TRENDS IN BUILDING ENERGY USAGE IN TEXAS STATE AGENCIES

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ABSTRACT

In late 1983, a cost containment program was initiated out of the governor's office directed at the major state agencies. The Energy Management Group at Texas A&M University provided technical expertise in obtaining agency energy usage and cost figures for the fiscal years 1981 to 1983. While there is considerable diversity from agency to agency, the trend is toward dramatically higher energy cost per square foot for virtually all agencies. This alarming trend can be partially explained by rising unit costs for gas and electricity and a lack of incentives for conservation efforts due to the method of utility budget allocations. A building standard signed into law in 1976 could have reduced energy consumption, but was never enforced. Beginning in fiscal year 1986, universities will be allowed to comingle utility money with capital operating money so that conservation can really pay off for them.

INTRODUCTION

In November of 1983, governor Mark White sent letters to the directors of the largest state agencies to inform them of his utility cost containment program and to request that an energy manager be appointed for each agency to correspond with the governor's office on energy matters. A meeting was called in Austin to inform the agency

future utility budgets would at best be equal to the then current levels. The Energy Training Division of the Texas Engineering Extension Service was called upon to provide training to agency personnel in basic energy auditing techniques and followup procedures. The Energy Efficiency Division of the Public Utility Commission of Texas was asked to coordinate the effort of a massive data gathering and energy audit program. The PUCT contracted with the Energy Management Group of the Mechanical Engineering Department at Texas A&M University to prepare a survey form to be sent out to the agencies and then to analyze the data sent in from each agency. This paper will summarize some of the findings of that data acquisition process along with some pertinent policy recommendations.

DATA ANALYSIS

Because many of the appointed agency energy managers had no technical background, the data collection form had to be as simple and straightforward as possible. The combination of utilities that are used and methods of paying utility bills varied for each agency. In order to get a basic understanding of the agency energy budget situation and where the money was going, monthly utility data were requested and then the annual figures used to calculate energy utilization and cost indices (EUI and ECI's). The data form accounted for almost any type of energy usage, from conventional electricity and pipeline gas to purchased steam and chilled water and any combination in between. The annual energy figures were converted to Btu/sq. ft./year for the EUI without the conversion to primary energy. Since the utility costs were of prime concern, it would not be beneficial to deal with primary energy exclusively when the manner of conversion becomes a large determining factor in the bottom line cost.

Because of the different energy conversion processes used, the agencies had to be broken into several different categories before any meaningful comparisons could be made. It was not just a case of comparing apples and oranges, but a number of pears and grapefruit were thrown in for good measure. The agencies were subdivided into six categories.

Health Centers/Hospitals
1) produce their own thermal energy
2) purchase all their thermal energy

Universities
1) cogenerate some or all of their electricity

All other state agencies

By not converting the EUI to primary energy, these numbers should be somewhat low relative to conventional figures used for such purposes. The categorization provides for meaningful comparisons while primary energy figures would tend to cloud the issue.

The data which was received from the agency energy managers were often in a form different from what was called for. The issue of "conditioned" area caused numerous problems, especially for the larger university campuses. Available data were normally in the form of "gross" square feet, which includes all unconditioned space (barns, parking garages, etc.) as well as roof overhangs. Consequently, all numbers were converted to gross square feet, giving a further reduction in the EUI numbers relative to conventional practice.

The billing data were not always regular, depending on when the meters were read and how they were paid. Some data were very repeatable from year to year, such as the electicity usage for Austin State Hospital shown in Figure 1. Other data were just the opposite, as shown by the gas consumption of Texas Tech Health Science Center in Figure 2. Wild fluctuations caused by irregular meter reading times will have little impact on the annual figures which are computed by adding all monthly figures together. Some agencies had higher bills because they never paid them on time and were subject to the *customary* 5-10% late penalty. Average charges for gas and electricity varied by a factor of about 2 for gas and 3 for electricity.

