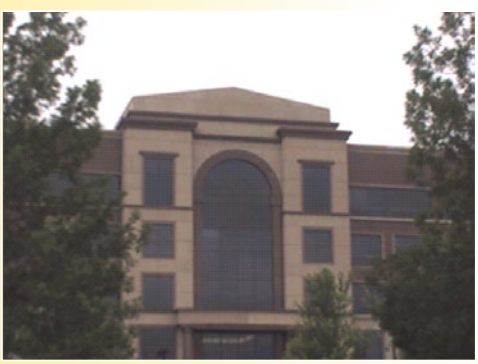
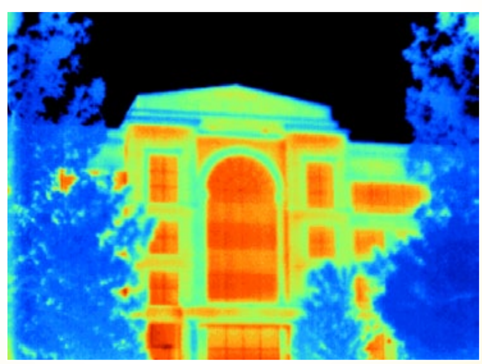
A considerable amount of energy loss is actually temperature related. Hot or cold air leaks from a building are an obvious issue. It took energy to heat or cool that air, and when it dissipates due to a leak, you've wasted that energy. But many other systems and pieces of equipment also manifest their wasted effort/energy in terms of heat.

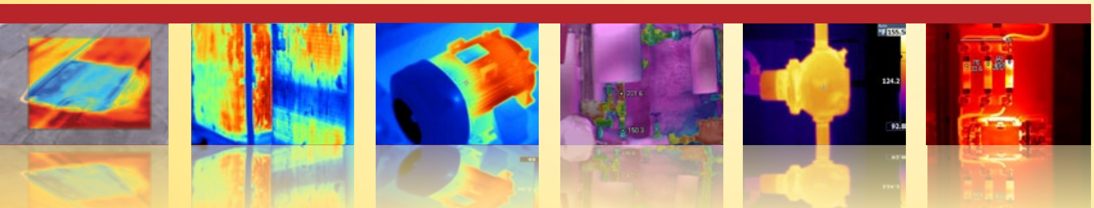
Top 6 places to look for energy losses in commercial buildings





Small, consistent changes can make a big difference in the profitability of any facility. Find problems fast, fix them, and win by realizing the cost savings.

Thermal imaging experts suggest that building owners, building managers and/or facilities engineers inspect the following systems to identify energy losses:



Unlike regular digital cameras that capture images of the visible light reflected by objects, thermal imagers create pictures by detecting infrared energy or heat. The thermal imager then assigns colors based on the temperature differences it detects.

With a small amount of training, most people can readily spot abnormal heat flow patterns and follow the heat trail to energy waste. The technique works best when used by people who already possess a good working knowledge of the structures and systems being scanned and can better interpret the temperature variances they see on camera.

A typical scan can show energy saving opportunities of up to 15 percent, with varying degrees of repair investments.

