February 1, 2000

Dear Mr.:

This letter is in response to your request for a study of the economic impact of Texas' potential adoption of a commercial building energy standards that meets or exceeds ASHRAE/IESNA Standard 90.1-1989. In this preliminary report, I will have to make use of our existing analyses to the largest extent possible. In the rest of this report, energy use is viewed in terms of differences in annual energy usage in kBtu/ft^2/year for a number of building types in a climate similar to that of Texas. Cost impact is viewed in terms of differences in construction cost.

Background: Texas currently has no statewide energy requirements for commercial buildings. Texas is considering adoption of a statewide commercial building energy code that meets or exceeds ASHRAE/IES Standard 90.1-1989.

Energy Use Impacts: A recent PNL report (Hadley and Halverson, 1993) examined the energy use of ten building types in six climatic regions of the United States under three different building standards (including ANSI/ASHRAE/IES 90A-1980 and the Federal standard- technically equivalent to ASHRAE/IES Standard 90.1-1989). I have enclosed a copy of this report but will summarize the important results with special attention to the results that impact Texas.

The ten building types were: Apartment, Small Office, Medium Office, Large Office, Church, School, Hotel, Anchor Retail, Strip Shopping Mall, and Warehouse. These ten buildings represent real buildings designed and built in the mid-1980's and used in a number of standards development activities by ASHRAE and DOE. The six climatic regions were represented by: El Paso, Texas; Lake Charles, Louisiana; Madison, Wisconsin; Los Angeles, California; Seattle, Washington; and Washington, D.C. The three different building standards compared were: ANSI/ASHRAE/IES Standard 90A-1980; 10 CFR 435 - the current Federal standard (which is almost identical to ASHRAE/IES Standard 90.1-1989 in terms of technical requirements); and 10 CFR 435 with reduced lighting power allowance.

The portions of this report applicable to Texas' request are the comparison of 10 CFR 435 to ANSI/ASHRAE/IES Standard 90A-1980 for all building types in El Paso, Texas and Lake Charles, Louisiana. Granted that El Paso and Lake Charles represent only two climatic areas of Texas, but these locations do represent the climate in large portions of Texas, as shown by the table below: (Data taken from ASHRAE/IES Standard 90.1-1989, Appendix C).

City	Heating Degree Days (HDD65)	Cooling Degree Days(CDD50)
Brownsville, TX	642	8531
Laredo, TX	842	8827
Kingsville, TX	874	8302
Corpus Christi, TX	889	8200
Houston, TX	1346	7215
Del Rio, TX	1397	7376
Port Arthur, TX	1416	6888
Lake Charles, LA	**1455**	**6849**
San Antonio	1579	7170
Austin, TX	1735	6873
Lufkin, TX	1846	6667
San Angelo, TX	2110	6522
Waco, TX	2166	6676
Fort Worth, TX	2354	6174
Midland, TX	2573	5695
El Paso, TX	**2605**	**5617**
Sherman, TX	2708	5844
Abilene, TX	2714	5968
Wichita Fall, TX	3049	5708
Lubbock, TX	3643	4754
Amarillo, TX	4331	4113

Lake Charles is seen to be very similar in climate to Houston, San Antonio, and Austin, while El Paso is representative of somewhat cooler climates such as Fort Worth and Abilene.

The results of the study may be viewed either across all buildings simulated in Lake Charles or El Paso or by building type. Table 3.2 (page 3.14 of the report) shows that for all ten building types, annual energy usage in Lake Charles decreased from 72 to 64 kBtu/ft^2/yr going from ANSI/ASHRAE/IES Standard 90a-1980 to a standard that is technically equivalent to ASHRAE/IES Standard 90.1-1989. The same comparison for El Paso shows a decrease from 74 to 65 kBtu/ft^2/yr. This represents a 11% savings in energy averaged across all ten building types in Lake Charles and a 15% savings in El Paso.

Appendix B (pages B.1 through B.10) show the results by building type of this analysis. As can be seen from these tables, the energy savings are highly dependent on building type, ranging from 3% to 4% for residential occupancies (Apartment) to nearly 30% for large retail building types. Using these results and an estimate of Texas' new construction volume by square foot, an estimate could be made of the total energy savings that could be obtained in Texas. I do not have an estimate of Texas new construction starts by building type, but would expect that much of Texas' commercial construction falls in the office or retail categories. Based on the results shown for these categories, Texas can expect that requiring ASHRAE/IES Standard 90.1-1989 will save 11% to 30% of the total energy usage of new commercial construction assuming current buildings are being built to the requirements of ANSI/ASHRAE/IES Standard 90A-1980.

