DEVELOPING TOOLS TO IMPROVE HVAC COMMISSIONING: THE ANNEX 40 APPROACH

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ABSTRACT

The Energy Conservation in Building and Community Systems program of the International Energy Agency has set up a research working group (Annex 40) on Commissioning of Building HVAC Systems for Improved Energy Performance. The objective of this new Annex is to develop, validate and document tools for commissioning buildings and building services. The paper describes the annex work which includes 5 tasks: 1) the commissioning process 2) manual commissioning tools 3) building energy management system assisted commissioning tools 4) use of models for commissioning 5) commissioning projects. The work on commissioning process starts with the description of the different tasks included in commissioning. Then the parameters which could lead to different level of commissioning activities are discussed. Finally the different work assignment between a commissioning authority and usual partners in a construction project are discussed. The objectives of the other activities of the annex are presented in a more synthetic way.

KEYWORDS

Building, energy, commissioning, HVAC

INTRODUCTION

The Energy Conservation in Building and Community Systems program of the International Energy Agency has set up a research working group (Annex 40) on Commissioning of Building HVAC Systems for Improved Energy Performance [1]. The objective of this new Annex is to develop, validate and document tools for commissioning buildings and building services. More than 20 organizations representing 10 countries are involved in this research work. One presents here the work program as well as the first findings on this research group.

WHAT IS COMMISSIONING

The definition chosen by Annex 40 is the following: Commissioning is the process of ensuring that systems are designed, installed, functionally tested and capable of being operated and maintained to perform in conformity with design intent and to keep building in optimal conditions. The commissioning begins with program and includes design, construction, acceptance, operation and training and can be applied throughout the life of the building.

This definition is a mix of American ASHRAE definition and Japanese SHASE definition. It considers commissioning as a process and not as an action. This process goes along the whole construction project. One shall note that commissioning is here described in a much broader way than it is generally described in UK where commissioning is the advancement of an installation from the stage of static completion to full working order to specified requirements [2]

WHY COULD COMMISSIONING DEVELOP IN THE FUTURE

Commissioning will probably develops in the coming years due to 1) Energy and environmental reasons. Global warming has increased the pressure to reduce energy use in buildings and many countries are willing to develop green buildings 2) Business reasons.

Many companies are developing new services to diversify their activities in the building and energy industries 3)Technological reasons. Building automation systems are now standard in recent buildings and are being installed in many older ones. These systems automatically collect building and plant operating data, and offer possibilities for innovative commissioning services.

Clearly, lack of awareness, lack of time and costs are the primary obstacle that impedes the adoption of commissioning as a routine process for all buildings. Hence, efforts for improvement should consider how new tools and organization can increase awareness of commissioning interest and decrease the cost of delivering commissioning and/or demonstrate the benefits obtained by performing commissioning.

ANNEX 40 GOAL AND ORGANIZATION

The objective of the Annex is to develop, validate and document tools for commissioning buildings and building services. These tools include guidelines on commissioning procedures and recommendations for improving commissioning processes, as well as prototype software that could be implemented in stand-alone tools and/or embedded in building energy management systems (BEMS). The work performed in the annex is focus on HVAC systems and their associated control systems.

The annex includes also the test of the tools developed in real projects which will be used to improve awareness of commissioning interest.

The Annex is organized according to the structure illustrated in Figure 1.

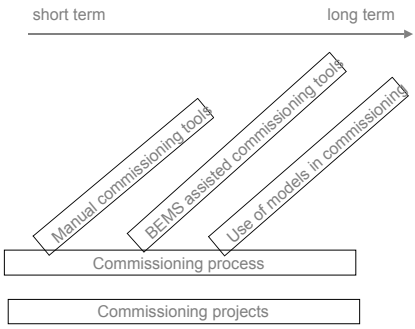

Figure 1: Structure of Annex 40 work.

The work performed in the commissioning process task is detailed in this paper. An overview of the work on the four other tasks is also presented.

THE CX PROCESS

The first issue to describe the commissioning process is to define the tasks to be performed to commission a building. This is important to clarify what is really covered by commissioning activities. The tasks lists defined by the annex will help to define the tools which are needed and where they can best be used. The second issue consists in selecting the intensity of commissioning which is necessary for a given building. The annex works on the development of a tool enabling to select for a given project the intensity which will lead to a good cost ratio of commissioning activities. The third issue consists in defining who will perform the commissioning tasks. We try to describe different possibilities with their pro and cons.

