

AN EVALUATION OF INSTITUTIONAL ENERGY AUDITS PERFORMED FOR THE TEXAS LOANSTAR PROGRAM

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The building energy audit process has improved dramatically since it was first popularized in the early 1970s. Effective energy audit firms use some combination of site visits, utility bill analysis, engineering experience, and sometimes computer modeling to determine which energy conservation measures will reduce a building's energy bill while maintain interior environmental conditions. Unfortunately, the effectiveness of an energy audit can vary dramatically from one firm to the next or even among auditors within the same firm. In an effort to improve the energy audit process we have begun to investigate prescreening indices intended to improve the audit process by consistently guiding the auditor to those problems that need the most attention.

Several indices have shown some potential for unraveling the complexities of building energy use, namely: 1) energy usage and demand expressed as power levels (W/ft^2), and 2) comparisons of Electric Load Factor (ELF) and Occupancy Load Factor (OLF). In Figure 1 we illustrate the use of these indices for a building currently in our Texas LoanSTAR program, a \$98 Million conservation revolving loan program for publicly owned buildings in Texas.

Monthly power levels represent energy use scaled to the conditioned floor area. Power levels provide a comparative index that displays, on one graph, electricity usage, thermal energy usage and electric demand.

ELF, also known as the diversity factor, is the electricity consumption (kWh) divided by the product of the electric demand times the hours in the period under consideration. The OLF is the ratio of the hours that a building is occupied divided by the total hours in the period under consideration. We have found that a comparison of monthly ELF

and OLF provides a rough sense of whether or not scheduled electricity use approximates the building occupancy schedule.

In the 300,000 square foot office building (Figure 1) we display the power levels (upper graph) and the ELF and OLF comparisons (lower graph). Monthly power levels are shown for the electric demand (+), the total energy usage (triangular symbol), electricity usage (kWh, the square symbol), and natural gas (diamond symbol). First, with a total monthly power level rarely dropping below $5 \text{ W}/\text{ft}^2$, the building is a high energy user. Clearly, electricity represents the largest energy usage. Second, we can see that natural gas is significantly influenced by the heating season. Electricity energy usage is essentially flat and actually rises somewhat in the heating season. Electric demand is erratic, peaking in September and February.

OLF indicates that the building is occupied, on the average, 26% of each day. Roughly, this equates to a Monday through Friday schedule of about 9 hours per day. At 60% the ELF may be indicating that there is considerable electricity usage when the building is unoccupied.

Site visits and an energy audit confirm our suspicions. Namely, that there is a large dedicated computer facility in the building, constant volume air-handling units which are rarely shut-off during unoccupied hours and cooling provided by chilled water that is generated in a central plant located nearby.

One common energy conservation retrofit that may benefit from the application of these indices is the installation of variable speed drives, usually to air-handling units or pumps. With prescreening information from power levels, ELF and OLF indices, and some preliminary site description

