Audit Costs for the 1986 Texas Energy Cost Containment Program

by

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ABSTRACT

Direct program costs for detailed audits of 13.5 million square feet of institutional building space in the 1986 Texas Energy Cost Containment Program were $0.047/SF. The building area was 63 percent simple (offices, schools, and universities) and 37 percent complex (medical buildings and power plants). Allowing for the influence of one large facility which received less-extensive treatment due to previous work, thorough audits were obtained for an average cost of $0.050/SF. Large medical buildings (greater than about 170,000 square feet) were audited for $0.050/SF or less, and program costs for survey audits of 17.2 million square feet were $0.0028/SF. The effect on audit costs of complexity of recommended modifications, amount of savings determined, amount of implementation costs, building size, and building complexity are discussed. Primary effects on audit costs are size and complexity of buildings. Program guidelines limited consideration of projects with greater than a four year payback.

The Texas Energy Cost Containment Programs (TECCP) began in 1983 as a joint effort of the Governor's Office and The Public Utility Commission of Texas. The program was a response to rapidly increasing building energy costs for state agencies, which had grown by 1984 to five times their 1974 amount (1,2).In order to identify ways to contain these rapidly escalating costs, 21.6 million square feet of state-owned building space were surveyed and audited in 1984. Of this 21.6 million square feet, 20.8 million square feet received detailed audits and 0.8 million square feet were surveyed and determined not to present sufficient savings opportunities to justify further auditing (3). Energy projects were identified in the audited 20.8 million square feet which would save $9.2 million annually with a required capital investment of $15.6 million (1).

Although energy costs to state agencies for building operation dropped from $207 million in 1984 to $188 million in 1986 (1), the size of the state's building energy budget was still large, representing an energy cost index of $1.30/gross square feet in 1986 (3) and sizable opportunities for savings. Much of the drop in cost was attributed to a lowering in energy prices which produced severe economic problems for Texas and provided further reason to identify and implement cost savings opportunities. As a result, in 1986 a second round of energy audits was sponsored by the Public Utility Commission of Texas (1,3), and 18.7 million square feet of space were surveyed and audited to identify ways to contain energy costs. Of this amount, 14.5 million square feet received surveys and detailed audits by five engineering consulting firms and the Texas Engineering Extension Service (TEEX). In the 14.5 million square feet audited, energy projects were identified which would save $12 million annually with an implementation cost of $27 million. The private consulting firms were reimbursed for surveys and detailed audits of 13.5 million square feet of building space and for surveys of an additional 3.7 million square feet which were subsequently not audited. The costs of detailed audits and surveys by TEEX, a state government agency, are not covered here.

Energy projects were identified in both [illegible] projects that the building maintenance and operation staff should perform as a regular part of their duties. ECRMs were projects which required outside skills and labor (4). Although cost was not a direct consideration, items which could not be funded from existing utility budgets due to high capital cost generally also required outside skills and labor for installation. It is accurate, therefore, to regard the M&Os as "no cost, low cost" projects, and the ECRMs as projects requiring more significant expenditures. The energy savings are presented on a dependent basis. That is, any dependency between the various M&Os and ECRMs recommended in the buildings of an agency is taken into consideration. For example, the effect of an ECRM which specifies relamping with energy efficient lighting on a simultaneously proposed chiller replacement is covered.

The five private consulting engineering firms which performed surveys and audits for the State under contract to the Energy Efficiency Division of the Public Commission of Texas were selected, based upon their qualifications from over twenty applicants. In the discussion which follows, they are referred to by a number assigned by the

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authors based on the total area audited by each firm. The audit assignments of the contractors were coordinated and made by the program manager's office at Texas A&M University.

BUILDING SPACE AUDITED

The State of Texas owns buildings of varying types and complexity. The buildings audited in the 1986 program were divided for the purposes of this study into five types: offices, schools, universities, medical buildings, and power plants. In addition these buildings were classified according to the complexity of the space they contained. Offices, schools, and universities were considered to be "simple" areas. Generally, these buildings have fewer hours of daily use and contain simpler systems than medical buildings and power plants, which results in both a lower energy use index and energy cost index (5).

