Analyzing 12,000 Commercial SEM Measures

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ABSTRACT

How do SEM programs save energy? Strategic Energy Management (SEM) is a system of organizational practices, policies, and processes that creates persistent energy savings by integrating energy management into business practices[1]. But what specific energy-saving measures are taken when SEM is adopted at a facility? A comprehensive analysis of measures from Energy Trust of Oregon's commercial SEM program opportunity register tells us which specific actions lead to energy savings at a wide range of commercial facilities, offering insights to better support customer implementation with targeted recommendations.

This analysis of 6,000 completed measures out of 12,000 identified opportunities across 276 sites offers a deeper understanding of the relationship between actions and results in commercial SEM engagements. All data in this analysis is aggregated and de-identified.

This dataset allows us to explore questions such as:

- What types of measures and activities are identified?
- What measures and activities are most likely to be completed?
- What types of Commercial SEM participants are most successful?

Answers to these questions will support future SEM program enhancements designed to target effective interventions.

Introduction

Strategic Energy Management at Energy Trust of Oregon

Strategic Energy Management (SEM) is a system of organization practices, policies and processes that creates persistent energy savings by integrating energy management into business practices. Energy savings are achieved through a mixture of operational, behavioral, and maintenance measures, and are typically claimed by the program sponsor on an annual basis. Historically, few datasets have been available to analyze the details of the specific measures that in aggregate form the basis of energy savings in SEM programs.

For the purposes of this paper, an SEM "measure" is defined as a single technology, energy-use practice, or behavior that, once installed or operational, results in a reduction in the electricity use required to provide the same or greater level of service at an end-use facility, premise, or equipment connected to the delivery side of the electricity grid. (U.S. EPA)

Energy Trust of Oregon's Commercial Strategic Energy Management (SEM) program launched in 2011 and has cumulatively served approximately 200 participants with a total of 700 sites. Many participants enroll multiple sites, and individual energy-saving measures are tracked at the site level. Over 14 years and counting of program implementation, program participants have identified and completed thousands of measures. Most measures are identified in a collaborative treasure hunt process with participant energy team members and SEM coaching team members. Treasure Hunts are on-site building assessments used to identify O&M low-/no-cost opportunities as well as capital measures. Energy teams also identify additional measures outside the treasure hunt event. All measures are tracked by participants and SEM coaches in site-level opportunity registers.

Until 2023, Energy Trust's SEM opportunity registers were stored in site-level Microsoft Excel workbooks. The decentralized nature of this dataset made it difficult to identify program-wide measure completion trends. In 2023, Energy Trust migrated their SEM program models, including opportunity registers to a confidential and proprietary online energy performance platform Energy Sensei ®. During this migration, historical measure data back to 2011 was uploaded to the energy performance platform. With all site-level opportunity register data in one centralized platform, this program-wide analysis of measures became feasible.

Data Sources

Three data sources were used to conduct this analysis:

1. A dataset maintained by the program management contractor with baseline electric and gas consumption for 657 participating sites and the number of years the site has participated in the SEM program.
2. A dataset exported from the energy performance platform containing the facility type for all 657 sites. This site count does not contain sites that have completed or been unenrolled in the SEM program.
3. A dataset exported from the energy performance platform containing all metadata fields for the 11,916 individual measures stored in the opportunity registers for the 657 sites.

These data sources were joined by a unique site ID.

Opportunity Register Completeness

Not all historical opportunity registers were uploaded into the energy performance platform, so the 11,916 measure data set is not a fully comprehensive record of all identified and completed measures. For some sites with many years of program participation, only recent years were uploaded. For other sites, no data was uploaded.

To appropriately analyze results across the varying level of data completeness, the 657-site data set was split into three categories:

- **Dataset A: 276 sites** with at least one completed measure within two years after the site's program start year. These sites identified 8,142 measures and completed 4,019 measures. This dataset is assumed to have a full historical record of completed measures and is used to calculate measure completion metrics.

- **Dataset B: 249 sites** with at least one measure completed, but the first measure was completed three or more years after the site joined the program. We assume this dataset is incomplete and missing an earlier part of the historical record of identified and completed measures, but the characteristics of the 3,774 measures in this partial dataset are representative of the full dataset. Therefore, this dataset is used in analysis related to measure characteristics, but not used in analysis related to measure completion.

