



**Executive Summary**

**FINAL REPORT**

**ENERGY ENGINEERING ANALYSIS (EEA) PROGRAM**

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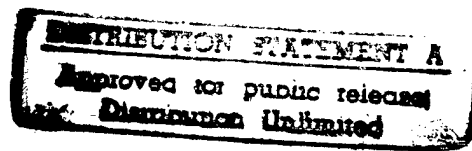
**RED RIVER ARMY DEPOT  
TEXAS**

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CORPS OF ENGINEERS  
FORT WORTH, TEXAS**

Under



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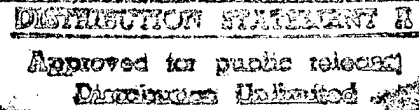
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## EXECUTIVE SUMMARY

ENERGY ENGINEERING ANALYSIS (EEA) PROGRAM  
RED RIVER ARMY DEPOT, TEXAS



### INTRODUCTION

The objectives of this Energy Engineering Analysis (EEA) for RRAD were three-fold:

- o Develop a systematic plan of projects which will result in reducing energy consumption.
- o Consider renewable energy sources with the objective of establishing an orderly procedure for reducing use of non-renewable energy sources.
- o Determine the feasibility of Total Energy (TE), Selective Energy (SE), and Central Heating Plant (CHP) concepts using alternative fuels.

In essence, an assessment of the entire energy picture at RRAD was undertaken. This report is a summary of that effort.

RRAD was originally built during 1941 and 1942 as a reserve ordnance depot for the Army. Since then, the missions and activities at RRAD have broadened to the point that it is now one of the largest Army depots in the continental United States. Located just west of Texarkana, Texas, RRAD encompasses an area of approximately 19,886 acres.

The primary missions at RRAD are general supply and maintenance of vital Army equipment and ordnance material. The supply activities constitute the stocking, distribution, storage and supply of general Army supplies for the central region of the United States. Supply of vehicles, ammunition and guided missiles from RRAD encompasses a much larger region. The maintenance and repair functions at RRAD consists of the overhaul, modification, conversion and repair of automotive equipment and combat vehicles, missile systems and components, armament, and ammunition. Approximately 5500 people are currently employed at RRAD to carry out its mission.

### DATA BASE FOR ANALYSIS

The study commenced with the collection of all the raw data and information required to determine the present energy distribution throughout the Depot and the forms of present energy consumption. This raw data and information consists of building envelope characteristics, type and method of operating environmental and process energy systems, building population and occupancy schedules, historical energy usage, etc.. This data was then used as the basis for determining a detailed energy data base for the entire facility, which traces the form and quantity of energy consumption from the receiving point, through conversion processes, and on to the point of end use for heating, cooling, lighting, process, etc.. The energy data base provides a detailed picture of present energy consumption which was then used in the process of identifying energy conservation opportunities (ECOs) and to serve as a gauge against which energy savings calculations were compared.

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In this case, present energy consumption was considered to be the actual total energy consumption recorded for FY 1979, which was the most recent, complete year of data when the study was commenced. Thus, the energy data base used is a detailed breakdown of the actual total energy consumption of FY 1979. Table ES-1 below shows the composite breakdown from an itemized building assessment in five categories. A more detailed breakdown on a building by building basis may be found in Table 3.9 on page 3-41 in Volume I of the report.

TABLE ES-1

ENERGY DATA BASE (FY 1979)

	<u>FOSSIL FUEL</u>		<u>ELECTRICITY</u>	
	<u>10<sup>6</sup> Btu</u>	<u>% of Total</u>	<u>kWh</u>	<u>% of Total</u>
Heating	157,647	29.1	392,430	1.0
Cooling	-	-	5,521,670	13.4
Lighting	-	-	8,768,610	21.3
Process	167,032	30.8	23,430,768	56.9
Other:				
o Distribution and transformer losses	72,127	13.3	2,240,666	5.4
o Conversion losses	98,687	18.0	-	-
o Condensate losses	44,686	8.2	-	-
o Domestic hot water and miscellaneous	545	0.1	69,886	0.2
o Little use facilities	1,587	0.5	740,970	1.8
	<u>542,311</u>		<u>41,165,000</u>	

