OPERABILITY AND RESULTS OF RETRO AND ON-GOING COMMISSIONING TOOLS APPLIED TO AN EXISTING BUILDING

Stéphane Ginestet[*], Dominique Marchio[*] and Olivier Morisot[**]
** Centre d'énergétique (Cenerg) – Ecole Nationale Supérieure des Mines de Paris – 60 Bd Saint Michel 75 272 Paris*
*** Elyo Cylergie - Chemin de la Forestière – 69 130 Ecully*

Summary

Several tools in the scope of Annex 40 (PECI Model Commissioning Plan and Guide specification, Emma-CTA, IPMVP) have been used to realise the retro and the on-going commissioning of an existing building. The aim of the work was to evaluate operability, consumed time, results of these tools used by HVAC operation technicians. Analysis of making use of the different tools in a common framework is proposed, giving feedback information to creative authors.

Keywords: retro-commissionning, on-going commissioning, tools, operability on existing buildings

INTRODUCTION

Many tools used for commissioning of existing air-conditioned buildings are today developed, especially to satisfy new requirements in energy efficiency, and sometimes indoor air quality. This paper deals with tests and feedback experience of using some commissioning tools listed in the scope of Annex 40 of the IEA. The aim of the work was to evaluate usefulness of the different tools, level of qualification of the user, and efficiency on the field of such procedures.

OBJECTIVES AND FRAME OF THE WORK

The works presented here are focused on how to implement the chosen tools in existing buildings (for retro and on-going commissioning). Accounting the variety of HVAC systems which can be concerned, the tools are restricted to air handling units. They have been tested in their November 2002 version. The tester is typically an end-user.

Twelve tools itemised have been evaluated. Among these, five were considered applicable on a real building, according the French context. For the three tools really available: PECI guide, Emma-CTA from CSTB, and IPMVP from DOE and ASHRAE, a synthesis, and a feedback report were drawn up.

PRESENTATION OF THE BUILDING SUPPORT OF THE STUDY

The support of the study is a faculty building located in France (Rhône-Alpes area). The considerate rooms are made up of two amphitheatres, each of them are only heated by an air handling unit. The instrumentation installed (sensors, meters…), linked to a recording system (instantaneous measures, each five minutes) brings precise information on the behaviour and the energy consumption of the two AHU.

The building can be seen as a particular case, permitting to conclude on the operability of the tools, and this for at least, three reasons:

- The absence of interactions between heating sources: the air supplied by AHU is the only source of heating of the two rooms. What's more, the important insulation and the absence of windows contribute to reduce the influence of external loads
- The easy access to AHU: they are located in an insulated room.
- The sensors installed are sufficient and give access to all the necessary parameters for using the commissioning tools. The two amphitheatres are strictly identical, especially in their architecture. They are well-insulated and have a high inertia. Both plants are new (October 2001). The supply end extracting network of each room is also new and is equally identical.

The control of both heat exchangers is done by three-way valves, acting on water temperature.

In both cases, the objective is to maintain constant extract air temperature near to the set point, controlling, the following parameters, according the considered plant:

"Classical" control: air handling unit n°1

- the supply air flow rate is constant
- the ratio outdoor air / recycle air is 25% and is constant
- the supply temperature is only controlled by exhaust air, by changing water temperature in the heat exchanger

Mixed "CO_2-temperature" based control: air handling unit n°2

The control of CO_2 rate (measured in exhaust air) has priority.
The CO_2 rate pilots in parallel the damper's opening and the fan motor speed, by PI mode.

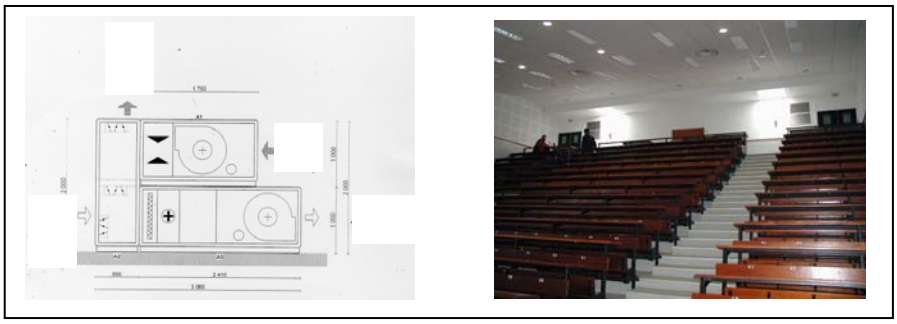

Figure 1. Amphitheatre overview and diagram of the system used to test the three tools

Three tools, really available (PECI guide, Emma-CTA, IPMVP) have been tested on the two air handling units.

