10 Common Problems in Energy Audits

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Energy audits drive energy savings in existing buildings. Good energy audits followed by solid implementation result in substantial energy savings. Bad energy audits, no matter how good the implementation, result in lower-than-expected savings or no energy savings—and occasionally even increased energy use, wasted investment, angry building owners, and a bad name for energy conservation.

Reviews of actual savings in real buildings show a wide discrepancy in delivered savings, with many projects delivering savings well under 10% of preexisting energy costs, far short of predicted savings and barely discernible within the noise of utility bills, while other projects successfully deliver savings of 40% and more. We look to energy audits for possible explanations.

After reviewing more than 300 energy audits, the following 10 problems were identified as the most common. To assess the frequency and other characteristics of these problems, 30 energy audits were reviewed in more detail. All 30 audits were conducted by different firms, were completed in the last five years, and were drawn from work in buildings across the United States.

Fifteen audits were in commercial buildings, and 15 were in single-family residential buildings. Single-family residential audits were included as a distinct portion of this study because this sector has long had well-defined programs with utility companies at the state and national levels, and also because this sector has recently developed its own national energy audit standard. The audits were not specifically chosen on the basis of "level" as defined by ASHRAE, or on the basis of auditor qualifications.

The methodology of the study is described within each of the problem descriptions below, but the study was intentionally limited in scope and likely only scratches the surface of the issues at hand.

About the Author

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The Problems

The problems are presented in order from least to most frequent.

10. Inadequate review: 30% of audits.

Inadequate review was defined as three or more obvious mistakes, other than mistakes in calculation. Examples included sections in a report that were duplicated within the same report; a reference to heat pump thermostat savings in a building that actually has a gas furnace; 1 cfm being defined as the air in a basketball (presumably meant to be 1 cubic foot); and electric air conditioning savings shown in units of therms. We speculate that inadequate proofreading may not be solely the fault of the energy auditor, but rather may be the result of inadequate supervision and review. In our experience, energy audits are frequently performed by entry-level staff. It is critical that senior staff participate actively at every stage, including planning, field investigation, and review. A solid quality control plan includes review of the building description and proposed list of improvements to be evaluated, before modeling begins. A model review is also important, to ensure that the model matches the building description, that assumptions are reasonable, and that results have been interpreted correctly. And finally, review of the final report is vital.

9. Overestimated savings: 53% of audits.

The bar was set high for defining overestimated savings. An audit had to have an improvement with savings more than twice as high as reasonable (or no savings given along with claims of payback in less than one year). Overestimated savings arise from poor modeling, incorrect measurements or assumptions, or not accounting for interactive effects between improvements. For savings to be overestimated, either energy use by existing equipment is overestimated, or energy use by proposed equipment is underestimated, or a combination of the two. Our experience has shown that the energy auditor can sometimes overenthusiastically bias assumptions to nudge an improvement toward "recommended."

Examples included residential lights presumed to operate more than eight hours per day (research shows that residential lighting use averages under three hours/day)[1] and heating controls that presume a 10°F (6°C) reduction in indoor temperature. Because of the high threshold needed for an audit to qualify as having overestimated savings, the number of audits with overestimated savings that might still be measurable in terms of undelivered savings in utility bills is likely a good bit higher than 53%. The separate problem of underestimated savings, which could result in unwarranted rejection of an improvement, was not examined because of the likely exclusion of such improvements from the reviewed audits.

8. Inadequate billing analysis: 57% of audits.

For an audit to be classified as having this problem, it must be missing at least three out of four of the following: monthly summaries of fuel bills (at least one year); a true-up of bills to the energy audit model; projected savings being a reasonable fraction of total annual use; and some form of benchmarking (even if simple).

7 (tie). Poor building description: 60% of audits.

Again, the bar was set fairly low. We sought only a basic description of at least five components of a building from among 10 possible components: wall/roof (either R-values or a simple description); infiltration; ventilation; heating/cooling; lighting; appliances/plug-loads; domestic hot water; motors/drives; windows; and controls.

