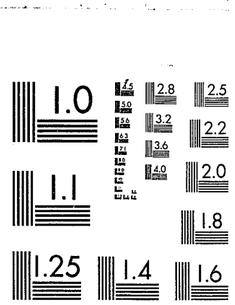

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Energy Conservation Opportunities
Chisago County Jail
at
Chisago, Minnesota

Prepared for
Law Enforcement Assistance Administration
U.S. Department of Justice
Washington, D.C. 20531

Prepared by
Unified Industries Incorporated
6551 Loisdale Court
Springfield, Virginia 22150

and

JRB Associates, Incorporated
8400 Westpark Drive
McLean, Virginia 22102

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1. INTRODUCTION AND GENERAL BACKGROUND INFORMATION

1.1 BACKGROUND

The Law Enforcement Assistance Administration (LEAA) national program for improved energy conservation in correctional facilities has three major objectives. These are:

- o To demonstrate that there are cost-effective, readily available energy conservation strategies that are particularly effective in a correctional environment
- o To develop and disseminate accurate energy conservation information to corrections personnel
- o To provide guidance and technical assistance in developing and implementing an energy conservation program for various types of correctional facilities

To meet these objectives and to initiate allied energy conservation programs, LEAA sought the services of Unified Industries Incorporated (UII) and JRB Associates (JRB). The coordinated effort by these two firms has provided serveral areas of emphasis in this project. They are: onsite energy conservation surveys of two maximum security prisons, two medium security prisons, and three jails at locations selected by LEAA; preparation of an energy conservation handbook as a guide to facility management and engineering personnel; and the conduct of four regional energy conservation workshops at sites selected by LEAA. This report deals with the energy conservation survey conducted April 13-14, 1981 at the Chisago County Jail, Minnesota.

The site survey involved investigation into several areas of potential energy conservation including, but not limited to, the following:

- o HVAC system analysis for enthalpy control and temperature setbacks
- o Equipment shutdown during periods of non-use
- o Electrical demand-limiting methods
- o Analysis of lighting systems

- o Electric power factor correction
- o Heat recovery for water heating systems
- o Evaluation of the building envelope for reduced heat loss and infiltration

1.2 CONTENTS OF THE REPORT

The purpose of this report is twofold. It will serve to detail the findings of the energy conservation survey at the Chisago County Jail, and it will make recommendations concerning measures which can be taken to reduce consumption. These measures are presented in section 3, Retrofit Options. Also, the potential cost savings associated with each option are presented to aid in the selection of the most cost-effective techniques for reduction of energy use.

2. SUMMARY OF RECOMMENDED RETROFIT PROJECTS

Option #	Description	Annual Energy Savings	Annual Cost Savings	Capital Cost	Payback Period (Yrs.)
1	Reduce Outside Air Intake During Heating Season	194 MBtu 31,771 kWh	$1,962	$1,700 or 1,950	0.88 or 1.01
2	Install Flue Restrictors on Boilers, DHW Heaters	50 MBtu	182	310	1.7
3	Reduce Domestic Hot Water Temperature	49 MBtu	221	10	0.05
4	Lower Space Temperature to 68° F	52 MBtu	189	100	0.53
5	Lower Space Temperature During Unoccupied Periods	20 MBtu	73	400	5.5
6	Recalibrate Outside Air Reset Controls	24-40 MBtu	87-140	100	0.7-1.1
7	Replace Standard with Energy-Saving Fluorescents		See Table 7-1		
8	Replace Incandescents with Fluorescents	981 kWh	32	352	11

3. RETROFIT OPTIONS

3.1 OPTION 1 - REDUCE OUTSIDE AIR INTAKE DURING THE HEATING SEASON

Approximately 4,400 cfm of fresh air is being supplied to the facility. The maximum amount of fresh air (outside air) recommended in the ASHRAE Ventilation Standard 62-73 is 15 cfm per person. With a maximum of 25 persons (inmates and staff) occupying each living unit, the total amount of fresh air required is 375 cfm. Presently, the exhaust air fans remove 1,640 cfm of conditioned air.