EVALUATION OF ENERGY CONSERVATION OPPORTUNITIES

Potential ECOs were identified in a number of areas during the initial energy analysis. Not only did typical building envelope ECOs exist due to the age of most buildings, but opportunities also exist in industrial process areas of ventilation systems, outside air reductions, steam curing processes, cleaning operations, paint booths, boiler/steam/and condensate return system modifications, fuel systems, and extension of the Energy Monitoring and Control System (EMCS) functions beyond that already programmed for implementation. As a result, ECOs were identified and investigated in numerous areas, with economically feasible ECOs determined in nearly all functional areas at RRAD. All ECOs were evaluated to determine feasibility in accordance with the requirements of the Energy Conservation Investment Program (ECIP) guidelines.

Since many ECOs are interrelated (i.e., the savings of one affect the savings of another), energy conservation analysis of a building with multiple ECOs identified was done in the following sequence in order to account for those interrelationships:

- o The building envelope was evaluated first to insure that it was as weathertight as is economically feasible under ECIP guidelines.

- o Next, the heating, ventilating, air conditioning (HVAC) and exhaust systems were evaluated, assuming the feasible building envelope ECOs were implemented. Also, internal process systems and functions were evaluated at the same time, if they did not affect the functional requirements being performed.
- o Centralized control of energy systems through use of an Energy Monitoring and Control System (EMCS) was evaluated.
- o Site electrical and steam distribution systems were evaluated.
- o Central steam plants were evaluated.

The results of the detailed analysis of ECOs based on ECIP criteria are summarized in Table ES-2 on the following two pages. ECO descriptions and identification of buildings to which they apply may be found in Volume I, Sections 4.0 and 5.0.

TABLE ES-2

FEASIBLE ECOS FOR RRAD

<u>ECO Description</u>	<u>Energy Savings (Increase)</u>		<u>Capital Cost Estimate (FY 1983)</u>	<u>E/C Ratio</u>
	<u>Fossil Fuel (10<sup>6</sup> Btu/yr)</u>	<u>Electricity (kWh/yr)</u>		
Building envelope weatherization (caulk and weather-stripping, roof insulation, wall insulation, window insulation, door insulation, and building skirt insulation).	20,398	157,556	\$376,765	59.0
Insulate heated cleaning vats.	1401.5	-	22,630	61.0
Install cleaning vat covers.	3288	-	10,748	306
Utilize H.P. Water cleaning in lieu of steam cleaning.	6086	(56,400)	25,000	217.0
Add additional insulation to steam and condensate lines.	11,354	-	258,102	44.0
Replace selected boilers, or modify burners and controls.	10,403	(154,395)	245,390	35.1
Improve tire/tread mold operations.	36,097	-	58,060	621.7
Modify paint booths.	2325	59,761	67,245	44.9
Insulate domestic hot water heaters and add flue gas dampers.	810.6	-	19,195	42.2
Install push-pull ventilation systems over cleaning vats.	2440.8	290,213	136,400	42.6
Reduce airflow in process ventilation systems.	96.7	40,270	6,075	92.8
Replace furnaces in family housing.	729	-	40,800	17.9
Install ceiling fans.	2064	(48,520)	70,916	21.6

TABLE ES-2-Continued

FEASIBLE ECOs FOR RRAD

<u>ECO Description</u>	<u>Energy Savings (Increase)</u>		<u>Capital Cost Estimate (FY 1983)</u>	<u>E/C Ratio</u>
	<u>Fossil Fuel (10<sup>6</sup> Btu/yr)</u>	<u>Electricity (kWh/yr)</u>		
Reduce outside airflow/automatic ignition system on makeup air.	521.5	48,050	\$ 22,500	48.0
Install night and weekend setback on Bldgs. not on EMCS.	714	14,883	9,500	93.3
Extend EMCS to more than initial 53 Bldgs..	7333	350,891	447,584	25.5
	<u>106,057.1</u>	<u>702,309</u>	<u>\$1,806,162</u>	<u>63.2</u>