The description sought was also minimal. For example a window description such as "double-pane" was deemed sufficient to meet the criterion of having been described. The purposes of a building description are many, including allowing review of the energy audit by senior staff and by the client, as well as regulatory or funding agencies, allowing the insightful development of improvements, and ensuring program compliance for audits occurring within the context of large energy programs. A poor building description also can be used to identify auditor weaknesses, insufficient time spent in the building, and other systemic problems with the audit. In our experience, a poor building description is often associated with a greater likelihood of missed improvements (see below).

6 (tie). Low (or missing) installed costs: 60% of audits.

The criterion for this problem was for a cost estimate to be less than half what might be reasonable for a specific improvement. Underestimating installed costs can be a serious mistake, as the installed cost estimate in an energy audit often serves as the owner's initial budget for implementation. When subsequent bid costs are received by the owner, and are higher than anticipated, we have found that there is a greater risk of the improvement being abandoned before implementation.

Another risk is poor prioritization of improvements. An underestimated improvement might mistakenly be chosen for implementation instead of a more cost-effective improvement. Examples of underestimating included $62,000 to install more than 70 heat pump water heaters, and $2,000 to install 40 daylight controls. We recognize that installed costs are often overestimated, but such problems are not usually seen within the audit, as the improvement is falsely rejected on the basis of overestimated costs.

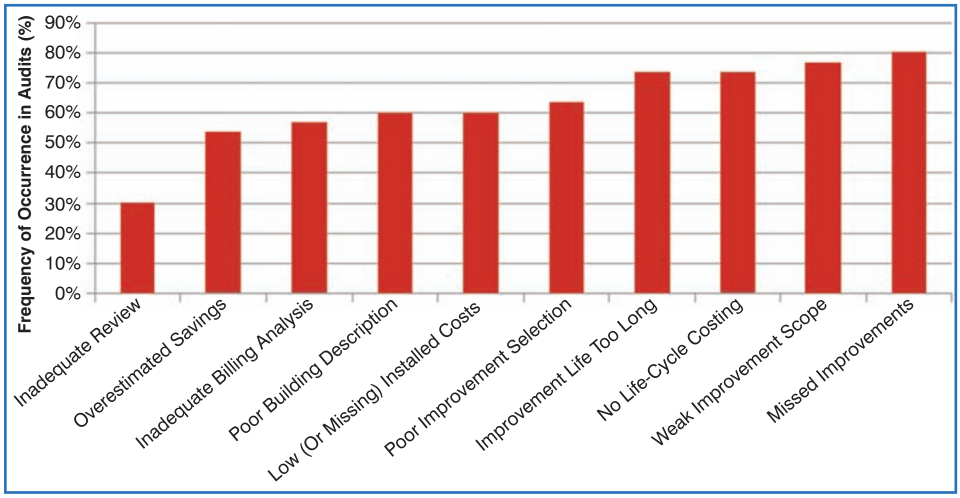

Figure 1: Ten most common problems identified in a survey of 300 energy audits.

5. Poor improvement selection: 63% of audits.

To be categorized as having this problem, an audit needed to have an improvement with a payback longer than the anticipated life of the improvement. Examples included crawlspace insulation with a payback of more than 100 years, a large-scale replacement of individual boilers serving apartments with a payback of 39 years, and a wind turbine recommendation with an anticipated payback also of more than 100 years.

In some cases, we recognize that long-payback improvements may still be attractive to a building owner, for non-energy reasons; but in many cases it appears that the payback is simply not compared to the anticipated life of the improvement. We have seen many examples of audits where long-payback improvements were recommended while several short-payback improvements were not evaluated.

The energy audit that recommended the long-payback wind turbine missed such common improvements as attic insulation, air sealing, lighting controls, and laundry improvements. We have observed that a variety of stakeholders can influence the energy auditor to include recommendation of poor improvements in the energy audit.

For example, vendor-driven improvements arise when an equipment vendor has been calling on the owner or energy auditor to promote their products and has influenced consideration of product-specific improvements, which might not be the best investments. Improvements may also be owner-driven. For example, a maintenance manager may advocate for a specific technology. Just because one individual advocates for a specific technology does not necessarily mean that the technology makes sense, or that others at the property (for example, the board of directors) agree that this poor energy investment should be made. Our experience has shown that poor improvements are often selected by energy auditors who are seeking to "push the envelope" to consider less proven technologies.