To reduce the overventilation and energy waste during the winter season, the exhaust air and supply air should be decreased and the return air must be increased. The recommended changes will supply 945 cfm of fresh air and maintain a slight positive pressure to minimize infiltration.

Two methods have been suggested to achieve the proposed energy savings:

1) Replace the existing fan motors with 2-speed motors.

2) Install variable sheave pulleys on each fan.

Alternative #1 requires that switches be thrown to either the summer or winter position to provide the recommended ventilation levels. Alternative #2 requires the pulleys be moved to modify the air volumes.. Both alternatives will necessitate about 2 mandays of labor to rebalance the system for summer and winter operation.

Energy Savings

o System Design

Supply Air - 5,689 cfm

Return Air - 1,285 cfm

Exhaust Air - 1,640 cfm

Outside Air = 33% x 5,689 cfm = 1,877 cfm[(1)]

Unaccounted for Return Air = 5,689 cfm - 1,285 cfm

= 2,527 cfm

- o Design Temperature - -16° F
- o Equivalent Full Load Hours (EFLH) - 2,361 hours/year
- o Full Load ΔT [+65° F - (-16° F)] = 81° F
- o Maximum Occupancy - 25 persons
- o ASHRAE Design Criteria (Ventilation Standard 62-73)
  = 15 cfm/person
- o Maximum Required Fresh Air - 15 cfm/person x 25 persons
  = 375 cfm
- o Winter Operation -
  - Decrease Exhaust Air from 1,640 cfm to 820 cfm (-50%)
  - Decrease Supply Air from 5,689 cfm to 2,845 cfm (-50%)
  - Return Air - 1,907 cfm
  - New Outside Air - 938 cfm
- o Summer Operation - use existing system

Annual Energy Savings (Heating)[2]:

1.08 x ΔT x outside air cfm x EFLH

= 1.08 x 81° F x (1,877 cfm - 938 cfm) x 2,361 hours/yr

= 194 x 10^6 Btu/year

Raw Source Energy Savings (assume 80% boiler efficiency):

194 x 10^6 Btu/year ÷ 0.8

= 242 x 10^6 Btu/year

	Existing	Proposed Winter
Fan Hp - O.A. Fan -	½ Hp	0.10 Hp
S.A. Fan -	5 Hp	1.2 Hp
(2) Power Ventilators -	3/4 Hp	0.25 Hp
Total	7 Hp	1.8 Hp

Annual Electricity Savings:

(7 Hp - 1.8 Hp) x 0.746 kW/Hp x 39 weeks/yr x 168 hours/week

÷ 80% motor efficiency

= 31,771 kWh/year

Energy Cost Savings

242 x 10^6 Btu/year x \$3.63/10^6 Btu + 31,771 kWh/year x \$0.033/kWh

= \$1,926/year

Capital Cost

Alternative #1 - Two-speed fan motors

o 2 - 1.0/.025 Hp Power Ventilator motors	\$500
o 1 - 5.0/1.2 Hp Supply Air Motor	350
o 1 - summer/winter pulley (outside air fan)	100
o Two-speed controls	300
	\$1,250
Annual Maintenance to Rebalance	450
Total	\$1,700

Alternative #2 - Variable sheave pulleys

o 4 sets of variable pitch sheaves and matching belts @ 300/each	\$1,200
	240
o Installation \$30/hr @ 2 hr/unit	60
o Additional Maintenance System balance (Annual)	450
Total	\$1,950

Payback Period Alternative #1 - $1,750 / $1,926/year

= 0.88 year

Alternative #2 - $1,950 / $1,926/year

= 1.01 year

(1) Generally, outside air (fresh air) is equal to the supply air less the return air. Using this method, the calculated energy use is nearly double the billed (actual) energy use. Therefore, air is being returned to the air handling unit which is not shown on the mechanical drawings. An alternative calculation method assumes the outside air supplied to the building is slightly greater than the exhaust air. If 33% outside air is supplied, the building will be under a slight positive pressure and the calculated energy usage will more accurately reflect actual bills.

(2) A heating fuel bill was supplied for February. No other heating fuel bills were available.