The results of these activities will consist in a series of customisable "standard models commissioning plans". These plans will consist in a detailed list of activities. Plans will be defined for different type of building projects. The other tools developed within the annex will help to apply one or more actions of the commissioning plans.

Commissioning tasks

The list of actions to be performed to commission a building could be quite long and it is important to well structure it. The approach chosen in the annex is based on a Dutch tool called "model quality control matrix"[3]. This matrix consists of 5 columns corresponding to project phases: program, design, elaboration, realization and operation. It includes 9 lines corresponding to different quality control aspects: definition, action, organization, tools, purchase and finance, documentation, others… All actions are located in one cell of the matrix. A detailed description as well as tools can be linked to each matrix cell. A synthetic list of 20 tasks is given below; more extensive lists are defined within the annex:

Program: 1) assists owner establish quality level of the project 2) ensure owner's project requirement (OPR) is developed at a level of detail which is consistent with quality level expected

Design: 1) check the basis of design, the plans and the specifications against owner's project requirements, 2) check completeness of design documents 3) elaborate commissioning plan and organization 4) Assist owner in updating OPR

Elaboration: 1) develop functional test procedures and forms 2) develop performance test 3) update commissioning plan and organization 4) check that commissioning, training and documentation requirements are included in the construction contracts

Realization: 1) review construction submittals, 2) observe installations and start-up, 3) verify testing and balancing results and functional test 4) practice functional performance test, 5) develop the Systems Manual, 6) review traditional O&M manuals 7) verify operator training

Operation: 1) assists in resolution of unresolved commissioning issues 2) practice seasonal performance testing 3) verify yearly performance of the system.

Customized commissioning plan

The actions to perform to commission properly a building depend on the following parameters:

Building owner and operator strategy: when the future user of the building is involved in the project since the beginning, the approach chosen to look at future operation of the building is much more detailed. So the effort put in commissioning can be much more intensive.

Criticalness of building operation: laboratories, computer centre, industrial buildings, headquarters are example of buildings where malfunction may have high economic or image impacts. In such buildings the commissioning effort can also be more intensive than in standard buildings.

Building and HVAC system complexity: The risk of malfunctions increases when one moves from small heated buildings to large air conditioning buildings.

Packaged units/ systems: HVAC packaged units are mainly industrial products which are selected for a given building. Distributed systems such has hydronic heating system, centralized air conditioning systems include a set of industrial component connected through air or water network to constitute a unique system. The risk of poor design and installation is clearly higher with distributed system, so they do require more intensive commissioning.

The annex is developing a tool enabling building owners to assess rapidly the level of commissioning needed for their project. This assessment will be the basis for the customisation of the commissioning plan which is necessary to reach a good cost benefit ratio. 5 example of commissioning levels have already been defined which corresponds to : 1) complex critical building 2) large commercial building with centralised HVAC system 3) medium size building with simple HV system 4) medium size building with independent HVAC units 5) small size building with simple HV system

Commissioning organization

The annex has performed an analysis of the different organization for commissioning. Three main organizations can be differentiated.

In the first approach the commissioning tasks are performed by a commissioning authority which depends only of the building owner and which is fully independent of the other players in the construction process. This first approach warranties that a new eye is looking at all aspects especially taking into account exploitation and maintenance issues. It gives a maximum security to the owner. The main disadvantages are the extra costs for this new activity and the risk of lower involvement of the other players in the quality aspects. Commissioning addicts consider that these costs lead to high savings and that the cost benefit ratio is very good.

In the second approach commissioning tasks are performed by the usual players: architects, engineers, installers… This lead to a commissioning process much more embedded in the day to day practice of these players. The challenge here is to well differentiate the commissioning tasks from the usual design, installation, testing and balancing tasks. It is also to make the building owner confident that these tasks are really performed. This confidence could be obtained through a certification of the players by a third party. Different certification procedures can be used. For single family houses the certification can be a certification of the house itself. For larger project it is not manageable to certify the building which is the final product, process certification seems to be an efficient way to get confidence.

The third approach is an intermediate one and consists in having most of the actions performed by the usual players and to have a commissioning authority in charge of verifying that they are effectively performed.