These ECOs represent an energy savings (rounded) of 21 percent for fossil fuel and 2 percent for electricity, when compared to the data base year of analysis: FY 1979. This equates to a 12 percent source energy savings, based on FY 1979 use. When using the FY 1975 reference year for comparison as outlined in the Army Facilities Energy Plan, it is noted that the FY 1979 energy use at RRAD is greater than FY 1975 base. Fossil fuel use in FY 1979 is 21.4 percent greater than FY 1975, and electrical energy consumption is 7.1 percent more. Therefore, these ECO savings represent a 26.8 percent savings in fossil fuel, 1.8 percent savings in electricity, and a 14 percent source energy savings when compared to the FY 1975 data base.

Other ECIP projects presently programmed at RRAD and not included in these savings results (but considered implemented before evaluating ECOs in this Study) are:

- Phase I EMCS - 53 buildings.
- Building and Window Insulation - 29 buildings.
- Solar film on air conditioned facilities - 20 buildings.

Also, other energy conservation measures have been placed in effect at RRAD since the initial data base was established, which were not funded by ECIP funds, such as:

- Solid state battery chargers.
- Precipitators on portable welding machines.
- Time clocks on formerly 24-hour ventilation systems.

In addition, a new coal/wood fired central heating plant is planned and scheduled for FY 1982 funding to replace the boilers in Plants 319 and 591. Various Energy Showcase projects are also planned at RRAD.

The feasible ECOs, based on a E/C ratio of 14\* or more, were developed into ECIP projects by grouping ECOs into packages of \$100,000 or more for funding, and are included in Volume IV of the report with Form DD-1391s and Project Development Brochures (PDBs). Identification of these projects are as follows:

<u>Project No.</u>	<u>Project Title</u>
RR/E - 0100	Building Weatherization.
RR/E - 0101	Process ECO Modifications.
RR/E - 0102	HVAC System and Control Modifications.
RR/E - 0103	Additional Steam and Condensate Line Insulation.
RR/E - 0104	Proposed EMCS Expansion.

In preparing the programming documents, economic computations and DD Form 1391s for each project, guidance\*\* was received from the Fort Worth District, Corps of Engineers as follows:

\* DAEN-MPO-U TWX dated 29 December 1980.  
\*\* 27 February 1981.

- o On construction cost escalation factors, AR415-17 and EIRS Bulletin should be used, which would be data shown in paragraph 1 (ECIP Economic Analysis Summary) and items 8 and 9 DD form 1391 (Project Cost and Cost Estimates).
- o Paragraph 2 and 3 (ECIP Economic Analysis Summary) should be computed using the differential fuel escalation rates set forth in ECIP guidance.

This was done for each project, preparing each project for FY 1983 and adjusting economic justification to that year. Construction costs were escalated to Midpoint of Construction Date (MCD) per AR-415-17 and fuel costs were escalated per ECIP criteria.

Based on the ECIP criteria for the average E/C ratio for all ECIP projects in a given program year (32 for FY 1983; 30 for FY 1984), the recommended implementation program for these projects is as follows:

<u>Description</u>	<u>Project No.</u>	<u>Savings (mBtu)</u>	<u>Capital Cost Estimate (1983\$)</u>	<u>E/C Ratio</u>	<u>Avg E/C Ratio</u>
<u>FY 1983</u>					
Process Modifications	RR/E-0101	41,349	107,100	386.1	
Bldg. Weatherization	RR/E-0100	30,228	547,300	55.3	
		<u>71,577</u>	<u>654,400</u>		<u>109.4</u>
EMCS Extension	RR/E-0104	11,403	519,800	23.2	
		<u>82,970</u>	<u>\$1,174,200</u>		<u>70.7</u>
<u>FY 1984</u>					
HVAC/Controls	RR/E-0102	9,354	262,500	35.6	
Stm & Cond Insulation	RR/E-0103	11,354	333,700	34.0	
		<u>20,708</u>	<u>\$596,200</u>		<u>34.7</u>

