented by Elisabeth Jenicek and Dahtzen Chu. On a per unit basis, the new luminaires consume 34 percent less energy than the existing systems. Installing occupancy sensors also further reduced consumption. Electrical consumption data for the lighting circuits was collected in the months preceding the retrofit, and following the retrofit (for FY98) for comparison. Figure 15 shows the impact of lighting retrofit on energy consumption. Plots of the currents drawn from Building 1 lighting panel #1 before and after retrofits show a one-third reduction in energy usage for a typical weekday.

Ceiling/Roof Insulation

Insulation reduces building heat gain or loss and thus saves utilities payment. It can also make building occupants more comfortable by helping to maintain a uniform temperature throughout the office. Insulation can also act as a sound absorber or barrier to keep noise levels down.

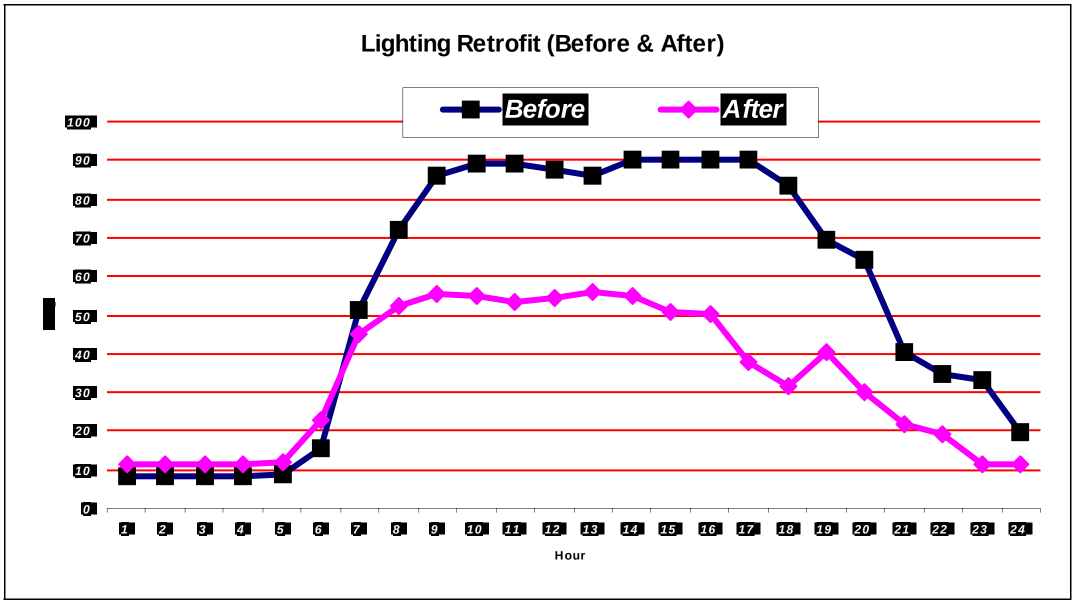


Figure 15. Impact of lighting retrofit on energy use.

It is important to choose and install the insulation properly. The amount of energy conserved depends on local climate; the size, shape, and construction of the building; the living habits of the staff; the type and efficiency of the heating and cooling systems; and the fuel used. Once energy savings have paid for the installation cost, energy conserved is money saved—and the annual savings will further increase if utility rates rise.

It is most important to insulate the ceiling/attic to the recommended level followed by providing the recommended level of insulation under floors above unheated spaces, around walls in a heated basement or unventilated crawl space, and on the edges of slabs-on-grade. Compressed insulation will not give its full rated R-value. Also, the overall R-value of a wall or ceiling will be somewhat different from the R-value of the insulation itself because some heat flows around the insulation through the studs and joists. That is, the overall R-value of a wall with insulation between wood studs is less than the R-value of the insulation itself because the wood provides a thermal short-circuit around the insulation. The short-circuiting through metal framing is much greater than that through wood-framed walls; sometimes the metal wall's overall R-value can be as low as half the insulation's R-value. A computer program (*ZIP-Code*) is available to help calculate the amount of insulation appropriate for your building. The program is named "*ZIP-Code*" because it includes weather and cost information for local regions defined by the first three digits of each postal service zip code. The program also allows the user to define local costs and certain facts about a specific building to improve the accuracy of the recommendations.

R-Value Recommendations for Existing Buildings

The following results were obtained by running the ZIP CODE computer program from the web site (http://www.ornl.gov/~roofs/Zip/ZipHome.html):

Table 12. R-Value recommendations for existing buildings in Champaign-Urbana, IL.

Heating System:	Natural Gas Furnace
Cooling System:	Electric Air Conditioning
First 3 digits of ZIP code:	618
Location:	Champaign/Urbana, IL

Insulation Location	R-Value*	Notes
Attic	38	
Wood frame wall cavity	11	Blow insulation into any uninsulated exterior wall cavity
Floor	19	Over unheated, uninsulated space.
Crawl space wall	19	Crawl space walls are only insulated if the crawl space is unvented and the floor above the crawl space is uninsulated.
Basement wall interior	11	
Insulative sheathing on empty wall	7	Recommendation assumes that the exterior siding was removed for other purpose, i.e., does not include any consideration of the cost of removing and replacing the exterior siding.
Add insulative sheathing to R11 wall	5	

* R-values have units of °F-sq ft-h/Btu. The recommended R-values were produced using the ZIP-Code computer program. The recommendations are based on an analysis of cost effectiveness, using average local energy prices, regional average insulation costs, equipment efficiencies, climate factors, and energy savings for both the heating and cooling seasons.

Noted that the suspended ceiling in Buildings 1 and 2 are not insulated in many areas. The insulation is generally 4-in thick. Part of the insulation previously installed on top of the suspended ceiling was removed during maintenance. The insulation batts tended to promote the growth of mold, which can seriously affect indoor air quality when they become damp, as they frequently do. Small leaks from the heating/cooling distribution piping and valves above the ceilings (a recurring maintenance problem) get the insulation batts wet. When saturated, the heavy batts tend to come crashing down on people. Moreover, since the batts absorb the fluid from the leaks, they can hide a small leak until it becomes a serious one. Some of the older ceilings may still have insulation above. If there has been no problem, the insulation was left alone until remodeling. Fifty percent may remain of what was originally put above the ceilings. Most of the A/C ducts in Buildings 1 and 2 are believed to be insulated.

4 Fan Coil Unit (FCU) Controls Upgrade

Fan Coil unit controls were upgraded in 2001 (Table 13). This was done to increase occupant comfort, notwithstanding the possible negative impact on energy consumption since energy usage has increased since the controls upgrade. (In the light of this increase, it is recommended to turn off the fan after working hours to reduce energy use.) Figure 16 shows the mixed correlation between upgrades and energy use indices. Energy use indices decreased from 143.1 KBtu/sq ft/yr in FY96 to 126.6 KBtu/sq ft/yr in FY98, then increased to 160.5 KBtu/sq ft/yr in FY02. The initial drop may be due to the chiller system and lighting upgrades. However, the increases after FY98 may be due to summer boiler operation (starting FY00) for dehumidification and to the fan coil unit control upgrade in FY01.

Table 13. Energy-related upgrades at CERL.

Time	System
FY 93	Chiller replacement
FY 97	Ice storage system commission
FY 97	Lighting upgrades
FY 01	Fan coil unit control upgrade

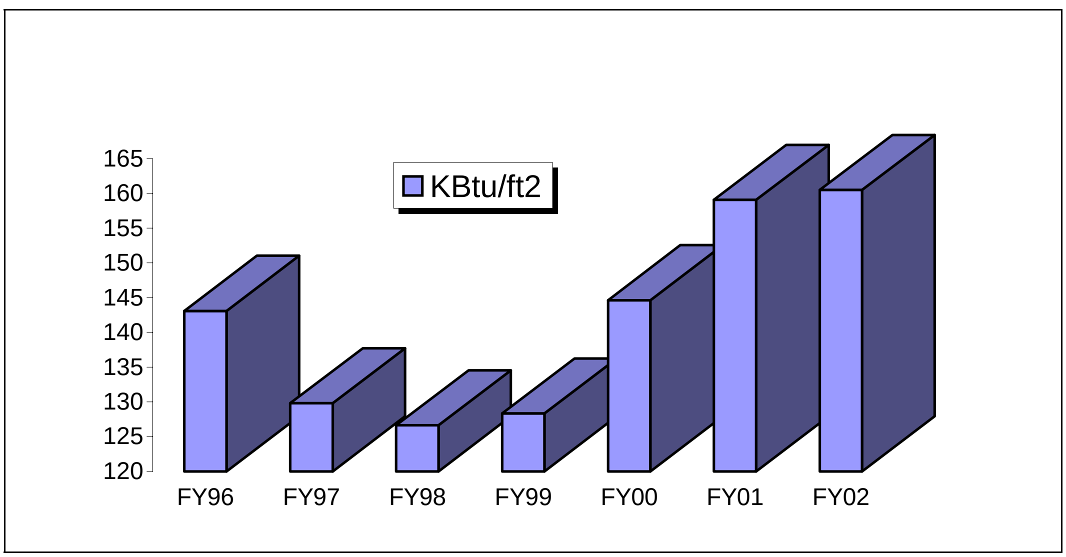


Figure 16. Mixed correlation between upgrades and energy use indices.

CERL Main Complex HVAC problems

Buildings 1 and 2

Buildings 1 and 2 at CERL are being used totally outside their design envelope. The east portions of Buildings 1 and 2 were never intended to be used as offices or to be air conditioned. The air handlers serving the west portions of Buildings1 and 2 are "energy hogs" under all circumstances. Operating the system heating in the summer is likely the main culprit. Multizone air handlers consume a significant amount of energy when heating and cooling are made simultaneously available. Pumping hot water for heating during the 6 months when heating is not required wastes a good deal of energy. Perimeter fan coil units consume heat and provide cooling when only cooling is needed. Moreover, operating the building 24 hours a day, 7 days a week is an energy waste. Running the fans alone consumes a large amount of energy independent of cooling and heating energy expenditures. An obvious process change to increase efficiency would be to shut off the air handlers at least some hours each day, and to shut off fan coils when the office is unoccupied.

Building 3

The Zackrison building HVAC system and controls have been historically problematic. The building has a variable instead of multizone air volume system, which has never worked correctly. Building occupants complain of discomfort and often use space heaters and fans. A controls retrofit, to include monitoring and data collection, should help to improve occupant comfort and to better control system performance. Before a controls retrofit, a detailed assessment of the HVAC system performance should be done. This assessment should include a basic test, adjust and balance type measurements, resulting in a TAB report. A standard TAB report, coupled with a few functional tests of certain control devices (dampers, valves, actuators), should provide enough performance data to determine if and how to proceed with a controls retrofit.

5 Energy Management Opportunities

CERL Main Complex HVAC Problem Fixes

The following tasks are suggested to address the main complex HVAC problems:

- Monitor buildings using LonWorks utility monitor/control system (UMCS).
- Investigate the operation of the existing multizone air handlers to maximize occupant comfort without using heat in summer.
- Develop a solution to summer dehumidification and reheat problems.
- Install a UMCS on the air handlers to get good control of them.
- Find/develop automatic ways to turn off fan coils completely when rooms are not occupied at night and on weekends.
- Find/develop a way to shut off hot water to fan coils in summer even if it is circulated to air handlers.
- Analyze and resolve HVAC operation problems in Building 3.
- Fix HVAC problems in exercise area.

Note that the fan coil units in some offices had LonWorks controllers installed when the FCUs were retrofitted in 2001. With twisted-pair wire connections, these units can be put on a CERL-wide LonTalk network. More importantly, they can be interfaced with occupancy sensors to turn them off during periods of non-occupancy and during scheduled unoccupied periods. This will reduce existing motor loads and could significantly impact energy consumption.

If this solution is chosen, the work should be coordinated with UIUC maintenance staff. UIUC staff (Chris Dilks) suggested the possibility of putting the chiller on the network as part of a project currently in the planning stages. Converting the AHUs to LonWorks control is under consideration. LonWorks is a good alternative to the (currently used) pneumatic controls. In any case, plans derived in this work should strive for consistency with future plans.

While checking the fan coil units, researchers found holes/gaps in the walls where condensate drain pipes penetrate the wall are not sealed at the penetration point, and in other areas as well. This infiltrated air is drawn into the FCU. This increases thermal load and causes a temperature control problem because the room sensor is located under the FCU where it is colder than inside the room. Though the infiltration provides fresh air, it wastes energy.

An interesting case study was done for a commercial office building, built in 1967, located in Skokie, IL (NW of Chicago). The building occupies 82,000 sq ft, and has a 14,500 sq ft window area. It also has two gas-fired boilers and one 350-ton centrifugal chiller. The annual electric bill is about $110K and the gas bill is about $40K. The building has a pneumatic HVAC control (constant volume reheat box serving perimeter rooms and a variable volume box serving interior rooms). In late 1989, three things were done (savings listed as reported by performing contractor):

1. Conversion to a Variable Air Volume (VAV) system, which saved $44K in utilities
2. Installation of a Direct Digit Control (DDC) for heat/cool, which saved $11K
3. Installation of window films and a lighting upgrade that saved $7.4K.