Audits in simple buildings were generally paid for according to the schedule shown in Table 1. The rate schedule shown there was determined prior to the first 1986 audit. In general, a building classified as simple was not audited if it was less than 50,000 square feet in area. In contrast, medical buildings and power plants were considered to be "complex" areas, because of the longer time of daily use and presence of more complicated energy using systems. The contractors submitted cost proposals for complex space based on the number of hours of engineering and technician time estimated to be required for the audit.

The total area audited by the five contractors is shown in Table 2 according to type of building. Also shown is the percentage of the total area audited by the various contractor firms. Universities dominated the simple space, while in the complex category, medical building area was more than one-hundred times that of power plants. Medical building area considered here included hospitals, medical research buildings such as some at the University of Texas Health Science Centers, and in one case a laundry associated with Terrell State Hospital. Power plants included traditional areas such as buildings containing boilers and large machine rooms (containing chillers, for example) which were not part of another building being audited. When boiler rooms and machine rooms were an integral part of an audited building such as an office building, they were included in the category for the building. In Table 3, the area is divided between the two categories of complex (medical buildings and power plants) and simple (all else). Table 3 shows that 63 percent of the area audited was simple and 37 percent was complex. The mixture of building space audited by Contractors 1, 3 and 5 was reasonably similar; however, Contractor 2 was assigned relatively more simple space and Contractor 4 audited relatively more complex space.

AUDIT COSTS

The availability of audit cost data for a large-scale audit program involving institutional buildings provides an excellent opportunity to analyze that data to determine the effect of various influences on the audit costs. Experience with other audit programs leads to the expectation that both size of buildings and type of space will influence the costs. Other factors include payback limitations and possibly types of recommendations. In general, the projects discussed here were limited to paybacks of about four years or less (4). Finding other cost and energy conservation projects in these buildings would be possible, but the cost of achieving those savings and the associated paybacks would be larger. In the sections which follow, audit costs are normalized by the area involved and compared.

EFFECTS OF SIZE AND COMPLEXITY OF SPACE ON AUDIT COSTS

Table 4 shows audit costs per square foot according to contractor and type of space. The relatively greater costs of audits in office and school buildings ($0.057/SF and $0.052/SF, respectively) compared to the audit cost of $0.047/SF for university buildings can be understood in terms of size and the audit cost algorithm in Table 1. Table 2 indicates that university buildings dominate the simple area, further shown in Tables 4 and 5 where the audit costs of all simple buildings are the same as that for universities. The total number of individual office and school buildings audited was seven, while the number of university buildings was 56. Dividing the simple area audited from Table 3 by the total number of simple buildings yields an average size of 135,300 square feet. The differences among the various contractors for audit costs of simple areas in Tables 4 and 5 is explicable in terms of Table 1 costs and sizes of buildings assigned to the contractor by the program manager.

The data on power plants in Table 4 refers to buildings at three different state agencies (two audited by Contractor 2 and one audited by Contractor 4). The cost of the audit by Contractor 4 is high due to the small area of the facility, and due to the inclusion of projects defined in other buildings served by the power plant. There is not sufficient data on power plants to draw significant conclusions about audit costs. The well-known fact that they are relatively expensive to audit is reinforced by Table 4.

However, data is available for sixteen[1] medical buildings with considerable variation in size. No simple algorithm such as that in Table 1 was available to guide the pricing of medical building audits which, as noted previously, was on a proposal basis. Costs for these audits varied

1. The four units of the University of Texas Health Science Center at Tyler are treated as one building, as they were by the auditing contractor. Also, a complex of five units at the Smithville Science Park of the University of Texas System Cancer Center is treated as one building as it was by the auditing contractor. General Land Office records differ.

by more than a factor of four on an area basis (Table 4).