Other ECOs were evaluated in the process of determining feasible projects. Those ECOs which were evaluated but did not meet ECIP criteria, or were eliminated because of Army Regulations (as noted below) were:

- Storm Windows.
- Shading Devices, Insulating Films or Reflective Films.
- Reduced Ceiling Height.
- Air Curtains.
- Economizer Cycles.
- Conversion to Variable-Air-Volume.
- Exhaust Heat Recovery.
- Flue Gas Heat Recovery.
- Airless spray vs. air spray paint application.
- Direct gas fired makeup air units for paint booths (eliminated because of increased dependence on a critical fuel - natural gas).
- Electric Infrared curing versus paint booths/ovens (eliminated because of increased use of electricity for heating purposes).
- Electrostatic spray in paint booths.
- Consolidation of painting operations.
- Entrance Vestibules.

## SOLAR ENERGY AND RENEWABLE ENERGY SOURCES

Following the ECO evaluations and ECIP project development, an evaluation of renewable energy sources was performed. Solar energy utilization at RRAD is detailed in Volume I, Section 7.0. The results of the solar energy analysis are summarized in Table ES-3 below:

TABLE ES-3  
Solar Energy Analysis

	<u>Domestic Hot Water Systems</u>	<u>Process Solar Heating Systems</u>	<u>Passive Solar Energy Systems</u>
No of Bldgs. Meeting Criteria	23	2	None
Total Capital Cost Estimate	\$ 97,200	\$103,210	None
Escalated Payback Periods (years)	12.6-19.4*	13.3-16.2	None
Net Fuel Savings (10 <sup>6</sup> Btu/yr)	740.9	816	None

\*The range of paybacks for all buildings evaluated; specific escalated payback period depends on the specific building. See Tables 7.4 and 7.5 for details.

Although the criteria for selection and presentation of results associated with solar energy applications is met (ETL-1110-3-302), all of these solar projects have a negative present worth life cycle cost over the economic life of the analysis (25 years). Also, the doctrine of least payback period dictates minimally sized systems; not necessarily optimum, as noted in Volume I, Section 7.0. For example, nearly all of the domestic hot water systems meeting the criteria are 1, 2 or 3 panel systems and satisfy only the 35 percent minimum fraction of annual loads.

Wind energy applications for generation of electricity at RRAD were also examined but were not cost effective. See Section 7.0 for details.

### BIOMASS

In-forest biomass residue left by commercial harvesting is estimated to be amount to 1,850 tons per year, while it is estimated that natural reforestation could produce 12,200 tons of green wood annually (assuming minimal forest management). Other management techniques could increase annual yields if necessary. Therefore, it can be assumed that biomass renewable energy resources are more than adequate for RRAD to use in small boiler applications. Assuming a heating value of 4,300 Btu/lb for green wood, sufficient sources for fuel exist from recovering harvesting waste and selective strip cutting in the unmanaged forest area to support boilers located in the Security Area, which presently utilize No. 2 fuel oil.

The actual harvesting of biomass can be accomplished using either government personnel and equipment or sub-contracting the harvesting and chipping operation to local contractors. Minimizing government manpower and equipment costs, the use of a subcontractor appears to be the most effective approach. A cost per ton of green wood chips was estimated, sufficient to administer the fuel harvesting program.

The harvesting technique which has been recommended by previous studies (CERL and Oklahoma Biological Survey) is that of stripcutting with emphasis on timber stand improvement. This involves clearcutting a number of small forest sections on a selective basis, providing both a biomass fuel and improved forest timber stands. Specific areas to be harvested would be selected by knowledgeable timber management personnel from the Foresters Office at RRAD.

A life cycle cost analysis was performed on four alternate equipment configurations using three different fuels (wood, coal/wood mixture, and coal), and No. 2 fuel oil was assumed to be the base case in all comparisons. The life cycle costs ranged from a high of \$4,276,642 for the conventional grate type boilers using green wood chips for fuel to a low of \$3,376,157 for the alternative using close coupled gasifier/fluidized bed boilers and coal as the fuel. The base case (No. 2 fuel oil) has a life cycle cost of \$6,215,395. On the basis of the life cycle cost analysis, all wood and coal alternatives evaluated are economically viable. The alternatives which appear to have the greatest potential are as follows in Table ES-4.