The period of 1981 to 1983 was one of exploding fuel prices. Gas contracts were still rising from the aftereffects of the Iranian revolution. Electricity costs were doing likewise since many long-term gas contracts had expired or been broken earlier and the future price of gas was highly uncertain given the transition to an unregulated environment. To illustrate the impact of the rising rates, the following table shows the EUI and ECI numbers for three state agencies. Texas A&M had a 12% drop in usage, yet paid out over 40% more for utilities. Nearly the same sort of increases are seen for Southwest Texas State and the Department of Corrections Eastham Unit.

ENERGY PRICE COMPARISONS

	1981	1982	1983
Texas A&M University			
EUI	430417	422386	380761
ECI	$1.26	$1.68	$1.78
Southwest Texas State			
EUI	274088	296196	270007
ECI	$1.38	$1.76	$1.83
TDC Eastham Unit			
EUI	267177	265430	270238
ECI	$1.19	$1.46	$1.81

A brief summary of some of the agencies which submitted data is shown in Table 1, broken down into the categories discussed previously. The logic behind the categories can be seen once the numbers are examined. The hospitals or health centers must follow certain guidelines for proper air quality, often calling for extremely high ventilation rates for all or part of the facility. The UT Health Center at Houston for example is designed to provide 16 air changes per hour for the entire building. UT-Austin and Texas A&M are penalized by high EUI numbers due to their generation of nearly their entire electrical loads and the accompanying rejection of waste heat in that process. Generally the lowest EUI numbers are for those agencies that produce their own steam and chilled water using gas boilers and electric chillers. The electric chillers use about one Btu of electricity for every three Btu of chilled water produced. This same group will have an advantage on the ECI figures as well, since operating and maintenance costs are not reflected in these figures whereas such costs will be rolled into the charges levied on customers who purchase chilled water and steam. The Department of Corrections facilities are somewhat different from the rest in that they have light industrial facilities at many of their units. However, they do not air condition the prison cells and the net results are EUI and ECI numbers that are not too different from those of other agencies.

The trends of 1981-1983 can be misleading since they may indicate only a short term change which could be brought on by extreme or mild weather or other temporary factors. Similar indices were tabulated in the 1973-1975 time period for a number of universities. Table 2 shows the comparison of these figures alongside some of the 1981-1983 data. If these figures can be believed, some agencies have nearly doubled their consumption per square foot while others have cut theirs in half. Growth in facilities will produce an increase in absolute energy usage, but should not increase the usage per square foot unless the new buildings being constructed are vastly inferior to the older buildings with regard to energy consumption. The use of reheat, double duct, or multizone systems can be expected to be a large reason why the newer buildings use more than the older ones that use two-pipe systems and possibly window air conditioners. With regard to conservation potential, the 1973 numbers may be a better indicator for a particular ageny than comparing it to another agency. The differences in the agency building stock and functions can cause a large difference in EUI, but if the EUI has already dropped 25%, there may not be a lot left to do to reduce it further. On the other hand, if the EUI has risen by 50%, there are many things that can be done to conserve energy.

CORRECTIONS FOR LOCAL WEATHER CONDITIONS

When agencies from all across the state of Texas are subjected to comparisons of energy usage, they should appropriately be normalized somehow to account for weather differences. A number of studies have shown that commercial buildings use considerably less energy for HVAC applications when located in southern regions as compared to more northern climates. Within the state of Texas the north to south distance is nearly equivalent to travelling from Chicago to Atlanta. East to west distances are just as great, although the major metropolitan centers are situated primarily in the eastern half of the state.

When dealing with more than 50 agencies, most of which occupy a diverse set of buildings ranging in age from brand new to more than 100 years old, any attempt to provide detailed HVAC load analysis becomes futile. As a first approximation of the impact of weather on HVAC loads, heating and cooling degree-days were used. To further reduce the apples-and-oranges comparisons of dissimilar agencies at different latitudes, two agencies were "moved" around the state by imposing on them different degree-day data. It was recognized that a dominant part of the overall agency load, whether gas or electrical, is often independent of weather conditions. A "typical" load curve is shown in Figure 3 where such a curve could apply to either gas or electricity where gas heating and electric cooling are implemented. Cooling derived from gas heat would produce a double humped curve, peaking in January and again in July or August. The base load for the utility usage was determined by simply taking the average of the lowest 3 or 4 monthly bills. The area under the peak, but above the base load figure, represented all the energy usage effects which could be associated with weather conditions. To determine the annual energy usage figure for a particular agency if it were located in another climatic zone,

