

Lean Energy Audits

*Rethinking Common Management Practices of Multi-Building Energy Audits*

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In their groundbreaking book *Lean Thinking*, James P. Womack and Daniel T. Jones outlined the lean manufacturing process that significantly impacted the manufacturing world. The book denounced as wasteful the traditional manufacturing method of batch processing in which each piece of an assembly was made one at a time and then later assembled as a whole. This revolutionary concept of lean processes isn't exclusive to the manufacturing realm. There are valuable lessons about streamlining and reducing wasted effort that can be applied to many types of processes.

As energy efficiency consciousness grows, energy audits are becoming more common practice. Increasingly, the private and public sectors are turning to energy professionals to perform large-scale, multi-building energy audits. Traditionally, these audits are similar to a batch manufacturing process in that a host of measurements are taken across all of the buildings and then various analyses are performed with these measurements. While this method is theoretically sound, in practice it can be especially complicated—particularly on multi-building campuses. By applying “lean” principles, traditional batch style energy audits can be turned into “lean energy audits.”

Lean auditing has four distinct advantages over traditional energy audit management methods: the propagation of errors is avoided, energy savings can be realized earlier by reducing work in progress (WIP), project management control can be increased through better metrics, and systems-level understanding can be increased by narrowing efforts.

The batch and lean energy audit processes are outlined in Figure 1 and Figure 2, respectively.

**Avoiding propagation of errors**

In traditional manufacturing, if a particular product requires three distinct manufacturing processes, it is common to perform step one on all of the desired pieces

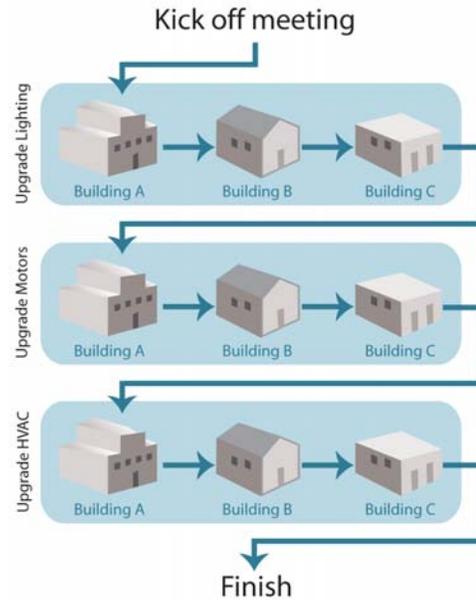


Figure 1. Typical Batch Energy Audit Process

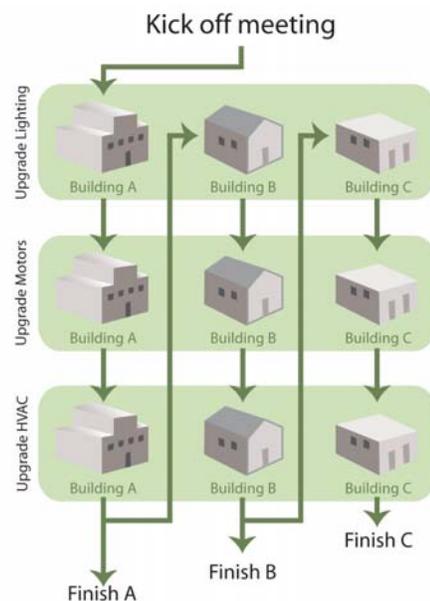


Figure 2. Typical Lean Energy Audit Process

then step two, then step three. This “batch processing” method can lead to many problems. For example, if a mistake is made in process A, it will be repeated on all of the pieces before being caught in process B or C—wasting the partially finished units and the time associated with manufacturing them. In lean manufacturing, a single piece is manufactured from step one through step three. This way, any errors or problems in the manufacturing process are identified quickly, preventing successive mistakes from being made on all products.

The same lean principles help avoid mistakes in energy audits by verifying that the process of collecting data, analyzing data, and implementing recommendations is sound from start to finish. By completing an energy audit and implementing recommendations in just one building of a multi-building campus, problems with implementation, client preferences (e.g., the client has a particular dislike for the recommended manufacturer), or incorrect assumptions can be caught before they are repeated in other buildings.