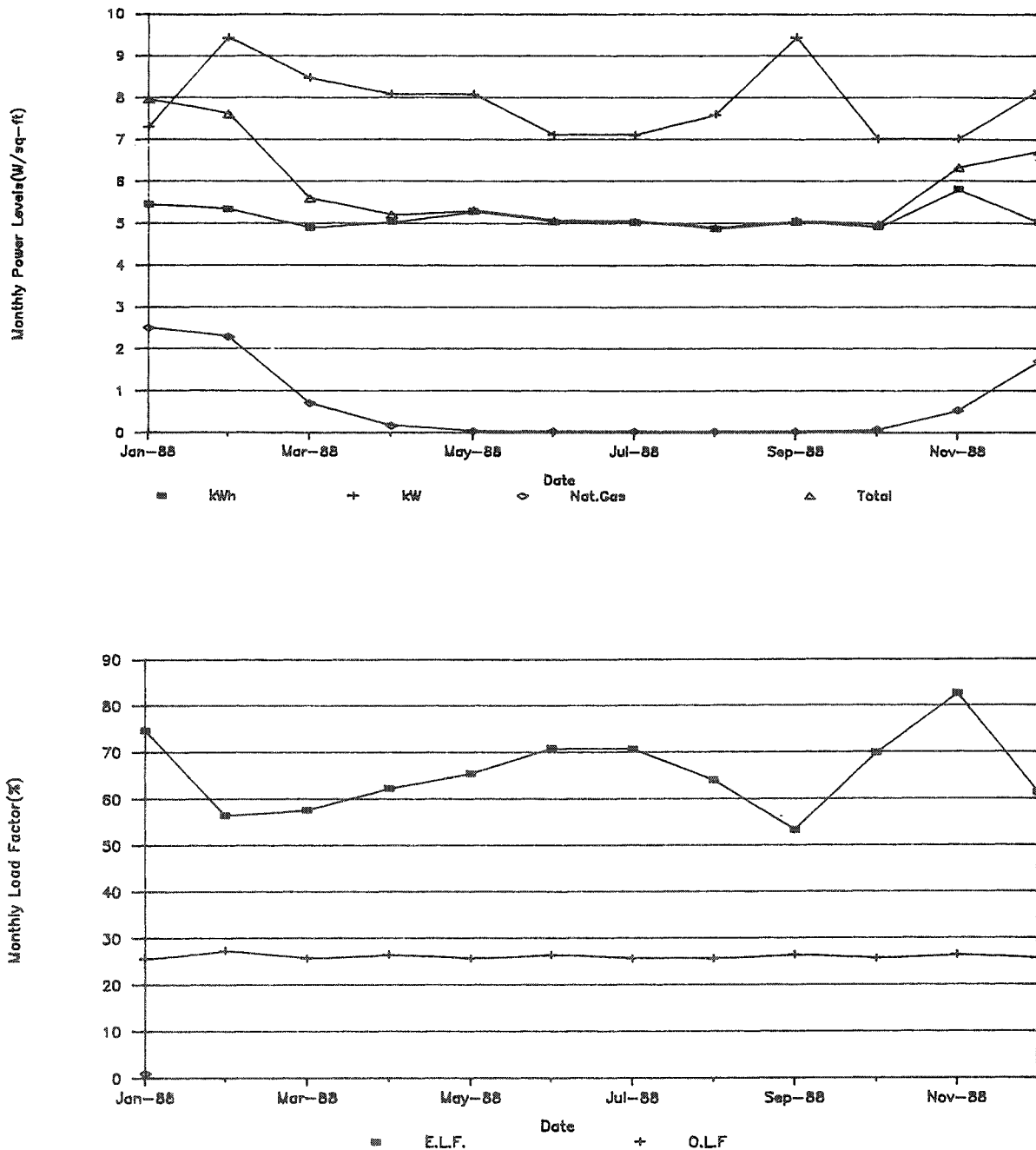


Figure 1. Energy Usage and Comparisons of ELF and OLF for a 300,000 Square Foot Office Building. Energy usage expressed as monthly power levels (W/ft^2) and comparisons of ELF and OLF are shown for a large office building located in Austin, Texas. Electricity is used for lights, fans, pumps, a large central computing facility and portions of the cooling load provided by two 460 ton chillers. A large portion of the cooling load is provided by chilled water produced at a neighboring central plant, and is not reflected in the monthly consumption. Natural gas is consumed for domestic water heating and space heating.

Table 1. Ranking of Monthly Power Levels. This table contains some thoughts about the types of relationships we are seeing when we compare the indices to audit recommendations and reports from the site visits. W/ft^2 are calculated using 3,413 Btu/kWh, and 1,000 Btu/CF.

	Low (W/ft ²)	Med (W/ft ²)	High (W/ft ²)
Total Use	0 - 3	4 - 6	6+
Electric (kWh)	0 - 2	3 - 4	4+
Natural Gas	0 - 1	1 - 2	2+
Electric (kW)	0 - 3	4 - 7	7+

information one can determine whether or not a facility has constant volume air-handling units and whether or not those units are currently being operated during unoccupied periods.

Results from applying the prescreening indices to buildings can be roughly summarized as follows:

1. *ELF > OLF*: Electricity usage profiles may be indicating that fans, lights or other systems are operating during evenings and weekends.
2. *ELF = OLF*: Electricity usage profiles probably indicate that fans, lights and other systems are not operating during evenings and weekends.

3. *ELF < OLF*: a) Occupancy load factors may not be representing the actual facility usage, b) possible presence of electric demand spikes, c) facility may be in use 24 hours per day.
4. *Low ELF (<30%)*: a) Typical of Monday through Friday, 8 hour per day use, or b) spikes in electric demand, or infrequent use of a large electrical device may be lowering ELF.
5. *High ELF (>60%)*: a) Electrical systems operating around the clock, b) building may be a good candidate for co-generation, c) building may be employing load-shedding or thermal energy storage.
6. *ELF dips below OLF in the spring and fall months*: Economizers may not be present or may not be operating properly, requiring infrequent use of air-conditioning.

The results from our initial efforts are encouraging and indicate that such prescreening indices can be developed to improve the consistency of energy audits and assist us in evaluating the hundreds of audits in the program. Additional work will be required to refine the indices, apply the indices to a broad range of buildings, and assess the cost effectiveness of using the indices.