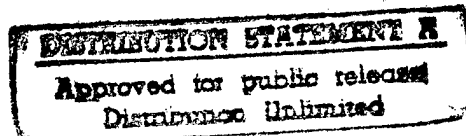


VOLUME I, BOOK 1
FINAL REPORT

ENERGY SAVINGS OPPORTUNITY SURVEY (ESOS)

WHITE SANDS MISSILE RANGE
NEW MEXICO



Prepared for

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
FORT WORTH, TEXAS

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By

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This study consists of VOLUME I BOOK 1, VOLUME I BOOK 2, AND VOLUME II

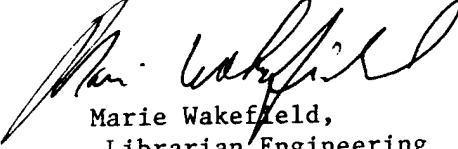


DEPARTMENT OF THE ARMY
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EXECUTIVE SUMMARY

INTRODUCTION

Purpose

The purpose of this study is to analyze the application of selected Energy Conservation Opportunities (ECOs) to designated buildings and systems at the White Sands Missile Range (WSMR). The study has nine elements:

1. Perform a field survey of designated buildings.
2. Evaluate ten ECOs applied selectively to 45 buildings in the Main Post Area. (General ECOs).
3. Evaluate six specified ECOs at Building P300.
4. Perform complete energy surveys on Buildings P21140, P21695, and P24072.
5. Evaluate the refurbishment of the chilled water plant in P24066 to serve four buildings in Launch Complex 38.
6. Identify and evaluate other ECOs. (Contractor-identified ECOs)
7. Analyze historical electrical demand readings for the Main Post Area and recommend ways to reduce and limit peak demand. (Demand Side Management)
8. Evaluate the feasibility of constructing a consolidated chilled water plant to serve the Tech Area. Consider thermal storage and cogeneration as alternatives.
9. Present all findings and recommendations in a comprehensive report.

Recent Historical Energy Consumption for WSMR Lower Range

Both electrical energy consumption and peak electrical demand have been quite constant for FY89, FY90, and FY91.

Electricity	FY89	FY90	FY91
Electrical energy (kWh)	100,656,817	100,335,675	100,241,069
Average peak electrical demand (kW)	18,150	17,760	17,550

The 1991 electrical unit prices are \$0.0221/kWh and \$19.50/kW. FY91 electrical energy costs were \$2,241,268, whereas on peak demand charges were \$4,110,113. Currently, the peak demand charge is almost twice the electrical energy charge.

Natural gas consumption is decreasing slightly:

Natural Gas	FY89	FY90	FY91
Total kcf	275,184	268,695	247,931

The current unit gas price (1,031 Btu/cu ft) is \$2.2124/MBtu.

Launch Complex 38 is supplied propane gas at a unit price of \$6.71 per million BTU.

For the entire WSMR, the specific energy consumption (kBtu/SF) and goal are indicated below:

	Actual (kBtu/SF)	Goal (kBtu/SF)
FY85	133.95	--
FY91	123.34	127.52
FY2000	--	107.16

GENERAL ECOs

Table ES-1 below lists the general ECOs evaluated for designated buildings.

**TABLE ES-1
ECOS TO BE EVALUATED FOR DESIGNATED BUILDINGS**

ECO #	Short Title	Designated Buildings
2	Add roof insulation	T117, P1830
4	Lower ceiling	P1782, P1830, P1530
7	Install air curtains	P160
9	Replace windows with energy efficient windows	P100, P102, P124, P128, P129, P143, P501, P502, P503, P504
10	Install instantaneous domestic water heaters (point-of-use)	P102, P124, P153, P236, P254, P260, P300, P380, P464, P1504, P1506, P1512, P1526, P1528, P1530, S1558, P1621, P1622, P1624, P1751, S1753, S1790, P1794
12	Replace existing lighting fixtures	P1743, P1751, S1753, S1790, P1794, P1830, P1845
13	Replace old fluorescent fixtures with efficient fixtures, lamps and ballasts	P1743, P1751, S1753, S1790, P1794, P1830, P1845
17	Install infra-red or radiant gas heaters in high bay areas	S1550, S1554, P1644, S1680, P1751, S1753, P1788, P1794, P1827, P1833
19	Install thermostatically controlled radiator/convector valves	P100, P124
20	Modify heating controls	P100, P124
29	Install a steam booster heater on a dishwasher	P1330
30	Install a boiler for summer domestic hot water load	P236

