

ENERGY ENGINEERING ANALYSIS PROGRAM  
REDSTONE ARSENAL, ALABAMA  
ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS

FINAL REPORT

JUNE, 1987

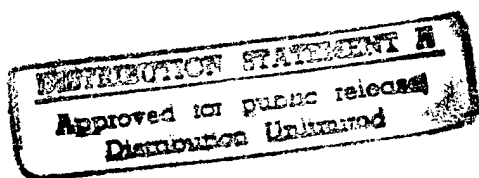
VOLUME I - EXECUTIVE SUMMARY

Prepared for

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By

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BENATECH, INC.

*Engineering & Energy Consultants*

1215 HIGHTOWER TRAIL

SUITE D-220

ATLANTA, GEORGIA 30350

ARMY CONTRACT NO. DACA01-85-C-0131,

PART I & II DTIC QUALITY INSPECTED 3



DEPARTMENT OF THE ARMY  
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## 1. INTRODUCTION

### 1.1 BACKGROUND

This report is the prefinal report of an Energy Engineering Analysis Program (EEAP) study of boilers and chillers at Redstone Arsenal, Huntsville, Alabama. Work was begun January, 1986 on the project by BENATECH, INC. under Contract No. DACA01-85-C-0131, Parts I and II, with the Mobile District, U.S. Army Corps of Engineers, Mobile, Alabama. The following activities have been accomplished:

- A detailed field investigation has been conducted.
- ECO calculations have been performed and ECIP analyses have been accomplished.
- Interim Report has been submitted.
- Low Cost/No Cost project documentation packages have been compiled.
- Prefinal Report is complete and submitted for review.

### 1.2 SCOPE

The Scope of Work specified in contract no. DACA01-85-C-0131, Parts I and II (and included in this report in Appendix A) requires the performance of a specific energy study. The Energy Conservation Opportunities analyzed under this study will serve as part of Redstone Arsenal's overall effort to reduce basewide energy use in accordance with the objectives set forth in the Army Energy Plan. The contract Scope of Work (SOW) for Redstone Arsenal outlines the following specific requirements:

- Determine the efficiency of the boiler/chiller plants by appropriate tests.
- Survey the boiler/chiller plants to determine if efficiency can be improved by the repair, addition, or modification of equipment and recommend improvements.
- Evaluate the control system and recommend changes, repairs, or new controls which will improve the efficiency of the plant.
- Review operation and maintenance procedures and provide site-specific recommendations which will increase the efficiency of the plants to the maximum level.
- Prepare a comprehensive report to document the work performed, the

results, and recommendations.

All of these Scope of Work items have been accomplished.

## 2. ENERGY CONSERVATION OPPORTUNITIES (ECOs)

### 2.1 TECHNICAL APPROACH

The Scope of Work contains a list of specific ECOs to be studied for Redstone Arsenal Boilers and Chillers. These ECOs were investigated after completing our field survey visits and compiling the raw data from the visits. The steps in collecting the field data are:

- Obtain nameplate data and methods of operation for the boilers and chillers.
- Inspect types and conditions of control systems.
- Take field measurements on boilers and chillers.

Using the field data, the various ECOs were analyzed for their feasibility of being enacted under Army guidelines.

### 2.2 ECOs ANALYSES

#### 2.2.1 BOILERS

##### Boiler Feedwater Economizer.

This ECO investigates the energy savings achievable by preheating the boiler feedwater with recovered waste heat from the flue gas. Borosilicate heat exchangers are used so that potential corrosion problems are reduced in the temperature range between 100 F - 150 F. Feedwater economizers already exist in Building 3624, although these devices were inoperable when the boilers were surveyed.

##### Burner Replacement.

This ECO analyzes the energy savings achievable by replacing existing burners with modulating, cam-type burners. These burners modulate the air-to-fuel ratio as a function of boiler load. This modulation results in a combustion efficiency of approximately 80% over the operating range of the boiler. This ECO is not applicable to boilers in Buildings 3624 and 4725 which already employ modulating burners.

in the temperature range between 100 F - 150 F. Feedwater economizers already exist in Building 3624, although these devices were inoperable when the boilers were surveyed.

#### Boiler Tune-Up.

This ECO evaluates the potential for energy savings by performing semi-annual boiler tune-ups. The boilers should be tuned for minimum excess air at their respective average operating loads. A well-tuned boiler operates at its peak combustion efficiency at the load for which it is tuned.

#### Preheat Combustion Air.

The purpose of this ECO is to use waste heat recovered from the flue gas in order to preheat combustion air. Boiler efficiency can be improved by implementing this technique. For this ECO, improved combustion efficiencies are calculated using the higher preheated inlet air temperature; however, all other test conditions remain the same as the existing test conditions. Preheaters already exist in Building 4725. Borosilicate heat exchangers are used so that corrosion problems are reduced in the temperature range between 100 F - 150 F.

#### "Summer" Boiler.

This ECO analyzes the potential of installing a boiler to handle the steam production requirements during the "summer" months. The boiler fuel consumption and operating logs were examined to isolate the steam capacity requirements for each month. It was determined that during the period of May 16 - October 15, the boiler demands were at their minimum levels. The "summer" boilers were then sized to meet these average summer loads. The energy savings are realized in the increased efficiency of the new boilers (approximately 80%) as compared with the underloaded (in summer operation) existing boilers.

#### Variable-Speed Motor Drives.

This ECO analyzes the potential for savings by installing inverters on combustion air fan motors. Inverters save energy by controlling the fan power in response to actual air flow requirements.

### Boiler Replacement.

This ECO evaluates the savings to be achieved by replacing the existing boiler with a new, 80% efficient boiler of the same size.

### Downsize Boilers.

This ECO analyzes the energy savings that could be achieved by installing smaller boilers designed to meet the average operating load of the boiler plant. This ECO is applicable to boiler plants which are operating in underloaded conditions. The savings to be realized result from the increased efficiencies (approximately 80%) of the new boilers as compared with the existing underloaded boilers.

### Installation of Turbulators.

This ECO analyzes the energy savings achievable by installing turbulators in fire-tube boilers. Turbulators are baffles which create turbulent flow in the core of hot combustion gases. This turbulent flow maximizes heat transfer from combustion gases through the tube walls to the boiler water. Thus, more heat is used in the generation of steam and less is lost out the exhaust stack. Fuel savings of 1% can be achieved by installing turbulators in fire-tube boilers. This ECO is not applicable to water-tube boilers. The use of Fuel Efficiency, Inc. information does not constitute an endorsement of their product, but merely an actual representation of achievable performance levels.

### Oxygen Trim System.

The purpose of an oxygen trim system is to control the air/fuel ratio of a boiler within the most efficient operating parameters. This is achieved by using an oxygen analyzer in the flue stack in conjunction with a microprocessor controller. The oxygen analyzer measures the oxygen content in the flue gas, and a potentiometer monitors the fuel flow rate. The microprocessor controls adjust the air flow damper in order to get the most efficient combustion process. The use of Westinghouse "Veritrim" oxygen analyzer and control information does not constitute an endorsement of their product, but merely an actual representation of achievable performance levels.

### Steel Feedwater Economizer.

This ECO investigates the energy savings achievable by preheating the boiler feedwater with recovered waste heat from the flue gas. Alloy steel heat exchangers are used so that potential corrosion problems are reduced



## 2.2.2 CHILLERS

### Automatic Chiller Tube Cleaning.

This ECO establishes representative savings which result from the installation of an on-line condenser tube cleaning system. This system uses slightly oversized brushes fitted into each condenser tube to remove rust and deposits. The brushing action is initiated by a diverter valve, which changes the direction of water flow, pushing the brushes to either end of the condenser. Flow through the condenser automatically changes. Savings result from improved heat transfer from the condenser water through the condenser tube wall. The savings were calculated using manufacturers' data. The use of Water Services of America and ATB information does not constitute an endorsement of their product, but merely an actual representation of achievable performance levels.

### Condenser Tube Cleaning.

This ECO analyzes the potential for savings by manually cleaning condenser tubes. This operation reduces the tube fouling factor to its minimum achievable value. Reduced fouling factor results in increased heat transfer capabilities of the system, and consequently less energy is required to achieve the same cooling capacity.

### Chiller Shutdown.

This ECO analyzes the energy savings achievable when equipment is operated only when it is needed to provide comfort conditioning. The savings are calculated for chillers (partially loaded), chilled water and condenser water pumps, and the cooling tower. No credit is taken for reheating or air handling savings which will also result. The methodology used to calculate the savings is shown in "Standardized EMCS Energy Savings Calculations", CR 82.030, September 1982.

### Chilled Water Temperature Reset.

This ECO analyzes the energy savings resulting from resetting the chilled water supply temperature upward, without appreciably affecting comfort conditions. Savings result from decreasing the demand on the chiller compressor, and therefore, the amount of energy input to the chiller. The methodology used to calculate the savings is shown in the "Standardized EMCS Energy Savings Calculations", CR 82.030, September 1982.

### Water Treatment/Fill Replacement

This ECO analyzes the energy savings resulting from maximizing cooling tower performance. Water treatment and replacement of cooling tower fill are offered as one composite ECO, because one recommendation will improve and maintain the savings of the other. Considered separately, neither will offer long term savings. Replacing deteriorated cooling tower fill PVC polymer will ensure that the condenser water will flow through the cooling tower and achieve even distribution and maximum heat transfer with the air. Introduction of water treatment will maintain the desirable effects of the new fill, but will offer no improvement with the existing cooling tower fill. The reduction in condenser water supply temperature will result in reduced compressor load. The methodology used is similar to Chilled Water Temperature Reset. ECO's are presented for the buildings with the highest SIRs. The methodology used to calculate the savings is shown in the "Standardized EMCS Energy Savings Calculations", CR82.030, September 1982.

### Waterside Economizer

This ECO evaluates the feasibility of installing a plate heat exchanger, new valves and controls to enable the chiller to be shutdown during periods of the year when the wet bulb temperatures will provide sufficient evaporative cooling effect. Building load fluctuates with internal and external loads. During the fall, winter, and spring, the external cooling loads on a building are at a minimum. During these seasons, the wet bulb temperatures are low enough to maintain evaporation in sufficient quantity to provide condenser water cold enough to meet the internal loads of the building. The analysis utilizes cooling tower performance data used to determine the expected cooling tower water temperatures for a given wet bulb temperature. It was recommended by plate heat exchanger sales representative (for analysis purposes) to use a heat exchanger with a four degree approach temperature because it is less expensive. It was assumed that the building loads could be adequately met with chilled water supply temperatures between 48 and 44 degrees F. In addition, the cooling tower is assumed to cycle half the time for all those hours when the cooling tower is less than 40 degrees F. The cooling tower will cycle off and on to prevent the cooling tower from freezing. This bin hour calculation determines the electrical savings resulting from shutting down the chiller (partially loaded) and the cooling tower when it is possible to do so. The

methodology used to calculate the savings is shown in "Standardized EMCS Energy Savings Calculations", CR 82.030, September 1982. The use of Marley and Mueller manufacturer's data does not constitute an endorsement of their product but merely an actual representation of achievable performance levels.

#### Variable Speed Pumping

This ECO analyzes the energy savings potential of installing variable speed pumping (accomplished with the installation of a variable frequency drive) in place of the existing constant speed pumping. Included with the installation of a variable speed drive is the replacement of all three-way valves with two-way valves and a differential pressure control system. Electrical energy is saved when the amount of energy devoted to pumping chilled water is varied as the cooling load on the building. It was assumed that the pump speed is proportional to the building load. The power required to operate the pump varies as the cube of the speed. Savings are determined by calculating the energy required for constant speed pumping and subtracting the energy necessary to operate the variable speed pump. The methodology used to calculate the savings is shown in ASHRAE Equipment 1983.

#### Two Speed Cooling Tower Fans

This ECO examines the energy savings resulting from replacing the constant speed cooling tower fan motor with a two speed motor. Savings result from the fan law which states that the power required to operate a fan varies as the cube of the fan speed. The methodology used to calculate the savings is shown in "Heating, Ventilating and Air Conditioning", Parker and McQuistone, 1982.

### 3. RESULTS, CONCLUSIONS AND RECOMMENDATIONS

#### 3.1 RESULTS

A complete listing of all Boiler ECO's and OMR's is provided in Table ES 1. This is sorted by SIR. A similar list for all Chiller ECOs and OMRs is shown in Table ES 2, sorted according to SIR.

All ECOs with SIRs greater than 1.0 were considered for project packaging.

#### 3.2 CONCLUSIONS

Candidate ECOs for project packaging are show in Table ES 3 and ES 4. Both tables are sorted by Boiler/Chiller number and descending SIR for each boiler or chiller. RENATECH combined ECOs into projects to be implemented on a per boiler/chiller basis. This strategy allows for projects with low construction costs to be funded on a local level.

For a given boiler of chiller, some of the recommended ECOs were mutually exclusive. An example of two mutually exclusive ECOs are "Preheat Combustion Air" and "Steel Feedwater Economizer". Both of these ECOs function to recover waste heat from boiler exhaust gases. In a case where two ECOs indpendently have SIRs greater than 1.0, but are mutually exclusive, BENATECH used good engineering judgement to select the ECO yielding maximum energy savings.

Project synergy calculations between candidate boiler ECOs begins with the average boiler load (MBTU). Each "Step" is explained below:

**Step 1.** Calculations start with the determination of the Annual Savings. Annual savings are calculated in one of three ways:

- a.) For ECOs where a nominal percentage reduction of energy consumption is known, the annual savings are calculated as shown below:

$$(\% \text{ reduction})(\text{average boiler load}) = \text{Annual Savings (MBTU/yr.)}$$

Applicable ECOs: Turbulators

b.) In the cases where the expected boiler efficiency is used to calculate the annual savings as shown below:

$$\begin{aligned} & (\text{average boiler load}) [ 1 - (\text{average boiler eff.}/\text{expected boiler eff.}) ] \\ & = \text{Annual Savings (MBTU/yr.)} \end{aligned}$$

Applicable ECOs: Burner Replacement

c.) In the case of recommendation swher the consumption reduction is calculated in the ECO, the annual savings equals the expected consumption reduction.

Applicable ECOs: Summer Boiler, Boiler Tune-up

Second, the Annual Fuel Consumption is calculated by subtracting the annual savings from the average boiler load.

Third, the Boiler Efficiency is recalculated using the following formula:

$$(\text{average boiler efficiency})/[1-(\text{annual savings}/\text{average boiler load})]$$

**Step 2, Step 3.** The calculations for these steps are performed iteratively based on the number of analytical **Steps** in the project.

Per guidance received in the Prefinal Review Meeting, several ECOs identified by BENATECH had already been implemented, are currently in progress, or already have programming documentation in place. Given this information, BENATECH prepared low cost/no cost project documentation for all remaining recommended ECOs.

