THE RETROFIT OF EXISTING VENTILATION AND AIR TREATMENT UNITS: AN EXPERIMENTAL AND METHODOLOGICAL APPROACH.

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ABSTRACT

Recent studies in Switzerland showed that in large non residential buildings, witch can be compared for typology and ventilation needs, the consumption of electricity for mechanical ventilation can vary considerably from case to case. Moreover in such a building it represents a percentage not negligible of the whole consumption of electricity. We had a confirmation of that behaviour with a study we made during 1999-2000 on a set of eighty air treatment units of the Civic Hospital in Lugano (Southern Switzerland). In the case in point the consumption for the electrical engines for switching on the fans came to 15% of the whole consumption of electricity (this figure does not include the electricity consumption for the air treatment -post heating, humidification, etc.-).

The analysis pointed out high possibilities of energy savings (40-60%) for many air treatment units both by the mean of simple and cheap measures of retrofitting of the plants, and thanks to a review of the ventilation needs in each interested room. In some cases it was possible to implement the proposed solutions and confirm, within experimental error and according to control measurements, the effective improvement estimated on paper.

KEYWORD

Air treatment unit, electricity saving, fan engines, energy saving, hospital building, electrical motor

THE STARTING POINT

The high electricity consumption of the plants

Various research carried out during past few years demonstrated how the electricity consumption due to the mechanical ventilation and air conditioning plants for the treatment and movement of the air is very large and cannot be ignored.

For the case described here, the Civic Hospital in Lugano (~350 beds), has been demonstrated that the annual costs for electricity consumed to run all the fan engines amounts to about 150'000 Fr. This quantity represents 15% of the global costs spent for the electricity (See Fig. 1)

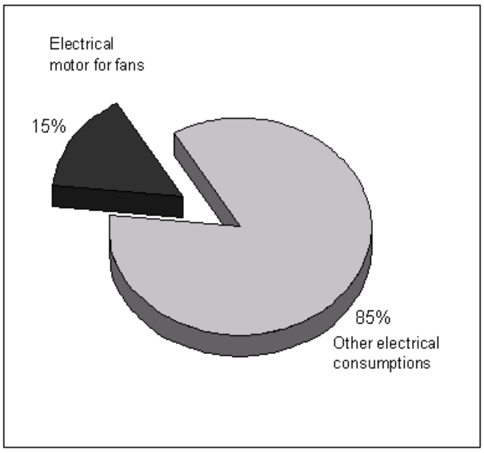

Fig. 1 Consumption of electricity in the Civico Hospital - Lugano

The limited efficiency of the plants

An experimental analysis made on a set of eighty air treatment units showed that the measured efficiencies are far below referring to the values suggested from the Swiss technical codes (SIA 382/3), especially in the case of lower air flow volume rates.

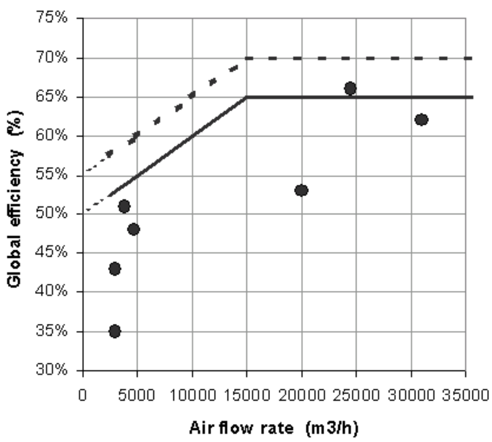

Fig. 2 Comparison of measured efficiency (black dots) and suggested value from Swiss standards

The Fig. 2 explains what mentioned above: investigated plants with small air flow rate(< 5000 m^3/h) have an efficiency lower than 50%, in some cases lower than 30%, clearly below the values suggested from the technical codes (the continuous line represents the normal efficiency requested, while the hatched line indicates higher requirements). In the case of Civic Hospital was evident the possibility to reach high energy savings.

THE RESEARCH GOAL IN THE FRAME OF E2000

The research goal was to propose a methodology easy and fast that allows the HVAC manager to plan the right measures in order to lower significantly the electricity consumption of the hospital ventilation plants both from the energetic and economic point of view.