ECO #4 (lower ceiling) was not evaluated for Buildings P1530 and P1782, as during the survey it was determined that energy would not be saved.

The Consolidated Mess, Building P160, was not evaluated for ECO #7 (air curtains) because air curtains are already installed on the entries and exits.

ECO #10 (electric point-of-use water heaters) is not practically feasible for P236 (gymnasium) and P1621 (photo lab).

ECO #19 applies to Building P100. ECO #20 applies to P124. Both involve modifying heating controls, and are evaluated as a single ECO.

ECO #29 (install steam booster heater on a dishwasher) was not evaluated at Building P1330, because one is already in place.

The results of the evaluations are shown in Tables ES-2 and ES-3.

**TABLE ES-2
RECOMMENDED GENERAL ECOS**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P124	19-20	Install heating control valves/modify heating controls	747.3	1,779	5,191	3.3	3.8
S1790	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	57.0	369	9,643	5.0	2.9
P1794	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	135.1	875	24,962	5.5	2.7
P1743	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	119.3	773	26,824	6.7	2.2
P1845	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	1.1	7	281	7.4	2.0
P1751	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	38.0	246	9,515	7.5	2.0
P100	19-20	Install heating control valves/modify heating controls	839.4	2,082	12,071	6.5	1.9
P1830	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	45.7	296	12,211	8.0	1.9
S1753	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	26.6	174	7,396	8.2	1.8
T117	2	Add roof insulation	45.6	109	1,450	14.9	1.3
P1794	17	Infrared heaters in high-bay areas	369.4	906	14,602	9.7	1.2
P1788	17	Infrared heaters in high-bay areas	111.8	270	5,677	10.3	1.1
P1827	17	Infrared heaters in high-bay areas	226.0	517	10,695	11.5	1.0
P1751	17	Infrared heaters in high-bay areas	223.3	532	10,584	11.7	1.0

2,985.0 8.93

**TABLE ES-3
NONRECOMMENDED GENERAL ECOs**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P1833	17	Infrared heaters in high-bay areas	117.2	278	8,268	13.8	0.8
S1644	17	Infrared heaters in high-bay areas	65.3	232	3,873	13.9	0.8
S1753	17	Infrared heaters in high-bay areas	91.3	221	6,793	14.4	0.8
P502	9	Replace windows with energy efficient windows -grey glass	30.0	187	29,046	17.6	0.8
P502	9	Replace windows with energy efficient windows -clear glass	30.3	196	26,747	21.2	0.7
S1550	17	Infrared heaters in high-bay areas	140.6	531	10,313	18.0	0.6
S1554	17	Infrared heaters in high-bay areas	140.6	531	10,313	18.0	0.6
S1680	17	Infrared heaters in high-bay areas	241.6	577	10,530	20.3	0.6
P501A	9	Replace windows with energy efficient windows -grey glass	33.0	213	42,361	24.2	0.6
P501A	9	Replace windows with energy efficient windows -clear glass	33.0	213	39,008	26.9	0.6
S1790	10	Install instantaneous DHW heaters	28.9	53	2,334	49.2	0.4
P1751	10	Install instantaneous DHW heaters	21.2	39	2,324	67.3	0.3
P1506	10	Install instantaneous DHW heaters	86.3	106	9,176	96.4	0.3
P1512	10	Install instantaneous DHW heaters	37.4	72	8,458	131.8	0.2
P1830	4	Lower ceiling	66.9	114	93,109	124.9	0.1
P124	9	Replace windows with energy efficient windows	312.4	764	102,092	149.0	0.1
P501B	9	Replace windows with energy efficient windows -clear glass	69.0	160	27,507	154.4	0.1
P129	9	Replace windows with energy efficient windows	73.4	240	37,866	175.6	0.1
P143	9	Replace windows with energy efficient windows	73.4	240	37,866	175.6	0.1
P128	9	Replace windows with energy efficient windows	135.9	402	72,187	200.1	0.1
P153	10	Install instantaneous DHW heaters	10.1	11	2,314	243.1	0.1