4 (tie). No life-cycle costing: 73% of audits.

Life-cycle costing has gained wide acceptance in federal and state programs, as a more holistic metric for energy improvements than simple payback. Simple payback cannot distinguish between the merits of two improvements with the same payback, which may have dramatically different expected lifetimes. For example, consider two hypothetical improvements with the same one-year payback. A boiler tune-up and an exit light replacement. The boiler tune-up has a one- to two-year life, whereas the exit light replacement might have a 10-year life. The simple payback cannot capture the difference, whereas life-cycle costing will give a better picture of the cost benefits of the exit lights, over the expected life of the improvements. For the purpose of this study, "no life-cycle costing" meant the absence of any of a variety of life-cycle metrics, such as savings-to-investment ratio, net present value, return on investment, etc.

3 (tie). Improvement life too long or not provided: 73% of audits.

Improvement life is used for life-cycle costing and is also used as a check against the anticipated payback to ensure that an improvement is not recommended if it will take longer to pay back than it is anticipated to last. If an audit showed an improvement life longer than typically recognized anticipated life,[2] or if the anticipated improvement life was not provided, it was classified as having this problem.

2. Weak improvement scope: 77% of audits.

An energy audit has to clearly convey the scope of the conceived improvement from the energy auditor to the owner, and to the professionals or contractors who will work to implement the improvement. Without a clear description of the scope, chances are likely higher that an incomplete or incorrect scope will be implemented, and full energy savings will not be delivered.

The criterion used for this problem was two out of three of the following conditions were missing for the majority of improvements: location/quantity; energy rating; and testing requirements. For example, for a lighting improvement, location/quantity would mean the rooms and quantity of fixtures, the energy rating would mean the wattage of the new lamps, and testing requirements might be a requirement to visually inspect the lights to ensure that there is no objectionable flicker. Almost none of the audits provided any requirements for testing, so the 77% result ended up representing audits missing either or both the location/quantity of the improvement, or the energy rating.

1. Missed improvements: 80% of audits.

To be classified as having missed improvements, an audit needed to have neglected at least three improvements from the following list: high-efficiency HVAC; high-efficiency domestic hot water; high-efficiency lighting; lighting power density (not applied to single-family homes); lighting controls; wall or roof insulation; motors/drives; HVAC controls; and fenestration improvements.

We believe that the importance of comprehensiveness in energy audits has been widely recognized as critical for many reasons (economy of scale, allowing full owner choice to achieve deeper savings, societal needs to achieve substantial energy conservation, and more). But this study finds that many readily available improvements are still being missed. We speculate that energy auditors miss evaluating good improvements for many reasons, including lack of training, insufficient time spent in the building, insufficient budgets, and owner directives to not evaluate specific improvements. But we believe that our responsibility as energy auditors is to evaluate all generally recognized and reasonable improvements. This is the purpose of the energy audit in the first place: to give the owner options from which to choose improvements for implementation. The majority of energy audits fail to give owners a reasonable selection of such options.

Other Findings

The survey of energy audits turned up other interesting findings.

Audits in single-family residential buildings are more likely to have problems, averaging almost 8.1 out of 10 types of problems per audit, compared to audits in commercial buildings that averaged only 4.6 types of problems per audit.

Audits that were performed as part of state, federal, or utility company energy programs were less likely to have problems. There were 6.3 types of problems, on average, for energy audits in commercial buildings not participating in energy programs, compared to 4.0 types of problems, on average, per audit for energy audits that were part of energy programs. For residential audits, there were 8.4 types of problems per audit for non-program audits, compared to 7.5 types of problems, on average, for audits that were part of energy programs. Clearly, there is a benefit to the standards and quality control that are set by energy programs.

Interestingly, but perhaps not surprisingly, energy auditors who perform commercial energy audits appear to favor lighting and HVAC systems, while energy auditors who perform residential energy audits tend to focus on the envelope (insulation, infiltration). This is captured in the building descriptions: 93% of commercial energy audits describe HVAC systems, and similarly 93% describe lighting, but only 53% describe insulation and also only 53% describe infiltration. Meanwhile, only 53% of residential energy audits describe HVAC systems, a whopping 0% (0 out of 15 audits) describe lighting, while doing much better in describing insulation in 67% of audits and describing infiltration in 73% of audits.

