AuditAC

Technical guides for owner/manager of an air conditioning system : volume 4

AN AUDITAC PROPOSED PRELIMINARY AUDIT METHODOLOGY FOR AIR-CONDITIONING FACILITIES

Supported by

Intelligent Energy Europe

Team

France (Project coordinator)
Armines - Mines de Paris

Austria
Austrian Energy Agency

Belgium
Université de Liège

Italy
Politecnico di Torino

Portugal
University of Porto

Slovenia
University of Ljubljana

UK
Association of Building Engineers

BRE
(Building Research Establishment Ltd)

Welsh School of Architecture

Eurovent-Certification

Authors of this volume
Jerome ADNOT (Armines, France)
Daniela BORY (Armines, France)
Vincenc BUTALA (University of Ljubljana)
Ian KNIGHT (Welsh School of Architecture, UK)
Marco MASOERO (Politecnico di Torino)
Simon MUHIC (University of Ljubljana)
Chiara SILVI ***(Politecnico di Torino)***

AN AUDITAC PROPOSED PRELIMINARY AUDIT METHODOLOGY FOR AIR-CONDITIONING FACILITIES

In this brochure we present a typical procedure for a preliminary audit for air-conditioning facilities.

Preliminary audit is a first step of the audit procedure where the auditor has a first approach with the plant. This procedure is very important for the comprehension of the design of the plant and its use. The auditor will be able, at the end of the procedure, to identify preliminary energy saving opportunities. Some easy energy saving actions can be made operational immediately after the preliminary audit, whereas other potential actions may require normally a more detailed analysis, in order to assess their effectiveness and their economic performance. The actions requiring a deeper analysis of the system are best performed during the subsequent detailed audit.

The preliminary audit structure

In a preliminary audit procedure one detects the errors in the AC systems through data gathering, visual detection and with measurements. Preliminary audit involves an interview of the site operating staff, a review of facility utility bills and other operating data, and a walk-through of the facility (to become familiar with the building operation and to identify obvious areas of energy waste or inefficiency). Typically, only major problem areas will be discovered during this type of audit. This level of detail, while not sufficient to take all improvement decisions, is adequate to prioritize energy efficiency projects and determine the need for a more detailed audit.

Preliminary audit activities should include the following sequential steps:

- Identify the air-conditioning system type(s) in use in the building
- Evaluate the conditions of use and the operational state of the system
- Find out and describe the possible impact of improvements to this system
- Write up a preliminary audit report

The preliminary audit is less expensive than the detailed one, but is nonetheless an important study that can yield a very useful estimate of savings potential and a list of low-cost savings opportunities, through improvements in operational and maintenance practices. The preliminary audit information will be used to underpin the more detailed audit, if the energy saving potentials appear to warrant further auditing activity.

The first step of the preliminary audit process should be the collection of information. The information may be collected on the structural and mechanical components that affect building energy use and the operational characteristics of the facility. Much of this information can be collected prior to the site visit. Evaluating energy use and systems before going on-site helps identify potential savings and makes best use of time spent on-site.

The preliminary audit consists of three distinct steps:

Step 1: preliminary data collection and evaluation,
Step 2: site visit,
Step 3: analysis and reporting.

Step1: Preliminary Data Collection and Evaluation

A pre-site review of building systems and their operation should generate a list of specific questions and issues to be discussed during the actual visit to the facility. This preparation will help ensure the most effective use of on-site time and minimize disruptions to building personnel. A thorough pre-site review will also reduce the time required to complete the on-site portion of the audit.

The first task is to collect and review two years worth of utility energy data for electricity. The air-conditioning system consumption data should be provided if the system energy is measured separately. This information is used to analyse operational characteristics, calculate some energy benchmarks for comparison to averages, estimate savings potential, set an energy reduction target, and establish a baseline to monitor the effectiveness of implemented measures.

The building manager should provide occupancy schedules, operation and maintenance practices, and plans that may have an impact on energy consumption. This kind of information can help identify times when building systems such as lighting, recirculating pumps or outside air ventilation can be turned off and temperatures set back. The building manager should ideally also provide documentation for all the above information. If the data are not available, or they don't correspond to reality, then the first action should be to help to collect the data.

Analysing Energy Data

If the A/C system energy consumption is available separately, then a Cooling Energy Index (CEI) could be calculated to compare energy consumption to similar building types or to track consumption from year to year in the same building. The CEI consist of calculated ratios based on the annual consumption and the area (gross or conditioned square meters) of the building. CEI is a good indicator of the relative potential for energy savings. A comparatively low CEI indicates less potential for large energy savings. By tracking the CEI using a rolling 12-month block, building performance can be evaluated based on increasing or decreasing energy use trends. This method requires a minimum of two years of energy consumption data to establish the trend line and values including weather correction.
Caution has to be used in benchmarking in order to compare comparable values between different buildings. The best benchmark method would take into account different parameters (weather, sector, air control factors etc.). Actually, there are few air-conditioning benchmark references and often general benchmarks (all thermal energy

use, or all electricity use) are most commonly used and available. In that case it is more difficult to track air conditioning specifically. However when metering is periodic (monthly, e.g.) it becomes possible to estimate the additional electricity use related with hot weather.