An overall 40 percent cost saving was achieved with a capital investment of $177,348, which amounts to a simple payback of 2.84 years. The building had an EUI of 170 KBtu/sq ft/yr before the three changes were made and 98 KBtu/sq ft/yr after. By comparison, CERL's two main buildings, which were built in 1969, currently have an EUI of 160 KBtu/sq ft/yr. Similar changes may reduce the EUI to 98, which would be close to the Army facility energy goal in 2002.

Executive Order 13123, Sec. 202, requires each agency to reduce energy consumption per gross square foot of its facilities by 30 percent by 2005 and 35 percent by 2010 relative to 1985 through life-cycle cost-effective measures. No facilities will be exempt from these goals unless they meet new criteria for exemptions, to be issued by the Department of Energy (DOE). Figure 17 shows the Army facility energy goal as it applies to CERL. To meet this goal, CERL must achieve an approximately 40 percent energy reduction. Presently, CERL has fan coil units serving the perimeter offices and constant volume air handling units serving the interior rooms in Buildings 1 and 2. According to Dr. Thomas Miller, DPW Chief of Operations, Champaign Site, leaving the fan coil units in place would decrease the benefits derived from retrofit to a VAV system for the perimeter offices, but would forgo the considerable extra expense associated with VAV implementation. Adding supplies, returns, and associated ducting to those perimeter offices would be quite expensive. Also, the constant volume units would need to have variable frequency drives added. Since all the fan coil units have just been replaced, there is little impetus to change the entire system right away. However, reworking the constant volume air handling of interior offices first may offer some definite advantages, although the benefits may be less dramatic than those of the case study. In its daily operations, CERL's DPW spends most of its time trying to keep the present system functioning and maintained, which leaves little time to investigate and propose more general system changes.

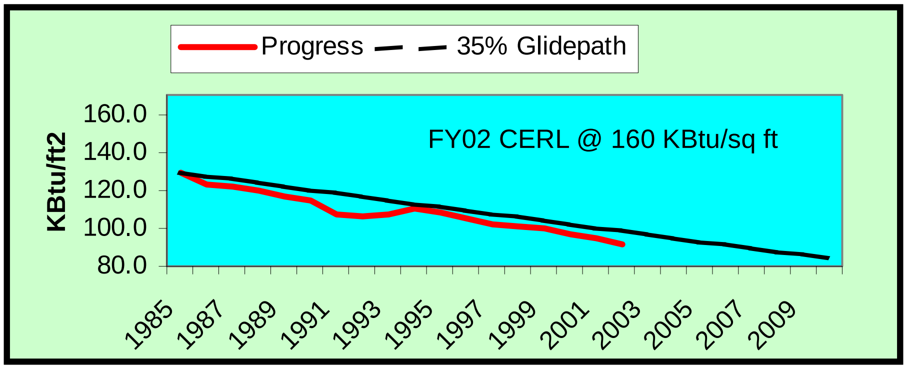


Figure 17. Army facility energy goal.

In either Building 1 or 2, there are two large multizone air handling units with air flow capacity greater than 8500 CFM. These four units serve the building central interior zones, which covers about 25 percent of the three-building main complex floor space. The multizone units have a single heating coil serving the hot deck and a single cooling coil serving cold deck. Each zone supply temperature is adjusted by mixing the required quantities of hot and cold air from these coils. The hot deck temperature must be sufficiently high to meet the heating demands of the coldest zone, and cold deck air must be sufficiently low to meet the demands of the hottest zone. All intermediate zones are supplied with a mixture of hot and cold air, which wastes energy in the cooling season as all of the supply air must be cooled to a low enough temperature to meet most critical load zone, but must be reheated for zones of lesser loads to avoid overcooling. A significant amount of energy can be saved by adding VAV boxes to each of the major branch ducts. Each VAV box should be controlled by a space thermostat located in its particular zone. Also, its associated reheat coil should be provided with controls to prevent reheat until the VAV box has reduced the zone supply air volume to 50 percent or lower. It is a good idea to de-energize or shut off terminal reheat coils, raise the chilled water, supply air temperature of the central system, and add re-cooling coils in ducts in areas where lower temperatures are needed.

Hot deck and cold deck dampers often allow considerable leakage even when fully closed. To conserve energy, it is necessary to check these dampers frequently and adjust linkage, repair damaged damper blades, and weatherstrip to insure tight closure.

Even though multizone air handler systems are notoriously inefficient, the few multizones at CERL are not seen as the main energy issues since they only serve about 25 percent of the floor space. Getting rid of those units (or changing them to VAVs) will likely appear low on the CERL DPW's list of "good ideas." Money designated to “fix-up” CERL’s HVAC systems would be better allocated to higher priority items, which would not include replacing perimeter fan coils with a VAV. If used correctly, fan coils are more efficient than VAVs. (Note that CERL’s fan coils are nearly new.)

Any energy conservation efforts to be undertaken at CERL should concentrate more heavily on reducing the loads on the systems, and on ensuring that building occupants have their correct share of fresh air and comfort. In other words, conservation efforts should address issues like:

- Re-insulating above the suspended ceilings in Buildings 1 and 2. (In the winter, roof deck temperature of 75 °F was measured when outside air temperature was at 20 °F.)
- Investigating whether the heating/cooling use of Building 2 high bay area can be reduced by simply turning down the HVAC without undue occupant discomfort.
- Investigating whether a suspended, insulated ceiling can be installed in the low bay in Building 1 where the exercise area is located (and in other locally populated places).
- Investigating the feasibility and merit of installing thermopane windows and wall insulation.
- Finding an optimal amount of time—less than the current 24 hours a day, 7 days a week, 365 days a year—to run the HVAC equipment.

The first actual HVAC related modification to be suggested is to install DDC controls on existing equipment to: (1) record operating parameters, and (2) fine tune HVAC control. Only after this is accomplished, should major system retrofits be addressed.

LonWorks Building Energy Management System

Issue

Building an energy management system can identify candidate energy reductions and increase occupant comfort.

Proposal

The following tasks are proposed using LonWorks UCMS:

1. Meter all lighting panels and whole building (*Energy Monitoring*).
2. Monitor all offices (*Occupancy Monitoring*).
3. Install LonWorks data collection equipment.

4. Install and configure a LonWorks web-server. This system serves up webpages to display real-time and stored data (accessible through any web browser).
5. Install a network services tool (used to define and set up the communications network and to bind the nodes together).

Cost Estimate

Appendix H details six priced options ranging from $45k to $150k (estimated by CERL PI David Schwenk). A variety of options are considered for implementing a LonWorks-based system. Phase 1 work is proposed to include a web-based interface, all six CERL lighting panels, the main CERL power meter, the multizone air handler serving Building 2 West wing interior office spaces, and FCU on/off control (based on LonWorks occupancy sensors) for all Building 2 West wing perimeter offices (30 FCUs).

A complete, more functional interface is recommended as part of Phase 2 work. Details of system implementation are described in the Design Intent Document (DID) which will be updated as more precise information becomes available. This work, if carried out successfully, could become a showcase example.

Summer Air Dehumidification

Issue

High humidity in summer resulted in discomfort of building occupants and possibly lower productivity.

Analysis

- CERL DPW is now dehumidifing through air reheat using a central boiler low temperature hot water system.
- This low firing of boiler in the summer consumes about 430 MBtu/month of natural gas ($3/hr or $8640 per 4 summer months when gas is priced at $5 /MBtu).
- For more efficient operation, a small packaged hot water gas-fired boiler could be installed for summer dehumidification. A small boiler run at full load has a higher efficiency than a larger boiler run at low load.

Cost Estimate

A 3.2MBtu/hr boiler will cost $50,000. Assuming that the existing boiler efficiency at a low firing rate is 65 percent, that the efficiency of a new small boiler is 80 percent, and that the new boiler will achieve $1504 savings for $8,000 fuel cost, then the simple payback for the new boiler would be $50,000/$1504 = 33 yr. A 1.2 MBtu/hr boiler will cost $22,000. Assuming that the existing boiler efficiency at low firing rate is 65 percent, that the efficiency of a new small boiler is 80 percent, and that the new boiler will achieve $1504 savings for $8,000 fuel cost, then the simple payback for the new boiler would be $22,000/$1504=15 Yrs. These payback periods are relatively long; i.e., from these calculations, installation of a small boiler for summer air dehumidification does not appear to be a "high payoff" idea.

The working group considered a desiccant dehumidification system; however, on the advice of (CERL Branch Chief) Martin Savoie, who recently headed Congressionally funded desiccant system demonstrations at several DoD facilities, the technology was not considered. It is recommended to continue searching for lower cost dehumidification options such as using a heat pump or adjusting outside air damper in humid summer days to minimize humidity intake. Also, improving the building envelope seal would help reducing humid air infiltration. Installing dehumidifiers in high humidity areas may be a solution if the problems are only found in localized areas.

Space Air-Conditioning of Building 2 High Bay Area

Issue

The Building 2 high bay area occupies a large space and consumes energy for heating/cooling.

Analysis

- The high bay occupies an area of about 15,000 sq ft (more than 10 percent of the main complex floor space) and a volume of 400,000 cu ft (more than 16 percent of the total complex volume).
- HVAC test equipment is used only infrequently.
- Only a small portion of the rest of the area is used, and only some of the time.
- Task heating and lighting in working areas may be sufficient.

Proposal

Use portable radiant heaters in working areas to reduce heat to high bay area. Consider portable units for localized cooling as well.

Cost Estimate

Estimated cost of 10 electric heaters with cooling fans ~ $5,000 to $10,000.

Fenestration: Insulation/Window Improvements

Issue

- Roof/suspended ceiling insulation was found to be in poor condition.
- Air leaks from outside air dampers and doors/windows may need attention.

Analysis

- Roof for Buildings 1 and 2 has a R value of 20.
- Suspended ceiling in Buildings1 and 2 are not insulated in many areas.

Insulation previously installed on top of suspended ceiling was removed since the insulation batts were found to promote the growth of mold. They can (and frequently do) seriously affect indoor air quality when they become damp. Small leaks from the pipes and valves above the ceilings (a recurring maintenance problem) wet the insulation batts, which—when saturated—have been known to fall through the ceiling. Since the batts absorb the fluid from the leaks they can hide a small leak until it becomes a serious one.

Evaluation of Central and Rooftop Units

Issue

Over the past 20+ years, CERL has modified some of its high bay test areas to accommodate additional offices. Packaged roof-top air conditioning units have been incrementally added to provide localized occupant comfort. The net result is an unknown mix of new and aging central and roof-top heating and cooling units.

Analysis

A systems analysis should be made to baseline the heating and cooling loads along with the inter-relationships of the central and roof-top units.

Proposal for Evaluating Central and Roof-Top Units Plus Fenestration

- Develop a long-range plan to upgrade building systems
- Upgrade roof insulation
- Upgrade exterior wall/windows
- Replace packaged AC units in Buildings 1 and 2
- Replace multizone units in Buildings 1 and 2
- Upgrade heat and cool plant.

Plan A

Hire a reputable A/E firm to conduct a building energy modeling/simulation/analysis and to develop a long-range upgrade plan. A computer program like DOE2 or EnergyPlus shall be considered for building energy modeling/simulation/analysis. Detailed plan and cost for roofing/exterior wall/windows/packaged AC units/multizone units/heating and cooling plants are to be included. Configuration, size, order of project works (timing), and costs shall be determined.

Plan B

Look into the possibility of getting Louisville District or some other Corps District/Division to work on this job. (CERL PI) Dale Herron has contacted the Louisville District to find out if they have an interest in assisting with a CERL energy study. The Louisville District did express an interest in helping with the study. The POC there is Michael Layman (502-315-6861), who is their outreach coordinator. Mr. Layman shall be contacted for job cost info.

Plan C

Solicit an Energy Service Company (ESCo) to propose an Energy Savings Performance Contract (ESPC) package for CERL. (Note: According to Louisville District, this may not be feasible in State-owned buildings.)

Cost Estimate

The estimated cost for the project is from $35,000 to $40,000 for an AE firm to develop the plan (perhaps less for Louisville District to do the work).

6 Water Conservation Opportunities

Description

Figure 18 shows a plot of water consumption (in kgal), HDD, and CDD, by month. A very large amount of water usage in April 1997 (761 kgal) was attributed to a water experiment conducted by a CERL researcher. Although monthly water consumption does not appear to correlate with HDD, the consumption does seem to correlate with CDD, at least for the past 2 years. The use of the chiller cooling tower water in the summer may account for this.

An average household consisting of three individuals, uses water at an average rate of approximately 8 kgal/month. The current usage levels for February 2003 indicated that CERL was operating at a very low usage level (66 kgal for approximately 300 personnel).