- **Dataset C: 132 sites** with no completed measures. Twenty-three of these sites had one or more identified measures (total of 240 identified measures) and 109 sites had no identified measures. We assume the sites in this dataset are either new to the program or missing historical data and are only used to calculate what types of buildings participate in the program.

Measure Metadata Completeness

Each measure has 45 available metadata fields (some user-entered and some calculated), but only measure name, site name and completion date (if completed) are required in the energy performance platform. Historical data uploaded from Excel-based opportunity registers has a wide range of data completeness in each category. This analysis uses the as-is dataset; no data filling or extrapolation was used.

Findings

How many measures do sites complete?

We used Dataset A (276 sites with completed opportunity registers within 2 years of enrollment) to answer this question. Overall, participants completed **49%** of all 8,142 identified measures. On average, each site **identified 30 measures and completed 15 during their SEM engagement**. Since many participants are still engaged in the SEM program, these numbers will continue to rise. Additionally, 545 measures were currently in progress at the time of this analysis, or an average of 2 per site.

What types of buildings participate?

We used the full dataset of A, B and C of 657 sites to determine what types of buildings participate in the Energy Trust of Oregon SEM program. Schools, offices, higher education and retail are the most common program participants and together comprise approximately 60% of

all participating sites. The remaining 40% of sites span many commercial subsectors as seen in Figure 1.

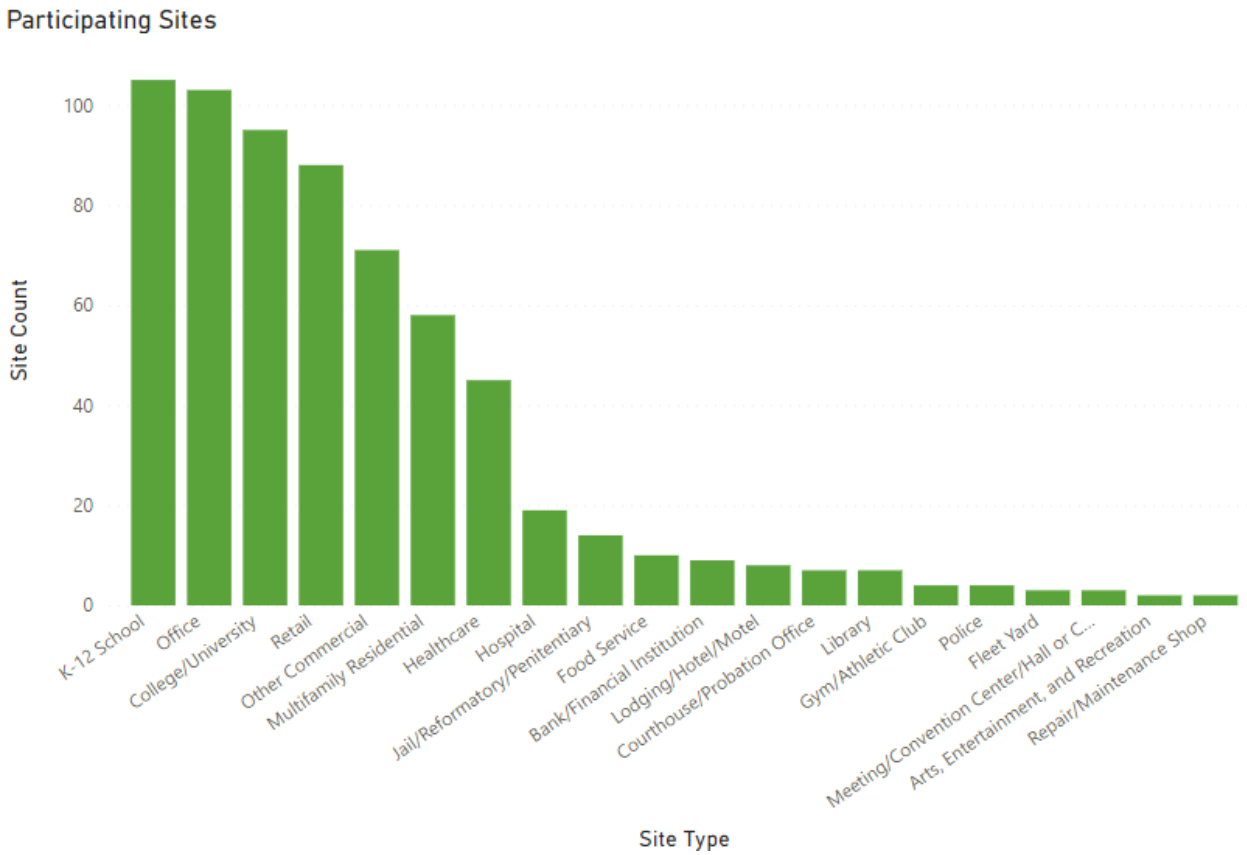

Figure 1: Participating sites by type.