Even if the research interested the air treatment units of an hospital building all the actions pointed out can be applied usefully in mostly of HVAC plants.

MAIN ENERGY DEFECTS

In the following chapters we present the main defects that were identified during this research.

Insufficient management and control

Very often the running of the mechanical ventilation system does not fit the real needs and usage of the rooms. The Fig. 3 shows that the global electricity consumption varies according to the needs (it is lower both during the night and the weekend days). On the same diagram we can see that the power used for running the fan keeps fairly constant. This means that a lot of plants run even if the rooms are unoccupied.

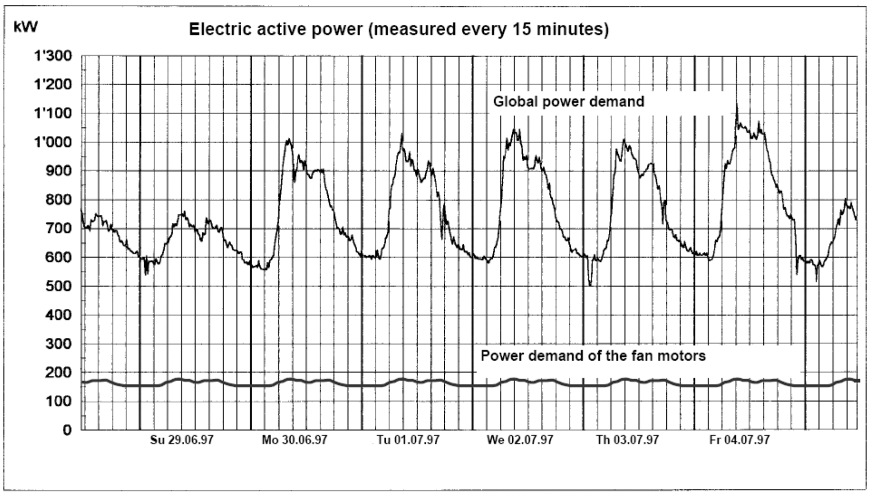

Fig. 3 Measured electricity consumption over a week

Air treatment units with useless components

Very often the air treatment units have components unnecessary, no longer used or overstated.

The following cases are some examples:

- The filters were not corresponding to the needs of the rooms;
- The humidifiers, even if installed, were never used;
- The ducts can have unjustified extension and curves.

At the same time air flow rate if an additional component is installed, we have an additional resistance to the air flow leading to an higher consumption of mechanical energy and electricity.

Unsuitable air flow rate

The air flow rates are often unsuitable to the real needs of the room according to the new standards and in many case the is a lack of efficient control systems. For high performance buildings, the trend during last years is to reduce the ventilation losses at the minimum air flow rates that allows a good indoor comfort (~15-25 m^3/h.pers). From the energetic point of view this topic is very important because the engine power is proportional to the third power of the air flow rate. Lowering the air flow rate of 20% leads to an energy saving of 50% in electricity consumption.

Overstatement of the engines

From the measurements came out that more than 50% of the engines are overstated with a factor 2 or higher (See Fig. 4). The effects of this behaviour are very negative on the electricity consumption because the efficiency of the motor decreases sharply when the engine runs at a partial charge lower than 25 – 50% of the nominal value. This aspect has a double negative consequence for the plant manager because he pays more to buy an engine too big for his purpose and he spends yearly more electricity.

The overstatement ε came from Eqn. 1

$$\varepsilon = \frac{P_{n,out}}{\eta \, P_{e,in}} \qquad \text{Eqn. 1}$$

Since $\eta = f(\varepsilon)$ it is possible, even without know the nominal efficiency η_n (or $\cos\varphi_n$) to estimate the maximum value of η and then the minimum value of ε referring to the database of electric motors EuroDEEM 2000.

