Sponsor: Georgia Department of Offender Rehabilitation

Type Agreement: Standard Research Project Agreement A-3865

Award Period: From 5/24/84 To 5/23/85 (Performance) 5/23/85 (Reports)

Sponsor Amount:
- Estimated: $_________________________
- Funded: $_________________________
- This Change: $7,500
- Total to Date: $7,500

Cost Sharing Amount: $_________________________

Cost Sharing No: _______________________

Title: "Studies in Energy Efficiency and Alternate Fuels"

ADMINISTRATIVE DATA
1) Sponsor Technical Contact:
   Clyde Stovale
   Georgia Dept. of Offender Rehabilitation
   2 Martin Luther King, Jr. Dr., S.E.
   Atlanta, GA 30334
   (404) 656-6002

2) Sponsor Admin/Contractual Matters:
   Ms. Gail A. Grieser, Contract and Real Property Specialist Court Services
   Ga. Dept. of Offender Rehabilitation
   Room 756, East Tower, Floyd Veterans Memorial Bldg., Atlanta, GA 30334

Defense Priority Rating: n/a

Military Security Classification: n/a
(or) Company/Industrial Proprietary: n/a

RESTRICTIONS
See Attached n/a Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with sponsor; none proposed.

COMMENTS:
- Phase 1 funding.
SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date: 10/30/84

Project No. A-3865

Includes Subproject No.(s) n/a

Project Director(s) Doug Moore

Sponsor Ga. Dept. of Offender Rehabilitation

Title "Studies in Energy Efficiency and Alternate Fuels"

Effective Completion Date: 10/10/84 (Performance) 10/10/84 (Reports)

Grant/Contract Closeout Actions Remaining:

☐ None

☒ Final Invoice or Final Fiscal Report

☐ Closing Documents

☐ Final Report of Inventions

☐ Govt. Property Inventory & Related Certificate

☐ Classified Material Certificate

☐ Other

Note: Proj. was set up for a year thru 5/23/85, but work was never anticipated to take that long, and, in fact, did not.

Continues Project No. Continued by Project No.

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/EES Supply Services
Research Security Services
Reports Coordinator (OCA)

Library
GTRI
Research Communications (2)
Project File
Other A. Jones; M. Heyser

Legal Services
July 3, 1984

Mr. Clyde D. Stovall
Department of Offender Rehabilitation
2 Martin Luther King, Jr. Drive, S. E.
East Tower - 8th Floor
Atlanta, Georgia 30334

Re: Energy Conservation Survey Program - Phase I
Monthly Progress Report - Georgia Tech Project No. A-3865

Dear Mr. Stovall:

The following is a summary of activities on the subject project through June 30, 1984, since the effective start date of May 24, 1984.

Activities for the current month:

- The five designated facilities were visited and energy surveys conducted:

<table>
<thead>
<tr>
<th>Survey Date</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/31/84</td>
<td>Georgia Diagnostic &amp; Classification Center, Jackson</td>
</tr>
<tr>
<td>6/6/84</td>
<td>Central Correctional Institution, Macon</td>
</tr>
<tr>
<td>6/6/84</td>
<td>Lee Correctional Institution, Leesburg</td>
</tr>
<tr>
<td>6/7/84</td>
<td>Wayne Correctional Institution, Odum</td>
</tr>
<tr>
<td>6/21/84</td>
<td>Women's Correctional Institution, Milledgeville</td>
</tr>
</tbody>
</table>

- Energy usage information on all five facilities was received from D.O.R. Supplemental information was also received from Bob Youngblood with the Office of Planning and Budget.

- Energy Survey and Energy Conservation Opportunity forms have been designed and are currently in production.
Plans for July, 1984

- Compile survey information into standardized format.
- Submit survey reports for each of the five facilities.
- Submit final report with recommendations for Phase II.