Looking at Loads for cooling

Cooling loads include occupants, lighting, office equipment, appliances, solar gains and specific processes. High loads are in general easy to detect and the energy management efforts should be focused in these areas. High loads may reveal opportunities to reduce consumption by making improvements to the air conditioning equipment, temperature controls, the building envelope, or to other systems which are affected by operation. After utility use has been allocated, the auditor should prepare a list of the major energy-using systems in the building and estimate the time when each system is in operation throughout the year. The list will help identify how each system uses energy and potential savings. Building systems can then be targeted for more detailed data collection. One of the easiest ways to evaluate energy data is to watch for the trends in use, demand, or costs over time. Either graphing two or more years of monthly data on one graph or graphing only the annual totals for several years can help.

Building Profile

Obtaining mechanical, architectural, and electrical drawings and specifications for the original building as well as for any additions or remodelling work that may have been done is the first step to creating a building profile. Any past energy audits or studies should be reviewed. The auditor can use this information to develop a building profile narrative that includes age, occupancy, description, and existing conditions of architectural, mechanical, and electrical systems. The profile should note the major energy-consuming equipment or systems and identify systems and components that are inherently inefficient. A site sketch of the building(s) surveyed should also be made. The sketch should show the relative location and outline of each building; the name of each building; year of construction of each building and additions; dimensions of each building and additions; location and identification numbers of utility meters; central plant; and orientation of the complex.

While completing the pre-site visit review, the auditor should note areas of particular interest and write down any questions about the lighting systems and controls, HVAC zone controls, or setback operation. Other questions may regard equipment maintenance practices. At this point the auditor should discuss preliminary observations with the building manager or operator. The building manager or operator should be asked about their interest in particular conservation projects or planned changes to the building or its systems. The audit should be scheduled when key systems are in operation and when the building operator can take part.

Some AUDITAC tools (Case Study database, AC-Cost spreadsheet and Customer Advising Tool) will become available from our website (http://www.energyagency.at/(en)/projekte/auditac.htm) to support this activity.

Step2: The Site Visit

The site visit will be spent inspecting actual systems and answering specific questions from the preliminary review. The amount of time required will vary depending on the completeness of the preliminary information collected, the complexity of the building and systems, and the need for testing equipment.

Having several copies of a simple floor plan of the building will be useful for notes during the site visit. A separate copy should be made for noting information on locations of HVAC equipment and controls, heating zones, light levels, and other energy-related systems. If architectural drawings are not available, emergency fire exit plans are usually posted on each floor; these plans are a good alternative for a basic floor plan.

Prior to touring the facility, the auditor and building manager should review the auditor's energy consumption profiles.

Step3: Analysis and Reporting

Post-site work is a necessary and important step to ensure the preliminary audit will be useful. The auditor needs to evaluate the information gathered during the site visit, research possible Energy Conservation Opportunities (ECO’s), organize the audit into a comprehensive report, and make recommendations on improvements. The report from the preliminary audit, with possible ECO’s, should be used as the basic input for subsequent more detailed audits.

This brochure includes an extensive list of ECOs for air-conditioned buildings covering three major aspects:

- ENVELOPE AND LOADS
- PLANT
- OPERATION AND MAINTENANCE (O&M)

The “O&M” ECO’s include all actions that may in general be implemented in a building, HVAC system, or facility management scheme. The costs involved in implementing “O&M” ECO’s are generally limited if not negligible, application is therefore normally recommended, provided their technical feasibility is assessed.

“Plant” ECO’s, on the contrary, can involve radical intervention on the HVAC system. Their applicability should therefore be carefully assessed both from the technical and economical standpoint. For this purpose, a review of the main cost-benefit evaluation methods is presented in this report.

In the “Envelope and Loads” categories, ECO’s aimed at reducing the building cooling load are listed. These ECO’s may be either of the operational type, or may involve renovation work on the building envelope. Therefore, the evaluation methods may be similar to those normally applied either to category “O&M” or “Plant”.

Several of the ECO's of each of the above categories may be effectively implemented with the aid of a Building Energy Management System (BEMS). Use of BEMS is highlighted in a specific column of the ECO list.