TABLE ES-4

ECONOMIC SUMMARY OF BIOMASS ALTERNATIVES

	<u>Capital Cost</u>	<u>Total Life Cycle Cost</u>	<u>Benefit/ Cost Ratio</u>
o <u>By Lowest Life Cycle Cost</u>			
Coal w/gasifiers and fluidized bed boilers.	\$415,690	\$3,376,157	7.8
Coal w/conventional and fluidized bed boilers.	492,710	3,448,049	6.6
Coal/wood mix w/gasifiers and fluidized bed boilers.	415,690	3,526,786	7.5
o <u>By Highest Benefit-to-Cost Ratio</u>			
Coal/wood mix w/close coupled gasifiers.	167,920	3,531,707	17.0
Coal w/close coupled gasifiers.	167,920	3,607,120	16.5
Wood w/close coupled gasifiers.	167,920	3,939,220	14.6

Based on the fuel cost comparison and the life cycle cost analysis, systems using fluidized bed boilers and low Btu close coupled gasifiers in conjunction with coal have the lowest life cycle costs. However, the highest benefit-to-cost ratio can be attained by retrofitting close coupled, low Btu gasifiers to the existing boilers and using a fuel mixture of 70 percent coal and 30 percent wood.

Based on the benefit-to-cost ratio results obtained, as well as total present worth life cycle cost, it is recommended that the alternative configuration of close coupled low Btu coal/wood gasifiers on boilers at plants 1174, 448, 676, 957, 911 and 1142 be considered for RRAD. This program would replace 36,143 x 10<sup>6</sup> Btu/yr (260,600 gal) of No. 2 fuel oil used at RRAD with 1,470 tons/yr of coal and 630 tons/yr biomass from the forests at RRAD. This amount of biomass is available from the in-forest residue left by commercial harvesting operations on an average annual basis.

#### TOTAL ENERGY, SELECTIVE ENERGY AND CENTRAL HEATING PLANT FEASIBILITY STUDIES

Total Energy (TE), Selective Energy (SE), and Central Heating Plant (CHP) concepts were evaluated as long range alternatives for supplying the thermal and electric energy needs of RRAD. The new coal/wood fired CHP programmed for funding in FY 1982 to replace boiler plants 319 and 591 was assumed to be the base case for comparison of alternatives.

The reference point for comparison of the various alternatives was the common load base all would have to serve, i.e., the thermal and electrical requirements projected for RRAD after consideration of historical data, detailed analysis of FY 1979 energy usage, and energy savings resulting from ECIP projects already programmed and those recommended as a result of this study.

Variations in the economic attractiveness of the alternatives result from differences in equipment utilization and performance, and in the cost of generating on-site electricity as compared to purchasing it from SWEPCO. Both TE and SE concepts utilize the process of cogeneration to produce all (TE) or part (SE) of the electricity required at RRAD. However, the efficiency of a cogenerating facility is highly sensitive to the relative amounts of steam and electricity required at any given time. As a result, it is crucial in accurately assessing plant performance to correctly account for the time-variation in thermal/electric load ratios. This accounting can be accomplished through multiple performance computations based on hourly varying thermal/electric load data. Computer utilization therefore emerges as an applicable analytical tool. Finding no existing programs with sufficient capability to perform the required simulations, EMC, Inc., had previously developed a program, TESEP, to serve these computational requirements.

TESEP is a multi-faceted program which calculates the turbine generator and boiler fuel requirements necessary to supply the needs of a time variant thermal electric load base. Program methodology optimizes performance through selection logic which matches equipment part load operating characteristics to the instantaneous load requirements to yield the best combination efficiency.

The base case for comparison of TE, SE and CHP concepts was developed using TESEP with time varying thermal and electric loads, to compute boiler operational

performance and purchased electricity requirements. This established a common analytical base for comparison. The most critical step was the development of the load base. FY 1979 energy savings from implementing feasible ECOs, and EMCS projects (both Phase I and II) were considered in the determination of the load base. Also, a review of planned new construction projects was undertaken to determine additional loads. Although the details of these projects are not finalized to a point that an accurate determination of future loads could be made, an estimate was made of future additional loads and was added to the load base.