Respectfully submitted,

Douglas M. Moore, P.E.
Research Engineer, II

mro
August 3, 1984

Mr. Clyde D. Stovall
Department of Offender Rehabilitation
2 Martin Luther King, Jr. Drive, S. E.
East Tower - 8th Floor
Atlanta, Georgia 30334

Re: Energy Conservation Survey Program - Phase I
Monthly Progress Report - Georgia Tech Project No. A-3865

Dear Mr. Stovall:

The following is a summary of activities on the subject project for
the month of July, 1984.

Activities for the current month:

- Energy Survey and Energy Conservation Opportunity forms were
  completed.

- Survey reports for the five facilities have been prepared and
  are approximately 90% complete.

Plans for August, 1984

- Submit survey reports for each of the five facilities.
- Submit final report with recommendations for Phase II.

Respectfully submitted,

Douglas M. Moore, P.E.
Research Engineer II
FINAL SUMMARY REPORT

ENERGY CONSERVATION SURVEYS

FOR

GEORGIA CORRECTIONAL FACILITIES

August 31, 1984

Prepared for the
Georgia Department of Offender Rehabilitation

Prepared by:

D. M. Moore
Research Engineer II

Georgia Institute of Technology
Technology Applications Laboratory
Engineering Experiment Station
Atlanta, Georgia 30332
Executive Summary

During the months of May and June, 1984, the Technology Applications Laboratory of the Georgia Tech Engineering Experiment Station conducted energy surveys at five representative institutions of the Georgia Department of Offender Rehabilitation. The surveys were preliminary in scope, with no more than one day spent at each location; nonetheless, significant energy conservation potential was revealed at each facility. Separate reports have previously been submitted for all five. The specific institutions surveyed are:

Georgia Diagnostic and Classification Center; Jackson, Georgia
Central Correctional Institution; Macon, Georgia
Lee Correctional Institution; Leesburg, Georgia
Wayne Correctional Institution; Odum, Georgia
Women's Correctional Institution; Milledgeville, Georgia

The surveys of these facilities revealed a total of 52 energy conservation measures which, if implemented, would result in annual energy savings of 19.2 million BTU's and annual cost savings of $160,000. The total cost to implement these measures is estimated to be $175,000, resulting in a simple payback of just over one year.

The five facilities surveyed were selected to represent a typical cross-section of all the DOR institutions. Department-wide, our analysis yields an estimated annual conservation potential of 96 billion BTU's and $800,000. This estimate is considered to be highly conservative and is based on projections of potential energy and cost savings over the combined floor area of all DOR facilities, assuming that the average level of savings can be maintained. In-depth energy audits of each facility, followed by an aggressive energy conservation program, could potentially double the projected savings.

In order to develop and conduct an effective energy conservation program, it is important to establish a solid baseline of energy usage.
data and consumption patterns for each facility, and to identify potential energy conservation opportunities. We recommend that comprehensive energy audits be performed for each institution. These audits will provide the foundation upon which each institution's energy conservation program will be built, and therefore are of key importance. The staff of the Technology Applications Laboratory have an extensive background in the area of energy conservation and energy auditing, and should be considered as a valuable resource for this activity.
Introduction

Conducting an effective energy management program in a prison environment presents some unique problems. In many cases, inmates are utilized to operate energy consuming equipment, including large central energy plants, and to serve on the maintenance staff. These individuals cannot be expected to exhibit a positive attitude regarding an energy conservation program, and typically have little or no training in energy conservation. The department's maintenance engineers and staff members, although highly capable in basic facility maintenance, also have little knowledge and training in conservation theory and technology. For these reasons, correctional facilities tend to be operated with little attention to energy consumption.

There are certain basic elements that must be incorporated into an effective energy management program. First of all, a specific individual at each facility must be assigned the responsibility for conducting and monitoring the program. In this particular case, the appropriate person would be the maintenance engineer. Secondly, a comprehensive energy conservation program must be designed that is custom tailored to the particular facility. This is most effectively done by a person or persons within the central office knowledgeable of energy conservation techniques. Training of the maintenance engineers is extremely important as they must be able to understand and interpret the program that has been created for their facility. Without this training, they will not support the program, and they will be less effective in participating in its design. Attendance at seminars and workshops should be encouraged at every opportunity.