One mistake that can be propagated over many buildings occurs during the collection of equipment data. Typically, senior engineers deploy data collectors to survey and document existing equipment. Collecting and analyzing data for a host of buildings all at once allows mistakes to be repeated. By handling the data building-by-building, common mistakes such as misunderstandings between engineers and data collectors, erroneous assumptions on the part of the engineers and/or data collectors, and the collection of unnecessary information are avoided.

In a recent very large multi-building energy audit for a New York state municipality, data was meticulously collected by subcontractors over a series of weeks. This data was then checked and rechecked by the collectors. Any missing or questionable data was recollected during additional site visits. This entire process took about three months.

When the energy auditors received the data, they realized that unnecessary data was collected across many of the buildings. Later, they also determined that the collected data was deficient in certain areas and that more site visits would have to be conducted before energy-saving measures could be implemented.

If lean data collection had been implemented, the unnecessary data would not have been collected past the first building and the missing data would have been noticed before surveying the second building.

***Realizing energy savings earlier by reducing WIP***

The batch manufacturing method generates significant work in progress (WIP), which increases the lead time of finished products. For example, if a customer orders one widget, that customer’s order will become one of many orders that the manufacturer is trying to fill simultaneously. The result is that each customer will have to wait until an entire batch of widgets is complete before receiving their order. This process increases the lead time of customer orders regardless of the order size.

The WIP problem manifests itself in energy audits through the time it takes to finish a traditional batch-type project. The longer an implementation takes, the longer the client’s facility is operating at less than optimum conditions. Lean auditing addresses this problem by breaking the audit into smaller pieces. The entire process of collecting and analyzing data, and implementing recommended measures is completed on a single building before moving on to the next building. This process repeats itself until all buildings have been audited and cost-saving measures have been implemented. This way energy savings are realized more quickly.

The problem of WIP in energy audits became apparent in another large-scale energy audit in New York. The audit discovered that the client could realize a savings of \$40,000 by turning off equipment that was operating during unoccupied hours. The simple payback for implementing this measure was less than two months. However, since this audit did not take advantage of lean principles, this significant energy-saving measure was only brought to the client's attention in the final report. More than a year passed before the governing body responsible for approving and implementing measures accepted the final report. If this had been a lean audit, this measure could have been presented for approval immediately, instead of waiting for all of the buildings on the campus to be evaluated first. Consequently, the cost-saving benefits of the measure were not realized as quickly as possible.

***Increasing project management control through better metrics***

Because the batch manufacturing method generates significant work in progress, it is difficult to track specific customer orders. In a batch energy audit, it is hard to predict when the entire project will be completed and even harder to give the client an estimate of what portion of the work is complete at any given time. In a lean energy audit, project progress is much easier to track and communicate. In a traditional management approach, project progress is estimated by the project manager, which might be based on no more than "gut feeling."

Lean auditing has a concrete way to measure progress. In lean audits, progress is measured by the percent completion of the total square footage of space. For example, if the total area of all the buildings being audited is 1,000,000 square feet and a 100,000-square-foot building has been completely finished, then the audit is 10% complete. This solid figure is not based on an estimate or other non-concrete data, but represents an actual amount of work completed.

The problem of estimating completion dates became evident during an energy audit for a New York State municipality. During this audit, a senior client representative contacted the auditor and asked for a progress report. The auditor made a list of all of the project tasks and assigned a percentage complete figure to each specific task based on their personal opinion. The percentage completion of the entire project and its subsequent completion date were then based on these figures. This project started in early June and the progress report, issued in early August, stated that the project was 42 percent complete. Since it took about two months to complete roughly 40 percent of the work, it looked like the project would be completed by November of that year. However, the project was actually not finalized until early May of the next year.

The lean auditing approach has a clear and concise method of project tracking that reduces guesswork. Project progress reports can be easily generated and documented throughout the project life cycle.