$$\text{Annual Energy Usage} = \text{Base Area} + \text{Area Under Peak} \times \frac{DD_2}{DD_1}$$

where DD_2 is the desired degree-day condition to look at, while DD_1 is the condition which produced the particular load curve used to find the base and peak areas. This simple equation could perform two different tasks quite simply. It could take a normal weather year degree-day figure and determine how a particularly extreme or mild season affected energy consumption. While there is no denying that unseasonable weather can have profound impacts on HVAC energy consumption, the state of Texas experienced near normal weather conditions in the 1981-1983 time period. Degree-day data from all the major cities around the state failed to produce more than a 3% difference in energy usage associated with the actual weather conditions of a particular year.

The other use for the above equation is to compare the energy usage of a particular agency were it to be located at other places around the state. Two agencies were chosen for test cases because of their simple load profiles. North Texas State University (NTSU) was selected to represent the university type of load, while Austin State Hospital (ASH) was used to characterize the health center type of facility. Both agencies had load profiles which very closely duplicated the ideal profile shown in Figure 3. The results of this comparison are shown in Table 3. It is very interesting to note the wide range between Amarillo and Brownsville, on the order of 45% for NTSU and 26% for ASH. This simple procedure indicates that if West Texas State (located in Canyon, TX near Amarillo) were instead located in Brownsville, its utility bills would be no more than about half of its current expenses. This reasoning partly explains why Texas A&I is perennially at the bottom of the EUI list. However, weather alone does not explain differences in EUI figures, as the highest EUI's were found for agencies situated in the central portion of the state. In fact West Texas State came in near the middle of the list in terms of EUI ranking. This simple exercise merely shows that weather can have an important impact on monthly or annual energy usage, but proper maintenance or smart operation can more than compensate for severe weather conditions.

BUILDING STANDARDS

Just a quick glance at the EUI figures would convince anyone that most agencies use far more energy than is recommended. Adoption of building standards will nearly insure the EUI to drop in future years for a particular agency.

However, a little bit of investigation turned up a set of new building standards which were put forth by the state legislature in 1975. The standard applied to all state agency buildings constructed since 1975. New buildings were to be constructed according to the standards, and be equipped with metering equipment so that energy consumption data could be reported to the State Building Commission.

Upon checking into these standards, it became apparent that even folks in Austin did not know they existed any longer. It was a classic case of unenforced legislation. It was particularly unfortunate that the standard was ignored, since it was basically a revised ASHRAE 90-75 standard. The ASHRAE standard has found wide acceptance in most of the 50 states.

The real unfortunate part of the standards situation centers around the question of cost. Because of the widespread growth at most of the universities since 1975, a prime opportunity to impact future energy costs has been missed. For instance, suppose the schools of Southwest Texas State, UT-Austin and UT-Arlington had followed the standard in their new building construction since 1976. An office building constructed according to ASHRAE 90-75 standards should use less than 100,000 Btu/sq. ft./year in overall energy usage. If the new buildings on these three campuses used only 100,000 Btu/sq. ft./year, the state of Texas would be paying over $3.3 million less per year for utility bills. It is not hard to understand why other states have adopted these standards, at least for their own construction programs.

An effort to promote an acceptance of the ASHRAE standard was made in the most recent meeting of the Texas legislature. The bill did not receive much support. Currently the PUCT and Texas A&M are looking into ways to implement the current standard that is on the books, and find some way to enforce it as it now stands. The long term energy cost figure demands that efforts be continued in that direction before the problem has snowballed further with current building expansions around the state.