In order to overcome the obstacles of indifference and lack of cooperation on the part of inmates, (as well as staff personnel not directly connected with the energy conservation program), the program should stress measures that are not operator dependent, such as replacement of a particular piece of equipment with another piece of equipment that is inherently more energy efficient. Where significant
savings are possible through revised operating procedures, these procedures should be automated whenever possible. Time clocks or programmable controllers should be considered in these instances. Consistent with this approach, the conservation measures outlined in the five survey reports are primarily of this type.

**Facility Energy Usage**

Annual energy consumption at each of the five facilities is summarized by energy source in Table I. Natural gas is the most common fossil fuel; No. 2 oil is utilized by only two of the facilities. Total combined expenditures for energy for the five facilities amounted to $1,293,115. Combined energy usage amounts to over 162 billion BTU's.

An interesting measure of the relative efficiency of the five facilities is given by the calculated value of BTU's per square foot of floor area, obtained by dividing annual energy usage of the facility by the gross floor area. A relatively low value indicates greater efficiency. Values of BTU's per square foot of floor area for each of the facilities surveyed are shown in Table II. The most efficient of the five facilities, on this basis, is Wayne Correctional Institution at 156,200 BTU/ft². Even though this facility is fully air conditioned, it is relatively efficient due to its lack of large glass areas on exterior walls, and its general layout as a single rectangular building with a low surface-to-volume ratio. Georgia Diagnostic and Classification Center, at 287,000 BTU/ft², is the least efficient facility, even though it has the lowest percentage of air conditioned space. The exceptionally high energy usage of this facility results primarily from high heating energy requirements created by the large amount of single pane glass in dormitory wings, and the long narrow configuration of these wings, which results in a high surface to volume ratio. Comparisons of this type are useful in pointing out areas of excessive energy use or waste.
Surprisingly, Georgia Diagnostic has the lowest energy cost per square foot, and Wayne the highest. The explanation for this apparent contradiction lies primarily with two factors. First, since Georgia Diagnostic consumes a substantially greater amount of electricity than Wayne, its cost per kilowatt-hour is less ($0.045/KWH compared to $0.055/KWH). Of greater significance, however, is the relative utilization of electricity versus fossil fuels. Electricity accounts for 88% of the total energy consumption at Wayne, but only 17% of the total at Georgia Diagnostic. The No. 2 fuel oil utilized at Wayne costs more than twice as much per BTU as the natural gas purchased by Georgia Diagnostic. The net results of these patterns is an average energy cost of $15.30/MBTU at Wayne as compared to $5.94/MBTU at Georgia Diagnostic. The conclusion that can be reached, when making comparisons between various institutions, is that a variety of factors must be taken into consideration including building configuration, energy cost and utilization, and services provided (such as cooking and laundry).

Energy Conservation Opportunities

The surveys of the five facilities revealed a total of 52 energy conservation opportunities, or "ECO's", covering a variety of types. The total estimated savings amounts to 19.2 billion BTU's, or nearly $160,000 annually, an average of $32,000 per facility. These savings represent 11.8% of total energy consumption, and 12.4% of total energy cost. A summary of pertinent ECO data is given in Table III.

The most frequently recommended ECO's fall into the category of improved lighting efficiency. This category includes replacement of existing lamps and/or light fixtures with higher efficiency sources. Replacement types suggested are felt to be the most suitable choice based on usage, lamp life, light output, and other significant factors. A variety of types of high intensity discharge (HID) lamps are recommended, including low and high pressure sodium and metal halide. These lamps are typically two to three times more efficient than
conventional sources such as incandescent, fluorescent, or mercury vapor. In many cases, energy savings will be accompanied by increased lighting levels of 50% or more. Whenever possible, the recommended lamps utilize existing ballasts, minimizing the implementation costs. Where this assumption is made, the actual compatibility of the retrofit type lamps with existing ballasts should be verified before any material is purchased. Reducing lighting energy by disconnecting unnecessary light fixtures is another very effective measure, which has been done extensively at Georgia Diagnostic and Classification Center. Many other correctional facilities could benefit from this low cost measure by establishing department-wide standards for maximum and minimum lighting levels, and eliminating excessive illumination where possible.