TABLE ES 1 - BOILER ECOs EVALUATED SORTED BY SIR

| ECO                        | Boiler No. | Life (YRS) | MBTUs Saved |                |              | Annual Savings | Cost Estimate | SIR     | Simple Payback (Years) |
|----------------------------|------------|------------|-------------|----------------|--------------|----------------|---------------|---------|------------------------|
|                            |            |            | Elec. MBTUs | Nat. Gas MBTUs | #2 Oil MBTUs |                |               |         |                        |
| Boiler Tune-Up OMR         | 4725       | -3         | 15          | 57931          |              | \$251,998      | \$2,705       | 1341.68 | 0                      |
| Boiler Tune-Up OMR         | 3624       | -4         | 10          | 34338          |              | \$149,372      | \$2,705       | 518.52  | 0                      |
| Boiler Tune-Up OMR         | 4725       | -2         | 15          | 21293          |              | \$92,626       | \$2,705       | 495.49  | 0                      |
| Boiler Tune-Up OMR         | 3624       | -3         | 10          | 8599           |              | \$37,407       | \$2,705       | 124.60  | 0                      |
| Boiler Tune-Up OMR         | 4725       | -1         | 15          | 1945           |              | \$8,460        | \$2,705       | 36.27   | 0                      |
| Boiler Tune-Up OMR         | 3624       | -1         | 10          | 2449           |              | \$10,655       | \$2,705       | 30.48   | 0                      |
| Boiler Tune-Up OMR         | 8977       | -1         | 10          | 1965           |              | \$8,548        | \$2,705       | 23.08   | 0                      |
| Boiler Tune-Up OMR         | 115        | -2         | 25          | 903            |              | \$3,927        | \$2,705       | 21.18   | 1                      |
| Boiler Tune-Up OMR         | 8028       | -2         | 25          |                | 529          | \$3,125        | \$2,705       | 19.21   | 1                      |
| Turbulator Installation    | 8028       | -2         | 25          |                | 98           | \$579          | \$861         | 12.43   | 1                      |
| Turbulator Installation    | 115        | -2         | 25          | 120            |              | \$522          | \$1,295       | 9.10    | 3                      |
| Burner Replacement         | 115        | -2         | 25          | 977            |              | \$4,248        | \$11,622      | 8.26    | 3                      |
| Turbulator Installation    | 7579       | -1         | 10          | 156            |              | \$679          | \$861         | 7.50    | 1                      |
| Boiler Tune-Up OMR         | 7105       | -4         | 10          | 925            |              | \$4,025        | \$2,705       | 7.16    | 1                      |
| Turbulator Installation    | 8874       | -1         | 15          |                | 49           | \$290          | \$518         | 6.82    | 2                      |
| Turbulator Installation    | 7153       | -1         | 5           | 82             |              | \$357          | \$287         | 5.64    | 1                      |
| Oxygen Trim System         | 8028       | -2         | 25          |                | 853          | \$5,041        | \$16,420      | 5.49    | 3                      |
| Boiler Tune-Up OMR         | 3624       | -2         | 10          | 748            |              | \$3,254        | \$2,705       | 4.45    | 1                      |
| Turbulator Installation    | 7105       | -3         | 25          | 69             |              | \$300          | \$1,723       | 3.93    | 6                      |
| Turbulator Installation    | 8874       | -2         | 15          |                | 28           | \$165          | \$518         | 3.90    | 3                      |
| Burner Replacement         | 7579       | -1         | 10          | 858            |              | \$3,734        | \$10,319      | 3.44    | 3                      |
| Downsize Boiler            | 115        | -2         | 25          | 1,488          |              | \$6,475        | \$45,285      | 3.23    | 7                      |
| Burner Replacement         | 8977       | -1         | 10          | 749            |              | \$3,257        | \$10,319      | 3.00    | 3                      |
| Burner Replacement         | 7105       | -3         | 25          | 413            |              | \$1,795        | \$13,575      | 2.99    | 8                      |
| Burner Replacement         | 8874       | -1         | 15          |                | 319          | \$1,882        | \$9,017       | 2.55    | 5                      |
| Turbulator Installation    | 8977       | -1         | 10          | 52             |              | \$226          | \$861         | 2.50    | 4                      |
| Summer Boilers             | 115        | -2         | 25          | 559            |              | \$2,430        | \$25,478      | 2.16    | 11                     |
| Turbulator Installation    | 7105       | -4         | 10          | 86             |              | \$374          | \$1,723       | 2.07    | 5                      |
| Downsize Boiler            | 7105       | -3         | 25          | 774            |              | \$3,368        | \$40,907      | 1.86    | 12                     |
| Turbulator Installation    | 8977       | -2         | 10          | 38             |              | \$165          | \$861         | 1.83    | 5                      |
| Boiler Replacement         | 115        | -2         | 25          | 977            |              | \$4,248        | \$55,905      | 1.72    | 13                     |
| Burner Replacement         | 8874       | -2         | 15          |                | 200          | \$1,182        | \$9,017       | 1.60    | 8                      |
| Turbulator Installation    | 7579       | -2         | 10          | 33             |              | \$144          | \$861         | 1.59    | 6                      |
| Burner Replacement         | 7770       | -2         | 10          | 345            |              | \$1,499        | \$10,319      | 1.38    | 7                      |
| Burner Replacement         | 7770       | -1         | 10          | 344            |              | \$1,497        | \$10,319      | 1.38    | 7                      |
| Oxygen Trim System         | 115        | -2         | 25          | 238            |              | \$1,037        | \$16,420      | 1.24    | 16                     |
| Burner Replacement         | 8977       | -2         | 10          | 303            |              | \$1,317        | \$10,319      | 1.22    | 8                      |
| Preheat Combustion Air     | 115        | -2         | 25          | 580            |              | \$2,523        | \$46,257      | 1.16    | 18                     |
| Steel Feedwater Economizer | 115        | -2         | 25          | 306            |              | \$1,331        | \$23,496      | 1.15    | 18                     |
| Burner Replacement         | 7579       | -2         | 10          | 283            |              | \$1,232        | \$10,319      | 1.14    | 8                      |
| Steel Feedwater Economizer | 7579       | -1         | 10          | 607            |              | \$2,640        | \$20,862      | 1.12    | 6                      |
| Downsize Boiler            | 7105       | -4         | 10          | 1102           |              | \$4,792        | \$40,907      | 1.12    | 9                      |
| Turbulator Installation    | 8028       | -1         | 10          |                | 39           | \$230          | \$1,723       | 1.12    | 7                      |
| Turbulator Installation    | 7770       | -2         | 10          | 44             |              | \$191          | \$1,723       | 1.06    | 9                      |
| Turbulator Installation    | 7770       | -1         | 10          | 44             |              | \$191          | \$1,723       | 1.06    | 9                      |
| Boiler Tune-Up OMR         | 7153       | -1         | 5           | 705            |              | \$3,067        | \$2,705       | 1.05    | 1                      |
| Summer Boilers             | 7291       | -1         | 15          | 257            |              | \$1,118        | \$16,100      | 1.01    | 14                     |
| Burner Replacement         | 7105       | -4         | 10          | 732            |              | \$3,184        | \$30,026      | 1.01    | 9                      |
| Preheat Combustion Air     | 8028       | -2         | 25          |                | 522          | \$3,085        | \$53,996      | 1.00    | 18                     |
| Downsize Boiler            | 7770       | -1         | 10          | 517            |              | \$2,251        | \$22,041      | 0.97    | 10                     |
| Downsize Boiler            | 7770       | -2         | 10          | 517            |              | \$2,251        | \$22,041      | 0.97    | 10                     |
| Burner Replacement         | 8028       | -1         | 10          |                | 192          | \$1,134        | \$10,319      | 0.92    | 9                      |

TABLE ES 1 - BOILER ECOs EVALUATED SORTED BY SIR

| ECO                         | Boiler No. | Life (YRS) | MTUs Saved |               |             | Annual Savings | Cost Estimate | SIR  | Simple Payback (Years) |
|-----------------------------|------------|------------|------------|---------------|-------------|----------------|---------------|------|------------------------|
|                             |            |            | Elec. MTUs | Nat. Gas MTUs | #2 Oil MTUs |                |               |      |                        |
| Steel Feedwater Economizer  | 7105 -3    | 25         |            | 254           |             | \$1,105        | \$24,773      | 0.88 | 22                     |
| Summer Boilers              | 7855 -1    | 15         |            | 347           |             | \$1,512        | \$25,478      | 0.86 | 17                     |
| Oxygen Trim System          | 7105 -3    | 25         |            | 172           |             | \$748          | \$16,420      | 0.84 | 22                     |
| Boiler Feedwater Economizer | 7579 -1    | 10         |            | 1054          |             | \$4,585        | \$51,720      | 0.81 | 11                     |
| Turbulator Installation     | 7105 -2    | 5          |            | 34            |             | \$148          | \$862         | 0.78 | 6                      |
| Turbulator Installation     | 7105 -1    | 5          |            | 34            |             | \$148          | \$862         | 0.78 | 6                      |
| Boiler Replacement          | 7579 -1    | 10         |            | 858           |             | \$3,734        | \$45,285      | 0.78 | 12                     |
| Boiler Feedwater Economizer | 115 -2     | 25         |            | 472           |             | \$2,053        | \$58,185      | 0.74 | 28                     |
| Boiler Tune-Up OMR          | 7105 -1    | 5          |            | 660           |             | \$2,872        | \$2,705       | 0.73 | 1                      |
| Steel Feedwater Economizer  | 8028 -2    | 25         |            |               | 168         | \$993          | \$20,862      | 0.73 | 21                     |
| Summer Boilers              | 7579 -1    | 10         |            | 441           |             | \$1,917        | \$25,478      | 0.72 | 13                     |
| Preheat Combustion Air      | 7579 -1    | 10         |            | 724           |             | \$3,149        | \$41,117      | 0.68 | 13                     |
| Burner Replacement          | 7153 -1    | 5          |            | 346           |             | \$1,506        | \$10,319      | 0.66 | 7                      |
| Boiler Feedwater Economizer | 7105 -3    | 25         |            | 440           |             | \$1,914        | \$61,418      | 0.65 | 32                     |
| Oxygen Trim System          | 7579 -1    | 10         |            | 295           |             | \$1,285        | \$16,420      | 0.63 | 13                     |
| Summer Boilers              | 8874 -1    | 15         |            |               | 140         | \$827          | \$16,100      | 0.63 | 20                     |
| Oxygen Trim System          | 8874 -1    | 15         |            |               | 174         | \$1,028        | \$16,420      | 0.62 | 16                     |
| Preheat Combustion Air      | 7105 -3    | 25         |            | 337           |             | \$1,466        | \$48,827      | 0.61 | 33                     |
| Burner Replacement          | 7105 -1    | 5          |            | 314           |             | \$1,365        | \$10,319      | 0.60 | 8                      |
| Burner Replacement          | 7105 -2    | 5          |            | 314           |             | \$1,365        | \$10,319      | 0.60 | 8                      |
| Variable-Speed Fans         | 4725 -4    | 15         | 1518       |               |             | \$5,644        | \$86,064      | 0.59 | 15                     |
| Downsize Boiler             | 7105 -2    | 5          |            | 1177          |             | \$5,122        | \$40,907      | 0.57 | 8                      |
| Downsize Boiler             | 7105 -1    | 5          |            | 1177          |             | \$5,122        | \$40,907      | 0.57 | 8                      |
| Boiler Feedwater Economizer | 8028 -2    | 25         |            |               | 365         | \$2,157        | \$67,883      | 0.54 | 31                     |
| Summer Boilers              | 7770 -1    | 10         |            | 238           |             | \$1,033        | \$19,226      | 0.51 | 19                     |
| Steel Feedwater Economizer  | 7105 -4    | 10         |            | 373           |             | \$1,623        | \$27,381      | 0.50 | 17                     |
| Preheat Combustion Air      | 8874 -1    | 15         |            |               | 265         | \$1,566        | \$35,978      | 0.46 | 23                     |
| Boiler Replacement          | 8874 -2    | 15         |            |               | 200         | \$1,182        | \$32,361      | 0.45 | 27                     |
| Oxygen Trim System          | 7105 -4    | 10         |            | 221           |             | \$963          | \$16,420      | 0.44 | 17                     |
| Boiler Feedwater Economizer | 8874 -1    | 15         |            |               | 311         | \$1,838        | \$45,255      | 0.44 | 25                     |
| Steel Feedwater Economizer  | 8874 -1    | 15         |            |               | 137         | \$810          | \$18,254      | 0.41 | 23                     |
| Variable-Speed Fans         | 4725 -3    | 15         | 1032       |               |             | \$3,837        | \$86,064      | 0.40 | 22                     |
| Variable-Speed Fans         | 3624 -4    | 10         | 535        |               |             | \$1,989        | \$34,725      | 0.40 | 17                     |
| Boiler Replacement          | 7105 -4    | 10         |            | 732           |             | \$3,184        | \$77,646      | 0.39 | 24                     |
| Boiler Feedwater Economizer | 7105 -4    | 10         |            | 645           |             | \$2,806        | \$67,883      | 0.37 | 24                     |
| Downsize Boiler             | 7153 -1    | 5          |            | 592           |             | \$2,574        | \$32,361      | 0.36 | 13                     |
| Variable-Speed Fans         | 3624 -2    | 10         | 470        |               |             | \$1,747        | \$34,725      | 0.35 | 20                     |
| Variable-Speed Fans         | 4725 -2    | 15         | 860        |               |             | \$3,197        | \$86,064      | 0.33 | 27                     |
| Steel Feedwater Economizer  | 8977 -1    | 10         |            | 212           |             | \$922          | \$20,862      | 0.33 | 23                     |
| Summer Boilers              | 7153 -1    | 5          |            | 346           |             | \$1,506        | \$22,353      | 0.31 | 15                     |
| Boiler Replacement          | 7770 -1    | 10         |            | 344           |             | \$1,497        | \$45,285      | 0.31 | 30                     |
| Boiler Replacement          | 7770 -2    | 10         |            | 344           |             | \$1,497        | \$45,285      | 0.31 | 30                     |
| Preheat Combustion Air      | 7105 -4    | 10         |            | 431           |             | \$1,875        | \$53,966      | 0.30 | 29                     |
| Oxygen Trim System          | 8874 -2    | 15         |            |               | 100         | \$592          | \$16,420      | 0.29 | 28                     |
| Boiler Feedwater Economizer | 8977 -1    | 10         |            | 367           |             | \$1,596        | \$51,720      | 0.26 | 32                     |
| Boiler Replacement          | 7579 -2    | 10         |            | 283           |             | \$1,232        | \$45,285      | 0.26 | 37                     |
| Variable-Speed Fans         | 3624 -1    | 10         | 338        |               |             | \$1,256        | \$34,725      | 0.25 | 28                     |
| Preheat Combustion Air      | 8874 -2    | 15         |            |               | 152         | \$898          | \$35,978      | 0.24 | 40                     |
| Oxygen Trim System          | 8028 -1    | 10         |            |               | 115         | \$682          | \$16,420      | 0.23 | 24                     |
| Preheat Combustion Air      | 8977 -1    | 10         |            | 267           |             | \$1,161        | \$41,117      | 0.22 | 35                     |
| Variable-Speed Fans         | 3624 -3    | 10         | 299        |               |             | \$1,112        | \$34,725      | 0.22 | 31                     |
| Preheat Combustion Air      | 8028 -1    | 10         |            |               | 216         | \$1,277        | \$41,117      | 0.21 | 32                     |

TABLE ES 1 - BOILER ECOs EVALUATED SORTED BY SIR

| ECO                         | Boiler No. | Life (YRS) | Elec. MBTUs | MBTUs Saved    |              | Annual Savings | Cost Estimate | SIR   | Simple Payback (Years) |
|-----------------------------|------------|------------|-------------|----------------|--------------|----------------|---------------|-------|------------------------|
|                             |            |            |             | Nat. Gas MBTUs | #2 Oil MBTUs |                |               |       |                        |
| Boiler Feedwater Economizer | 8874 -2    | 15         |             |                | 168          | \$993          | \$45,255      | 0.21  | 46                     |
| Boiler Replacement          | 8028 -1    | 10         |             |                | 192          | \$1,134        | \$45,285      | 0.21  | 40                     |
| Oxygen Trim System          | 8977 -1    | 10         |             | 125            |              | \$542          | \$16,420      | 0.20  | 30                     |
| Boiler Replacement          | 8977 -1    | 10         |             | 749            |              | \$3,257        | \$170,520     | 0.18  | 52                     |
| Steel Feedwater Economizer  | 7153 -1    | 5          |             | 194            |              | \$844          | \$15,646      | 0.18  | 19                     |
| Steel Feedwater Economizer  | 7579 -2    | 10         |             | 133            |              | \$579          | \$20,862      | 0.17  | 36                     |
| Downsize Boiler             | 8977 -1    | 10         |             | 640            |              | \$2,786        | \$164,058     | 0.16  | 59                     |
| Steel Feedwater Economizer  | 8874 -2    | 15         |             |                | 74           | \$437          | \$18,254      | 0.16  | 42                     |
| Boiler Replacement          | 7153 -1    | 5          |             | 346            |              | \$1,506        | \$45,285      | 0.15  | 30                     |
| Boiler Feedwater Economizer | 7579 -2    | 10         |             | 230            |              | \$1,001        | \$51,720      | 0.15  | 52                     |
| Boiler Replacement          | 7105 -1    | 5          |             | 314            |              | \$1,365        | \$45,285      | 0.14  | 33                     |
| Preheat Combustion Air      | 8977 -2    | 10         |             | 180            |              | \$783          | \$41,117      | 0.14  | 53                     |
| Boiler Replacement          | 7105 -2    | 5          |             | 314            |              | \$1,365        | \$45,285      | 0.14  | 33                     |
| Oxygen Trim System          | 7770 -2    | 10         |             | 99             |              | \$429          | \$16,420      | 0.14  | 38                     |
| Oxygen Trim System          | 7770 -1    | 10         |             | 99             |              | \$429          | \$16,420      | 0.14  | 38                     |
| Preheat Combustion Air      | 7153 -1    | 5          |             | 325            |              | \$1,414        | \$41,117      | 0.13  | 29                     |
| Oxygen Trim System          | 7579 -2    | 10         |             | 93             |              | \$406          | \$16,420      | 0.12  | 40                     |
| Oxygen Trim System          | 7153 -1    | 5          |             | 155            |              | \$676          | \$16,420      | 0.12  | 24                     |
| Boiler Feedwater Economizer | 8028 -1    | 10         |             |                | 158          | \$934          | \$51,720      | 0.11  | 55                     |
| Boiler Feedwater Economizer | 7153 -1    | 5          |             | 341            |              | \$1,483        | \$51,720      | 0.11  | 35                     |
| Preheat Combustion Air      | 7770 -1    | 10         |             | 179            |              | \$779          | \$51,396      | 0.11  | 66                     |
| Preheat Combustion Air      | 7770 -2    | 10         |             | 179            |              | \$779          | \$51,396      | 0.11  | 66                     |
| Preheat Combustion Air      | 7579 -2    | 10         |             | 145            |              | \$631          | \$41,117      | 0.10  | 65                     |
| Oxygen Trim System          | 8977 -2    | 10         |             | 83             |              | \$363          | \$16,420      | 0.10  | 45                     |
| Downsize Boiler             | 8977 -2    | 10         |             | 361            |              | \$1,569        | \$164,058     | 0.09  | 105                    |
| Steel Feedwater Economizer  | 8028 -1    | 10         |             |                | 82           | \$485          | \$27,381      | 0.08  | 57                     |
| Steel Feedwater Economizer  | 7770 -2    | 10         |             | 90             |              | \$392          | \$26,077      | 0.07  | 67                     |
| Boiler Feedwater Economizer | 7770 -2    | 10         |             | 158            |              | \$687          | \$64,650      | 0.07  | 94                     |
| Steel Feedwater Economizer  | 7770 -1    | 10         |             | 90             |              | \$392          | \$26,077      | 0.07  | 67                     |
| Boiler Replacement          | 8977 -2    | 10         |             | 303            |              | \$1,317        | \$170,520     | 0.07  | 130                    |
| Boiler Feedwater Economizer | 7770 -1    | 10         |             | 158            |              | \$687          | \$64,650      | 0.07  | 94                     |
| Boiler Feedwater Economizer | 7105 -2    | 5          |             | 184            |              | \$800          | \$51,720      | 0.05  | 64                     |
| Boiler Feedwater Economizer | 7105 -1    | 5          |             | 183            |              | \$796          | \$51,720      | 0.05  | 65                     |
| Variable-Speed Fans         | 4725 -1    | 15         | 138         |                |              | \$513          | \$86,064      | 0.05  | 168                    |
| Steel Feedwater Economizer  | 7105 -1    | 5          |             | 105            |              | \$457          | \$20,862      | 0.05  | 46                     |
| Steel Feedwater Economizer  | 7105 -2    | 5          |             | 106            |              | \$461          | \$20,862      | 0.05  | 45                     |
| Preheat Combustion Air      | 7105 -1    | 5          |             | 141            |              | \$613          | \$41,117      | 0.04  | 67                     |
| Preheat Combustion Air      | 7105 -2    | 5          |             | 141            |              | \$613          | \$41,117      | 0.04  | 67                     |
| Oxygen Trim System          | 7105 -1    | 5          |             | 76             |              | \$329          | \$16,420      | 0.03  | 50                     |
| Oxygen Trim System          | 7105 -2    | 5          |             | 76             |              | \$329          | \$16,420      | 0.03  | 50                     |
| Boiler Tune-Up OMR          | 8874 -1    | 15         |             |                | 33           | \$197          | \$2,705       | -8.20 | 14                     |
| Boiler Tune-Up OMR          | 7105 -3    | 25         |             | 102            |              | \$443          | \$2,705       | -7.91 | 6                      |
| Boiler Tune-Up OMR          | 8977 -2    | 10         |             | 45             |              | \$196          | \$2,705       | -6.31 | 14                     |
| Boiler Tune-Up OMR          | 8028 -1    | 10         |             |                | 151          | \$895          | \$2,705       | -5.51 | 3                      |
| Boiler Tune-Up OMR          | 7579 -2    | 10         |             | 103            |              | \$448          | \$2,705       | -5.42 | 6                      |
| Boiler Tune-Up OMR          | 8874 -2    | 15         |             |                | 245          | \$1,447        | \$2,705       | -2.54 | 2                      |
| Boiler Tune-Up OMR          | 7770 -2    | 10         |             | 307            |              | \$1,336        | \$2,705       | -2.30 | 2                      |
| Boiler Tune-Up OMR          | 7105 -2    | 5          |             | 288            |              | \$1,252        | \$2,705       | -1.99 | 2                      |