We speculate that this discrepancy between commercial and residential energy audits is attributable to differences in training. Commercial energy auditors are likely engineers, of whom many may have come out of the consulting/design field, where they have designed HVAC and lighting systems. They generally are not trained in envelope improvements, even though it is increasingly recognized that large buildings have many insulation and infiltration issues, exacerbated by stack effect in multistory buildings. Meanwhile, residential energy auditors are trained in envelope issues and in the use of tools such as blower doors to diagnose infiltration and infrared cameras to diagnose deficient insulation. But they are not trained in lighting or HVAC. This discrepancy is likely the cause of many missed improvements: the number one problem in energy audits.

Standards

Although there is no national energy audit standard for commercial buildings, ASHRAE's *Procedures for Commercial Building Energy Analysis*,[3] if followed, would prevent many of the common problems identified in the survey. For example, an ASHRAE Level II energy audit includes requirements for monthly energy analysis (*Procedures*, p. 7), benchmarking (p. 7), building descriptions including "inventories of major energy-using equipment" (p. 8), safeguards against overestimating savings (p. 8), installed cost estimates (p. 8), expected life of the proposed new equipment (p. 9), descriptions of improvements (p. 9), and more.

For residential buildings, a national energy audit standard has recently been developed.[4] It, too, if followed, would prevent many common problems. It requires a building description that includes most of the 10 basic building description components that were sought in the survey (the exceptions being heating controls and motors/drives). Reference is made to the expected life of proposed improvements, attention to quality in specification of improvements, benchmarking of home performance, and other areas where problems were seen in this study.

Many federal, state, and utility company programs have their own standards, and these programs increasingly require building descriptions, reports of utility bills by month, benchmarking, truing-up of models to bills and other precautions against overestimating savings, lifecycle costing, and both internal and external quality control. But the standards are uneven and, in many cases, are absent altogether. Harmonization of the standards might help in achieving more uniformly consistent energy audits.

Best Practices

We have found that the following best practices in energy audits and large-scale audit programs can help prevent the problems identified in the survey:

- Clear standards, either set by energy programs or, preferably, through harmonized national standards.
- Strong energy audit templates. However, it is critically important that prior audits not be used as templates for energy audits, because the risk of mistakenly carrying forward material from prior audits is great.
- Energy auditor training and accreditation. Training should not only cover energy estimating methods, but also technical aspects of improvements, estimating installed costs, and the importance of comprehensiveness. Training should account for predictable areas of weakness of the target audience. Engineers need more training in envelope improvements (insulation, windows, air-sealing); energy auditors from the contracting fields need more training in HVAC improvements, controls, and lighting.
- Strong quality control. The best energy audit programs advocate internal review by a supervisor of the energy auditor, quality control review by a program implementer, as well as spot checking of quality by a third-party quality assurance provider.
- Adequate funding of energy audits and energy audit programs, to ensure adequate quality and quality control.
- Measurement and verification of actual energy savings, and feedback to energy auditors about savings.

Conclusions

While this study was intended only to be a small-sample survey, and to be a preliminary assessment of quality in energy audits, the findings appear to indicate that there are many and diverse problems. Nine out of 10 common problems are evident in over 50% of energy audits, and the two most common problems appear in almost 80% of energy audits. The two biggest problems are unfortunately complementary. The most common problem is that too many opportunities are missed, and the second is that the identified opportunities are inadequately described, leading to a greater risk of no implementation and poor operation.

Between these two problems, significant potential energy savings opportunities are being lost. If 80% of energy audits have possible improvements that are not even being evaluated, and 77% of energy audits have poor descriptions of the recommended improvements, we have a good explanation for why savings of well under 10% of pre-retrofit energy costs are commonly delivered, rather than the savings of more than 40% that have been routinely delivered in comprehensive and well-executed projects.

Energy audit standards urgently need to be refined, harmonized, disseminated, and enforced. Training and accreditation also need to be improved, as does quality control. Despite approaching 40 years since the first energy crisis of 1973, we are still in what might be called the Wild West period of energy audits, with a lot of gunslingers out there, a lot of energy audits missing their mark, and few sheriffs in sight.

References

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Acknowledgments

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