Results for Lake Charles

Building Type	Energy Savings	Biggest Savings in
Apartment	3.4%	Cooling
Small Office	11.5%	Lights, Cooling
Medium Office	13.5%	Lights, Cooling
Large Office	11.9%	Lights, Cooling
Church	7.4%	Cooling, Heating
School	10.0%	Lights
Hotel	7.8%	Cooling
Anchor Retail	28.6%	Lights, Cooling
Strip Shopping Mall	10.1%	Cooling, Lights
Warehouse	10.7%	Lights

Results for El Paso

Building Type	Energy Savings	Biggest Savings in
Apartment	4.1%	Heating
Small Office	10.6%	Lights, Cooling
Medium Office	11.1%	Lights, Cooling
Large Office	8.6%	Lights, Cooling
Church	9.8%	Cooling, Heating
School	11.9%	Lights, Heating
Hotel	6.3%	Cooling
Anchor Retail	28.9%	Lights, Cooling
Strip Shopping Mall	15.7%	Cooling, Lights
Warehouse	22.9%	Lights, Heating

Without extensive surveys of current construction practice in the State of Texas, the assumption that buildings are built to the requirements of Standard 90A-1980 is the best assumption to make. If architects, builders, or designers are not using Standard 90.1 but are using a standard, Standard 90A-1980 is the logical choice. Standard 90A-1980 was the basis of the commercial requirements in the CABO MEC until quite recently and was the basis of many state standards developed in the 1980s. Of course, if baseline current practice is "no standard", as it may be in the case of jurisdictions with no building codes, these savings estimates may be low. While Standard 90A-1980 is outdated, it is better than no standard at all, and buildings built to the requirements of Standard 90A-1980 are better than buildings built without consideration of standards.

Estimated energy savings are nearly always associated with lighting and cooling. The lighting savings reflect the more stringent (lower) lighting power allowances associated with Standard 90.1. The cooling savings reflect both the lower lighting power allowances and the more stringent (higher) chiller efficiencies associated with Standard 90.1. Recent experience with the development of new Federal energy standards and the new Standard 90.1 indicate that even more stringent lighting power allowances are easily met with existing technologies, good lighting designs, and minimal cost increase. Texas may wish to consider adopting one of the new sets of lighting requirements to achieve even greater savings.

Energy Cost Savings: Energy savings can be calculated from the numbers presented in the Energy Use Impacts section if annual gas and electricity prices are estimated and if enduses discussed in Appendix B of Hadley and Halverson (1993) are assumed to be electricity or gas.

For purposes of this analysis, assume electricity at 8 cents per kWh and gas at 56 cents per them. (These are not necessarily the best values for use in Texas, but are approximate national average fuel prices.) Applying this information to the Medium Office building type in Lake Charles (Page B.6 of Hadley and Halverson, 1993), we get the following:

Savings from	Savings (kBtu/ft2/yr)	Fuel
Heating	2	Gas
Cooling	3	Electricity
Lighting	7	Electricity
Fans	-1	Electricity

The estimated gas savings are 2 kBtu/ft2/yr. Gas dollar savings are then 2 kBtu/ft2/yr times 1 therm/100,000 Btu times 56 cents per therm. The estimated savings on gas are 1.1 cents/ft2/yr. The estimated electricity savings are 9 kBtu/ft2/yr. Electricity dollar savings are then 9 kBtu/ft2/yr times 1 kWh/3413 Btu times 8 cents/kWh. The estimated savings on electricity are 21 cents/ft2/yr.

Applying a similar process to the other building types in Lake Charles yields the following results:

Building Type	Energy Savings	Savings (cents per ft2 per year)
Apartment	3.4%	2
Small Office	11.5%	22
Medium Office	13.5%	22
Large Office	11.9%	21
Church	7.4%	3
School	10.0%	6
Hotel	7.8%	19
Anchor Retail	28.6%	65
Strip Shopping Mall	10.1%	19
Warehouse	10.7%	3
Straight Average	11%	18 cents per ft2 per year

Applying the same process in El Paso yields

Building Type	Energy Savings	Savings (Cents per ft2 per year)
Apartment	4.1%	1
Small Office	10.6%	26
Medium Office	11.1%	26
Large Office	8.6%	18
Church	9.8%	2
School	11.9%	6
Hotel	6.3%	13
Anchor Retail	28.9%	65
Strip Shopping Mall	15.7%	21
Warehouse	22.9%	7
Straight Average	13%	19 cents per ft2 per year

Total annual estimated energy savings for all building types are on the order of 18 to 19 cents/ft2/yr. Energy User News estimates typical office total building electricity and gas costs of $1.85 per ft2 per year for office buildings in New Orleans. Thus, the estimated dollar savings attributable to adoption of Standard 90.1 are approximately 10% of typical building energy costs. These calculations point out that there are considerable savings associated with office, retail and hotel occupancies, but relatively small savings associated with high-rise apartments, churches, schools, and warehouses. The wide variation in savings by building type also points out the need to use estimates of the square footage of each building category if an "average" for the state of Texas is to be developed.