For use with the TESEP program, load data was synthesized to reflect the hourly variation anticipated for future electrical and steam demands at RRAD. The synthesized load base was constrained to reflect the monthly and annual averages, and future peak usages and demands projected for RRAD. Peak demand used in sizing the alternative concepts for the facility taken as a whole is difficult to determine because of the diversity of multiple building use. Therefore, the following conservative approach for concept sizing was used:

- o Electric demand reductions were only credited to EMCS demand control, not for reduced loads since electric demand is determined from 15 minute interval readings.
- o Steam demand reduction was estimated to be 50 percent of that implied by a constant load factor and reduced loads.

As a result, the base case synthesized loads for the new coal/wood fired Central Heating Plant programmed for funding during FY 1982, are as follows:

Peak Electric Demand for RRAD:	9,488 kW
Annual Electrical Energy Consumption:	40,311,000 kWh
Peak Steam Demand for Central Plant Area:	95,678 lb/hr*
Annual Steam Production for Central Plant:	197,647,000 lbs.

\*Future estimated loads for maintenance modernization project included in estimate.

Based on these loads and the capital cost associated with this plant, the annual and present worth life cycle costs for the base case were determined. Refer to Volume II, Sections 11.0, 12.0 and 13.0 for detailed development of loads and cost data.

The selection process for TE concept development, using TESEP as a tool, involves:

- o Identifying the load extremes in which the system must function.
- o Selecting units, or combinations thereof, which could operate within these limits.
- o Performing analysis (TESEP) to determine the optimum combination.
- o Sizing auxiliary and support systems to the major system components selected.

- o Determining capital cost estimates associated with implementing the concept.
- o Determining the manpower and maintenance requirements associated with proper operation and reliability.

Once completed, an economic assessment of feasibility was made.

The approach to selecting the optimum SE plant alternative is similar to that for the TE plant except for one major item: Purchased electricity. Selective energy, a concept where only a portion of the electrical energy requirements are generated on-site by the central plant, necessitates a detailed analysis in order to determine how much electricity optimizes, or minimizes, the overall cost of purchased energy.

The first determination is whether the prevailing plant operating mode should be peak shaving or base loading. Peak shaving refers to reducing the peak electrical energy purchased during periods of peak demand, while base loading refers to levelized loading of the SE plant. Base loading extends the operating time in the cogeneration mode. Thus, the process for SE concept development using TESEP involves:

- o Identifying the total energy load requirements
- o Determining the cost of purchasing power
- o Determining the mode of operation which best utilizes any differences in the costs of purchasing power and on-site generation (TESEP)
- o Determining the extent of operation (equipment size and run-time) that minimizes net power costs (TESEP)
- o Sizing auxiliary and support systems to the major system components selected
- o Estimating associated capital costs
- o Determining manpower and maintenance requirements.

Again, when this process was completed, an economic assessment of feasibility was made.

Since installation of a 135,000 lb/hr coal/wood fired CHP has already been scheduled for FY82 at RRAD, and the program year for ECIP projects developed in this study is FY83, operation of the new CHP was assumed as a part of the base case alternative. Therefore, rather than addressing the general question of CHP feasibility at RRAD, the Increment E (Central Heating Plant) portion of the study dealt with the feasibility of extending the service of the new CHP to include additional areas at RRAD currently served by gas and/or oil burning boilers.

Basically, the feasibility of such an extension was evaluated by comparing the savings in fuel costs (resulting from use of coal/wood instead of gas/oil) to the additional costs of installing transmission piping, and compensating for heat losses from it, plus any additional equipment needs.

The results of the TE, SE and CHP concepts were compared to the base case to determine the feasibility of each with respect to the others. A present worth life cycle cost analysis was developed for the optimum TE, SE and CHP concepts developed. Capital costs, annual operating and maintenance costs, and fuel costs were determined for each.