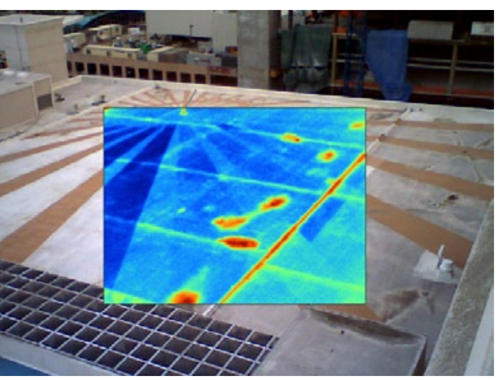
1. Building envelope

"Building envelope" refers to the building structure as well as the climate controls within it. The envelope is what separates the outside environment from the inside, and it's frequently imperfect. The problem with building envelope inspection is that the degree of temperature variance detected may often be very small, only a few degrees in some cases. So, the best time to scan is during a heating or cooling season, when there is a large difference in temperature, or Delta T, from the inside to the outside of the structure. In general, the larger the Delta T the better. While a Delta T of 18 °F is typically recommended for insulations inspections, only a minimum Delta T of 3 °F is recommended for air leak inspections. Similarly, beware of solar loading, wind, precipitation (rain or snow), and other environmental factors, which could mask or distort potential problems. For instance, be careful to understand the direction and amount of heat flow when scanning an exterior wall if the sun is shining on it. When performing flat or low-slope roof scans, make sure that the roof has been dry and free of water or ice. Achieve best results by performing inspections on clear, windless evenings after dusk, or before dawn, when thermal differentials in the roofing materials are in a transient state. (Be aware that not all roofs can be effectively inspected using thermal imaging. Flat or low slope built-up roofs are usually the best candidates.)

What to scan:

- **Roofs.** Wet roofing insulation loses much of its R-rating. This means that heat can escape or enter the building much easier through wet insulating materials. In addition to looking for moisture issues, scan the roof surface and follow temperature differences to possible air leak entry/exit points. Note: Spot repairs are less expensive than replacement, and old roofs are often a challenge to dispose of because of their contents.
- **Walls between conditioned and unconditioned spaces, including outside walls.** Due to the natural flow of air with different temperatures (example: hot air rises), significant air leaks tend to occur at the top and bottom of conditioned spaces, where air either enters or escapes a structure.
- **Construction joints and connections.** For example, at floor slabs that extend outdoors, there are often heating or cooling losses by conduction through the slab. (Unisulated concrete that is a foot thick has an eqivalent R-value of a single pane of glass.)
- **Penetrations of the building envelope (pipes, conduits, chimneys, etc.).** Uninsulated or unsealed gaps often exist around roof and wall penetrations.
- **Door and window frames and seals.** Locate air leaks around windows and doors caused by worn or missing seals. Window and door casings should be inspected for air leaks as well. Repairs are often as simple as caulking or weather stripping.

Anticipated savings:
The Department of Energy estimates that following up on the findings of an energy audit of a building's envelope saves most facilities at least 15 percent on energy bills.



Extend the life of your roof by repairing only damaged areas—replacement roofs can cost $8 to $12 per square foot.

2. Boilers

Boilers are the heart of steam and hot water heating systems.

What to scan:

- **Refractory and insulation.** Thermal imaging makes possible the in-service monitoring and inspection of the condition of refractory linings for performance issues.
- **Fan motors.** As with motors in other applications, check for impeded airflow, electrical unbalance, overheated bearings and failing insulation.
- **Pumps.** Look for hot bearings, leaking seals and, as with fans, motor faults.
- **Valves.** Thermal imagers can identify blocked valves that are nominally open and leaking valves that are nominally closed.
- **Electrical connections.** As with other kinds of systems, look for loose or corroded connections that increase resistance.

Anticipated savings:
In boilers, major energy losses—those associated with stack losses as well as radiation and convention losses—typically represent 10 % to 20 % of fuel input, depending upon fuel type. Insulation and boiler economizers can reduce these losses.[2]

If your facility uses a boiler, scan the steam lines to check for leaks, blockages, and failed traps.

3. Motors and generators

Electric motors are one of the biggest energy consumers in any facility. Overheating and malfunctioning motors and generators tend to indicate mechanical or electrical inefficiencies that lead to unnecessary energy use and sometimes even failure. Since generators are, in a sense, "reverse motors," diagnostics are similar for both kinds of units.