TABLE ES 2 - CHILLER ECOs SORTED BY SIR

| ECO's PERFORMED                        | TONS | Chiller No. | Life (Yrs) | Elec. MBIUs | Annual Savings | Cost Estimate | SIR    | Simple Payback (Years) |
|--|------|-------------|------------|-------------|----------------|---------------|--------|------------------------|
| CHILLER SHUTDOWN                       | 440  | 4488-2      | 15         | 12396       | \$46,088       | \$1,496       | 277.22 | 0.03                   |
| CHILLER SHUTDOWN                       | 373  | 5250-1      | 10         | 15600       | \$58,001       | \$1,496       | 271.61 | 0.03                   |
| CHILLER SHUTDOWN                       | 160  | 7120-1      | 20         | 5170        | \$19,222       | \$1,496       | 133.29 | 0.08                   |
| CHILLER SHUTDOWN                       | 200  | 4484-1      | 10         | 3206        | \$11,920       | \$1,496       | 71.70  | 0.13                   |
| CHILLER SHUTDOWN                       | 225  | 3220-1      | 10         | 3961        | \$14,727       | \$1,496       | 68.96  | 0.10                   |
| CHILLED WATER TEMPERATURE RESET        | 660  | 5400-1      | 20         | 343         | \$1,276        | \$329         | 40.21  | 0.3                    |
| CHILLED WATER TEMPERATURE RESET        | 670  | 3305-1      | 10         | 229         | \$850          | \$329         | 18.13  | 0.4                    |
| CHILLED WATER TEMPERATURE RESET        | 440  | 4488-2      | 15         | 162         | \$603          | \$329         | 16.47  | 0.5                    |
| CHILLED WATER TEMPERATURE RESET        | 225  | 3220-1      | 10         | 135         | \$503          | \$329         | 10.70  | 0.7                    |
| CHILLED WATER TEMPERATURE RESET        | 250  | 5681-2      | 10         | 133         | \$496          | \$329         | 10.53  | 0.7                    |
| CHILLED WATER TEMPERATURE RESET        | 373  | 5250-2      | 5          | 132         | \$492          | \$329         | 10.45  | 0.7                    |
| CHILLED WATER TEMPERATURE RESET        | 373  | 5250-1      | 10         | 132         | \$492          | \$329         | 10.45  | 0.7                    |
| CHILLED WATER TEMPERATURE RESET        | 200  | 4484-1      | 10         | 81          | \$301          | \$329         | 8.24   | 1.1                    |
| CHILLED WATER TEMPERATURE RESET        | 160  | 7120-1      | 20         | 68          | \$254          | \$329         | 7.97   | 1.3                    |
| CHILLED WATER TEMPERATURE RESET        | 155  | 5681-1      | 10         | 83          | \$307          | \$329         | 6.57   | 1.1                    |
| CHILLED WATER TEMPERATURE RESET        | 180  | 7770-1      | 10         | 70          | \$262          | \$329         | 5.54   | 1.3                    |
| CHILLED WATER TEMPERATURE RESET        | 155  | 5681-3      | 10         | 55          | \$205          | \$329         | 4.35   | 1.6                    |
| WATERSIDE ECONOMIZER                   | 247  | 4500-1      | 20         | 2953        | \$10,979       | \$31,696      | 3.59   | 2.9                    |
| WATERSIDE ECONOMIZER                   | 660  | 5400-1      | 20         | 3215        | \$11,953       | \$81,131      | 1.53   | 6.8                    |
| TWO SPEED COOLING TOWER FAN - 2        | 200  | 3485-1      | 20         | 110         | \$410          | \$3,156       | 1.35   | 7.7                    |
| TWO SPEED COOLING TOWER FAN - 2        | 130  | 109-1       | 15         | 110         | \$410          | \$3,156       | 1.17   | 7.7                    |
| WATERSIDE ECONOMIZER                   | 180  | 7770-1      | 10         | 1247        | \$4,637        | \$30,408      | 1.07   | 6.6                    |
| TWO SPEED COOLING TOWER FAN - 2        | 225  | 3220-1      | 10         | 110         | \$410          | \$3,156       | 0.91   | 7.7                    |
| VARIABLE SPEED PUMPING                 | 225  | 3220-1      | 10         | 874         | \$3,250        | \$44,612      | 0.69   | 13.7                   |
| TWO SPEED COOLING TOWER FAN - 2        | 180  | 7770-1      | 10         | 74          | \$273          | \$2,800       | 0.68   | 10.3                   |
| WATERSIDE ECONOMIZER                   | 670  | 3305-1      | 10         | 1895        | \$7,046        | \$74,707      | 0.66   | 10.6                   |
| WATERSIDE ECONOMIZER                   | 204  | 4505-1      | 10         | 813         | \$3,022        | \$33,132      | 0.64   | 11.0                   |
| VARIABLE SPEED PUMPING                 | 200  | 3485-1      | 20         | 586         | \$2,178        | \$32,462      | 0.64   | 14.9                   |
| VARIABLE SPEED PUMPING                 | 155  | 5681-1      | 10         | 1904        | \$7,080        | \$118,325     | 0.57   | 16.7                   |
| TWO SPEED COOLING TOWER FAN - 1        | 200  | 3485-1      | 20         | 42          | \$157          | \$3,156       | 0.52   | 20.1                   |
| TWO SPEED COOLING TOWER FAN - 1        | 130  | 109-1       | 15         | 42          | \$157          | \$3,156       | 0.45   | 20.1                   |
| TWO SPEED COOLING TOWER FAN - 2        | 247  | 4500-1      | 20         | 37          | \$137          | \$3,156       | 0.45   | 23.1                   |
| WATERSIDE ECONOMIZER                   | 440  | 4488-1      | 10         | 725         | \$2,696        | \$56,074      | 0.43   | 20.8                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 660  | 5400-1      | 20         | 369         | \$1,373        | \$25,092      | 0.42   | 18.3                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 660  | 5400-2      | 20         | 369         | \$1,373        | \$25,092      | 0.42   | 18.3                   |
| WATERSIDE ECONOMIZER                   | 160  | 7120-1      | 20         | 297         | \$1,104        | \$30,408      | 0.38   | 27.5                   |
| TWO SPEED COOLING TOWER FAN - 1        | 225  | 3220-1      | 10         | 42          | \$157          | \$3,156       | 0.35   | 20.1                   |
| TWO SPEED COOLING TOWER FAN - 2        | 204  | 4505-1      | 10         | 37          | \$137          | \$2,800       | 0.34   | 20.4                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 670  | 3305-2      | 10         | 370         | \$1,376        | \$25,463      | 0.32   | 18.5                   |
| VARIABLE SPEED PUMPING                 | 200  | 4484-1      | 10         | 274         | \$1,020        | \$31,133      | 0.31   | 30.5                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 670  | 3305-1      | 10         | 370         | \$1,376        | \$25,463      | 0.29   | 18.5                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 200  | 3485-1      | 20         | 131         | \$487          | \$13,789      | 0.27   | 28.3                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 160  | 7120-1      | 20         | 110         | \$411          | \$11,709      | 0.26   | 28.5                   |
| TWO SPEED COOLING TOWER FAN - 1        | 180  | 7770-1      | 10         | 28          | \$105          | \$2,800       | 0.26   | 26.7                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 200  | 4484-1      | 10         | 131         | \$487          | \$13,789      | 0.23   | 28.3                   |
| WATERSIDE ECONOMIZER                   | 130  | 109-1       | 15         | 212         | \$786          | \$30,408      | 0.23   | 38.7                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 247  | 4500-1      | 20         | 138         | \$513          | \$16,336      | 0.22   | 31.8                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 130  | 109-1       | 15         | 85          | \$316          | \$9,514       | 0.21   | 30.1                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 373  | 5250-1      | 10         | 214         | \$796          | \$21,006      | 0.20   | 26.4                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 373  | 5250-2      | 5          | 214         | \$796          | \$21,006      | 0.20   | 26.4                   |
| WATERSIDE ECONOMIZER                   | 200  | 3485-1      | 20         | 154         | \$571          | \$31,856      | 0.19   | 55.8                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 225  | 3220-1      | 10         | 146         | \$541          | \$14,881      | 0.19   | 27.5                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 180  | 7770-1      | 10         | 114         | \$424          | \$13,173      | 0.17   | 31.1                   |
| TWO SPEED COOLING TOWER FAN - 1        | 247  | 4500-1      | 20         | 14          | \$52           | \$3,156       | 0.17   | 60.4                   |

TABLE ES 2 - CHILLER ECOS SORTED BY SIR

| ECO's PERFORMED                        | TONS | Chiller No. | Life (Yrs) | Elec. MBTUs | Annual Savings | Cost Estimate | SIR   | Simple Payback (Years) |
|--|------|-------------|------------|-------------|----------------|---------------|-------|------------------------|
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 204  | 4505-1      | 10         | 117         | \$435          | \$13,777      | 0.16  | 31.7                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 155  | 5681-1      | 10         | 89          | \$331          | \$11,343      | 0.15  | 34.3                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 155  | 5681-3      | 10         | 89          | \$331          | \$10,906      | 0.15  | 32.9                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 250  | 5681-2      | 10         | 144         | \$534          | \$16,531      | 0.14  | 31.0                   |
| TWO SPEED COOLING TOWER FAN - 1        | 204  | 4505-1      | 10         | 14          | \$52           | \$2,800       | 0.13  | 53.8                   |
| WATERSIDE ECONOMIZER                   | 225  | 3220-1      | 10         | 142         | \$528          | \$32,011      | 0.12  | 60.6                   |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM | 200  | 5400-3      | 5          | 115         | \$427          | \$13,789      | 0.11  | 32.3                   |
| CENTRIFUGAL CHILLER REPLACEMENT        | 373  | 5250-2      | 5          | 405         | \$1,506        | \$113,074     | 0.05  | 75.1                   |
| WATERSIDE ECONOMIZER                   | 373  | 5250-1      | 10         | 77          | \$286          | \$49,612      | 0.04  | 173.5                  |
| WATER TREATMENT / FILL REPLACEMENT     | 130  | 109-1       | 15         | 24          | \$88           | \$14,150      | -1.73 | 160.8                  |
| CONDENSER TUBE CLEANING                | 373  | 5250-2      | 5          | 428         | \$1,591        | \$5,412       | -2.87 | 3.4                    |
| CONDENSER TUBE CLEANING                | 200  | 5400-3      | 5          | 230         | \$855          | \$2,902       | -2.87 | 3.4                    |
| WATER TREATMENT / FILL REPLACEMENT     | 180  | 7770-1      | 10         | 35          | \$131          | \$8,782       | -2.99 | 67.0                   |
| WATER TREATMENT / FILL REPLACEMENT     | 204  | 4505-1      | 10         | 36          | \$134          | \$9,765       | -3.06 | 72.9                   |
| WATER TREATMENT / FILL REPLACEMENT     | 225  | 3220-1      | 10         | 45          | \$167          | \$10,263      | -3.20 | 61.5                   |
| WATER TREATMENT / FILL REPLACEMENT     | 440  | 4488-1      | 10         | 78          | \$290          | \$18,380      | -3.51 | 63.4                   |
| WATER TREATMENT / FILL REPLACEMENT     | 373  | 5250-1      | 10         | 66          | \$245          | \$15,153      | -3.60 | 61.8                   |
| WATER TREATMENT / FILL REPLACEMENT     | 670  | 3305-1      | 10         | 114         | \$425          | \$24,957      | -3.94 | 58.7                   |
| WATER TREATMENT / FILL REPLACEMENT     | 670  | 3305-2      | 10         | 114         | \$425          | \$24,957      | -3.94 | 58.7                   |
| WATER TREATMENT / FILL REPLACEMENT     | 247  | 4500-1      | 20         | 44          | \$163          | \$13,796      | -3.96 | 84.6                   |
| WATER TREATMENT / FILL REPLACEMENT     | 160  | 7120-1      | 20         | 34          | \$126          | \$8,307       | -4.23 | 65.9                   |
| WATER TREATMENT / FILL REPLACEMENT     | 440  | 4488-2      | 15         | 81          | \$301          | \$18,380      | -4.55 | 61.1                   |
| CONDENSER TUBE CLEANING                | 225  | 3220-1      | 10         | 291         | \$1,082        | \$3,265       | -4.67 | 3.0                    |
| CONDENSER TUBE CLEANING                | 180  | 7770-1      | 10         | 228         | \$848          | \$2,612       | -4.72 | 3.1                    |
| CONDENSER TUBE CLEANING                | 155  | 5681-1      | 10         | 178         | \$662          | \$2,249       | -4.93 | 3.4                    |
| CONDENSER TUBE CLEANING                | 250  | 5681-2      | 10         | 287         | \$1,067        | \$3,627       | -4.93 | 3.4                    |
| CONDENSER TUBE CLEANING                | 155  | 5681-3      | 10         | 178         | \$662          | \$2,249       | -4.93 | 3.4                    |
| CONDENSER TUBE CLEANING                | 440  | 4488-1      | 10         | 505         | \$1,878        | \$6,384       | -4.94 | 3.4                    |
| CONDENSER TUBE CLEANING                | 373  | 5250-1      | 10         | 428         | \$1,591        | \$5,412       | -4.94 | 3.4                    |
| CONDENSER TUBE CLEANING                | 204  | 4505-1      | 10         | 234         | \$870          | \$2,960       | -4.94 | 3.4                    |
| CONDENSER TUBE CLEANING                | 670  | 3305-2      | 10         | 740         | \$2,751        | \$9,721       | -5.01 | 3.5                    |
| CONDENSER TUBE CLEANING                | 670  | 3305-1      | 10         | 740         | \$2,751        | \$9,721       | -5.01 | 3.5                    |
| WATER TREATMENT / FILL REPLACEMENT     | 200  | 3485-1      | 20         | 40          | \$149          | \$8,259       | -5.33 | 55.4                   |
| WATER TREATMENT / FILL REPLACEMENT     | 660  | 5400-1      | 20         | 114         | \$424          | \$24,719      | -5.91 | 58.3                   |
| WATER TREATMENT / FILL REPLACEMENT     | 660  | 5400-2      | 20         | 114         | \$424          | \$24,676      | -5.92 | 58.2                   |
| CONDENSER TUBE CLEANING                | 200  | 4484-1      | 10         | 262         | \$974          | \$2,902       | -6.06 | 3.0                    |
| CONDENSER TUBE CLEANING                | 440  | 4488-2      | 15         | 524         | \$1,948        | \$6,384       | -6.33 | 3.3                    |
| CONDENSER TUBE CLEANING                | 130  | 109-1       | 15         | 153         | \$569          | \$1,886       | -6.36 | 3.3                    |
| CONDENSER TUBE CLEANING                | 160  | 7120-1      | 20         | 221         | \$822          | \$2,322       | -6.88 | 2.8                    |
| CONDENSER TUBE CLEANING                | 200  | 3485-1      | 20         | 262         | \$974          | \$2,902       | -7.07 | 3.0                    |
| CONDENSER TUBE CLEANING                | 247  | 4500-1      | 20         | 276         | \$1,026        | \$3,584       | -7.58 | 3.5                    |
| CONDENSER TUBE CLEANING                | 660  | 5400-1      | 20         | 739         | \$2,748        | \$9,576       | -7.58 | 3.5                    |
| CONDENSER TUBE CLEANING                | 660  | 5400-2      | 20         | 737         | \$2,740        | \$9,576       | -7.58 | 3.5                    |
| STM DRIVEN VS. ELEC. DRIVEN CHILLERS   | 225  | 3220-1      | 10         | 4650        | \$2,028        | \$188,975     | NA    | 93.2                   |