BUDGET DISINCENTIVES

The straw that normally broke the backs of agency physical plant directors when trying to conserve energy was the separate funding arrangement that the state used to pay for utilities and operating costs. The utility budget was a completely separate pot of money which could be spent only on utilities. Operating costs covered manpower, maintenance, and any capital improvements. If a particular energy conservation item were to be implemented, it would have to be purchased with operating budget funds. The saved utility money went back into the utility budget pot, which was returned to Austin at the end of the fiscal year. Consequently, to save energy costs an agency had to spend its own budget money and not receive any sort of return on its investment. While theoretically all state employees want to reduce operating costs

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for the state, a university president will spend his operating budget to promote scholarship, not save kWh. A further complication arose in that if an agency ran out of utility money before the end of the fiscal year, they simply made an emergency request for additional appropriations from the legislature to finish the year. Such requests were never opposed. So in fact, the utility money pot was viewed as an infinite reservoir, always there for the asking. There was no incentive whatsoever to spend operating money on conservation items rather than other budget items, because the utility money would always be there to bail them out if they needed more at the end of the year.

This counterproductive budget arrangement was attacked by the Energy Management Group. Every agency representative that was contacted expressed the same concern about spending their own budget money to save utility money that they never even got to see. In testimony before a special legislative committee, it was recommended that the state find a way to share any documented savings with the agencies so that energy conservation becomes a lucrative investment for the agency directors. Effective in September 1985, universities will no longer have different pots of money to spend for operating and utility costs. Therefore, a penny saved on utility costs becomes a penny earned for other budget items. This arrangement puts much more responsibility in the hands of the local directors, because now there is no longer the infinite reservoir in Austin to bail them out at the end of the year if they have not been efficient in the use of their utility budget. At the same time, for those agencies which are aggressive in energy conservation, they will be able to plow back their savings into other conservation programs to produce further savings. Such a situation is clearly one where everyone wins.

CONCLUSIONS

Energy use data collected from over 50 Texas agencies show that utility costs are rising dramatically even where the usage per square foot is dropping. The EUI figures of virtually all Texas agencies were much higher than currently achievable levels using ASHRAE standard 90-75 as a guideline. Although local weather can account for a big difference in utility costs as one goes from north to south in the state, it appears that other factors have at least an equally large impact on actual usage figures. The apparently energy intensive buildings being added to the current stock of state owned buildings is causing the usage per square foot to go higher and higher at a number of locations. This problem could be alleviated by the enforcement of building standards which were legislated in 1975. The change in budget format for state universities to let them share in utility savings will have a pronounced impact on their willingness to spend some of their budget money in order to save utility money.

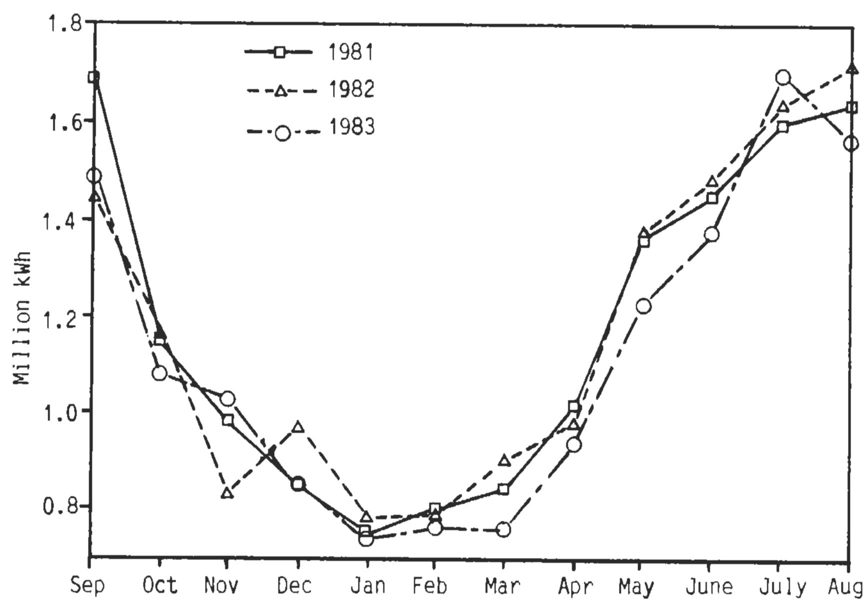

Figure 1 Monthly electrical consumption for Austin State Hospital.