CERL DPW staff (Michael Ashby), investigated the following areas requiring water and are ranked them for potential water conservation:

1. The chiller appears to be a major water user in the summer months, doubling water usage during that period. Minimizing water overflow with active monitoring could achieve better water conservation.
2. The paint test tank in room 1175 next to Ion Plating Room uses approximately 10 kgal of water per year at a slow rate, approximately 1ml/sec. Although this water cannot be recirculated through the tank (which would alter experimental conditions), the water may be used for other purposes.
3. The environmental chamber located in the foam panel building uses water for cooling. According to UIUC technicians, the system can use 3 gal /min when operating at full cooling levels. The environmental chamber is currently turned off; the lab will monitor water usage after it is activated again. A water meter could be added to the foam panel building to actively monitor the water usage including the environmental chamber and other experimental devices used in the building.
4. Domestic water conservation can begin by installing low flow showerheads, toilets, and faucets throughout the complex. Showerheads of four different flow rates ranged from less than 1 GPM to 2 GPM were purchased, but have not yet been installed.

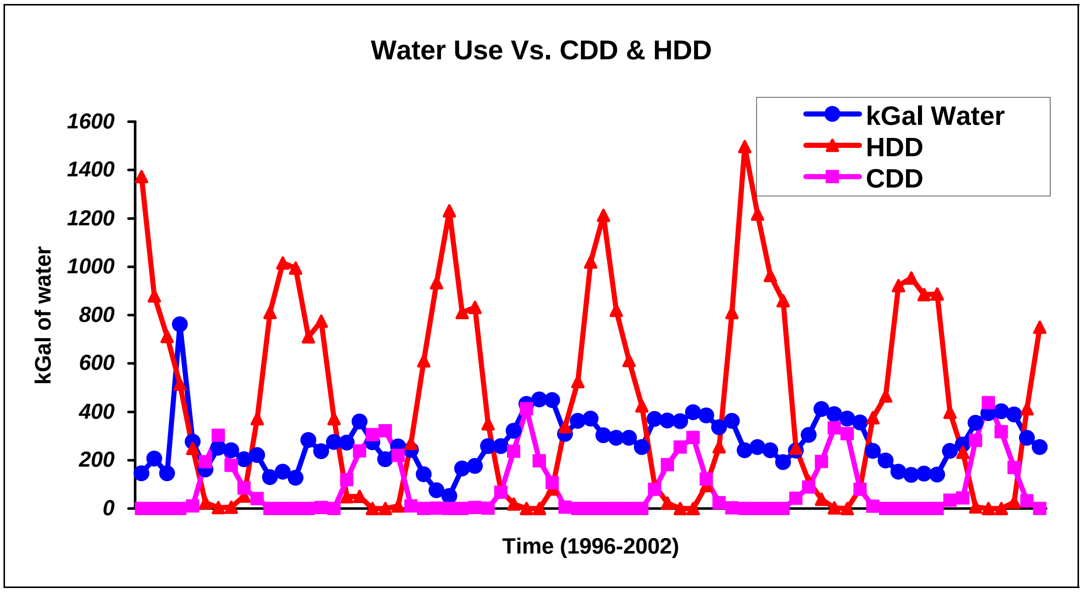


Figure 18. Monthly water consumption, HDD and CDD.

5. Records kept since 1989 indicate that water-cooled MTS hydraulic equipment in the Hi-Bay area has been used less than 225 hours per year. The MTS hydraulic equipment in TESS building was replaced and does not require water during operation.
6. Infiltration of water in manholes on site appears to be limited. It may not be economical to divert the water.
7. The boiler is a closed water system and does not appear to have any significant leaks. It is inspected every 2 years.

Three waterless urinals were installed in the men's room of Building 1 as a test of a good water conservation measure in 2001. Current State of Illinois building codes do not address waterless urinals. (Illinois Codes currently require a water flush.) Although the state codes do not apply to CERL's (Federal) facility, CERL is working with the Illinois EPA and state plumbing inspectors to resolve the code issue. While the building code remains unchanged, state plumbing inspectors have recently approved a trial installation of a waterless urinal in a state building.

Conclusion

Although the average annual water bill at CERL is only about $6K, some water conservation efforts can be taken to preserve water resources.

7 Summary and Recommendations

Summary

As a fellow-up to the CERL sustainability workshop, a Phase I energy audit for CERL main complex was conducted. The goals of the audit were to review the current main complex building energy and water usage, energy system equipment inventory, and to provide short- and long-term energy improvement and water conservation strategies. Baseline references on utilities consumption and cost were developed to help future periodic monitoring efforts. Facility and energy systems information, and energy management and water conservation opportunities were documented in an effort to achieve the 40 percent reduction in building energy use targeted for CERL to meet the Army facility energy goal, i.e., to reduce the current EUI of 160 KBtu/sq ft/yr to below 100 KBtu/sq ft/yr.

Despite completion of several energy conservation projects including chiller replacement (FY93), lighting retrofit (FY96), ice storage system (FY96) and fan coil unit control upgrade (FY01), EUI was found to be increasing since 1998. This work concluded that summer air dehumidification (starting in FY00) and inadequate building insulation have contributed to this increase.

Phase II work is currently being planned. Staff from CFE, DPW and PAO will collaborate to prepare a detailed plan including implementation costs for each short term recommendation. Short- and long-term energy improvement recommendations follow.

Recommendations

Short-Term Recommendations

- Perform public energy awareness/education/training
  - CERL personnel must care about energy situation
  - Post a real-time energy status display at main entrance
  - Institute voluntary shutoff of unnecessary equipment
    - Turn fan coils, lights, computers off at night
    - Set temperature back at nights and weekends
    - Reduce personal electric heater/fan usage

- Develop and implement rational strategy for less-than-24/7 operation of HVAC systems
  - Shut off most heat and AC in high bay
  - Set back all central systems at nights and weekends
  - Turn off individual office fan coils when offices are unoccupied
- Fully implement LonWorks/UMCS
  - Include as much control as is affordable
  - Aggressively track and report energy use
    - Check effectiveness of all energy improvements
    - Report energy status to CERL
- Develop solution to summer dehumidification problem
  - Turn boilers off in Summer once an alternative is found
  - Quantify problem and determine solutions
  - Implement solutions
- Analyze/Resolve HVAC operation problems in Building 3
- Fix HVAC problems in exercise area
- Seal-up the building envelope
- Develop long-range plan to upgrade building systems
  - Upgrade roof insulation
  - Upgrade exterior wall/windows
  - Replace packaged AC units in Buildings 1 and 2
  - Replace multizone units in Buildings 1 and 2
  - Upgrade heat and cool plant.

Long Term Recommendations

- Sustain public energy awareness/education
- Sustain LonWorks/UMCS
- Implement long range upgrade plan

Although the average annual water bill at CERL is only about $6k, conservation of water resources should not be ignored. The following potential water conservation opportunities are recommended for further investigation:

- Monitor chiller cooling tower water usage in the summer months. Minimizing water overflow with active monitoring could result in water conservation.
- Consider reusing the paint test tank effluent (10 kgal per year) in room 1175.
- Install a water meter to the foam panel building to monitoring the cooling water used in the environmental chamber (3 gal/min when operational) and in areas in the building containing other experimental devices.
- Install low flow showerheads, toilets, and faucets throughout the complex for domestic water conservation.
- Monitor cooling water used in MTS hydraulic equipment, infiltration of water into manholes on site, and boiler make-up water.
- Install waterless urinals wherever feasible after the code issue is resolved.

Appendix A: Highlight of the CERL Sustainability Workshop

CERL Sustainability Conference
Final Sustainability Goal Presentations—31 Oct 2002

Issue: UTILITIES

Breakout Group Members

The breakout group members were:

- Donald Fournier (facilitator)
- Marty Savoie
- Diane P. Mann
- Terri Norman.

Goal

The goal of this group activity was to reduce energy consumption and demand by 50 percent and become carbon neutral. Note that Donald Fournier mentioned that the 50 percent was just a best guess goal because an energy audit has not been conducted to know whether 50 percent is an aggressive, yet achievable, goal.

Metrics

Energy: KBtu/sq ft/yr

- KBtu/cap/yr
- Demand: Peak KW
- Carbon: CO_2 Balance

Responses/Actions

1. Conduct energy audit (quantify, baseline, process) in FY03
2. Benchmarking in FY03
3. Strategic Energy Plan by 1st qtr FY04—incorporating plug loads (computers), lighting, envelope and windows, process loads, central utilities, and renewables

4. Investigate financing options (FY04)
5. Screen O&M projects and enhance for energy (FY03 and continuous)
6. Project implementation:
   a. Plug loads (FY03-06)
   b. Lighting (FY04)
   c. Process loads (FY04/5)
   d. Envelopes (FY04-10)
   e. Central plants and distributed generation (FY05)
   f. Renewables (FY06-08).

Issue: WATER

Breakout Group Members

The breakout group members were:

- Don Fournier (facilitator)
- Marty Savoie
- Diane P. Mann
- Terri Norman.

Goal

The goal of this group activity was to reduce water consumption by 75 percent and process water effluent to tertiary standards.

Metrics

- kgal/yr
- gal/cap/yr

Responses/Actions

1. Conduct water audit and benchmark (FY03)
2. Develop strategic water plan (FY04)
3. Auto faucets/high efficiency showerheads (FY04)
4. Waterless urinals and low-flow toilets (FY04)
5. Process water control (FY05/6)
6. Harvest rainwater for greywater system for flushing (FY06)
7. Living machine (FY08).

Issue: LANDSCAPING

Breakout Group Members

The breakout group members were:

- Brian Deal (facilitator)
- Julie Webster
- Larry Kimball
- Patricia Lampo
- Elisabeth Jenicek.

Goal

The goal of this group activity was to create a sustainable landscape at CERL.

Metrics

1. Reduced operations and maintenance activity costs
2. Increased use of outdoor spaces
3. Increased biodiversity
4. Reduced security concerns.

Responses/Actions

1. Site energy
   a. Plant shade trees to the south of the existing buildings
      (1) Short-term: Implement 75 percent
      (2) Mid-term: Remaining 25 percent
   b. Plant shrubs and trees for use as a wind block
      (1) Short-term: Implement 75 percent
      (2) Mid-term: Remaining 25 percent
   c. Site lighting—provide efficient and specific lighting
      (1) Short-term: For existing buildings and pedestrian walkways
      (2) Mid-term: For new parking
2. Maintenance
   a. Reduce lawn cover and mowing
      (1) Plant native ground cover
      (2) Short-term: Adjust mowing height, replace 50 percent of lawn, plant wildflower prairie and trees
      (3) Mid-term: Attain 75 percent lawn replacement, plant wildflower prairie and trees
      (4) Long-term: Attain 90 percent lawn replacement

- b. Reduce site water consumption
  - (1) For short-term, mid-term, and long-term: Plant native tolerant species
3. Provide outdoor spaces
   - a. Recreation paths
     - (1) Short-term: Plan
     - (2) Mid-term: Implement
     - (3) Long-term: Enjoy
   - b. Seating areas
     - (1) Short-term: Plan and implement 50 percent
     - (2) Mid-term: Implement remaining 50 percent
     - (3) Long-term: Enjoy
   - c. Open recreation areas (for CERL functions)
     - (1) Short-term: Use existing open recreation areas and plan for new/revised areas
     - (2) Mid-term: Implement planned new/revised areas
     - (3) Long-term: Enjoy
4. Improve habitat—using native species and enhancing biodiversity
   - a. Prairie restoration project
     - (1) Short-term: Develop plan and implement 50 percent
     - (2) Mid-term: Implement remaining 50 percent
   - b. (Oak) Grove (partners)
     - (1) Short-term: Develop plan and implement 75 percent
     - (2) Mid-term: Implement remaining 25 percent
   - c. Build wetlands/ponds for storm water management
     - (1) Short-term: Develop a plan
     - (2) Mid-term: Implement the plan
     - (3) Long-term: Improve where needed
5. Provide buffers
   - a. Between noise and incompatible uses
     - (1) Short-term: Develop a buffer plan
     - (2) Mid-term: Implement the plan
6. Site disturbance
   - a. Develop erosion control plan for new structures
   - b. Develop site distribution plan for any new structures.

Appendix B: Phase 1 Energy Audit – Preparation, Schedule, Items of Focus

Audit Preparation

- Drawings: Floor plan, mechanical/electrical drawings
- Equipment list (boiler, chiller, packaged units, water heater, air handling units, fan/coil units, light fixtures, etc.): Location, age, condition, specification, standard operation procedure, controls, operating schedule, maintenance records
- Building function: Operating hours, days and number of people
- Building O&M info: Number/type of trouble calls; requests for service (6 to 12 months data)
- Utility consumptions and costs: Rate schedules for gas, electric, water, other fuels; Utility meter points; Characteristics of distribution system
- Contacts with utility reps.: Options to reduce rates, improve reliability and upgrade infrastructure
- Determine Participants and Responsibility of each.

Schedule

Table B1 lists the audit schedule.

Table B1. Audit schedule.