| EOO                         | MBTUs Saved |               |             |                |              | Annual Savings | Cost Estimate | SIR     | Simple Payback (Years) |
|-----------------------------|-------------|---------------|-------------|----------------|--------------|----------------|---------------|---------|------------------------|
|                             | Boiler No.  | Economic life | Elec. MBTUs | Nat. Gas MBTUs | #2 Oil MBTUs |                |               |         |                        |
| * Boiler Tune-Up OMR        | 115-2       | 25            |             | 903            |              | \$3,927        | \$2,705       | 21.18   | 0.69                   |
| Turbulator Installation     | 115-2       | 25            |             | 120            |              | \$522          | \$1,295       | 9.10    | 2.50                   |
| ** Burner Replacement       | 115-2       | 25            |             | 977            |              | \$4,248        | \$11,622      | 8.26    | 2.70                   |
| ** Boiler Downsizing        | 115-2       | 25            |             | 1488           |              | \$6,475        | \$45,285      | 3.23    | 7.00                   |
| Steel Economizer            | 115-2       | 25            |             | 306            |              | \$1,333        | \$23,496      | 1.15    | 18.00                  |
| Summer Boiler               | 115-2       | 25            |             | 559            |              | \$2,430        | \$25,478      | 2.16    | 10.50                  |
| ** Boiler Replacement       | 115-2       | 25            |             | 977            |              | \$4,248        | \$55,905      | 1.72    | 13.20                  |
| Oxygen Trim System          | 115-2       | 25            |             | 238            |              | \$1,037        | \$16,420      | 1.24    | 16.00                  |
| Preheat Combustion Air      | 115-2       | 25            |             | 580            |              | \$2,523        | \$46,257      | 1.16    | 18.00                  |
| * Boiler Tune-Up OMR        | 3624-1      | 10            |             | 2449           |              | \$10,655       | \$2,705       | 30.48   | 0.25                   |
| * Boiler Tune-Up OMR        | 3624-2      | 10            |             | 748            |              | \$3,254        | \$2,705       | 4.45    | 0.83                   |
| * Boiler Tune-Up OMR        | 3624-3      | 10            |             | 8599           |              | \$37,407       | \$2,705       | 124.60  | 0.07                   |
| * Boiler Tune-Up OMR        | 3624-4      | 10            |             | 34338          |              | \$149,372      | \$2,705       | 518.52  | 0.02                   |
| * Boiler Tune-Up OMR        | 4725-1      | 15            |             | 1945           |              | \$8,460        | \$2,705       | 36.27   | 0.32                   |
| * Boiler Tune-Up OMR        | 4725-2      | 15            |             | 21293          |              | \$92,626       | \$2,705       | 495.49  | 0.03                   |
| * Boiler Tune-Up OMR        | 4725-3      | 15            |             | 57931          |              | \$251,998      | \$2,705       | 1341.68 | 0.01                   |
| Turbulator Installation     | 7105-3      | 25            |             | 69             |              | \$300          | \$1,723       | 3.93    | 5.70                   |
| Burner Replacement          | 7105-3      | 25            |             | 413            |              | \$1,795        | \$13,575      | 2.99    | 7.60                   |
| Boiler Downsizing           | 7105-3      | 25            |             | 774            |              | \$3,368        | \$40,907      | 1.86    | 12.10                  |
| *** Boiler Tune-Up OMR      | 7105-4      | 10            |             | 925            |              | \$4,025        | \$2,705       | 7.16    | 0.67                   |
| *** Turbulator Installation | 7105-4      | 10            |             | 86             |              | \$374          | \$1,723       | 2.07    | 4.60                   |
| *** Boiler Downsizing       | 7105-4      | 10            |             | 1102           |              | \$4,792        | \$40,907      | 1.12    | 8.50                   |
| *** Burner Replacement      | 7105-4      | 10            |             | 732            |              | \$3,184        | \$30,026      | 1.01    | 9.40                   |
| Turbulator Installation     | 7153-1      | 5             |             | 82             |              | \$357          | \$287         | 5.64    | 0.80                   |
| * Boiler Tune-Up OMR        | 7153-1      | 5             |             | 705            |              | \$3,067        | \$2,705       | 1.05    | 0.88                   |
| Summer Boiler               | 7291-1      | 15            |             | 257            |              | \$1,118        | \$16,100      | 1.01    | 14.40                  |
| Turbulator Installation     | 7579-1      | 10            |             | 156            |              | \$679          | \$861         | 7.50    | 1.27                   |
| Burner Replacement          | 7579-1      | 10            |             | 858            |              | \$3,734        | \$10,319      | 3.44    | 2.80                   |
| Steel Economizer            | 7579-1      | 10            |             | 607            |              | \$2,640        | \$20,862      | 1.12    | 6.00                   |
| Turbulator Installation     | 7579-2      | 10            |             | 33             |              | \$144          | \$861         | 1.59    | 6.00                   |
| Burner Replacement          | 7579-2      | 10            |             | 283            |              | \$1,232        | \$10,319      | 1.14    | 8.40                   |
| **** Burner Replacement     | 7770-1      | 10            |             | 344            |              | \$1,497        | \$10,319      | 1.38    | 6.90                   |
| Turbulator Installation     | 7770-1      | 10            |             | 44             |              | \$191          | \$1,723       | 1.06    | 9.00                   |
| **** Burner Replacement     | 7770-2      | 10            |             | 345            |              | \$1,499        | \$10,319      | 1.38    | 6.90                   |
| Turbulator Installation     | 7770-2      | 10            |             | 44             |              | \$191          | \$1,723       | 1.06    | 9.00                   |
| Turbulator Installation     | 8028-1      | 10            |             |                | 39           | \$230          | \$1,723       | 1.12    | 7.48                   |
| * Boiler Tune-Up OMR        | 8028-2      | 25            |             |                | 529          | \$3,125        | \$2,705       | 19.21   | 0.87                   |
| Turbulator Installation     | 8028-2      | 25            |             |                | 98           | \$579          | \$1,723       | 6.21    | 2.98                   |
| Oxygen Trim System          | 8028-2      | 25            |             |                | 279          | \$1,649        | \$16,420      | 1.67    | 9.96                   |
| Preheat Combustion Air      | 8028-2      | 25            |             |                | 522          | \$3,085        | \$53,996      | 1.00    | 18.00                  |
| Turbulator Installation     | 8874-1      | 15            |             |                | 49           | \$290          | \$518         | 6.82    | 1.79                   |
| Burner Replacement          | 8874-1      | 15            |             |                | 319          | \$1,882        | \$9,017       | 2.55    | 4.80                   |
| Turbulator Installation     | 8874-2      | 15            |             |                | 28           | \$165          | \$518         | 3.90    | 3.13                   |
| Burner Replacement          | 8874-2      | 15            |             |                | 200          | \$1,182        | \$9,017       | 1.60    | 7.60                   |
| * Boiler Tune-Up OMR        | 8977-1      | 10            |             | 1965           |              | \$8,548        | \$2,705       | 23.08   | 0.32                   |
| Burner Replacement          | 8977-1      | 10            |             | 749            |              | \$3,257        | \$10,319      | 3.00    | 3.20                   |
| Turbulator Installation     | 8977-1      | 10            |             | 52             |              | \$226          | \$861         | 2.50    | 3.81                   |
| Turbulator Installation     | 8977-2      | 10            |             | 38             |              | \$165          | \$861         | 1.83    | 5.21                   |
| Burner Replacement          | 8977-2      | 10            |             | 303            |              | \$1,317        | \$10,319      | 1.22    | 7.80                   |

\* Package in place (work to be completed in summer 1987) } Per guidance through letter dated May 18, 1987,  
 \*\* Work completed } from Keith Kirkly for Paul W. Hancock, Director  
 \*\*\* Discontinued - new system in place } of Engineering and Housing, to Norm Meinert of  
 \*\*\*\* Boiler rehabilitation package # 1 (work in progress) } Benatech, Inc.

TABLE ES 4 - CHILLER ECOs WITH SIR > 1 (SORTED BY BUILDING)

| ECO's PERFORMED                   | Chiller<br>TONS | Life<br>No. | (YRS.) | Elec.<br>MBTUs<br>Savings | Annual<br>Savings | Cost<br>Estimate | SIR    | Simple<br>Payback<br>(Years) |
|-----------------------------------|-----------------|-------------|--------|---------------------------|-------------------|------------------|--------|------------------------------|
| TWO SPEED COOLING TOWER FAN - 2   | 130             | 109-1       | 15     | 110                       | \$410             | \$3,156          | 1.17   | 7.70                         |
| CHILLER SHUTDOWN                  | 225             | 3220-1      | 10     | 3961                      | \$14,727          | \$1,496          | 68.96  | 0.10                         |
| CHILLED WATER TEMPERATURE RESET   | 225             | 3220-1      | 10     | 135                       | \$503             | \$329            | 10.70  | 0.65                         |
| * CHILLED WATER TEMPERATURE RESET | 670             | 3305-1      | 10     | 229                       | \$850             | \$329            | 18.13  | 0.39                         |
| TWO SPEED COOLING TOWER FAN - 2   | 200             | 3485-1      | 20     | 110                       | \$410             | \$3,156          | 1.35   | 7.70                         |
| CHILLER SHUTDOWN                  | 200             | 4484-1      | 10     | 3206                      | \$11,920          | \$1,496          | 71.70  | 0.13                         |
| CHILLED WATER TEMPERATURE RESET   | 200             | 4484-1      | 10     | 81                        | \$301             | \$329            | 8.24   | 1.09                         |
| CHILLER SHUTDOWN                  | 440             | 4488-2      | 15     | 12396                     | \$46,088          | \$1,496          | 277.22 | 0.03                         |
| * CHILLED WATER TEMPERATURE RESET | 440             | 4488-2      | 15     | 162                       | \$603             | \$329            | 16.47  | 0.55                         |
| WATERSIDE ECONOMIZER              | 247             | 4500-1      | 20     | 2953                      | \$10,979          | \$31,696         | 3.59   | 2.89                         |
| CHILLER SHUTDOWN                  | 373             | 5250-1      | 10     | 15600                     | \$58,001          | \$1,496          | 271.61 | 0.03                         |
| * CHILLED WATER TEMPERATURE RESET | 373             | 5250-1      | 10     | 132                       | \$492             | \$329            | 10.45  | 0.67                         |
| * CHILLED WATER TEMPERATURE RESET | 373             | 5250-2      | 5      | 132                       | \$492             | \$329            | 10.45  | 0.67                         |
| CHILLED WATER TEMPERATURE RESET   | 660             | 5400-1      | 20     | 343                       | \$1,276           | \$329            | 40.21  | 0.26                         |
| WATERSIDE ECONOMIZER              | 660             | 5400-1      | 20     | 3215                      | \$11,953          | \$81,131         | 1.53   | 6.79                         |
| CHILLED WATER TEMPERATURE RESET   | 155             | 5681-1      | 10     | 83                        | \$307             | \$329            | 6.57   | 1.07                         |
| CHILLED WATER TEMPERATURE RESET   | 250             | 5681-2      | 10     | 133                       | \$496             | \$329            | 10.53  | 0.66                         |
| CHILLED WATER TEMPERATURE RESET   | 155             | 5681-3      | 10     | 55                        | \$205             | \$329            | 4.35   | 1.60                         |
| CHILLER SHUTDOWN                  | 160             | 7120-1      | 20     | 5170                      | \$19,222          | \$1,496          | 133.29 | 0.08                         |
| CHILLED WATER TEMPERATURE RESET   | 160             | 7120-1      | 20     | 68                        | \$254             | \$329            | 7.97   | 1.30                         |
| CHILLED WATER TEMPERATURE RESET   | 180             | 7770-1      | 10     | 70                        | \$262             | \$329            | 5.54   | 1.26                         |
| WATERSIDE ECONOMIZER              | 180             | 7770-1      | 10     | 1247                      | \$4,637           | \$30,408         | 1.07   | 6.56                         |

\* Work to be accomplished in FY88 per guidance of letter dated May 13, 1987, from Keith Kirkley for Paul W. Hancock, Director of Engineering and Housing, to Norm Meinert of Benatech, Inc.

### 3.3 RECOMMENDATIONS

Once all the ECOs which offered project potential were isolated, the synergistic effects of each combination were evaluated. The results of the iterative analysis are the No cost/Low Cost Projects. There are four projects as described below.

1. Boiler Optimization

- These projects are on a per-boiler basis. They include all ECOs per respective boiler, with SIRs greater than 1.0, that are not already being implemented and are not mutually exclusive with other ECOs for the same boiler.

2. Chiller Optimization

- These projects are on a per-chiller basis and include ECOs for the respective chiller with SIRs greater than 1.0. ECOs included in optimization projects are chilled water reset and chiller shutdown if they already are not implemented. The term optimization describes chiller operation and obtaining the appropriate amount of refrigeration affect when it is necessary.

3. Chiller Economizer

- These projects are on a per-chiller basis and include ECOs for the respective chiller with SIRs greater than 1.0. ECOs included in optimization projects are water side economizer and two-speed cooling tower unless they have already been implemented. The term economizer refers to the condenser water side of the chilled water system.

4. Complete Chiller Optimization

- These projects are on a per-chiller basis and include ECOs for the respective chiller with SIRs greater than 1.0. ECOs included in complete optimization projects include chilled water reset, condenser tube cleaning, automatic chiller tube cleaner, water treatment/fill replacement, water side economizer, variable speed pumping, two-speed cooling tower and chiller shutdown. The term economizer refers to all projects which will enhance the performance of the chiller.

The results of the Boiler and Chiller study are shown in Table ES 5. Table ES 6 is a summary of boiler projects by type of project. Table ES 7 is a summary of chiller projects sorted by building number. Graphs ES 1 and ES 2 depict current boiler plant fuel consumption compared with the reduced energy consumption should all boiler projects be implemented. Graphs ES 3 through ES 5 show the energy savings from the Chiller Projects, broken down by type and by building number. Graph ES 6, shows energy savings by fuel type for both Boiler and Chiller Projects.

TABLE ES 5 - SUMMARY OF PROJECTS

|                | ANNUAL SAVINGS      |                    |                   | Annual<br>\$\$ | Cost<br>Estimate | Simple<br>Payback<br>(Years) |
|----------------|---------------------|--------------------|-------------------|----------------|------------------|------------------------------|
|                | ELECTRIC<br>(MBTUs) | NAT GAS<br>(MBTUs) | #2 OIL<br>(MBTUs) |                |                  |                              |
| BOILER TOTALS  | 0                   | 4,821              | 1,636             | \$30,636       | \$231,957        | 7.57                         |
| CHILLER TOTALS | 48,820              | 0                  | 0                 | \$181,178      | \$159,659        | 0.88                         |
| STUDY TOTALS   | 48,820              | 4,821              | 1,636             | \$211,814      | \$391,616        | 1.85                         |

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TOTAL MBTUs/YR:        55,277

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TABLE ES 6 - SUMMARY OF BOILER PROJECTS BY BUILDING

| PROJECT TITLE       | Boiler No. | Life (YRS) | SAVINGS         |                | Annual Savings | Cost Estimate | SIR  | Simple Payback (Years) |
|---------------------|------------|------------|-----------------|----------------|----------------|---------------|------|------------------------|
|                     |            |            | NAT GAS (MBTUs) | #2 OIL (MBTUs) |                |               |      |                        |
| BOILER OPTIMIZATION | 115-2      | 25         | 1466            |                | \$6,375        | \$59,174      | 2.38 | 9.28                   |
| BOILER OPTIMIZATION | 7105-3     | 25         | 477             |                | \$2,076        | \$15,298      | 3.06 | 7.37                   |
| BOILER OPTIMIZATION | 7153-1     | 5          | 82              |                | \$357          | \$287         | 5.65 | 0.80                   |
| BOILER OPTIMIZATION | 7291       | 15         | 257             |                | \$1,118        | \$16,100      | 1.01 | 14.40                  |
| BOILER OPTIMIZATION | 7579-1     | 10         | 1006            |                | \$4,377        | \$11,180      | 3.73 | 2.55                   |
| BOILER OPTIMIZATION | 7579-2     | 10         | 314             |                | \$1,365        | \$11,180      | 1.16 | 8.19                   |
| BOILER OPTIMIZATION | 7770-1     | 10         | 44              |                | \$190          | \$1,723       | 1.05 | 9.07                   |
| BOILER OPTIMIZATION | 7770-2     | 10         | 44              |                | \$190          | \$1,723       | 1.05 | 9.07                   |
| BOILER OPTIMIZATION | 8028-1     | 10         |                 | 39             | \$232          | \$1,723       | 1.12 | 7.43                   |
| BOILER OPTIMIZATION | 8028-2     | 25         |                 | 1006           | \$5,947        | \$72,139      | 1.44 | 12.13                  |
| BOILER OPTIMIZATION | 8874-1     | 15         |                 | 365            | \$2,154        | \$9,535       | 2.76 | 4.43                   |
| BOILER OPTIMIZATION | 8874-2     | 15         |                 | 226            | \$1,336        | \$9,535       | 1.71 | 7.14                   |
| BOILER OPTIMIZATION | 8897-1     | 10         | 794             |                | \$3,452        | \$11,180      | 2.94 | 3.24                   |
| BOILER OPTIMIZATION | 8897-2     | 10         | 337             |                | \$1,467        | \$11,180      | 1.25 | 7.62                   |
| TOTALS:             |            |            | 4821            | 1636           | \$30,636       | \$231,957     |      | 7.57                   |
|                     |            |            | =====           | =====          | =====          | =====         |      | ===                    |