Figure 1 is a plot of fourteen of the sixteen medical buildings showing the variation of the cost per square foot for the audit with the size of the building. Two buildings have been eliminated in Figure 1 - the 11,520 square foot laundry at Terrell State Hospital which was audited for $0.16/SF and the large 1.1 million square foot M. D. Anderson Hospital in Houston in which some major energy projects have been previously identified. Therefore, a full-scale audit of M. D. Anderson on the level of other medical building audits was not required. Two areas are immediately obvious in Figure 1. Below about 75,000 square feet (the juncture of the two lines in Figure 1) there are three data points indicating a very steeply increasing cost with decreasing size. These are fairly consistently arrayed and are fit by the following equation:

$$C_1 = \$0.25/SF - \$2.6 \times 10^{-6}\ A/SF^2 \qquad (1)$$

where A is the building area in square feet and C is the audit cost in $/SF. This equation is based on a very limited amount of data. Above about 75,000 square feet are data representing eleven buildings which are fit by:

$$C_2 = \$0.054/SF - \$2.4 \times 10^{-8}\ A/SF^2 \qquad (2)$$

Several things can be observed about the latter set of data. The average cost of these audits is $0.046/SF; however, the cost obtained by dividing the total audit costs for those eleven buildings by the total area is $0.042/SF. The average cost of $0.046/SF gives more weight to the smaller buildings, as expected. The average size of the eleven medical buildings over 75,000 square feet in size in Figure 1 is 328,200 square feet. If the cost of auditing M. D. Anderson were plotted on Figure 1, it would fall below the extension of the line fitting the larger facilities, as expected. Equation 2 yields a cost of auditing a medical building larger than 75,000 square feet of about $0.052/SF or less. Above 170,000 SF, the indicated cost is about $0.050/SF or less.

The information in Table 4 is simplified in Table 5 to show only the effect of simple and complex areas. It shows, in comparison to Table 4, the dominance of the greater area of universities in the simple category, and the influence of the small number of relatively expensive power plants on complex area audit costs.

Contractors 2 and 5 represent the extremes of total audit costs in Table 4, varing by over 50% based on the total audit costs of Contractor 5. Contractor 2 had a higher proportion of simple area (Table 2). However, Contractor 2 had larger simple building audit costs (Table 5) which accounts for a significant portion of the difference. Larger simple building audit costs are dependent solely upon the assignment of smaller buildings (on average) for audit. Also, Contractor 2 audited six small power plant buildings of relatively high cost (Table 4), and two medical buildings with an average size near 30,000 square feet (Table 2). Contractor 5 was assigned no power plant buildings and audited two medical buildings averaging over 500,000 square are dependent solely upon the assignment of smaller buildings (on average) for audit. Also, Contractor 2 audited six small power plant buildings of relatively high cost (Table 4), and two medical buildings with an average size near 30,000 square feet (Table 2). Contractor 5 was assigned no power plant buildings and audited two medical buildings averaging over 500,000 square feet.

It is worthy of note that Contractors 1 and 4, with approximately equal medical building audit costs (Table 4 - excluding M. D. Anderson), had approximately the same average size for their medical buildings - 346,000 and 340,000 square feet, respectively. The average size of the medical buildings audited by Contractor 3 was 156,000 square feet. In fact, descending order of audit costs of medical buildings by the contractor is the same as that for ascending order of average medical building size.

The size and complexity of complex buildings audited and the size of simple buildings assigned appear to reasonably explain audit cost differences among the various contractors.

EFFECTS OF RECOMMENDED MEASURES

The total cost of ECRMs and the total savings due to ECRMs and M&Os by the various contractors are shown in Table 6 normalized by the total area audited by the contractor. Projects by Contractors 2 and 5 have the most comparable paybacks and reasonably comparable costs and savings; yet, these contractors represent the extremes of audit costs as discussed earlier. Contractor 4 (including data for M. D. Anderson) has the largest costs and total savings, a result of major effort on complicated HVAC and energy management systems. Yet the audit cost (excluding M. D. Anderson which lowers the total cost) of Contractor 4 is only four percent above the average value in Table 4. Also, Contractor 3 who according to ECRM costs and annual savings (calculated independently and normalized by area) placed over twice as much emphasis on lighting systems as the other contractors achieved the shortest payback and second largest savings shown in Table 6, while having an audit cost very near the average.