A second category of frequently recommended measures is HVAC (heating, ventilation, and air conditioning). The most common recommendation within this group concerns turning off equipment when the space is not occupied. In many DOR facilities, air handling units run continuously, simply because no automatic control is provided, or the existing controls are not flexible enough to follow the varying schedules throughout the building. This results in excessive energy consumption by supply air fans, and from heating and cooling energy being utilized to maintain room temperatures during unoccupied hours. Also, combustion efficiency of boilers is seldom checked, resulting in excess fuel consumption. A modest increase in boiler efficiency of 2% has been assumed to be possible for all forced draft type boilers.

Computerized energy management systems appear to be feasible for all of the five surveyed institutions except Lee Correctional Institution. This facility could not benefit from the demand limiting function of an EMS since its electricity is metered at several different points. Energy management systems produce savings primarily through load scheduling, duty cycling, and demand limiting, usually by turning off HVAC units according to varying schedules. This is easily accomplished by moderately priced control equipment. In most areas, air handling units do not need to run continuously. Turning off these
units for five or six minutes out of each 20 minute period, for example, would reduce running time by 25 to 30 percent, with no sacrifice in comfort. Since DOR facilities are typically billed for electricity according to a demand-based rate schedule, limiting maximum demand by shedding non-critical loads during periods of peak usage can greatly reduce the cost per kilowatt-hour of electricity.

Some of the less frequently encountered ECO's include: modifications to the building envelope (such as increased insulation), installation of heat pump type water heaters, equipment insulation, and plastic strip doors. It should be noted, however, that the conservation potential of many ECO's is site specific. The economic benefits must be analyzed for each individual location, taking into account such items as fuel availability and costs, utilization of facilities, and climatic conditions.

Solid Fuels Substitution

A great degree of interest has been expressed by the Department of Offender Rehabilitation toward the utilization of wood and other solid fuels to replace oil and natural gas. Although wood fired boilers have been installed at two institutions, their operation has been less than optimal. Because the steam produced by these boilers is used principally for space heating and domestic water heating, the total steam requirement is highly dependent on climatic conditions. Although the steam requirements for water heating create a relatively constant base load during the summer months, the magnitude of this load is small in comparison to the peak winter demand. Solid fuel boilers sized to meet peak demand requirements do not operate efficiently at low loads, and therefore are not being utilized during these months. Also of concern is the additional manpower required for operation and supervision of wood fired boilers, since salaried personnel are typically utilized as boiler operators.
The above problems do not necessarily preclude the feasibility of solid fuel boilers at all DOR facilities, however. Where widely varying steam requirements exist, consideration should be given to a multiple boiler installation with two boilers of unequal size. A small boiler sized to meet summer base loads could be operated with acceptable efficiency and reduced manpower. In certain situations where steam demand is less seasonal, or where installation of a steam powered absorption water chiller might be considered in conjunction with a solid fuel boiler, the economics of wood energy could prove highly attractive. The energy audit phase of an overall energy conservation program would provide an excellent opportunity for the identification of potential applications for solid fuel energy systems, through study and analysis of steam utilization and historical energy consumption data.

Conclusions and Recommendations

The average level of savings of approximately 12% that has been identified for the five institutions under examination can be achieved by relatively simple, low first cost measures that would produce paybacks typically within two years. More capital intensive measures, such as upgrading of deficient glazing systems (as exemplified by Georgia Diagnostic and Classification Center) may provide significant energy conservation potential, although the simple payback interval can be expected to increase. In the case of permanent modifications to the building envelope, paybacks of 5 to 6 years or more are often considered acceptable. In these cases, a thorough economic analysis which takes into consideration multiple factors such as the cost of capital, projected energy costs, operating and maintenance costs, etc. should be undertaken.