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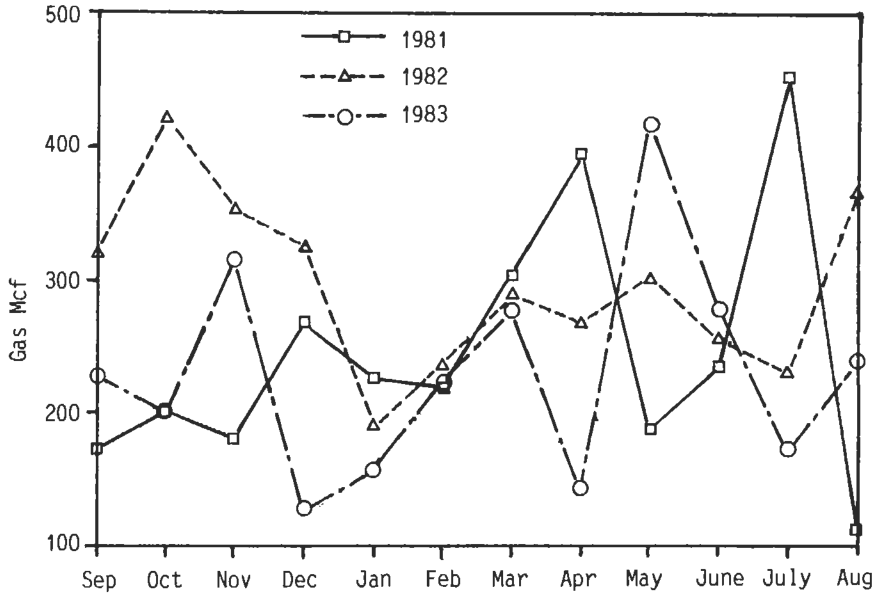

Figure 2 Monthly gas consumption for Texas Tech Health Science Center.

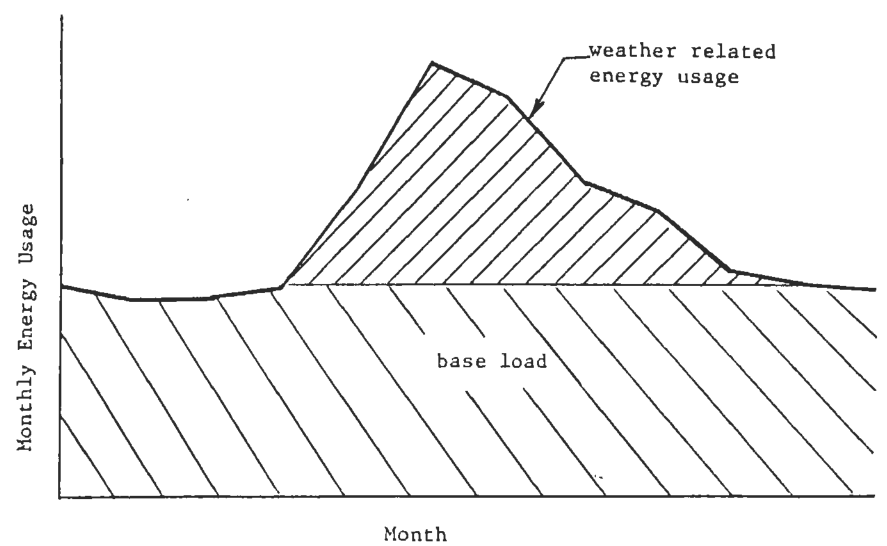

Figure 3 Breakdown of energy usage into base load and weather related.

