Some AuditAC project results: the air-conditioning running costs tool and the system recognition guide

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Abstract

Owners of air-conditioning (AC) systems are more and more responsible of the good operation and more conscious about the possible energy and money savings through a "wise" management.

The incoming inspection is an incentive for AC owners to go through process of renovation or retrofit. In the frame of the AuditAC project, we have created two basic tools in order to help building owners to decide of investments in a retrofit after an energy audit.

As a guide towards owners or energy managers of AC plants, the first tool illustrates how to do an inventory of existing equipments walking through technical rooms and the building, in case of lack of the documentation about the system. Our goal is to propose simple checks allowing to identify the type of the cold generating system and condensing technique in order to prepare and fasten the incoming inspection or audit.

The second tool is a spreadsheet called AC-cost. Some simple inputs allow to estimate *past* and *future* running costs of the equipment (namely energy, operation and maintenance). Four common energy saving measures (ESM) are moreover proposed and money savings generated by their (combined or not) implementation are calculated in order to advise users about their economical relevancy. Figures used in the tool are taken from the EECCAC [EECCAC 2003] study.

Introduction

The European air-conditioning (AC) market is still increasing and AC owners are more and more careful about the good operation of their systems and conscious about the possible energy and economic savings through a "wise" management of it. Energy audits are promoted and a global approach allows to efficiently assess how different measures can lower energy consumptions for different uses.

Moreover, the incoming inspection [EU 2002/91/EC] is an incentive for AC owners to go through process renovation or complete retrofit of obsolete or defective systems. Although the inspection could be easier and quicker with an exhaustive documentation, the latter is unavailable in most of AC installations. In a first time, the inspection requires and will help to create a complete documentation of the existing plant, including commissioning results, operation and maintenance logbooks, dates and contents of modifications since the construction etc. This will be a fundamental step that will help the inspector in the subsequent inspections to easily understand and observe the evolution of the system all along its life. Owners in most buildings or dedicated energy managers in charge of energy facilities in larger buildings would benefit much more from the inspection if it has been anticipated by preparing the relevant documentation. Indeed, the time spent by the inspector to collect information is not dedicated to analyse the process, evaluate its performances and propose technical solutions. Possible gains generated by the procedure are then reduced whereas its cost is unchanged.

Time being, owners and managers need for tools and advise to best face the incoming inspection and full profit from it. The AuditAC project especially aims to support these actors in different ways. We describe here two of its main results: a guide including some guidelines to increase the awareness of the owner about the AC systems he has in its building, and a spreadsheet to calculate AC running costs and to estimate the benefit from some energy saving measures.

Leading the owner to the knowledge of its plant

In the frame of the AuditAC project we have already published a technical guide [AuditAC TC3/2006] for owners/managers of air-conditioning systems including system recognition guidelines for field visit. The main idea of this guide is to allow a non-expert user to recognise equipments installed in his building. The guide uses a basic language, avoids technical terms and tries to guide the user visiting the facility through simple instructions and visual observations to individuate the different aspects until a univocal identification of the AC system.

It introduces firstly the basis of the AC system and makes distinction between:

- Room air conditioning (RAC): "when cooling needs are punctual and/or localised, we can find one single or several low capacity equipment in each room"
- Central air conditioning (CAC): "when the building requires AC in several areas and for longer durations, and a single equipment in place can cool several rooms at the same time using a cold carrier".

The guide is then developed around two aspects separately through two consecutive methods: the *recognition* of the cold production equipment on the one hand and the *recognition* of the heat rejection technology on the other hand. Terminology tables are included for the two aspects.

The first method is a five-step method that concludes on the determination of the process to produce and distribute the cold energy into the building. It is based on simple questions to answer looking at the system components. Each answer leads to a branch of a decision tree. The observations are focused on the CAC or RAC type, on the type of cold carrier and the distribution

and the location of the system. Questions are summed-up in the Figure 1. At the end of these five steps, the users can identify the cold generating system by a number.