Based on this analysis of recommended measures, we conclude that factors other than complexity of recommended modifications, amount of savings determined, and level of implementation costs influenced audit costs. The other factors of size and complexity of space provide a far more consistent explanation of audit costs when compared to this limited analysis of the effect of recommended measures.

SURVEY OR WALK-THROUGH AUDIT COSTS

The areas and costs associated with survey audits, known in this program as preliminary on-site screenings, are shown in Table 7. The total area of 17.2 million square feet does not include the area surveyed by TEEX (1.03 million square feet) or a group of buildings of 0.44 million square feet area which were surveyed by one contractor at his own expense. The addition of these areas brings the total to 18.7 million square feet surveyed.

Each facility in the program received a preliminary screening to establish the need for a detailed engineering analysis. A facility generally included all the buildings at one location of a particular state agency which were identified by the agency as audit candidates. Prior to assignment to a contractor, screening by the agency, the PUC, and the program manager further eliminated buildings with low energy use indices, simple buildings under 50,000 square feet in area, and buildings which had been audited in the 1984 CCP or in a recent cycle of the Institutional Conservation Program. The sizes of the facilities receiving preliminary on-site screenings were much larger than the individual buildings audited, and varied from 26,000 to 1.1 million square feet. The average size was 465,000 square feet. The contractors were paid based on hourly rates for the engineers and technicians required, up to a predetermined maximum of $1,500 excluding travel and per diem. In a few cases, billings exceeding this maximum were approved based on requests made by the contractors. After surveying each facility, the contractor involved submitted to the PUC a preliminary on-site screening report (POSSR) describing the need for detailed auditing or explaining why a detailed audit was not recommended.

Table 7 shows that 78% of the area given preliminary on-site screenings at a total cost of $0.0028/SF received detailed audits. If the effect of travel and per diem reimbursements is removed, the cost drops to $0.0026/SF. This is less than six percent of the cost for auditing of $0.050/SF in Table 4. A break-down of pre-screening costs showing the effect of facility or building complexity is not available.

INFLUENCE OF AUDIT COSTS ON PAYBACK

The total cost of auditing for the 1986 CCP is the sum of the audit cost of $0.047/SF (Table 4) and the screening costs of $0.0028/SF (Table 7) or $0.0498/SF, an increase of six percent. This value is less than three percent of the cost of the recommended energy cost reduction measures. Comparison of the paybacks in Table 8 which are based on costs including the audit costs for both survey and detailed audits with the paybacks in Table 6 based on ECRM costs alone shows an increase of one-tenth year or less.

COMPARISON WITH ICP SAVINGS

The data in Table 6 provides an interesting comparison with another large-scale institutional audit program in the State of Texas. Data from cycle VIII of the Institutional Conservation Program (ICP) has been analyzed (5) for 4.4 million square feet of hospital, elementary school, junior high school, high school, and college buildings. That data yields an investment cost of $0.51/SF and a savings of $0.13/SF/yr for projects equivalent to ECRMs. These values are well below the values in Table 6, and also have a longer payback (four years).

Of the ECRM-type data analyzed (5), junior high schools (with an average size of 35,000 SF) had both the largest investment cost ($0.790/SF) and the highest savings ($0.154/SF/yr), still well below the values in Table 6. M&Os in cycle VIII of the ICP, however, saved $0.051/SF/yr (5).

CONCLUSION

Audit costs for both survey audits and detailed audits for the 1986 TECCP, a large-scale institutional audit program sponsored by the State of Texas, has been presented. These costs decrease with size of the buildings and increase with complexity of space audited. Effect (if any) of complexity of modifications recommended, amount of savings determined, and the amount of investment required to accomplish the building changes could not be identified.

The overall cost of accomplishing the detailed audits in this program with its payback guideline of four years or less was $0.047/SF. Without the effect of the less extensive M. D. Anderson Hospital audit, the cost is $0.050/SF. The effect of that less extensive audit was to decrease overall audit costs slightly. When discussing program costs for the 1986 TECCP, $0.047/SF is appropriate. However, for comparison with similar detailed audit programs, $0.050/SF is an appropriate value to use. The cost of pre-screening, walk-through, or survey audits is $0.0026/SF. Reimbursements for travel and per diem for out of town screenings increased this by eight percent to $0.0028/SF. Had the program called for consideration of additional measures with paybacks greater than four years, the cost would have been increased. If audit costs are to be recovered within the payback period, the payback is increased by one-tenth year or less.