How does measure completion vary by building type?

This analysis uses dataset A (276 sites) and includes facility types represented by five or more buildings in dataset A. Facility types with less representation than five buildings were excluded. Banks and offices have the highest completion rate at 83% and 78%, respectively, while hospitals complete the most measures with 32. Healthcare (non-hospital) has significantly lower completed measure count and completion rate than hospitals.

Table 1: Measure Completion by Site Type

Site Type	Site count	Identified measures per site	Completed measures per site	Completion rate
Multifamily Residential	50	20	10	50%
College/University	49	34	17	49%
Office	43	16	12	78%
Other Commercial	34	35	19	53%
K-12 School	23	35	12	33%
Retail	23	10	4	43%
Hospital	11	63	32	51%
Food Service	10	65	24	37%
Healthcare	9	21	7	32%
Lodging/Hotel/Motel	7	45	16	36%
Bank/Financial Institution	5	26	22	83%
Library	5	40	20	49%
Total	**269**	**29**	**14**	**49%**

What types of measures are most likely to be completed?

The following fields are the primary ways that programs characterize and sort SEM measures.

- Subsystem (HVAC, lighting, etc)
- Measure Type (O&M, Capital, Energy Management, Learning Assignment)
- Source (Treasure hunt, workshop, etc.)
- Quadrant (Gem, quick win, strategic, low priority) Note: these are common SEM program terms based on a 2-dimensional value mapping matrix of low/high impact and low/high effort (see Figure 2).

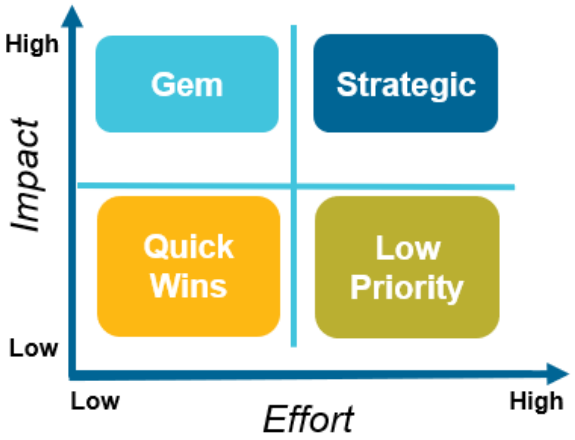

Figure 2: Energy Trust of Oregon's SEM value mapping matrix

Most historical measures in this analysis had limited metadata to characterize measures. Using datasets A and B, the subsystem field was entered for 22% (2,453) measures. We assume the subsystem of those 22% are representative of the full dataset. 35% percent of measures are HVAC, followed by miscellaneous at 25% and lighting at 16%.

In Datasets A and B, completion percentage by subsystem is highest for maintenance and boilers/steam, and lowest for refrigeration and miscellaneous. HVAC measures, which are most common by measure count, have a 61% completion rate.