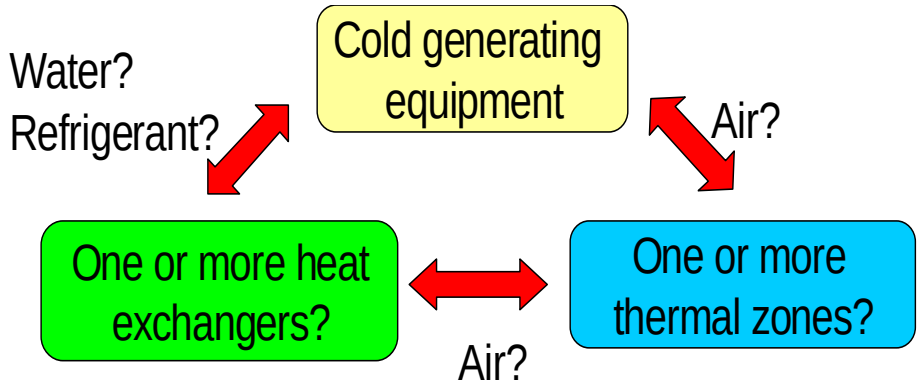


Figure 1 Scheme of the question in the first procedure

Except for RAC that are directly determined from the previous procedure, the second method is necessary for CAC and it allows to conclude on the type of heat rejection of the cold generating system previously determined with only four steps. The procedure is made of four questions about the fluid linking the cold generating system and the outside. The scheme of the questions is showed in Figure 2.

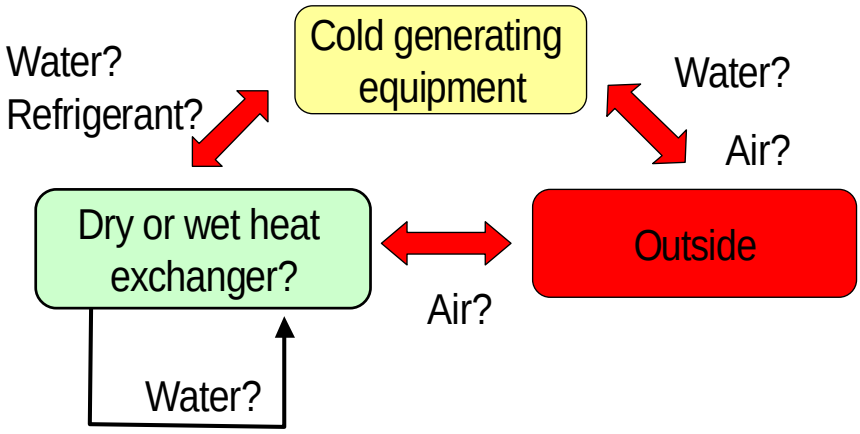


Figure 2 Scheme of the question in the second procedure

The heat rejection system will be identified by a letter. Both the latter and the number associated to the cold generating system allow to identify the whole AC installation. Simple diagrams describing each combination are finally presented.

In order to be exhaustive, we added a list of documents related to an AC system, these documents should be collected and prepared for the incoming inspection, in order to maximize the time spent by the inspector on the analysis by minimizing the time spent by him to collect the information and guiding him in the comprehension of the system to examine.

Finally, energy savings in a building must not be achieved to the detriment of thermal comfort. The guide hence includes some considerations about comfort criteria that have to be respected in any building.

Rising the awareness on the operation aspects

The first task of an auditor or inspector is the assessment of the existing plant status through the analysis of the available documentation. This task can require a lot of time when there is no

follow-up of energy consumptions. Owners and operators seldom track or record the operation of the existing plant (even when Building Energy Management Systems are available). A method to lower this task can be easily performed through the collection and analysis of the documents generally available for a plant: the bills. The yearly, monthly or exceptional bills can help interpreting the system operation through its energy and water consumption drifts and its operation and maintenance costs. This is why we developed, in the AuditAC frame, a simple spreadsheet based tool (called AC-cost) allowing to estimate the existing equipment running costs.