RETRO-COMMISSIONING TOOL :PECI MODEL COMMISSIONING PLAN AND GUIDE SPECIFICATION

Design by PECI (Portland Energy Conservation Inc.) for new installations receipt, this guide [1] has been adapted to be used in retro-commissioning phase. When an ESCO takes in hand a new installation, it first appreciates the technical state of the materials and equipments to achieve necessary modifications. The aims of the phase are:

- to collect information on equipments and installation
- to control equipment's general aspect and to verify its good operation, in order to propose a renewal plan and to anticipate immediate correcting actions
- to control the standard's compliance
- to control good and people's safety
- to evaluate the potential of the plants to satisfy expressed requirements and the ability to provide expected work

As explained before, the only part of the guide which was used was the air handling unit chapter.

The PECI guide is made up of:

- An **organisational chapter:** tasks to be done, by whom, when… This part in **not applicable in France**, actors and practices in building sector are strongly different.

- A **technical chapter** which proposes a set of pre-functional tests and of functional tests for different installations

Pre-functional data sheets include sensors calibration, verification of some actuators (dampers, valves). **The procedure can be fully exploited only if control is well-known.**

PECI's tool has been designed for a particular air-conditioning plant (components and above all control). Only common tests for all air handling units have been investigated.

ON GOING-COMMISSIONING TOOL: EMMA CTA (FDD AHU: FAULT DETECTION DIAGNOSIS FOR AHU)

This document [2] presents an expert system for air-conditioning plants and examines the performances. The expert system is made up of logical and simple laws which are able to identify some obvious problems on AHU behaviour.

Emma-CTA (FDD-AHU) includes:

- a set of 28 expert rules checking correct global management of the AHU
- a connection chart between rules and likely roots, which propose a diagnosis help
- a software interface corresponding to both previous items grading different faults

If the tool is user-friendly, however, the use of Emma-CTA directly on the field wasn't possible for the following reasons:

- Temperature sensors were different of Emma-CTA requirements (no mixed temperature sensor on the pilot site)
- The control laws of the AHU were different of those programmed in Emma-CTA

Thus, the set of rules had to been modified to take into account the differences between Emma-CTA basis case and our test site. The set of rules had been programmed for the use of the tool.

Regarding the use of the tool, three points could be improved:

- Nowadays, the tool uses the installation's off-line data. An on-line installation will be user-friendly for technicians who work on the field
- The existing tool is not flexible. For this reason, it would be interesting to customise it with available sensors, proper control . Since our tests, Emma-CTA has been completed to become CITE AHU.

The advantages of the tool are:

- the use of simple rules, easy to run and to understand
- a high-performance fault detection of much control faults

- a user-friendly interface and a high quality in terms of results presentation
- a significant help in diagnosis of fault detection

TRANSVERSE TOOL : IPMVP INTERNATIONAL PERFORMANCE MEASUREMENT AND VERIFICATION PROTOCOL

IPMVP [3], [4] proposes a « standard » methodology to validate energy savings. In France, this evaluation concerns ESCO (Energy Services Company) and building owners through performance contracts.

The several documents named in the rapport [3], permit:

- to build a general methodology of measurement and verification of energy savings
- to tackle calculation of energy savings following the Energy Conservation Measure (ECM) considered and available parameters
- to chose between four calculation options. Options A to D are presented in the IPMVP document. Following the ECM and the parameters (measures, software…) available, the ESCO will choose which option is the most suitable (accuracy, cost and time consumed).

The ECM tested on the field was the substitution of a constant air-flow rate AHU (AHU1) by a CO_2-driven air-flow rate AHU (AHU2). The test permits to underline the following points:

- If the ECM is simple to evaluate: the option A (use of energy keys) or the option C (metering) have to be used. The cost of the method is reasonable (little measures and little calculations)
- If the ECM is innovative or complex: the use of a long-time measurement (option B) could be necessary. The user must be watchful: the measurement and the study's costs shouldn't overtake saving's value.
- If the user has the required competences, the simulation, based on many hypothesis and some on-site metering can be an interesting solution. What's more, some defaults and their influence on energy consumption can be detected.