What to scan:

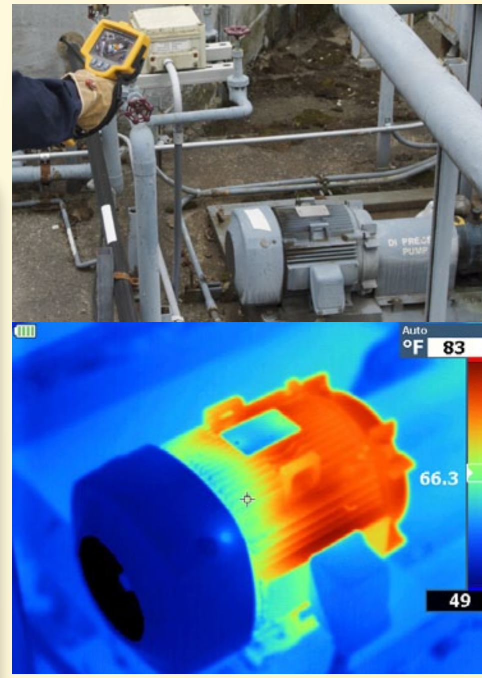
- **Airflow.** In fan-cooled motors, restricted airflow can cause general overheating often manifesting itself on the entire housing.
- **Electrical unbalance.** A common cause, a high-resistance connection in the switchgear, disconnect or motor junction box, can usually be pinpointed by an infrared inspection and confirmed using a multimeter, clamp meter or a power quality analyzer.
- **Bearings.** When thermal images reveal bearing housings with abnormally high temperatures, either lubrication of the bearing or its replacement is often called for. Beware that over-lubrication can cause abnormal heating as well.
- **Insulation.** Look for higher than normal housing temperatures in areas associated with windings. For each 18 °F (10 °C) rise over the maximum rated temperature of a motor, approximately half the life of the motor is lost due to insulation failure.
- **Electrical connections.** As with electrical connections in HVAC systems, look for loose or corroded connections that increase resistance. Heat losses due to high-resistance connections means that your energy is being given off as heat instead of being used for useful work.

Anticipated savings:
With motors and generators, specific energy losses are usually of less consequence than failure of the unit. The impact of a motor or generator failure will be contingent upon the nature of the enterprise and the system(s) affected.

That said, the two best ways to reduce motor energy expenditures are to:

1. Keep motors well maintained/operating at maximum efficiency
2. Size them appropriately and operate at constant speeds

Doing this for a period of time will yield incremental energy savings, after which you can re-invest in motor controls that will significantly reduce energy usage.



When inspecting motors, pumps, or other rotating equipment, make sure to scan electrical connections, housings, end bearing caps, and couplings (from different perspectives) to obtain the best images from which to determine potential problems. Scan the components of rotating equipment, especially the bearings and shaft. Be aware of shiny metal, or other low-emissivity materials or surfaces, as these can cause confusing results if not accounted for.

4. Steam heating systems

Today, steam systems are more common in industrial settings than commercial settings, but some commercial buildings still use them for central heating.

Where to look and what to look for:

- **Steam traps.** Check traps using both thermal imaging and ultrasonic testing. Each technology works better than the other for certain traps and trap configurations.
- **Radiator coils.** Check for obvious steam leaks in radiators and at all visible pipe and joint connections.
- **Steam lines and valves.** Look for telltale signs of leaks and blockages and for blow-by at valves that are supposed to be "closed."
- **Condensers.** Look for leakage of outside air, which reduces the condenser's vacuum, thereby decreasing its efficiency.

Anticipated savings:
In a 100-psig-steam system, if a medium-sized trap fails open it will waste about $3,000 per year.

Correctly operating steam traps should show a temperature differential from one side to the other. All high or low temperatures on both sides of trap may mean that the trap is stuck open or closed. Be aware that a trap may have just cycled, which can also make it appear to be malfunctioning.

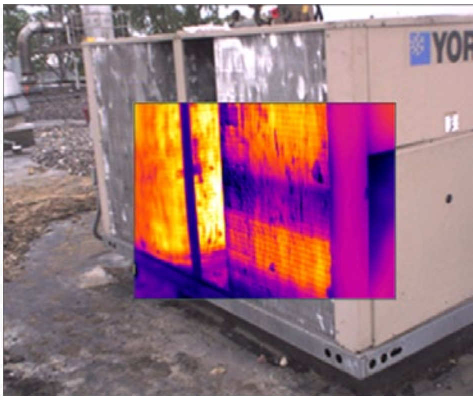
5. HVAC system

The heating, ventilation and air conditioning (HVAC) system is usually one of the biggest energy consumers within a facility.