Moreover, in order to promote energy efficiency, we propose to estimate by simple calculations the impact of several energy saving measures. Speaking in terms of "bills" and "money" allow us to directly communicate with users (owner or energy manager) in a simpler and more understandable way than speaking in "energy" terms that are less familiar and sometimes difficult to translate correctly in euros. The impact is therefore easier to understand and more appreciable for a common owner who is looking for advise on how to reduce his running costs by improving his plant.

We developed a global approach of the running costs of an AC plant starting from the past years bills; this allow us to understand the evolution of the operation of the plant from its installation until today and to forecast the development of its future operation.

The net present value of these future costs is calculated.

Next, another aim of this tool is to simply calculate money savings due to some measures of retrofit or replacement of existing AC plant taking into account all running costs.

For simplicity, the tool does not take in account inflation effects and TVA, it considers running costs forecasting for electricity consumptions and water consumptions (for system with water condenser), maintenance costs and it needs also for the initial investment (real or estimated).

The existing plant

In a first step the running costs of the existing plant are evaluated, we speak only of running costs because if some actions is profitable in terms of running costs it should be done, even if the existing plant can still run sometime or even if present plant is not amortized from this point of view. If different systems are used in the same building, the calculation should be performed separately for each system and its cooled area.

At the beginning a short description of the system is asked, the specific parameters required for calculations are: the cooled area, the climate type (three choices are proposed for the moment as representative of three European different climates: London, Milan and Seville), the nominal capacity of the system (if not available a button allows to estimate it on a basis of 120 W/m² installed for CAC and 240 kW/m² for RAC), and if the system is water cooled. The calculations are independent from the type or use of the building.

A time frame is required to establish the period over which the calculation will be performed. We consider the remaining life of the plant as time basis and in order to calculate it, it requires of course the knowledge of the installation year and the lifetime of the plant.

Great uncertainty exists in the determination of the lifetime of an AC plant and many factors can influence it. In general, even if a first term is forecast, its duration can be extended, so it is in general very difficult to establish a real value. The lifetime of the plant can depend on the type of the system, on the maintenance level, on the climate, on the design and on the will of the owner.

To establish the time basis for the calculation we consider different possibilities: if the owner has already forecasted a date for renovation, the number of remaining years of life of the plant can be used as time frame. But if no renovation is envisaged and no precise renovation time is specified, a fault value of conventional lifetime of the plant is considered (for central systems ~20 years) and the time basis is calculated as the difference of this period and the existing years.

