

## Energy Auditing of Air Conditioning Systems: Main Results of the AUDITAC Project

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### Abstract

The European Directive on the Energy Performance of Buildings states that Member States shall lay down measures to establish a regular inspection of air conditioning (AC) systems of effective output of more than 12 kW. This legislative measure – in conjunction with the fact that about one third of the existing AC system will become obsolete in the next years – opens a vast opportunity for significantly reducing the primary energy use of such systems. This paper presents the main results of the AUDITAC Project, funded by the EC within the Energy Intelligent Europe program, in which a set of documents, procedures, and data applicable to the energy auditing of AC systems have been developed.

### 1. Introduction

The European Directive on the Energy Performance of Buildings (EPBD) states, at article 9, that *“Member States shall lay down the necessary measures to establish a regular inspection of air conditioning systems of an effective rated output of more than 12 kW. This inspection shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building. Appropriate advice shall be provided to the users on possible improvement or replacement of the air-conditioning system and on alternative solutions”*. (Bory, 2006)

By examining article 9 it appears that, even if the emphasis of the EPBD is placed on the assessment of efficiency and sizing of the air conditioning (AC) system, it is the long-term goal of the legislator to promote energy efficiency by more radical actions, i.e. by improving or replacing the existing equipment, or by adopting alternative solutions. It is clear that a simple - albeit thorough, - inspection of the AC system would not be sufficient to pursue such more ambitious goal, for which a complete Energy Audit is necessary. The EC, acknowledging the potential of this further step, has provided funding within the Energy Intelligent Europe (EIE) program to the AUDITAC project, whose output has been the development of a set of materials and procedures applicable to the Energy Audit of existing AC systems (Bory and Adnot, 2006).

In the coming years the stock of AC equipment in use in Europe (Figure 1) will partly become obsolete. Most systems will be renovated for the first time (after 10-15 years of operation) and an opportunity exists to introduce higher efficiency systems. Out of the 2.200 Mm<sup>2</sup> of air conditioned building area in use in 2010 in Europe, 800 Mm<sup>2</sup> will date by more than 15 years and will need urgent renewal. A SAVE Study (EECCAC – Energy Efficient Centralised Air Conditioning Systems) indicated that a potential energy saving of about 50% may be obtained with such renovation: this means that AC Systems may be able to operate with about 50% less energy.

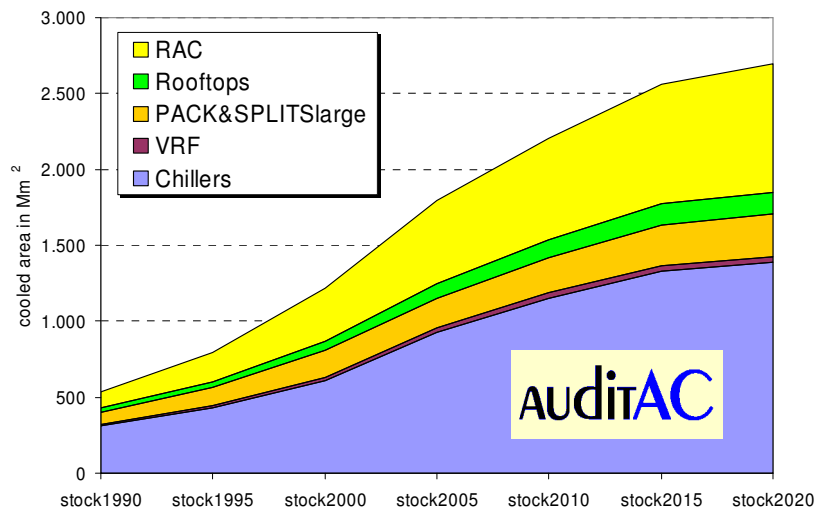


Figure 1 - Cooled area (Mm<sup>2</sup>) in Europe (source EECCAC)

## 2. Energy Audit procedures

The main purpose of an Energy Audit is to identify a suitable set of actions, or Energy Conservation Opportunities (ECOs), that should lead to significant energy savings, within the specified operational and financial constraints. The audit procedure developed within the AUDITAC project is organised into two steps: a Preliminary Audit – whose main purpose is to identify a set of candidate ECOs, taken from a comprehensive list, through a relatively fast and inexpensive survey of the existing AC system – followed by a Detailed (or Investment-Grade) Audit, in which the technical feasibility and cost-effectiveness of each candidate ECO is thoroughly evaluated (Adnot et al. 2006).

The ECO list is therefore the core of the entire audit procedure, and the link connecting the two phases (Masoero and Silvi 2006a). The ECOs are grouped into the following categories and subcategories:

### E. ENVELOPE AND LOADS

- E.1 Solar gain reduction / Daylight control improvement
- E.2 Ventilation / Air movement / Air leakage improvement
- E.3 Envelope insulation
- E.4 Other actions aimed at load reduction

In the “Envelope and Loads” categories, ECOs aimed at reducing the building cooling load are listed. These ECOs 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”.