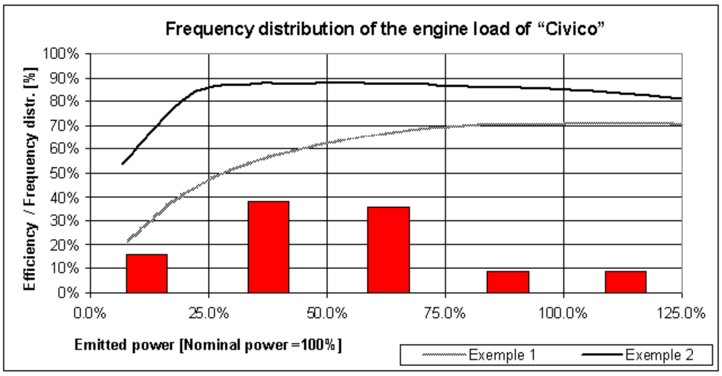

Fig. 4 Frequency distribution of the engine load of Civico Hospital - Lugato

METHODOLOGY

As usual in other sector, the methodology is divided in two main parts: a “Brief Analysis” and a “Detailed Analysis”.

Brief Analysis

During the first phase in order to evaluate a possible overstatement, to list the first measures of energy improvement and their cost, and to select the air treatment unit witch should be analysed in detail afterwards, all the data of the ventilation plants and of the ventilated rooms are collected and the electric power of each air treatment unite are measured (See Fig. 5).

In detail the answer to the following questions has to be found:

- Which sort of plant are we dealing with? And which need it has to satisfy?
- Which elements compose the air treatment unit? And how they are maintained?
- Which are the rooms served by the plant and their dimensions?
- How many hours and when the rooms are occupied? And which are the working hours of the system?
- How big is the designed air flow rate?
- Which control system are installed?
- How much energy spend each air treatment unit yearly?

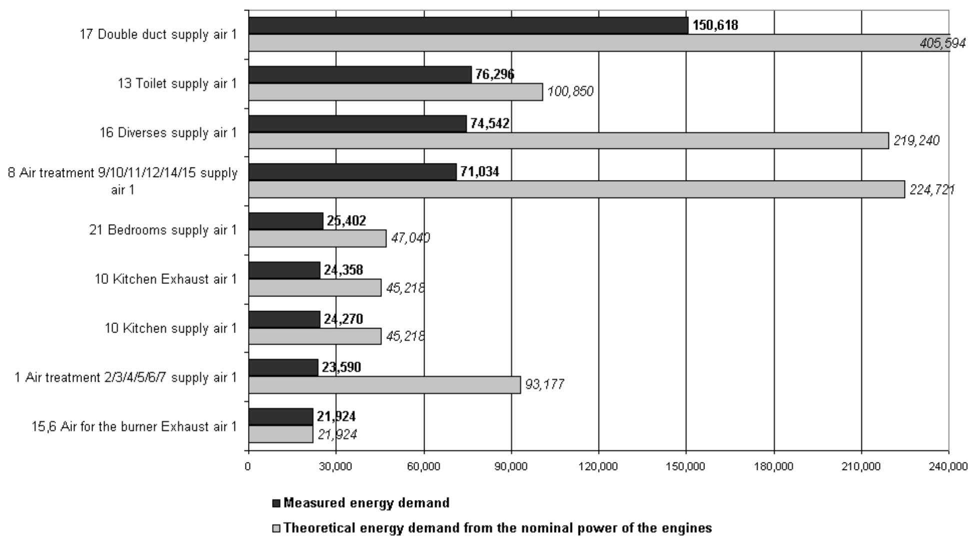

Fig. 5 Theoretical and measured yearly energy demand (kWh) for the Civico Hospital

In this context it is essential to measure for each treatment unit the electric power absorbed by the engine. In fact the real energy consumption can be notably lower than the theoretical value obtained from the nominal values of the installed engines. This can happen because of the overstatement of the motor.

To know the exact figure of the energy consumption for each air treatment unit is important to evaluate the profitability of the actions and to state which units have to be studied in detail furthermore.

Detailed Analysis

During the second phase in order to have a comprehensive description of the starting situation all the efficiencies of the selected air treatment units are measured.

In detail the following physical quantities has to be measured:

- air flow volume rate;
- the global pressure drop across the fan;
- the frequency of rotation on the fan and of the engine;
- the pressure losses related to the various component of the air treatment unit;
- the electric power absorbed by the engine.