The Commercial Building Energy Consumption Survey provides estimates of the building stock in the census regions in the United States. For the South census region, the estimated building type fractions are shown below. Combining these with the estimated energy cost savings results in the following table.

CBECS Type	Estimated Fraction of Building Stock	Hadley and Halverson Savings Estimate (cents per ft2 per year)	Estimated Texas Savings
Offices	0.169	18 to 26	3.0 to 4.4
Education	0.105	6	0.6
Religious Worship, Public Assembly	0.154	2 to 3	0.3 to 0.5
Mercantile and Service, Food Sales, Food Service	0.195	19 to 65	3.7 to 12.7
Lodging	0.039	13 to 19	0.5 to 0.7
Warehouse and Storage	0.186	3 to 7	0.6 to 1.3
Other	0.152	Assume 10	1.5
Total			10.2 to 21.7 cents per ft2 per year

Applying this total savings to the 1993 estimated new construction in Texas of xxxx square feet, the total annual energy savings in the state is between $xxxxx and xxxxx.. This estimate is heavily dependent on the estimated savings from retail buildings, which in turn is very dependent on the building size. Note that the estimate of new construction volume is taken from U.S. Census Bureau data taken from building permit surveys.

Construction Cost Impacts: A companion volume to the energy impacts report mentioned above (DiMassa, Hadley, and Halverson, 1993) included an analysis of construction cost impacts for four of the building types used above (Apartment, Small Office, Anchor Retail, and Strip Retail) and for two different U.S. locations (Los Angeles and Madison). I have enclosed a copy of this report also, but will summarize the results briefly.

The construction cost study found that while energy usage did go down for the buildings when more stringent standards were applied, construction costs did not necessarily go up. This was due to the flexibility built into the newer, more stringent standards that allowed the builder a range of options for meeting the requirements. In some cases, it was found that the same building could actually be built at a lower cost under the more stringent standards. This was attributed mainly to the reduced lighting power requirements, which require fewer lighting fixtures and lower labor costs. The lower lighting power requirements also led to lower cooling loads. The lower cooling loads, combined with changes in envelope requirements and increased HVAC efficiency requirements, allowed the HVAC equipment to be sized smaller and led to additional construction savings. Overall, it appears likely that buildings built to ASHRAE/IES Standard 90.1-1989 will cost about the same as buildings built to ANSI/ASHRAE/IES Standard 90A-1980. With the construction costs for either standard about the same, the influence of current construction practice is minimal.

While Texas costs would not be expected to be identical to either Los Angeles or Madison, neither of these cities represent extremes in the construction industry and they can probably be considered to be typical of the range of costs that might be found in Texas. The conclusion above about the flexibility of the standards is another issue that deserves another mention. ASHRAE/IES Standard 90.1-1989 offers three distinct compliance paths - prescriptive, system performance, and energy cost budget - each with its' own set of requirements, tradeoffs and costs. ANSI/ASHRAE/IES Standard 90A-1980 offers a single path more or less equivalent to a system performance approach with a different set of tradeoffs and costs. Given the wide range of compliance options under both standards, comparison of construction cost is difficult.

Estimated incremental cost documented in DiMassa, Hadley and Halverson (1993) ranged from plus 1.7% for a strip mall store in Los Angeles to minus 1% for the same building in Madison. The largest absolute first cost increase was also associated with the Los Angeles strip mall. An additional $10,600 was added to the first cost by energy efficiency measures associated with Standard 90.1. Assuming that these same first costs would apply in Texas leads to the following table.

Building Type	Strip Mall
Building Size	11,760 ft2
Location	Lake Charles, LA (or similar climate)
Estimated First Cost Increase	$10,600
Estimated Annual Energy Savings	$ 2,234

Note that even using the worst case found in the study, the energy efficiency measures have a simple payback of less than 5 years. Reducing lighting allowances below those allowed by Standard 90.1 would decrease this payback period. Note also that the study referenced above typically found decreases in first cost attributable to smaller HVAC equipment requirements. If first costs go down and energy savings accrue, adoption of Standard 90.1 is definitely cost effective.

Sincerely,

attachments