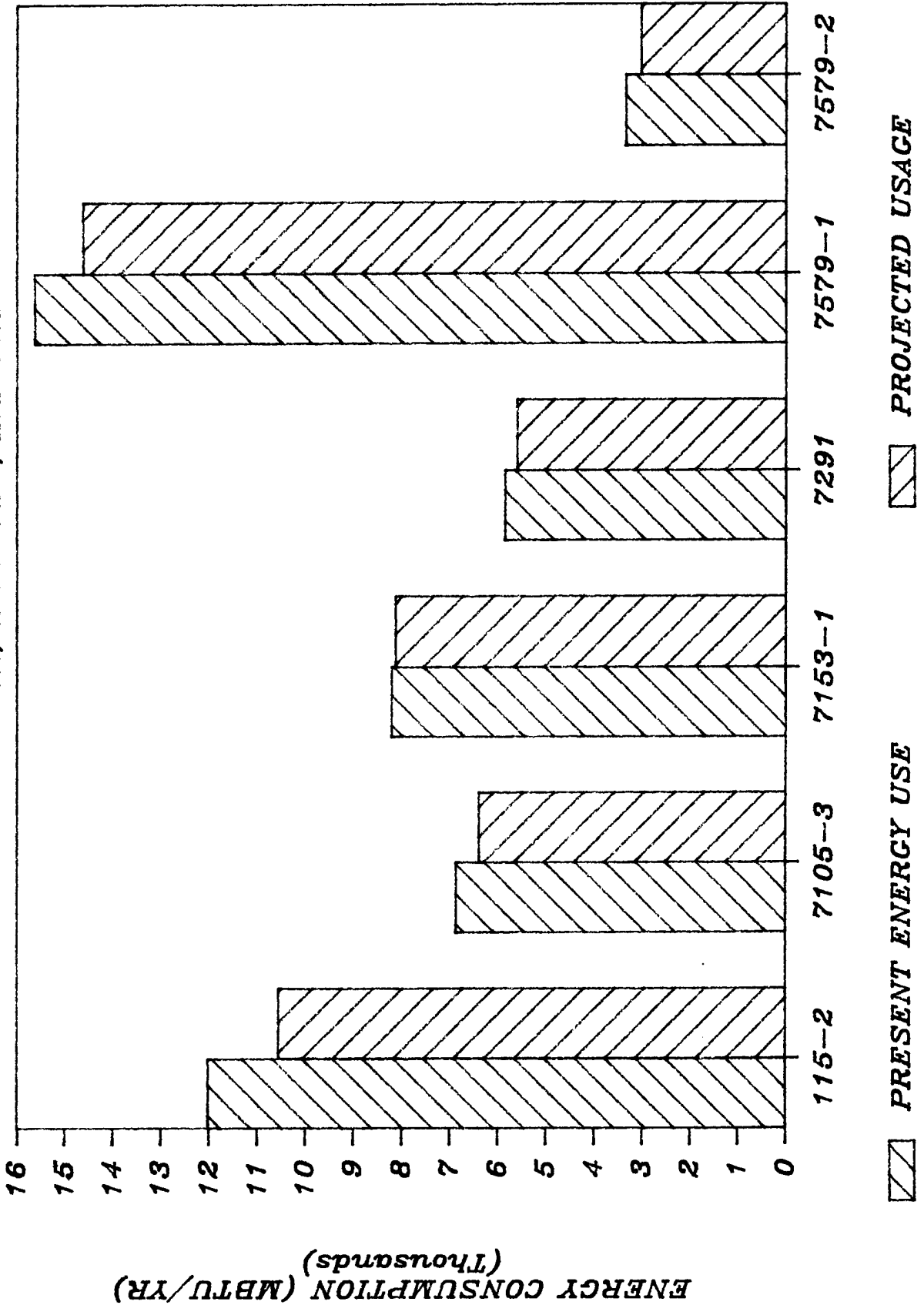
TABLE ES 7 - SUMMARY OF CHILLER PROJECTS BY BUILDING

| PROJECT TITLE                 | TONS | Chiller No. | Life (YRS) | Elec. MBTUs Savings | Annual Savings | Cost Estimate | SIR    | Simple Payback (Years) |
|-------------------------------|------|-------------|------------|---------------------|----------------|---------------|--------|------------------------|
| CHILLER ECONOMIZER            | 130  | 109-1       | 15         | 110                 | \$409          | \$3,156       | 1.17   | 7.72                   |
| CHILLER OPTIMIZATION          | 225  | 3220-1      | 10         | 4096                | \$15,229       | \$1,825       | 58.46  | 0.12                   |
| CHILLER ECONOMIZER            | 200  | 3485-1      | 20         | 110                 | \$410          | \$3,156       | 1.35   | 7.70                   |
| CHILLER OPTIMIZATION          | 200  | 4484-1      | 10         | 3287                | \$12,221       | \$1,825       | 60.26  | 0.15                   |
| CHILLER OPTIMIZATION          | 440  | 4488-2      | 15         | 12396               | \$46,088       | \$1,496       | 277.22 | 0.03                   |
| CHILLER ECONOMIZER            | 247  | 4500-1      | 20         | 2953                | \$10,979       | \$31,696      | 3.59   | 2.89                   |
| CHILLER OPTIMIZATION          | 373  | 5250-1      | 10         | 15600               | \$58,001       | \$1,496       | 271.61 | 0.03                   |
| COMPLETE CHILLER OPTIMIZATION | 660  | 5400-1      | 20         | 3387                | \$12,593       | \$81,460      | 1.60   | 6.47                   |
| CHILLER OPTIMIZATION          | 155  | 5681-1      | 10         | 83                  | \$309          | \$329         | 6.57   | 1.06                   |
| CHILLER OPTIMIZATION          | 250  | 5681-2      | 10         | 133                 | \$494          | \$329         | 10.53  | 0.67                   |
| CHILLER OPTIMIZATION          | 155  | 5681-3      | 10         | 55                  | \$204          | \$329         | 4.35   | 1.61                   |
| CHILLER OPTIMIZATION          | 160  | 7120-1      | 20         | 5328                | \$19,475       | \$1,825       | 110.70 | 0.09                   |
| COMPLETE CHILLER OPTIMIZATION | 180  | 7770-1      | 10         | 1282                | \$4,766        | \$30,737      | 1.09   | 6.45                   |
| TOTALS:                       |      |             |            | 48820               | \$181,178      | \$159,659     |        | 0.88                   |
|                               |      |             |            | =====               | =====          | =====         |        | ===                    |