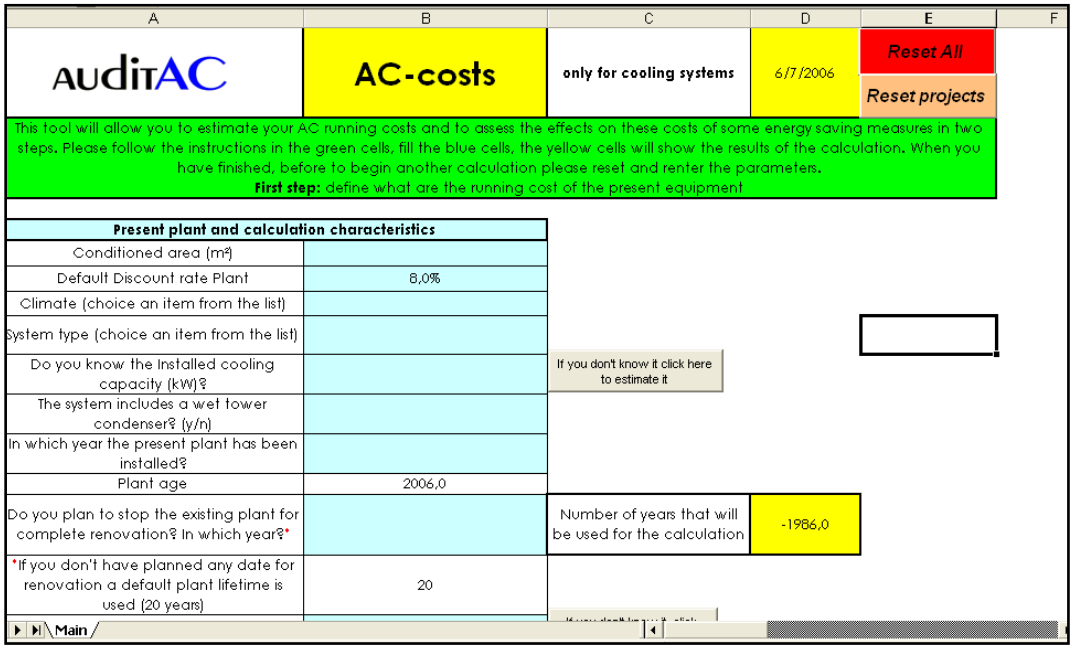


Figure 3 Spreadsheet for the characteristics

The running costs

The energy costs are mainly the electricity costs for the AC plant all over the plant lifetime. These values are not always available to the owner because they are not measured or indicated in the electricity bill. Indeed, the latter accounts several uses that can hardly be disaggregated and hence be benchmarked precisely. Moreover it is difficult to track the consumption at the same time of both the cooling equipment and auxiliaries that can be numerous in the building. Logged energy data from a BEMS can be translated into costs using an average electricity price.

Despite these problems, the user has the possibility to directly enter directly his energy costs for at least two different years in order to compute an average energy cost that is considered constant during the entire time basis.

If the system consumption is completely unknown, a button activates a program that can estimate the energy consumption (kWh/year) using EECCAC reference values for office buildings [EECCAC 2003].

If a wet cooling-tower is used, the annual water bill and consumption are also required to complete the running cost assessment. As for the energy, the owner can fill some year from available water bills (if a separate counter exist for the tower) and a mean value is considered for the rest of the time frame. If water consumptions are unknown, a button (wet tower condenser? Yes) also performs a water consumption calculation following the climate and the type of system.

Several scenarios can be considered for maintenance costs. In a first case, a contract of maintenance is available so that associated costs are defined (for normal and preventive maintenance) and almost constant in time. Therefore the user enters contract values and a button allows to calculate a mean value that is considered constant for the incoming years. In a second case, the user does not have subscribed for a continuous maintenance contract and can only provide some costs for at least two years for repairs. The tool is able to calculate an average cost that is applied to the entire time basis although it should increase in theory. In a third case, maintenance costs are unavailable and a formula allows to calculate them for different types of installations as a percentage (Table 1) of the initial investment (calculated if unknown with the values in Table 2) that increases with the time. When initial investments are unavailable, they are automatically estimated using a ratio in euro per square meter that depends on the system type.

	Maintenance cost as % of equipment cost
RAC - Room Air Conditioners & other unitary without primary air	1%
RAC with primary air	3%
Packages and splits with primary air	3%
CAC - Central Air Conditioners with Air Handling	6%
CAC - Central Air Conditioners without Air Handling (except primary)	4%
VRF & primary air	6%

Table 1 Maintenance costs of air conditioning systems [EECCAC 2003].