Table 1 Listing of selected state agency EUI and ECI data

AGENCY	EUI (Btu/sq.ft./yr)			ECI ($/sq.ft./yr)		
	1981	1982	1983	1981	1982	1983
Health Centers/Hospitals which produce their own thermal energy						
San Antonio State Chest Hospital	448097	493395	512860	2.22	3.16	3.53
Austin State Hospital	219935	239568	274447	1.56	1.98	2.23
San Antonio State Hospital	171969	173933	173365	1.06	1.40	1.52
Health Centers/Hospitals which purchase thermal energy						
U T Health Center at Houston	482598	473390	474002	4.77	5.37	5.75
Texas Tech Health Sciences Center	358528	340124	343310	3.14	3.37	4.22
U T Health Science Center/San Antonio	267801	277837	240979	2.24	2.89	2.88
Universities that cogenerate						
University of Texas at Austin	430385	460588	473210	1.55	1.91	2.25
Texas A&M University	430417	422386	380761	1.26	1.68	1.78
Universities that purchase thermal energy						
U T San Antonio	211047	233985	223073	2.60	2.88	3.25
Pan American University	182640	201482	205268	2.32	2.69	3.14
U T El Paso	125953	120305	134653	1.47	1.50	1.84
Texas Tech University	168000	161306	164097	1.02	1.18	1.36
Universities that produce their own thermal energy						
University of Houston/University Park	239449	260404	287726	1.63	2.30	2.67
Southwest Texas State University	274088	296196	270007	1.38	1.76	1.83
Prairie View A&M University	243744	229204	267337	1.36	1.57	1.75
U T Arlington	216787	234396	215050	1.20	1.61	1.63
North Texas State University	137076	131371	131335	1.67	1.39	1.47
Stephen F. Austin University	174398	159236	155124	1.17	1.29	1.37
Texas A&I University	89809	86907	83680	0.95	1.13	1.22
West Texas State University	129450	128616	122732	0.75	0.85	0.92
Major state agencies						
Department of Corrections/Huntsville	246169	243790	244678	1.44	1.71	2.08
Austin State School	167370	168322	175339	1.23	1.56	1.61
Department of Corrections/Darrington	338923	364573	214986	1.56	2.06	1.49
State Purchasing/Gen Serv Commission	217538	182089	159733	1.11	1.34	1.42

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Table 2 Comparison of 1973-75 and 1981-83 EUI data for selected agencies

AGENCY	ENERGY UTILIZATION INDEX 1973	1974	1975	1981	1982	1983	%CHANGE 73-83
Department of Corrections	315489	265628	307860	253518	250632	251778	-20.2
University of Houston	427425	354103	330356	239449	260404	287726	-32.7
Texas Tech University	333628	322594	311058	168000	161306	164097	-50.8
Southwest Texas State	294853	261274	278740	274088	296196	270007	-8.4
Stephen F. Austin Univ.	201640	180077	198194	174398	159236	155124	-23.1
Prairie View A&M Univ.	187770	188722	184640	243744	229204	267337	42.4
West Texas State Univ.	162195	157928	171209	129450	128616	122732	-24.3
North Texas State Univ.	161956	151483	146753	137076	131371	131335	-18.9
Pan American University	156758	129841	136746	182640	201482	205268	30.9
U T El Paso	137329	115317	116091	125953	120305	134653	-1.9
U T Arlington	112312	88371	119529	216787	234396	215050	91.5
Texas A&I University	95111	87524	87450	89809	86907	83680	-12.0
Texas A&M University	479191	478690	441424	430417	422386	380761	-20.5
U T Austin	378402	366661	393899	430385	460588	473210	25.1

Table 3 Comparison of EUI for North Texas State University and Austin State Hospital using various degree-day data for 1981

	NTSU		ASH	
Location	EUI Btu/sq.ft./yr	% difference from Austin	EUI Btu/sq.ft./yr	% difference from Austin
Austin	125,900	0	219,100	0
Dallas	139,300	10.6	231,700	5.8
Houston	120,100	-4.6	213,600	-2.5
Amarillo	168,700	34.0	259,000	18.2
Brownsville	107,300	-14.8	201,800	-7.9
El Paso	139,400	10.7	231,650	5.7
Midland-Odessa	139,500	10.8	231,700	5.8