OPTION 2 - INSTALL FLUE RESTRICTOR ON BOILER AND DHW HEATER

The boiler and domestic hot water flue stacks permit heated air to escape without any obstruction. Energy savings can be achieved by minimizing the natural draft effect through a controlled flow rate. International Flue Saver, Inc. manufactures an "Energy Saver" that is installed directly in the two 6-inch flues. Energy savings of up to 14% have been recorded by users of the flue gas flow controller. Due to the 24-hour operation at the facility and the cold climate, the unit should obtain at least a 5% savings. The unit has no moving parts and therefore, is virtually fail-safe. This is an important feature in any building but especially a correctional facility.

Energy Savings

- o February Energy Usage (Bill) - 136×10^6 Btu
- o February DHW Energy Usage - 40 gpd x 20 persons x 30 days x (130° F - 50° F) x 8.33

  = 16×10^6 Btu for February
- o February Heating Energy Use - $(136 \times 10^6$ Btu) - $(16 \times 10^6$ Btu)

  = 120×10^6 Btu
- o Equivalent Full Load Hours (Heating)
  - February/March (Average) - 352
  - Annual - 2,361
- o Annual Heating Energy Use (1)

  120×10^6 Btu x $\frac{2,361 \text{ EFLH}}{352 \text{ EFLH}}$

  = 805×10^6 Btu/year
- o Annual DHW Energy Use

  12 months/yr x 16×10^6 Btu/month

  = 192×10^6 Btu/year

Annual Energy Savings:

5% x [805 x 10^6 Btu/year + 192 x 10^6 Btu/year]

= 50 x 10^6 Btu/year

Energy Cost Savings

50 x 10^6 Btu/year x \$3.63/10^6 Btu

= \$182/year

Capital Cost

Material - 2 units @ \$125/unit	\$250
Labor - 4 hours @ \$15/hour (using in-house personnel)	60
	\$310

Payback Period

\$310 / \$182/year

= 1.7 years(2)

(1) Annual heating energy use can be calculated by the heating degree day method.

- o 8,382 heating degree days - Minneapolis, MN
- o 7,800 gross square feet
- o 20 to 35 Btu/gsf/HDD (Typical for correctional facilities)

Annual heating energy use = 8,382 x 7,800 x 20

= 1,308 x 10^6 Btu/year

The annual heating energy use calculated by equivalent full load hours represents about 12.5 Btu/gsf/HDD. Although this seems very low, it is used to reflect some actual data and does provide a conservative estimate of the potential savings.

(2) The manufacturer's literature estimates a 2-year or less payback period. Depending on the distributor, Chisago County could get a guarantee on a 2-year payback!

OPTION 3 - REDUCED DOMESTIC HOT WATER TEMPERATURE

Currently, the domestic hot water temperatue is maintained at 130° F. It is recommended that the DHW temperature be lowered to 110° F by adjusting the aquastat setting on the hot water heater. To accomplish this option, it may be necessary to lower the water temperature in stages (5° F or 10° F) to minimize inmate complaints. Also, any preset mixing valves will have to be reset to accommodate the reduced water temperature.

Energy Savings

- o DHW Usage - 40 gallons/person/day(1)
- o Occupancy - 20 persons
- o DHW Temperature -

  Present - 130° F

  Proposed - 110° F

Annual Energy Savings:

40 gpd x 20 persons x 365 days/year x (130° F - 110° F) x 8.33

= 49 x 10^6 Btu/year

Raw Source Energy Savings (80% boiler efficiency):

49 x 10^6 Btu/year ÷ 0.8

= 61 x 10^6 Btu/year

Energy Cost Savings

16 x 10^6 Btu/year x \$3.63/10^6 Btu

= \$221/year

Capital Cost

Labor to Reset	\$10
DHW Heater Thermostat	

Payback Period $\frac{\$10}{\$221/\text{year}}$

= 0.05 year

(1) Without natural gas and water bills, it is impossible to accurately calculate the DHW usage in the building. Based on our previous experience at correctional facilities, an optimum DHW usage is about 40 gpd. Some facilities have exceeded 200 gpd. For purposes of this option, the 40 gpd is assumed.