**TABLE ES-3
NONRECOMMENDED GENERAL ECOs (Concluded)**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
S1753	10	Install instantaneous DHW heaters	9.7	10	2,314	251.2	0.1
P100	9	Replace windows with energy efficient windows	188.2	251	57,602	256.3	0.1
P102	9	Replace windows with energy efficient windows	43.1	101	27,622	305.2	0.1
P504	9	Replace windows with energy efficient windows	46.3	118	32,969	310.4	0.1
P503	9	Replace windows with energy efficient windows	54.9	133	40,750	342.5	0.1
P380	10	Install instantaneous DHW heaters	11.3	21	7,620	400.8	0.1
P1622	10	Install instantaneous DHW heaters	44.2	32	12,378	430.6	0.1
P254	10	Install instantaneous DHW heaters	18.4	10	4,628	529.2	0.1
P1528	10	Install instantaneous DHW heaters	33.3	8	6,234	857.7	0.1
P102	10	Install instantaneous DHW heaters	33.5	10	7,820	891.6	0.1
P124	10	Install instantaneous DHW heaters	36.1	19	16,158	927.4	0.1
P260	10	Install instantaneous DHW heaters	11.9	3	3,830	1382.8	0.1
P1794	10	Install instantaneous DHW heaters	13.6	10	12,374	1410.7	0.1
P300	10	Install instantaneous DHW heaters	78.7	14	20,826	1704.1	0.1
P1624	10	Install instantaneous DHW heaters	39.3	2	10,892	7394.5	0.1
P1504	10	Install instantaneous DHW heaters	27.7	(4)	3,830	N/A	N/A
P464	10	Install instantaneous DHW heaters	9.0	(8)	4,588	N/A	N/A
S1558	10	Install instantaneous DHW heaters	15.2	(13)	7,666	N/A	N/A
P1530	10	Install instantaneous DHW heaters	45.6	(47)	12,408	N/A	N/A
P1526	10	Install instantaneous DHW heaters	7.0	(51)	6,104	N/A	N/A
P1621	10	Install instantaneous DHW heaters	212.0	(1,210)	2,314	N/A	N/A

BUILDING P300: RANGE CONTROL

The following ECOs were designated in the Scope of Work for P300:

1. Use more efficient lighting fixtures.
2. Reduce lighting levels.
3. Use recovered waste heat.
4. Use dry bulb economizers.
5. Reduce outside air quantities.
6. Use thermal storage for demand reduction.
7. Convert constant volume air handlers to variable air volume.
8. Consolidate multiple air-cooled chillers onto two high-efficiency, water-cooled centrifugal chillers.

ECO #2 was not evaluated because lighting energy conservation is widely practiced in the building. ECO #5 was not evaluated because makeup air is currently a fixed rate that is in compliance with ventilation standards.

Tables ES-4 and ES-5 present the results of the evaluated ECOs.