Then, according to the ventilation and air treatment needs of the rooms, by the means of an audit and an optimisation of the plant in each component, it is possible to find out a schedule of retrofitting procedure (short, medium and long term).

The possible strategies for energy savings must focus on:

- reduction of number of working hours of fan;
- minimization of air flow rate;
- minimization of pressure resistances in the plant;
- increase of the efficiency of the system “fan-transmission-engine”.

CONCLUSIONS

The suggested procedure should represent a good starting point to manage the problem of retrofitting of existing air treatment units taking into account both the energy savings and the economical resources even if it is under a continuous improvement phase (See Fig. 6), from the collection of new experiences during the practical implementation by the means of courses and seminars running in some region of the Switzerland.

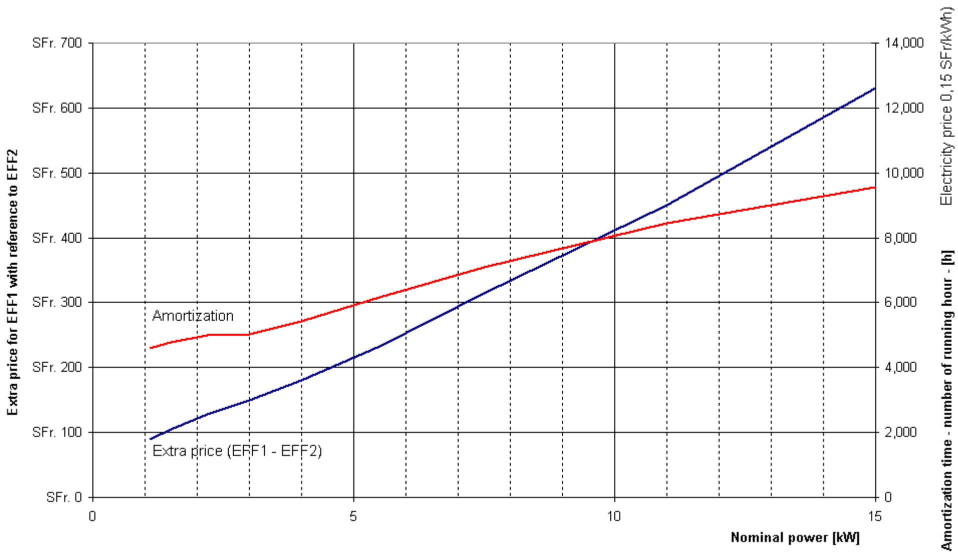

Fig. 6 Profitability of a 4 poles motor with an higher efficiency (EFF1)

EXAMPLES

During our experimental research we had the occasion to test some simple actions of energetic upgrade for some air treatment units.

Example 1: air treatment unit of supply air for the Chapel (Lugano Hospital)

For the case of the Chapel we choose three different actions.

Reduction of number of working hours
Originally the plant was switched on continuously at low velocity. Considered the scarce use of the chapel, a timer to switch off the fan from 22:00 to 6:00 was installed. By the mean of this simple measure it was possible to reduce the yearly consumption of electricity (less 33%)

Adjustment of the transmission-gear to the engine speed
The analysis showed that the efficiency of the engine was better at higher velocity (~85% instead of ~70% for small velocity). The solution was to move the engine to high velocity and to change the sheaves in order to assure the same air flow rate: the electricity savings was around 20%.

Replacement of the fan
The fan was removed because the efficiency was very low and replaced by another fan, with a good characteristics for the plant, from a disused air treatment unit. With this action and the adjustment of the transmission-gear to reach the aimed air flow rate the energy savings were around 21%. All these measures together allow to save around 43% in energy consumption referring to the base case.

Example 2: treatment unit for the supply air in the kitchen (Lugano hospital)

The easy action in this case was to reduce the air flow rate by 20% simply with the replacement of the sheaves, because the measures showed that the flow was overstated. This measure alone reduced the energy consumption of 43%

Example 3: air treatment unit for therapy rooms (Sursee Hospital)

In this case the analysis showed the presence of an unnecessary filter: without this filter and adjusting the transmission-gear in order to reach the correct air flow value the reduction in consumption was around 30%.

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