## P. PLANT

- P.1 BEMS and controls / Miscellaneous
- P.2 Cooling equipment / Free cooling
- P.3 Air handling / Heat recovery / Air distribution
- P.4 Water handling / Water distribution
- P.5 Terminal units
- P.6 System replacement (in specific limited zones)

“Plant” ECOs involve more or less radical intervention on the HVAC system. Their applicability should therefore be carefully assessed both from the technical and economical standpoint.

## O. OPERATION AND MAINTENANCE (O&M)

- O.1 Facility management
- O.2 General HVAC system
- O.3 Cooling equipment
- O.4 Fluid (air and water) handling and distribution

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

Several of the ECOs of each of the above categories may be effectively implemented with the aid of a Building Energy Management System (Masoero and Silvi 2006b). Such circumstance is highlighted in a specific column of the ECO list.

## 3. Documents and tools produced within AUDITAC

The following material developed within AUDITAC may be accessed from the web site [http://www.energyagency.at/\(en\)/projekte/auditac.htm](http://www.energyagency.at/(en)/projekte/auditac.htm):

- *A Training Package of 160 slides on AC inspection, audit and renovation: what you should know if you own or manage an AC plant* (downloadable from [http://www.energyagency.at/\(en\)/projekte/auditac.htm](http://www.energyagency.at/(en)/projekte/auditac.htm))
- *A database of case studies*. A large number of detailed success case studies with different systems and in different climates that demonstrate real savings (downloadable from [http://www.energyagency.at/\(en\)/projekte/auditac.htm](http://www.energyagency.at/(en)/projekte/auditac.htm))
- A route for retrieval of the *performance of equipment that has been certified by Eurovent* in the past but is not currently on the market – and default values for use when equipment cannot be identified or has not been certified. Using information from this database, the inspector can assess the savings that would result from replacement by modern equipment. Available at <http://www.eurovent-certification.com/>
- *A Customer Advising Tool (CAT)* provides information on the potential savings in AC system energy consumption that may be achieved through certain actions on the building shell. (follow directions from [http://www.energyagency.at/\(en\)/projekte/auditac.htm](http://www.energyagency.at/(en)/projekte/auditac.htm))

- *A quantitative audit tool (EES-Auditac)*, based on the calculation of loads and energy consumption with a customized dynamic simulation package EES and its user manual;  
(downloadable from [http://www.energyagency.at/\(en\)/projekte/auditac.htm](http://www.energyagency.at/(en)/projekte/auditac.htm))
- *A tool for profitability computation (AC-Cost)*. AC-Cost allows you also to estimate the AC running costs when they are not separated from the rest of your bill  
(downloadable from [http://www.energyagency.at/\(en\)/projekte/auditac.htm](http://www.energyagency.at/(en)/projekte/auditac.htm)).

Technical Guides (downloadable from <http://www.eva.ac.at/projekte/auditac.htm>) are:

- TG 1: *Are you sure you are not paying for inefficient cooling?*
- TG 2: *Energy Auditing of Air Conditioning Systems and the Energy Performance in Buildings Directive : what does the new regulation say?*
- TG 3: *System recognition guideline for field visit*
- TG 4: *The AUDITAC method of preliminary audit for air-conditioning facilities.* 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. Only major problem areas will be discovered – qualitative estimation of possible savings
- TG 5: *Analysis of Energy Conservation Opportunities (ECOs) for air-conditioned buildings*
- TG 6: *How to benefit from the Eurovent-Certification database and to retrieve past equipment data in the audit process*
- TG 7: *A benchmarking guide for owners and energy managers adapted to air conditioning based on electricity bills*
- TG 8 : *Recommendations to manufacturers to make audit easier*
- TG 9 : *Recommendations and competencies for auditors and structures for training*
- TG 10: *Case studies of improvements in AC systems*
- TG 11: *A model-supported audit method*

#### 4. Conclusions

The AUDITAC project has contributed to increasing the awareness of energy use in AC systems, but it has also highlighted a number of open questions, that will have to be addressed before energy auditing in AC will become a widespread practice. The main problem is that available information on actual energy consumption is limited. Several reasons lay behind this lack of information, namely:

- The main energy input for AC systems is the electricity used by the motors that drive refrigerating compressors, fans, and pumps; generally, electrical energy is centrally metered at the grid interface (main delivery board) without separating the individual users (i.e., lighting, appliances, AC, etc.).
- Most energy service contracts (particularly in commercial buildings) actually include AC systems. However, while for space heating energy metering is

normally required as a means for determining the cost of the service, electricity bills are generally paid directly by the building owner / tenant; the contract therefore includes the AC system operation and maintenance costs only. Consequently, no real reasons exist for implementing a costly and relatively complex procedure of gathering disaggregated electricity use data.

Furthermore, most AC system retrofits carried out in the past (at least in Italy) were determined by reasons different from energy conservation, namely:

- Improving the comfort condition in work spaces;
- Solving IAQ problems, or complying with compulsory regulations on air changes (e.g. in hospitals);
- Replacing room air conditioners with a central HVAC system to overcome maintenance problems and to avoid excessive differences in indoor environmental conditions.

Most of these issues will be the focus of the new EIE project HARMONAC (Harmonizing Air Conditioning Inspection and Audit Procedures in the Tertiary Building Sector) that is scheduled to start in the Fall of 2007.

## 5. Acknowledgements

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