**TABLE ES-4
RECOMMENDED ECOs, P300**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Total Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P300	6	Thermal storage	(224.3)	40,285	165,000	4.6	3.3
P300	8	Convert existing chiller plant to consolidated chiller plant	635.0	4,112	56,100	5.2	2.9
P300	1	Replace lighting fixtures with efficient fixtures, lamps, & ballasts	190.0	1,305	38,783	6.0	2.5
P300	7	Convert existing AHUs to variable-air-volume	4877.6	28,301	268,913	6.0	1.8

**TABLE ES-5
NONRECOMMENDED ECOS**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Total Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P300	3	Waste heat recovery from chiller plant	2607.8	7375	91,996	7.4	2.2
P300	4	Dry bulb economizers on AHUs	(798)	3,970	149,536	14.9	0.7

BUILDING ENERGY SURVEYS

Complete energy surveys were performed at Buildings P21140, Temperature Test Facility, P21695, Special Weapons Assembly Building (SWAB), and P24072, Helicopter Drone Maintenance Facility.

The TRACE 600 program was used to model the existing building baseline and ECO configurations. Each of these buildings was constructed as a special use facility, and applicable ECOs are very limited.

Table ES-6 presents baseline energy consumption data, and Tables ES-7 and ES-8 present ECO evaluation results.

**TABLE ES-6
BASELINE ENERGY DATA**

Building	Annual Energy Consumption			Specific (Btu/SF)
	Elec. (kWh)	Elec. Demand (kW)	Gas (MBtu)	
P21140 (no temperature test energy use included)	458,686	94	0	66,250
P21695	252,112	81.3	869.6	99,147
P24072	452,691	61.9	(Propane) 659.0	61,989

TABLE ES-7
RECOMMENDED ECOs, P21140, P21695, P24072

Bldg. No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P21695	Setback/thermostats	517.4	1,675	136	0.1	128.0
P24072	Modify HVAC Controls	359.2	2,366	2,016	0.7	16.6
P24072	Replace lighting fixtures with efficient fixtures, lamps & ballasts; disconnect lighting in non-use areas	376.8	2,361	11,338	1.9	6.9
P21140	Replace lighting fixtures with efficient fixtures, lamps & ballasts	1.1	7.3	281	7.4	2.0
P21695	Replace lighting fixtures with efficient fixtures, lamps & ballasts	6.4	90	4,259	8.2	1.8
21140	Reduce stratification	12.8	234	4,077	13.6	1.1

TABLE ES-8
NONRECOMMENDED ECOs, P21140, P21695, 24072

Bldg. No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P24072	Dry-bulb economizer on AHU	10.2	66.2	2,047	21.7	0.5
P21695	Replace windows with energy efficient windows	6.0	29.0	5,107	83.0	0.2
P21695	Dry-bulb economizer on AHU	0.6	5.0	997	242	0.1

LAUNCH COMPLEX 38

The chilled water plant located in P24066 was surveyed to determine the feasibility of refurbishing the plant and using it to supply P24072, P23638, P23640, and P23642 in Launch Complex 38. It was determined that the condenser water side of the plant is too deteriorated to refurbish and the two 550-ton chillers are much too large in capacity to efficiently supply the load on the four buildings. While, P24066 is adjacent to P24072, it is a mile away from the other three buildings. Piping costs are prohibitive.

Four chilled water (CW) plant alternatives were identified and evaluated:

- Alt. #1A: Install a CW plant near P23638 with air-cooled chillers to supply the four buildings.
- Alt. #1B: Install a CW plant near P23638 with water-cooled chillers to serve the four buildings.
- Alt. #2A: Install CW plant near P23642 with air-cooled chillers to serve P23638, P23640, and P23642. Use the existing air-cooled chillers at P24072 to serve that building.
- Alt. #2B: The same as for Alt. #2A except use water-cooled chillers in the new plant.

The results are shown in Table ES-9.

**TABLE ES-9
SUMMARY OF ECOs, LC38**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
LC38 Chiller Plant Study	Alt #2B	130-ton water-cooled chiller plant	4,161	26,966	367,262	7.8	2.2
LC38 Chiller Plant Study	Alt #2A	140-ton air-cooled chiller plant	3,974	25,751	325,091	9.4	1.9
	Alt #1A	200-ton air-cooled chiller plant	4,505	29,190	371,979	11.5	1.6
	Alt #1B	150-ton water-cooled chiller plant	4,691	30,398	703,072	15.8	1.1

At the time of the interim report presentation and review conference (May 28, 1992), it was learned that new air-cooled chillers have been installed at P23640. Also, a work order for new air-cooled chillers for P23638 has been requested. As a result, it is not feasible to proceed with any of the 4 alternatives considered, and none is recommended for implementation.