	Fix cost	Equipment	Installation
Type	€	€/m²	€/m²
RAC without primary air			
Multi Split systems	20000	75	25
Packaged systems (under windows)	0	60	20
Single Duct	0	100	10
RAC with primary air			
Multi Split systems	30000	79	30
Packaged systems (under windows)	20000	64	25
CAC - Central Air Conditioners			
Large packages (Roof tops...) with all internal ducts	10000	40	20
Large splits without primary air	10000	48	40
CAV Air Systems (air cooled chiller)	16000	50	110
VAV Systems (air cooled chiller, TR)	16000	58	110
2-pipe FCU (air cooled) without primary air	20000	50	50
2-pipe FCU (air cooled) & primary air	30000	54	90
4-pipe FCU (air cooled) without primary air	20000	54	50
4-pipe FCU (air cooled) & primary air	30000	58	90
Two Water Loops System without primary air	20000	54	50
Two Water Loops systems & primary air	30000	58	90
WLHP without primary air	20000	35	5
WLHP & primary air	30000	40	45

VRF without primary air	10000	100	25
VRF & primary air	10000	104	65

Table 2 Equipment initial costs: fix, equipment and installation [EECCAC 2003].

The first interesting aspect of the sheet is the representation of past costs already paid by the owner. When they are most filled by the owner, a simple observation can show real cost drift due to system ageing or changes in maintenance procedures etc. It can be useful to recognise good maintenance activities, specific hot years, etc.

The second interesting point is that once all these values are entered, a net present value (NPV) of the future operation costs of the existing plant is computed as the sum of energy, water and maintenance costs, with an 8% discount rate (default value). This value is useful to establish optimal management programmes or specific actions and it will be later compared to the values computed in case of plant improvements and is a measurement of the interest of such retrofit.

Four projects of renovation for energy improvement

The opportunity to introduce better energy efficiency in AC is presented here through four major measures:

1) Project 1: replacement the cooling system with a same capacity system, better efficiency
2) Project 2: replacement with lower capacity system (eventually higher efficiency)
3) Project 3: convert a constant air volume system (CAV) to a variable air volume system (VAV)
4) Project 4: introduce free cooling

These measures are in some case easy to implement, in other case they are necessary, as in the case of replacement, but the tool helps to decide when it is the best moment to do it and subsequent advantages. In the case or replacement with reduction of sizing, it can be useful when accompanied by another measures aimed to the reduction of the cooling load such as the replacement of the lighting with high performance bulbs or more important measures such the use of solar shades or improving the building insulation.

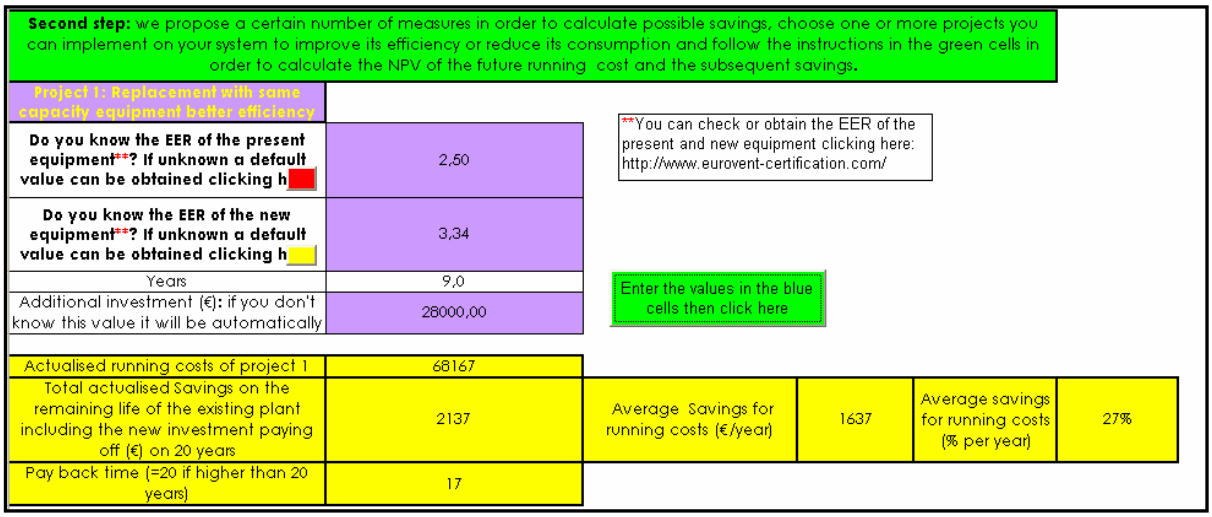
In order to evaluate the interest of each solution the user can fill another table to calculate the present value of the costs for the modified plant. The difference between the net present costs of the modified plant and of the present plant “as it is” will be a measure of the opportunity of savings (€).