Task	Date
Planning (1 day)	12-16-02
Data Gathering (3 weeks)	12/16 /02 – 1/17/03
Walkthrough w/DPW (1 day)	1/10/03
Data Analysis (3 weeks)	1/13/03 – 1/31-03
Walkthrough audit follow up meeting	1/16/03
Phase 1 review meeting with BC	1/23/03
RPMA FY04 funding recommendations	1/30/03
Phase 1 draft presentation	2/5/03
Letter report	2/28/03
Phase 1 results presentation	3/13/03

Audit Items of Focus

- Energy Improvement Strategy (Figure B1)
- Exterior Walk Around
  - Assess building envelope condition—wall, roof, slab, door, window, etc., envelope thermal profile
  - Exterior lighting—on/off, control device
- Interior Walkthrough
  - Verify building drawings, find use and zone
  - HVAC equipment: location, appearance, obvious problem, control function
  - Draw in all supply/return/exhaust diffuser and registers
  - Exhaust fans: location, appearance, obvious problem, control function
  - Talk to occupants on hot/cold spots, make notes
- Exterior Walk Around
  - Assess building envelope condition—wall, roof, slab, door, window, etc.; envelope, thermal profile
  - Exterior lighting—on/off, control device

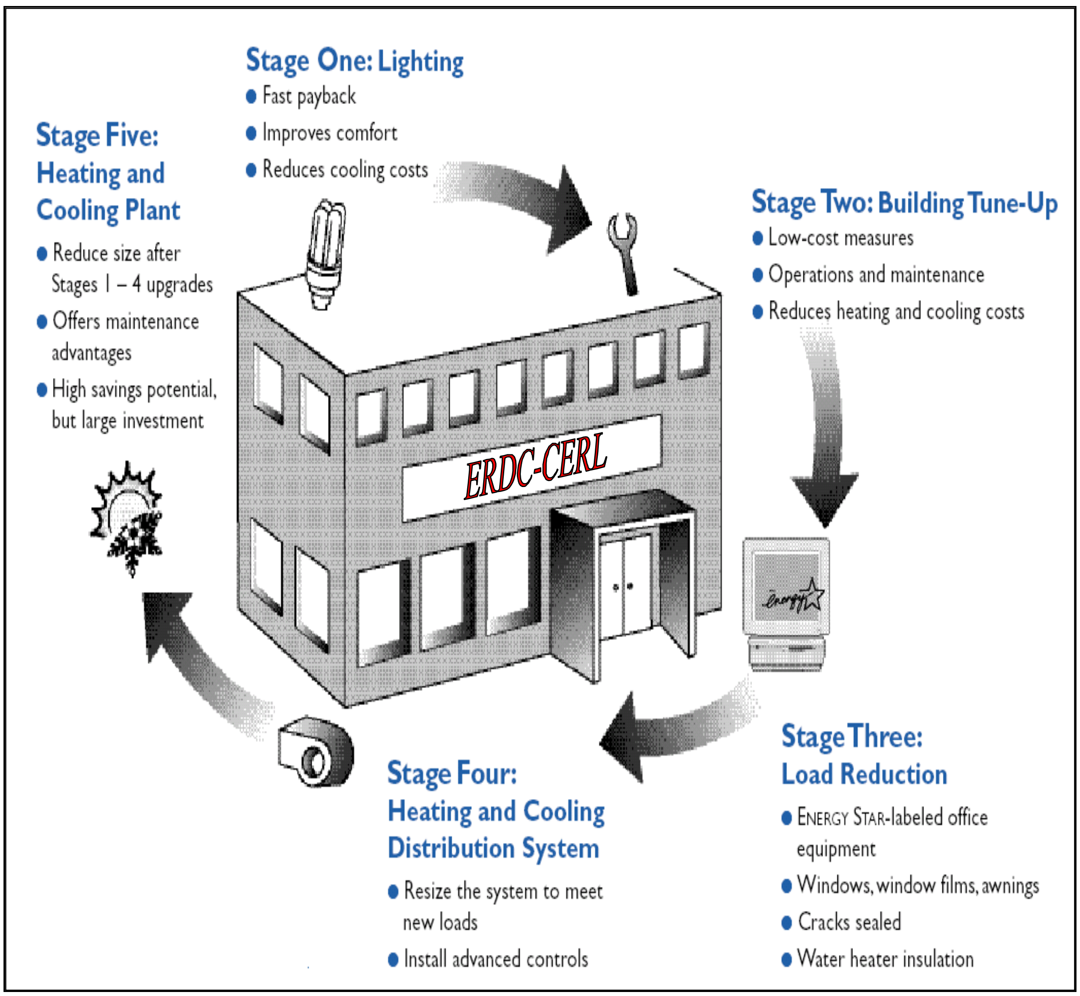


Figure B1. Energy improvement strategy.

- Interior Walkthrough
  - Verify building drawings, find use and zone
  - HVAC equipment: location, appearance, obvious problem, control function
  - Draw in all supply/return/exhaust diffuser and registers
  - Exhaust fans: location, appearance, obvious problem, control function
  - Talk to occupants on hot/cold spots, make notes
  - Note control system thermostat/sensor locations, any damage
  - Check EMCS operation if present
  - Location/size/# of space heaters if present
  - Location/size/# of window AC if present
  - Number/type of light fixtures in each room
  - Number of task lighting if present
  - Note wall switch if not available
  - Note of area motion sensors
  - Vending machine location and if de-lamping desired.
  - Heating appliances location, see if can be disperse
  - Location/#/use status of PC, printer, copier, see if ENERGY STAR® rated, turn off at night?
  - Location/#/size coffee disperser, centrally located?
  - Domestic hot water temp setting, measure actual temperature
  - Check for water system leaks (pipe, faucets).

Appendix C: CERL Input to ENERGY STAR® FY03

The Construction Engineering Research Laboratory (CERL) is part of the U.S. Army Engineer Research and Development Center (USAERDC), which is the Army Corps of Engineers' integrated research and development (R&D) organization. CERL conducts research to support sustainable military installations. Research is directed toward increasing the Army's ability to more efficiently construct, operate, and maintain its installations and ensure environmental quality and safety at a reduced life-cycle cost .

The Energy Branch of CERL focuses on the secure, efficient, and sustainable use of facilities' energy systems. Efforts include National Strategic Energy Planning, Energy Modeling and Simulation, Installation Assessment and Recommendations on Heating, Cooling and Power Plants and Industrial Processes, Building Audits and Commissioning, Sustainable Building Design and Operation, Building Control Strategies, Equipment Evaluation and Demonstration, and Chemical Biological Radiological Protection in Buildings.

Our Strategic Energy Planning Group provides guidance to the United States Congress, the Office of Secretary of Defense, the Army's Assistant Chief of Staff for Installation Management, and the Army's Logistics Integration Agency on energy policy, goals establishment and attainment, and strategies for the future. This guidance has included:

- Estimates to Congress on the energy savings potential for Army facilities and its associated economic and environmental impact resulting in the DOD-FEMP program (now superceded by DOE-FEMP).
- Drafting and reviewing Army Energy Plans, which recommends ENERGY STAR® Methods and Tools.
- Goals from Army Energy Management Plan Response to the Energy Policy Act and Executive Order 13123, May 2000 (Figure C1).

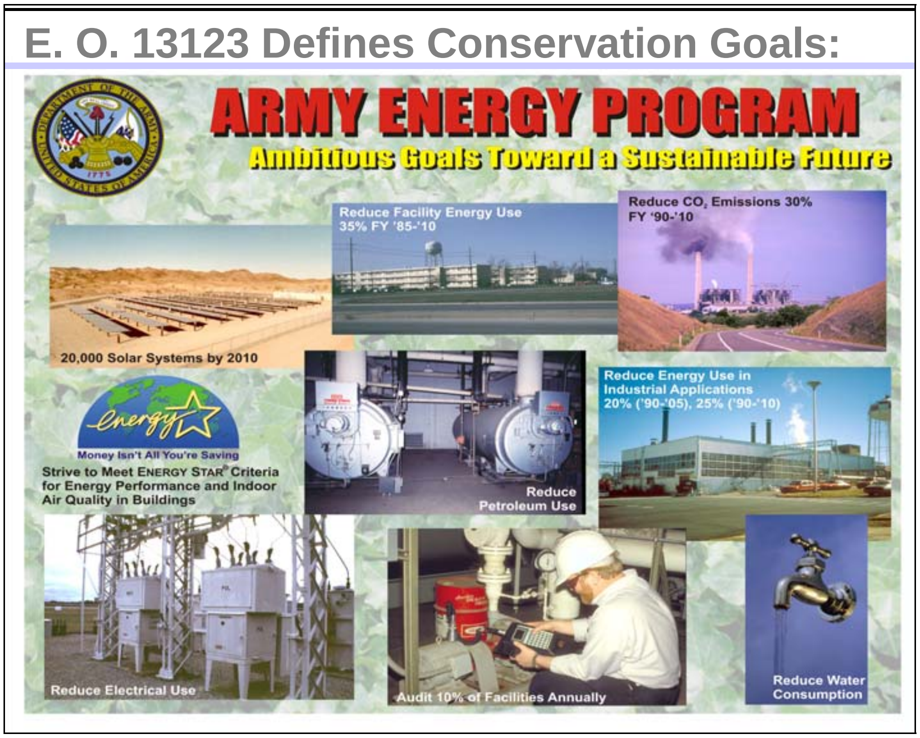


Figure C1. Goals of Executive Order 13123.

Energy Star® Buildings and Products

ENERGY STAR® Buildings is a program developed by the U.S. Environmental Protection Agency (EPA) to promote energy efficiency in buildings. Army installations shall assess their buildings and leasing activities against the ENERGY STAR® Building criteria by the end of 2002. ENERGY STAR® Buildings must meet a set of criteria based on going through an integrated set of steps to reduce energy consumption. The five-stage implementation strategy (cf. Figure B1) consists of lighting upgrades, building tune-up, other load reductions, fan system upgrades, and heating and cooling system upgrades. Actual ENERGY STAR® Building certification and labeling is based on measured building data and a comparison with archetypes in various regions of the country. Since Army buildings are not generally metered and temporary metering schemes are cost prohibitive, the installation may self-certify and develop a local label for non-metered buildings based on the knowledge of what retrofits and no cost/low cost options have been completed in those buildings. Where metered data is available, the installation will use that data to input the Benchmarking software program available on the EPA web site to certify the buildings against criteria and label accordingly. To the greatest extent practicable, installations shall select

ENERGY STAR® and other energy efficient products when acquiring energy-using products.

From Army FY2003 Draft Implementation Plan:

The Army continues to have an active program to identify and procure energy-efficient products through the Defense Logistics Agency (DLA). DLA and General Services Administration (GSA) product catalogs will be widely used, as well as the Construction Criteria Base (available on CD-ROM and the Internet). Purchasing agents are strongly encouraged to procure ENERGY STAR® products and products in the top 25 percent of energy efficiency when they are cost-effective.

- Annual submission to ACSIM of approximately $600M in suggested energy efficiency investment projects across the Department of the Army that includes many ENERGY STAR® products.
- Mention of ENERGY STAR® on a wall display and in briefings on the Army Energy Program.
- The use of ENERGY STAR® Five Stage Approach methods in an FY03 Audit/commissioning of CERL's main building complex.
- The planning link to ENERGY STAR® from our Strategic Energy Planning Website, currently under reorganization.

Appendix D: Building Mechanical Condition Audit Results (Conditions as of 12/30/02)

Table D1. Units in use, Building #1.

Location	ID	Description / Comments
Above Rm. 1023	Unit 1	Library South AHU Trane Climate Changer Type M2-17 Serial # K158307. The pan in the unit is rusting and pipes shows indication of leaking.
Above Rm. 1023	Unit 2	North AHU Trane Climate Changer Type TMC-I 7 Serial # K158234 north unit. The pan in the unit is rusting and shows signs of outside rusting also. The pipes show signs of leaking.
Small unit above Rm. 1053.	Unit 3	
Small unit above Rm. 1051	Unit 4	
In Rm. 1050.	Unit 5	Unit in an open, free space. Appears to be in fair condition
Rm. 1035.	Unit 6	Put on new filter section. Works fine.
	Unit 7	Used to be return air fan. Converted to hallway exhaust fan for Chem. Lab.
	Unit 8	Reworked some of the duct to it. Has some rust, aging. Cleaned up as well as possible.
Rm. 1119	Unit 9	Small unit, works fine.
Rm. 1130	Unit 10	East unit has rust inside. Unit has a moisture problem. Hard to work on. Note: Also has a west unit that is no longer in service that could be removed. To make more space. Rm. 1150 has old unit no longer in service that could be removed.
Rm. 1108	Unit 11	Small unit, works fine.
Rm. 1108	Unit 12	Very dirty. Has some rust. The electricity for the light switch needs to be looked at. The pipes show signs of leaking.
Rm. 1168	Unit 13	Small unit. Needs duct changed from flex to work better.
Rm 1137	Unit 14	In good shape.
Rm. 1167	Unit 15	Unit is fine, but needs work on some of its associated ducts.
Rm. 1167	Unit 16	Small unit is fine.
Rm. 1175	Unit 17	Unit has small amount of rust. Just reworked return air upstairs—helped a lot.
Rm. 1175	Unit 18	Small unit. Fine.
Rm. 1175	Unit 19	Unit in open space. Has a small amount of rust, but seems

Location	ID	Description / Comments
		to work fine.
Rm. 1142	Unit 20	Small unit. Seems ok.
Rm. 1220	Unit 21	Small unit. Works ok.
Rm. 1215	Unit 22	Unit is in open space. Seems to work ok.
	Unit 23	Small a/c unit. Fine.
	Unit 24	Small unit. Fine.