What to scan:

- **Ductwork and registers.** Even the highest rated HVAC system wastes energy without a well-sealed duct system. With thermal imaging one can see the thermal pattern of air loss or gain in ducting and also monitor registers to determine whether heating or cooling output is optimal.
- **Fans and blowers.** These mechanical elements are, of course, motor driven. For more details about what to look for in motors, see "Generators and motors," below. In fans and blowers, mechanical imbalance will manifest itself in overheated bearings and other components. Thermal images of these systems can also identify shaft misalignment in couplings between the motor and fan.
- **Electrical connections.** Loose or corroded connections increase resistance at the connection point, resulting in increased energy costs.
- **Compressors and coils.** Regular inspections of the compressors and coils can also help reduce energy costs. A malfunctioning compressor can have a different thermal signature than a properly-operating one. If coils are blocked, or cooling fins are clogged, improper airflow and heat exchange can take place. This can greatly impact system efficiency, and also further reduce component lifespan.

Anticipated savings:
Studies indicate that commercial buildings with constant-air-volume systems often experience energy losses from air leakage of as much as 33 %. Also, studies indicate that air-supply temperature differentials due to conduction losses can be as great as 6 °C (10.8 °F) or more.[1] Considerable savings can be achieved in with duct-sealing and insulation remedies.



Clogged or malfunctioning cooling fins drastically reduce the efficiency of HVAC units.

6. Electrical system

Many people don't realize that electrical systems can actually waste money. As components degrade and resistance increases, waste occurs.

What to scan:

- **Distribution panels.** Check for unbalance in circuits and loose and corroded connections at breakers, contacts, fuse clips, buss work, insulation deterioration, etc.
- **Transformers.** Be aware that if the temperature of one electrical leg on a transformer is significantly hotter than the others, that leg may be failing.
- **Lighting control circuits.** Check all wiring splices and connections at fuses, switches, in panels, and at the fixtures. Be aware that thermal imaging can also be used to monitor low-voltage control circuits.

Anticipated savings:
According to some estimates, lighting accounts for about 20 % of all electricity use in the U.S. and more than 40 % of electricity use in offices, stores, and other commercial buildings. While complete retrofits of lighting systems are producing phenomenal returns on investment, keeping lighting controls (time clocks, photo sensors, occupancy detectors, etc.) operating properly will also help save energy.


Abnormally hot electrical connections are not only a potential early warning of failure and a safety hazard, they're also consuming excess energy.

Conclusion

Thermal imagers have come down so far in price that most facilities can recoup the cost of purchase in terms of energy savings within six months. Plus, as this article indicates, incorporating infrared inspection into regular maintenance provides significant efficiencies to a maintenance team as well as helping them identify and prevent expensive failures.

[1] See, for example, the white paper (found at **http://eetd.lbl.gov/IE/pdf/LBNL-44221.pdf**), "Duct system performance and energy losses in large commercial buildings," written by researchers at the Lawrence Berkeley National Laboratory.

[2] This information is from the Canadian Office of Energy Efficiency at **http://oee.nrcan.gc.ca/english/index.cfm?attr=24**.

***ASTM Building Standard C 1060-90 Appendix X2.2** (Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings) states that a minimum temperature differential of 10 °C (for a period of at least four hours prior to inspection) is preferred for infrared inspections of frame construction.

ISO 6781 5.1a (Thermal insulation—Qualitative detection of thermal irregularities in building envelopes—Infrared method) states that: For at least 24 hours before the start of the examination, and during the examination, the air temperature drop across the building envelope shall be at least 10 °C.

ASTM 1153 (Standard Practice for the Location of Wet Insulation in Roofing Systems Using Infrared Imaging)

ASTM E1934 (Standard Guide for Examining Electrical and Mechanical Equipment Using Infrared Imaging)

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