GRAPH ES 1 BOILER SAVINGS BY BUILDING

# BOILER PROJECTS - ENERGY SAVINGS

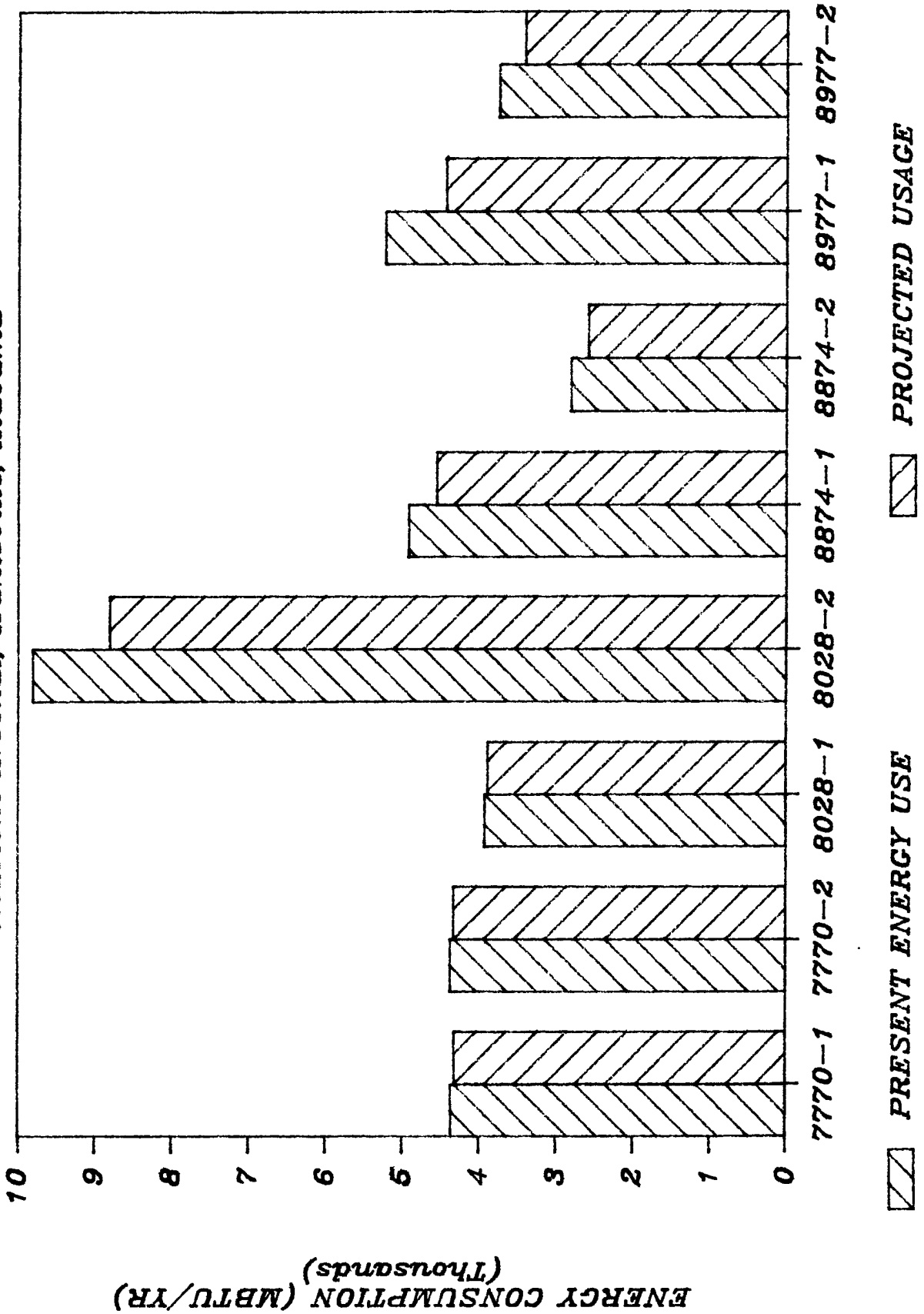
*Redstone Arsenal, Huntsville, Alabama*



GRAPH ES 2 BOILER SAVINGS BY BUILDING

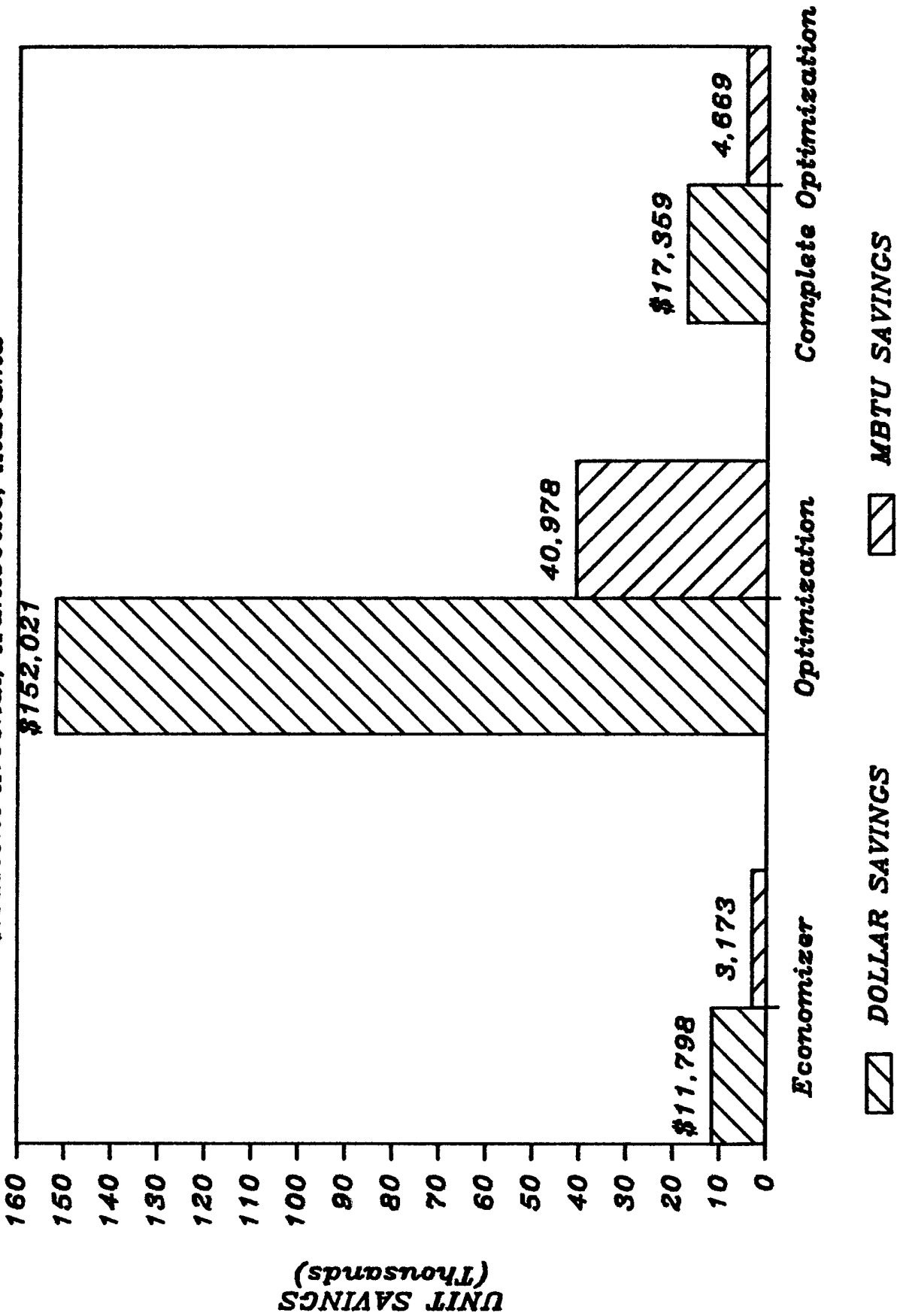
# BOILER PROJECTS - ENERGY SAVINGS

*Redstone Arsenal, Huntsville, Alabama*



# CHILLER PROJECTS SAVINGS

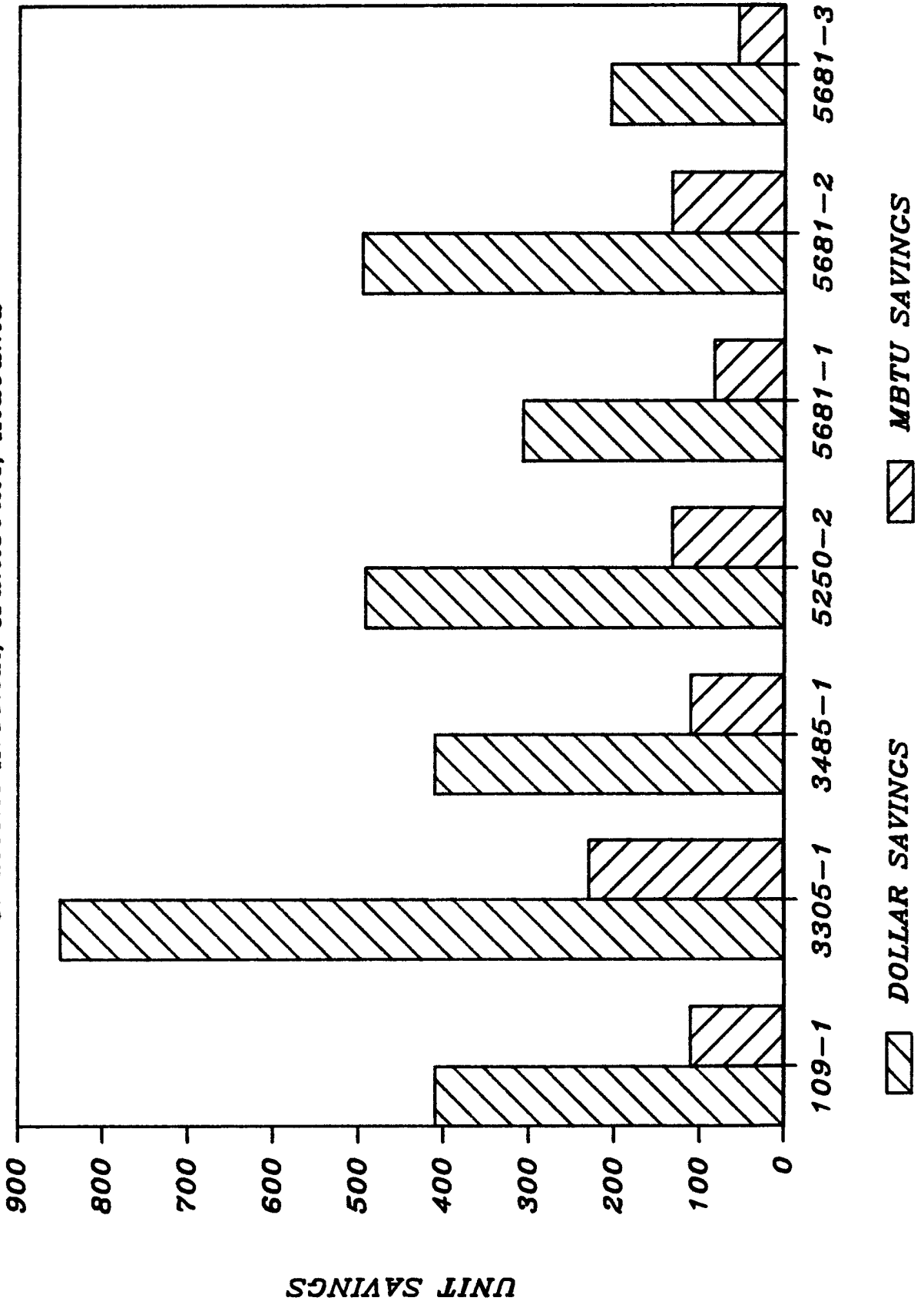
*Redstone Arsenal, Huntsville, Alabama*



GRAPH ES 4 CHILLER SAVINGS BY BUILDING

# CHILLER PROJECTS SAVINGS

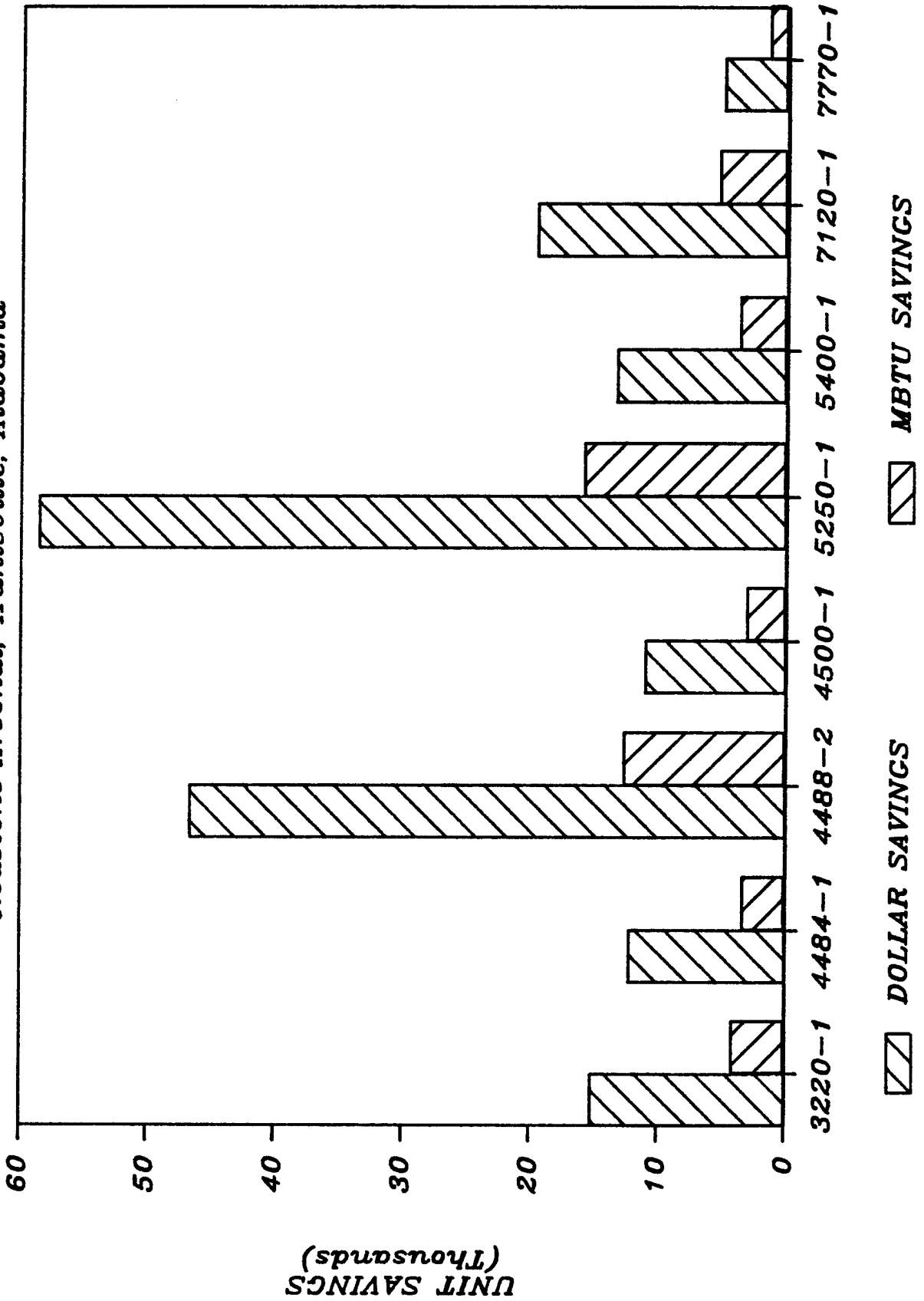
*Redstone Arsenal, Huntsville, Alabama*



GRAPH ES 5 CHILLER SAVINGS BY BUILDING

# CHILLER PROJECTS SAVINGS

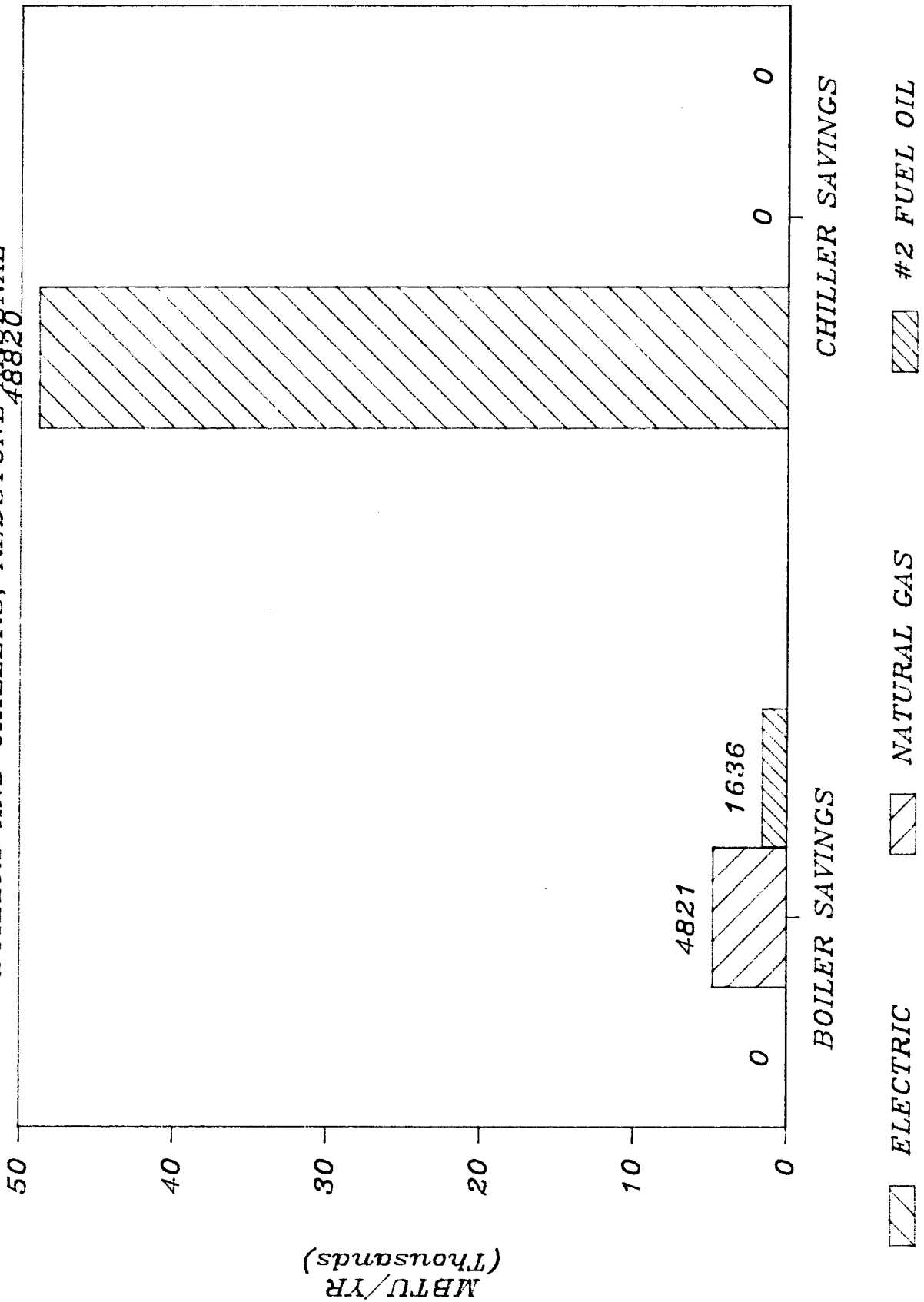
*Redstone Arsenal, Huntsville, Alabama*



GRAPH ES 6 ENERGY SAVINGS BY FUEL TYPE

# ENERGY SAVINGS BY FUEL TYPE

BOILERS AND CHILLERS, REDSTONE ARSENAL  
48820



I N D E X

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|--|-------|-------|----------|----------|--------------|---------------|-----------|-----------|------------|
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 109   | 1     | VIII - D | 83,84    | 82           | 85,86         | 87        |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 3220  | 1     | VIII - D | 88,89    | 82           | 90,91         | 92        |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 3305  | 2     | VIII - D | 98,99    | 82           | 100,101       | 102       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 3305  | 1     | VIII - D | 93,94    | 82           | 95,96         | 97        |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 3485  | 1     | VIII - D | 103,104  | 82           | 105,106       | 107       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 4484  | 1     | VIII - D | 108,109  | 82           | 110,111       | 112       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 4500  | 1     | VIII - D | 113,114  | 82           | 115,116       | 117       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 4505  | 1     | VIII - D | 118,119  | 82           | 120,121       | 122       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 5250  | 1     | VIII - D | 123,124  | 82           | 125,126       | 127       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 5250  | 2     | VIII - D | 128,129  | 82           | 130,131       | 132       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 5400  | 2     | VIII - D | 138,139  | 82           | 140,141       | 142       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 5400  | 1     | VIII - D | 133,134  | 82           | 135,136       | 137       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 5400  | 3     | VIII - D | 143,144  | 82           | 145,146       | 147       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 5681  | 1     | VIII - D | 148,149  | 82           | 150,151       | 152       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 5681  | 2     | VIII - D | 153,154  | 82           | 155,156       | 157       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 5681  | 3     | VIII - D | 158,159  | 82           | 160,161       | 162       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 7120  | 1     | VIII - D | 163,164  | 82           | 165,166       | 167       |           |            |
| AUTOMATIC CHILLER TUBE CLEANING SYSTEM       | 7770  | 1     | VIII - D | 168,169  | 82           | 170,171       | 172       |           |            |
| BACKGROUND                                   | Ex    | I     | -        | 1        |              |               |           |           |            |
| BOILER AND CHILLER CONTROL SYSTEMS           | N     | II    | - 3      | 4        |              |               |           |           |            |
| BOILER AND CHILLER OPERATION AND MAINTENANCE | N     | II    | - 3      | 4        |              |               |           |           |            |
| BOILER FEEDWATER ECONOMIZER                  | 115   | 2     | VI - C   | 460-462  | 458          | 463           | 464       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7105  | 1     | VI - C   | 465-467  | 458          | 468           | 469       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7105  | 4     | VI - C   | 480-482  | 458          | 483           | 484       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7105  | 3     | VI - C   | 475-477  | 458          | 478           | 479       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7105  | 2     | VI - C   | 470-472  | 458          | 473           | 474       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7153  | 1     | VI - C   | 485-487  | 458          | 488           | 489       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7579  | 2     | VI - C   | 495-497  | 458          | 498           | 499       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7579  | 1     | VI - C   | 490-492  | 458          | 493           | 494       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7770  | 2     | VI - C   | 505-507  | 458          | 508           | 509       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 7770  | 1     | VI - C   | 500-502  | 458          | 503           | 504       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 8028  | 2     | VI - C   | 515-517  | 458          | 518           | 519       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 8028  | 1     | VI - C   | 510-512  | 458          | 513           | 514       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 8874  | 1     | VI - C   | 520-522  | 458          | 523           | 524       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 8874  | 2     | VI - C   | 525-527  | 458          | 528           | 529       |           | 459        |
| BOILER FEEDWATER ECONOMIZER                  | 8977  | 1     | VI - C   | 530-532  | 458          | 533           | 534       |           | 459        |
| BOILER OPTINIZATION                          | 115   | 2     | IV - B   | 2        | 1            |               | 7         |           |            |
| BOILER OPTINIZATION                          | 7105  | 3     | IV - B   | 9        | 1            |               | 14        |           |            |
| BOILER OPTINIZATION                          | 7153  | 1     | IV - B   | 16       | 1            |               | 20        |           |            |
| BOILER OPTINIZATION                          | 7291  |       | IV - B   | 22       | 1            |               | 26        |           |            |
| BOILER OPTINIZATION                          | 7579  | 1     | IV - B   | 28       | 1            |               | 33        |           |            |
| BOILER OPTINIZATION                          | 7579  | 2     | IV - B   | 35       | 1            |               | 39        |           |            |
| BOILER OPTINIZATION                          | 7770  | 1     | IV - B   | 41       | 1            |               | 45        |           |            |
| BOILER OPTINIZATION                          | 7770  | 2     | IV - B   | 47       | 1            |               | 51        |           |            |
| BOILER OPTINIZATION                          | 8028  | 1     | IV - B   | 53       | 1            |               | 57        |           |            |
| BOILER OPTINIZATION                          | 8028  | 2     | IV - B   | 59       | 1            |               | 64        |           |            |
| BOILER OPTINIZATION                          | 8874  | 1     | IV - B   | 66       | 1            |               | 70        |           |            |
| BOILER OPTINIZATION                          | 8874  | 2     | IV - B   | 72       | 1            |               | 76        |           |            |
| BOILER OPTINIZATION                          | 8977  | 1     | IV - B   | 78       | 1            |               | 82        |           |            |
| BOILER OPTINIZATION                          | 8977  | 2     | IV - B   | 84       | 1            |               | 87        |           |            |
| BOILER TESTING                               | 115   | 2     | XI - F   |          | 51-56        |               |           | 57,58     |            |
| BOILER TESTING                               | 3624  | 2     | XI - F   |          | 51-56        |               |           | 61,62     |            |
| BOILER TESTING                               | 3624  | 4     | XI - F   |          | 51-56        |               |           | 65,66     |            |
| BOILER TESTING                               | 3624  | 1     | XI - F   |          | 51-56        |               |           | 59,60     |            |



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|--------------------|-------|-------|--------|----------|--------------|---------------|-----------|-----------|------------|
| BOILER TESTING     | 3624  | 3     | XI - F |          | 51-56        |               |           | 63,64     |            |
| BOILER TESTING     | 4725  | 2     | XI - F |          | 51-56        |               |           | 69,70     |            |
| BOILER TESTING     | 4725  | 1     | XI - F |          | 51-56        |               |           | 67,68     |            |
| BOILER TESTING     | 4725  | 3     | XI - F |          | 51-56        |               |           | 71,72     |            |
| BOILER TESTING     | 7105  | 1     | XI - F |          | 51-56        |               |           | 73,74     |            |
| BOILER TESTING     | 7105  | 3     | XI - F |          | 51-56        |               |           | 77,78     |            |
| BOILER TESTING     | 7105  | 2     | XI - F |          | 51-56        |               |           | 75,76     |            |
| BOILER TESTING     | 7105  | 4     | XI - F |          | 51-56        |               |           | 79,80     |            |
| BOILER TESTING     | 7153  | 1     | XI - F |          | 51-56        |               |           | 81,82     |            |
| BOILER TESTING     | 7291  | 1     | XI - F |          | 51-56        |               |           | 83,84     |            |
| BOILER TESTING     | 7291  | 2     | XI - F |          | 51-56        |               |           | 85,86     |            |
| BOILER TESTING     | 7579  | 2     | XI - F |          | 51-56        |               |           | 89,90     |            |
| BOILER TESTING     | 7579  | 1     | XI - F |          | 51-56        |               |           | 87,88     |            |
| BOILER TESTING     | 7579  | 5     | XI - F |          | 51-56        |               |           | 93,94     |            |
| BOILER TESTING     | 7579  | 4     | XI - F |          | 51-56        |               |           | 91,92     |            |
| BOILER TESTING     | 7770  | 2     | XI - F |          | 51-56        |               |           | 97,98     |            |
| BOILER TESTING     | 7770  | 1     | XI - F |          | 51-56        |               |           | 95,96     |            |
| BOILER TESTING     | 7855  | 1     | XI - F |          | 51-56        |               |           | 99,100    |            |
| BOILER TESTING     | 8028  | 2     | XI - F |          | 51-56        |               |           | 103,104   |            |
| BOILER TESTING     | 8028  | 1     | XI - F |          | 51-56        |               |           | 101,102   |            |
| BOILER TESTING     | 8874  | 1     | XI - F |          | 51-56        |               |           | 105,106   |            |
| BOILER TESTING     | 8874  | 2     | XI - F |          | 51-56        |               |           | 107,108   |            |
| BOILER TESTING     | 8977  | 2     | XI - F |          | 51-56        |               |           | 111,112   |            |
| BOILER TESTING     | 8977  | 1     | XI - F |          | 51-56        |               |           | 109,110   |            |
| BOILER TUNE-UP     | 115   | 2     | V - C  |          | 3            | 1             | 5         | 6         | 2          |
| BOILER TUNE-UP     | 3624  | 2     | V - C  | 11,12    | 1            | 13            | 14        |           | 2          |
| BOILER TUNE-UP     | 3624  | 3     | V - C  | 15,16    | 1            | 17            | 18        |           | 2          |
| BOILER TUNE-UP     | 3624  | 4     | V - C  | 19,20    | 1            | 21            | 22        |           | 2          |
| BOILER TUNE-UP     | 3624  | 1     | V - C  | 7,8      | 1            | 9             | 10        |           | 2          |
| BOILER TUNE-UP     | 4725  | 3     | V - C  | 31,32    | 1            | 33            | 34        |           | 2          |
| BOILER TUNE-UP     | 4725  | 2     | V - C  | 27,28    | 1            | 29            | 30        |           | 2          |
| BOILER TUNE-UP     | 4725  | 1     | V - C  | 23,24    | 1            | 25            | 26        |           | 2          |
| BOILER TUNE-UP     | 7105  | 4     | V - C  | 47,48    | 1            | 49            | 50        |           | 2          |
| BOILER TUNE-UP     | 7105  | 2     | V - C  | 39,40    | 1            | 41            | 42        |           | 2          |
| BOILER TUNE-UP     | 7105  | 3     | V - C  | 43,44    | 1            | 45            | 46        |           | 2          |
| BOILER TUNE-UP     | 7105  | 1     | V - C  | 35,36    | 1            | 37            | 38        |           | 2          |
| BOILER TUNE-UP     | 7153  | 1     | V - C  | 51,52    | 1            | 53            | 54        |           | 2          |
| BOILER TUNE-UP     | 7579  | 2     | V - C  | 55,56    | 1            | 57            | 58        |           | 2          |
| BOILER TUNE-UP     | 7770  | 2     | V - C  | 59,60    | 1            | 61            | 62        |           | 2          |
| BOILER TUNE-UP     | 8028  | 2     | V - C  | 67,68    | 1            | 69            | 70        |           | 2          |
| BOILER TUNE-UP     | 8028  | 1     | V - C  | 63,64    | 1            | 65            | 66        |           | 2          |
| BOILER TUNE-UP     | 8874  | 2     | V - C  | 75,76    | 1            | 77            | 78        |           | 2          |
| BOILER TUNE-UP     | 8874  | 1     | V - C  | 71,72    | 1            | 73            | 74        |           | 2          |
| BOILER TUNE-UP     | 8977  | 2     | V - C  | 83,84    | 1            | 85            | 86        |           | 2          |
| BOILER TUNE-UP     | 8977  | 1     | V - C  | 79,80    | 1            | 81            | 82        |           | 2          |
| BURNER REPLACEMENT | 115   | 2     | V - C  | 89,90    | 87           | 91            | 92        |           | 88         |
| BURNER REPLACEMENT | 7105  | 2     | V - C  | 97,98    | 87           | 99            | 100       |           | 88         |
| BURNER REPLACEMENT | 7105  | 1     | V - C  | 93,94    | 87           | 95            | 96        |           | 88         |
| BURNER REPLACEMENT | 7105  | 3     | V - C  | 101,102  | 87           | 103           | 104       |           | 88         |
| BURNER REPLACEMENT | 7105  | 4     | V - C  | 105,106  | 87           | 107           | 108       |           | 88         |
| BURNER REPLACEMENT | 7153  | 1     | V - C  | 109,110  | 87           | 111           | 112       |           | 88         |
| BURNER REPLACEMENT | 7579  | 2     | V - C  | 117,118  | 87           | 119           | 120       |           | 88         |
| BURNER REPLACEMENT | 7579  | 1     | V - C  | 113,114  | 87           | 115           | 116       |           | 88         |
| BURNER REPLACEMENT | 7770  | 1     | V - C  | 121,122  | 87           | 123           | 124       |           | 88         |