Table D2. Units in use, Rooftop.

Location	ID	Description / Comments
Rooftop	1	New unit. Works fine.
Rooftop	2	Has rust and has a lot of flex duct coming from it.
Rooftop	3	Needs to be replaced. Has very poor duct system.
Rooftop	4	Seems to work ok.
Rooftop	5	Unit ok. Installation method is poor.
Rooftop	6	New unit works fine. Need to change filters every month.
Rooftop	7	New unit. Works fine.
Rooftop	8	Seems to work fine. Coil has frozen at times.

Table D3. Units in use, Building #2.

Location	ID	Description / Comments
Rm. 2014	1	Unit has a lot of rust from snow blowing in it. Some pipes leak.
Rm. 2014	2	Liebert Unit. Fine.
Rm. 2127	3	Shows signs of rust, but is in an open area. Some pipes have been leaking.
Rm. 2121	4	Small unit. Fine.
Rm. 2140	5	Consider removing both #5 and #6 and put in 1 unit same as will be put in rooms 2132 and 2133.
Rm. 2140	6	See above.
Rm. 2120	7	Has some rust and is dirty; Need to put catwalk around unit so that it can be worked on more easily.
Rm. 2135	8	New Liebert unit. Fine.
Rm. 2136	9	Unit has a lot of flex duct associated with it. Has some rust.
Rm. 2134	10	Small unit. Looks good.
Rm. 2133	11	New unit in 2002.
Rm. 2150	12	Looks new. Has a number of long flex duct.
Rm. 2169	13	Looks new. In good shape.
Rm. 2192	14	Small unit. Ok.
Rm. 2190	15	In open area. Not bad. Just changed sheave. Seems to be running well.
Rm. 2161	Unit # 16	Has lots of rust. Some pipes have shown signs of leaking.
Rm. 2164	Unit # 17	Small unit. Ok.
Rm. 2017	Roof Top Unit #1	Looks good.

Table D4. Units in use, Building #3.

Location	ID	Description / Comments
Rm. 3215	Unit #1	Open area. Seems to be running good. Little rust.
Rm. 3215	Unit #2	Open area. Seems to be running good. Little rust.
Rm. 3003	Unit #3	Liebert. Fine.

Table D5. Units no longer in use.

Location	ID	Description / Comments
Building #1, Rm. 130	I unit	
Building #1, Rm. 1150	1 unit	
Building #2, Rm. 2150	1 unit	

Table D6. Individual A/C units and heat pumps.

Location	ID	Description / Comments
Building #1, Rooftop Unit, Rm 1011, Paint Lab and adjacent	MUA Unit	180,000 BTU Cooling 460 V. 3 Phase
Room 1023 Print Shop	York (RTU #8)	42,000 BTU Cooling
Room 1111 ECR	York Heat Pump (RTU #5)	5 Ton 460 V. 3 Phase
Room 1183 Ion Plating Room (inside building)		18,000 to 24,000 BTU window unit 208 V. 1 Phase
Room *1154* & adjacent PP	Trane (RTU # 4)	5 Tons Cooling 460 V. 3 Phase
Room 1205 (Composite Lab)		Rheem, 2 Ton 1 Phase 230 V.
Room 1217 Bunker (RTU #1)	Trane Package Roof Top	3 Ton 460 V. 3 Phase
Room 1220 (New VTC Room)	Whirlpool Roof Top	2 Ton 230 V. 1 Phase
Room 1213	(RTU #2)	Once served room 1214. A modified window unit now feeds room 1214
Ruud Roof Top Unit		2 Ton 230 V. 1 Phase
Room 1210	(RTU #3)	Trane Roof Top Unit, 460 V. 3 Phase
Room 1167 (Contracts)	York Split System	2 Units 7.5 Tons Each, Air Handlers are in the ceiling. Also serves rooms 1164, 1165, 1166.
Room 1162	York Split System	2 Ton AT 230 V. 1 Phase

Table D7. Units on the ground, Building 1.

Location	ID	Description / Comments
Room ll19 (Router Room)	Comfort Air	2 Ton 230 V. 1 Phase Split System
Room 1132 etc. (Travel Office)	Trane	18,000 BTU 230 V. 1 Phase
Room 1138-1140 (RM)	Carrier Split System	38,000 BTU 230 3 Phase

Table D8. Description roof top units, Building 2.

Location	ID	Description / Comments
Room 2135 Small (East) Computer Room	Liebert M# PFCO 27A-PL3	36,000 BTU 208/230 V. 3 Phase
Room 2014 Main (West) Computer Room	Liebert	10 Ton Split System 440 V. 3 Phase
Rooms 2015-2021	Ruud Package Roof Top Unit	5 Ton Capacity

Table D9. Description units on the ground, UCHI House and Buildings 2 and 3.

Location	ID	Description / Comments
Building 2, on ground, Room 2165	Rheem (Split System)	2 Ton 230 V.1 Phase
Building 2, on ground, Rooms 2132 & 2133	Comfort Maker (Split System)	1.5 Ton 208-230 1 Phase
Building 2, on ground, Rooms 2121, 2122, 2123, 2124, 2125 (West End of 2120 open area)	Split System	4 Ton 230 V. 3 Phase
Building 2, on ground, Room 2126, Telephone Equipment Room	York (Split System)	2.5 Ton 208-230 V. 1 Phase
Building 2, on ground, Room 2136 Conference Room	Ruud (Split System)	5 Ton 230 V. 1 Phase
Building 2, on ground, Room 2150 Open Area	Ruud (Split System)	10 Ton 230 V. 3 Phase
Building 3, Room 3003	Liebert (Split System)	3 Ton 208-230 V. 3 Phase
UCHI House (On Ground)	Heat Pump	2 Ton Cooling 230 V. 1 Phase

Table D10. Location and description of building lighting panels and air handling units.

LIGHTING PANEL
SCHEDULE

Unit	Bldg	Location	Service	Measured
MM	9001	Utilities Bldg/Plant		
LP-1	Bldg 1	Across from Rm 1118, storage closet, W restrm	277V/100A	20.40A
LP-2	.	Rm 1130	277V/100A	21.70A
LP-3	Bldg 2	B'twn Rm 2171 & E/W Hwy Dr Test Fac.	277V/100A	35.40A
LP-4	.	Near Rm 2128 (Mech/Elec Rm)	277V/100A	15.00A
LP-5	.	N of cafeteria door in N/S hall	277V/100A	14.90A
LP-6	Bldg 3		277V/200A?	?

AIR HANDLING UNIT
EQUIPMENT SCHEDULE

Unit	Bldg	Location	Description
AHU-1	Bldg 1	Rm 1023	Trane
AHU-2	.	Rm 1023	Trane
AHU-3	.	Rm 1053	Trane
AHU-4	.	Rm 1051	Trane
AHU-5	.	Rm 1050	Trane
AHU-6	.	Rm 1036	Trane
AHU-7	.	Chem Lab	Trane
AHU-8	.		Trane
AHU-9	.	Rm 1119	Comfort Air
AHU-10	.	Rm 1130	Trane
AHU-11	.	Rm 1108	Trane
AHU-12	.	Rm 1108	Trane
AHU-13	.	Rm 1168	Trane
AHU-14	.	Rm 1137	Trane
AHU-15	.	Rm 1167	Trane
AHU-16	.	Rm 1167	Trane
AHU-17	.	Rm 1175	Trane
AHU-18	.	Rm 1175	Trane
AHU-19	.	Rm 1175	Trane
AHU-20	.	Rm 1142	Trane
AHU-21	.	Rm 1220	Trane
AHU-22	.	Rm 1215	Trane
AHU-23	.		Trane
AHU-24	.		Trane
AHUR-1	.		Trane
AHUR-2	.		Trane
AHUR-3	.		Trane
AHUR-4	.	Rm 1154	Trane
AHUR-5	.	Rm 1111	York
AHUR-6	.		Trane
AHUR-7	.		Trane
AHUR-8	.	Rm 1023	York

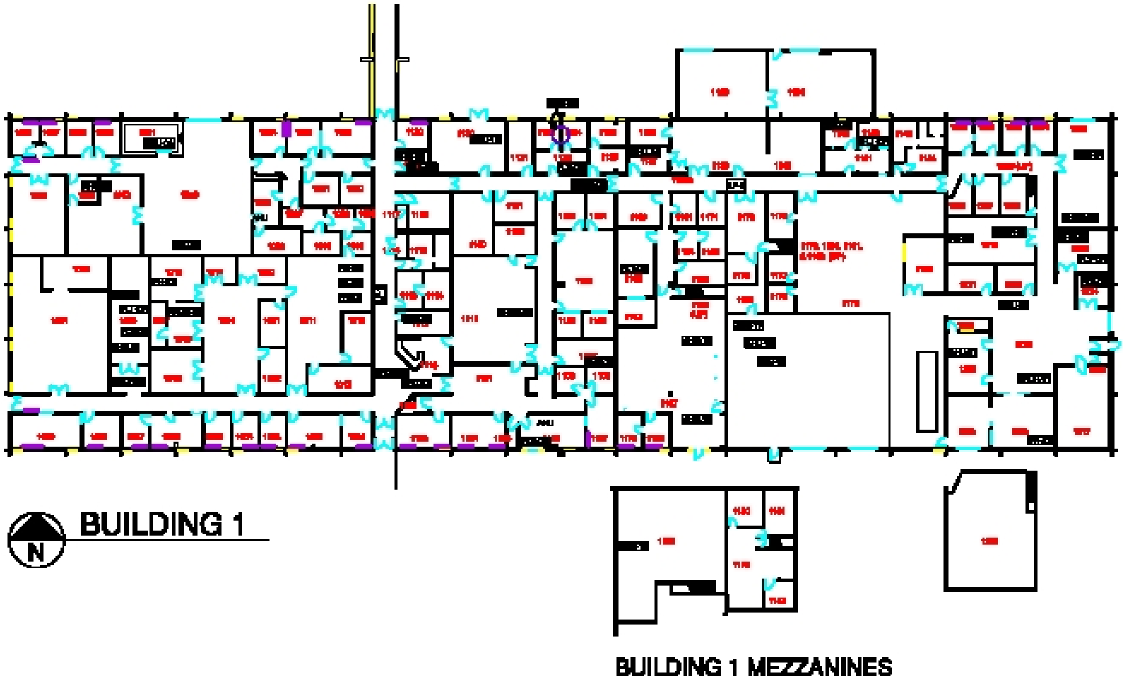
Unit	Bldg	Location	Description
AHU-1	Bldg 2	Rm 2014	Trane
AC-1	-	Rm 2014	Liebert
AHU-3	-	Rm 2127	Trane
AHU-4	-	Rm 2121	Trane
AHU-5	-	Rm 2140	Trane
AHU-6	-	Rm 2140	Trane
AHU-7	-	Rm 2120	Trane
AC-2	-	Rm 2135	Liebert
AHU-9	-	Rm 2138	Trane
AHU-10	-	Rm 2134	Trane
AHU-11	-	Rm 2133	Trane
AHU-12	-	Rm 2150	Trane
AHU-13	-	Rm 2169	Trane
AHU-14	-	Rm 2192	Trane
AHU-15	-	Rm 2190	Trane
AHU-16	-	Rm 2161	Trane
AHU-17	-	Rm 2164	Trane
AHUR-1	-	Rm 2017	Trane
HP-1	UCHI		2 Ton
EF-1	SHKTBL	W Rm 4101	
EF-2	-	N Rm 4110	
EF-3	-	SW Rm 4113	
EF-4	-	N Rm 12001	
EF-5	-	SE Rm 4113	
EF-6	-	NE Rm 4114	
EF-1	Bldg 2	South	
EF-2	-	South	
EF-3	.	Rm 2190	
EF-4	-	Rm 2190	
EF-5	-	Rm 2190	
EF-6	-	Rm 2190	

Unit	Bldg	Location	Description
AHU-1	Bldg 3	Rm 3215	Trane
AHU-2	.	Rm 3215	Trane
AC-1	.	Rm 3003	Liebert
EF-1	.	Rm 3004	