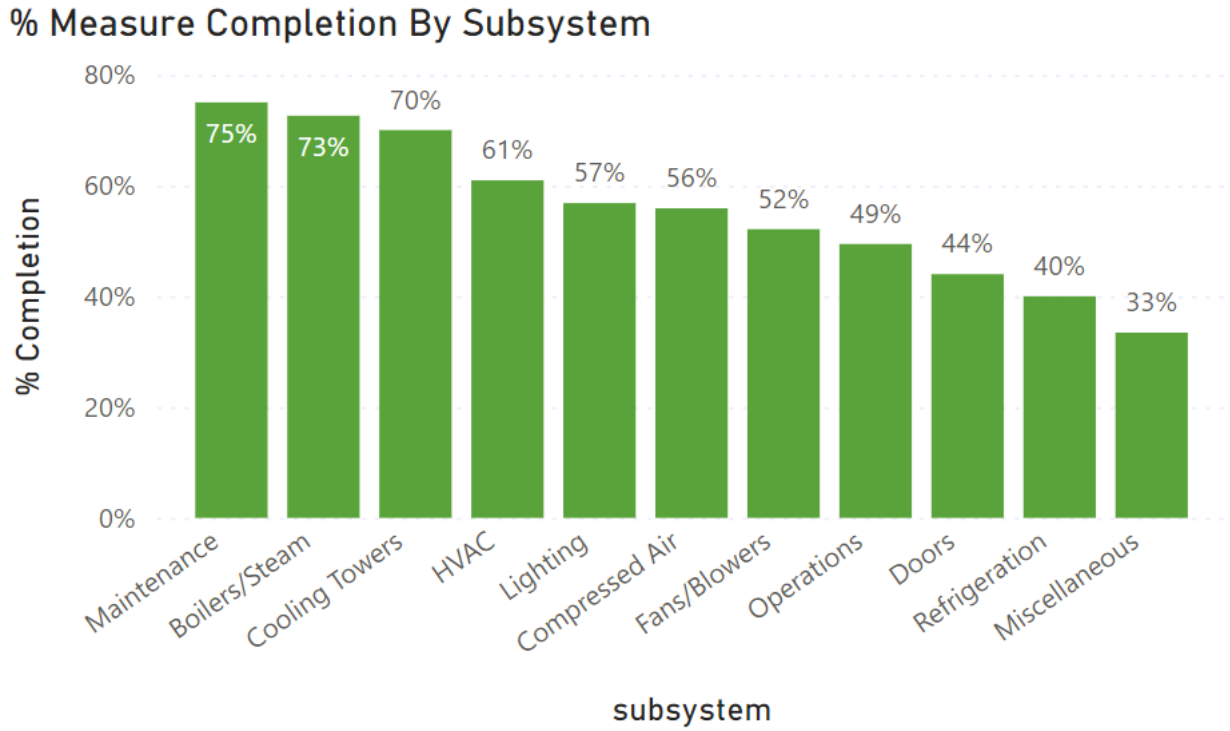

Figure 3: Measure completion rate by subsystem

What keywords are associated with successful measures?

We analyzed measure names for 44 keywords. These keywords were bundled into action, investigation, and equipment keywords. **57% of action measures were completed, whereas only 46% of investigation measures were completed.** Examples of action keywords are adjust, tune, clean, replace and fix. Examples of investigation keywords are check, inspect, investigate and consider. Examples of equipment keywords are HVAC, pump, damper, light, and cooling. The full list of keywords is listed in Appendix A.

Table 2: Completion rate by keyword family. Note: measure counts are higher than the full measure count because some measure names may have multiple keywords.

Keyword family	Identified measures	Completed measures	% Completion
Action	5,049	2,891	57%
Equipment	6,150	3,166	51%
Investigation	1,124	512	46%
Total	**12,323**	**6,569**	**53%**

The keywords in Table 3 are associated with measures least likely to be completed. Measures with the keyword "consider" are least likely to be completed, at just an 11% completion rate.

Table 3: Keywords associated with low completion rates

Keywords	Category	All measures	Completed measures	% completion
Consider	Investigation	134	15	11%
Engage	Action	203	26	13%
Standard	Action	62	8	13%
Daylight harvesting	Equipment	15	3	20%
Equipment	Action	19	5	26%
Investigate	Investigation	116	32	28%
Raise	Action	38	12	32%
Test	Investigation	54	18	33%

The keywords in Table 4 are associated with measures most likely to be completed.

Table 4: Keywords associated with high completion rates

Keywords	Category	All Measures	Completed measures	% completion
Change	Action	415	329	79%
Adjust	Action	316	249	79%
Tune	Action	46	34	74%
Clean	Action	326	238	73%

Figure 4 shows a word cloud of the most common words in measure names

Figure 4: Word cloud of measure names

How does measure completion vary by building size?

The baseline electric consumption is documented for 225 sites in Dataset A with a mean of 1,382,477 kWh/yr. Overall there is a very small positive trend of more completed measures at larger buildings, but this trend is not consistent across all business types. Retail and offices have a negative trend line (bigger buildings complete less measures). Hospitals and foodservice have positive trend lines. These trends are based only on completed measure count, not achieved savings.