The TE, SE and CHP concepts determined as optimum potential systems in each category for RRAD were:

TE - Three automatic extraction turbine generator units (2500 kW, 3750 kW and 5000 kW) and 3 spreader stoker boilers of 80,000 lb/hr capacity (each) rated at 610 psig/750°F outlet conditions.

SE - One 625 kW automatic extraction turbine generator and 3 spreader stoker boilers of 40,000 lb/hr capacity, rated at 610 psig/750°F conditions.

CHP - Extended service from new coal/wood fired CHP to additional areas now served by existing steam plants, 596, 186 and 112.

A summary of the present worth life cycle cost analysis for these alternatives is presented in Table ES-5 below. (It is noted that the total electrical energy needs are common to all alternatives to establish an equal, common base for analysis).

TABLE ES-5

LIFE CYCLE COST SUMMARY  
LONG RANGE ALTERNATIVES FOR RRAD

	<u>Base Case</u>	<u>TE</u>	<u>SE</u>	<u>CHP Alternative</u>
Capital Cost Estimate	\$ -0-	\$33,203,300	\$14,801,100	\$ 838,100
Total O&M and Energy Life Cycle Costs	<u>35,822,500</u>	<u>42,141,000</u>	<u>36,998,400</u>	<u>34,722,600</u>
Total Life Cycle Costs	\$35,822,500	\$75,344,800	\$51,799,500	\$35,560,700

It should be noted that the life cycle cost values used in this analysis were derived using the differential escalation rates contained in the Army engineering guidance for life cycle cost evaluations\*. Therefore they are valid only for comparison, not for absolute values.

As a result of this comparative analysis, TE and SE concepts of cogeneration are not as cost effective as central heating concepts and purchased electricity. This is due to two major factors:

- o The combination of thermal and electric loads which would provide optimum cogeneration do not occur at the same time.

\*"Engineering Instructions for Preparation of Feasibility Studies for Total Energy, Selective Energy and Heat Pump Systems", DAEN-MCE-U, 1 July 1977 with Change 1, dated 1 August 1978.

- o The cost of purchased electricity from SWEPCO, which is becoming a coal based electric utility, is sufficiently low that properly sized cogeneration concepts cannot save enough cost over a 25 year period to offset the capital investment required.

Therefore, TE and SE considerations for RRAD are not viable alternatives. However, the extension of the CHP budgeted for funding in FY 82 to 596, 186 and 112 is economically feasible.

One of the assumptions of major importance used in the analysis was the type of coal. This analysis assumed a 9747 Btu/lb, 0.56 percent sulfur coal, as was used in the Final Design Analysis of the Boiler Replacement Project (LI84, FY80 MCA). This coal can be referred to as "Compliance Coal", in that for an installation of less than 250 million Btu/hr fuel input, the sulfur emissions meet the environmental requirements ( $< 1.2 \text{ lbs SO}_2 \text{ mBtu fuel input}$ ) without  $\text{SO}_2$  scrubbing equipment. However, should a coal be used which is not a compliance coal, the total life cycle cost of all concepts would increase because of the additional cost of  $\text{SO}_2$  scrubbing equipment and associated O & M costs. However, since the CHP alternative and the base case would be affected equally by the additional capital cost requirements, the magnitude of capital cost comparisons remain the same. The increased cost of maintaining and operating the pollution control equipment is based on plant output, and is estimated at a rate of \$0.0014/lb of steam produced. Based on this O & M cost increase, the energy cost savings for extending CHP service to 596, 186 and 112 is offset by  $\text{SO}_2$  O & M costs and is no longer economically feasible.

Therefore, the conclusion of this central plant feasibility study is that some further centralization of steam producing operations (with concurrent conversion to solid fuel) offers life cycle economic savings over the presently planned method of thermal energy supply, only if "Compliance Coal" can be used. Furthermore, the attractiveness of any extension of the central steam plant service is predicated upon no additional boiler capacity increases. Should it be preferred to dedicate the full 135,000 lbs/hr capacity to serving the currently scheduled area (319 and 591), it would not be economically attractive to install additional boiler capacity just for the purpose of extending service to the areas referred to in this study.