In a long term view the two first approaches could lead to very different perspectives. With the first approach commissioning will become a work in itself with commissioning specialists. So the success of people working in the commissioning field will be to have that work recognized by the market. In the second approach commissioning could become a part of each party work and is only a way to improve quality. Commissioning work will in this second approach disappear as such and will only become common practice.

The annex is not discussing which approach or which mix of approaches is the most adapted to different market situations but describes different possibilities.

MANUAL COMMISSIONING PROCEDURES

A lot of work has already been performed by different organization throughout the world to develop checklists and performance testing procedures. The main challenge today is to make the best use of existing procedures and to develop new ones only to suit uncovered issues.

The strategy of the annex consists in defining tools specifications then in transferring, when possible, procedures from one country to others or in developing new procedures when needed. When defining the tools specifications each tool will have to be located in the standard model commissioning plans define above.

Main source of existing procedure have been located. The easiest access to US procedures is given through a test protocol library [4].

Two priorities were defined for the annex: 1) manual commissioning procedures adapted to air handling unit 2) procedures necessary to apply standard commissioning plan for a medium size building with simple HV system.

BEMS ASSISTED COMMISSIONING TOOLS

Using the BEMS to commission the HVAC system is an attractive option. Three issues have to be addressed to be able to implement this option. The first issue is the commissioning of the BEMS itself. No chance to use the BEMS to commission the HVAC system if the BEMS itself is not properly commissioned. The second issue is to define testing procedures which can be automated. The third issue is to implement these procedures in the BEMS.

Regarding the commissioning of the BEMS itself enquiries were performed in three countries to define what the main quality problems with BEMS are [5] [6]. From these analyses a list of possible actions to improve BEMS commissioning by automating some actions was defined. It covers the followings: 1) Simulation testing of control strategies on test bench before installation 2) Automatic report generation when checking that all equipments are installed 3) range check and auto calibration of input and output at panels 4) Test local controllers a) self discovery of communication points b) auto tuning and closed loop testing of control functions 5) Operator, workstation and supervisory controller set-up a) auto tuning b) bump test of communication c) Check of supervisory strategies through closed loop auto–testing d) automated limit setting of alarms…

Many manual procedures exist or are under development for performance testing of Air Handling Units. The development of automatic procedures starts in the annex with trying to automate some of these existing manual procedures.

Implementing automatic commissioning procedures in software and hardware raises specific questions. Two types of procedures are possible. Passive monitoring procedures use the BEMS to collect data about building and HVAC system behaviour. Then algorithms are applied on these data to determine if the behaviour is correct or not. Active testing procedures techniques not only monitor data but send test signal to the HVAC system. Such procedures could include for example stopping and starting up plants, opening or closing dampers … These procedures enable a much thorough testing of the system behaviour but imply a two way interaction with the system which is more complex to implement. Solutions to implement passive monitoring as well as active testing procedures are studied within the annex. In particular the possible hardware architectures and the use of open protocol such as Bacnet are analysed.

USE OF MODELS AND COMMISSIONING

The objective of this task is to evaluate the feasibility of using computer simulation based on models to verify the performance of subsystems and whole buildings. The work on component is focus on methods for performance evaluation of air handling units.

Regarding the use of models to perform commissioning tasks at the whole building level three main approaches seems promising. The first approach consists 1) to use simulation models developed during the design stage to predict heating and cooling use, 2) to compare with measured use 3) to use signature of deviations as clue to sources of deviations. This approach is adapted to initial commissioning. The second approach is more adapted to continuous commissioning. It consists in using simulation models calibrated during the initial commissioning phase. Simulated consumptions are compared to real consumption and deviations serve as alarm for changes. The third approach consists in using the simulation software as a test bench to assess the possible impact of changes in the control strategy.

COMMISSIONING PROJECTS

These projects will be used to test the tools developed within the annex as well as to demonstrate the advantage of commissioning. 17 projects are already selected in North America, Europe and Japan.

CONCLUSIONS AND PERSPECTIVE

Commissioning is a promising approach to improve the actual energy performance of HVAC systems. Applying commissioning needs at the same time 1) a clear definition of task to be performed, 2) a clear task assignment between the parties involved in the building project and the commissioning authority 3) a good toolset to help applying the different tasks. After having clarified the tasks to be performed for different types of building project Annex 40 is now developing new tools to be included in a coherent tool set.

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