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| BURNER REPLACEMENT              | 7770 | 2 | V     | - C | 125,126  | 87           | 127           | 128       |           | 88         |
| BURNER REPLACEMENT              | 8028 | 1 | V     | - C | 129,130  | 87           | 131           | 132       |           | 88         |
| BURNER REPLACEMENT              | 8028 | 2 | V     | - C | 133,134  | 87           | 135           | 136       |           | 88         |
| BURNER REPLACEMENT              | 8874 | 2 | V     | - C | 141,142  | 87           | 143           | 144       |           | 88         |
| BURNER REPLACEMENT              | 8874 | 1 | V     | - C | 137,138  | 87           | 139           | 140       |           | 88         |
| BURNER REPLACEMENT              | 8977 | 2 | V     | - C | 149,150  | 87           | 151           | 152       |           | 88         |
| BURNER REPLACEMENT              | 8977 | 1 | V     | - C | 145,146  | 87           | 147           | 148       |           | 88         |
| CENTRAL CHILLED WATER PLANTS    |      | N | II    | - 3 | 5        |              |               |           |           |            |
| CENTRIFUGAL CHILLER REPLACEMENT | 5250 | 2 | IX    | - D | 352,353  | 351          | 354           | 355       |           |            |
| CHILLED WATER TEMPERATURE RESET | 3220 | 1 | IX    | - D | 442,443  | 441          | 444           | 445       |           |            |
| CHILLED WATER TEMPERATURE RESET | 3305 | 1 | IX    | - D | 446,447  | 441          | 448           | 449       |           |            |
| CHILLED WATER TEMPERATURE RESET | 4484 | 1 | IX    | - D | 450,451  | 441          | 452           | 453       |           |            |
| CHILLED WATER TEMPERATURE RESET | 4488 | 2 | IX    | - D | 454,455  | 441          | 456           | 457       |           |            |
| CHILLED WATER TEMPERATURE RESET | 5250 | 1 | IX    | - D | 458,459  | 441          | 460           | 461       |           |            |
| CHILLED WATER TEMPERATURE RESET | 5250 | 2 | IX    | - D | 462,463  | 441          | 464           | 465       |           |            |
| CHILLED WATER TEMPERATURE RESET | 5400 | 1 | IX    | - D | 466,467  | 441          | 468           | 469       |           |            |
| CHILLED WATER TEMPERATURE RESET | 5681 | 1 | IX    | - D | 470,471  | 441          | 472           | 473       |           |            |
| CHILLED WATER TEMPERATURE RESET | 5681 | 2 | IX    | - D | 474,475  | 441          | 476           | 477       |           |            |
| CHILLED WATER TEMPERATURE RESET | 5681 | 3 | IX    | - D | 478,479  | 441          | 480           | 481       |           |            |
| CHILLED WATER TEMPERATURE RESET | 7120 | 1 | IX    | - D | 482,483  | 441          | 484           | 485       |           |            |
| CHILLED WATER TEMPERATURE RESET | 7770 | 1 | IX    | - D | 486,487  | 441          | 488           | 489       |           |            |
| CHILLER ECONOMIZER              | 109  | 1 | IV    | - B | 141      | 131          |               | 143       |           |            |
| CHILLER ECONOMIZER              | 3485 | 1 | IV    | - B | 137      | 131          |               | 139       |           |            |
| CHILLER ECONOMIZER              | 4500 | 1 | IV    | - B | 132      | 131          |               | 135       |           |            |
| CHILLER OPTIMIZATION            | 3220 | 1 | IV    | - B | 91       | 90           |               | 94        |           |            |
| CHILLER OPTIMIZATION            | 4484 | 1 | IV    | - B | 96       | 90           |               | 99        |           |            |
| CHILLER OPTIMIZATION            | 4488 | 2 | IV    | - B | 101      | 90           |               | 104       |           |            |
| CHILLER OPTIMIZATION            | 5250 | 1 | IV    | - B | 106      | 90           |               | 109       |           |            |
| CHILLER OPTIMIZATION            | 5681 | 1 | IV    | - B | 111      | 90           |               | 114       |           |            |
| CHILLER OPTIMIZATION            | 5681 | 2 | IV    | - B | 116      | 90           |               | 119       |           |            |
| CHILLER OPTIMIZATION            | 5681 | 3 | IV    | - B | 121      | 90           |               | 124       |           |            |
| CHILLER OPTIMIZATION            | 7120 | 1 | IV    | - B | 126      | 90           |               | 129       |           |            |
| CHILLER SHUTDOWN                | 3220 | 1 | IX    | - D | 289,290  | 288          | 291           | 292       |           |            |
| CHILLER SHUTDOWN                | 4484 | 1 | IX    | - D | 293,294  | 288          | 295           | 296       |           |            |
| CHILLER SHUTDOWN                | 4488 | 2 | IX    | - D | 297,298  | 288          | 299           | 300       |           |            |
| CHILLER SHUTDOWN                | 5250 | 1 | IX    | - D | 301,302  | 288          | 303           | 304       |           |            |
| CHILLER SHUTDOWN                | 7120 | 1 | IX    | - D | 305,306  | 288          | 307           | 308       |           |            |
| CHILLER TESTING                 | 109  | 1 | XI    | - F |          | 1,2          |               |           | 3-5       |            |
| CHILLER TESTING                 | 3220 | 1 | XI    | - F |          | 1,2          |               |           | 6-8       |            |
| CHILLER TESTING                 | 3305 | 1 | XI    | - F |          | 1,2          |               |           | 9-11      |            |
| CHILLER TESTING                 | 3305 | 2 | XI    | - F |          | 1,2          |               |           | 12-14     |            |
| CHILLER TESTING                 | 3485 | 1 | XI    | - F |          | 1,2          |               |           | 15-17     |            |
| CHILLER TESTING                 | 4484 | 1 | XI    | - F |          | 1,2          |               |           | 18-20     |            |
| CHILLER TESTING                 | 4488 | 2 | XI    | - F |          | 1,2          |               |           | 24-26     |            |
| CHILLER TESTING                 | 4488 | 1 | XI    | - F |          | 1,2          |               |           | 21-23     |            |
| CHILLER TESTING                 | 4505 | 1 | XI    | - F |          | 1,2          |               |           | 27-29     |            |
| CHILLER TESTING                 | 5250 | 2 | XI    | - F |          | 1,2          |               |           | 33-35     |            |
| CHILLER TESTING                 | 5250 | 1 | XI    | - F |          | 1,2          |               |           | 30-32     |            |
| CHILLER TESTING                 | 5400 | 1 | XI    | - F |          | 1,2          |               |           | 36-38     |            |
| CHILLER TESTING                 | 5681 | 2 | XI    | - F |          | 1,2          |               |           | 42-44     |            |
| CHILLER TESTING                 | 5681 | 1 | XI    | - F |          | 1,2          |               |           | 39-41     |            |
| CHILLER TESTING                 | 7120 | 1 | XI    | - F |          | 1,2          |               |           | 45-47     |            |
| CHILLER TESTING                 | 7770 | 1 | XI    | - F |          | 1,2          |               |           | 48-50     |            |
| COMPLETE CHILLER OPTIMIZATION   | 5400 | 1 | IV    | - B | 146      | 145          |               | 150       |           |            |

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| COMPLETE CHILLER OPTIMIZATION                | 7770 | 1   | IV - B   |     | 152      | 145          |               | 156       |           |            |
| CONCLUSIONS                                  |      | Ex  | I -      |     | 8        |              |               |           |           |            |
| CONCLUSIONS                                  |      | N   | II - 6   |     | 1        |              |               |           |           |            |
| CONDENSER TUBE CLEANING                      | 109  | 1   | VIII - D |     | 2,3      | 1            | 4             | 5         |           |            |
| CONDENSER TUBE CLEANING                      | 3220 | 1   | VIII - D |     | 6,7      | 1            | 8             | 9         |           |            |
| CONDENSER TUBE CLEANING                      | 3305 | 2   | VIII - D |     | 14,15    | 1            | 16            | 17        |           |            |
| CONDENSER TUBE CLEANING                      | 3305 | 1   | VIII - D |     | 10,11    | 1            | 12            | 13        |           |            |
| CONDENSER TUBE CLEANING                      | 3485 | 1   | VIII - D |     | 18,19    | 1            | 20            | 21        |           |            |
| CONDENSER TUBE CLEANING                      | 4484 | 1   | VIII - D |     | 22,23    | 1            | 24            | 25        |           |            |
| CONDENSER TUBE CLEANING                      | 4488 | 1   | VIII - D |     | 26,27    | 1            | 28            | 29        |           |            |
| CONDENSER TUBE CLEANING                      | 4488 | 2   | VIII - D |     | 30,31    | 1            | 32            | 33        |           |            |
| CONDENSER TUBE CLEANING                      | 4500 | 1   | VIII - D |     | 34,35    | 1            | 36            | 37        |           |            |
| CONDENSER TUBE CLEANING                      | 4505 | 1   | VIII - D |     | 38,39    | 1            | 40            | 41        |           |            |
| CONDENSER TUBE CLEANING                      | 5250 | 1   | VIII - D |     | 42,43    | 1            | 44            | 45        |           |            |
| CONDENSER TUBE CLEANING                      | 5250 | 2   | VIII - D |     | 46,47    | 1            | 48            | 49        |           |            |
| CONDENSER TUBE CLEANING                      | 5400 | 3   | VIII - D |     | 58,59    | 1            | 60            | 61        |           |            |
| CONDENSER TUBE CLEANING                      | 5400 | 2   | VIII - D |     | 54,55    | 1            | 56            | 57        |           |            |
| CONDENSER TUBE CLEANING                      | 5400 | 1   | VIII - D |     | 50,51    | 1            | 52            | 53        |           |            |
| CONDENSER TUBE CLEANING                      | 5681 | 2   | VIII - D |     | 66,67    | 1            | 68            | 69        |           |            |
| CONDENSER TUBE CLEANING                      | 5681 | 3   | VIII - D |     | 70,71    | 1            | 72            | 73        |           |            |
| CONDENSER TUBE CLEANING                      | 5681 | 1   | VIII - D |     | 62,63    | 1            | 64            | 65        |           |            |
| CONDENSER TUBE CLEANING                      | 7120 | 1   | VIII - D |     | 74,75    | 1            | 76            | 77        |           |            |
| CONDENSER TUBE CLEANING                      | 7770 | 1   | VIII - D |     | 78,79    | 1            | 80            | 81        |           |            |
| CONTRACT SCOPE OF WORK                       |      |     | III - A  |     | 1        |              |               |           |           |            |
| CORRESPONDENCE                               |      |     | III - A  |     | 26       |              |               |           |           |            |
| DOWNSIZE BOILERS                             | 115  | 2   | VI - C   |     | 301,302  | 299          | 303           | 304       |           | 300        |
| DOWNSIZE BOILERS                             | 7105 | 4   | VI - C   |     | 317,318  | 299          | 319           | 320       |           | 300        |
| DOWNSIZE BOILERS                             | 7105 | 3   | VI - C   |     | 313,314  | 299          | 315           | 316       |           | 300        |
| DOWNSIZE BOILERS                             | 7105 | 2   | VI - C   |     | 309,310  | 299          | 311           | 312       |           | 300        |
| DOWNSIZE BOILERS                             | 7105 | 1   | VI - C   |     | 305,306  | 299          | 307           | 308       |           | 300        |
| DOWNSIZE BOILERS                             | 7153 | 1   | VI - C   |     | 321,322  | 299          | 323           | 324       |           | 300        |
| DOWNSIZE BOILERS                             | 7770 | 2   | VI - C   |     | 329,330  | 299          | 331           | 332       |           | 300        |
| DOWNSIZE BOILERS                             | 7770 | 1   | VI - C   |     | 325,326  | 299          | 327           | 328       |           | 300        |
| DOWNSIZE BOILERS                             | 8977 | 1   | VI - C   |     | 333,334  | 299          | 335,336       | 337       |           | 300        |
| DOWNSIZE BOILERS                             | 8977 | 2   | VI - C   |     | 338,339  | 299          | 340,341       | 342       |           | 300        |
| ECO DESCRIPTIONS                             |      | N   | II - 4   |     | 2        |              |               |           |           |            |
| ECOs ANALYSES                                |      | Ex  | I -      |     | 2        |              |               |           |           |            |
| ECOs NOT APPLICABLE                          |      | N   | II - 4   |     | 18       |              |               |           |           |            |
| ENERGY CONSERVATION OPPORTUNITIES            |      | Ex  | I -      |     | 2        |              |               |           |           |            |
| ENERGY CONSERVATION OPPORTUNITIES CONSIDERED |      | N   | II - 4   |     | 1        |              |               |           |           |            |
| ENERGY CONSERVATION OPPORTUNITIES EVALUATED  |      | N   | II - 4   |     | 1        |              |               |           |           |            |
| ENERGY STUDIES BY OTHERS                     |      | N   | II - 5   |     | 1        |              |               |           |           |            |
| EXISTING CONDITIONS                          |      | N   | II - 2   |     | 1        |              |               |           |           |            |
| EXISTING EQUIPMENT CONDITIONS                |      | N   | II - 2   |     | 10       |              |               |           |           |            |
| EXISTING INSTALLATION EQUIPMENT              |      | N   | II - 3   |     | 4        |              |               |           |           |            |
| FIELD SURVEY                                 |      | N   | II - 2   |     | 1        |              |               |           |           |            |
| INSTALLATION OF TURBULATORS                  | 115  | 2   | VII - C  |     | 770      | 769          | 771           | 772       |           |            |
| INSTALLATION OF TURBULATORS                  | 7105 | 1   | VII - C  |     | 773      | 769          | 774           | 775       |           |            |
| INSTALLATION OF TURBULATORS                  | 7105 | 3   | VII - C  |     | 779      | 769          | 780           | 781       |           |            |
| INSTALLATION OF TURBULATORS                  | 7105 | 4   | VII - C  |     | 782      | 769          | 783           | 784       |           |            |
| INSTALLATION OF TURBULATORS                  | 7105 | 2   | VII - C  |     | 776      | 769          | 777           | 778       |           |            |
| INSTALLATION OF TURBULATORS                  | 7153 | 1   | VII - C  |     | 785      | 769          | 786           | 787       |           |            |
| INSTALLATION OF TURBULATORS                  | 7579 | 1   | VII - C  |     | 788      | 769          | 789           | 790       |           |            |
| INSTALLATION OF TURBULATORS                  | 7579 | 2   | VII - C  |     | 791      | 769          | 792           | 793       |           |            |

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| INSTALLATION OF TURBULATORS               | 7770  | 2      | VII - C | 797      | 769          | 798           | 799       |           |            |
| INSTALLATION OF TURBULATORS               | 7770  | 1      | VII - C | 794      | 769          | 795           | 796       |           |            |
| INSTALLATION OF TURBULATORS               | 8028  | 1      | VII - C | 800      | 769          | 801           | 802       |           |            |
| INSTALLATION OF TURBULATORS               | 8028  | 2      | VII - C | 803      | 769          | 804           | 805       |           |            |
| INSTALLATION OF TURBULATORS               | 8874  | 2      | VII - C | 809      | 769          | 810           | 811       |           |            |
| INSTALLATION OF TURBULATORS               | 8874  | 1      | VII - C | 806      | 769          | 807           | 808       |           |            |
| INSTALLATION OF TURBULATORS               | 8977  | 1      | VII - C | 812      | 769          | 813           | 814       |           |            |
| INSTALLATION OF TURBULATORS               | 8977  | 2      | VII - C | 815      | 769          | 816           | 817       |           |            |
| INTRODUCTION                              | N     | II - 1 |         | 1        |              |               |           |           |            |
| INTRODUCTION - Executive Summary          | Ex    | I -    |         | 1        |              |               |           |           |            |
| OPERATION AND MAINTENANCE RECOMMENDATIONS | N     | II - 4 |         | 8        |              |               |           |           |            |
| ORGANIZATIONAL TABLE FOR ECOS             | N     | II - 4 |         | 1        |              |               |           |           |            |
| OVERVIEW OF TECHNICAL APPROACH            | N     | II - 1 |         | 2        |              |               |           |           |            |
| OXYGEN TRIM SYSTEM                        | 115   | 2      | VII - C | 640-643  | 638          | 644           | 645       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7105  | 4      | VII - C | 664-667  | 638          | 668           | 669       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7105  | 1      | VII - C | 646-649  | 638          | 650           | 651       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7105  | 2      | VII - C | 652-655  | 638          | 656           | 657       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7105  | 3      | VII - C | 658-661  | 638          | 662           | 663       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7153  | 1      | VII - C | 670-673  | 638          | 674           | 675       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7579  | 2      | VII - C | 682-685  | 638          | 686           | 687       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7579  | 1      | VII - C | 676-679  | 638          | 680           | 681       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7770  | 1      | VII - C | 688-691  | 638          | 692           | 693       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 7770  | 2      | VII - C | 694-697  | 638          | 698           | 699       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 8028  | 2      | VII - C | 706-709  | 638          | 710           | 711       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 8028  | 1      | VII - C | 700-703  | 638          | 704           | 705       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 8874  | 1      | VII - C | 712-715  | 638          | 716           | 717       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 8874  | 2      | VII - C | 718-721  | 638          | 722           | 723       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 8977  | 1      | VII - C | 724-727  | 638          | 728           | 729       |           | 639        |
| OXYGEN TRIM SYSTEM                        | 8977  | 2      | VII - C | 730-733  | 638          | 734           | 735       |           | 639        |
| PERFORMANCE TESTING                       | N     | II - 3 |         | 1        |              |               |           |           |            |
| PREHEAT COMBUSTION AIR                    | 115   | 2      | VI - C  | 365-367  | 363          | 368           | 369       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7105  | 4      | VI - C  | 385-387  | 363          | 388           | 389       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7105  | 1      | VI - C  | 370-372  | 363          | 373           | 374       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7105  | 2      | VI - C  | 375-377  | 363          | 378           | 379       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7105  | 3      | VI - C  | 380-382  | 363          | 383           | 384       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7153  | 1      | VI - C  | 390-392  | 363          | 393           | 394       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7579  | 1      | VI - C  | 395-397  | 363          | 398           | 399       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7579  | 2      | VI - C  | 400-402  | 363          | 403           | 404       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7770  | 1      | VI - C  | 405-407  | 363          | 408           | 409       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 7770  | 2      | VI - C  | 410-412  | 363          | 413           | 414       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 8028  | 2      | VI - C  | 420-422  | 363          | 423           | 424       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 8028  | 1      | VI - C  | 415-417  | 363          | 418           | 419       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 8874  | 1      | VI - C  | 425-427  | 363          | 428           | 429       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 8874  | 2      | VI - C  | 430-432  | 363          | 433           | 434       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 8977  | 2      | VI - C  | 440-442  | 363          | 443           | 444       |           | 364        |
| PREHEAT COMBUSTION AIR                    | 8977  | 1      | VI - C  | 435-437  | 363          | 438           | 439       |           | 364        |
| PURPOSE AND OBJECTIVE                     | N     | II - 1 |         | 1        |              |               |           |           |            |
| RECOMMENDATIONS                           | N     | II - 7 |         | 1        |              |               |           |           |            |
| RECOMMENDATIONS                           | Ex    | I -    |         | 16       |              |               |           |           |            |
| REPLACEMENT BOILER                        | 115   | 2      | V - C   | 175,176  | 173          | 177           | 178       |           | 174        |
| REPLACEMENT BOILER                        | 7105  | 2      | V - C   | 183,184  | 173          | 185           | 186       |           | 174        |
| REPLACEMENT BOILER                        | 7105  | 4      | V - C   | 215,216  | 173          | 217           | 218       |           | 174        |
| REPLACEMENT BOILER                        | 7105  | 1      | V - C   | 179,180  | 173          | 181           | 182       |           | 174        |
| REPLACEMENT BOILER                        | 7153  | 1      | V - C   | 187,188  | 173          | 189           | 190       |           | 174        |