TESTED TOOLS : USER'S REQUIREMENT AND EFFECTIVENESS

For the three tested tools, it appears very interesting for the potential user to know the academic level requiered, as well as the effectivenes on site during the application.

Tool	PECI Guide	Emma CTA	IPMVP
Academic level requiered for the user	The level of the people who takes charge of the installation is perfectly suitable	The level of the fixed or travelling technician responsible of the plants. The tool is user-friendly and can be used by the accurate people.	The required level is here linked with the considerate ECM and so with the chosen option between the four proposed by IPMVP
Effectiveness / profitability	Detection of some faults: air leakage, sensor's bad localisation, rod out of order, sensor's inversion… On the other hand, control and programming faults , bad choice and selection of the equipment, bad balanced hydraulic and aeraulic networks, aren't taken into account. The tool's implementation corresponds to time spent (half a day for an AHU). No purchase and no particular training were necessary.	The modified expert rules permit to detect the following faults on the AHU n°1 : - fault on temperature sensor - pumping phenomena of the valve - wrong valve position - wrong alarm appearance The cost of the use of this tool can be reduced by using a new version on the tool, which can be parameter in function of the different layouts.	The study pointed out : - the rather high cost of many options (B and D) - the easiness and the quickness of other options (A and C) However, the user must be careful to write properly his hypothesis to justify accuracy of his calculations. The absence of procedure makes the IPMVP more a mental frame, in which procedures must be invented for each case.

RESULTS

The several tools tested during this study are the subject of detailed synthesis [5], which were transmitted to the respective creative authors. The three hold tools take place in different phases in existing building's commissioning. Among the main results of the study and the possible improvements, it can be noticed that:

- PECI tool : the taking charge of an installation, is limited in time and occur during occupancy of the building, so it is difficult (indeed impossible, according external conditions) to strain the equipment to work in all cooling modes. Thus, it is judicious to concentrate in this phase the detection of mechanical faults and the checking of the plant. Savings have been evaluated by simulation in terms of energy, but also in terms of indoor air quality. **The procedure appears efficient and cost-effective.**
  For instance, the detection of an air leakage of 30% on the aeraulic network involves an increase of 22% of energy consumption (base 573 kWh), which represents 180 €/year. Other detailed results can be found in [5]

- Emma-CTA tool: the tool presents **an interesting complement** to the retro-commissioning tool seen before. The desirable evolution will be to have an adaptable version on the main existing AHU architectures, without being exhaustive and keeping its simple use. A major point to consider is also the solution chosen to recover equipment's data. Off-line version, easier on technical point of view, could be never used, while on-line version, more complex on technical considerations, allows a continuous and easy use. The complexity level of detected faults is very interesting because it completes those detected by PECI. The tool permits to realise on-line control tests which cannot be realised during the previous phase (taking charge of the installation). So PECI and Emma CTA constitute a coherent tool adapted to the different phases (taking charge of the installation, running, periodical tests). According to this approach, the tool CITE-AHU (CSTB, NIST) build during Annex 40 fulfil the phases commissioning / retro-commissioning / on-going commissioning

- IPMVP tool : the four options (or operational declinations) evaluations of IPMVP have been applied on pilot site. To come within the scope of

the methodology presented is rather easy; however **procedures are to be written in each case and will be different in each category of considered solution.** The procedures should be developed during a dialog between customer and ESCO. The main contribution of IPMVP is to propose **a common frame**, allowing more transparency and repeatability.

CONCLUSION AND PROSPECTS

Other tools (especially taking into account indoor air quality) should also be tested and confronted to real equipments to enhance the potentials of commissioning techniques on indoor environment, and not only on energy savings. At last, a library of the main different HVAC systems, for which operational commissioning tools are available (in various phases: retro, on-going…) will be listed to promote Annex 40 tools towards industrial users who want to practise commissioning techniques.

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Acknowledgements

This paper summarizes final report of « Implantation et test de méthodes de retro & on-going commissioning » project, lead in call for propositions 2002 ***Qualité Energétique, Environnementale et Sanitaire : Préparer le bâtiment 2010****, supported by ADEME and the PUCA.*