Audits of large medical buildings (above about 170,000 square feet) of the type performed here were obtained for $0.050/SF or less, based on a straight-line fit to the audit cost data. Below a size of about 75,000 square feet auditing costs appear to increase dramatically with decreasing size.

Comparison with a recent round of the ICP revealed that the TECCP involved far greater costs and savings for capital intensive projects.

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Table 1. Algorithm for audit costs in simple buildings. Building area in square feet is denoted by SF.

SIZE (SF)	COST ($/SF)
0 to 75,000	0.06
Next 25,000	0.05
Next 25,000	0.04
Next 50,000	0.03
All area over 175,000	0.02

Table 2. Building area audited by building type* in 1986.

	AUDITED AREA						
CONTRACTOR	OFFICES (SF)	SCHOOLS (SF)	UNIVERSITIES (SF)	MEDICAL BUILDINGS (SF)	POWER PLANTS (SF)	TOTAL (SF)	FRACTION OF TOTAL
1			632,717	346,257		978,974	7%
2			2,129,205	61,171	36,943	2,227,319	17%
3	54,590	242,390	2,006,535	934,094		3,237,609	24%
4			822,057	2,470,027	7,319	3,299,403	24%
5	215,829	65,960	2,354,089	1,090,116		3,725,994	28%
TOTAL	270,419	308,350	7,944,603	4,901,665	44,262	13,469,299	

* Building types and fractional amount of each type audited when compared to the total space audited do not match data in Ref. (1) and (2) because here the buildings primarily were assigned to types based on building function. In Ref. (1) and (2), the emphasis is on the function of the facility (such as a university campus) containing the building.

Table 3. Simple and complex building area. Also shown are percentages of contractor's total audit area.

	SIMPLE AREA		COMPLEX AREA	
CONTRACTOR	AREA (SF)	FRACTION OF CONTRACTOR TOTAL	AREA (SF)	FRACTION OF CONTRACTOR TOTAL
1	632,717	65%	346,257	35%
2	2,129,205	96%	98,114	4%
3	2,303,515	71%	934,094	29%
4	822,057	25%	2,477,346	75%
5	2,635,878	71%	1,090,116	29%
TOTAL	8,523,372		4,945,927	

Table 4. Audit costs per square foot by contractor and building type. The total is obtained by dividing the total audit cost by the total area for the category of building and contractor. Numbers in parentheses are applicable when M. D. Anderson Hospital is not included.

CONTRACTOR	OFFICES ($/SF)	SCHOOLS ($/SF)	UNIVERSITIES ($/SF)	MEDICAL BUILDINGS ($/SF)	POWER PLANTS ($/SF)	TOTAL ($/SF)
1			0.049	0.043		0.047
2			0.048	0.136	0.716	0.062
3	0.060	0.050	0.050	0.054		0.051
4			0.048	0.032 (0.044)	2.039	0.041 (0.052)
5	0.056	0.060	0.041	0.033		0.040
TOTAL	0.057	0.052	0.047	0.039 (0.045)	0.935	0.047 (0.050)

Table 5. Audit costs according to simple and complex categories. Numbers in parentheses are applicable when M. D. Anderson Hospital is not included.

CONTRACTOR	SIMPLE ($/SF)	COMPLEX ($/SF)
1	0.049	0.043
2	0.048	0.354
3	0.050	0.054
4	0.048	0.038 (0.055)
5	0.043	0.033
TOTAL	0.047	0.047 (0.055)

Table 6. Summary of investment costs and savings.