The hypothesis is that the duration of the project is equivalent to the remaining life of the plant.

Moreover, the plant cost can be calculated for different measures in order to compare them and determine the most interesting measure.

The energy and maintenance costs and the additional investment for the renovated plant are estimated from the results of the EECCAC project.

The results are presented in form of total savings on the remaining life of the project, a payback time is estimated, and the running costs savings are estimated in euros and as a yearly percent that gives the magnitude of the savings (example in Figure 4).



Second step: we propose a certain number of measures in order to calculate possible savings, choose one or more projects you can implement on your system to improve its efficiency or reduce its consumption and follow the instructions in the green cells in order to calculate the NPV of the future running cost and the subsequent savings.

Project 1: Replacement with same capacity equipment better efficiency

Do you know the EER of the present equipment? If unknown a default value can be obtained clicking h**	2,50	**You can check or obtain the EER of the present and new equipment clicking here: http://www.eurovent-certification.com/			
Do you know the EER of the new equipment? If unknown a default value can be obtained clicking h**	3,34				
Years	9,0	Enter the values in the blue cells then click here			
Additional investment (€): if you don't know this value it will be automatically	28000,00				
Actualised running costs of project 1	68167				
Total actualised Savings on the remaining life of the existing plant including the new investment paying off (€) on 20 years	2137	Average Savings for running costs (€/year)	1637	Average savings for running costs (% per year)	27%
Pay back time (=20 if higher than 20 years)	17				

Figure 4 AC-cost project for replacement with a better efficiency system.

Conclusions

Nowadays the impulsion given to the AC owners and manager to improve the energy efficiency and reduce the consumption related to AC systems is stronger than ever but there is a general leak of tools and a poor dissemination of knowledge about AC systems. Owners and managers need for tools and advice to improve their systems and also to best face the incoming inspection and full profit of it. One of the aims of the AuditAC project is then to support these actors in different ways. We have described here two of the results of the project: a guide including some guidelines to increase the awareness of the owner about the AC systems he has in its building, and an Excel sheet to calculate AC running costs and to estimate the benefit from some energy saving measures.

The guide is done in simplest manner in order to introduce a non-expert user in the identification of the AC systems installed in his building. The guide uses a simple language, guide the user in the recognition through simple question and tries to supply complete information to the univocal definition of the system. Some auxiliary tools are included such as terminologies, a list of the documentation that can be collected about the systems and some comfort principles.

The second tool, named AC-cost, is an Excel sheet completed with macros and a simple interface that firstly allows to define the main past running costs of an AC system. These costs are represented by energy cost (electricity), water and maintenance costs of present system. A simple observation of the evolution of these values with time can show cost drift due to system ageing or to changes in maintenance programmes etc. It can then be useful to recognise good maintenance activities, specific hot years, degradation of performances etc.

In the second part of the sheet, four energy savings measures are proposed: replacement the cooling system with a same capacity system, better efficiency, replacement with lower capacity system (eventually higher efficiency), convert a constant air volume system (CAV) to a variable air volume system (VAV), introduce free cooling. For each measure, a calculation is proposed to estimate the investment and the subsequent "€" savings for the running costs or estimating a payback time of the investment.

These tools have been recently disseminate through the AuditAC project systems and we are waiting for feedbacks and comment from the users in order to improve the quality of the tool corresponding to users needs.

References

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