A well-planned, coordinated effort is an essential element of any effective energy conservation program. A firm commitment to energy conservation at all levels of the state and departmental administration will be required. A comprehensive energy conservation
plan must be designed and implemented, realizing that funding for specific conservation projects will be necessary. The basic elements of an effective energy management program include:

- Administrative commitment, including allocation of necessary financial and human resources for program management and implementation.
- In-depth studies of energy usage and facility operations, for the purpose of identification of specific conservation measures for each facility.
- Detailed financial analyses of proposed measures.
- Implementation of acceptable conservation measures.
- Continued monitoring and analysis of program results.
- Continued growth and development of the program as necessary to stay abreast of changing price structure and availability of various energy sources.

In light of dwindling energy resources and the inevitable growth of energy costs, an effective energy conservation program should be considered not only as an economic advantage, but as a social obligation. The Department of Offender Rehabilitation has taken some very positive steps in this direction. Now, this department has an excellent opportunity to implement a program that will set an example for every state agency.
### TABLE I

**ANNUAL ENERGY CONSUMPTION HISTORY**

**Georgia Diagnostic and Classification Center**  
May, 1983 - April, 1984

<table>
<thead>
<tr>
<th></th>
<th><strong>Electricity</strong></th>
<th><strong>Natural Gas</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage</td>
<td>4,607,080 KWH</td>
<td>761,850 Therms</td>
</tr>
<tr>
<td>Energy Equivalent</td>
<td>15,710 MMBTU</td>
<td>76,185 MMBTU</td>
</tr>
<tr>
<td>% of Total Energy</td>
<td>17.1</td>
<td>82.9</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$213,695</td>
<td>$332,316</td>
</tr>
<tr>
<td>% of Total Cost</td>
<td>39.1</td>
<td>60.9</td>
</tr>
</tbody>
</table>

**Central Correctional Institution**  
April, 1983 - March, 1984

<table>
<thead>
<tr>
<th></th>
<th><strong>Electricity</strong></th>
<th><strong>Natural Gas</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage</td>
<td>3,150,000 KWH</td>
<td>160,079 Therms</td>
</tr>
<tr>
<td>Energy Equivalent</td>
<td>10,741 MMBTU</td>
<td>16,008 MMBTU</td>
</tr>
<tr>
<td>% of Total Energy</td>
<td>40.1</td>
<td>59.9</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$144,178</td>
<td>$87,629</td>
</tr>
<tr>
<td>% of Total Cost</td>
<td>62.2</td>
<td>37.8</td>
</tr>
</tbody>
</table>
### TABLE I (continued)

**ANNUAL ENERGY CONSUMPTION HISTORY**

**Lee Correctional Institution**
May, 1983 - April, 1984

<table>
<thead>
<tr>
<th>Usage</th>
<th>Electricity</th>
<th>No. 2 Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage</td>
<td>2,869,516 KWH</td>
<td>69,968 Gals.</td>
</tr>
<tr>
<td>Energy Equivalent</td>
<td>9,785 MMBTU</td>
<td>9,795 MMBTU</td>
</tr>
<tr>
<td>% of Total Energy</td>
<td>50.0</td>
<td>50.0</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$167,706</td>
<td>$65,542</td>
</tr>
<tr>
<td>% of Total Cost</td>
<td>71.9</td>
<td>28.1</td>
</tr>
</tbody>
</table>

**Wayne Correctional Institution**
April, 1983 - March, 1984

<table>
<thead>
<tr>
<th>Usage</th>
<th>Electricity</th>
<th>No. 2 Oil</th>
<th>Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage</td>
<td>1,631,520 KWH</td>
<td>4,727 Gals.</td>
<td>668 Gals.</td>
</tr>
<tr>
<td>Energy Equivalent</td>
<td>5,560 MMBTU</td>
<td>660 MMBTU</td>
<td>60 MMBTU</td>
</tr>
<tr>
<td>% of Total Energy</td>
<td>88.5</td>
<td>10.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$89,500</td>
<td>$6,194</td>
<td>$440</td>
</tr>
<tr>
<td>% of Total Cost</td>
<td>93.1</td>
<td>6.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>
## TABLE I (continued)