***Increase system level understanding by narrowing efforts***

During traditional batch-style audits, a senior engineer examines the HVAC system of each building to look for systems-level energy improvements. These systems-level improvement measures usually save the greatest amount of energy. However, in multi-building energy audits, the same engineer may look at up to fifteen buildings in a short period of time—making it difficult to remember which system is which. To address this problem, engineers often document visits by collecting drawings (if they are available), taking pictures, and taking notes. Despite all of these documentation methods, true system-level understanding of a building takes time.

This problem manifested itself in one of the New York State energy audits. The audit identified a measure for the main hydronic system of one of the buildings. The measure was approved for implementation, but during the implementation process it became evident that the hydronic system was more complicated than originally thought. As a result, a new senior engineer spent a large amount of time with the building's maintenance personnel walking through the system. The implementation process was delayed until the new senior engineer was able to fully understand the system and the implications of the proposed measure on that system.

The lean auditing method eliminates this problem by allowing engineers to concentrate on one system at a time. This allows them to develop a full and complete understanding of the entire building before making recommendations.

### ***Hurdles to Lean Auditing***

There are many hurdles to implementing lean energy audits. First, clients need to be educated about lean audits and request proposals accordingly. In all of the examples cited, clients requested traditional energy audits, making it difficult for the auditor to implement large-scale lean practices.

Secondly, government agencies that subsidize large-scale energy audits must be aware of lean techniques and structure their incentives to support these types of audits. Currently, the set up of some government incentives would require multiple contracts to perform a lean energy audit. Incentives need to be set up so that one campus can undergo the lean audit process under one contract.

Finally, energy consultants must educate themselves about these processes (see sidebar for a simplified summary). They must understand the advantages of the lean concept and apply it appropriately—knowing that there may be instances where a traditional batch process is still preferable. Consultants must become familiar with their client's entire campus before deciding which method is best for their specific project.

### ***Summary and Conclusions***

Lean manufacturing changed the manufacturing industry by forcing it to examine its traditional batch processing techniques. These same lean principles can improve the energy-auditing world. The lean audit approach to multi-building energy auditing has four distinct advantages over traditional energy audit management methods:

#### **Lean Auditing**

##### ***Step By Step***

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Once you have decided to perform a lean audit what do you do next?

- 1. Identify all of the energy conservation measures (ECMs) that will be pursued across the campus. For example, installation of high-efficiency motors.*
- 2. Begin with a smaller building to evaluate all of the measures in question. (Beginning small allows you to get your feet wet before diving in!)*
- 3. Implement measures that are shown to have an acceptable payback*
- 4. Repeat on subsequent buildings until finished. (Choose the building order as appropriate)*

The advantages of this method are:

- You can learn from your mistakes sooner than later
- You are less likely to bite off more than you can chew.

- The propagation of errors is avoided
- Energy savings are realized earlier by reducing WIP
- Project management control is increased through better metrics
- Systems-level understanding is increased through narrowed efforts

The lean approach has the potential to revolutionize the process of energy audits, making them more efficient and more effective. For example a batch energy audit of a large campus could take years before energy conservation measures are actually implemented and savings are being realized. Lean energy audits offer the promise of faster implementation.

This can be seen by reiterating the previous example about “reducing WIP.” In this example the client failed to realize \$40,000 a year in savings from an energy opportunity that was identified very early in the audit. This measure had a payback period of about two months, but because the project used the batch method, no recommendations or implementations were made until the entire campus had been audited and the findings approved. While ongoing, this process is estimated to take about two years. Thus the client failed to realize \$80,000 in positive cash flow as a result of their batch auditing technique.

Unfortunately, the batch method of energy audits is the status quo. Obstacles to changing the set way of doing things are large, but as the benefits of lean audits are explored and accepted, there can be a change in the way most audits are conducted. While the lean approach may not be ideal for every type of campus, its benefits are clear when it comes to large, multi-building campuses. In the end, the techniques employed by lean auditing approach will make energy audits more efficient for the auditors and more effective for their clients.

### ***References***

- [1] Womack, J., and Jones D., “Lean Thinking- Banish waste and create wealth in your corporation,” Simon & Schuster, 1996

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### ***About the Author***

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