OPTION 4 - LOWER SPACE TEMPERATURE TO 68° F

Space temperatures measured in the jail ranged from 64.3° F in cell block #5 (unoccupied) to 77.4° F in room 133. The average measured temperature was 73° F which is higher than the recommended 68° F space temperature. Recalibrating the thermostats throughout the building can save approximately 6.5% of the energy required for heating.

Energy Savings

- o Percent Savings - 1.3%/°F
- o Existing Space Temperature - 73° F (average)
- o Proposed Space Temperature - 68° F
- o Heating Energy Use - 805×10^6 Btu/year(1)

Annual Heating Energy Savings:

805×10^6 Btu/year x 1.3%/°F x 5° F

$= 52 \times 10^6$ Btu/year(1)

Energy Cost Savings: 52×10^6 Btu/year x $\$3.63/10^6$ Btu

= \$189/year(1)

Capital Cost: Implementation cost to replace or recalibrate thermostats = \$100

Payback Period $\frac{\$100}{\$189/\text{year}}$

= 0.53 year

(1) If option #1 is implemented, the energy and cost savings are decreased but the payback period remains under 1 year.

- o Annual Heating - 563×10^6 Btu/year
- o Energy Savings - 37×10^6 Btu/year
- o Cost Savings - \$134/year
- o Payback Period - 0.75 years

OPTION 5 - LOWER SPACE TEMPERATURE DURING UNOCCUPIED PERIODS

The library, gymnasium, jail offices and kitchens are not occupied from 10 p.m. - 7 a.m. Room temperatures can be lowered to 55° F during unoccupied periods by installing automatic reset thermostats which control the reheat coils supplying each area. Clocks operating the thermostat settings will signal the reheat coils to return the space termperature to 68° F prior to morning occupancy.

Energy Savings

o Space Temperature -

Existing - 68° F (See option #4)

Proposed - 55° F between 10 p.m. and 6 a.m.

- 68° F other times

o Energy Savings - LEAA Handbook - 25%

- EFLH Method-

Night Bin - @ 68° F - 895 ELFH

@ 55° F - 733 EFLH

Overall Savings - $\frac{(895 - 733)}{2,361}$

= 7%

o Heating Energy - 12.5 Btu/gsf/HDD

- 8,382 HDD

o Total Area - 1,283 gsf

Annual Heating Energy Savings:

12.5 Btu/gsf/HDD x 8,382 HDD x 1,283 gsf x 15%

= 20 x 10^6 Btu/year

Energy Cost Savings

20 x 10^6 Btu/year x \$3.63/10^6 Btu

= \$73/year

Capital Cost — Installed cost 4 thermostats @ \$100/unit - \$400

Payback

$\frac{\$400}{\$73/year}$

= 5.5 years

OPTION 6 - RECALIBRATE OUTSIDE AIR RESET CONTROLS FOR HEATING SYSTEM HOT WATER

The boiler has an outside air heating hot water reset control. As the outside air temperature decreases, the temperature of the hot water used to heat the jail increases. The reset schedule is presented in table 6-1. During the site visit, the outside air temperature was measured at 45° F. The control system based on the design reset schedule should have supplied a heating hot water temperature of 155° F to the air handling unit and reheat coils. The actual temperature was measured at 165° - 170° F. A "rule-of-thumb" for energy savings is about 3 - 5% after correcting a 10° F on the reset controls.

Energy savings are achieved because of reduced piping distribution losses, boiler flue gas losses, boiler conduction losses, and improved air handling unit and reheat coil heat transfer.

The present payback period ranges from 0.7 to 1.1 years. With existing fuel cost, it is recommended that the controls be checked biannually. If natural gas fuel costs increase as expected, an annual check of the entire system (including thermostats) is cost-effective.