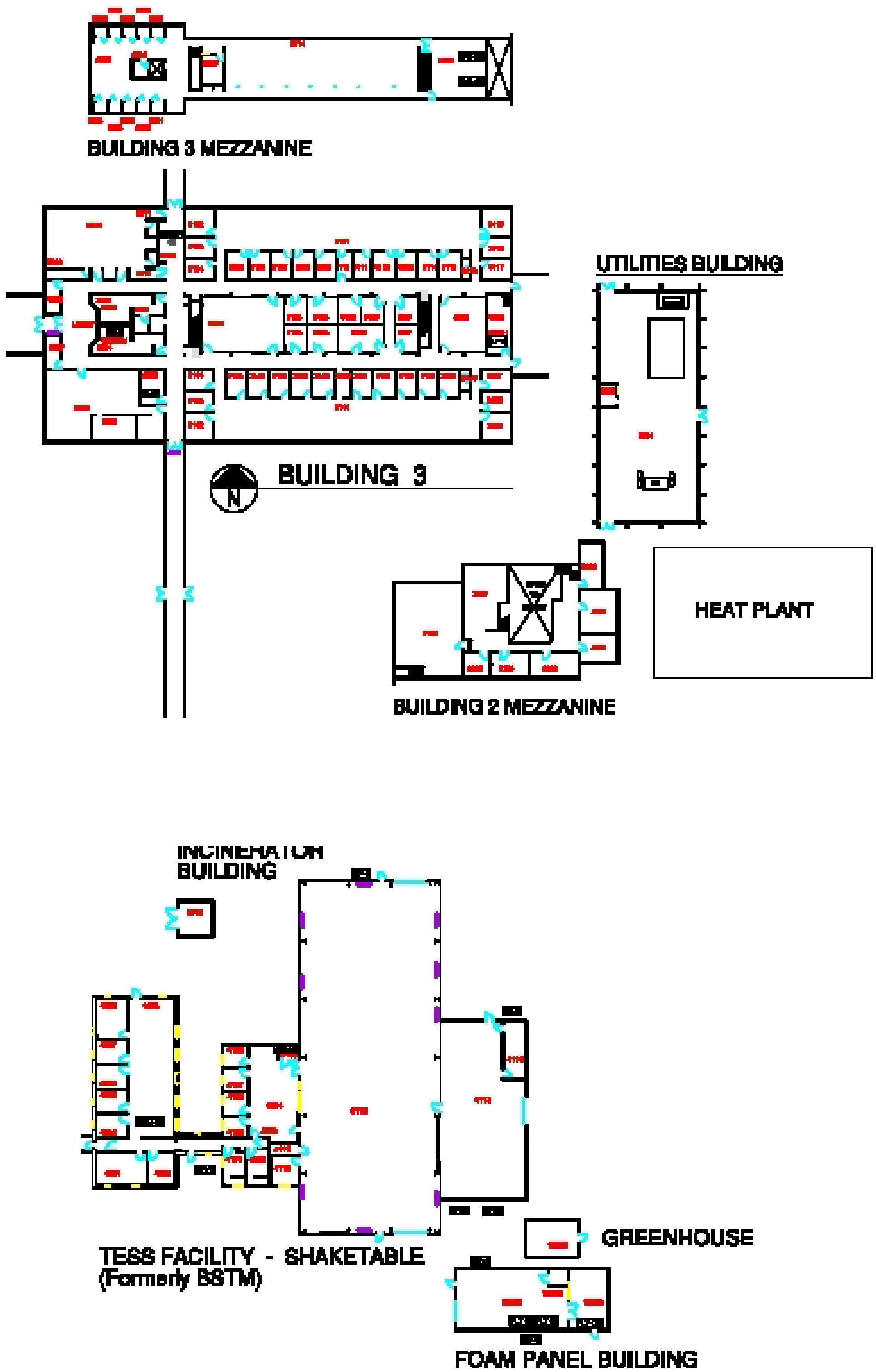
Appendix E: Updated Building Drawings with Associated HVAC Equipment

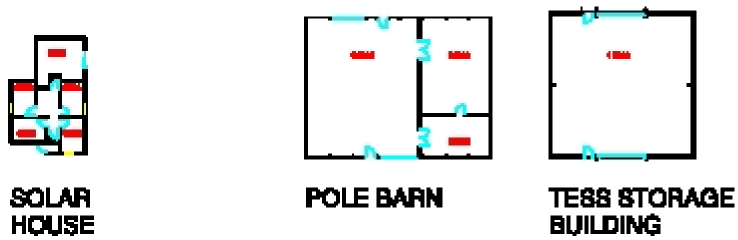
LEGEND 3-5-03

AC-X	A/C UNIT, SPLIT-SYSTEM AND COMPUTER ROOM PACKAGED UNITS	FLT-OA	FILTERS, OUTSIDE AIR
MLS-XX	AHU, BUILDING 1	FH-XX	FUME HOOD FAN
CLS-XX	AHU, BUILDING 2	HP-X	HEAT PUMP
AHUR-XX	AHU, ROOF TOP	LP-X	LIGHT PANEL
EF-XX	EXHAUST FAN	MM	MAIN (POWER) METER
	FAN COOL UNIT	RM-O	ROOM OCCUPANCY SENSOR
FLT-G	FILTER GRILLE		SMOKE EATER


BUILDING 1
N
BUILDING 1 MEZZANINES


BUILDING 2
N
BUILDING 2 BASEMENT


BUILDING 3 MEZZANINE
UTILITIES BUILDING
BUILDING 3
N
HEAT PLANT
BUILDING 2 MEZZANINE
INCINERATOR BUILDING
GREENHOUSE
TESS FACILITY - SHAKETABLE
(Formerly BSTM)
FOAM PANEL BUILDING


SOLAR HOUSE
POLE BARN
TESS STORAGE BUILDING

Appendix F: IL Power Rate Schedule Applicable to CERL Main Complex:

ILLINOIS POWER COMPANY

SCHEDULE OF RATES FOR ELECTRIC SERVICE

SERVICE CLASSIFICATION 19

Intermediate Power Service

l. Availability

Service under this service classification is available to any Customer subject to the following conditions:

(a) that Customer's Billing Demand in one Summer Season Billing Period In each twelve month period equals or exceeds 200 kW, and

(h) that Customer's Distribution Capacity is not less than 200 kW and is not equal to or greater than 1,000 kW, and

(c) that Customer taking service under Service Classification 35 at the same Point of Delivery that Customer takes service hereunder, shall enter into a written contract with Utility for service hereunder specifying an initial Firm Power Capacity not less than 200 kW and not equal to or greater than 1,000 kW.

This service classification is subject to the Standard Terms and Conditions of Ill. c. c. No. 31

2. Rates

(a) Facilities Charges

Customer shall be billed, for each billing period, a charge based on Customer's

Delivery Voltage as set forth below.

Customer's Delivery Voltage

Below 2.4 kV	2.4 kV to 12.47 kV	34.5 kV and 69 kV	138 kV
$100.00 per month	$375.00 per month	$760.00 per month	$1,900.00 per month

(b) Distribution Capacity Charge

Customer served from Supply Line Voltage below 138 kV shall be billed, for each billing period, a charge of $1.75 per kW for each kW of Distribution Capacity, but no less than 200 kW.

(c) Demand Charges

The following Demand Charges shall apply to each kW of Billing Demand for Customer served from supply lines having the following voltages:

Customer's Supply Line Voltage

Summer Season	12.47 kV and Below	34.5 kV, 69 kV and 138 kV
For each kW of Billing Demand	$14.00 per kW	$12.00 per kW
Winter Season		
Per each kW of Billing Demand	$ 7.00 per kW	$ 6 50 per kW

Billing Demand is the Maximum On Peak Demand in the billing period, except that if Customer is also served under Service Classification 35, Billing Demand is as provided therein.

*(d) Energy Charges

The charges below shall apply to all kWh used during the billing period based on Customer's Supply Line Voltage:

For All KWh Used — Customer's Supply Line Voltage

During the Billing Period	12.47 kV and Below	34.5 kV, 69 kV and 138 kV
For the first 50,000 kWh	5.089 ¢ per kWh	4.989 ¢ per kWh
For the next 50,000 kWh	4.389 ¢ per kWh	4.289 ¢ per kWh
For all over 100,000 kWh	3.899 ¢ per kWh	3.799 ¢ per kWh

(e) Time Of Use Energy Credit

A credit of 1.00¢ per kWh shall apply to all kWh used during the Off Peak Period of the billing period.

(f) Summer Demand Credit

Demand Charges are subject to the Summer Demand Credit provided in Rider T and the Summer Demand Refund provided in Rider J.

(g) Space Heating Credit

A credit of 1.75¢ per kWh shall apply to all kWh of Space Heat Usage during a Winter Season billing period for any Customer with permanently installed electric space heating equipment capable of providing more than 50 percent of Customer's space heating requirements.

Determination of Non-Space Heat Usage and Space Heat Usage.

(1) Non-Space Heat Usage for each Winter Season billing period shall be all kWh used during the billing period up to the product of the average daily usage of the two billing periods with the lowest non-zero kWh use per day occurring during the twelve consecutive billing periods ended with the current billing period multiplied by the number of days in the billing period, but not less than 1,000 kWh per day.

(2) For Customer taking space heating service without billing history at Customer's premises for at least one normal Summer Season billing period, Customer's Non-Space Heat Usage for each billing period of the initial Winter Season (or partial Winter Season) shall be determined by Utility based on Utility's audit of Customer's space heating equipment.

Space Heat Usage during any Winter Season billing period, if any, shall be all kWh used during the billing period in excess of Non-Space Heat Usage. At Utility's option, Customer's Space Heat Usage for each Winter Season shall be limited by Utility based on Utility's audit of Customer's space heating equipment.

*(h) Transformation Charge

If Utility owns and operates transformers to transform the voltage from Utility's available Supply Line Voltage to the Delivery Voltage required by Customer, Customer shall be billed, for each billing period, a charge of $0.75 per kW for each kW of Distribution Capacity, but not less than 200 kW.

3. <u>Firm Power Capacity</u>

Firm Power Capacity for Customer taking service under Service Classification 35 at the same Point of Delivery that Customer takes service hereunder, shall be determined under the provisions therein, but in no event shall Firm Power Capacity be less than 200 kW, nor less than the initial Firm Power Capacity during the first twelve billing periods for service hereunder.

* Asterisk indicates change

Issued March 6, 1998

Filed Pursuant to Section 9-220(f) as added to the Public Utilities Act, pursuant to amendments enacted on December 16, 1997

Issued by Robert D. Reynolds Vice President

Effective March 6, 1998

Appendix G: Lighting System Retrofit Project at CERL

A lighting system retrofit project was conducted in 1996 at CERL. Lighting consumes approximately 25 percent of Army facilities energy. Since lighting utilizes high-cost electrical energy it provides an attractive target for energy trimming efforts. Lighting systems are also cheaper to retrofit and less complex than many other building systems such as central heating or cooling plants or building automated control systems. New lighting technologies offer opportunities to decrease energy consumption while improving the quality of lighting.

The existing lighting equipment at CERL prior to 1996 was nearly all original building equipment consisting mainly of four-lamp 2x4-ft troffers delamped to two lamps. The equipment was dirty and, where minicell parabolic louvers had been installed to control glare, offices were dim with dark walls and ceilings. Existing lamps were F40T12 cool white with a color rendering index (CRI) of 52. Under the lighting retrofit project, the existing recessed troffers were replaced as they were beyond their expected life of 15 years—original building equipment was 27 years old. In many instances luminaire components, such as lenses and lamp end holders, would have required replacement. In addition, the existing fixtures were photometrically inefficient: designed to hold four lamps, they did not “shine” as much light as a new fixture designed for two lamps, Several lighting technologies were selected based on office size and arrangement. Parabolic luminaires with 4-in. deep louvers, in compliance with the recommended practice (RP) for offices with visual display terminals, were installed in large open spaces with high ceilings. These systems are best at controlling direct and reflected glare and limiting luminance both at the task and within the field of view. Smaller shared offices received 3-in. deep parabolic luminaires which also provided glare control. Private offices and hallways received new lensed troffers. All new luminaires contained two F32T8, 3500 °K, 75 CRI lamps with a rapid start electronic ballast, In addition, luminaires were wired in tandem where possible, with adjacent luminaires sharing one, four-lamp electronic ballast.

All surface mounted and pendant luminaires were retrofit with F32T8 lamps and electronic ballast. Exit signs were either retrofit or replaced utilizing LED technology ensuring that all signs contained a back-up battery. Split switching was maintained in the hallways where separate switches controlled alternating luminaires. Passive infrared (PlR) occupancy sensors were installed in over 150 private or small shared offices. These were mainly wall switch replacements, with some ceiling mounted PlRs included. These switches contain a daylight sensor allowing lights to be turned on only when insufficient daylight is present.

On a per unit basis, the new luminaires consume 34 percent less energy than the existing systems. Installation of occupancy sensors also reduced consumption further. Electrical consumption data for the lighting circuits was collected in the months preceding the retrofit. Post-retrofit data were also collected in FY98 for comparison. Occupancy and light loggers were installed to collect data on the frequency of on/off cycles of the lighting due to the PIP, sensors. In addition, lighting illuminance and luminance data was measured prior to the retrofit and post-retrofit to assess both foot candle levels and surface brightness achieved as a result of the upgrade.