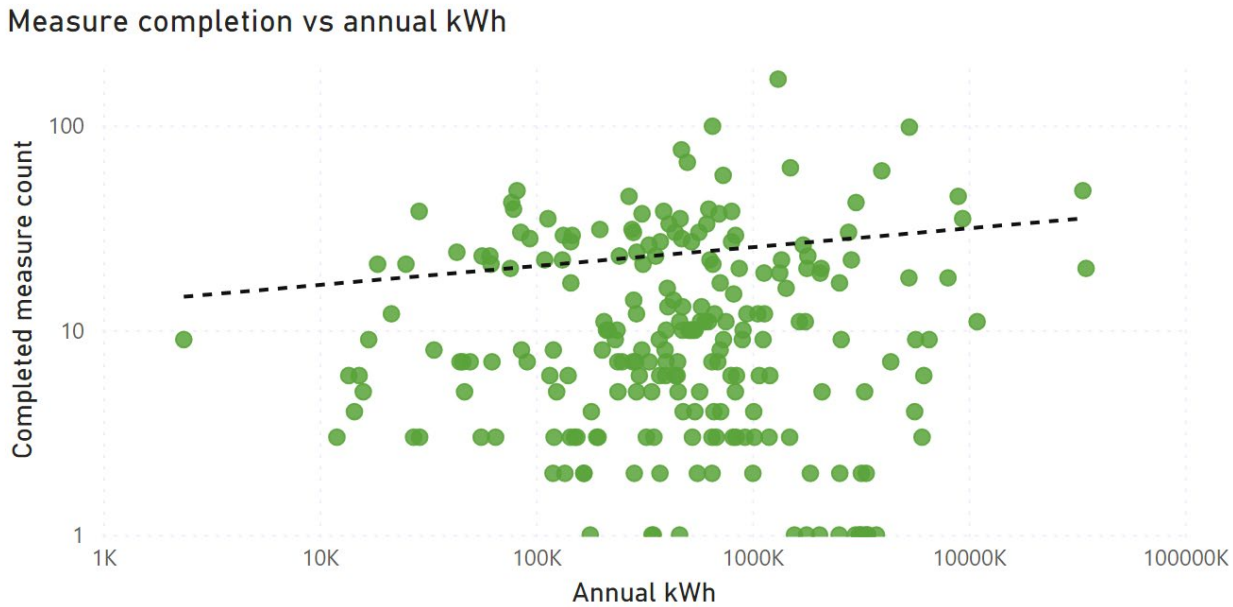

Figure 5: Correlation between measure completion and annual electricity consumption. Note the logarithmic axes.

Discussion

This analysis focuses on measure completion metrics across a diverse commercial SEM program. Analyzing measure completion metrics offers insights to improve future SEM program design. It's important to note that measure completion does not directly equal energy savings but serves as a proxy for participant engagement which is assumed to indirectly lead to higher energy savings. Future research could compare completed measures to claimed annual energy savings.

On average, Commercial SEM sites identify 30 measures and complete 15, a 50% completion rate. 15 completed measures per participant means that energy teams are engaging with the program, finding measures, and implementing them. 15 uncompleted measures represents a large body of potential energy savings. Based on site volume, identified measures, and completion rates, K-12 schools and retail have the highest potential to harvest additional savings.

This finding can be compared to the industrial SEM study (Podell-Eberhardt), which showed that on average, participants identified 40 measure and completed 16. Commercial SEM participants identify fewer measures, but complete approximately the same number.

Sites average two measures in progress, for a program total of 545 in-progress measures. This volume of in-progress measures suggests that large SEM programs are an engine for incremental savings each year, even years into a mature program. In-progress SEM measures can be a source of savings for programs looking to close gaps towards an annual savings target.

Hospitals, food service and banks complete the highest number of measures. These three high-performing building types fit into two categories: Hospitals are large energy consumers with technical staff and resources to focus on energy management. Conversely, food service and banks are organizations with multiple smaller, similar sites where the same measure can be repeated across the organization.

Retail and healthcare (non-hospital) complete the fewest measures, at only ~25% of the top performing building types. Hospitals are top performers but healthcare (non-hospital) are lower performers, which is a surprising finding. This might be related to challenges of driving change within individual leased office suites, vs large hospitals with dedicated facility staff. Retail and non-hospital healthcare may be more likely located in leased buildings, reducing the incentive to complete energy efficiency measures.