CONTRACTOR-IDENTIFIED ECOs

Buildings P23640 and P23642 were constructed as special purpose mission support buildings for the Nike Zeus program, which was discontinued about 30 years ago. The buildings are currently used to support new missions, totally incompatible with the original building designs. Several ECOs at each building were identified that potentially would save energy and correct severe building discrepancies for the current occupants.

In the case of both buildings, a modified configuration consisting of several ECOs was evaluated and compared to the baseline configuration.

Modified Configurations

P23640:

- Upgrade AHU-2 by installing a chilled water coil, repairing the makeup air damper actuator, and installing a dry bulb economizer control.
- Replace the fan motor on AHU-1 with a high efficiency motor and reduce supply airflow rate to 1.5 cfm/SF.

- Optimize the supply air temperature setpoint on AHU-1 and AHU-2.
- Install a 6°F chilled water setpoint reset on the two 50 ton chillers and control the returned chilled water to 55°F.
- Replace standard fluorescent lamps and ballasts with low wattage lamps and ballasts.

P23642:

- Replace standard fluorescent lamps and ballasts with low wattage lamps and ballasts.
- Reduce supply cfm on all 3 AHUs.
- Install dry bulb economizers on all 3 AHUs.
- Replace fan motors on all AHUs with smaller, high efficiency motors.

Results: The baseline and modified configuration were evaluated for each building using the TRACE 600 program. The results for the modified configurations are shown in Table ES-10 below.

**TABLE ES-10
RECOMMENDED ECOs, P23640, P23642**

Bldg. No.	Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P23640	Modified configuration	1,065	6,938	15,025	1.1	10.2
P23642	Modified configuration	171	1,104	24,053	4.3	2.5

DEMAND SIDE MANAGEMENT (DSM)

Copies of El Paso Electric Utility demand meter records for January, July, and October for 1989, 1990 and 1991 were analyzed, and measures to reduce and control on peak electrical demand were recommended.

Typical Demand Profiles: The following data characterize typical workday and nonworkday electrical demand profiles at the Main Post Area. On peak refers to the period from 0730 hours to 1630 hours, and off peak to the rest of the day. The demand kW values shown are nominal maximums.

Workdays	Offpeak kW	On Peak kW	Rise kW
January 1991	5,000	7,800	2,800
July 1991	6,000	11,700	5,700
October 1991	5,000	8,500	3,700
Nonworkdays			
January 1991	5,500	5,300	-200
July 1991	6,000	6,700	700
October 1991	4,800	5,500	700

The average El Paso Electric Company peak demand for WSMR is 10,150 kW, and is referred to as the conjunctive peak. It is the sum of peak kW readings recorded at each of the six substations corresponding to the date and time of the highest monthly demand registered. Usually the peak demand occurs at the time the Main Post substation peaks. Note that the Main Post Area peak demand occurs in July, and is nominally 11,700 kW, or about two-thirds of the conjunctive peak. The demand profiles at the other 5 substations are relatively flat, so the opportunities for DSM exist primarily at the Main Post Area.

DSM Opportunities: The significant opportunities to reduce peak electrical demand are shown in the matrix below. The electric service contract contains no demand ratchet clause, which increases opportunities for reducing demand charges.

<u>Opportunity</u>	<u>Priority</u>	<u>Annual Dollars Saved (\$/kW)</u>
Install efficient lighting systems	High	427.60
Thermal storage for chillers	Medium	234.00
Reduce excessive supply airflows	Medium	234.00
Install high efficiency motors	Low	427.60
Convert AHUs to VAV	High	234 to 427.60

At the time of this report submittal, the only DSM rebate available from El Paso Electric Company is \$190.00 per kW of shifted load, which applies only to thermal storage.