Additional benefits are achieved in the area of employee satisfaction. In addition to reducing glare and increasing surface brightness, the new lighting gave the offices a warmer feeling by utilizing a 3500°K lamp to replace the old cool white lamps. The improvement in color rendering index from 52 to 75, due to the tri-phosphor coating on the new T8 lamps, enhanced the appearance of people and furnishings creating a more inviting and pleasant place to work. An effort was made to assess this impact through a user survey. Occupant surveys were administered prior to the lighting retrofit to determine employee attitudes toward the working environment. Post retrofit surveys were given after the project was completed. Points of Contact (POC) for the lighting retrofit are Elisabeth Jenicek and Dahtzen Chu.

Appendix H: CERL LonWorks Design Intent Document / Master Plan

CERL Energy Monitoring and Control

Executive Summary

The CERL RPMA budget includes funding for FY04 ($160k) and FY05 ($60k) implementation of a CERL energy management system. As part of the CERL energy audit, we considered a variety of options for implementing a LonWorks-based system. We initially looked at installing a lot of occupancy sensors, in addition to monitoring the six lighting panels and the main CERL power meter, but due to the condition of the HVAC controls (antiquated pneumatics) and the potential for significant energy savings through automated on/off control of the numerous fan coil units (FCU), our inclination is to move in this direction as opposed to installing lots of occupancy sensors. As part of this we should incorporate an energy monitoring and management interface, where there are two approaches: A full-blown interface, or a simple web-server. Both approaches provide browser access. We should consider the full-blown and more functional/expensive interface—about $8000, but should do so as part of Phase 2 due to its expense. The web server approach serves a dual purpose, so it will not be a wasted Phase I investment.

We propose that Phase I include a web based interface, all six CERL lighting panels, the main CERL power meter, the multizone air handler serving Building 2 West wing interior office spaces, and FCU on/off control (based on LonWorks occupancy sensors) for all Building 2 West wing perimeter offices (30 FCUs). Details of this and other aspects of the implementation are contained in this document, the cost estimate, the draft architecture drawings, and the floor plan drawings. All of this documentation is in draft form and not all of the details are up to date.

Attachment 1 is a 1-page overview of the LonWorks system and features.

Background

LonWorks® is a technology, based on the LonTalk® ANSI/EIA standard communications protocol that comprised of multi-vendor devices that perform their application dependent functions while openly communicating and sharing data. In addition to energy monitoring and HVAC controls, LonWorks technology also supports lighting system control, security/access control, and a fire systems interface.

Objective

In coordination with the CFE energy audit work, develop a plan for a LonWorks-based system to provide energy monitoring and management (and possibly control) in the main three-building complex including development of a Design Intent Document (DID) describing options for a two-phase implementation (FY04 and FY05). The DID will be a master plan consisting of a one-line layout, functional description, schedule, and cost estimate. Each of these will serve to define technical requirements and specifications for use in execution of the work. The system must be designed to be extensible to accommodate future system expansion including implementation of energy conservation opportunities identified by the CERL energy audit team and other renovations.

Approach.

Key elements:

1. Develop Design Intent Document (DID)
2. Review DID. CERL (including IT & DPW), UIUC, and LonWorks System Integrator (SI).
3. Finalize DID. Select Phase I versus Phase II work.
4. Develop design drawings and specs (Louisville District?)
5. Award contract. Hardware installation and systems integration
6. Functional performance testing
7. Finalize as-built documentation
8. Training.

5. MASTER PLAN.

General

Phase 1 will include items 1 through 3 plus one or more additional items depending on need, applicability, and budget:

1. User interface (to display, store, and manage data)
2. Communications cabling
3. Electrical monitoring (six Lighting panels and main power meter)
4. Occupancy sensors in West wing of Building 2 only.
5. Occupancy sensors in all of Building 2.
6. Occupancy sensors in all Buildings 1, 2, and 3.
7. Perimeter fan coil unit control
8. Lighting control
9. Air handling unit monitoring/control
10. Chiller monitoring/control.

All prices mentioned below are hardware, uninstalled prices.

User Interface

Primary goal is to provide an operator interface in support of system monitoring and management. There are two options: A full blown client-server workstation ($5000–$10000) or a lower-level web server ($800). Both can collect/store data and serve up web pages (to display data). Example of this lower-level web-server approach is an i.LON100 brand device. Identify physical location for this device. May want to put it in the Heat Plant because we can use the i.LON100 “pulse” input to read the main CERL power meter. Will need to install an Ethernet connection in the Heat Plant. Identify and consider alternatives to i.LON100 brand? The i.LON100 has an optional modem for remote dial-up access. Seems like this might be handy for remote access. What can we do via remote access? Change setpoints? Turn equipment on/off? Seems like a potentially useful function for DPW staff. Identify needed accessories (i.e., enclosure?). Given CERL’s firewall, determine feasibility/options for an Internet interface to i.Lon100 located in Power Plant

Web-Services

Setup/configure to serve up web-pages to display real-time and stored data (accessible using any Browser). Develop list and description of info to be displayed – consider future system expansion and functions. Identify/describe desired screen displays. Etc.

Data Collection

Collect and store watt-hr and occupancy data. Identify needs and requirements. Store lighting panel watt-hr data every 15 minutes. Study WattNode cut sheet to determine if we would like additional/available (SNVT) data. Collect and store main power meter data every (1?) minute. Generate a real-time alarm (based on the main power meter) if power approaches the demand charge limit.

Consider installing a real-time display (via Browser near the front desk/reception area) of our energy use.

1. *Electrical Monitoring—Lighting Panel.* Install LonWorks power monitoring devices at each of six 3-phase lighting panels (LP-1 thru LP-6) in the main 3-building complex. WattNode brand device cost $500 each plus $150 for software to configure them (total = $3150). We have current transformers on-hand so these do not necessarily need to be purchased (otherwise they cost about $150 per panel).
2. *Electrical Monitoring—Main Power Meter.* Install LonWorks power monitoring device at the main CERL meter (on the East side of the Utilities/Heat Plant). The pulse output from the present electric meter was provided by Illinois Power and is used as an input to the YORK system. We could put a relay with 2 sets of contacts in the circuit and rewire the York panel input. The drawings show a set of dry contacts from the meter directly wired to a DI in the York panel. One of the relay outputs can be sent to an i.LON100 brand device ($725), which has the capability to monitor pulse inputs. Chris Dilks can get scaling info or we can get it from Illinois Power. Need to identify mounting location. Consider putting it in the Heat Plant office. May need an enclosure ($150). Thomas Miller said IP is already doing real-time monitoring of our power.
3. *Occupancy Sensors.* Most (all) perimeter spaces already have wall-switch-mounted occupancy sensors, but they are not LonWorks compatible. The existing sensors turn the lights on/off. We considered replacing the existing light switches with a LonWorks compatible occupancy sensor/light switch, but cannot find such a device. Also, cubicled spaces are not good candidates for occupancy sensors because multiple sensors would be required (approximately one per cubicled space for a total of about 300 sensors CERL-wide). A ceiling mount occupancy sensor that can be installed in the ceiling tile costs about $240 (indicated as "RM-O" in Building 2 drawing). ($240 per sensor x 300 sensors = $72,000). An option is to install a light sensor in cubicled spaces to sense whether or not the lights are on.

This begs the question of the purpose of occupancy sensors:

1. Turn A/C units on/off (fan coils, main air handlers, packaged units)
2. Adjust thermostat setpoints (occupied/unoccupied setpoints)
3. Adjust air handling unit fresh air quantity

4. Turn on/off lights
5. Activate/deactivate a switched AC outlet
6. Develop an energy versus occupancy profile
7. Personnel monitoring/security (i.e., after-hours alarm generation).

Design/specification guidance needs to include detailed guidance on occupancy sensors (where to install each sensor, adjustment/testing).

Communications Network and Cabling

1. Will consist of a LonWorks cabling network with IP interface via Lon-to-IP router. Might want to put a Lon/IP router in each of the three buildings so that we do not run LonWorks cable through the breezeways.
2. Need single-line drawing. Show LON network speed (there are two options with LonWorks). Show each device/controller/node. Show possible repeaters/routers. Show IP interface(s). Get a better estimate of length of cable that we will need.
3. Need to select cable type. CAT5 is 22 AWG (with multiple strands), but has length limitations. 16 and 18 AWG are more expensive options. We have ducted returns, so do not need plenum rated cable (at least in Buildings 1 and 2). Is there a standard for running the cable? (Is draped across drop ceiling OK?). Building 1 and 2 attic space is open (no exterior interior walls extend to roof). Mike Ashby recommendation: When running any type of wiring, plumbing, electrical, or anything else above the ceiling, it should be run in a manner not creating a safety hazard. I would suggest that you run the cable along the wire for the ceiling tile and make sure you have no trip hazards. Our contractors and other workers walk the walls and we need to make sure they are clear at all times. Need to make sure we do not exceed LonWorks cable length restrictions (approx. 5000 ft?), or else identify repeater location(s). Free Topology ranges from 250 to 500 meters node to node and from 450 to 500 meters for the total wire length (on that channel), depending on the cable used (they list five options in the FTT-10A users guide). Need to make sure we do not exceed maximum number of devices (64?), or else identify repeater location(s). Need to structure cabling to accommodate possible future expansion. Cabling will be laid across top of drop ceiling.
4. Need to get IP from main complex (via Building 3) to the Utility/Heat Plant. Chris Stack said he could get a cost estimate. It is about a 30-ft run between Building 3 and the utility plant, with a sidewalk in between. There apparently is an existing, fairly large, wire chase between the two buildings.
   a. System Integration. System Integrator sets up (configures via software tool – “LonMaker for Windows”) the communications network and binds node communications together. Also sets up web pages/does programming. Use existing “LonMaker for Windows” (LM4W) tool owned by CERL(?) Determine if we need to purchase node licensing rights.

b. **Fan Coil Units (FCU).** The FY01 FCU control upgrade included Trane brand (ZN-010) controllers. Do not know exactly how many FCUs there are. Thomas Miller said he could find out how many FCUs were included in the retrofit, but we have noticed upgraded units in perimeter office spaces of both Buildings 1 and 2.

(1) The existing controllers have a LonTalk neuron chip, but do not appear (per literature) to be capable of communicating. It may be feasible to add a comm module/interface of some sort, but we know no more than this.

(2) <u>Hardwired interface</u>. Each existing FCU controller has a set of presently unused terminal connections (dry contact input) where an occupied/unoccupied signal can be applied. We can interface to the controller using a LonWorks Binary output (BO) device (approx. $400). We are still checking, but think we can get a binary output device that has 8 contact outputs (so it can control 8 FCUs independently). Some BO devices use SCR outputs. Need to determine if SCR is compatible with the FCU dry contact input. The LonWorks device accepts a SNVT (network) command to independently control the occ/unocc status of each FCU. Will need to identify a location for the LonWorks binary device (need to consider ease of installation and maintenance access). Do not know if reprogramming of the is required, but it appears not. We tested one of the units, and it turned off when the occ/unocc input contacts are shorted.

(3) <u>FCU controller replacement</u>. The existing FCU controllers (Trane ZN-010) can be replaced with a very similar Trane unit (ZN 511) with GSA price of $143 each. Do not know if the thermostat also needs to be replaced. This option provides greater functionality and permits access to more data over the comm network than the hardwired interface (need to sort this out / details on capabilities). The LonWorks comm cable may need to be 18 AWG (per Trane specs). Configuration/programming of the FCU controller may require Trane's Rover Software (GSA price: $757). Do not know if reprogramming of the is required if we use the dry contact input on the existing controllers, but will be needed if we purchase new controllers.

(4) <u>LonWorks-compatible control strategy</u>. In either case (existing or new controller), a control strategy will be required. FCU could be turned off based strictly on signal from ceiling mount occupancy sensor. Might be wise to include an override (such as a switch) in the event of occupancy sensor or other hardware failure. Need to consider incorporating a low temperature override in the event the space gets too cold during unoccupied mode. Consider incorporating a user Browser interface to override FCU to on or off based on user desire (override to off for selected period while occupant is out of office for extended period). Optionally, via

browser interface, allow user to override temperature setpoint for extended period (setback during extended unoccupied periods).

c. **AHU Controls Renovation.** Most air handling units, with certain exceptions such as the roof top units, use antiquated pneumatic controls. These controls are notoriously inaccurate. The UIUC maintenance staff does well to keep up with them as best they do, but it is a losing battle. In addition, the control schemes used by these controls are energy inefficient and not optimized. And, none of the controls are being monitored/supervised, therefore problems and inefficiencies are difficult to predict and detect.

MZ AHU (Unit: CLS-04) in West Wing of Bldg 2 (Attic space above Rm 2014):

- Our assessment was based on a quick-look inspection. We had no documentation to work with.
- Consists of aged pneumatic-type controls.

  Has a "S/W" input (summer/winter?), but cannot tell if it is functional. The S/W input, if functional, is intended to switch the control of the OA damper from a fixed position to being under control from the modulating PI controller which is "sort of" an economizer, but basing the economizer decision on a summer/winter decision yields little energy savings.
- All necessary economizer control hardware (actuators, dampers) are in place (in support of renovation with digital controls).