CONTRACTOR	TOTAL ECRM COST ($/SF)	ANNUAL ECRM SAVINGS ($/SF/YR)	ANNUAL M&O SAVINGS ($/SF/YR)	ANNUAL ECRM & M&O SAVINGS ($/SF/YR)	SIMPLE PAYBACK (YR)
1	1.433	0.552	0.015	0.567	2.5
2	1.480	0.637	0.036	0.674	2.2
3	1.040	0.805	0.070	0.875	1.2
4	4.165	1.291	0.020	1.311	3.2
5	1.352	0.661	0.016	0.677	2.0
TOTAL	1.993	0.838	0.033	0.871	2.3

Table 7. Total area receiving survey audits and associated survey audit costs, by contractor. Also shown are the number of facilities surveyed and the fraction of the surveyed area which was eventually audited. The total survey audit cost column includes travel and per diem expenses, which were reimbursed for out-of-town survey audits only.

CONTRACTOR	AREA (SF)	NUMBER OF FACILITIES SURVEYED	FRACTION OF SURVEYED AREA AUDITED	SURVEY AUDIT COST ($/SF)	TOTAL SURVEY AUDIT COST ($/SF)
1	1,236,097	5	79%	0.0028	0.0035
2	3,113,181	6	72%	0.0033	0.0037
3	4,418,074	8	73%	0.0022	0.0023
4	3,900,350	10	85%	0.0039	0.0040
5	4,526,742	8	82%	0.0014	0.0015
TOTAL	17,194,444	37	78%	0.0026	0.0028

Table 8. Effect of audit costs on total costs and payback. The total cost column is the sum of audit costs from Table 4 (including M. D. Anderson), ECRM investment costs from Table 6, and total survey audit costs from Table 7. The payback is obtained by dividing the total cost by the Annual ECRM and M&O savings from Table 6.

CONTRACTOR	TOTAL COST ($/SF)	PAYBACK (YRS)
1	1.484	2.6
2	1.546	2.3
3	1.093	1.2
4	4.210	3.2
5	1.394	2.1
TOTAL	2.043	2.3

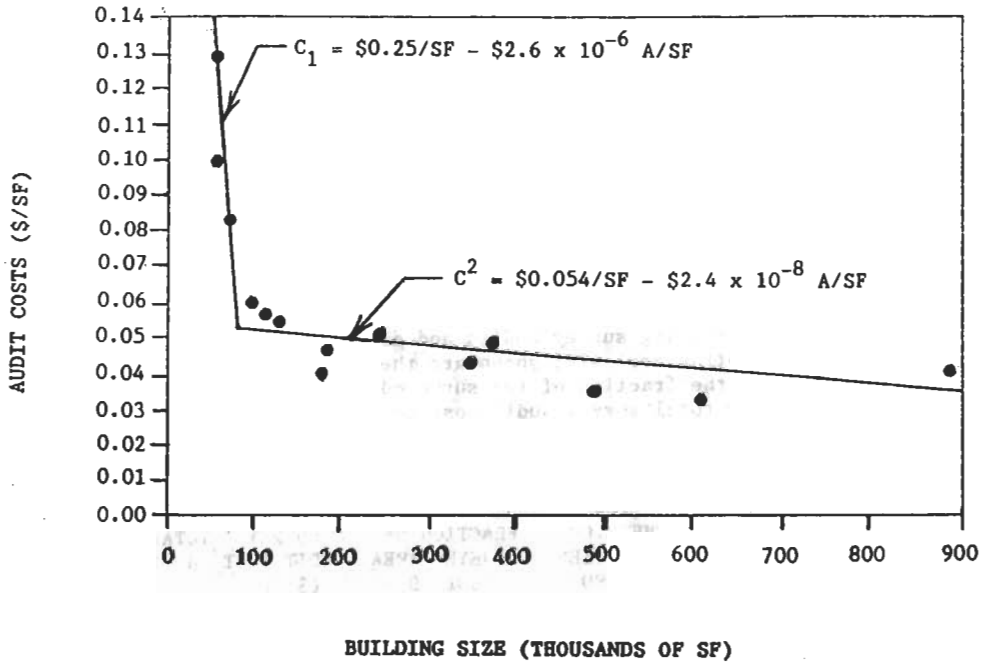

Figure 1. Audit costs (C_1 and C_2) in $/SF for the 1986 TECCP as a function of medical building size A, where A must be in square feet.