Energy conservation opportunities (ECO) for air-conditioned buildings

ENVELOPE AND LOADS		
CODE	**ECO**	**BEMS control**
SOLAR GAIN REDUCTION / DAYLIGHT CONTROL IMPROVEMENT		
E1.1	Install window film or tinted glass	
E1.2	Install shutters, blinds, shades, screens or drapes	
E1.3	Operate shutters, blinds, shades, screens or drapes	Y
E1.4	Replace internal blinds with external systems	
E1.5	Close off balconies to make sunspace/greenhouse	
E1.6	Modify vegetation to save energy	
E1.7	Maintain windows and doors	
VENTILATION / AIR MOVEMENT / AIR LEAKAGE IMPROVEMENT		
E2.1	Generate possibility to close/open windows and doors to match climate	Y/N
E2.2	Ensure proper ventilation of attic spaces	Y
E2.3	Optimise air convection paths in shafts and stairwells	
E2.4	Correct excessive envelope air leakage	
E2.5	Roller shutter cases – Insulate and seal air leaks	
E2.6	Generate possibility of night time cooling through overventilation	
E2.7	Add automatic door closing system between conditioned and unconditioned spaces	
E2.8	Replace doors with improved design in order to reduce air leakage	
ENVELOPE INSULATION IMPROVEMENT		
E3.1	Upgrade insulation of flat roofs externally	
E3.2	Upgrade attic insulation	
E3.3	Add insulation to exterior walls by filling cavities	
E3.4	Add insulation to exterior wall externally	
E3.5	Add insulation to basement wall externally	
E3.6	Upgrade insulation of ground floor above crawl space	
E3.7	Locate and minimize the effect of thermal bridges	
E3.8	Cover, insulate or convert unnecessary windows and doors	
E3.9	Use double or triple glazing replacement windows	
OTHER ACTIONS AIMED AT LOAD REDUCTION		

E4.1	Reduce effective height of room	
E4.2	Use appropriate colour exterior	
E4.3	Employ evaporative cooling roof spray	
E4.4	Provide means of reducing electrical peak demand through load shedding	Y
E4.5	Replace electrical equipment with Energy Star or low consumption types	
E4.6	Replace lighting equipment with low consumption types	
E4.7	Modify lighting switches according to daylight contribution to different areas	
E4.8	Introduce daylight / occupation sensors to operate lighting switches	Y
E4.9	Move equipment (copiers, printers, etc.) to non conditioned zones	

PLANT		
CODE	**ECO**	**BEMS control**
BEMS AND CONTROLS / MISCELLANEOUS		
P1.1	Install BEMS system	
P1.2	Define best location for new electrical and cooling energy meters	
P1.3	Modify controls in order to sequence heating and cooling	Y
P1.4	Modify control system in order to adjust internal set point values to external climatic conditions	Y
P1.5	Generate the possibility to adopt variable speed control strategy	Y
P1.6	Use class 1 electrical motors	
P1.7	Reduce power consumption of auxiliary equipment	Y/N
COOLING EQUIPMENT / FREE COOLING		
P2.1	Minimise adverse external influences (direct sunlight, air flow obstructions, etc.) on cooling tower and air cooled condenser (AHU, packaged, split, VRF systems)	Y
P2.2	Reduce compressor power or fit a smaller compressor	
P2.3	Split the load among various chillers	
P2.4	Repipe chillers or compressors in series or parallel to optimise circuiting	
P2.5	Improve central chiller / refrigeration control	Y
P2.6	Replace or upgrade cooling equipment and heat pumps	
P2.7	Consider feeding condenser with natural water sources	Y
P2.8	Apply evaporative cooling	Y
P2.9	Consider using ground water for cooling	Y
P2.10	Consider indirect free cooling using the existing cooling tower (free chilling)	Y
P2.11	Consider Indirect free cooling using outdoor air-to-water heat exchangers	Y
P2.12	Consider the possibility of using waste heat for absorption system	Y
P2.13	Consider cool storage applications (chilled water, water ice, other phase changing materials)	Y
P2.14	Consider using condenser rejection heat for air reheating	Y
AIR HANDLING / HEAT RECOVERY / AIR DISTRIBUTION		
P3.1	Reduce motor size (fan power) when oversized	
P3.2	Relocate motor out of air stream	
P3.3	Use the best class of fans identified by EUROVENT	
P3.4	Use the best class of AHU	
P3.5	Consider applying chemical (dessicant (?)) de-humidification	
P3.6	Apply variable flow rate fan control	
P3.7	Consider conversion to VAV	
P3.8	Exhaust (cool) conditioned air over condensers and through cooling towers	Y
P3.9	Introduce exhaust air heat recovery	Y
P3.10	Consider applying demand-controlled ventilation	Y
P3.11	Generate possibility to increase outdoor air flow rate (direct free cooling)	
P3.12	Replace ducts when leaking	