SEM programs could modify engagement strategies for higher-performing building types to leverage implementation capabilities and provide more support for the lower-performing types to maximize engagement experience and savings potential for all building types. Further research is required to understand why top performing types complete four times more measures than low-performing types. Perhaps current SEM design is less tailored towards retail stores, for example, and an alternative design could lead to improved participation.

Measures containing keywords associated with action are significantly more likely to be completed than measures containing keywords associated with investigation. The keyword

"consider" is associated with an especially low completion rate of 11%, while "change" and "adjust" are associated with 79% completion. This finding suggests that more actionable and precise measures are more likely to be completed than one-size-fits-all recommendations.

The count of completed measures has some correlation to site energy consumption, although there is inverse correlation within specific facility types. This suggests a wide range of facility sizes can engage in an SEM program, and there may not be one "ideal size"

Recommendations

To the authors' knowledge, this is the first large-scale analysis of completed commercial SEM measures. 2023 was the first year that Energy Trust had all opportunities identified in SEM in one central location and the ability to analyze them at a program level. Takeaways from this analysis can inform future program design. Additionally, this analysis has informed future best practices for data collection within the Energy Trust Commercial SEM program.

Recommendations For SEM Program Design

- Half of measures get implemented. On one hand, this is an impressive feat resulting in over 4,000 completed measures across 276 sites. On the other hand, this means half the identified measures are not completed and some of those measures represent untapped energy savings potential that can be mined by deeper program engagement. This is helpful in planning for on-site treasure hunts and scoping out enrolled sites in Commercial SEM.
- On average, a site has 2 in-progress measures, or 545 in-progress measures across 276 sites. This data shows that incremental savings can be achieved year-over-year even from mature SEM participants. Ongoing engagement in SEM helps support customers through changes that inevitably occur within their organizations, but also gives them access to support from coaches with implementing activities identified in previous engagement years.
    - Checking for in-progress measures and influencing additional measure completion can be a source of additional energy savings**.** Assessing progress at the end of each engagement year could provide good insight for the SEM coaching team and the customer on where resources are best allocated for the subsequent engagement year.
- Preloading common opportunities would create consistency in naming and would allow participants to more systematically address similar or identical opportunities that exist across sites.
- Measures with specific instructions to change, adjust or tune equipment are associated with higher completion rates than instructions to consider, engage or investigate. Coaching teams can influence higher measure completion by helping to clearly define actionable opportunities.

Recommendations For Future Data Collection

- Collecting additional metadata such as subsystem and priority/quadrant will allow for additional future insights and opportunities with systematic and efficient implementation of measures.
- Identifying what types of measures that *don't* get completed can help re-prioritize program resources to the most effective measures. Consistent measure naming conventions and use of subsystem tagging could help with this identification.
- Comparing completed measures to claimed annual savings is a future research opportunity.

Citations and References

U.S. Environmental Protection Agency. "Guidebook for Energy Efficiency Evaluation, Measurement and Verification". June 2019. https://www.epa.gov/sites/default/files/2019-06/documents/guidebook_for_energy_efficiency_evaluation_measurement_verification.pdf

Podell-Eberhardt, Z. 2023. "Analyzing 17,000 energy saving measures." In *Proceedings of the 2023 Energy Efficiency as a Resource Conference.* Washington DC: ACEEE https://drive.google.com/file/d/1dA62cE10yCUewaw4vCuIhg-zx6ha8J_H/view

Appendix A: Measure Keywords

Keywords	Category		
Change	Action	**light**	Equipment
Adjust	Action	**Turn**	Action
Tune	Action	**AHU**	Equipment
clean	Action	**Update**	Action
HVAC	Equipment	**Controls**	Equipment
Setpoint	Action	**day**	Action
Sweep	Action	**Close**	Action
Weekend	Action	**Night**	Action
Schedule	Action	**open**	Action
boiler	Equipment	**Confirm**	Investigation
Inspect	Investigation	**sensor**	Equipment
Check	Investigation	**Fan**	Equipment
Repair	Action	**Calibrate**	Action
Lower	Action	**building**	Equipment
LED	Equipment	**Test**	Investigation
Replace	Action	**Raise**	Action
Fix	Action	**Investigate**	Investigation
Pump	Equipment	**Equipment**	Action
Damper	Equipment	**Daylight harvesting**	Equipment
Air	Equipment	**Standard**	Action
Turn off	Action	**Engage**	Action
Cooling	Equipment	**Consider**	Investigation