CONSOLIDATED CHILLED WATER PLANT TO SERVE THE TECH AREA

General: Nine buildings in the Tech Area have chilled water systems, and there is a continuous chilled water load in a few buildings. It is necessary to operate some chillers all year long. Most of the existing refrigeration units are air-cooled cold generators and are quite inefficient in hot ambient temperature conditions. Four consolidated chilled water plant alternatives were evaluated, each using water-cooled equipment.

- Alt. #1: Consolidated chilled water plant without chilled water thermal storage.
- Alt. #2: Same as Alt. #1 but with chilled water thermal storage.
- Alt. #3: Cogeneration plant with gas turbine-generator set, steam driven rotary chillers, and heat recovery steam generator.
- Alt. #4: Same as Alt. #3 except the chillers are steam powered double effect absorption chillers.

Each alternative includes a chilled water loop to serve the nine buildings, sized for the summer peak load. Alt. #3 and Alt. #4 include a steam and condensate loop that serves all heated buildings in the Tech Area.

Table ES-11 presents the results. None of the alternatives qualifies for implementation under the ECIP guidelines.

**TABLE ES-11
NONRECOMMENDED ECOs, TECH AREA**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$1,000)	SPB (yrs)	SIR
Technical Area Chiller Plant Study	Alt. #1	Consolidated chiller plant w/o thermal storage	7,654	49,559	1,681	N/A	0.53
	Alt. #2	Consolidated chiller plant w/chilled water storage	7,410	47,981	2,378	N/A	0.37
	Alt. #3	Cogeneration plant w/steam turbine-driven chillers	(54,001)	(93,273)	4,814	142	0.01
	Alt. #4	Cogeneration plant w/absorption chillers	(45,646)	(50,767)	4,592	114	0.04

The recommended solution for the Tech Area chilled water systems is to continue to use the existing air-cooled chillers, but to install precoolers on each air-cooled chiller. This will reduce the kW demand somewhat, and will conserve electrical energy. Replacement with water-cooled equipment would provide better demand reduction, but would significantly increase maintenance and saving requirements, is is therefore not recommended.

IDENTIFIED ENERGY RETROFIT PROJECTS

Four buildings were identified for energy retrofit projects:

- No. 1 Modifications to P300 to include:
- convert air handlers to VAV
 - replace one air-cooled chiller with a water-cooled unit
 - replace all standard 40 watt fluorescent lamps and standard ballasts with reduced wattage lamps and ballasts
 - install a chilled water thermal storage system
- No. 2 Modifications to P24072 to include:
- improved fluorescent lighting system
 - setback thermostat
 - install cooling coil control valve
- No. 3 Modifications to P23640 to include:
- improved fluorescent lighting
 - modifications to both air handlers
- No. 4 Modifications to P23642 to include:
- improved fluorescent lighting
 - modifications to three air handlers

Project energy savings and economic parameters are presented in Table ES-12.

**TABLE ES-12
DATA SUMMARY FOR ENERGY PROJECTS**

Bldg. No.	Project Description	Construction Cost (\$)	Funding Authority	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	SPB (yrs)	SIR
P300	Modified configuration	446,296	ECIP	5,488	32,367	4.7	2.3
P24072	Improve fluorescent lighting, setback thermostat, install cooling coil control valve	13,355	OMA & unit funds	8,662.4	5,741	1.5	7.3
P23640	Improve fluorescent lighting, modify both AHUs	15,025	OMA & unit funds	1,064.7	6,938	1.1	10.2
P23642	Improve fluorescent lighting, modify 3 AHUs to reduce air flow	24,053	OMA & unit funds	171.5	1,103	4.3	2.5

sub-total	15,506	40,408
O & M, P2 ES-4	2,985.6	8,935
Total	18,371.2	49,343