  Has no minimum position setting for the outside air (OA) damper. It can close completely (via "EP main" input), if the "EP main" input does anything. The damper was visually observed to be near full open during inspection on 2/5/03 while it was below freezing outside. The damper had 10 psi pressure applied to it.

  Appears to have no occupied/unoccupied mode. Runs 24/7. The day/night switch located on the front of the controls enclosure is disconnected. The time clock above the enclosure is disconnected. There is a P/E switch at the fan H-O-A switch, that could be used to turn the fan on/off, but cannot determine what feeds the P/E switch (speculate that is may at one time have been the day/night switch on the front of the controls enclosure, but this switch is disconnected).

  The "EP Main" input to the enclosure performs an occ/unocc function to close the OA damper when the AHU is shut off. The "EP Main" signal originates at the fan H-O-A switch.

> Hot and cold decks are under control, but the cold deck temp gage reads 8 degrees lower than the mixed air temp gage. This suggests mis-calibration (because the chiller is not "on").
>
> Zone thermostats are pneumatic type.

Replace the Building 2 West Wing MZ AHU controls (and later, the five zone thermostats and zone damper actuators, serving the entire West wing interior spaces) with LonWorks controls. Keep existing AHU pneumatic actuators. Need controller ($2000 est.). Need new sensors (OA, RA, MA, HD, CD) ($800 est.). New 5 thermostats ($400). Consider replacing existing zone damper actuators with electric actuators ($1000). Or, if we keep the pneumatic zone actuators, we will need 5 electronic-to-pressure transducers ($500), but not exactly sure how to control the zone dampers. Could be done from the AHU controller (via zone thermostat input to the AHU controller, with the AHU controller sending a signal to each of the zone dampers). Need to investigate.

d. **High Bay.** There are 16 perimeter fan coil units for heating and one large air handling unit for conditioning the high bay area. There are four thermostats near four corners for temperature control. The fan coil units and the AHU should be converted to LonWorks, to provide for automated/remote monitoring and control, including scheduling capability. Consider installing Trane fan coil unit (LonWorks) controllers (ZN 511) with GSA price of $143 each.
e. **Building 3 Controls.** The Zackrison building HVAC system and controls have been historically problematic. A retrofit of the controls, to include monitoring and data collection, should serve to improve the occupant comfort and control system performance. BUT, prior to a controls retrofit, a detailed assessment of the HVAC system performance should be done. This assessment should include a basic test, adjust and balance type measurements, resulting in a TAB report. A standard TAB report, coupled with a few functional tests of certain control devices (dampers, valves, actuators), should provide ample performance data to determine if and how to proceed with a controls retrofit.
f. **Chiller.** Install LonWorks interface to existing DDC controller (eventually – not part of present Phase I or II plan). Thomas Miller/Christopher Dilks say that a remote dial-up interface is presently being installed for the existing proprietary York controls.
g. **New HVAC Equipment.** Recommend requiring all new HVAC equipment to have LonWorks controls. Preferably LonMark certified. Many vendors supply factory installed LonWorks controls. Need to define specs/requirements.

h. **Lighting.** Present lights use (non-LonWorks) light switches with occupancy sensors. Recommend that all future lighting upgrades and retrofits use LonWorks technology. Take advantage of LonWorks occupancy sensors. May require a LonWorks lighting controller (1 controller per 4 to 8 offices).
i. **Security and Access Control.** Not familiar with existing system or requirements, but LonWorks is a viable technology.
j. **Functional Performance Test.** Need to define methodology and specific tests.
k. **As-Built Documentation.** Drawings. Data sheets. O&M manuals.
l. **Training.** Identify needs, materials and cost. Include DPW and UIUC.
m. **Cost Estimate**. Located at N:\Research\CF Division\CF-E\LonWorks.
n. The cost estimates are best guess. Some pricing and costs are not known. Probably needs work.
o. Sheet: Estimate1 (The original estimate – 1/28/03) has been updated to account for things listed below (ESTIMATE1 updates), <u>but</u> is no longer valid because we are looking at contracting out the work, whereas we originally thought about doing most of it in-house. The estimate included:
   (1) Basic system: User interface (to display, store, and manage data), Communications cabling, Electrical monitoring (Lighting panels and main power meter)
   (2) **Option 1**: Basic system plus Occupancy sensors in West wing of Building 2 only.
   (3) **Option 2**: Basic system plus occupancy sensors in all of Building 2.
   (4) **Option 3**: Basic system plus occupancy sensors in all Buildings 1, 2, and 3.

Estimate 1 Updates

- Assumed we had only 3 lighting panels. We have 6.
- Do not need current transformers (CTs). We have boxes of them in-house.
- Assumed we needed 2 i.LON100s. We only need 1.
- Options 2 and 3 were very rough guesstimates.
- 24 VAC power to Occ sensors was not included
- Number of occupancy sensors was an estimate.
- Did not include training

p. Sheet: ESTIMATE 2. Includes (out-sourcing the work, i.e., Louisville District):
   (1) **Option 4.** WebServer and LonWorks network with IP interface, Bldg2 West wing 30 exterior offices fan coil unit (FCU) binary input module occ/unocc control interface via ceiling mount occupancy sensors, MZ AHU control, six light panel power monitors, main CERL power meter: $71,000

(2) **Option 5.** Same as Option 4, except add Wonderware (or similar full-blown operator interface) Software: $81,000

(3) **Option 6.** Same as Option 4, except replace existing FCU controllers with LonWorks controllers instead of using a binary input module to perform occ/unocc control: $72,500

(4) **In all cases, the scope can be trimmed to meet budget constraints.** (i.e., instead of retrofitting all 30 Building 2 West wing FCUs, we can do fewer offices.

LonWorks Features Table (Attachment 1)

(A/O 11 Mar 03)

Feature	Location	Objective / Benefit	IT vs. DPW	Priority/ Dependence
Web Server	Utility Plant	-User Interface (Internet)	IT installs	First
(i.LON-100)		-Alarm generation (email) -Scheduling -Data collection -Energy management -CERL front desk energy display	Ethernet to Utility Plant?	
IT network, LonWorks network, routers	CERL-wide	Multi-vendor piecemeal integration	IT coordination	As-you-go
Power meter – Main	Utility Plant	- Energy monitoring and management -Real-time load shedding		First
Power meter – Bldg	Each Building	- Energy monitoring and management -Disaggregation		Requires WebServer
Power meter – Lighting	Building 1 (Qty 2)	- Energy monitoring and management		Requires WebServer
	Building 2 (Qty 3)	-Disaggregation		
	Building 3 (Qty 1)			
FCU on/off control module	-Perimeter spaces	-Energy reduction		-Requires occupancy sensor
	-Bldg 2 high bay	-Performance Monitoring		-Scheduling via WebServer
	-Other misc.	(Need to replace FCU controllers for “monitoring”)		

Feature	Location	Objective / Benefit	IT vs. DPW	Priority/ Dependence
FCU controller replacement		-Energy reduction		-Requires occupancy sensor
		(turn unit off when space		-Scheduling via WebServer
		is unoccupied and after		
		hours/weekends)		
		-Performance Monitoring		
Multizone (MZ) AHU	-Building 1	-Control improvement		-Independent
	-Building 2	(Setpoints, economizer,		
	-Possibly more	Minimum outside air)		-Scheduling via WebServer
		-Energy reduction		
		(turn unit off after hours		
		/weekends)		
		-Performance Monitoring		
MZ zone thermostats	MZ AHU(s)	-Control improvement		Need MZ AHU for unocc. mode override, otherwise independent
		-Override of MZ AHU		
		(Occupant can turn on		
		AHU during unocc. period)		
		-Performance Monitoring		
Roof top AHU	Mainly Buildings 1 & 2	-On/off scheduling		Independent
		-Performance Monitoring		
Occupancy sensors	-Perimeter spaces	On/Off control of FCUs		Needed for FCU on/off control
	(Bldg 2 W. Wing)			
Chiller	Utility Plant	-Energy management		Web Server
(Future option)		-Remote control		
Lighting	CERL-wide	Energy management		Requires
(Future option)				occupancy sensor

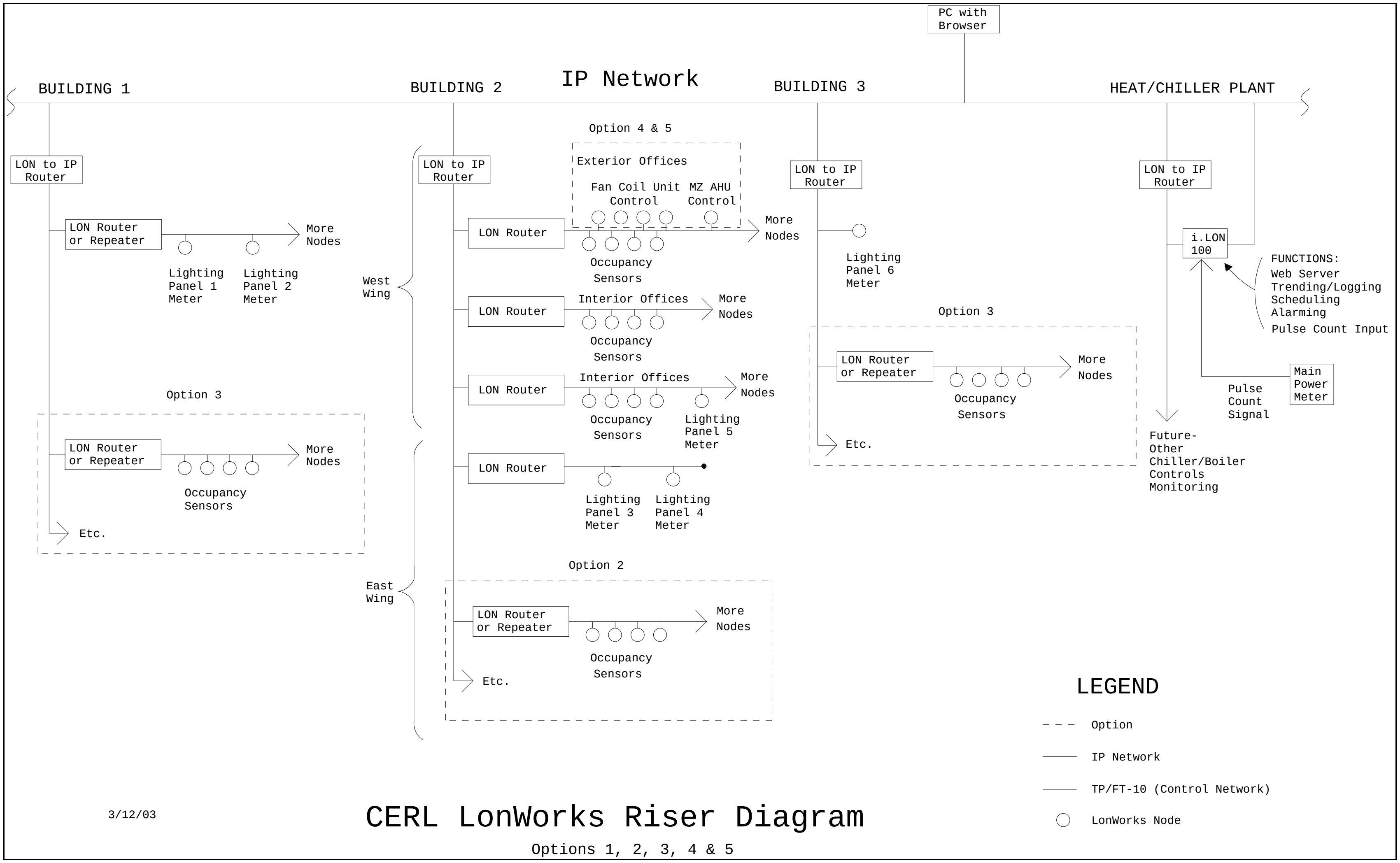


Figure H1. CERL LonWorks riser diagram.

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14. ABSTRACT

As a result of the CERL sustainability workshop, a Phase I energy audit was conducted for CERL main complex (Buildings 1, 2, and 3) was conducted. The goals of the audit were to review energy and water use in the current main complex building, to review and inventory energy system equipment, and to devise short- and long-term energy improvement and water conservation strategies. Baseline references on utilities consumptions and costs were developed to help future periodic monitoring efforts.

This report documents facility and energy systems information and energy management and water conservation opportunities identified in this study. A 40 percent reduction in building energy use is needed for CERL to meet the Army facility energy goal (by reducing the current Energy Use Index [EUI] of 160 KBtu/sq ft/yr to below 100 KBtu/sq ft /yr). Despite completion of several energy conservation projects at the CERL complex, it was found that the EUI has been increasing since 1998. Factors that likely contributed to this increase were summer air dehumidification (starting in FY00) and inadequate building insulation. Specific short- and long-term energy improvement strategies were recommended to address the site's water- and energy-conservation issues.

15. SUBJECT TERMS

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