Energy Savings

- o Annual Heating Energy - 805×10^6 Btu/yr
- o Energy Savings - 3% to 5%

Annual Energy Savings:

805×10^6 Btu/year x (3% to 5%)

= 24×10^6 Btu/year to 40×10^6 Btu/year

Energy Cost Savings

$24 \text{ to } 40 \times 10^6$ Btu/year x $\$3.63/10^6$ Btu

= \$87 - \$140/year

TABLE 6-1

Heating Hot Water Outside Air Reset Schedule

Outside Air Temperature	Hot Water Temperature
0° F	200° F
10° F	190° F
20° F	180° F
30° F	170° F
40° F	160° F
50° F	150° F

Measured - 9 p.m. - April 13, 1981

45° F 165° - 170° F

Capital Cost	Labor -	
	control system repairperson	
	4 hours @ $25/hour	$100
Payback Period	$100	
	$85 to $140	
	= 0.7 to 1.1 years	

OPTION 7 - REPLACE EXISTING STANDARD FLUORESCENT LAMPS WITH ENERGY-CONSERVING TYPE LAMPS

It is recommended that energy-conserving fluorescent lamps replace all standard 4-foot fluorescent lamps at the Chisago County Jail. By using Lite White type 4-foot fluorescent lamps, the lighting level is reduced by 3 percent but the energy used is reduced by 15 percent. The standard designation for this new lamp is:

Existing	Replacement
F40 CW	F40/LW/RS

Energy-conserving lamps are also available to replace F48T12, F96T12 (Slimline), F96PG17 (Power Groove), F30T12, and F96T12/CW/1500 lamps. Although there were none located in the jail, other county facilities may benefit from the energy-conserving lamps. However, energy-conserving fluorescent lamps should not be used outdoors. Where ambient temperatures fall well below 60° F, the new lamps may not start. See table 7-1 for summary of energy and cost savings.

Burn-out replacement requires only the incremental cost of the lamp itself. For group replacement, the cost of the new lamp and the labor to install the lamp must be used. The longer the annual hours of operation, the more cost-effective the burn-out replacement and group relamp with energy-conserving lamps will be. Each replacement should be evaluated for its own merit. Generally, if a 4-foot lamp is used continuously (24 hours/day), it is cost-effective* to group-relamp.

* < 2.5 year payback period

Table 7-1. Energy and Cost Savings for Energy-Conserving Fluorescent Lamps

(Lamp type F40LW/RS; Lamp life 6 years)

No. of Lamps	Average Annual Hours of Operation	Energy Savings Per Lamp Watts	Total Energy Savings (kWh)	Cost Savings @ 0.033/ (kWh)	Capital Cost: Burn-out Replacement	Capital Cost: Group-Relamp*	Payback Period: Burn-out Replacement	Payback Period: Group-Relamp
100	3,000	6	1,800	$59	$81	$400	1.4 yrs	6.8 yrs

*Using inmate labor

OPTION 8 - REPLACE EXISTING INCANDESCENT FIXTURES WITH FLUORESCENT FIXTURES

In the carport of the Chisago County Jail, there are four (4) 100-watt incandescent lamps. Each incandescent fixture should be replaced with a single-tube flourescent fixture. The new fixtures will increase the lumen output by 50 percent, thereby increasing the present illumination level and improving officer safety. In addition, the total wattage will decrease from 100 watts to 44 watts per fixture. Another advantage of the fluorescent lighting system is the 20,000-hour lamp life, compared to 750 hours for the incandescent. Therefore, the cost to maintain the lighting system will be decreased significantly.

Energy Savings	4 fixture x [(1 incandescent lamp x 100 watts/lamp)	
	- (1 fluorescent lamp x 44 watts/lamp)] x 12 hours/day	
	x 365 days/year ÷ 1,000 W/kW	
	= 981 kWh/year	
Energy Cost		
Savings	981 kWh/year x $0.033/kWh	
	= $32/year	
Capital Cost	Cost to remove 4 old fixtures	
	@ $25/fixture =	$100
	Materials & labor to install	
	4 1-tube fluorescent fixture w/	
	energy-conserving lamps and	
	ballasts - @ $63/fixture =	252
		$352

Payback Period $352 / $32/year = 11 years(1)

(1) If the 100-watt lamps have to be replaced 4 times/year @ $3/replacement, the payback period becomes less than 5 years.

END