**ANNUAL ENERGY CONSUMPTION HISTORY**

**Women's Correctional Institution**  
May, 1983 - April, 1984

<table>
<thead>
<tr>
<th>Usage</th>
<th>Electricity</th>
<th>Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Usage</strong></td>
<td>2,602,200 KWH</td>
<td>96,094 Therms</td>
</tr>
<tr>
<td><strong>Energy Equivalent</strong></td>
<td>8,870 MMBTU</td>
<td>9,610 MMBTU</td>
</tr>
<tr>
<td><strong>% of Total Energy</strong></td>
<td>48.0</td>
<td>52.0</td>
</tr>
<tr>
<td><strong>Energy Cost</strong></td>
<td>$132,596</td>
<td>$53,319</td>
</tr>
<tr>
<td><strong>% of Total Cost</strong></td>
<td>71.3</td>
<td>28.7</td>
</tr>
</tbody>
</table>
### TABLE II

**SUMMARY OF ANNUAL ENERGY USAGE**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Total Energy MMBTU</th>
<th>Energy Cost-$</th>
<th>$/MMBTU</th>
<th>Gross Floor Area-Ft²</th>
<th>BTU/Ft²</th>
<th>$/Ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ga. D &amp; C, Jackson</td>
<td>91,895</td>
<td>546,011</td>
<td>5.94</td>
<td>320,000</td>
<td>287,000</td>
<td>1.71</td>
</tr>
<tr>
<td>Central C.I., Macon</td>
<td>26,749</td>
<td>231,807</td>
<td>8.67</td>
<td>113,400</td>
<td>236,000</td>
<td>2.04</td>
</tr>
<tr>
<td>Lee C.I., Leesburg</td>
<td>19,580</td>
<td>233,248</td>
<td>11.91</td>
<td>108,000</td>
<td>181,300</td>
<td>2.16</td>
</tr>
<tr>
<td>Wayne C.I., Odum</td>
<td>6,280</td>
<td>96,134</td>
<td>15.31</td>
<td>40,000</td>
<td>156,200</td>
<td>2.40</td>
</tr>
<tr>
<td>Women's C.I., Millegeville</td>
<td>18,480</td>
<td>185,915</td>
<td>10.06</td>
<td>98,800</td>
<td>187,000</td>
<td>1.88</td>
</tr>
</tbody>
</table>
TABLE III
ENERGY CONSERVATION OPPORTUNITIES

<table>
<thead>
<tr>
<th>Facility</th>
<th>No. of ECO's</th>
<th>Estimated Savings MMBTU</th>
<th>Estimated Savings $</th>
<th>实施成本 MMBTU</th>
<th>简单回付年数</th>
<th>% of Total Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ga. D. &amp; C., Jackson</td>
<td>15</td>
<td>12,275</td>
<td>68,420</td>
<td>53,070</td>
<td>0.8</td>
<td>13.3</td>
</tr>
<tr>
<td>Central C. I., Macon</td>
<td>13</td>
<td>2,750</td>
<td>32,050</td>
<td>39,960</td>
<td>1.2</td>
<td>10.3</td>
</tr>
<tr>
<td>Lee C. I., Leesburg</td>
<td>6</td>
<td>1,710</td>
<td>19,680</td>
<td>14,500</td>
<td>0.7</td>
<td>8.7</td>
</tr>
<tr>
<td>Wayne C. I., Odum</td>
<td>8</td>
<td>940</td>
<td>16,150</td>
<td>29,200</td>
<td>1.8</td>
<td>15.0</td>
</tr>
<tr>
<td>Women's C. I., Millegeville</td>
<td>10</td>
<td>1,490</td>
<td>23,510</td>
<td>38,180</td>
<td>1.6</td>
<td>8.1</td>
</tr>
</tbody>
</table>

Combined Results:

| Total                  | 52           | 19,165                  | 159,810             | 174,910      | -           | 11.8            |
| Average                | 10           | 3,830                   | 31,960              | 34,982       | 1.1         | -               |