P3.13	Modify ductwork to reduce pressure losses	
P3.14	Install back-draught or positive closure damper in ventilation exhaust system	Y
WATER HANDLING / WATER DISTRIBUTION		
P4.1	Use the best class of pumps	
P4.2	Modify pipework to reduce pressure losses	
P4.3	Convert 3-pipe system to 2-pipe or 4-pipe system	
P4.4	Install separate pumping to match zone requirements	Y
P4.5	Install variable volume pumping	Y
TERMINAL UNITS		
P5.1	Consider applying chilled ceilings or chilled beams	
P5.2	Consider introducing re-cool coils in zones with high cooling loads	
P5.3	Increase heat exchanger surface areas	
P5.4	Consider displacement ventilation	
P5.5	Install localised HVAC system (in case of local discomfort)	Y
SYSTEM REPLACEMENT (IN SPECIFIC LIMITED ZONES)		
P6.1	Consider water loop heat pump systems	Y
P6.2	Consider VRF (Variable Refrigerant Flow) systems	

O&M		
CODE	**ECO**	**BEMS control**
FACILITY MANAGEMENT		
O1.1	Generate instructions (“user guide”) targeted to the occupants	
O1.2	Hire or appoint an energy manager	
O1.3	Train building operators in energy – efficient O&M activities	
O1.4	Introduce an energy – efficient objective as a clause in each O&M contract	
O1.5	Introduce benchmarks, metering and tracking as a clause in each O&M contract, with indication of values in graphs and tables	
O1.6	Update documentation on system / building and O&M procedures to maintain continuity and reduce troubleshooting costs	
O1.7	Check if O&M staff are equipped with state – of – the – art diagnostic tools	
GENERAL HVAC SYSTEM		
O2.1	Use an energy accounting system to locate savings opportunities and to positively identify savings made through improvements	Y
O2.2	Shut off A/C equipment when not needed	Y
O2.3	Shut off auxiliaries when not required	Y/N
O2.4	Maintain proper system control set points	Y
O2.5	Adjust internal set point values to external climatic conditions	Y
O2.6	Implement pre-occupancy cycle	Y
O2.7	Sequence heating and cooling	Y
O2.8	Adopt variable speed control strategy	Y
COOLING EQUIPMENT		
O3.1	Shut chiller plant off when not required	Y
O3.2	Sequence operation of multiple units	Y
O3.3	Operate chillers or compressors in series or parallel	
O3.4	Track and optimize chillers operation schedule	Y
O3.5	Maintain proper starting frequency and running time of (reversible) chillers	Y
O3.6	Improve part load operation control	Y
O3.7	Maintain proper evaporating and condensing temperatures	Y
O3.8	Raise chilled water temperature and suction gas pressure	Y
O3.9	Lower condensing water temperature and pressures	Y
O3.10	Check sensor functioning and placement for (reversible) chillers	Y
O3.11	Maintain efficient defrosting (reversible chillers)	Y
O3.12	Maintain proper heat source/sink flow rates	Y
O3.13	Maintain functioning of (reversible) chiller expansion device	Y
O3.14	Check (reversible) chiller stand-by losses	Y
O3.15	Maintain full charge of refrigerant	Y/N
O3.16	Clean finned tube evaporator / condenser air side and straighten damaged fins	
O3.17	Clean condenser tubes periodically	

O3.18	Repair or upgrade insulation on chiller	
O3.19	Clean and maintain cooling tower circuits and heat exchanger surfaces	
O3.20	Apply indirect free cooling using the existing cooling tower (free chilling)	Y
FLUID (AIR AND WATER) HANDLING AND DISTRIBUTION		
O4.1	Consider modifying the supply air temperature (all–air and air–and–water systems)	Y
O4.2	Perform night time overventilation where appropriate	Y
O4.3	Shut off coil circulators when not required	Y
O4.4	Replace mixing dampers	
O4.5	Adjust fan belts (AHU, packaged systems)	
O4.6	Eliminate air leaks (AHU, packaged systems)	
O4.7	Increase outdoor air flow rate (direct free cooling)	Y
O4.8	Adjust/balance ventilation system	Y
O4.9	Reduce air flow rate to actual needs	Y/N
O4.10	Check maintenance protocol in order to reduce pressure losses	
O4.11	Reduce air leakage in ducts	
O4.12	Clean fan blades	
O4.13	Maintain drives	
O4.14	Clean or replace filters regularly	
O4.15	Repair/upgrade duct, pipe and tank insulation	
O4.16	Consider the possibility to increase the water outlet – inlet temperature difference and reduce the flow rate for pumping power reduction	
O4.17	Balance hydronic distribution system	Y
O4.18	Bleed air from hydronic distribution system	Y
O4.19	Switch off circulation pumps when not required	Y
O4.20	Maintain proper water level in expansion tank	Y
O4.21	Repair water leaks	
O4.22	Reduce water flow rates to actual needs	Y/N