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| REPLACEMENT BOILER                        | 7579  | 2     | V - C   | 195,196  | 173          | 197           | 198       |           | 174        |
| REPLACEMENT BOILER                        | 7579  | 1     | V - C   | 191,192  | 173          | 193           | 194       |           | 174        |
| REPLACEMENT BOILER                        | 7770  | 1     | V - C   | 199,200  | 173          | 201           | 202       |           | 174        |
| REPLACEMENT BOILER                        | 7770  | 2     | V - C   | 203,204  | 173          | 205           | 206       |           | 174        |
| REPLACEMENT BOILER                        | 8028  | 1     | V - C   | 211,212  | 173          | 213           | 214       |           | 174        |
| REPLACEMENT BOILER                        | 8874  | 2     | V - C   | 207,208  | 173          | 209           | 210       |           | 174        |
| REPLACEMENT BOILER                        | 8977  | 2     | V - C   | 224,225  | 173          | 226,227       | 228       |           | 174        |
| REPLACEMENT BOILER                        | 8977  | 1     | V - C   | 219,220  | 173          | 221,222       | 223       |           | 174        |
| RESULTS                                   |       | Ex    | I -     |          | 8            |               |           |           |            |
| RESULTS, CONCLUSIONS, AND RECOMMENDATIONS |       | Ex    | I -     |          | 8            |               |           |           |            |
| SCOPE                                     |       | Ex    | I -     |          | 1            |               |           |           |            |
| SCOPE OF WORK                             |       | N     | II - 1  |          | 1            |               |           |           |            |
| STEAM VS. ELECTRICALLY DRIVEN CHILLERS    | 3220  | 1     | IX - D  | 357,358  | 356          | 359           | 360       |           |            |
| STEEL FEEDWATER ECONOMIZER                | 115   | 2     | VII - C | 551-553  | 549          | 554           | 555       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7105  | 3     | VII - C | 566-568  | 549          | 569           | 570       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7105  | 2     | VII - C | 561-563  | 549          | 564           | 565       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7105  | 4     | VII - C | 571-573  | 549          | 574           | 574       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7105  | 1     | VII - C | 556-558  | 549          | 559           | 560       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7153  | 1     | VII - C | 576-578  | 549          | 579           | 580       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7579  | 1     | VII - C | 581-583  | 549          | 584           | 585       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7579  | 2     | VII - C | 586-588  | 549          | 589           | 590       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7770  | 1     | VII - C | 591-593  | 549          | 594           | 595       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 7770  | 2     | VII - C | 596-598  | 549          | 599           | 600       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 8028  | 2     | VII - C | 606-608  | 549          | 609           | 610       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 8028  | 1     | VII - C | 601-603  | 549          | 604           | 605       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 8874  | 2     | VII - C | 616-618  | 549          | 619           | 620       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 8874  | 1     | VII - C | 611-613  | 549          | 614           | 615       |           | 550        |
| STEEL FEEDWATER ECONOMIZER                | 8977  | 1     | VII - C | 621-623  | 549          | 624           | 625       |           | 550        |
| SUMMER BOILER INSTALLATION                | 115   |       | V - C   | 251,252  | 249          | 253           | 254       |           | 250        |
| SUMMER BOILER INSTALLATION                | 7153  |       | V - C   | 255,256  | 249          | 257           | 258       |           | 250        |
| SUMMER BOILER INSTALLATION                | 7291  |       | V - C   | 259,260  | 249          | 261           | 262       |           | 250        |
| SUMMER BOILER INSTALLATION                | 7579  |       | V - C   | 263,264  | 249          | 265           | 266       |           | 250        |
| SUMMER BOILER INSTALLATION                | 7770  |       | V - C   | 267,268  | 249          | 269           | 270       |           | 250        |
| SUMMER BOILER INSTALLATION                | 7855  |       | V - C   | 271,272  | 249          | 273           | 274       |           | 250        |
| SUMMER BOILER INSTALLATION                | 8874  |       | V - C   | 275,276  | 249          | 277           | 278       |           | 250        |
| TECHNICAL APPROACH                        |       | Ex    | I -     |          | 2            |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 115   | 2     | X - E   |          | 1,2          |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 3624  | 3     | X - E   |          | 7,8          |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 3624  | 4     | X - E   |          | 9,10         |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 3624  | 2     | X - E   |          | 5,6          |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 3624  | 1     | X - E   |          | 3,4          |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 4725  | 1     | X - E   |          | 11,12        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 4725  | 2     | X - E   |          | 13,14        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 4725  | 3     | X - E   |          | 15,16        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7105  | 3     | X - E   |          | 21,22        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7105  | 2     | X - E   |          | 19,20        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7105  | 1     | X - E   |          | 17,18        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7105  | 4     | X - E   |          | 23,24        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7153  | 1     | X - E   |          | 25,26        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7291  | 2     | X - E   |          | 29,30        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7291  | 1     | X - E   |          | 27,28        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7579  | 1     | X - E   |          | 31,32        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7579  | 5     | X - E   |          | 37,38        |               |           |           |            |
| TESTED COMBUSTION EFFICIENCY              | 7579  | 2     | X - E   |          | 33,34        |               |           |           |            |

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| TESTED COMBUSTION EFFICIENCY      | 7579 | 4 | X     | -   | E        | 35,36        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 7770 | 1 | X     | -   | E        | 39,40        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 7770 | 2 | X     | -   | E        | 41,42        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 7855 | 1 | X     | -   | E        | 43,44        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 8028 | 1 | X     | -   | E        | 45,46        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 8028 | 2 | X     | -   | E        | 47,48        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 8874 | 2 | X     | -   | E        | 51,52        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 8874 | 1 | X     | -   | E        | 49,50        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 8977 | 2 | X     | -   | E        | 55,56        |           |          |           |           |            |
| TESTED COMBUSTION EFFICIENCY      | 8977 | 1 | X     | -   | E        | 53,54        |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 115  | 2 | X     | -   | E        | 107,108      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 3624 | 2 | X     | -   | E        | 111,112      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 3624 | 1 | X     | -   | E        | 109,110      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 3624 | 3 | X     | -   | E        | 113,114      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 3624 | 4 | X     | -   | E        | 115,116      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 4725 | 3 | X     | -   | E        | 121,122      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 4725 | 1 | X     | -   | E        | 117,118      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 4725 | 2 | X     | -   | E        | 119,120      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 4725 | 4 | X     | -   | E        | 123,124      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7105 | 2 | X     | -   | E        | 127,128      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7105 | 3 | X     | -   | E        | 129,130      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7105 | 1 | X     | -   | E        | 125,126      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7105 | 4 | X     | -   | E        | 131,132      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7153 | 1 | X     | -   | E        | 133,134      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7291 | 2 | X     | -   | E        | 137,138      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7291 | 1 | X     | -   | E        | 135,136      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7579 | 2 | X     | -   | E        | 141,142      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7579 | 1 | X     | -   | E        | 139,140      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7770 | 1 | X     | -   | E        | 143,144      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7770 | 2 | X     | -   | E        | 145,146      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7855 | 2 | X     | -   | E        | 149,150      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 7855 | 1 | X     | -   | E        | 147,148      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 8028 | 2 | X     | -   | E        | 153,154      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 8028 | 1 | X     | -   | E        | 151,152      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 8874 | 1 | X     | -   | E        | 155,156      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 8874 | 2 | X     | -   | E        | 157,158      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 8977 | 2 | X     | -   | E        | 161,162      |           |          |           |           |            |
| TUNED FOR AVERAGE LOAD CONDITIONS | 8977 | 1 | X     | -   | E        | 159,160      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 115  | 2 | X     | -   | E        | 163,164      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 3624 | 4 | X     | -   | E        | 165,166      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 4725 | 4 | X     | -   | E        | 167,168      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 7153 | 1 | X     | -   | E        | 169,170      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 7291 | 1 | X     | -   | E        | 171,172      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 7579 | 1 | X     | -   | E        | 173,174      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 7770 | 1 | X     | -   | E        | 175,176      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 7855 | 1 | X     | -   | E        | 177,178      |           |          |           |           |            |
| TUNED FOR SUMMER LOAD CONDITIONS  | 8874 | 2 | X     | -   | E        | 179,180      |           |          |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS  | 115  | 2 | X     | -   | E        | 57,58        |           |          |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS  | 3624 | 1 | X     | -   | E        | 59,60        |           |          |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS  | 3624 | 4 | X     | -   | E        | 65,66        |           |          |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS  | 3624 | 3 | X     | -   | E        | 63,64        |           |          |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS  | 3624 | 2 | X     | -   | E        | 61,62        |           |          |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS  | 4725 | 2 | X     | -   | E        | 69,70        |           |          |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS  | 4725 | 1 | X     | -   | E        | 67,68        |           |          |           |           |            |

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| TUNED FOR TESTED LOAD CONDITIONS | 4725  | 3     | X - E    | 71,72     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7105  | 4     | X - E    | 79,80     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7105  | 2     | X - E    | 75,76     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7105  | 3     | X - E    | 77,78     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7105  | 2     | X - E    | 85,86     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7105  | 1     | X - E    | 73,74     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7153  | 1     | X - E    | 81,82     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7291  | 1     | X - E    | 83,84     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7579  | 2     | X - E    | 87,88     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7579  | 4     | X - E    | 89,90     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7770  | 2     | X - E    | 91,92     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 7855  | 1     | X - E    | 93,94     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 8028  | 2     | X - E    | 97,98     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 8028  | 1     | X - E    | 95,96     |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 8874  | 1     | X - E    | 99,100    |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 8874  | 2     | X - E    | 101,102   |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 8977  | 2     | X - E    | 105,106   |              |               |           |           |            |
| TUNED FOR TESTED LOAD CONDITIONS | 8977  | 1     | X - E    | 103,104   |              |               |           |           |            |
| TWO-SPEED COOLING TOWER FAN      | 109   | 1     | IX - D   | 310,311   | 309          | 312           | 313-316   |           |            |
| TWO-SPEED COOLING TOWER FAN      | 3220  | 1     | IX - D   | 317,318   | 309          | 319           | 320-323   |           |            |
| TWO-SPEED COOLING TOWER FAN      | 3485  | 1     | IX - D   | 324,325   | 309          | 326           | 327-330   |           |            |
| TWO-SPEED COOLING TOWER FAN      | 4500  | 1     | IX - D   | 330A,330B | 309          | 330C          | 330D,330E |           |            |
| TWO-SPEED COOLING TOWER FAN      | 4505  | 1     | IX - D   | 331,332   | 309          | 333           | 334-337   |           |            |
| TWO-SPEED COOLING TOWER FAN      | 7770  | 1     | IX - D   | 338,339   | 309          | 340           | 341-344   |           |            |
| UTILITY RATES                    |       | N     | II - 2   | 3         |              |               |           |           |            |
| VARIABLE SPEED FANS              | 3624  | 4     | VII - C  | 754       | 742          | 755           | 756       |           | 743,744    |
| VARIABLE SPEED FANS              | 3624  | 1     | VII - C  | 745       | 742          | 746           | 747       |           | 743,744    |
| VARIABLE SPEED FANS              | 3624  | 2     | VII - C  | 748       | 742          | 749           | 750       |           | 743,744    |
| VARIABLE SPEED FANS              | 3624  | 3     | VII - C  | 751       | 742          | 752           | 753       |           | 743,744    |
| VARIABLE SPEED FANS              | 4725  | 4     | VII - C  | 766       | 742          | 767           | 768       |           | 743,744    |
| VARIABLE SPEED FANS              | 4725  | 2     | VII - C  | 760       | 742          | 761           | 762       |           | 743,744    |
| VARIABLE SPEED FANS              | 4725  | 3     | VII - C  | 763       | 742          | 764           | 765       |           | 743,744    |
| VARIABLE SPEED FANS              | 4725  | 1     | VII - C  | 757       | 742          | 758           | 759       |           | 743,744    |
| VARIABLE SPEED PUMPING           | 3220  | 1     | IX - D   | 494,495   | 493          | 497,498       | 499       |           |            |
| VARIABLE SPEED PUMPING           | 3485  | 1     | IX - D   | 500,501   | 493          | 503,504       | 505       |           |            |
| VARIABLE SPEED PUMPING           | 4484  | 1     | IX - D   | 506,507   | 493          | 509,510       | 511       |           |            |
| VARIABLE SPEED PUMPING           | 5681  | 1     | IX - D   | 512,513   | 493          | 515,516       | 517       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 109   | 1     | VIII - D | 201,202   | 200          | 203,204       | 205       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 3220  | 1     | VIII - D | 206,207   | 200          | 208,209       | 210       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 3305  | 2     | VIII - D | 216,217   | 200          | 218,219       | 220       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 3305  | 1     | VIII - D | 211,212   | 200          | 213,214       | 215       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 3485  | 1     | VIII - D | 221,222   | 200          | 223,224       | 225       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 4488  | 1     | VIII - D | 226,227   | 200          | 228,229       | 230       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 4488  | 2     | VIII - D | 231,232   | 200          | 233,234       | 235       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 4500  | 1     | VIII - D | 236,237   | 200          | 238,239       | 240       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 4505  | 1     | VIII - D | 241,242   | 200          | 243,244       | 245       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 5250  | 1     | VIII - D | 246,247   | 200          | 248,249       | 250       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 5400  | 1     | VIII - D | 251,252   | 200          | 253,254       | 255       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 5400  | 2     | VIII - D | 256,257   | 200          | 258,259       | 260       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 5681  | 1     | VIII - D | 261,262   | 200          | 263,264       | 265       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 7120  | 1     | VIII - D | 266,267   | 200          | 268,269       | 270       |           |            |
| WATER TREATMENT/FILL REPLACEMENT | 7770  | 1     | VIII - D | 271,272   | 200          | 273,274       | 275       |           |            |
| WATERSIDE ECONOMIZER             | 109   | 1     | IX - D   | 365,366   | 364          | 368           | 369       |           |            |
| WATERSIDE ECONOMIZER             | 3220  | 1     | IX - D   | 370,371   | 364          | 373           | 374       |           |            |

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| WATERSIDE ECONOMIZER | 3305  | 1     | IX - D | 375,376  | 364          | 378           | 379       |           |            |
| WATERSIDE ECONOMIZER | 3485  | 1     | IX - D | 380,381  | 364          | 383           | 384       |           |            |
| WATERSIDE ECONOMIZER | 4484  | 1     | IX - D | 385,386  | 364          | 388           | 389       |           |            |
| WATERSIDE ECONOMIZER | 4488  | 1     | IX - D | 390,391  | 364          | 393           | 394       |           |            |
| WATERSIDE ECONOMIZER | 4500  | 1     | IX - D | 395,396  | 364          | 398           | 399       |           |            |
| WATERSIDE ECONOMIZER | 4505  | 1     | IX - D | 400,401  | 364          | 403           | 404       |           |            |
| WATERSIDE ECONOMIZER | 5250  | 1     | IX - D | 405,406  | 364          | 408           | 409       |           |            |
| WATERSIDE ECONOMIZER | 5400  | 3     | IX - D | 410,411  | 364          | 413           | 414       |           |            |
| WATERSIDE ECONOMIZER | 5681  | 1     | IX - D | 415,416  | 364          | 418           | 419       |           |            |
| WATERSIDE ECONOMIZER | 7120  | 1     | IX - D | 420,421  | 364          | 423           | 424       |           |            |
| WATERSIDE ECONOMIZER | 7770  | 1     | IX - D | 425,426  | 364          | 428           | 429       |           |            |
| WORK ACCOMPLISHED    |       | N     | II - 3 |          | 1            |               |           |           |            |